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A METHOD FOR DEVELOPING REFERENCE ENTERPRISE ARCHITECTURES

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ABSTRACT

In the age of globalization and digitization, organizations face rapid environmental changes, such as short technology lifecycles, digital disruption, or increasing regulatory pressure. These developments affect whole industries and demand organizational flexibility. Enterprises have to adapt their strategies, business models, and use information systems effectively in order to stay competitive. In many cases, these requirements address groups of various enterprises in a particular domain. However, they often lack the knowledge and resources to holistically adapt their business and IT structures, which paralyzes their organizational development and leads to isolated solutions.

From the perspective of information systems research, enterprise architecture management (EAM) is a widely-accepted discipline that helps enterprises to understand their organizational structures from a business and IT alignment perspective and support their organizational change processes. Furthermore, the reference modeling (RM) discipline provides methods to develop reusable IT-based reference models for a group of stakeholders. Reference models help organizations to identify desired future states in a particular problem context. In this regard, research acknowledges the potential of *Reference Enterprise Architectures (REA)* to support organizations overcoming the challenges of industrial change. However, academic efforts dedicated to the methodological support of constructing REAs are scarce as research focuses on reference process models or software architectures.

This thesis applies the design science research paradigm and proposes *REAM*—a method for developing REAs. After investigating the local practices of the utility industry and the financial services domain, the author derives the practical problem that industries characterized by change lack holistic approaches such as REAs for organizational transformation. A thorough knowledge base analysis further reveals an absence of method support for developing REAs. REAM aims to close this research gap. In an iterative search process, the thesis shows REAM's utility. In the end, REAM's design evolved over seven evaluation episodes that primarily assessed REAM's fit to prior formulated requirements in naturalistic settings and collected feedback from practical and scholar audiences.

The main contribution to the scientific body of knowledge of this thesis is REAM. Besides, the thesis provides an improved comprehension of the REA concept. Further, the application of REAM produced two domain-specific REAs that have been validated and used in the utility industry and the financial services domain.

KURZFASSUNG

Im Zeitalter der Globalisierung und Digitalisierung sehen sich Organisationen mit schnellen Umweltveränderungen konfrontiert, wie z.B. kurzen Technologie-Lebenszyklen, digitalen Disruptionen oder zunehmendem Regulierungsdruck. Diese Entwicklungen betreffen ganze Branchen und erfordern organisatorische Flexibilität. Um in diesem Kontext wettbewerbsfähig zu bleiben müssen Unternehmen ihre Strategien und Geschäftsmodelle anpassen sowie ihre IT-Landschaften effektiv nutzen. In vielen Fällen richten sich diese Anforderungen gleichzeitig an eine Vielzahl verschiedener Unternehmen in einer bestimmten Domäne. Oft fehlt diesen jedoch das Wissen und die Ressourcen, um ihre Geschäfts- und IT-Strukturen ganzheitlich anzupassen, was ihre organisatorische Entwicklung lähmt und zu Insellösungen führt.

Aus der Perspektive der Informationssystemforschung ist Unternehmensarchitektur-Management (engl. EAM) eine weithin akzeptierte Disziplin, die Unternehmen hilft, ihre Organisationsstrukturen aus der Perspektive der Geschäfts- und IT-Entwicklung zu verstehen und ihre organisatorischen Veränderungsprozesse zu unterstützen. Darüber hinaus bietet die Disziplin der Referenzmodellierung (RM) Methoden zur Entwicklung wiederverwendbarer IT-basierter Referenzmodelle für eine Gruppe von Interessengruppen. Referenzmodelle helfen Organisationen, gewünschte zukünftige Zustände in einem bestimmten Problemkontext zu identifizieren und anzuwenden. In dieser Hinsicht erkennt die Forschung das Potenzial von Referenz-Unternehmensarchitekturen (engl. REA) an, welche Organisationen bei der Bewältigung der Herausforderungen des industriellen Wandels unterstützen können. Allerdings bietet die Forschung bislang keine zur methodische Unterstützung zur Entwicklung solcher REAs und konzentriert sich stattdessen vor allem auf auf Referenzprozessmodelle oder –softwarearchitekturen.

Diese Doktorarbeit wendet das Forschungsparadigma Design Science Research an und schlägt REAM vor—eine Methode zur Entwicklung von REAs. Nach einer Problemuntersuchung in der Versorgungsindustrie und des Finanzdienstleistungsbereichs leitet der Autor das praktisches Problem ab, dass Branchen, die durch Wandel gekennzeichnet sind, ganzheitliche Ansätze wie REAs für die organisatorische Umgestaltung fehlen. Eine gründliche Analyse der Wissensbasis zeigt außerdem, dass es keine methodische Unterstützung für die Entwicklung von REAs gibt. REAM zielt darauf ab, diese Forschungslücke zu schließen. In einem iterativen Suchprozess zeigt diese Arbeit den Nutzen von REAM auf. Die Methode REAM bildete sich über sieben Evaluationszyklen heraus, wobei in erster Linie die Eignung von REAM für die zuvor formulierten Anforderungen in naturalistischen Evaluationsumgebungen bewertet und Verbesserungsvorschläge von praktischen und wissenschaftlichen Methodenanwendern gesammelt wurden.

REAM stellt den Hauptbeitrag dieser Arbeit zum wissenschaftlichen Wissensbestand dar. Außerdem ermöglicht die Arbeit ein besseres Verständnis des REA-Konzepts. Darüber hinaus hat die Anwendung von REAM zwei industriespezifische REAs hervorgebracht, die validiert und in der Versorgungsindustrie und im Finanzdienstleistungsbereich eingesetzt wurden.

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Felix Timm
Rostock, June 18, 2020

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ABBREVIATIONS

ADM	ARCHITECTURE DEVELOPMENT METHOD
AML	ANTI-MONEY LAUNDERING
ATAM	ARCHITECTURAL TRAD-OFF ANALYSIS METHOD
BPO	BUSINESS PROCESS OUTSOURCING
cRMM	CONFIGURATIVE REFERENCE MODELING METHOD
DSR	DESIGN SCIENCE RESEARCH
EA	ENTERPRISE ARCHITECTURE
EAM	ENTERPRISE ARCHITECTURE MANAGEMENT
EE	EVALUATION EPISODE OF FEDS APPLICATION
ERP	ENTERPRISE RESOURCE PLANNING
FEDS	FRAMEWORK FOR EVALUATION IN DSR
FRA	FUTURISTIC REFERENCE ARCHITECTURE
FREQ	FUNCTIONAL REQUIREMENT
GRC	GOVERNANCE, RISK, AND COMPLIANCE
IS	INFORMATION SYSTEM
ISR	INFORMATION SYSTEMS RESEARCH
ISV	INDEPENDENT SOFTWARE VENDOR
IT	INFORMATION TECHNOLOGY
KBA	KNOWLEDGE BASE ANALYSIS
KYC	KNOW YOUR CUSTOMER
LP	LOCAL PRACTICE
MCC	MINIMAL COSTS OF CHANGE
MEM	METHOD EVALUATION MODEL
NFREQ	NON-FUNCTION REQUIREMENT
PRA	PRACTICE REFERENCE ARCHITECTURE
PU	PUBLIC UTILITY
RA	REFERENCE ARCHITECTURE
RC	ROOT CAUSE
RCM	REGULATORY COMPLIANCE MANAGEMENT
RCO	REFERENCE COMPLIANCE ORGANIZATION
REA	REFERENCE ENTERPRISE ARCHITECTURE
REAM	REFERENCE ENTERPRISE ARCHITECTURE METHOD
REQ	REQUIREMENT
RM	REFERENCE MODEL(ING)
RQ	RESEARCH QUESTION
rSLR	RELEVANT SLR
SBVR	SEMANTICS OF BUSINESS VOCABULARY AND BUSINESS RULES
SGAM	SMART GRIDS ARCHITECTURE MODEL
SLR	SYSTEMATIC LITERATURE REVIEW
SME	SMALL AND MEDIUM-SIZED ENTERPRISES
S-RMM	SITATIONAL REFERENCE MODEL MINING
TOGAF	THE OPEN GROUP ARCHITECTURE FRAMEWORK

I. INTRODUCTION

Across many industries, the age of globalization and digitalization confronts organizations with the challenge of aligning their businesses with an increasingly complex information systems landscape. However, far-reaching organizational transformation programs caused by technological disruptions or demanding regulatory frameworks often showcase the lack of adequate alignment. While such changes can impact various stakeholders or even entire industries, affected organizations usually lack not only the procedural knowledge of how to change but also what state is desirable. In that context, reference models and reference architectures for concrete domains help to structure necessary knowledge of that desired state and make it accessible to affected organizations. Before concretizing how this thesis contributes in this context, subsequent paragraphs summarize observations that laid the foundation for the research documented in work.

1.1 COMPLEXITY CHALLENGE TO ORGANIZATIONAL CHANGE PROCESSES

The challenge to keep up with the high dynamics of technological innovations increases the complexity of organizations' structures, processes, IT landscapes, products, and overall working conditions (Latos et al. 2017). In their 2018 Global CIO Report, Dynatrace found that 76% of the 800 respondents stated that the pressure to adopt new technologies would make it impossible to manage increasing IT complexity (Dynatrace LLC 2018). While information systems research does still not provide an established notion of complexity (Schneider et al. 2015; Backlund 2002), literature agrees that the alignment of business and IT is an essential task of any organization in this context (Kahre et al. 2017; Legner et al. 2017; Haffke et al. 2017). Business and IT alignment addresses the business value of information systems and their supporting role to translate business strategy into operation (Henderson and Venkatraman 1993; Chan and Reich 2007; Coltman et al. 2015).

Next to their increasing structural complexity, organizations operate in volatile business environments that are determined by increasingly complex market structures, disrupting technology innovations, growing product IT, empowered customers, and various regulatory frameworks. Stated factors force organizations to adapt their IT with their operational structures (Ahlemann et al. 2012; Proper et al. 2017, p. 2). While internal factors such as strategy shifts induce organizational change, organizations also face change processes that are triggered by external factors, such as market changes, technological disruptions, or regulatory requirements (Proper et al. 2017, p. 2). To illustrate the extent of impact industrial changes can have on organizational practice, one can take a closer look at developments of different industries. Market liberalization of European energy markets (Bundesrepublik Deutschland 1998; German Federal Government 8/29/2016) and governmental enforcements to promote renewable energy sources (German Federal Government 7/21/2014), confronted traditional public utilities (PUs) with transformational processes that prolong until today (Hall and Roelich 2016). Likewise, globally acting financial institutes and related financial service providers have to comply with complex regulatory frameworks that emerged after the global financial crisis from 2007 (Ricketts 2013; Mellon 2017). Moreover, their legacy IT landscapes hinder them from keeping up with companies that provide products based on blockchain and artificial intelligence technologies (Gomber et al. 2018). Similar developments appear in the telecommunications industry, where increased competition and short innovation cycles force communication providers to develop new IT-based products (Czarnecki and Dietze 2017c).

Investigating the concrete effects of environmental change on organizations, it becomes apparent that they often not only require transformational activities in specific areas—i.e., designing and implementing new business processes, hiring new personnel, or purchasing new IT services—but rather affect organizations' structures holistically. In the case of the European energy sector, traditional PUs had to transform their legacy structures regarding different perspectives: (i) restructure their organizations into separate legal entities (BDEW 2008); (ii) improve their IT capabilities by, among other things, developing their infrastructure to enable smart meter integration (Jagstaidt et al. 2011) or implementing technologies that handle volatile renewable energy sources (Buhl and Weinhold 2012; Lampropoulos et al. 2010); (iii) develop their legacy IT landscapes to manage new these IT assets (Goebel et al. 2014; Holzamer and Vollmer 2017; PWC 2017); and to (iv) innovate their business models to compete with the increasing competition of new energy providers (Aliff 2013; Scheller et al. 2018). In the financial services industry, national, European, and international authorities forced institutes to enhance their compliance process thoroughly. Single directives such as the anti-money laundering act (European Union 2018) require structural changes and enforce the implementation of enhanced risk management or client and reporting monitoring processes. Such demands indirectly affect legacy IT landscapes of financial institutes as well. Although governments recently increase pressure on institutes to improve interoperability and transparency of their IT structures (Federal Financial Supervisory Authority 2018), institutes fail to implement an integrated regulatory management approach as they develop isolated compliance programs (Gozman and Currie 2015). Meanwhile, akin developments occur in other industries like the telecommunications industry (Czarnecki and Dietze 2017c), health care (Sultanow et al. 2018; Chircu et al. 2017) or manufacturing (Heidel et al. 2017).

More often than not, there exist several problem stakeholders directly or indirectly affected by the above illustration example. A problem stakeholder may be any organization, institutes, or authority that acts in the domain where industrial change takes place. While the consequences for each of them may differ in detail, they face the same challenges of organizational transformation—at least to a different degree of intensity. Developments in the energy sector and the concomitant need of PUs to restructure their IT architectures changed the demands regarding software and service providers. On the one hand, the functionality of standard enterprise resource planning (ERP) software products become more complex. On the other hand, stated developments increase the demand for business process outsourcing, which triggered a shift of business models of service providers (Sandkuhl and Koc 2014). Independent software providers (ISVs) from the financial industry face similar challenges. The same applies to consultancy and auditing companies, who have to keep up with new regulatory requirements to maintain their service products.

Previous statements describe observations that are usually well documented in both practice and research. However, as the author learned during the development of this thesis, many problem stakeholders are not aware of organizational consequences at the time such changes occur in their business environment**.** Actions for adaptation are usually a complicated and cost-intense learning and organizational change process (Proper et al. 2017; Morakanyane et al. 2020). The absence of explicit knowledge that prescribes a target state increases the effort of an organization's change process. For instance, regulatory requirements focus on global demands, while they often lack guidance on how to reach them (Akhigbe et al. 2015; Boella et al. 2014)**.** Likewise, German PUs lose a significant number of clients to new competitors that can use the energy grid. At the same time, governmental plans obligate them to implement smart meter technologies by 2032 without providing concrete means for its practical implementation (German Federal Government 8/29/2016). The process of organizational transformation becomes an even more complicated task when environmental changes affect organizational structures, processes, IT landscapes, and their alignment—as is in the example cases demonstrated above.

Based on these observations, the author summarizes that there exist problem domains in which various stakeholders share the obstacle to adequately react to environmental changes that affect different aspects of there organizational structures (i.e., processes, IT landscapes). In this context, this thesis aims to provide methodological guidance to overcome this problem. To further introduce the scope and topic of the thesis, the remainder of this chapter will first summarize related research domains and how they relate to the above observations (section 1.2). Afterward, section 1.3 will formulate the problem statement of the present research, summarize existing knowledge it can build from, and derive an overall research objective. On this basis, section 1.4 presents the utilized research strategy before section 1.5 will give an overview of the thesis' contributions. Finally, section 1.6 presents the structure of this work.

1.2 RESEARCH CONTEXT

Two domains of information systems (IS) research address the problems described in the previous section—enterprise architecture management (EAM) and reference modeling (RM). While the former provides methods and tools for organizations to facilitate alignment of complex business and IT systems (Jonkers et al. 2006), the latter concerns the development of conceptual models that provide suitable solutions for groups of organizations or industries sharing a particular problem space (Fettke and Loos 2006).

Lankhorst et al. define enterprise architecture (EA) as *"a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business process, information systems, and infrastructure"* (Lankhorst et al. 2017, p. 3). Doing so, an EA aims to paint a holistic picture of an organization by analyzing these different organizational perspectives and capturing their interdependencies (Winter and Fischer 2006). One central idea of EAM is to holistically describe desired states of the future to derive strategic directions from an organization's current state (Op't Land et al. 2009, p. 32). Research accepts EAM as a planning and governance approach to manage the complexity and constant change, and to align organizational resources toward a common goal (Niemi and Pekkola 2019; Tamm et al. 2011). Among others, literature agrees upon the following organizational benefits of using EAM that directly relate to the observations made in the previous section:

- **HANDLING COMPLEXITY:** while often a complicated challenge itself (Lucke et al. 2010; Schneider et al. 2014), literature agrees that EAM contributes to manage complex organizational systems (Boucharas et al. 2010; Zachman 2015; Niemi and Pekkola 2019; Foorthuis et al. 2016; Schmidt and Buxmann 2011)
- **ENABLING BUSINESS AND IT ALIGNMENT:** EAM provides practical methods for business and IT alignment (Boucharas et al. 2010; Niemi and Pekkola 2019; Foorthuis et al. 2016; Tamm et al. 2011)
- **SUPPORT ORGANIZATIONAL CHANGE:** research ascribes EAM a vital role when supporting managerial decisions during organizational change processes (Boucharas et al. 2010; Zachman 2015; Niemi and Pekkola 2019; Foorthuis et al. 2016; Proper 2014).

In general, the RM research domain investigates the means to construct RMs and how they can be applied. Thomas (2005) understands an RM as "*an information model used for supporting the construction of other models."* In general, an RM addresses a problem of a specific application class (e.g., a group of enterprises) and provides a reusable solution. The purpose of its development is to be reused in a concrete use case from that application class, usually improving the effectiveness and efficiency of IS development (Schütte 1998). In order to define the notion of RMs more precisely, IS research discusses their characteristics universality, recommendation, and reusability (Fettke and Loos 2006; Thomas 2005; Vom Brocke 2006). While these three characteristics sharpen the concept of RMs, the former two are neither measurable, nor can they be verified by objective reasoning. Consequently, both Thomas (2005) and Vom Brocke (2006) argue that only-the actual application of an RM to an enterprise-specific model and its acceptance within the problem domain defines its essence. From a life cycle perspective, IS research distinguishes between the phases of RM construction and RM application (Fettke and Loos 2006). During RM construction, the RM is developed and prepared for its application by the RM designer. In the application phase, the RM user applies the model to his or her individual use case. The IS research domain provides numerous methods for RM construction. While some approaches address the development of certain RM types—such as configurable reference process models (Becker et al. 2002)—others provide more generic RM construction methods (Schütte 1998; Delfmann 2006).

While RM research foundations were laid several decades ago, recent research activities investigate inductive reasoning for RM construction. Inductive RM approaches aim to abstract and aggregate RMs based on prior elicited enterprise models or system logs of individual organizations of the respective problem domain (Rehse 2019) adapting from process mining approaches and graph theory (Li et al. 2011; Leng and Jiang 2016). Regarding observations from the previous section, methods from the RM research domain provide means how to define a desirable state that represents the consequences of industrial change. They further offer affected problem stakeholders techniques to reuse this knowledge for individual organizational transformation processes.

The author concludes that methods and principles established in the EAM research domain not only help to make the impact of industrial changes on affected organizations transparent because they focus on a holistic view of organizational structures. They also support the learning process on how to perform organizational transformation from a current state of practice to a desired state that implements the requirements demanded by the respective change drivers. Meanwhile, theories from the RM domain help us to understand how to accumulate the knowledge necessary to define such a desired state. Although developed reference models primarily provide a more narrow scope (i.e., by using business process models representations), methods for constructing and applying reference models do not consider the specifics of EA structures and have to be aligned accordingly.

Although available knowledge from the EAM and RM research domains provide many techniques to overcome earlier stated problems, the author identifies a lack of approaches that combine both domains in order to develop reference EAs (see section 4.3). EAM methods suggest organizations to reuse existing reference models (The Open Group 2011) but lack methods of how to develop them. Methods in the RM domain either emphasize other enterprise model types like business process models (Becker et al. 2002; Rehse et al. 2016; Scholta et al. 2019) or software architectures (Nakagawa et al. 2014) or prove to be too broad for a successful adaptation to EA structures (Schütte 1998; Delfmann 2006).

Based on an extensive analysis of related research (see section 4.3), the author of this thesis defines a Reference Enterprise Architecture (REA) as follows:

DEFINING "REFERENCE ENTERPISE ARCHITECTURE"

AN REA IS A SPECIFIC TYPE OF A RM THAT USES THE STRUCTURE OF ENTERPRISE ARCHITECTURES. IT ADDRESSES A CONCRETE PROBLEM THAT AFFECTS A CLASS OF ORGANIZATIONS REGARDING THEIR BUSINESS AND IT STRUCTURES. THE REA STRUCTURES DOMAIN-SPECIFIC KNOWLEDGE IN A COHERENT EA MODEL, REPRESENTS A GENERALIZED SOLUTION FOR THE PROBLEM, AND PROVIDES MEANS FOR ORGANIZATIONS TO APPLY THAT MODEL IN THEIR PRACTICES.

1.3 PROBLEM RELEVANCE

The research problem addressed by this thesis emerged during the author's participation in two research projects. Both related in the above-discussed context of industrial change that affected a specific group of organizations active in that industry. Situated in two distinct industries (i.e., energy sector and financial services compliance), the author collaborated with different practitioners in both projects. A thorough investigation of both local practices revealed that they shared the overall research problem and arose from similar root causes. Situated in the energy sector, the ECLORA project aimed to support traditional PUs's need for organizational change regarding business and IT perspectives in the context of market liberalization and technological as well as sustainability shifts. While PUs were aware of EAM in general, they lacked the capability of implementing individual EAM programs. In the context of ECLORA, the author cooperated with the independent software provider (ISV) SIV group[1]. In the CO-FIN project—situated in the domain of regulatory compliance management (RCM) within the financial

[1] SIV group's offers the enterprise resource planning (ERP) system kVASy® and is a business service provider, who client base consists of European small- and medium-sized PUs.

services industry—the overall objective was to define an approach for holistic RCM. COFIN was initiated by a working group of the German IT-association bitkom1 that consisted of ten ISVs and IT consultancies from the financial service RCM domain. The project addressed the local problem that financial institutes tend to implement deadline-driven and, hence, isolated compliance programs, which leads to ineffective and inefficient compliance implementations that primarily rely on obscure regulatory texts impractical for their actual implementation. During the problem investigation (see chapter IV), the author identified a problem statement, which was proven to be of global relevance and laid the foundation of this thesis:

PROBLEM STATEMENT OF THIS THESIS
REFERENCE MODELS, ESPECIALLY REFERENCE ENTERPRISE ARCHITECTURES (REA), SUPPORT ENTERPRISES OF A PARTICULAR PROBLEM DOMAIN TO OVERCOME THE CHALLENGES OF INDUSTRIAL CHANGE. REAS PROVIDE A SOLUTION FOR AFFECTED ENTERPRISES BY INTEGRATING BOTH BUSINESS AND IT PERSPECTIVES IN THE CONTEXT OF THAT CHANGE. FURTHER, THEY OFFER MEANS HOW THESE ENTERPRISES CAN REUSE THAT KNOWLEDGE. HOWEVER, PRACTICE LACKS METHODOLOGICAL GUIDANCE HOW TO DEVELOP REAS SYSTEM-ATICALLY.

Not only both local practices from ECLORA and COFIN analyzed by the author, but also other industries—as was later identified (see section 4.3)—shared following root causes:

i. Organizations lack methodological support to capture the impact of industrial change from business, data, and IS perspectives, as these endeavors are complex and resource-intensive.
ii. Detailed knowledge for such endeavors is seldom available in explicit form, since most companies fall short on documenting beyond business processes and further tend to implement isolated solutions.

As elaborations from section 1.2 discussed, both research domains of EAM of RM contribute to the stated global problem. However, they do not provide methods for constructing reference models with an EA structure. Nevertheless, there exist research in this area that relates to the above problem statements and introduces the concept of "*Reference Enterprise Architectures*" (REA)[2] or "*Enterprise Reference Architectures*" to make the impact of environmental changes transparent from the perspectives defined by EAM that apply to the group of affected stakeholders. Originating from the generic concept of "reference architectures" (Cloutier et al. 2009; Nakagawa et al. 2014), authors of the relatively recent research define an REA as "*a generic EA for a class of enterprises, that is a coherent whole of EA design principles, methods, and models which are used as foundation in the design and realization of the concrete EA that consists of three coherent partial architectures: the business architecture, the application architecture and the technology architecture*" (Harmsen van der Beek, Wijke ten et al. 2012, p. 99). Although literature presents several REAs (Czarnecki and Dietze 2017c; Aulkemeier et al. 2016b; Adwan 2018), the overall REA domain is still very immature as there does not yet exist a concrete definition of what an REA is or how it is developed (Sanchez-Puchol and Pastor-Collado 2017). To summarize, the author identifies the following research gaps research needs to close in order to overcome the problem as mentioned earlier:

- ambiguity regarding the notion of the REA term
- lack of methodological guidance for constructing REAs
- lack of approaches for eliciting necessary knowledge for REA formulation
- lack of empirical evidence why to apply REAs

[1] see https://www.bitkom.org/Themen/Digitale-Transformation-Branchen/Banking-Finance/Forschungsprojekt-IT-gestuetzte-Compliance-im-Finanzsektor-2.html for more information (accessed 02/04/2020).
[2] the remaineder of this thesis addressed both terms with the abbreviation „REA“.

- absence of coherent REA documentation guideline for successful stakeholder communication

In order to tackle the global problem and fill the identified research gaps, **the objective of this work is to develop a method that supports the development of REAs**. In this context, the author defines the following research question:

RESEARCH QUESTION
HOW TO PROVIDE METHODOLOGICAL SUPPORT FOR SYSTEMATICALLY CONSTRUCTING AND APPLYING DOMAIN-SPECIFIC REAS?

In order to address this research question, the present thesis will investigate (i) what requirements towards a method for REA development exist; (ii) how methods from RM and EAM domain can be adapted for such endeavor; (iii) the necessary knowledge to elicit for REA construction; (iv) how to properly structure and document a REA; and (v) how to support a case-specific application of an REA.

1.4 RESEARCH STRATEGY

In order to achieve the above-defined research objective to design a method for REA development, the author conducted design science research (DSR) as an overarching research strategy. According to Hevner et al. (2004), DSR addresses research through building and evaluating artifacts (March and Smith 1995), which are defined to meet a thoroughly identified business need. The authors contrast DSR to behavioral science that focuses on the development and justification of theories. While the latter's goal is to find the truth, the former's is to reach utility. Although truth and utility are inseparable, different research strategies are necessary to reach them. Johannesson and Perjons (2014) define DSR as *"the scientific study and creation of artifacts as they are developed and used by people with the goal of solving practical problems of general interest."* In general, one shall conduct DSR when about to design an artifact that addresses a so-called wicked problem (Rittel and Webber 1973). Next to other criteria, the main characteristics of wicked problem are that their requirements are ill-defined and continuously changing, existing knowledge to solve them is incomplete, and a complex interplay among related problems exist.

Comparing these requirements for DSR, the author argues that this thesis' research objective qualifies for conducting DSR. Previous elaborations have shown that its underlying research motivation originates from a practical problem of general relevance. The author understands the problem to be wicked since neither literature thoroughly investigated the concept of REAs, nor does a knowledge base exist that gives insights regarding requirements towards it. Furthermore, the investigation of the local practices revealed that the development of REA requires the participation of many different problem stakeholders and, hence, depends on humans' social and cognitive abilities to produce an effective solution.

When conducting DSR, different types of artifacts can be designed to solve the problem at hand. While there exist different world views regarding a taxonomy of DSR artifacts (Offermann et al. 2010), literature agrees upon four central artifact types in DSR: constructs, models, methods, instantiations, or even design theories (March and Smith 1995; Hevner et al. 2004; Johannesson and Perjons 2014). In the context of this thesis, the author argues that the research question formulated in section 1.3 requires the design of a method. DSR methods "*express prescriptive knowledge by defining guidelines and processes for how to solve problems and achieve goals. In particular, they can prescribe how to create artifacts. Methods can be highly formalized like algorithms, but they can also be informal such as rules of thumb or best practices*" (Johannesson and Perjons 2014, p. 29). With this work, the author aims to design a method for REA development that solves the problem of developing an REA. An REA, in turn, relates to the notion of a model as it uses "*constructs to represent a real-world situation"* (Hevner et al. 2004, p. 78).

When conducting DSR, Hevner (2007) further characterizes the design of the desired artifact by dint of three research cycles and requires any DSR project to reflect on each of them explicitly. First, the relevance cycle investigates people, organizations, or systems to identify a relevant problem of general interest and derives requirements from it. Once designed, the artifact is further tested in that application context, which may trigger another iteration of the relevance cycle to identify improvement needs. Second, the rigor cycle ensures the innovative character of the DSR project by investigating the knowledge base regarding available artifacts or experiences, which may provide useful for the problem at hand. After its relevance is proven, the developed artifact will contribute and extend the knowledge base. Rigor DSR is essential to avoid the development of routine design. As it applies known solutions to known problems, routine design does not count as design science. Third, Hevner defines the design cycle at the heart of any DSR effort as it iterates between the construction of an artifact, its evaluations, and identified feedback for the redesign of an artifact. It uses identified requirements from the relevance cycle as input and uses design and evalution theories identified by the rigor cycle to first design the artifact and then assess its utility in the application context, before feedback from this may trigger another design cycle iteration.

This cycle perspective helps to put this thesis' research strategy and results into a DSR context. Regarding the relevance cycle, the author investigated two distinct local practices that share the global problem statement in order to formulate stable requirements towards a method for REA development. Therefore, the author had access to several domain experts from ISVs, IT consultancies, and organizations that were active in the respective practices—i.e., PUs in the context of the ECLORA project and financial institutes in the context of COFIN. Using several evaluation episodes with a naturalistic setting and a formative purpose, the author conducted various design cycles that iteratively provided feedback to the proposed version of the method. In total, this led to six different versions of the proposed method. Every version of the method design was informed by the rigor cycle as it identified methods and approaches from the EAM and RM research domains as well as other related work that contributed to the method design. After a final iteration of the design cycle, the method design contributed to the knowledge basis in terms of an improvement. As Gregor and Hevner (2013) define it, an improvement provides a new solution for known problems. As the challenges faced by organizations during industrial change are a thoroughly addressed problem space, research lacked the methodological support for REA development. This thesis will propose the first method that guides the development of REAs.

For conducting DSR, the author applied the method framework for DSR proposed by Johannesson and Perjons (2014). As their approach strongly relates to the DSR process by the widely-accepted work by Peffers et al. (2007), the authors provide more explicit knowledge regarding the respective DSR phases. To *(i) explicate the problem*, the author uses empirical evidence from the local practices to derive a practical problem of general interest. Based on that, the author *(ii) defines requirements* towards the anticipated method for REA development conducting systematic literature reviews, expert interviews, online surveys, focus groups, and action research, which results in a list of five functional and three non-functional requirements. During the *(iii) design and development of the artifact,* the author adapts from established methods for EAM and RM to iteratively design a sophisticated method. After a first iteration of (iii), the first version of the method was *(iv) demonstrated* by its application to develop an REA for the utility industry using action research. As that demonstration case validated the method's overall feasibility, the author traversed through seven iterations of *(v) evaluating* the artifact as collected feedback required adjustments so that a sixth version finally met all defined requirements. For evaluation, the author applied the framework for evaluation in DSR proposed by Venable et al. (2016), whereas the seven evaluation episodes utilized research methods that ranged from criteria-based evaluation over interviews to case studies and action research.

1.5 CONTRIBUTIONS

By answering the research question depicted in section 1.3 and using DSR as a methodological framework as outlined in section 1.4, this thesis produced several contributions to the scientific knowledge base and the respective practices that applied the designed artifact.

1.5.1 CONTRIBUTIONS TO THE KNOWLEDGE BASE

As section 1.2 discussed earlier, the research domains of EAM and RM built the theoretical basis to tackle this thesis' problem statement. In this context, this thesis primarily contributes to the recent research domain of REA development. The thesis' core contribution is "REAM"—a method for constructing and applying REAs. Thus, the design process and evaluation design presented in this work focuses on REAM. However, additional contributions evolved throughout the Ph.D. project. For instance, the final design of REAM provides approaches the author assesses valuable for the RM discipline in general (C4 and C5). Further, several evaluation cycles of REAM produced particular REAs that have been applied in practice (C6 and C7). The following list enumerates and shortly explains these contributions:

- ✓ **C1: METHOD SUPPORT FOR DEVELOPING REAS.** The main contribution of this thesis is REAM—a method for developing REAs. After REAM's design evolved cycling through its application in several real-world settings, the remainder of the thesis will prove REAM's actual effectiveness for the above stated global problem. In short, REAM defines ten method components that span over three REA development phases, i.e., preparation of REA development, REA construction, and REA application. REAM adapts accepted knowledge from the fields of EAM and RM to establish an innovative method tailored to the problem solving for developing REAs. That contribution to the knowledge base grounds on an iteratively increased understanding of the global problem and its requirements towards the artifact—facilitated by the author's involvement in the ECLORA and CO-FIN research projects (see chapter VI).

- ✓ **C2: CLARIFYING THE NOTION OF REAS.** The thesis defines the REA notion. It builds from previous definitions proposed by related work and aims to sharpen the understanding of the term as research still lacks a thorough understanding of it. In that context, this thesis contributes to paint a more thorough understanding of REAs (see section 6.2).

- ✓ **C3: STRUCTURED OVERVIEW OF REA RESEARCH.** In order to fulfill Hevner's (2007) demand to ensure scientific rigor, the thesis conducts a systematic literature review (SLR) on literature related to REA development. Conducting an SLR was especially crucial as that research direction appeared to be quite immature without any clear research agenda communicated within the research community. Although initial literature overviews of the field exist (cf. Sanchez-Puchol and Pastor-Collado 2017), the author understands them to be too imprecise to derive concrete action from it in order to develop REAM. Spanning over several years, the SLR provides a comprehensive overview regarding (i) the REA notion, (ii) methodological support for REA development, (iii), structuring and documenting REAs, and (iv) knowledge elicitation and reasoning in the context of REA construction (see section 4.3).

- ✓ **C4: CONTRIBUTION TO APPLICATION-ORIENTED REFERENCE MODELING.** Literature from the RM domain agrees upon the importance of a reuse-oriented understanding of the RM notion (Thomas 2005; Vom Brocke 2006). That reuse-oriented RM notion claims that an RM does only qualify as such if real-world users applied it in practice. However, research lacks both a comprehensive understanding of critical success factors for RM application and approaches that support the preparation of RM application. In this context, REAM introduces the concept of "application scenarios" that accompany the complete REAM development process in order to promote an application-oriented design of the REA. The author claims that every RM endeavor would benefit from using the concept of application scenarios. This is in line with other recent research that argues to consider application-related design decisions at the beginning of RM construction (see section 6.6).

- ✓ **C5: ADAPTING INDUCTIVE REFERENCE MODELING TO EA STRUCTURES.** As REAM emphasizes inductive reasoning for constructing REA models, the thesis contributes to the body of knowledge of inductive RM. As a relatively young research direction, inductive RM approaches focus on business process model structures like the Business Process Modeling Notation (BPMN) or event-driven process chains (EPC). Analyzing the feasibility to adopt these existing inductive methods to EA structures, this thesis provides a systematic overview of adaptable approaches and adjusts two selected approaches in real-world contexts to develop REAs that build from practical knowledge. Hence, the author claims to contribute to both EAM and RM domains in this regard (see section 6.5.4).

1.5.2 CONTRIBUTIONS TO RELATED PRACTICES

Activities during ECLORA and COFIN projects applied and evaluated above described contributions. Therefore, the thesis at hand provided the following contributions to the energy sector and RCM in financial services:

- ✓ **C6: UTILITY REA.** During its demonstration of feasibility, REAM was applied in the context of the ECLORA project. To understand the consequences of market liberalization and technological shifts on PUs' business and IT architectures, applying the first version of REAM produced the *Utility REA*. Still used by the ECLORA project partner SIV group to improve their ERP software and business process outsourcing processes, the Utility REA reveals interrelations among PUs' current business processes, responsibilities, necessary data, and supporting IT components. Further, it systematizes stated interrelations regarding the responsible market roles (e.g., grid operator or energy supplier) and provides insights regarding value creation in the domain (see section 2.1.2.4).

- ✓ **C7: REFERENCE COMPLIANCE ORGANIZATION.** The COFIN project aimed to develop a holistic approach to support regulatory compliance management from the perspective of financial institutes in the German legal sphere. In this context, COFIN conducted several REAM applications. By dint of these method applications, the *Reference Compliance Organization (RCO)* evolved, which was regularly reviewed and applied by practitioners of financial institutes, vendors of compliance software, and consultancy firms. With the guidance of REAM, the RCO provided insights regarding the RCM domains anti-money laundering, customer identification, and fraud prevention that not only built from requirements of legal texts, but instead used practical knowledge elicited from a representative sample of German institutes. RCO revealed regulatory implications of these three domains regarding institutes processes, organizational structures, data structures, and IT landscapes. Practitioners understood RCO to integrate previously isolated compliance programs of institutes. Different problem stakeholders like the ISVs, consultancies, and financial institutes assessed the application of RCO as valuable for achieving holistic RCM (see section 6.3).

1.5.3 PUBLISHED WORK IN THE CONTEXT OF THE THESIS

This section enumerates the conference papers, workshop papers, journal articles, and technical reports published in the course of the Ph.D. project that represent certain aspects of the overall DSR project. Each publication item is shortly related to the particular aspects of this work it contributes.

CONFERENCES AND WORKSHOP PAPERS

Timm, Felix; Sandkuhl, Kurt (2018): A Reference Enterprise Architecture for Holistic Compliance Management in the Financial Sector. In: *Proceedings of Thirty-Ninth International Conference on Information Systems (ICIS 2018)*, San Fransisco 2018, https://aisel.aisnet.org/icis2018/modeling/Presentations/2/. *This conference paper reports on the aggregated results of applying REAM in the financial sector. It refers to C1, C4, C5, and C7.*

Timm, Felix; Klohs, Katharina; Sandkuhl, Kurt (2018): Application of Inductive Reference Modeling Approaches to Enterprise Architecture Models. In Witold Abramowicz, Adrian Paschke (Eds.): *21st International Conference on Business Information Systems (BIS 2018)*, Berlin, Germany, July 18-20, 2018. Proceedings, vol. 320. Cham: Springer (Lecture Notes in Business Information Processing, 320), pp. 45–57. *This conference paper analyzes existing methods for inductive reference modeling regarding their feasibility for EA structures and proposes an adjustment for inductively constructing an REA. It refers to C5 and C7.*

Timm, Felix (2018): An Application Design for Reference Enterprise Architecture Models. In Raimundas Matulevičius, Remco Dijkman (Eds.): *Advanced Information Systems Engineering Workshops. CAiSE 2018 International Workshops*, Tallinn, Estonia, June 11-15, 2018, Proceedings, vol. 316. Cham: Springer International Publishing (Lecture Notes in Business Information Processing, 316), pp. 209–221. *This conference paper reports on the application design of the RCO produced by REAM. It refers to C4 and C7.*

Timm, Felix; Sandkuhl, Kurt (2018): Towards a Reference Compliance Organization in the Financial Sector. In Paul Drews, Burkhardt Funk, Peter Niemeyer, Lin Xie (Eds.): *Multikonferenz Wirtschaftsinformatik 2018*. Data driven X - Turning Data into Value : Leuphana Universität Lüneburg, 6.-9. März 2018. Lüneburg: Leuphana Universität Lüneburg Institut für Wirtschaftsinformatik. *This conference paper presents first results of REAM application in the COFIN project and discusses improvement needs for future REAM versions. It refers to C1, C2, and C7.*

Timm, Felix; Hacks, Simon; Thiede, Felix; Hintzpeter, Daniel (2017): Towards a Quality Framework for Enterprise Architecture Models. In H. Lichter, T. Anwar, T. Sunetnanta (Eds.): *5th International Workshop on Quantitative Approaches to Software Quality. 24th Asia-Pacific Software Engineering Conference (APSEC*). Nanjing, China, pp. 10–17. *This conference paper proposes an approach to assess the quality of EA models and applies it to REAs. It refers to C1 and C7.*

Timm, Felix; Sauer, Valentina (2017): Applying the Minimal Cost of Change Approach to inductive Reference Enterprise Architecture Development. In Alexander Rossmann, Alfred Zimmermann (Eds.): *Proceedings 272 "Digital Enterprise Computing (DEC 2017)"*. 11.-12. Juli 2017 Böblingen, Germany. Bonn: Köllen (GI-Edition. Proceedings, 272), pp. 15–26. *This conference paper reports on first insights for inductive REA construction and presents a naïve application of an inductive RM approach to an example REA. It refers to C1, C4, and C7.*

Timm, Felix; Sandkuhl, Kurt; Fellmann, Michael (2017): Towards A Method for Developing Reference Enterprise Architecture. In J. M. Leimeister, W. Brenner (Eds.): *Proceedings der 13. Internationalen Tagung Wirtschaftsinformatik (WI2017)*. St.Gallen, pp. 331–345. *This conference paper proposes an early version of REAM (cf. REAM v2 in section 7.2) and presents its application in the utility sector as well as lessons learned regarding method design. It refers to C1, C2, and C6.*

Timm, F.; Zasada, A..; Thiede, F. (2017): Building a RM for Anti-Money Laundering in the Financial Sector, in Krestel, R.; Mottin, D.; Müller, E. (Hrsg.): *Proceedings der 13. Conference Lernen, Wissen, Daten, Analysen (LWDA 2016)*, Potsdam, S. 111-120. *This conference paper reports on the first research activities to develop the RCO for the financial sector and provides an initial RM for anti-money laundering programs. It refers to C1 and C7.*

Timm, Felix; Köpp, Christina; Sandkuhl, Kurt; Wißotzki, Matthias (2015): Initial Experiences in Developing a Reference Enterprise Architecture for Small and Medium-Sized Utilities. In Jolita Ralyté, Sergio España, Óscar Pastor (Eds.): *8th IFIP WG 8.1 Working Conference on the Practice of Enterprise Modelling (PoEM 2015)*. Cham: Springer International Publishing (235). *This conference paper discusses findings for knowledge elicitation during inductive REA construction and presents the results after REAM application in the utility industry. It refers to C1, C4, and C6.*

Timm, Felix; Wißotzki, Matthias; Köpp, Christina; Sandkuhl, Kurt (2015): Current state of enterprise architecture management in SME utilities. In Douglas W. Cunningham, Petra Hofstedt, Klaus Meer, Ingo Schmitt (Eds.): *INFORMATIK 2015*. Bonn: Gesellschaft für Informatik e.V, pp. 895–907. *This conference paper identifies the need for a REA in the local practice of public utilities based on the findings of a representative survey. It refers to C1 and C6.*

JOURNALS

Timm, Felix; Herzog, Henning; Kopp, Reinhold; Sandkuhl, Kurt; Stephan, Gregor (2019) Eine Referenzarchitektur zur ganzheitlichen Umsetzung von regulatorischen Anforderungen in der Finanzindustrie. Corporate Compliance Zeitschrift (CCZ). pp. 81-87. *This is an articled published in a German journal for compliance management without a peer review. It presents the RCO based on a legal perspective on the domain and discusses its value for problem stakeholders. It refers to C7.*

Sandkuhl, Kurt; Herzog, Henning; Timm, Felix; Stephan, Gregor; Debski, Alina (2018): Eine Referenz für die Compliance-Organisation. In *ZRFC: Risk, Fraud & Compliance: Prävention und Aufdeckung in der Compliance-Organisation* 13 (1), pp. 16–22. *This is an article published in a German journal for compliance management without a peer review. It reflects on the results of applying REAM in the COFIN project (cf. evaluation episodes 3 and 4 in section 7.2). It refers to C1, C4, and C7.*

Timm, Felix; Sandkuhl, Kurt (2018): Towards a reference compliance organization in the financial sector. In *Banking and information technology / Deutsche Ausgabe* 19 (2), pp. 38–48. *This is a journal article based on Timm and Sandkuhl (2018) from Multikonferenz Wirtschaftsinformatik in 2018. It provides slight ajdustments from the conference paper and focuses on C5 and C7 as well.*

TECHNICAL REPORTS

Cammin, Ph., Wißotzki, M. & Timm, F. "*Entwicklung eines Rahmenwerks zur Analyse von Unternehmensarchitekturen in der Versorgerindustrie*" Technical Report (German), Chair of Business Information Systems, University of Rostock, Rostock, 2015, ISBN: 978-3-00-049541-0. *The results of this study provided evidence for the investigation of the current challenges of the local practice A: Utility Industry. This technical report thoroughly discusses the results of an online survey of PUs regarding EAM and provided evidence for one of this thesis' investigated local practices (see section 6.6.2).*

PUBLICATION RELATED TO THE SCOPE OF THE THESIS

Wißotzki, Matthias; Timm, Felix; Stelzer, Paul (2017): Current State of Governance Roles in Enterprise Architecture Management Frameworks. In Björn Johansson, Charles Møller, Atanu Chaudhuri (Eds.): Perspectives in Business Informatics Research. 16th International Conference, BIR 2017, Copenhagen, Denmark, August 28–30, 2017, Proceedings, vol. 295. Cham: Springer International Publishing (Lecture Notes in Business Information Processing), pp. 3–15. *(Conference Paper) This conference paper discusses essential roles for EAM programs and inspired the cooperation forms defined for using REAM (see section 6.2.3).*

Koç, Hasan; Timm, Felix; España, Sergio; González, Tania; Sandkuhl, Kurt (2016): A method for context modelling in capability management. In 24th European Conference on Information Systems, ECIS 2016. *(Conference Paper)*

H. Koc ̧, J.-C. Kuhr, K. Sandkuhl, and F. Timm, "Capability- Driven Development - A Novel Approach to Design Enterprise Capabilities," in Emerging Trends in the Evolution of Service-Oriented and Enterprise Architectures, ser. Intelligent Systems Reference Library, E. El-Sheikh, A. Zimmermann, and L. C. Jain, Eds., 2016, vol. 111, pp. 151-177. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-40564-3_9. *(Book Chapter) While the scope of this book chapter addresses a different problem, it provides further evidence for constant organizational change, from which this thesis builds.*

Wißotzki, Matthias; Timm, Felix; Sonnenberger, Anna (2015): A Survey on Enterprise Architecture Management in Small and Medium Enterprises. In: *Proceedings of the 17th International Conference on Enterprise Information Systems (ICEIS 2015)*: SciTePress. *(Conference Paper) This conference paper provides evidence that small- and medium-sized enterprises need support for EAM. The authors derive a need for REA development.*

1.6 THESIS STRUCTURE

The present thesis is structured into eight chapters. After this introduction, chapter I thoroughly presents how the author applied DSR to develop the envisioned method and what research methods were applied in the respective DSR phases.

Chapter III gives a comprehensive overview of the two research domains related to this work's problem statement. By discussing general concepts and theories of enterprise architecture management (EAM) and RM, it clarifies the research context and lays the theoretical foundations of the thesis.

In order to prove this thesis' relevance, chapter IV investigates the two local practices in more detail and analyzes their similarities in order to derive a practical problem of general interest. After identifying related root causes of that problem, the chapter further provides the results of a systematic literature review that analyzes the knowledge base related to these root causes. Next to systematizing reusable knowledge from the literature, it reveals current research gaps in the context of REA development, from which it derives the central research question of this thesis.

Based on these insights, chapter IV concretizes the type of artifact designed by the thesis—a method for REA development—and formulates requirements towards it by investigating stakeholders of the two local practices.

Chapter VI presents the final version of the artifact REAM—a Reference Enterprise Architecture Method. After explaining its structure and providing a systematic overview, the chapter uses a method description template to describe REAM's method phases and the related method components. By establishing a running example, the chapter illustrates how to apply each of the ten REAM components. The chapter concludes with an overview of the design rationales of the method and a transparent reflection of how REAM reuses approaches identified in the related knowledge base.

Chapter VII reflects how the artifact evolved and presents the results of the evaluation. It discusses the evaluation design of REAM and explains how the framework for evaluation in DSR by Venable et al. (2016) was applied. Presenting the chosen evaluation strategy and investigated evaluation properties, the chapter presents the results of the seven evaluation episodes of REAM and illustrates how the six method versions evolved.

The final chapter VII summarizes the thesis' findings, reflects on the design process, and discusses its limitations. By concluding the work, it addresses future research directions in the context of REA development.

II. RESEARCH DESIGN

Based on Kuhn (1996) and Lakatos (1978), Vaishnavi and Kuechler understand research as *"an activity that contributes to the understanding of a phenomenon"* (Vaishnavi and Kuechler 2008, p. 7). While a "phenomenon" is any entity (or its behavior) that is found interesting by a research community, the "understanding" of it relates to any knowledge of a phenomenon's behavior. The present Ph.D. thesis investigates the phenomenon of how to support organizations' business and IT alignment efforts in the context of industrial change processes. The author aims to contribute to that phenomenon's understanding by investigating different instances of it and deriving methodological guidance that aims to make such alignment efforts more transparent.

The set of activities a research community assesses adequate to improve the understanding of a phenomenon constitutes its research method. According to Vaishnavi and Kuechler (2008), information systems research (ISR) is a "multi-paradigmatic" community as it differs in terms of phenomena investigated and research methods deployed to understand them. In that context, the literature identifies two paradigms that the majority of ISR deploys, i.e., behavioral science and design science research (March and Smith 1995; Hevner et al. 2004; Johannesson and Perjons 2014). Behavioral science investigates the truth aiming to describe, explain, and predict the phenomenon. In contrast, design science research's (DSR) objective is the utility of a phenomenon. That phenomenon in DSR is an artifact created to help people fulfilling their needs. At the same time, DSR creates knowledge about that artifact (Hevner et al. 2004; Johannesson and Perjons 2014, p. 1). That is in line with Vaishnavi and Kuechler (2008), who emphasize that—in contrast to natural science—DSR creates all or parts of the phenomenon.

The present Ph.D.'s overall research question concerns the creation of methodological support for developing REAs (see chapter I). Based on the elaborations above, the author deployed a DSR approach. This chapter reports on the research design followed by this work. Its overall intention is to illustrate the research rigor from each section of a DSR documentation, as demanded by Gregor and Hevner (2013). Therefore, the remainder of this chapter is structured as follows. Section 2.1elaborates on the DSR domain in more detail. It further divides into two sub-sections. While section 2.1 provides general definitions and principles of DSR, section 2.1.2 reports on what process model for conducting DSR underlies this research and how the author instantiated it in the context of this Ph.D. project. As any DSR project makes use of different research strategies and methods, section 2.2 then provides brief theoretical background on all research methods utilized by this work, e.g., survey, action research, or systematic literature reviews.

2.1 DESIGN SCIENCE RESEARCH

According to Hevner et al. (2004, p. 76), DSR has its roots in the seminal work *The Sciences of the Artificial* by Simon (1981, p. 133). While Frank (2006b) argues that Simon primarily addresses artificial intelligence, he still provides a first definition of design, which *"is concerned with how things ought to be, with devising artifacts to attain goals*" Simon (1981, p. 133). Such artifacts embody the artificial. Based on Simon's work, first definitions of DSR appeared in further seminal DSR papers (March and Smith 1995, p. 253; Hevner and Chatterjee 2010, p. 5). Johannesson and Perjons (2014, p. 7) define DSR as *"the scientific study and creation of artifacts as they are developed and used by people with the goal of solving practical problems of general interest."* A practical problem is a gap between the current and a desirable state perceived by practitioners of a particular domain. In contrast to design, which produces original artifacts for solving a problem of a local practice, DSR focuses on problems that concern a global practice, i.e., a community of local practices (Johannesson and Perjons 2014). Consequently, DSR produces knowledge that is of general interest. Hevner et al. (2004) state that problems tackled by DSR are "wicked problems" (Rittel and Webber 1973). They summarize those problems to be characterized by:

- unstable requirements and constraints based upon ill-defined environmental contexts,
- complex interactions among subcomponents of the problem and its solution,
- inherent flexibility to change design processes as well as design artifacts (i.e., malleable processes and artifacts),
- a critical dependence upon human cognitive abilities (e.g., creativity) to produce effective solutions, and
- a critical dependence upon human social abilities (e.g., teamwork) to produce effective solutions

In order to position DSR in the context of ISR, Hevner et al. (2004) provide a framework for ISR, which reveals the interplay of DSR and behavioral science paradigms. As Figure 1. Information Systems Research Framework (Hevner et al. 2004, p. 80) illustrates, the framework positions ISR between the environment it relates to and the knowledge base it builds on. The *environment* defines the problem space addressed by the research. The researcher identifies a business need, i.e., the research problem. It is based on perceptions of people from the environment, their evaluation in organizational contexts while considering existing technological possibilities. The overall goal by investigating the environment is to reach research relevance.

Hevner et al. argue that there exist two complementary phases of *researching* the IS domain. Behavioral science addresses research that explain or predict phenomena related to the identified business needs by the development and justification of theories. Thus, behavioral science aims to discover the truth. DSR builds and evaluates artifacts that aim to meet the identified business need. Its objective is to reach utility. The framework incorporates both research paradigms as inseparable since truth informs design and utility informs theory. Although DSR builds artifacts and behavioral science develops theories, both paradigms use the evaluate/justify activities to assess the artifact or theory in order to refine them based on identified weaknesses.

In order to ensure research rigor, the *knowledge base* provides knowledge applicable to conduct research activities. While foundations provide theories, frameworks, or models to support the develop/build activities, existing methodologies guide justify/evaluate activities. By using adequate knowledge foundations and methodologies, the research achieves rigor.

The contributions of behavioral science and DSR are assessed by applying theory or artifacts in an adequate environment. They add to the knowledge base for future research and practice. Hevner et al. (2004, p. 98) demands ISR to conduct a complete research cycle where DSR creates artifacts for relevant problems based on related theories, and behavioral science provides knowledge to describe, explain, and predict these artifacts.

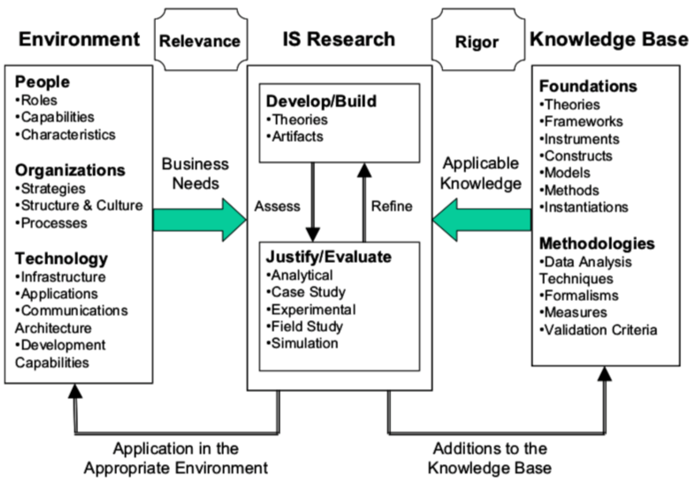


FIGURE 1. INFORMATION SYSTEMS RESEARCH FRAMEWORK (HEVNER ET AL. 2004, P. 80)

As subsequent sections will show, the present Ph.D. thesis concerns a practical problem of general interest that is based on business needs identified in different practice environments (i.e., the utility industry and the financial services domain) and qualifies for a wicked problem. That practical problem asks for methodological guidance on how to capture business and IT alignment practices for organizations that face organizational change. As this relates to the goal of utility, the author conducted DSR to solve the practical problem. Thus, the remainder of this section aims to shed more light on principles in DSR (see section 2.1.1) and reports on the applied DSR process (see section 2.1.2).

2.1.1 AN OVERVIEW OF DESIGN SCIENCE PRINCIPLES

DSR faces the dichotomy that a design is both a process and a product (Walls et al. 1992; Hevner et al. 2004). Hence, DSR relates to both the design product, i.e., the DSR artifact, and the design process. As Figure 1 shows, a sequence of activities that produce the artifact, its evaluation provides feedback and an improved understanding of the practical problem, which triggers the design of an improved version of the artifact. Hevner et al. (2004) argue that the researcher has to be aware of the evolving design process and design artifact in this build and evaluate loop. This section will discuss the concept of DSR artifacts and available methods that guide a design process in order to shed more light on these two aspects. Further, it discusses the role of knowledge in DSR endeavors and contributions of DSR projects to the scientific knowledge base. Doing so helps to position this Ph.D. thesis in the DSR context and illustrates why a DSR research design is adequate.

ARTIFACTS IN DESIGN SCIENCE RESEARCH. Artifacts are the output of any DSR project. In general, Johannesson and Perjons (2014, p. 3) define a DSR artifact as *"an object made by humans with the intention that it be used to address a practical problem."* The DSR domain distinguished between different types of DSR artifacts. While some authors identify more artifact types (Offermann et al. 2010, p. 83), there exist four general DSR artifacts types discussed among the DSR literature (March and Smith 1995, p. 256; Johannesson and Perjons 2014, p. 29; Hevner et al. 2004, p. 83): *constructs, models, methods, and instantiations*. Next to these four general DSR artifact types, DSR literature seems to reach a consensus about a fifth type of DSR output—the *design theory* (Gregor and Hevner 2013; Gregor 2006). While the former four types or often defined distinct from each other, a design theory systematizes the knowledge about an artifact and consists, for example, of testable propositions and justificatory knowledge (Johannesson and Perjons 2014, p. 34). Table 1 provides an overview of these five DSR artifact types.

TABLE 1. DEFINITION OF ARTIFACT TYPES IN DSR

ARTIFACT	SOURCE	DEFINITION
Construct	March and Smith (1995, p. 256)	*"Constructs or concepts **form the vocabulary of a domain**. They constitute a conceptualization used to **describe problems within the domain and to specify their solutions**. They form the **specialized language and shared knowledge** of a discipline or sub-discipline. Such constructs may be highly formalized as in semantic data modeling formalisms (having constructs such as entities, attributes, relationships, identifiers, constraints […]), or informal as in cooperative work (consensus, participation, satisfaction […])."*
Model	March and Smith (1995, p. 256)	*"A model is a set of propositions or statements **expressing relationships among constructs**. In design activities, **models represent situations as problem and solution statements**."*
Method	March and Smith (1995, pp. 257–258)	*"A method is a **set of steps** […] used to perform a task. Methods are **based on a set of underlying constructs (language) and a representation (model) of the solution space** […]. Although they may not be explicitly articulated, representations of tasks and results are intrinsic to methods. Methods can be tied to particular models in that the steps take parts of the model as **input**. Further, methods are often used to **translate from one model or representation to another** in the course of solving a problem."*
Instantiation	March and Smith (1995, p. 258)	*"An instantiation is the **realization of an artifact in its environment**. IT research instantiates both specific information systems and tools that address various aspects of designing information systems. Instantiations **operationalize constructs, models, and methods**. However, an instantiation may actually precede the complete articulation of its underlying constructs, models, and methods. That is, an IT system may be instantiated out of necessity, using intuition and experience."*

ARTIFACT	SOURCE	DEFINITION
Design Theory	Johannesson and Perjons (2014, pp. 34–35) based on (Jones and Gregor 2007)	*"A design theory is a theory that systematizes the knowledge about an artifact. The components in such a theory include purpose and scope constructs, principle of form and function, artifact mutability, testable propositions, justificatory knowledge, principles of implementation, and expository instantiations."*

CONTRIBUTIONS OF DSR OUTPUT. As depicted earlier, DSR outputs contribute to both the environment it is applied in and the knowledge base, to which it relates. In that context, Gregor and Hevner (2013) assert that DSR projects consume and produce descriptive and prescriptive knowledge. While descriptive knowledge addresses phenomena and the laws among them, prescriptive knowledge refers to the knowledge of human-built artifacts produced to solve similar problems, i.e., constructs, models, methods, instantiations, and design theories available in the knowledge base. Wieringa (2010, pp. 65–66) adds that DSR also provides so-called problem-solving knowledge to the knowledge domain. In contrast to prior descriptive and prescriptive knowledge, problem-solving knowledge refers to experiences of the DSR projects, best practices of applying artifacts, or other tacit knowledge (Johannesson and Perjons 2014, p. 26).

Gregor and Hevner (2013, p. 342) claim that the contribution of DSR output can be of different maturity., Building from the framework of Purao (2002), they define three maturity levels of DSR artifacts. As Table 2 illustrates, each maturity level relates to a particular contribution type and gives examples. The more abstract, complete, and mature the produced knowledge of a particular DSR project is, the more mature its artifact is. Gregor and Hevner claim that a DSR project may produce artifacts on or more of these maturity levels. This thesis applies DSR to design REAM—a method for developing REAs (REA). While the author claims that REAM relates to Level 2 of Gregor and Hevner's maturity levels, REAM's application in several distinct practices not only represents instantiations of REAM (Level 1), but also domain-specific REAs, which arguably relates to DSR contributions on Level 2 themselves.

TABLE 2. MATURITY OF DSR CONTRIBUTION TYPES (GREGOR AND HEVNER 2013, P. 342)

	CONTRIBUTION TYPES	EXAMPLE ARTIFACTS
more abstract, complete, and mature knowledge	**Level 3**. Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
↕	**Level 2.** Nascent design theory—knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules.
more specific, limited, and less mature knowledge	**Level 1.** Situated implementation of artifact	Instantiations (software products or implemented processes)

In order to concretize the different types of contributions, the output of a DSR project can have, Gregor and Hevner (2013) assert that they depend on their starting points in terms of *problem maturity* and *solution maturity*. While the former concerns the maturity of the practice, to which the contribution relates, the latter refers to the maturity of already available artifacts a DSR project can build from. Based on this assumption, Gregor and Hevner (2013, p. 345) provide the DSR knowledge contribution framework that uses a 2x2 matrix for identifying the four contribution types *invention*, *improvement*, *exaptation*, and *routine design*. Both axes of the framework span from high to low maturity of both the application domain and the available solutions. Although the framework lacks defining what by "low" and "high" maturity means, it helps to position the overall contribution of a DSR project. Table 3 defines the contribution types of the four quadrants. For a more detailed explanation, the author refers to Gregor and Hevner (2013, p. 345), as they discuss the contextual starting points, identify their contribution to descriptive and prescriptive knowledge bases, and analyze exemplar studies accordingly.

TABLE 3. CONTRIBUTION TYPES PRODUCED BY DSR

DSR CONTRIBUTION	DEFINITION
Invention (new solutions for new problems)	This kind of contribution is a radical innovation that addresses an unexplored problem context and offers a novel and unexpected solution. Such a contribution can enable new practices and create the basis for new research fields. Some examples of inventions are the first X-ray machine, the first car, and the first data mining system. Inventions are rare and typically require broad knowledge and hard work, as well as ingenuity and a bit of luck in order to occur.
Improvement (new solutions for known problems)	Improvements address a known problem and offer a new solution or a substantial enhancement to an existing one. They may concern efficiency, usability, safety, maintainability, or other qualities. Some examples of improvements are the first sportbike, an X-ray machine with substantially reduced radiation, and a data mining system able to handle vast data sets. Improvements are probably the most common kind of DSR contribution, and they can be challenging because a researcher needs to show that a proposed solution improves on state of the art.
Exaptation (known solutions extended to new problems)	Exaptations adapt an existing solution to a problem for which it was not originally intended. In other words, an existing artifact is repurposed or exapted to a new problem context. For example, the anticoagulant chemical warfarin was introduced as a rat poison but later repurposed as a blood-thinning medicine. Gunpowder started as a medical elixir in Chine centuries before it was repurposed for powering fireworks and firearms. Exaptations frequently occur in DSR.
Routine Design (known solutions for known problems)	Routine Desing is incremental to innovation that addresses a well-known problem by making minor modifications to an existing solution. Much of practical professional design would fit into this category, e.g., the design of a new smartphone with slightly better specifications than its predecessor.

There is a consensus in DSR literature to dismiss research that concerns routine design from DSR. Although routine design can provide valuable design contributions, the DSR community argues that it usually does not contribute to either the descriptive nor the prescriptive knowledge base (Hevner et al. 2004; Johannesson and Perjons 2014; Gregor and Hevner 2013, p. 347).

The general problem space addressed by this DSR project is that organizations are not aware of how externally enforced change processes affect their enterprise architectures (EA), i.e., the alignment of their organizational structures, process landscapes, and IT infrastructures. The challenges of organizations to adequately react to environmental change is a phenomenon already acknowledged by an existing body of research (Henderson and Venkatraman 1993; Lucke et al. 2010; Proper et al. 2017). Although there does not exist—to the knowledge of the author—research that concerns method support for capturing the effects of industrial changes on organizations from a holistic lense using EA structures, the author argues that the maturity of the problem space is somehow high. In contrast to the problem space, the knowledge base analysis later in section 4.3.6 will reveal an absence of adequate methods that support the development of REAs. Although this work can build from a high number of approaches from the general RM research domain and some related work concerning software reference architectures, they do not meet the requirements for an adequate solution. Consequently, the output of this thesis refers to the DSR contribution type improvement. It improves the knowledge from the research domains of EAM and RM in order to enable the development of REAs that capture the holistic effects of industrial change on a group of organizations from that domain.

PROCEDURAL GUIDANCE FOR CONDUCTING DSR. McKay et al. (2012, pp. 127–128) identify DSR endeavors to be primarily iterative problem-solving processes. Based on the IT research framework proposed by March and Smith (1995, p. 255), Hevner et al. (2004) distinguish between the construction and the evaluation of DSR artifacts represented by the two alternating activities *build* and *evaluate*. He refers to this as the design cycle of a DSR project. According to Hevner (2007, p. 2), the iterative perspective of DSR is further necessary regarding DSR rigor and relevance. Hence, he argues that any DSR endeavor embodies the closely related *relevance cycle*, *design cycle*, and *rigor cycle*.

- **Relevance Cycle:** The relevance cycle represents a researcher's interaction with the environment, in which the practical problem occurs (see left-hand-side of Figure 1). It concerns a thorough investigation of people's perceptions, organizations' challenges, and technological possibilities to understand the problem space and define requirements towards the DSR artifact. Further, it defines the acceptance criteria for the artifact's evaluation. After its design, the artifact is applied in the environment and assessed against the acceptance criteria. Feedback from this may initiate another iteration of the relevance cycle. That includes a refinement of evaluation criteria or a new design of the artifact. The rationale of the relevance cycle is to ensure the DSR project's relevance by identifying a practical problem of general interest and evaluating the artifact's utility in the addressed practices.

- **Rigor Cycle:** The rigor cycle represents a researcher's interaction with the available knowledge base (see the right-hand-side of Figure 1). A DSR project needs to analyze prior knowledge regarding the state-of-the-art in the addressed application domain, to consult existing artifacts that address similar problems, and to choose appropriate research methods to conduct the DSR activities (e.g., artifact conceptualization or evaluation). After designing and evaluating the artifact, the DSR project produces different kinds of knowledge that contributes to the knowledge base, e.g., the artifact itself, lessons learned from its application in the application domain, or practices to utilize research methods. The rationale of the rigor cycle is to ensure the originality of the produced knowledge and to guarantee that the artifact provides research contributions and not routine designs (see Table 3).
- **Design Cycle:** The design cycle represents the core activity of a DSR project, i.e., the design of the artifact (see middle of Figure 1). It iterates between the DSR activities build and evaluate. The design cycle uses the requirements from the relevance cycle and existing knowledge from the rigor cycle to design the artifact, generate possible artifact alternatives, and assess their performance against the requirements in order to improve the artifact's design. Highly dependent on the input from the other two DSR cycles, the design cycle' overall objective is to perform multiple iterations of build and evaluate. That ensures the generation of valuable contributions for the rigor and relevance cycle.

Next to the DSR cycles, Hevner et al. (2004) define seven guidelines for conducting DSR that provide a good baseline for planning and assessing a DSR endeavor. The following list shortly summarizes them:

✓ **GUIDELINE 1: DESIGN AS AN ARTIFACT.** Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
✓ **GUIDELINE 2: PROBLEM RELEVANCE.** The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
✓ **GUIDELINE 3: DESIGN EVALUATION.** The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
✓ **GUIDELINE 4: RESEARCH CONTRIBUTIONS.** Effective design-science research must provide transparent and verifiable contributions in the areas of the design artifact, design foundations, or design methodologies.
✓ **GUIDELINE 5: RESEARCH RIGOR.** Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
✓ **GUIDELINE 6: DESIGN AS A SEARCH PROCESS.** The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
✓ **GUIDELINE 7: COMMUNICATION OF RESEARCH.** Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Hevner's cyclic systematization on DSR provides a basis to understand DSR as an iterative process rather than a sequential order of activities. It is essential to understand that conducting DSR means that certain activities such as requirements elicitation or artifact evaluation iteratively approach completeness. For instance, the formulation of requirements towards the DSR artifact may be an activity that matures throughout the majority of a DSR project's duration.

However, there exist several approaches that aim to provide procedural guidance for conducting DSR (Nunamaker et al. 1990; Vaishnavi and Kuechler 2008; Peffers et al. 2007; Johannesson and Perjons 2014). They intend to provide a general order of DSR activities and help DSR researchers to plan their DSR projects. Further, there exist work that analyzes existing DSR procedures in order to synthesize them into a new method (Dresch et al. 2015; Peffers et al. 2007) or to provide a comparison framework that informs the decision what DSR process to choose (John R. Venable, Jan Pries-Heje, and Richard L. Baskerville 2017).

For this thesis, the author chose the process model of the DSR methodology suggested by Peffers et al. (2007). The author chose that approach as it is widely accepted in the ISR domain for conducting DSR, it refers to all guidelines for DSR stated by Hevner et al. (2004), and defines feedback loops that represent the iterative nature of DSR and, thus, realizes the three DSR cycles for relevance, rigor, and design. The following paragraph shortly summarizes the activities performed during each step. Peffers et al. investigated influential prior DSR literature to identify commonly accepted elements they used to define a DSR process consisting of six process steps, which Figure 2 illustrates.

Step 1 *"problem identification and motivation"* defines the practical problem and justifies its relevance as well as the value of a possible solution. It motivates the researcher and the audience of the research to pursue the solution and accept the results. Based on that DSR problem, step 2 *"define objectives of a solution,"* infers objectives of a possible solution to that problem. Often, requirements define quantitative (criteria that describe how a new solution improves existing ones) or qualitative (criteria that describe how the artifact shall solve the problem) desirable states. During step 3, *"design and development,"* the researcher creates the artifact that solves the identified problem. After an initial version of the artifact is design, the step 4 *"demonstration"* assesses and proves its feasibility. To do so, the demonstration applies the artifact in a first instance of the problem space, e.g., by dint of an experiment or case study. A successful demonstration of the artifact leads to step 5, its "*evaluation*." Now, the researcher compares the artifact's performance against the previously defined objectives. This requires observations and measurements during the demonstration step. Finally, step 6 *"communication"* publishes and discusses the results in appropriate research communities. Such publications include the importance of the research problem, the designed artifact, the rigor of its design, proof of its utility, and the overall contributions to practice and academic knowledge base. According to Peffers et al. (2007), results of evaluation and communication can trigger iterations of the DSR process. While the evaluation may identify flaws in the artifact's design, discussions with practitioners and researchers may provide new perspectives to improve the artifact. The authors state that any iteration can trigger either of step 2 *"define objectives of a solution"* or step three *"design and development."*

The following section presents how the author conducted DSR in the context of this Ph.D. thesis by reflecting on the research activities done in each of the DSR steps defined by Peffers et al. (2007). In that regard, the author conducted the problem investigation of the two local practices in different points of time. The author argues that this may be a drawback of Peffers' DSR process model and that it may benefit from integrating an iteration loop back to the activity "*problem identification and motivation*." Due to the iterative nature of DSR, the results of each step matured throughout the DSR project. The content of the chapters IV-VII provides an aggregated view on the results of the particular DSR activity. For instance, chapter VI presents the final list of requirements the author formulated towards REAM based on empirical insights. Likewise, chapter VI presents the final[1] version of REAM. However, each chapter discusses how results evolved during the DSR project. The next section discusses how the author applied each of Peffers' DSR process steps and what research methods he used. Although the section

[1] Please note that „final" here means the last version of REAM that has been evaluated. While this thesis will show that that version meets all requirements, chapter VI discusses potential future improvements of REAM.

sticks to the process by Peffers', it will provide additional perspectives from other procedural DSR approaches.

2.1.2 APPLIED PROCESS FOR DSR BY THIS THESIS

This section discusses how the author conducted each of the six steps for conducting DSR proposed by Peffers et al. (2007) in the context of this Ph.D. thesis. Although Peffers. et al. describe the general objectives of the six steps; their work lacks concrete tasks to accomplish. To overcome this, the author refers to the work of Johannesson and Perjons (2014). Their method framework for DSR is close to the DSR process by Peffers et al. (2007)—they define the same steps with the exception that they exclude the "communication" step and do not define feedback loops in their framework. For each step, Johannesson and Perjons (2014) define sub-activities. These help to structure the research activities more comprehensively. Further, they define inputs, outputs, resources, and controls for each step.

On that basis, the following subsections reflect on the six DSR phases of this Ph.D. project by describing them using the following perspectives:

- ***Sub-Activities***: How did the author conduct the different sub-activities of the DSR step?
- ***Input***: What knowledge or object did the DSR step use as input?
- ***Output***: What knowledge or object did the DSR step produce?
- ***Controls***: What research strategies and research methods did the particular DSR step use to govern the activities?
- ***Resources:*** What represented the knowledge base for the particular DSR step?

2.1.2.1 STEP 1: PROBLEM IDENTIFICATION AND MOTIVATION

In order to perform this step, the author conducted the three **sub-activities** *(i) define precisely*, *(ii) position and justify*, and *(iii) find root causes*, as defined by Johannesson and Perjons (2014, p. 92).

Concerning (i), the author defined the practical problem of general interest based on two local practices. As depicted earlier, the author investigated both practices at different points in time. Identifying similarities between them, the global problem statement of this DSR project evolved. While this procedure counters Peffers et al.'s DSR process since it does not define iterations back to step 1, the author refers to the work of Conboy et al. (2015), who argues that the problem statement may change during a DSR project. The author investigated both local practices in the context of two distinct research projects, in which the author participated (see section 4.1). The author investigated *Local Practice A* in the context of the ECLORA project and *Local Practice B* in the context of the COFIN project. Within these projects, the author regularly interacted with the following domain experts:

- business consultants, project managers, and enterprise architects from the SIV group (an independent software vendor (ISV) and project partner in ECLORA)
- revision manager and executives of Bechtle Financial Services (a leasing company and project partner in COFIN)
- IT and business consultants from ISVs and consultancies from the financial service domain (they were part of a working group of the German IT-association for financial service compliance that financed COFIN and acted as a focus group in this context)

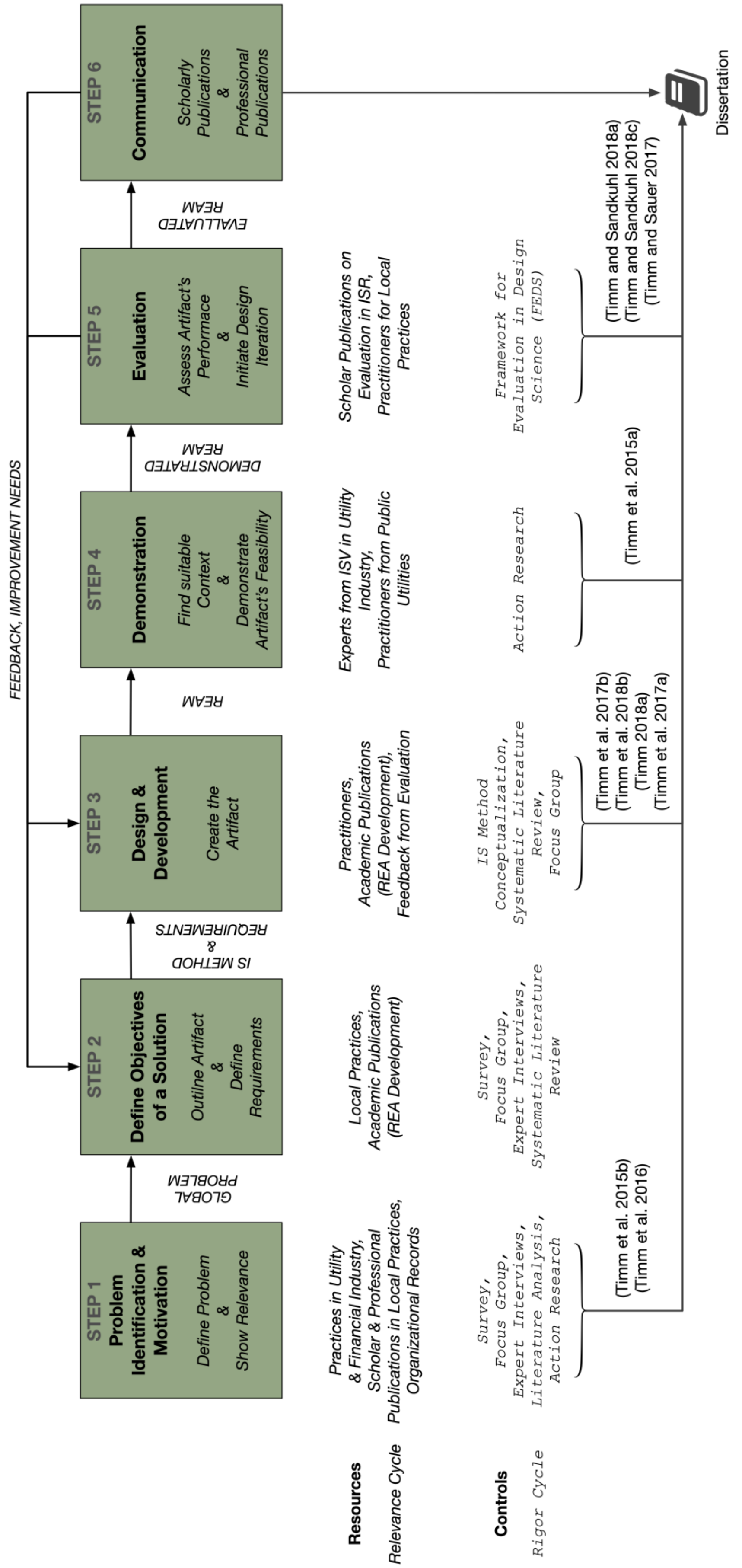


FIGURE 2. APPLIED DSR PROCESS IN THIS THESIS ADAPTED FROM PEFFERS ET AL. (2007)

The **input** for this DSR step were problems triggered by industrial changes in the energy sector, in which the ECLORA project was located. Traditional public utilities (PU) faced the challenge of transforming their organizational structures while simultaneously improving their competitiveness due to market liberalization and the promotion of renewable energy sources. Although these developments affected PUs' on all architectural layers (i.e., restructuring of legal entities, business processes landscapes, IS requirements), the author learned that they lacked capabilities to implement necessary means for aligning their business and IT structures during these transformational processes. While problem stakeholders from the energy sector verified the problem's relevance, the author was only able to assume that the identified local problem was of general interest in the IS research domain. Later, insights from the COFIN project verified this assumption, located in the financial services domain. Financial institutes, independent software vendors (ISV), and consultancies lamented to lack insights of regulatory consequences on business, data, and IS level of financial organizations. The increasing amount of deadline-driven and opaque regulatory requirements affected that financial institutes implemented isolated compliance programs that lacked a holistic perspective of regulatory consequences. From the perspective of this DSR project, this resulted in a more comprehensive understanding of the problem space. The author identified similarities in Local Practice A and Local Practice B that finally sharpened the practical problem of this thesis. In both practices, industrial changes force a certain group of organizations for change processes that affect their all architectural layers of their practices while these stakeholders lack the knowledge that captures these effects. The resulting problem statement represents the result of sub-activity (i) "define precisely" and is thoroughly discussed in section 4.2 of this thesis' on problem investigation (chapter IV).

As both Johannesson and Perjons (2014) and Peffers et al. (2007) demand, DSR researchers have to justify the problem (sub-activity (ii)). Several actions led to a justified problem statements. First, the author investigated the current developments of both local practices by analyzing domain-specific literature[1] (laws, market analyses, reports), interviewing practitioners, and also studying web-pages of related authorities. Second, the author identified problem stakeholders of both practices and the problems and challenges they faced in the context of their changing industry. DSR literature agrees that this is an essential aspect of the problem investigation. (Alismail et al. 2017, pp. 223–224; Wieringa 2014; Ian F. Alexander 2005). As documented below, the author applied several qualitative research methods to derive major challenges for the stakeholders in both local practices. Third, literature analyses in both domains intended to verify these identified challenges and to search for existing solutions. As the remainder of this work will show, research and practice of both problem domains agreed upon identified challenges. Hence, that justified the global problem of this work. The section dedicated to the analysis of the local practices document the stated results of both practices (see sections 4.1.1 and 4.1.2).

In order to get a more detailed understanding, the author performed a root cause analysis (sub-activity (iii)). A root cause analysis aims to identify causes that underlie a problem, to analyze, and to represent them (Johannesson and Perjons 2014, p. 94). Once these causes are identified, the treatment of a problem is more effective because it avoids only to treat its symptoms. Based on the findings from (i) and (ii), the author initially used a fishbone diagram (Ishikawa 1996) to structure phenomena that—to the knowledge of the author—caused the problems of the local practices. Several discussions with project partners from ECLORA and COFIN improved the author's understanding of these causes. In the end, practitioners and the authors agreed on two root causes. On the one hand, the affected organizations lack methodological guidance to capture the impact of industrial change on their business and IT landscapes. On the other hand, there is an absence of explicit practical knowledge necessary to represent these impacts. Section 4.2 discusses these results in more detail. Further, that section identifies the ISR domains of enterprise architecture management (EAM) and reference modeling (RM) that may provide reusable

[1] In section 4.1, the author provides a thorough summary of the consulted literature.

knowledge to tackle these root causes. While EAM provides means to structure the affected organizations from a holistic perspective and reveals interrelations, RM offers methods to develop information models that provide a universal solution applicable to the class of stakeholders of a problem domain.

On that basis, the author performed a knowledge base analysis (KBA) that concerned the current state of ISR in the domain of "reference enterprise architectures" (REA). The rationale behind this was to identify reusable knowledge from the EAM and RM domains in order to tackle the root causes mentioned above. Further, the KBA intended to justify the originality of this work by identifying research gaps in related research. Not only did the KBA prove that current research does not address the identified root cause yet. Also, it found related work, from which a potential solution from this work could build. Section 4.3 presents the approach of the KBA and its results in more detail.

Step 1 of this DSR project produced the following **outputs**. First, it produced an explicit *problem statement* of general interest based on the investigation of two distinct local practices. Second, the problem investigation identified *two root causes* underlying that problem. Third, the KBA identified *reusable knowledge* to tackle these root causes and *research gaps* of related literature in this context. Fourth, it compared research gaps to the overall problem and root causes and derived a *research question (RQ)* that guided the research at hand. In general, that research question asks how to develop an REA systematically. Section 4.4 discusses that RQ in detail and elaborates on aspects necessary for a potential solution.

Johannesson and Perjons (2014, p. 96) argue that most research methods may be appropriate to be used for the problem investigation, since this highly depends on the DSR project context. However, Sein et al. (2011, pp. 40–41) distinguish between practice- and theory-inspired research. While for the latter most probably a comprehensive analysis of scientific, professional, and technical literature is sufficient, the former leads to conducting methods like surveys, interviews, observational case studies, focus groups or action research (Johannesson and Perjons 2014; Wieringa 2014, pp. 45–49). To summarize, appropriate methods should be applied in order to elicit descriptive knowledge of the DSR problem (Gregor and Hevner 2013, p. 343). From the perspective of DSR cycles defined in Hevner (2007), the problem identification and motivation phase contributes to both the relevance cycle by analyzing the practical problem and the rigor cycle by investigating the knowledge base for related research. Table 4 summarizes all **controls** (research methods) and **resources** used to conduct this DSR step.

TABLE 4. RESEARCH METHODS AND RESOURCE USED FOR DSR STEP 1

PURPOSE	RESEARCH METHOD	RESOURCE
Developments in Local Practice A and Local Practice B	Expert Interviews	practitioners: • ISV from Utility Industry (SIV group) • leasing company from financial services (COFIN project partner)
	Document Analysis	• government publications, • personal communications with practitioners, • organizational records provided from practitioners, • market analyses by consulting agencies
Problems and Challenges in Local Practice A	Online Survey[1]	respondents from 53 distinct public utilities
Problems and Challenges in Local Practice B	Focus Group	experts from bitkom working group: • ISVs from financial services • consultancies from financial services
	Expert Interviews[2]	four distinct German banking federations
Investigating ISR in the context of Local Practice A and B	unstructured literature analysis	• academic publications • domain-specific professional publications • documentation of related research projects

[1] The survey was conducted and analyzed in the course of a master's thesis (Cammin et al. 2015). The author of this work further analyzed the gathered survey data for the purpose of this dissertation and the related ECLORA project.

[2] The interviews were conducted by another project employee. The author of this thesis took part in the interview design and the analysis of the gathered data.

PURPOSE	RESEARCH METHOD	RESOURCE
Root Cause Analysis	Action Research	experiences and insights gathered during ECLORA and COFIN projects
	Expert Interviews	see practioners enumerated above
Knowledge Base Analysis	Systematic Literature Review	academic publications in the domain of REA development

2.1.2.2 STEP 2: DEFINE OBJECTIVES OF A SOLUTION

The overall objective of this DSR step is to infer the objectives of a solution based on the findings from step 1 and existing knowledge, from which the author can learn what is feasible and possible. Peffers et al. understand objectives as qualitative or quantitative requirements, which originate from the problem definition and KBA (Peffers et al. 2007, p. 55). According to Johannesson and Perjons (2014), one shall outline the artifact that provides a potential solution for the problem at hand before eliciting requirements. They relate each artifact type to the type of knowledge they express or represent (Johannesson and Perjons 2014, p. 29). Next, DSR projects need to be transparent regarding requirements elicitation processes and utilized sources. The requirements engineering domain distinguishes between functional and non-functional requirements. Glinz (2007, p. 21) states that *"functional requirements focus on a system's functions (what it does) and behavioral aspects (inputs, outputs, and their behavioral relationships)."* While functional requirements are often precise regarding the addressed problem, "non-functional requirements are those requirements that are not functional and encompass both structural requirements and environmental requirements" (Johannesson and Perjons 2014, pp. 104–105). Johannesson and Perjons (2014, pp. 109–111) further provide a list of generic qualities that help to define non-functional requirements. Once requirements have been identified, one also has to define means how to evaluate potential solutions regarding them. Therefore, Robertson and Robertson (1999) introduce the concept of fit criteria. They define it as *"a quantification or measurement of the requirement such that you are able to determine if the delivered product satisfies, or fits, the requirement"* (Robertson and Robertson 1999, p. 392).

Eliciting requirements is an incremental process. Thus, the maturity of the defined requirements evolves throughout a DSR project. In that regard, Pohl (1994, p. 246) defines three dimensions that represent a requirement's maturity. The *specification dimension* recommends to use knowledge from the practical domain and related work to define specific requirements and avoid opaque formulations. The *representation dimension* asks to represent requirements using formal representations, if adequate. Lastly, the *agreement dimension* demands that defined requirements relate to a universal agreement of system stakeholders rather than personal views. While the author of this thesis understands the importance of all three dimensions, he claims that the representation dimensions primarily addresses requirements that concern the development of information systems.

Based on these aspects, the author conducted step 2 of by dint of three **sub-activities**: *(i) outline the artifact*, *(ii) elicit requirements*, and *(iii) identify fit criteria*.

Concerning (i), the author used the **input** from step 1 to first define the artifact type of a potential solution. Therefore, he compared the defined global problem, its related root causes, and research gaps identified in the knowledge base with the different DSR artifact types (see section 2.1.1). Afterward, the same input helped to sketch an initial outline of the artifact. As section 5.1 will discuss in more detail, the author decided to design a method that addressed the identified need for methodological guidance in the problem domain. The method intends to support users in constructing REAs that use practical knowledge to support organizations to identify the impact of industrial changes on their organizational structures. The remainder of this work refers to the artifact as *"REAM"*—the Reference Enterprise Architecture Method.

The central activity (ii) lasted a more extended period throughout this DSR project. Its primary **resources** were findings and observations of the ECLORA and COFIN project and discussions with problem stakeholders. To elicit functional and non-functional requirements towards REAM, the author applied several research methods in the context of both ECLORA and COFIN (i.e., **controls**; see below in Table 5). As a result, the set of requirements for REAM evolved throughout the DSR project. In order to ensure the transparency of the requirements elicitation process, the author distinguished between three periods, in which he elicited requirements. All requirements identified at the beginning of the ECLORA project refer to the *"early phase."* It relates to all requirements the author identified while studying the problem of Local Practice A in detail and developed an initial understanding of global demands towards REAM. After an initial REAM version was designed and applied in the context of ECLORA, findings and observations from that application led to the refinement of existing and the formulation of new requirements. As the ECLORA project finished, the author investigated the problem domain of Local Practice B, i.e., the COFIN project. The new project context, problem stakeholders, and new perspectives sharpened the picture of REAM and revealed new requirements. All activities during the late stages of the ECLORA and early stages of the COFIN project refer to the *"development phase."* Finally, applying REAM in the COFIN context led to further changes and additions to the set of REAM requirements. These refer to the "*late phase*." Every time the author identified a new requirement or changed an existing one, he used the same resources to define appropriate fir criteria for that particular requirement (sub-activity (iii)). In the end, these activities resulted in a set of five functional and three non-functional requirements. The author derived them from an initial list of 24 requirements that evolved during the different phases of the DSR project. While section 5.2 discusses the process behind the requirements elicitation in more detail and discusses how it affected the maturity of REAM requirements, section 5.3 provides the final list of the requirements using a template for structurally describing each of them.

Table 32 in section 5.2 and Table 33 in section 5.3 relate the **output** of this DSR step, i.e., all initial and final REAM requirements, to the source they were derived from the research methods utilized to define them. However, Table 5 gives an overview of the research methods utilized in this DSR step and relates them to the resources of information.

TABLE 5. RESEARCH METHODS AND RESOURCE USED FOR DSR STEP 2

RESEARCH METHOD	RESOURCE
Expert Interviews	practitioners: • ISV from Utility Industry (SIV group) • leasing company from financial services (COFIN project partner) • banking federations from Local Practice B
Online Survey[1]	respondings from 53 distinct public utilities from Local Practice A
unstructured literature analysis	• academic publications • domain-specific professional publications • documentation of related research projects
Focus Group	experts from bitkom working group: • ISVs from financial services • consultancies from financial services
Action Research	• applying REAM in ECLORA • applying REAM in COFIN consultancies from financial services
Systematic Literature Review	academic publications in the domain of REA development

[1] The survey was conducted and analyzed in the course of a master's thesis (Cammin et al. 2015). The author of this work further analyzed the gathered survey data for the purpose of this dissertation and the related ECLORA project.

2.1.2.3 STEP 3: DESIGN AND DEVELOPMENT

The third step of the DSR process has the overall objective of creating the artifact that solves the previously explicated problem. It used the description of the outlined artifact and the set of requirements from step 2 as **input**. According to Peffers et al. (2007), one shall determine the artifact's desired functionality as well as its architecture before creating the artifact. In terms of REAM, the author understands to clarify REAM's content ("functionality") and its structure ("architecture").

Hevner et al. (2004) state that this step is the most time-consuming step of any DSR project. Others stress the high degree of creativity required from researchers for conducting it (Johannesson and Perjons 2014). The design and development of the artifact differs from other DSR steps in that it does not primarily develop descriptive or explanatory knowledge, but prescriptive knowledge (i.e., the artifact) instead. Consequently, Johannesson and Perjons (2014, p. 125) state that research methods are less important than in the other steps. However, the author used some research methods (**controls**) during the design and development of REAM. For structuring REAM, the author deployed the method conceptualization approach by Goldkuhl et al. (1998). Among other things, it helped to define components of REAM and an overall REAM framework to represent REAM systematically. Furthermore, the results of the SLR provided reusable knowledge from the domain of EAM and RM in order to concretize the notion of REAs and to generate ideas for REAM functionality. After designing a new REAM version, the author conducted walkthroughs with team members of the ECLORA and COFIN projects and problem stakeholders from the particular practices, e.g., IT consultants, enterprise architects, or software developers.

For conducting step 3, the author used several **resources** from both the knowledge base and the DSR environment (see Figure 1). Methods and approaches from the method engineering domain improved documenting and structuring REAM. Further, the related research domains of EAM and RM provided a theoretical foundation during the method design. More specifically, the author used the results of the SLR regarding REA development (see section 4.3) to define the notion of REAs and to identify knowledge reusable for REAM development. In order to ensure the involvement of potential REAM users, the author worked in regular correspondence with stakeholders from both local practices (see section 2.1.2.1). At particular points in time, the author discusses design alternatives with problem stakeholders and presented different REAM versions to discuss their feasibility before he applied the particular REAM version during the artifact demonstration (step 4) and evaluation (step 5).

There is no consensus among DSR literature on what concrete actions to take for conducting this DSR step. However, research agrees that the actual design process depends on the artifact's problem environment and the type of the envisioned artifact, and that it is characterized by an iterative search process (Hevner et al. 2004). Some authors define generic actions for it. Johannesson and Perjons (2014, pp. 117–124) define four **sub-activities** that structure the design and development step more precisely. First, *(i) imagine and brainstorm*, researchers generate new ideas or elaborate on the existing one. Second, during *(ii) assess and select* designers to assess these ideas and select one or more of them in order to integrate them into the artifact design. Third, *(iii) sketch and build* then construct the artifact. Fourth and last, *(iv) justify and reflect* DSR research to argue about design decisions that have been made. Although it seems that these four activities are performed sequentially, the authors emphasize that they are carried out in parallel and iteratively.

The author designed the first REAM version after the investigation of Local Practice A and the initial requirements set from the early DSR phase (see section 2.1.2.2). Concerning sub-activity (i), the author and the other ECLORA project team members consulted existing methods for RM and Eam regarding ideas and approaches applicable to the local problem of ECLORA. Afterward, the researchers selected (sub-activity (ii)) the method for configurable RM by Becker et al. (2002) and adjusted them towards EAM concepts. That resulted in an initial REAM design that primarily stuck to the method by Becker et al. The domain experts from the SIV group discussed the overall approach (sub-activity (iii)). During these activities, the author documented any adjustment of the original method towards the initial REAM version (sub-activity (iv)). Throughout the DSR project, the overall design process of REAM traversed multiple iterations through the build and evaluate cycle. In total, REAM evolved over six method versions. The author designed each version based on the results of the previous version's evaluation. After an evaluated triggered the design of a new REAM version, the author essentially analyzed identified weaknesses of REAM, consulted related work for adequate reusable knowledge and developed potential solutions (i), discussed possible alternatives and their feasibility with researchers and practitioners (ii), designed new REAM versions (iii), and documented their design rationales (iv). However, the author points out that this description only provides a simplified perspective on the activities during step 3.

In the end, step 3 produced several **outputs**. Each version of REAM used an increasingly detailed documentation of its components, used concepts, and method framework based on Goldkuhl et al. (1998). Chapter VI presents the final REAM version in detail. Next to REAM itself, the author summarized the design rationales behind the final REAM version and provided a transparent list of how reused knowledge influenced the final REAM design. Section 6.7 documents these rationales. Moreover, the several iterations of the DSR process resulted in different instantiations of REAM. The output produced during each of them is represented by domain-specific REAs for both the utility and financial industry. Chapter VI provides a real-world running example based on the COFIN project. It provides additional knowledge on how to apply REAM in a concrete, practical environment.

2.1.2.4 STEP 4: DEMONSTRATION

Peffers et al. (2007) state that the primary objective of step 4 is to demonstrate the artifact's utility by applying it to one or more problem instances of its problem domain. According to Johannesson and Perjons (2014), this produces descriptive knowledge describing how the artifact works in a representative situation and explanatory knowledge explaining why it does. They divide step 4 into the **sub-activities** (i) choose or design case and (ii) apply artifact.

In order to demonstrate REAM's feasibility, the author decided that it would not be illustrative to apply REAM to an example case as it relies on the interaction with problem stakeholders to gather domain-specific knowledge used to construct the REA. Consequently, concerning (i), the author applied REAM in the context of the ECLORA project to demonstrate its feasibility. The **input** of step 4 was the initial version of REAM produced by the first iteration of "*Step 3 Design and Development*". The first version of REAM primarily adjusted the configurative RM method introduced by Becker et al. (2002). Figure 3 provides an overview of REAM. It consisted of the main steps to define REAM application objective, developing a modeling approach, conducting the RM (i.e., gathering relevant data and abstracting it into an REA model), and evaluating the REA. The objective of the ECLORA project was to develop a Utility REA that helps PUs and other problem stakeholders to transform their legacy organizational structures to overcome the challenges following the market liberalization and the trend of renewable energy sources. Utility REA defined four domain-specific business processes that represented the core of the REA: meter data collection, customer acquisition, domestic connection, and consumption billing.

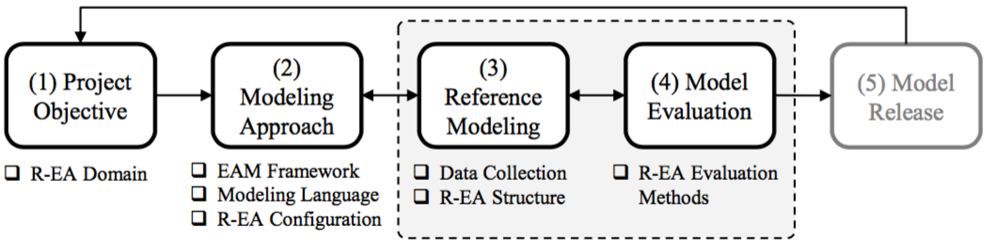


FIGURE 3. THE INITIAL VERSION OF REAM APPLIED IN THE DSR DEMONSTRATION

Regarding the (ii) application of REAM in the ECLORA project, the author participated in the demonstration as a project team member of ECLORA with the responsibility to provide the methodological support for developing the Utility REA. Thus, he applied action research as a research method (**controls**). In doing so, the demonstration used several **resources**. First, the initial version of REAM and additional descriptive knowledge was the primary resource as it provided the methodological guidance. The second resource was the knowledge about the application case. That included results from *"Step 1 Identify Problem & Motivate"* regarding Local Practice A, primarily the problems and challenges of public utilities in the context of recent developments in the utility industry. Next to this domain-specific knowledge, domain experts from the SIV group and a multitude of practitioners of four German PUs represented the third resource.

Demonstrating REAM in the ECLORA project took around ten months and finally resulted in two essential **outputs**. It produces descriptive knowledge on how to apply REAM. Next to input for the first evaluation episode, this knowledge further helped to formulate guidelines for applying REAM. Moreover, the demonstration of REAM produced the *Utility REA*. It provided an EA perspective on the four central PU-specific business processes based on practical knowledge elicited from expert knowledge and four German PUs (see chapter VII for more details). Furthermore, it provided a high-level perspective on value networks in the utility domain and a systematization of market roles with their associated business functions. Figure 4 shows a screenshot of the modeling environment[1] used for applying the "reference modeling" step of REAM. It illustrates a high-level perspective of the market roles energy supplier and grid operator and their related business functions. After the market liberalization, traditional PUs had to separate both roles from each other legally. As the evaluation in chapter VII will discuss in more detail, the problem stakeholders from the SIV group assessed the Utility REA as valid and, thus, rated the initial version of REAM to be feasible and effective. However, the demonstration revealed many flaws in the method design, so that a subsequent evaluation resulted in a new build-evaluate cycle. Stakeholders emphasized that the integration of deductive and inductive reasoning provided by REAM was an essential factor for the project's success.

[1] the modeling suite used for modeling the Utility REA was

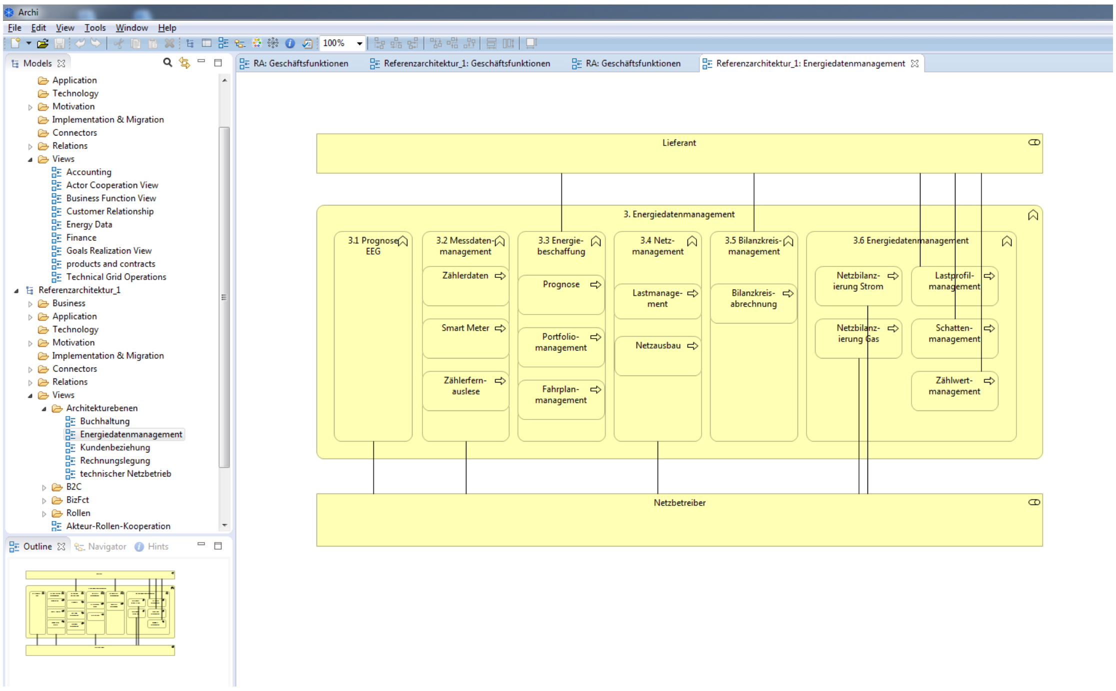


FIGURE 4. ARTIFACT DEMONSTRATION: HIGH-LEVEL VIEW ON UTILITY REA

2.1.2.5 STEP 5: EVALUATION

The evaluation represents one of the most critical steps of a DSR project as it has to rigorously demonstrate the artifact's utility (Hevner et al. 2004). It observes and measures how well the artifact solves the defined problem from step 1 by comparing its performance against defined objectives from step 2 (Peffers et al. 2007). Thus, DSR evaluation depends on the environment the problem addresses, the nature of the artifact, its requirements, and the resources available to the researcher. After an evaluation of the artifact, the researcher decides whether to iterate back to step 2, to step 3, or o continue with step 6.

For conducting the evaluation, Johannesson and Perjons (2014) state that one has to analyze the evaluation context and define overall evaluation goals, before deriving an adequate evaluation strategy and finally carrying the evaluation. According to Venable et al. (2012), there exist different evaluation goals. Next to test the artifact's utility, an evaluation can aim to evaluate the artifact's functional and non-function requirements, to investigate formalized knowledge about the artifact and its utility (i.e., its design theory), to compare the artifact's performance with similar existing artifacts, or to investigate side effects of the artifact. Furthermore, Venable et al. distinguish between *formative* and *summative* evaluation purposes. Formative evaluations aim to identify opportunities for design improvements and lead to new iterations of the build-evaluate cycle. Summative evaluations, in contrast, aim to make a final assessment of the artifact and do not lead to another design process iteration.

The **input** of the evaluation step of this work was the different versions of REAM design. While the author utilized different research methods (**controls**) for conducting the evaluation, the evaluation of REAM followed the framework for evaluation in DSR (FEDS) proposed by Venable et al. (2016). Section 2.2.2 discusses the approach by FEDS in more detail. It provides an overall procedure for conducting evaluations that consist of the four **sub-activities** (i) explicate the goals, (ii) choose a strategy or strategies for the evaluation, (iii) determine the properties to evaluate, and (iv) design the individual evaluation episodes. For each of the defined episodes, the author carried out an iteration of the evaluation step. Chapter VII provides a detailed discussion on how the author applied FEDS and presents the results of each evaluation episode. In total, the author conducted seven evaluation episodes. That resulted in six iterations of the DSR design cycle. Further, chapter VII presents the evolution of REAM design, illustrates the six different REAM versions, and identified improvement needs identified after each evaluation episode.

Next to others, the primary goal of evaluating REAM was to assess its effectiveness. In the context of developing REAs, that requires not only to test whether REAM produces an REA model that fulfills its objective, but also to investigate whether problem stakeholders apply the produced REA in their practice (see chapter III). Thus, the evaluation of REAM required the involvement of problem stakeholders in one or more evaluation episodes. Consequently, the author used different **resources** for conducting the evaluation step. Next to artifact-related knowledge and evaluation methods to assess its performance, the author relied on the participation of practitioners. The project contexts of ECLORA and COFIN allowed this. Furthermore, the different project partners provided access to REA users, such as PUs and financial institutes. That helped the author to investigate the user-oriented perspective on the REAs produced by REAM.

The seven evaluation episodes produced different **outputs**. First, it discussed insights regarding functional and non-functional requirements. Second, it derived improvement needs that were the input for the next design cycle iteration. Third, each application of REAM contributed to either the Utility REA (ECLORA project) or Reference Compliance Organization (RCO, COFIN project) and, thus, produced new domain-specific knowledge. In the end, the evaluation step verified the utility and effectiveness of the final REAM version as it showed that the respective problem stakeholders accepted both Utility REA and RCO.

2.1.2.6 STEP 6: COMMUNICATION

The objective of the last DSR step, defined by Peffers et al. (2007), aims to communicate the results of the DSR project. That includes the tackled problem, its relevance, the artifact, its novelty, utility, effectiveness, and the rigor of its design. In order to address both the rigor and relevance cycles, Peffers et al. (2007) require researchers not only to publish these results in academic outlets (e.g., conferences, journals, or conference workshops), but also to relevant audiences from the problem practices. Adequate outlets may range from simple professional exchange and discussions to publications in outlets specific to certain industries or an actual dissemination of the artifact to practical contexts. It contributes to the seventh guidelines for DSR formulated by Hevner et al. (2004).

In the scope of this Ph.D. thesis, the author communicated the results of the DSR project via different channels. The contribution list provided by the introduction in section 1.5 enumerates all publications the author published during the DSR project. While some publications present interim versions of REAM and its evaluation (Timm et al. 2017b; Timm et al. 2018b), others were positioned at related conference workshops to discuss certain aspects of specific REAM components with researchers from the EAM and RM domains (Timm et al. 2015a; Timm et al. 2017a; Timm 2018a). Further, the author published the results of particular REAM applications (Timm and Sandkuhl 2018a). The feedback of scholars helped to improve REAM's method design and hinted at additional literature, which the author might consult for future research.

Next to these academic publications, the author published the results of the COFIN project in cooperation with the research team and partners from practice in journals dedicated to the compliance industry (Sandkuhl et al. 2018; Timm et al. 2019). Furthermore, the author communicated REAM and its descriptive knowledge with the practitioners from within the ECLORA and COFIN projects. The successful results in both research projects led to an ongoing professional correspondence between the author and different domain experts. The SIV group used the produced Utility REA for improving their enterprise-resource-planning systems, which they offer to PUs. Moreover, SIV intends to expand the Utility REA to the domain of water management based on the lessons learned from applying REAM in the ECLORA project. In this context, the author supervises a master's thesis and consults regarding methodological guidance at the time of writing this thesis. Likewise, the professional exchange with practitioners from the domain of regulatory management in financial services prolonged the scope of COFIN. The regular exchange in the context of new related projects provided additional insights for the final design of REAM, e.g., concerning the maintenance and evaluation of REAs.

2.2 RESEARCH METHODS UTILIZED BY THIS THESIS

After the previous section described the overall research approach of this thesis, this section sheds more light on research methods the author applied at specific points of the Ph.D. projects for different purposes. While the section intends to give comprehensive insights regarding the several research methods, it does not cover each research method in detail. It instead discusses general objectives of the research methods, common approaches or guidelines, and describes the purposes, for which the author utilized the research methods.

In general, the author applied the research methods for different purpose. First, section 2.2.1 presents the method conceptualization by Goldkuhl et al. (1998) that underlies the structure of REAM. Second, section 2.2.2 describes the framework by Venable et al. (2016) the author used for evaluating REAM. Third, section 2.2.3 summarizes two approaches for conducting systematic literature reviews the author used to analyze the knowledge base. Fourth and last, sections 2.2.4, 2.2.5, and 2.2.6 present the primary research strategies the author applied throughout the DSR project and discusses the utilized data collection and data analysis methods in these respects. The last three sub-sections will mainly follow the work by Johannesson and Perjons (2014, pp. 39–73). They define a research strategy to guide a researcher in planning, executing, and monitoring their study. Each research strategy utilizes research methods for collecting adequate data and analyzing it.

2.2.1 METHOD CONCEPTUALIZATION FOR REAM

During step 2, "define objectives of a solution," the author chose to develop a method as the central artifact of this work (see section 5.1). Although March and Smith (1995, pp. 257–258) define a method as "a set of steps […] used to perform a task", which are based on underlying constructs and use a representation model of the envisioned method output, the author decided to shed a more detailed light on the concepts necessary to describe an IS method. Therefore, this thesis uses the method conceptualization for the development of information systems by Goldkuhl et al. (1998) for describing REAM. At its core, the authors define an IS method to consist of exchangeable and reusable *method components*, which address specific subproblems of the overall problem. Each component, therefore, defines a clear *process* of actions to take in order to solve this particular subproblem. Next to this, a method defines essential *concepts* and forms of representation (i.e., *notation*) for each of its components. As there may exist multiple method components, the method needs to provide a *framework* that documents the order of using the components. Depending on its application context, different stakeholders shall be defined that perform the actions of the method. Hence, Goldkuhl et al. (1998) require methods to describe recommended *cooperation forms*. They describe, for instance, who may perform the different steps as well as the required knowledge for doing so. In most cases, cooperation forms relate to the specific problem domain in which users apply the method. Finally, the method designer's values and beliefs may influence its feasibility or comprehensibility when being applied in practice. Thus, Goldkuhl et al. (1998) define a method *perspective* as another important concept regarding method development. A method designer shall document the values, principles, definitions, or intentions the included in the method. Figure 5 summarizes all these method concepts and visualizes their relations, as Goldkuhl et al. (1998) describe them. Before presenting the final version of REAM, section 6.1 reflects on how the author adjusted this conceptualization according to this work's specifics.

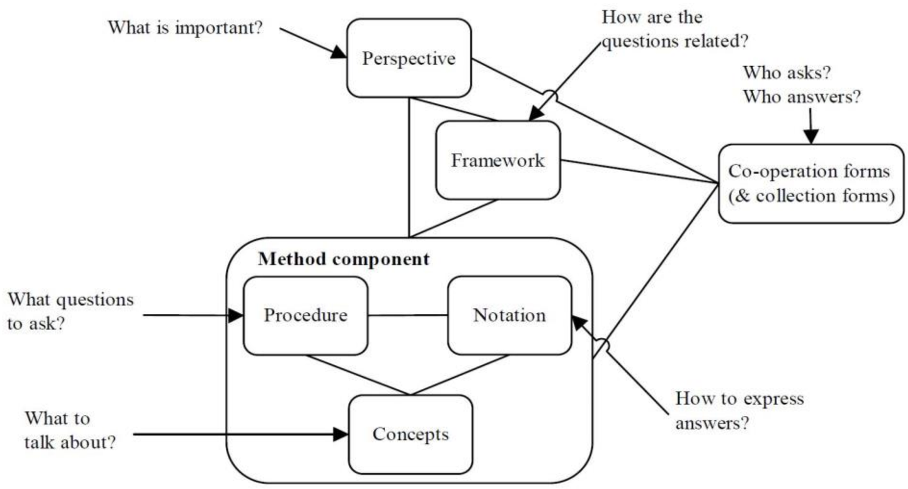


FIGURE 5. THE CONCEPTUALIZATION OF METHODS AS PROPOSED BY GOLDKUHL ET AL. (1998)

2.2.2 FRAMEWORK FOR EVALUATION IN DESIGN SCIENCE (FEDS)

Together with the "build" activity, the evaluation of the DSR output, i.e., the artifact or design theory, is one of the two key activities of any DSR project (Hevner et al. 2004; March and Smith 1995). With FEDS, Venable et al. (2016) provide a framework that guides DSR research to plan and conduct an evaluation that contributes to both the relevance and rigor cycle claimed by Hevner (2007). Therefore, they provide an evaluation framework that positions evaluation activities regarding two orthogonal evaluation dimension and identify four different strategies for conducting DSR evaluation. On that basis, they define a procedure for developing an evaluation plan. While this section shortly describes the basics of FEDS, the author refers to the different publications related to FEDS for a more detailed picture of FEDS (Venable et al. 2012, 2016).

FEDS systematizes evaluation in DSR by dint of two dimensions: functional purpose and paradigm of study. The *functional purpose* of DSR evaluations address the question *"why to evaluate"* and distinguishes between formative and summative evaluation (Wiliam and Black 1996):

- **Formative evaluations** produce empirically based interpretations that provide a basis for improving the characteristics or performance of the DSR artifact. Their functional purpose is to help improve the outcomes of the process under evaluation.
- **Summative evaluations** produce empirically based interpretations that provide a basis for creating shared meanings about the DSR artifact in the face of different contexts. Their functional purpose is to judge the extent that the outcomes match expectations, e.g., usability.

The *paradigm of study* of DSR evaluations address the question "how to evaluate" and distinguishes between artificial and naturalistic evaluation (Venable 2006):

- **Artificial evaluations** assess the DSR artifact in a controlled environment and can be empirical or non-empirical. They include laboratory experiments, simulations, criteria-based analysis, theoretical arguments, and mathematical proofs.
- **Naturalistic evaluations** explore a DSR artifacts performance in its real environment, e.g., within a particular organization or local practice. They are always empirical as they embrace all of the complexities of social practice in real organizations. Naturalistic evaluation methods usually include case studies, field studies, field experiments, surveys, ethnography, phenomenology, hermeneutic methods, and action research.

While artificial evaluation is less costly and provides more precise findings, naturalistic evaluations reveal knowledge about the artifact's utility in the environment of real users and real systems while addressing real problems. Figure 6 illustrates the framework proposed by (Venable et al. 2016). It defines both dimensions as one axis of the framework. Both axes are entirely orthogonal to each other, meaning that both naturalistic and artificial evaluation methods can deploy formative or summative purposes. The authors state that DSR evaluation typically progresses from a state of no evaluation towards a state where evaluation is conducted more comprehensively and more realistically. Any evaluation chronologically traverses through both dimensions employing evaluation episodes. While early stages of a DSR evaluation often have a formative purpose of improving the quality of the artifact, summative evaluations enable comparison of the research outcomes with research expectations. Regarding the second dimension, Venable et al. (2016) state that an increasing use of naturalistic evaluations will improve the artifact's quality concerning its effectiveness in real use. The authors simplify the chronological progress of a DSR project to typically start at the lower-left corner and aims to finish at the upper-right corner. They define the trajectory of evaluation activities from the former to the latter as an evaluation strategy. On that basis, they define four possible DSR evaluation strategy. While they emphasize that each DSR project has its specifics regarding proper evaluation and, thus, will use individual trajectory, the four strategies provide orientation.

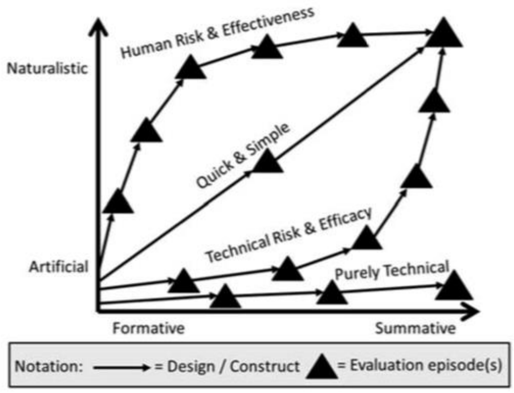


FIGURE 6. FRAMEWORK FOR EVALUATION IN DESIGN SCIENCE (FEDS) BY VENABLE ET AL. (2016)

As Figure 6 indicates, Venable et al. (2016) define four evaluation strategies. Each triangle in their trajectory represents evaluation activities, so-called evaluation episodes. Throughout an evaluation strategy, researchers shall conduct many evaluation episodes that relate to one of each FEDS dimension. The authors point out that provided trajectories for the four strategies are only indicative. The evaluation strategies are defined as follows:

- The **Quick & Simple Strategy** conducts relatively few formative episodes and progresses quickly to summative and more naturalistic evaluations. It performs includes few episodes in general and relates to a low-cost strategy. While it encourages quick conclusions, it may not be reasonable regarding various design risks. Venable et al. (2016) suggest to use it in case of small and simple construction of an artifact design, which possesses low social and technical uncertainties.
- The **Human Risk & Effectiveness Strategy** emphasizes formative episodes early in the process. While both artificial and naturalistic settings are possible, it focuses on naturalistic formative evaluation as soon as possible. It shall finally conclude with summative evaluations that investigate an artifacts effectiveness in real-world scenarios. Thereby, the strategy intends to ensure that the DSR artifact provides utility despite possible complications of personal and social difficulties of adoption and use. Venable et al. (2016) suggest to use that evaluation strategy if the significant design risk is social or user-oriented, a critical evaluation goal is to establish

the artifact's utility in actual practices, and the evaluation context allows such evaluation without too many costs and effort.

- The **Technical Risk & Efficacy Strategy** focuses on artificial evaluations that iterative through several formative episodes before moving towards summative evaluations towards the end of the trajectory. The artificial episodes intend to ensure the artifact's efficacy and to exclude external factors that might bias the evaluation results. However, a naturalistic setting may be possible as well. Venable et al. (2016) suggest using this strategy only if the technology is a significant design risk, and an evaluation with real users is too expensive.
- The **Purely Technical Strategy** addresses artifacts that are purely technical and do not require the involvement of real users for either application or deployment purposes. The strategy favors artificial evaluation throughout the process.

Next to FEDS, Venable et al. (2016) further provide a four-step approach to plan a DSR evaluation. The remainder of the section shortly describes them.

Step 1: Explicate the Evaluation Goals. This step establishes the overall objective of the DSR evaluation. An evaluation builds the basis for designing an evaluation strategy. While there may exist several goals, researchers shall prioritize to support decision-making later on in the evaluation design process. FEDS discusses four generic goals, which may compete with each other. First, *rigor* relates to the artifact's efficacy and effectiveness. While efficacy investigates whether it is the artifact that causes observed utility, effectiveness concerns the artifact's efficacy in real situations. Second, the goal of *uncertainty and risk reduction* aims to minimize previously identified design risks, which may be of social or technological nature. Third, *ethics* may play an important role when evaluating DSR artifacts. That may apply to safety-critical systems or artifacts that could put users or other stakeholders at risk. Fourth, an evaluation also may intend to be *efficient*. That goal balances the other goals against resources available for the evaluation, e.g., time and money.

Step 2: Choose a Strategy. Based on the defined evaluation goals, researchers shall formulate an adequate evaluation strategy. That implies decisions about why, when, and how to evaluate. Therefore, FEDS provides several heuristics: evaluate and prioritize design risks; evaluate the cost of involving real users and real systems for conducting episodes; evaluate the artifact's nature (i.e., is it purely technical?); evaluate the anticipated complexity of the artifact (i.e., small and simple versus large and complex).

Step 3: Determine Evaluation Properties. The third step identifies what to evaluate. Researchers have to identify features, requirements, qualities, or other properties that are subject to evaluation. Venable et al. (2016) state that these evaluation properties are unique to the artifact under investigation and the evaluation goals set earlier. FEDS discusses different authors that provide lists of generic artifact properties (Kellaghan and Stufflebeam 2003; Lars Mathiassen et al. 2000; Smithson and Hirschheim 1998; Ying Sun and Paul B. Kantor 2006). Following heuristics are suggested for choosing the properties: enumerate a list of potential evaluands; assessing them regarding the goals from step 1; align the evaluands regarding the chosen strategy from step 2 (e.g., formative and summative episode will usually focus on different properties).

Step 4: Design the Individual Evaluation Episodes. Based on the results from the previous three steps, researchers design particular evaluation episodes that represent concrete evaluation activities conducted at different points in time (see triangles in Figure 6). While it is usually not possible at the begin of a DSR project to foresee all evaluation episodes, following heuristics help for an initial planning: identify and analyze constraints of the evaluation context in terms of time, available people, budget, research sites; prioritize these contextual factors; design a plan that defines the amount and timing of evaluation episodes as well as involved stakeholders.

Venable et al. (2016) point out that research might jump for- and backward between these four steps. As a DSR project often lasts over a long period, evaluation contexts and, thus, specifics of the evaluation strategy might alter. As depicted in section 2.1.2, the author applied FEDS to evaluate REAM throughout seven evaluation episodes. Chapter VII discusses how the author designed REAM's evaluation using FEDS and presents the design of the particular episodes as well as their results and implicates for the several REAM versions.

2.2.3 CONDUCTING SYSTEMATIC LITERATURE REVIEWS

There exist many different terms that refer to the process of systematically reviewing literature, e.g., literature analysis, literature review, or research literature review. The remainder of this thesis uses the term systematic literature review (SLR) for that purpose. Fink (2010, p. 3) defines an SLR as *"a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by research, scholars, and practitioners."* Kitchenham (2004, p. 5) further states that an SLR focuses on a particular research question, topic area, or phenomenon of interest. Overall, an SLR aims to uncover knowledge relevant to a topic under investigation. It contributes to both relevance and rigor of research. It improves a study's relevance as it avoids reinvestigating what is already known and ensures rigor by using the knowledge effectively (Vom Brocke et al. 2009). Based on Okoli (2015, p. 888) and Kitchenham (2004, pp. 6–7) the author distinguishes between the following purposes for conducting SLRs:

(i) to analyze the progress of a specific research stream
(ii) to identify research gaps and make recommendations for future research
(iii) to review the application of one theoretical model or methodological approach in the IS literature by summarizing existing empirical evidence in the knowledge base
(iv) to develop a model or framework
(v) to analyze existing empirical evidence in order to verify a theoretical hypothesis or their generation

Although the importance of an SLR is widely acknowledged, not all research endeavors require conducting one. Petticrew and Roberts (2006) thoroughly discuss when an SLR is appropriate. To summarize, the necessity of SLRs depends on four aspects. First, one shall check whether there already exist relevant SLRs in the addressed research area. Comparing their findings with one's review intentions clarifies the need to conduct a new SLR. Second, the evolutionary state of the research field determines the feasibility of conducting an SLR. Petticrew and Roberts (2006) argue that an SLR is inappropriate of only a limited amount of relevant studies exist. Third, a successful SLR depends on clearly formulated research questions. Too broad questions hinder a systematic and relevant analysis of data. Fourth, one shall assess whether the anticipated results of an SLR justify the effort, time, and costs that come with it. Kitchenham (2004) agrees with Petticrew and Roberts and emphasizes analyzing existing reviews as a first step. This approach is in line with the guidelines provided by the Centre for Reviews and Dissemination (CRD 2009). Here, the authors state that a new SLR is not necessary if another review exists, that investigates the same questions, is of adequate quality, and was recently conducted (CRD 2009). Although their guidelines focus on reviews in health care research, the author claims that the line of reasoning is adaptable to IS research, since SLRs serve the same purposes in any research domain (Okoli 2015).

While the overall objective of SLRs are similar, there exist some variations regarding why authors conduct an SLR. Webster and Watson (2002, p. 14) generally distinguish between these SLRs that review a mature research domain and that review literature in a new field. Fettke (2006) analyzes previous work on conducting SLRs and derives eight categories from characterizing SLRs. Table 6 presents the morphological box Fettke provides to help researchers describe their SLR regarding these categories.

- **Type**: While *natural-language* SLRs analyze research based on descriptions and argumentation, *statistical* SLRs use mathematical models to analyze the knowledge base.
- **Focus**: An SLR may focus on analyzing particular research outcomes, utilized research methods, deployed theories, or shared experiences after applying methods or theories.
- **Objective**: While most SLRs explicitly state their overall objective (recommended), some do not refer to a particular review objective. Fettke distinguishes between three general review objectives, which are non-exclusive. Next to highlighting central aspects of recent efforts, an SLR may also critically assess available knowledge or integrate it into a framework.
- **Perspective**: Author of SLRs may either analyze the body of knowledge from a neutral perspective or explicitly position themselves in the context of academic discourse.
- **Literature**: SLRs differ regarding their documentation of the study selection process. While some SLRs only analyze seminal articles, others aim to cover the knowledge base exhaustively.
- **Structure**: This category defines how the authors of an SLR structure their findings.
- **Audience**: Depending on the addressed audience of the SLR, authors may approach the documentation of their results differently.
- **Research Agenda**: While some SLRs aim to identify possible future research stream of the research field under study, others do not.

TABLE 6. CATEGORIZATION OF SYSTEMATIC LITERATURE REVIEWS BY FETTKE (2006)

CHARACTERISTIC		CATEGORY			
Type		natural-language	statistical		
Focus		research outcomes	research methods	theories	applications
Objective	**Formulation**	non-explicit	explicit		
	Content	integration	criticism	central aspects	
Perspective		neutral	position		
Literature	**Selection**	non-explicit	explicit		
	Coverage	seminal articles	representative	selective exhaustive	exhaustive
Structure		historical	conceptual	methodological	
Audience		general public	practitioners	general scholars	specialized scholars
Research Agenda		non-explicit	explicit		

The literature agrees that SLRs related to a predefined research strategy (Kitchenham 2004; Vom Brocke et al. 2009; Okoli 2015). Okoli (2015) argues for providing a guide to conduct standalone SLRs in ISR by synthesizing the existing methodological approach to SLR. The author of this work understands this as a basis to understand necessary phases when performing an SLR. Okoli states eight activities any SLR team shall conduct: identify the purpose; draft the review protocol and train the team; apply a practical screen to ensure consistent study selection; conduct literature search; extract data, appraise study quality; synthesize studies; and, write the review. Okoli (2015) discusses existing approaches to perform the several phases. However, there exists a more acknowledged paper that provides guidelines for conducting SLRs. The seminal paper by Webster and Watson (2002) is widely used throughout the ISR community in that regard. They emphasize a concept-driven approach and, thus, introduce conceptual matrices to structure relevant studies regarding the topics investigated by the SLR and to reveal research gaps. Further, they argue to search back- and forward from relevant studies. Despite being widely-used, Webster and Watson (2002) lack presenting a concrete process to conduct SLRs.

For conducting the SLR in the context of this thesis' knowledge base analysis (KBA), the author consulted two methods for performing SLRs in more detail: the framework for literature reviewing by Vom Brocke et al. (2009) and the systematic review process suggested by Kitchenham (2004). Although both approaches have mainly the same scope, there exist some differences between them. First, Kitchenham's approach puts more emphasis on an SLR's transparency. While vom Brocke identifies the documentation of the SLR equally important, Kitchenham's process reflects this in more detail. She restricts reviewers to focus on a specific set of research outlets under investigation, which the reviewer chose beforehand. Further, Kitchenham does not use back- and forward search. Second, in contrast to Kitchenham, vom Brocke integrates a step for conceptualizing the investigated research field. Third, vom Brocke integrates search by outlets with a subsequent back- and forward search, after an initial list of relevant studies is identified. Fourth, vom Brocke requires SLRs to finally arrive at a research agenda based on the findings of the data synthesis.

The author understands that the differences of the SLR approaches by Kitchenham (2004) and Vom Brocke et al. (2009) are due to a slightly different focus on the type of SLRs they are promoting. Having its roots in the medical domain, Kitchenham's process may be adequate for SLRs that have a clear set of research questions and where authors already identified adequate research outlets. The approach by vom Brocke seems to be more suited for SLR endeavors that have a more explorative nature. However, the author argues that one may combine the strengths of both approaches when conducting SLRs. Consequently, this work applies the SLR framework by Vom Brocke et al. (2009) and concretizes its different steps with certain aspects defined by Kitchenham (2004). Therefore, the remainder of this section will shortly present vom Brocke's framework.

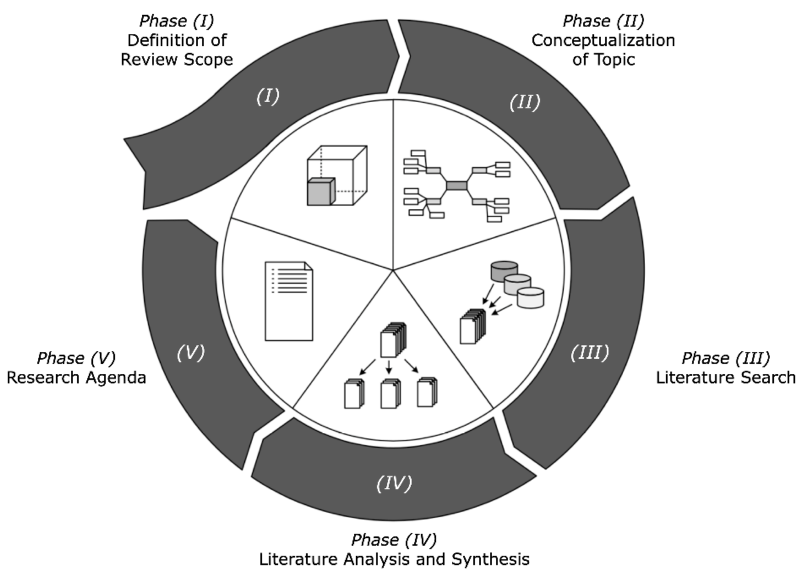


FIGURE 7. FRAMEWORK FOR LITERATURE REVIEWING BY VOM BROCKE ET AL. (2009)

Figure 7 illustrates the framework for conducting literature reviews, as proposed by Vom Brocke et al. (2009). The authors define five phases when reviewing literature. *Phase (I)* defines the overall scope of the SLR. According to Vom Brocke et al. (2009), there exist many different types of literature reviews with various possible purposes. Thus, they recommend using the taxonomy of literature reviews proposed by Cooper (1988), from which the previously presented taxonomy by Fettke (2006) builds. Afterward, *phase (II)* conceptualizes the topic under investigation by defining key terms. Therefore, one shall consult seminal textbooks, encyclopedias, or other available essential sources. In this regard, the authors propose concept mapping as a useful technique that lays a foundation for subsequent phases. Identifying, defining, and interrelating core concepts helps to identify important search terms and provides a starting point for synthesizing the identified studies. The next phase (III) conducts the actual search for literature. Vom Brocke et al. (2009) recommend to start searching for relevant articles in scholarly journal outlets or the proceedings of renowned conferences as they have typically been peer-reviewed. Afterward, the framework states to conduct a keyword search applied at adequate literature databases, such as *Scopus*, *IEEExplore*, *EBSCOhost*, and others. After finishing the search, phase (IV) analyzes the identified studies regarding the scope of the literature review from phase (I) and synthesizes the findings. Vom Brocke et al. (2009) hint at using a conceptual framework based on the conceptualization from phase (II) in order to support that phase (IV). Finally, phase (V) derives a research agenda based on the synthesized findings.

This thesis applies the presented framework for analyzing the knowledge base regarding REA development. Therefore, the KBA applies the five phases and concretizes each phase by defining several steps taken to perform them. These steps integrate recommendations of other literature on conducting SLRs (Bandara et al. 2015; Kitchenham 2004; Webster and Watson 2002). Section 4.3 describes that in more detail.

2.2.4 SURVEYS (INTERVIEWS, QUESTIONNAIRES, DOCUMENT ANALYSIS, FOCUS GROUP)

The research strategy survey aims to map out a physical or social world and provides a broad overview of an area of interest (Johannesson and Perjons 2014, p. 42). Robson and McCartan (2016, p. 245) define surveys as designs that collect small amounts of data using a standardized form from a relatively large number of individuals, which are representative from a defined population. Surveys are a common research strategy in social sciences and useful for collecting data on narrow and well-defined topics. There exist various types of surveys, such as telephone surveys, internet surveys, face-to-face surveys, observational surveys, or document surveys.

One major concern when conducting surveys is whether the participating individuals are representative of the population, so that results can be generalized. That problem is called sampling. Before conducting surveys, researchers have to define a sample of respondents, from which data is collected. When designing a survey, one can aim for a "representative sample" or an "exploratory sample." While the former intends to offer a complete image of the entire population, the latter does aim for representativity but rather explores a new area. Different techniques are available to define samples. Random Sampling randomly chooses individuals from the population and is useful for generating representative samples. Purposive sampling enables researchers to identify a small number of individuals that can provide valuable information and is useful for generating exploratory samples.

A survey can use different research methods for collecting data. Throughout the Ph.D. project, the author used interviews, questionnaires, focus groups, and documents for this purpose. The following list shortly defines these methods:

- **Questionnaires:** In order to gather information that is brief and unambiguous, questionnaires consist of a list of questions distributed to the sample of survey respondents. By answering these questions, respondents provide answers regarding simple facts (e.g., personal information), opinions, or choose from a list of options. Thus, when designing the questionnaire, researchers define open or closed questions, which shall be brief, relevant, clear, specific, and objective (Peterson 2000).
- **Interviews:** Interviews are suitable for collecting complex and sensitive information as they require a communication session between a researcher and a respondent. The researcher controls the agenda of the interview and asks questions related to the survey's objective. That interaction can follow a structured (predefined protocol similar to questionnaire), semi-structured (list of open questions discussed in a flexible order), or unstructured (respondents freely talks about the topic of interest) interview design. Interviews can be documented using notes, audio, or video recordings (Johannesson and Perjons 2014).

- **Focus Groups:** Simply put, a focus group is an interview with a group of participating respondents that discuss a specific topic. These respondents may be a certain user group, which discusses ethical aspects or their perception of a new product, or experts that discuss a complex problem or possible solutions for it. As a collection method, focus groups aim to understand and interpret the topic of interest from the participants' point of view and, thus, requires a design that supports free and fruitful discussions. Researchers both moderate and document focus group sessions (Johannesson and Perjons 2014). In some cases, several focus group meetings take periodically and accompany, e.g., the development cycle of a solution. In the context of DSR, literature distinguishes between exploratory focus groups and confirmatory focus groups (Tremblay et al. 2010). The author applied both types within the several build and evaluate cycles of this thesis (see chapter VII for a detailed explanation).
- **Documents:** As an alternative source of data, documents often provide additional or in-depth textual data that extends data gathered through questionnaires or interviews. While researchers have to ensure the documents' credibility, investigating government publications, organizational records, or academic publications is a means to achieve triangulation during the data collection (Rothbauer 2008).

In the context of this Ph.D. thesis, the author conducted several surveys using different research methods for collecting data. The relevant section will refer to these methods. However, the following list enumerates the main research activities in that regard:

- In the context of Local Practice A, the author conducted an internet survey based on a standardized questionnaire with an exploratory sample of public utilities. The aim was to get an overview of their challenges in the context of the energy industry change and to understand the required structure of a RM that supports them (see section 4.1.1.2). The author primarily deployed quantitative analysis methods to analyze the results.
- In the context of Local Practice B, the author periodically surveyed experts of the financial service domain using a focus group design. Section 4.1.2 introduces the focus group and their members in more detail. The regular meetings of the focus group supported the build and evaluate cycle during the COFIN project and, thus, represented a fruitful source for different versions of REAM design. Therefore, the author used both confirmatory and exploratory focus group designs (see chapter VII).
- Throughout the Ph.D. project, the author interviews experts from the local practices to gain an understanding of the global problem (chapter IV), to identify requirements towards REAM (chapter VI), and to evaluate REAM (chapter VII). The majority of interviews followed a semi-structured approach.
- Throughout the Ph.D. project, the author analyzed different types of documents in order to gain additional insights regarding the research objective. The problem investigation studied governmental publications and organizational records. Academic publications helped to paint a more detailed picture during the problem investigation, too (chapter IV), as well as the formulation of requirements (chapter VI).

For a more detailed picture of the survey and how to conduct them, the author refers to Robson and McCartan (2016), Fowler (2014), and Denscombe (2017).

2.2.5 ACTION RESEARCH

In contrast to many other research strategies, action research involves active practitioner involvement in the research process. While in most research activities consults practitioners for verification of research results, they are actively involved in action research strategies. Johannesson and Perjons (2014, p. 49) assert that action research is especially feasible in domains where practitioners themselves can contribute to their practices' improvement, like in healthcare or organizational change processes. Thus, the purpose of conducting action research is the simultaneous process of conducting research and taking action in a real-world practice. Its overall objective is to ensure the applicability of results in a particular practice domain (Kemmis et al. 2014; McNiff 2013).

Johannesson and Perjons (2014, p. 49) summarize action research with the characteristics focus on practice, change in practice, active practitioner participation, cyclical research process using feedback loops, and its contributions to both practical and scholar knowledge bases. While there exists some confusion about the distinction between action research and DSR (Papas et al. 2012; Järvinen 2007), Baskerville (2008) argues that action research focuses on problem-solving through social and organizational change, while DSR solves problems by creating an artifact in a natural setting. He concludes that action research is a research methodology, and DSR is a research paradigm. This conclusion is in line with Johannesson and Perjons (2014), who position action research as a research strategy that many DSR projects utilize.

When conducting, action research can have different purposes. Literature distinguishes these into technical, practical, and critical action research (Kemmis et al. 2014; McNiff 2013). *Technical action research* aims at functional improvements, such as improving the artifact's effectiveness and efficiency in the practice. *Practical action research* further addresses the practitioner's understanding of themselves and their work. Thus, next to improving the practice, such studies focus on self-education to change people themselves. Critical action research goes beyond technical and practical action research by critically investigating their practice, its organizational and social context, and questioning the goals of their organization.

The author conducted technical action research to evaluate several versions of REAM. As stated above, technical action research focuses on the artifact applied in practice, i.e., REAM in the context of the local practices of ECLORA and COFIN projects. Wieringa (2014) defines three roles or researchers when conducting technical action research: technical researcher, empirical researcher, and helper. As a *technical researcher*, the author designed the artifact REAM later applied in the practices in order to solve the local problem delineated in section 4.1. As one member of the project teams, the author acted (likewise to his project team members) as an *empirical researcher*. The project team actively applied REAM in practice in order to answer questions regarding REAM's validity. Finally, the author acted as a *helper* supporting the clients of the practices to apply REAM. While, in the context of ECLORA, the client was the ERP provider SIV group, the working group of the bitkom federation was the client in the COFIN project.

The author argues that applying action research for evaluating DSR artifacts is feasible, especially when conducting formative evaluation activities, which aim to improve an artifact's design (see FEDS in section 2.2.2). That is due to the cyclic nature of action research processes themselves. Based on Denscombe (2017), Johannesson and Perjons (2014, p. 50) define action research cycles by dint of five phases:

(i) *Diagnosis*: Investigate and analyze the problem situation in order to understand how it can be changed.
(ii) *Planning*: Plan actions that can change and improve the current situation.
(iii) *Intervention*: Carry out actions in order to change the current situation following the plan.

(iv) *Evaluation*: Evaluate the effects of the intervention, in particular, whether the situation has improved.
(v) *Reflection*: Reflect on the research carried out, in particular, the results for the local practice and the new knowledge generated; decide whether to carry out a new action research cycle.

Comparing these five phases to the steps of the applies DSR design discussed in section 2.1.2, one can identify similarities that indicate a seamless integration of action research in the build and evaluate cycle of DSR. While phase (i) directly relates to the findings made in the local practices of ECLORA and COFIN during step 1 of the DSR process, the author argues that some aspects of (ii) planning relate to defining objectives for the DSR artifact (DSR step 2) and designing it (DSR step 3). However, the majority of the five phases directly relate to the DSR steps of demonstration (DSR step 4) and, especially, evaluation (DSR step 5). Here, the action research phases (iii) – (iv) are performed and may result in another feedback loop to the DSR step *"design & development."*

To conclude, the author performed action research as follows. First, the findings from the problem investigation (see chapter IV) were used to plan particular action research cycles resulting in five evaluation episodes that evaluated REAM (see chapter VII). By conducting these episodes, the author intervened in the particular practices and evaluated REAM's effectiveness (and other aspects of the artifact, see chapter VII). Reflections on these results led to new versions of REAM, except for the last summative evaluation episode. The methods the author applied for *data collection, and data analys*is depended on the particular project context. For collecting data, the author primarily used questionnaires, interviews, focus groups, and document analysis (see section 2.2.4). For analyzing the gathered data, the author used qualitative methods, such as content analysis (Denscombe 2017).

2.2.6 CASE STUDY RESEARCH

Case Studies investigate one instance of a phenomenon and aims to gain in-depth insights into that instance. Johannesson and Perjons (2014, p. 44) characterize case studies regarding their focus on one instance, their focus on depth, their naturalistic setting, a holistic investigation of the instance (its environment, processes, and relationships), and a multitude of user data collection methods (interviews, observations) as well as different sources (triangulation). However, the authors further point out that case studies can concern a small number of instances as long as these are self-contained. An instance might be, among other things, a person, an organization, a project, or an IT system.

Researcher can deploy case studies for different purposes. *Exploratory case studies* are suitable, when the researcher investigates a new research area, as they intend to generate research questions or hypotheses. *Descriptive case studies* produce a detailed analysis of a particular instance using different sources of knowledge. An *explanatory case study* goes one step further and aims to identify cause and effect relationships that explain observed phenomena (Runeson and Höst 2009). One crucial aspect to consider when designing case studies is to choose an adequate instance. Depending on the research objective, Johannesson and Perjons (2014) recommend to use instances that are representative, extreme, or even convenient, i.e., accessible to the researcher. When conducting case studies, Robson and McCartan (2016) requires researchers to follow a minimal set of activities: define objective, describe the instantiation, refer to the related theory, formulate research questions, design data collection methods, and select data sources. For collecting data, Runeson and Höst (2009, pp. 144–145) require researchers to aim for triangulation (Rothbauer 2008). They present techniques on how to conduct interviews, observations, or systematically investigate documents for a rigorous case study design. For more detailed information regarding case study research, the author of this thesis refers to Yin (2014), whom's textbook is one of the most cited in that research domain.

In the context of this Ph.D. project, the author conducted a small-sized case study as part of the last episode for evaluating REAM (see section 7.2.7). The case study aimed to investigate how a payment service provider applied the RCO (the output of one REAM application, see section 6.3) to extend its service portfolio. Thus, the author of this work deployed a descriptive case study. The author conducted interviews with experts from the company to understand how they applied RCO and analyzed the developed software with the help of the company's software developer. These activities resulted in the findings discussed in section EE7 of the evaluation in chapter VII.

III. RESEARCH CONTEXT: SETTING THEORETICAL FOUNDATIONS

Before the remaining chapters document the results of the several DSR phases, as chapter II presented earlier, this chapter aims to provide a general overview of the research fields that provide this Ph.D. thesis' theoretical foundation. The author emphasizes that this chapter summarizes the research disciplines of *Enterprise Architecture Management (EAM)* and *Reference Modeling (RM)* in order to provide readers a general understanding of REAM's research context. Consequently, this chapter does not provide the results of a KBA, as demanded by DSR research (Hevner et al. 2004). Furthermore, this chapter does not concentrate on Reference Enterprise Architectures (REA) in specific and describes the overall concepts of EAM and reference modeling disciplines. This thesis provides a thorough KBA on REAs in section 4.3.

From a general perspective, this thesis relates to the overall research discipline of conceptual modeling. *Conceptual models* are *"… descriptions of a world/enterprise/slice of reality which correspond directly and naturally to our own conceptualizations of the object of these descriptions"* (Mylopoulos and Levesque 1983). Next to describing reality, a conceptual model further is a (re-) constructing description of a domain. Thus, it is descriptive and prescriptive (Frank 1994). In this context, an *Enterprise Model* is a specific type of conceptual model. It *"is a computational representation of the structure, activities, processes, information, resources, people, behavior, goals, and constraints of a business, government, or other enterprises. It can be both descriptive and definitional—spanning what is and what should be. The role of an enterprise model is to achieve model-driven enterprise design, analysis, and operation"* (Mark S. Fox and Michael Gruninger 1998). *Enterprise Modeling* is the process of externalizing the knowledge for developing enterprise models. It makes models of the structure, behavior, and organization of the enterprise. These enterprise models are shared within the organization. These processes add value to the enterprise (Vernadat 2002).

The thesis at hand relates to these ISR research fields of conceptual and enterprise modeling. As depicted in the chapter I, the domain of EAM provides means to align an enterprise's business and IT landscapes by holistically capturing its structure and behavior in an enterprise model. Further, Reference Models (RM) are reusable conceptual models that provide a solution for a particular problem domain and its stakeholders. Based on the problem statement addressed by this thesis (see chapter I), the research fields of EAM and reference modeling form the overall research context of this thesis.

The remainder of this chapter structures as follows. Section 3.1 introduces the overall concepts of EAM and presents approaches on how to structure and model EAs. Afterward, section 3.2 discusses the notion of RMs and general approaches on how to develop, apply, and evaluate them.

3.1 ENTERPRISE ARCHITECTURE MANAGEMENT

This section provides an overview of the enterprise architecture management (EAM) research discipline. That is important because REAM reuses many of its concepts and approaches. After section 3.1.1 defines the notion of enterprise architectures (EA) and introduces its related concepts, section 3.1.2 discusses the concepts of the EAM domain. Afterward, sections 3.1.3 and 3.1.4 present what frameworks and modeling standards exist that describe how to structure and model EAs.

3.1.1 DEFINING ENTERPRISE ARCHITECTURES AND RELATED CONCEPTS

The growing complexity of their organizational structures, their increasing reliance on advanced information technologies, as well as their constantly changing business environments, force enterprises to implement an integrated approach to business and IT. Nowadays, most enterprises' strategic decisions have consequences within all domains of their practice. Thus, they have to understand the interrelations among their business processes, information systems, and infrastructure components in order to make informed decisions. Based on the metaphor for building a house, Enterprise Architectures (EA) aims to develop a holistic understanding of an enterprise's elements and their intertwined relations in order to facilitate business and IT alignment (Lankhorst et al. 2017). Therefore, an EA systematizes an enterprise from different perspectives, i.e., regarding its business aspects (e.g., business processes, organizational structures, actors and roles, or strategic units), IS landscapes (e.g., data structures, software applications, or interfaces), and infrastructure elements (e.g., hardware or network components). Beyond the understanding of an enterprise's current state, EA also captures possible future states, which it derives from the organization's goals. Consequently, EA is implemented at an enterprise's management level (Ahlemann et al. 2012).

While IS literature provides many different definitions on EA, the majority builds from the ISO/IEC/IEEE standard (ISO/IEC/IEEE 42010:2011). It defines architectures as *"fundamental concepts or properties of a system in its environment, embodied in its elements, relationships, and in the principles of its design and evolution."* On that basis, the thesis uses the definition for EA by Lankhorst et al. (2017, p. 3):

> *"An Enterprise Architecture is a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business process, information systems, and infrastructure."*

Lankhorst et al. acknowledge the several perspectives an EA provides on an organization, e.g., its business and IT-related components, refer to its role of understanding and designing an organization, and state that EA endeavors require a set of tools. While the EA itself encapsulates and enterprise's elements and their interrelations, the process for designing and realizing an EA is referred to as EAM. Ahlemann et al. (2012, p. 3) define EAM as follows:

> *"EAM is defined as a management practice that establishes, maintains, and uses a coherent set of guidelines, architecture principles and governance regimes that provide direction and practical help in the design and development of an enterprise's architecture to achieve its vision and strategy."*

From a general perspective, organizations benefit from using EAM as it creates a clear understanding of their structures, products, operations, technologies, and the web of interrelations that tie these together. Lankhorst et al. (2017, p. 5) enlist internal and external drivers why organizations use EAM. From an internal perspective, better business and IT alignment leads to organizational benefits, such as cost reduction, quality enhancement, time-to-market improvement, and higher customer satisfaction. From an external perspective, volatile business environments force organizations to improve their insights on their structure in order to stay competitive or comply with regulatory requirements (Proper et al. 2017).

3.1.2 IMPORTANT CONCEPTS OF EAM

As there exist a plethora of research streams and interests in the domain of EAM research, this section intends to give an overview of basic concepts relating to EA and EAM. Before the next section discusses existing EA frameworks and EA models in concrete, this section introduces a product and process perspective of EAM, its general stakeholders, usage scenarios of EAM, organizational benefits, and EAM success factors.

EA AS PROCESS AND PRODUCT. Literature emphasizes that using EA relates to both a process and a product. EA processes concern EA management operations that provide direction and support in the design and management of the EA to support organizational transformation. They include EA planning, i.e., define what future state the organization desires to achieve (Nikpay et al. 2017), and EA governance, i.e., ensure that individual transformation projects comply with the overall organizational transformation strategy (Shanks et al. 2018). These activities are often related to the responsibilities of EAM.

EA products are the outputs of EA processes and divide into EA documentation and EA services. EA documentation refers to architectural descriptions, used EA standards, EA principles, and other knowledge that describes the organization from business, information, IS, and technology perspective. Architectural descriptions are referred to as “EA models” and address both the organization’s current and target state as well as a plan on how to reach the latter (Tamm et al. 2011; Lankhorst et al. 2017; Op't Land et al. 2009). EA services represent communication and collaboration interfaces of EA processes among EA stakeholders, such as EA implementation support, conformity checks with EA principles, EA planning support, or decision support (Shanks et al. 2018; Lankhorst et al. 2017; Lange et al. 2016).

EA STAKEHOLDERS. Lankhorst et al. (2017, p. 81) define stakeholders in the context of EAM as *“an individual, team, or organization (or classes thereof) with interests in, or concerns relative to,”* the architecture or its outcomes. Concerns are interests relating to the system’s development, its operation, or any other aspects relevant to one or more stakeholders (Lankhorst et al. 2017, p. 62). An organization has a vast majority of stakeholders whose concerns towards the enterprise and its future state differ (Greefhorst and Proper 2011, p. 66). As section 3.1.3.1 will show, EA addresses these various stakeholder concerns by dint of architectural viewpoints. Due to ist holistic lense and management perspective, EA addresses stakeholders on both the management and operational level of an organization (Ahlemann et al. 2012). According to Op't Land et al. (2009), they may exist general groups of stakeholders: (i) those, who are involved in an EA initiative, (ii) those, who are impacted by an EA initiative, and, (iii) those, who sponsor it. While (i) relate to concrete EA roles like enterprise architect, solution architects, or business architects (Wißotzki et al. 2017), group (ii) represents those organizational stakeholders that are impacted by the changes resulting from organizational transformation. Group (iii) refers to the management level of the organization that applies EAM, such as chief technical officers or chief information officers.

USAGE SCENARIOS OF EA. In the context of organizational development, Op't Land et al. (2009, p. 41) identify seven key applications for EA. The author of this thesis focuses on the seven key applications as they provide a comprehensive overview of EA usage. Likewise, these key activities shed light on an example of how to traverse through an EAM program:

- **Situation Description:** Organizations can use EA as a means for goal-and-cause analysis to investigate problems in an existing situation. That involves the creation of an understanding of the existing situation, which is shared by the different EA stakeholders.
- **Strategic Direction:** Organizations can use EA to express the future direction of an enterprise, as well as analyze different alternatives. That involves the creation of a conceptualization of the potential future directions and an agreement for the selected alternative (agreed among EA stakeholders).
- **Gap Analysis:** Organizations can use EA to identify critical problems, challenges, issues, impediments, chances, threats, as well as make well-motivated design decisions that enable a move from the current situation into the desired strategic direction.
- **Tactical Planning:** Organizations can use EA to provide boundaries and identify intermediary steps for the enterprise transformation toward the desired strategic direction. Here, EA acts as a planning tool and makes the realization of a strategy more tangible.

- **Operational Planning:** Organizations can use EA to give a clear context and direction for a portfolio of projects working toward the realization of the next intermediary step as defined at the tactical planning level.
- **Selection of Partial Solutions:** Organizations can use EA to select one or more standard solutions or packages that are to become part of the solution. Further, EA may lead to the decision to outsource an entire business process or service to another organization.
- **Solution Architecture:** Organizations can use EA to create the high level design of an actual step in the enterprise transformation as implemented in the context of a specific project.

Op't Land et al. (2009, p. 32) illustrate these usage scenarios of EA in Figure 8. Based on the current situation of the organization ("AS-IS"), the strategic direction defines a desired state ("TO-BE"), which is reached by dint of iterative tactical and operational planning and accompanied by recurrent gap analyses. There exist many articles that investigate actual EA uses by dint of case study research. For instance, Niemi and Pekkola (2017) analyze different EA endeavors and identify 15 usage scenarios that concretize the high-level activities defined by Op't Land et al. (2009), such as architecture reviews or trainings. Further, literature acknowledges the importance of adequate communication of EA artifacts (Lankhorst et al. 2017; Aier et al. 2011).

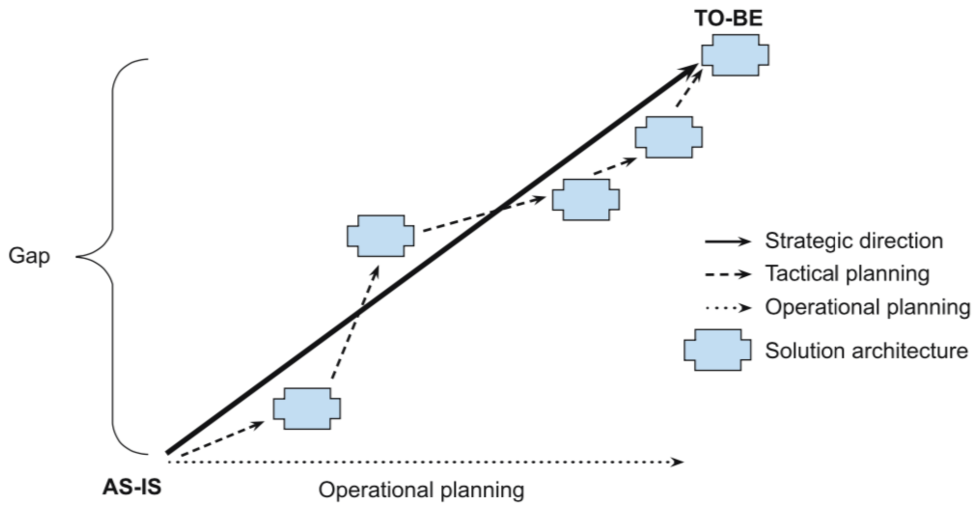


FIGURE 8. APPLICATIONS OF ENTERPRISE ARCHITECTURES (32OP'T LAND ET AL. 2009, P. 41)

VALUE AND BENEFITS OF EA. Investigating the value of EA and its related organizational benefits is a popular research stream within the EA research domain. The works of Tamm et al. (2011), Niemi and Pekkola (2019), and Gong and Janssen (2019) provide comprehensive overviews of benefits literature ascribes to EA. Depending on the scope of an EA initiative, organizations can benefit from EA differently. Niemi and Pekkola (2019) identify 250 different benefits of EA literature discusses. In their EA benefits model, Tamm et al. (2011, p. 150) identify four benefit enablers that results from successful EA initiatives and finally lead to organizational benefits, such as cost reduction, organizational performance, competitive differentiation, or strategic flexibility:

- **Organizational Alignment:** The extent to which an organization‘s subunits share a common understanding of its strategic goals, and contribute towards achieving these goals (e.g., business and IT alignment, alignment of goals, alignment of strategic business units, shared understanding of organizational structures).

- **Information Availability:** The extent of useful, high-quality information accessible to organizational decision-makers (e.g., shared reference information, information access, more accurate and timely data, improved information quality).
- **Resource Portfolio Optimization:** The extent to which an organization leverages its existing resources, invests in resources that target performance gaps, and minimizes unnecessary investments in duplicated resources (e.g., avoidance of redundancy, technology standardization, efficient IT interfaces, usage optimization of human resources, IT resources, and business processes).
- **Resource Complementarity:** The extent to which the organization's resources synergistically support the pursuit of its strategic goals (e.g., enhanced interoperability, identification of cross-organizational synergies).

SUCCESS FACTORS OF EA. Next to understanding the value of EAM and related benefits, the EA research domain investigates success factors for EA and how they lead to organizational benefits (Foorthuis et al. 2016; Lange et al. 2016; Niemi and Pekkola 2019; Schmidt and Buxmann 2011). Foorthuis et al. (2016, p. 557) show that EA initiatives do not directly lead to these benefits. Based on their explanatory model, the authors claim that EA success depends on the correct use of EA norms, a clear understanding of the organizations current and desired state, and the existence of EA-related capabilities within the organization. That is in line with other approaches to define EA success factors. Based on the IS Success Model proposed by DeLone and McLean (2003), Lange et al. (2016) provide an empirically validated model of EA success factors. In their structural model, they define four key constructs that represent EA success factors:

- **EAM Product Quality:** The quality of the outputs from EA processes, such as the architectural description of the current and the desired state, roadmaps, and EA principles.
- **EAM Infrastructure Quality:** The EAM infrastructure refers to the required foundational structures for EAM, such as the assignment of accountability, an appropriate governance scheme, or EAM tool support. The EAM infrastructure quality, therefore, determines the extent to which the formal conditions, under which EAM is executed, are appropriate. Thus, this includes not only the different EA processes (see above), but also available resources, capabilities, or reusable knowledge (e.g., reference architectures).
- **EAM Service Delivery Quality:** Relevant EA stakeholders receive EAM services. EAM service delivery quality is, therefore, concerned with the quality of the services provided, which include EAM and value communication, compliance validation, and decision-making.
- **EAM Organizational Quality:** Lange et al. (2016) define organizational anchoring of EAM as the characteristics and conditions through which EAM is embedded in the organization to enable, drive, and influence an organization's performance. That includes the commitment of an organization's top management level to the EA initiative, awareness towards EAM throughout the organization, and an understanding of EAM.

Thus, not only the knowledge of EAM methods and principles and on how to appropriately apply them results in EAM success. Empirical evidence reveals that there further exist social and cultural dimensions to successful EA initiatives (Lange et al. 2012).

While the benefits of EA are promising, literature discusses the justification of cost-intense EA projects as they are primarily driven by enterprises' IT departments (Ross and Quaadgras 2012). Therefore, Winter (2014) demands enterprises to establish an EA thinking that spans throughout the organization and goes beyond IT departments' borders in order to unfold EA's full potential.

The thesis at hand presents a method for developing reference models that use EA structures. Thus, it primarily relates to the product dimension of EA. In concrete, the method reuses EAM approaches of how to structure EA in order to arrive at an appropriate architectural description that is relevant to a particular group of organizations. Consequently, the remainder of this section discusses the concepts of EA frameworks and EA modeling languages. While the former addresses the question of how to systematize an EA, the latter provides concrete means to represent them.

3.1.3 ENTERPRISE ARCHITECTURES FRAMEWORKS

There exist many different frameworks that help to systematize the necessary EA layers. EA frameworks further offer “principles, models, and guidance to help one develop an EA program. It elaborates what architectural documents should include and provides instruction on how to operationalize EA“ (Bui 2017; Greefhorst et al. 2006). Thus, EA frameworks guide organizations regarding the product and process dimension of EA initiatives. An EA initiative can choose from a plethora of available EA frameworks. According to Bui (2017), the number of frameworks has doubled over the last decade. There exist several works that compare the different EA frameworks with each other. For a detailed discussion about them, the author refers to Schekkerman (2006), Matthes (2011), and Bui (2017). Bui (2017) identifies essential components EA frameworks consist of and further identifies the three types of technical, operational, and strategic EA frameworks. Matthes (2011) investigates 34 different EA frameworks and categorizes them regarding their purpose. Doing so, he distinguishes between government and agency frameworks, management frameworks, military frameworks, manufacturer-specific frameworks, technically oriented frameworks, interoperability frameworks, and add-on frameworks.

Presenting a representative number of EA frameworks is out of this thesis’ scope. However, this section explains the essential EA layers defined by most frameworks and presents the EA framework by The Open Group (2011), which the author primarily used in the scope of the Ph.D. project.

As the previous section discussed, EA aims to describe organizations holistically in order to reveal interrelations between the elements of, e.g., their processes, IT landscapes, and technical infrastructure. Therefore, EA defines different perspectives, from which it investigates the organization in detail. In order to develop an architectural description of an organization, it is essential to agree on the investigated EA perspectives. EA literature refers to these perspectives as “EA layers.” Winter and Fischer (2006) provide a useful overview of essential EA layers for a business-oriented approach towards EAM. While particular EA frameworks may add domain-specific layers, e.g., the military or government domains, their list of five EA layers provides a comprehensive overview. They propose the following layers. Figure 9 illustrates their interrelation.

- **Business Architecture:** This layer represents the structural organization of the corporation from a business strategy viewpoint. Typical elements represented on this layer are value networks, relationships to customer and supplier processes, targeted market segments, offered services, organizational goals, and strategic projects.
- **Process Architecture:** This layer addresses the organization of service development, service creation, and service distribution. Typical elements represented on this layer are business processes, organizational units, responsibilities, business roles, and information flows.
- **Integration Architecture:** This layer represents the organization’s information system components in their business context. Typical elements represented here are enterprise services, application components, integration systems, and data flows.
- **Software Architecture:** The software architecture represents the organization of software artifacts, e.g., software services, interfaces, and data structures.

- **Technology Architecture:** The technology architecture represents the organization of computing hardware and networks. Typical elements are devices, servers, or network components.

As Figure 9 illustrates, each layer identifies elements on different levels of granularity and interrelates them with each other. An EA reveals interrelations among the different EA layers and, thus, provides a holistic perspective on the organization. For each EA layer, the different EA frameworks define what elements to identify. The frameworks further use meta-models to define possible interrelations among these EA elements.

Before section 3.1.4 concretizes how to develop EA models on that basis, the remainder of this section provides an overview of the ISO/IEC 42010 standard for architecture descriptions and the TOGAF EA framework. While the standard provides a conceptual model that interrelates prior discussed concepts of EAM, the author understands TOGAF to be an appropriate representative of EA frameworks, as many practitioners apply it.

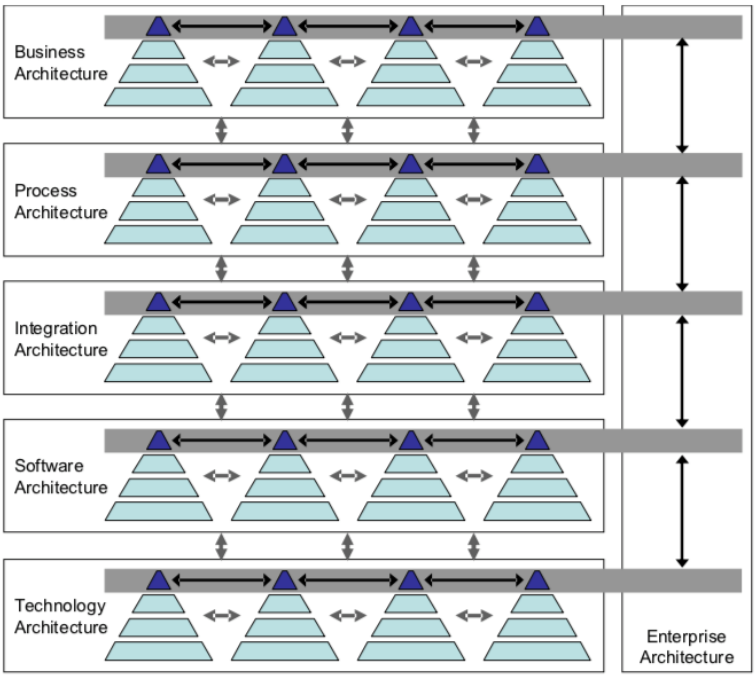


FIGURE 9. ESSENTIAL EA LAYERS (WINTER AND FISCHER 2006)

3.1.3.1 ISO/IEC 42010 AND ZACHMAN FRAMEWORK

The ISO/IEC 42010 standard provides a comprehensive theoretical base for understanding essential concepts of EA (ISO/IEC/IEEE 42010:2011). Although it addresses system architectures in general, many EA frameworks relate to the concepts defined by the standard. The standard provides a conceptual model that interrelates the key terms for architectural descriptions with each other. Figure 10 illustrates this conceptual model. In general, the standard defines a system that fulfills a particular mission and acts in an environment, i.e., an enterprise with its goals acts in a particular industry pursuing organizational objectives. Such systems have an architecture that can be described by dint of architectural descriptions. It encompasses all necessary elements of the different EA layers and their interrelations among each other in order to fulfill a prior established architectural rationale. A model stores all this information and represents the actual system architecture. As described above, stakeholders of an enterprise possess different concerns the architectural description shall address. Therefore, the architectural description uses viewpoints to tailor the complex architecture model to the various stakeholders' concerns. Libraries help to standardize these viewpoints. In concrete, views instantiate a viewpoint of a particular stakeholder on the architecture model.

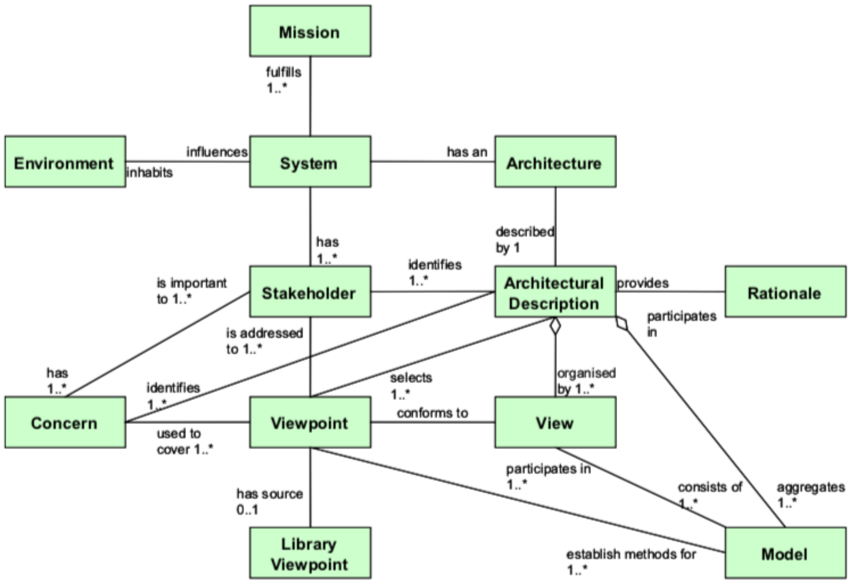


FIGURE 10. CONCEPTUAL MODEL OF ARCHITECTURE DESCRIPTION (LANKHORST ET AL., 2017)

While this conceptual basis underlies any EA framework, the standard does neither provide concrete systematizations what to include in an architectural description (i.e., what EA layers, elements, and relationships exist) nor propose methods how to develop a system architecture. Thus, it is not sufficient for an EA initiative.

The Zachman framework was one of the first attempts for an EA framework (Zachman 1987). It provides a logical structure for classifying architectural descriptions of an enterprise, which are essential to the management and the development of its systems. Represented as a matrix, it defines architectural perspectives based on the different roles of the design process and product abstractions. Zachman identifies the different roles of *planner, owner, designer, builder* and *subcontractor* and abstracts the product perspective regarding the questions *what* (material), *how* (process), *where* (location), *who* (involved people), *when* (time aspect), and *why* (motivation based on goals). On that basis, Zachman identifies 36 cells that represent possible architectural viewpoints. For instance, a product owner's concerns relate to other architectural elements than the concerns of a system designer, who is more interested in technical aspects. As an example, an independent service provider sells software products. Regarding the column *who:* while the designer and builder need information regarding the different software users or necessary interfaces, the product owner rather concerns possible clients and departments that might buy the particular software product.

Although the Zachman framework is easy to comprehend and provides a holistic view of organizations, the large number of cells represents an obstacle for its implementation. Practices lament the opaque relations among the cells and perspectives as the framework further lacks a transparent process for developing an EA.

3.1.3.2 THE OPEN GROUP ARCHITECTURE FRAMEWORK (TOGAF)

This section shortly presents an overview of The Open Group Architecture Framework (TOGAF) developed byThe Open Group (2011). From the plethora of different EA frameworks, it is one of the most applied by practitioners (Matthes 2011; Bui 2017). TOGAF originated as a generic framework and methodology for developing technical architectures. Throughout its different versions, it is now dedicated to EA as well. Its current version 9.2 consist of the following main components (The Open Group 2018):

- **Architecture Capability Framework:** This sub-framework defines what processes, skills, roles, and responsibilities are necessary to establish an EA function within an enterprise.
- **Architecture Development Method (ADM):** This method guides the process of how to conduct EAM using TOGAF. ADM defines a cyclic approach to develop the EA.
- **Architecture Content Framework:** This sub-framework provides a systemization of how TOGAF structures an EA using four closely interrelated architectural layers: business architectures, data architecture, application architecture, and technology architecture.
- **The Enterprise Continuum** describes how an enterprise's individual EA may build from reusable reference architectures. Therefore, TOGAF defines the Technical Refer*ence Model*, *The Open Group's Standards Information Base*, and *The Building Blocks Information Base*.

The Architecture Capability Framework refers to the EA process (see section 3.1.2). Hence, it is out of this thesis' scope since the Ph.D.'s artifact primarily contributes to the EA as a product, in concrete, the EA model. In chapter VI, the author further discusses how Reference Enterprise Architectures (REA) relate to the TOGAF's Enterprise Continuum. Thus, this section will focus on presenting the ADM and the Architecture Content Framework.

THE ARCHITECTURE CONTENT FRAMEWORK. The content framework defines the phenomena an organization has to investigate when using TOGAF for developing its architectural description. As Figure 11 illustrates, TOGAF distinguishes between (i) *Architecture Principles, Vision, and Requirements*, (ii) the *four EA Layers*, and (iii) *Architecture Realization*. While (i) defines the overall rationale behind the EA program and defines general requirements towards the EA initiative and (iii) encompasses necessary capabilities and EA governance, (ii) provides an overview of the central elements the architectural description shall contain (see middle of Figure 11). The *Business Architecture* defines organizational drivers, goals, or measures, describes the organizational structure, and delineates services, business functions, or business processes the enterprise offers or utilizes. Further, it identifies external and internal actors and roles. The *Information Systems Architecture* encapsulates both the *Data Architecture* and *Application Architecture*. While the former structures the data used by the enterprise and their physical representation, the latter analyzes and designs the enterprise's IS landscape. Finally, the *Technology Architecture* represents the physical infrastructure components (e.g., network nodes) that store the organizational data and, on which the software components are installed. In summary, the content framework provides the conceptual basis for modeling the architecture representation.

THE ARCHITECTURE DEVELOPMENT METHOD. The ADM defines an iterative approach to design and develop an enterprise's EA. In total, it defines ten ADM phases. TOGAF defines the "AS-IS" EA as the "baseline architecture" and refers to the "TO-BE" EA as the "target" architecture. Figure 12 provides an overview of these phases and how they are interrelated (The Open Group 2011). First, the preliminary phase establishes the capabilities desired for the EA initiative. Then, Phase (A) develops a high-level vision of the business value the initiative shall deliver. The Phases (B) – (D) concern the development of the several EA layers. Therefore, they develop a baseline and (later on in the process) target architecture. Regarding the latter, each phase identifies candidate roadmap components based on a gap analysis between the baseline and target state. Phase (E) concerns the iterative development of an architecture roadmap based upon previous results. This roadmap in input of Phase (F) that implements identified changes at the enterprise. While Phase (G) governs the implementation and its conformance with the target architecture, Phase (H) ensures the implementation of an architecture lifecycle. The requirements management accompanies each phase of ADM. It ensures that every activity of the EA initiative is in line with the overall vision from Phase (A).

Each iteration of ADM makes new decisions regarding the breadth, to which the EA covers the enterprise, the architectural description's level of detail, or the time horizon of the target architecture. The remainder of this thesis will primarily address phases A-D as well as the requirements management.

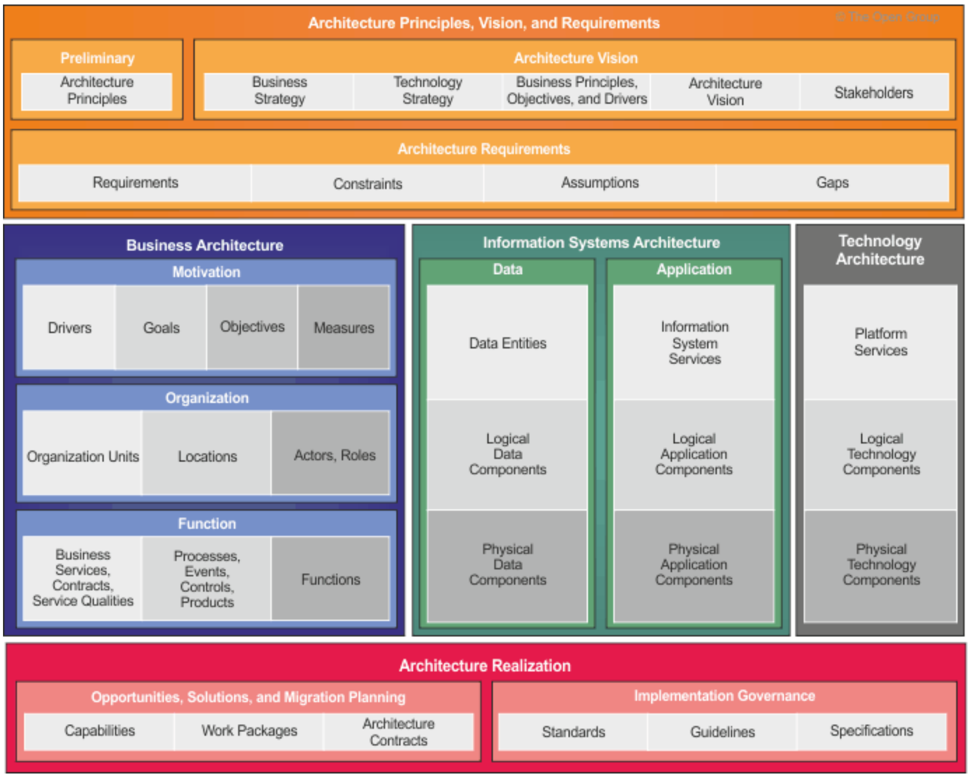


FIGURE 11. THE ARCHITECTURE CONTENT FRAMEWORK (THE OPEN GROUP 2011)

3.1.4 ENTERPRISE MODELING IN THE CONTEXT OF EAM

Although EA frameworks guide how to structure an EA, they usually do not provide concrete concepts for developing the actual architectural description (Lankhorst et al. 2017, p. 22). This section gives an overview of general modeling activities required to gather the relevant information for developing architectural descriptions. Afterward, it gives an overview of *ArchiMate*. Based on TOGAF's Content Framework, ArchiMate is a widely-accepted modeling notation for developing architectural description and, thus, fits the purpose to introduce enterprise modeling in the context of EA development. Moreover, EA models presented in the remainder of this thesis use ArchiMate for the representing EA models.

3.1.4.1 MODELING ENTERPRISE ARCHITECTURES

Figure 13 provides a comprehensive overview of the overall EA modeling process. The left-hand-side shows enterprise architects that develop EA models based on existing partial models (e.g., process models or entity-relationship models), logs from IT systems of the enterprise, relevant documents (e.g., process documentation or forms), or interviews with domain experts from the organization. The several EA stakeholders with their various concerns have a particular viewpoint on that EA model. EA model views instantiate these viewpoints. Enterprise architects communicate them to the stakeholders by using these models themselves (i.e., stakeholders have access to the EA modeling tool), generated reports, presentation slides, dashboards, or EA steering meetings (Lankhorst et al. 2017). As EAs are always subject to change, stakeholders such as chief information officers may have specific questions that concern the analysis of the enterprise's current architectural state. Thus, dedicated EA analysis methods exist that measure the current state regarding predefined performance measures.

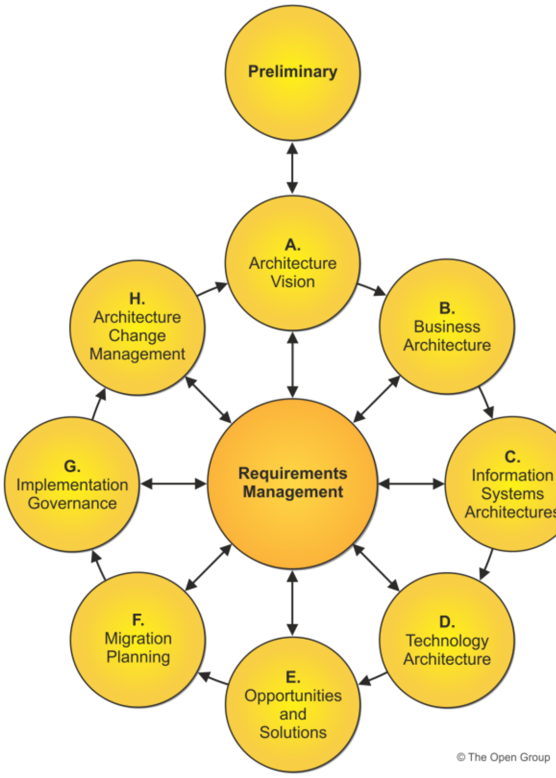


FIGURE 12. THE ARCHITECTURE DEVELOPMENT METHOD (THE OPEN GROUP 2011)

Although that analysis aspect of EAs in essential for any successful EA initiative, in primarily concerns individual EA initiatives. Thus, it is not the scope of this thesis. The author refers to the work of Lankhorst et al. (2017, pp. 215–252) and Lantow et al. (2016) for more information in that regard. The remainder of this section will discuss the aspects of the modeling process itself. Next to techniques from knowledge elicitation regarding EA Model development, it discusses general guidelines literature gives when developing EA models. Afterward, section 3.1.4.2 presents how ArchiMate structures EA models.

The author of this thesis points out that almost any technique for knowledge elicitation from the research domain of enterprise modeling can be applied for EA modeling activities as well. Thus, the author refers to the literature that is established in that area of research (Sandkuhl et al. 2014; Vernadat 2002). Furthermore, research methods such as expert interviews, surveys, document analysis, or focus groups are appropriate means for conducting EA modeling, as well (see section 2.2.4).

In the concrete context of modeling EAs, Lankhorst et al. (2017, pp. 59–72) systemize modeling elicitation depending on knowledge goals and conversation techniques. *Knowledge goals* relate to the different classes of knowledge relevant during EA modeling conversations. The authors identify three classes of knowledge goals:

- **Introduction of knowledge:** It refers to situations that introduce or create new knowledge in the EA development community. These goals apply to domains that have not been covered by the EA initiative.
- **Agreement to knowledge**: This class refers to situations in which the different EA stakeholders shall achieve and validate mutual agreement. These goals often occur during the several iterations of EA modeling.
- **Commitment to knowledge**: Beyond the stakeholders' agreement about knowledge covered by the EA model, this class of knowledge goals intends that stakeholders are willing to act upon the knowledge they agreed on. That often occurs when implementing means of the roadmap to arrive at the "TO-BE" state.

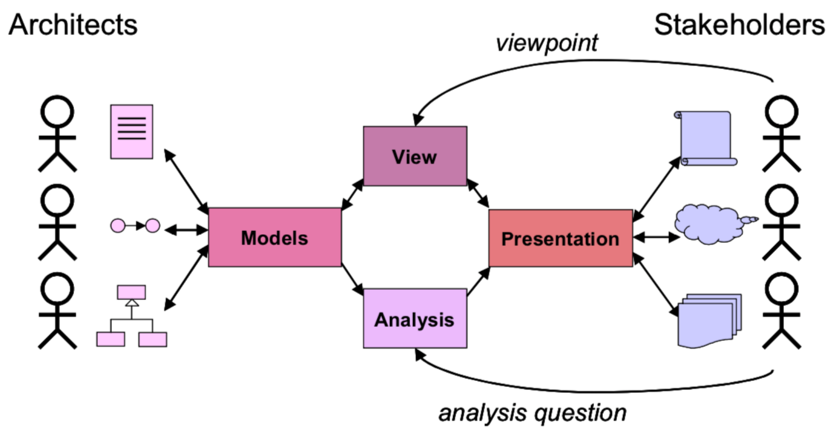


FIGURE 13. MODELING AN ENTERPRISE ARCHITECTURE (LANKHORST ET AL. 2017, P. 4)

Conversation techniques define the style of how a conversation is design when communicating or eliciting EA model relevant knowledge. Lankhorst et al. (2017) state the following techniques to be adequate for EA modeling: structured brainstorm-like group sessions, elicitation interviews, workshops, validation interviews, committing reviews (stakeholders select from alternative solutions), presentation, and mailing. Table 7 gives an overview of how adequate conversation techniques are depending on the knowledge goals. Lankhorst et al. (2017) systemize these based on experiences shared by EAM practitioners. A "+" indicates that a particular conversation class is well suited for the selected techniques of knowledge goals, while "++" indicates that it is particularly well suited. On the other hand, a "–" indicates that a particular conversation technique is ill-suited for the selected class of knowledge goals, while – indicates that it is particularly ill-suited.

One very effective way of eliciting knowledge for EA models are workshops. As Table 7 indicates, workshops help to achieve all three knowledge goals. However, Lankhorst et al. (2017) fail to provide a detailed description of how to conduct such modeling workshops. Therefore, the author of this thesis refers to the approach of *"participative enterprise modeling"* proposed by Stirna et al. (2007). It provides concrete guidelines on how to organize, prepare, and conduct modeling sessions with domain experts. The main characteristics of that approach are that it defines a modeling team that conducts the workshop (moderator, modeling facilitators), its interactivity between knowledge carriers and EA modelers, and increases both the awareness and commitment of EA stakeholders of the EA initiative.

TABLE 7. CONVERSATION TECHNIQUES FOR EA MODELING (LANKHORST ET AL. 2017, P. 71)

CONVERSATION TECHNIQUE	KNOWLEDGE GOAL		
	Introduce	*Agree*	*Commit*
Brainstorm Group Session	++	+	-
Elicitation Interview	++	+	-
Workshop	+	++	+
Validation Interview	-	++	+
Committing Review	-	-	++
Presentation	++	-	-
Mailing	+	-	-

Next to knowledge elicitation, the actual modeling of the EA is an essential task as well. In the context of EA, Lankhorst et al. (2017, pp. 141–170), provide basic guidelines for modeling activities, guidelines for model creation, and guidelines for ensuring EA model readability. Table 8 gives an overview of these guidelines. For more information, the author refers to the respective chapter of the book by Lankhorst et al. (2017) and additional literature on enterprise modeling guidelines (Becker et al. 2012) and quality of models (Krogstie 2012).

TABLE 8. EA MODELING GUIDELINES BASED ON LANKHORST ET AL. (2017)

GUIDELINES FOR EA MODELING		
Types of Modeling Activities	***Modeling Guidelines***	***Readability and Usability of Models***
Establish Purpose, Scope, and Focus	Maxim of (adequate) Quantity	Reduce the visual complexity of Models by dint of proximity, continuity, closure, similarity, common fate
Select one or more EA viewpoints	Maxim of Quality	Define Layout Conventions
Create and Structure the EA Model	Maxim of Relevance	Define Color Conventions
Visualize the EA Model regarding Stakeholders and Concerns	Maxim of Manner (no obscurity, brief, orderly)	Define Symbol Conventions
Communicate the EA Model	Use recognizable concepts and reoccurring structures	Define Text Conventions
Maintain the Model	Define a limited number of abstraction levels	
Basic Modeling Actions: - Introduce elements - Refine elements - Abandon elements - Abstract elements from concepts - Translate an element - Document Modeling Actions	Structuring Models and Visualizations: - Make Model Self-Explanatory - Separate internal and External Behaviour - Use EA Layers - Group by Phase, Product, or Information	

3.1.4.2 ARCHI MATE: AN EA MODELING NOTATION

Based on the EA framework TOGAF, *ArchiMate* is a modeling notation standard defined by The Open Group and is currently available in version 3.1 (The Open Group 2019). In general, it builds from TOGAF's Architecture Content Framework and relates to the four TOGAF EA layers. Likewise to TOGAF, ArchiMate summarizes the data and application layer to one. In contrast to TOGAF, it calls it the "application layer." ArchiMate consists of:

- **ArchiMate Core Framework**: It defines the several architectural perspectives and distinguishes between active, passive, and behavior EA elements on each of them. Next to the core layers business, application, and technology, ArchiMate further defines a strategy, physical, and implementation & migration layer (the thesis does not cover the latter three).

- **ArchiMate Meta Models:** It defines generic and layer-specific meta-models that define EA model element types as well as the possible relationship type among them.

- **Specifications of the ArchiMate layers**: For each of its layers, ArchiMate defines the different element types, possible relationship types, and gives examples. Further, it provides an overview of how (the different element types of) these layers interrelated to each other.

- **ArchiMate Viewpoints:** ArchiMate provides a list of example viewpoints that represent generic standard viewpoints that relate to common stakeholder concerns.

Figure 14 illustrates the core framework of ArchiMate. For each layer, it defines passive, active, and behavior element types. The figure does not reveal the relationships these elements can have. Neither is the list of model elements complete. In total, ArchiMate 3.1 defines 53 model element types and 12 relationship types.

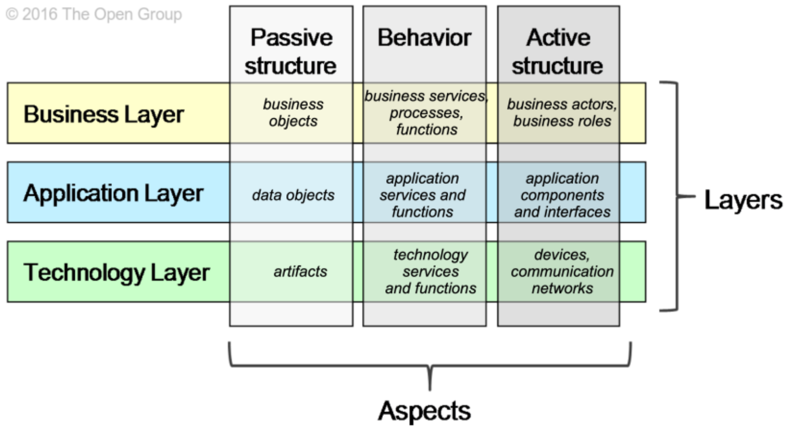
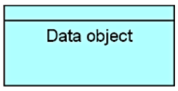
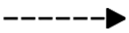
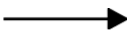
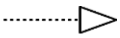
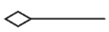


FIGURE 14. ARCHIMATE CORE FRAMEWORK (THE OPEN GROUP 2019)

As a small excerpt, Table 9 defines a set of model elements and relationship types the thesis at hand uses the most. Thus, it instead aims to improve the understandability of the ArchiMate models provided in this work than giving a complete overview of the modeling language.

TABLE 9. EXCERPT OF ARCHIMATE 3.1 ELEMENTS, RELATIONS, AND STANDARD VIEWPOINTS

	NOTATION	ELEMENT	DEFINITION
	ARCHIMATE MODEL ELEMENT TYPES		
Business Layer		Business Actor	A business actor represents a business entity that is capable of performing behavior. Business actors may be specific individuals or organizations. *Examples: "John Smith" or "ABC Corporation"*
Business Layer		Business Function	A business function represents a collection of business behavior based on a chosen set of criteria (typically required business resources or competencies), closely aligned to an organization, but not necessarily explicitly governed by the organization. *Examples: customer management or claims administration*
Application Layer		Data Object	A data object represents data structured for automated processing. *Examples: customer record, client database, or insurance claim*
Application Layer		Application Component	An application component represents an encapsulation of application functionality aligned to the implementation structure, which is modular and replaceable. *Examples: "MS Office" or Customer Relationship Management System*
	ARCHIMATE RELATIONSHIP TYPES		
		Flow Relation	The flow relationship represents the transfer from one element to another. The flow relationship is used to model the flow of, for example, information, goods, or money between behavior elements. A flow relationship does not imply a causal relationship.
		Triggering Relation	The triggering relationship represents a temporal or causal relationship between elements. The triggering relationship is used to model the temporal or causal precedence of behavior elements in a process.
		Realization Relation	The realization relationship represents that an entity plays a critical role in the creation, achievement, sustenance, or operation of a more abstract entity.
		Serving Relation	The serving relationship represents that an element provides its functionality to another element. The serving relationship describes how the services or interfaces offered by a behavior or active structure element serve entities in their environment.
		Assignment Relation	The assignment relationship represents the allocation of responsibility, performance of behavior, storage, or execution. It links active structure elements with units of behavior that are performed by them.
		Aggregation Relation	The aggregation relationship represents that an element combines one or more other concepts. Unlike composition, aggregation does not imply an existence dependency between the aggregating and aggregated concepts.
	ARCHIMATE STANDARD VIEWPOINTS		
	Concerns: Domain and Information Architects **Elements:** e.g., Data Object	Information Structure Viewpoint	The information structure viewpoint is comparable to the traditional information models created in the development of almost any information system. It shows the structure of the information used in the enterprise or a specific business process or application, in terms of data types or (object-oriented) class structures. Furthermore, it may show how the information at the business level is represented at the application level in the form of the data structures used there and how these are then mapped onto the underlying technology infrastructure, e.g., by means of a database schema.

NOTATION	ELEMENT	DEFINITION
Concerns: Dependencies between processes, responsibilities **Elements:** e.g., Business Function, Business Actor	Business Process Cooperation Viewpoint	The business process cooperation viewpoint is used to show the relationships of one or more business processes with each other or with their environment. It can be used both to create a high-level design of business processes within their context and to provide an operational manager responsible for one or more such processes with insight into their dependencies.

ArchiMate is a semi-formal modeling notation and can be understood as a grammar language for modeling EA descriptions. That means that while ArchiMate defines a vast number of model elements and relationship types, users are not obligated to use all ArchiMate elements depending on the modeling context. For instance, Figure 15 illustrates an abstract example of an ArchiMate model. As can be seen, it further distinguishes between an internal and external model perspective. While the internal perspective concerns phenomena that occur within the enterprise, the external perspective represents phenomena outside the enterprise. Thus, ArchiMate uses the paradigm of service-oriented architecture (Sweeney 2010). The various ArchiMate layer interact with each other using interfaces and services. However, enterprise architects are not obliged to use all model elements even it would be possible to incorporate them in the EA model. For instance, depending on the modeling context, it may be necessary to define a particular user interface of an application component.

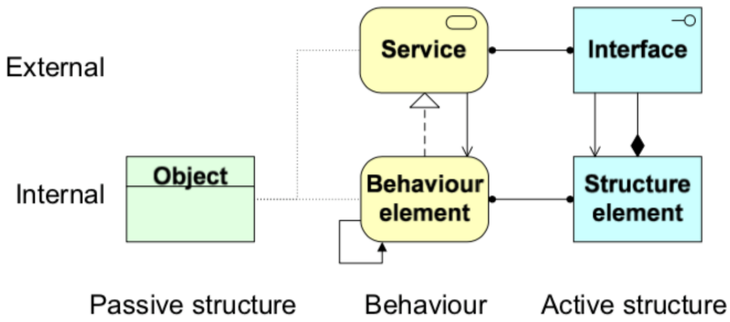


FIGURE 15. CORE CONCEPTS OF ARCHIMATE LANGUAGE (LANKHORST ET AL. 2017, P. 77)

In contrast, in another context, such an interface is not relevant and, thus, may be excluded from the EA model. For a more comprehensive discussion of this optionality—and more practices for modeling with ArchiMate—the author of this works refers to Wierda (2017). Furthermore, the online specification of ArchiMate 3.1[1] provides many modeling examples of the standard viewpoints.

3.2 REFERENCE MODELING

REAM's design builds from widely accepted methods from the reference modeling (RM) research discipline. Thus, this section intends to provide an overview of RM concepts and methods. After section 3.2.1 discusses the author's understanding of the reference model (RM) notion, the remainder of this section introduces different perspectives on method support for RM. While section 3.2.2 explains methods that guide RM construction, section 3.2.3 focuses on methods for applying RMs in practice. Finally, section 3.2.4 presents approaches on how to evaluate RMs.

3.2.1 REFERENCE MODELING RESEARCH DOMAIN

Reference models (RM) are conceptual models that address a particular problem domain and provides a solution for stakeholders of that domain. The RM research domain investigates how to construct, apply, and evaluate RMs. Although this discipline is widely established in ISR and provides numerous approaches for RM construction, there is a lack of a commonly accepted definition of the RM term—

[1] see https://pubs.opengroup.org/architecture/archimate3-doc/toc.html, accessed 2020-05-11.

instead, there exist several definitions as depicted by Fettke and Loos (2006). For instance, Thomas (2005, p. 491) understands an RM as *"an information model used for supporting the construction of other models."* In general, an RM addresses a problem of a particular application class, e.g., a group of enterprises, and provides a reusable solution. The purpose of its development is to be reused in a concrete use case from this application class, usually to improve the effectiveness and efficiency of IS development (Fettke and Loos 2006). In order to define the notion of RMs more precisely, IS research (ISR) discusses RMs' characteristics **universality**, **recommendation,** and **reusability** (Vom Brocke 2006; Schütte 1998; Fettke and Loos 2006):

- **UNIVERSALITY:** A RM does represent a particular enterprise, but a class of domains. Hence, an RM is valid for a class of domains.
- **RECOMMENDATION:** RMs provide a solution for the class of domains. These solutions recommend particular enterprises on how to solve the addressed problem. In this context, RMs serve as default solutions, from which enterprise-specific concretizations can be derived. This default solution may claim to be common (or even best) practices for the problem at hand.
- **REUSABILITY:** RMs are blueprints for IS development. Thus, an RM is a conceptual framework that could be reused in a multitude of IS projects.

While these three characteristics sharpen the concept of RMs, the former two are neither measurable, nor can they be verified by objective reasoning. Consequently, both Thomas (2005) and (Vom Brocke 2006) argue that only the actual application of an RM to an enterprise-specific model and its acceptance within the problem domain defines it. Thomas further distinguishes between an RM that is declared by its developer (e.g., an IS researcher providing an RM for a critical business process in the automotive sector) and an RM that is accepted by practitioners (e.g., automotive manufacturers use the RM). He further claims that only the latter case is a sufficient criteria for the notion of an RM. By implication, declaring a conceptual model as an RM is not sufficient. Figure 16 illustrates this by contrasting models declared as RMs (left circle) and models applied for the construction of enterprise-specific models (right circle). Every model that is part of the latter qualifies as an RM, according to Thomas (2005). That is in line with the understanding of this thesis' author. Consequently, a method for developing reference enterprise architectures (REA) shall produce REAs practitioners accept.

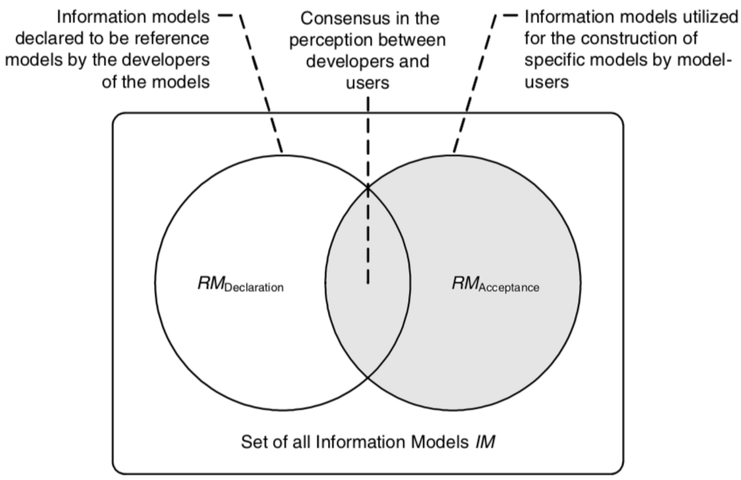


FIGURE 16. REUSABILITY AS A SUFFICIENT CRITERION FOR DETERMINING REFERENCE MODELS

VALUE OF REFERENCE MODELS. In order to justify the effort of RM application, the RM user (e.g., an enterprise) has to understand an RM's value. IS researchers do agree that the primary value of RMs is to make the design and development of IS more efficient and effective (Fettke and Loos 2004c; Schütte 1998). Becker and Knackstedt explicitly state metrics that describe the economic effects RM applications offer from a user perspective: a decrease in costs due to the reusability; a decrease of modeling time for enterprise-specific models; an increase of the model quality; a competitive advantage; and, a decrease in modeling risk since reference models are already validated (Becker and Knackstedt 2003). Other IS researchers agree with these metrics (Fettke and Loos 2006; Schütte 1998).

Despite this consensus, IS research misses to investigate the value of RMs empirically (Fettke 2008). To the knowledge of the author, only two contributions provide a cross-sectional analysis of RM application benefits. Schütte surveyed 22 RM users, and his findings revealed that most RM users applied the RMs primarily for means of cost reduction. Only a minority did so for aspects of proceeds or risk mitigation. In concrete, the majority of RM users stated efficient realization of organizational concepts and the minimization of software lead times as the main reasons for RM application. Interestingly, more than every second RM user stated that they further observed unquantifiable effects. Unfortunately, Schütte did not inquire about them explicitly (Schütte 1998). These findings could imply that both the RM designers and the RM users are not entirely aware of the value an RM can generate.

Fettke (2008) interviewed users of the Supply Chain Operations RM (SCOR(Supply-Chain Council 13/05/20). The basis of his study was the hypothesis that the success of RM depends on RM application. He operationalized these two variables and interviewed 153 enterprises of the Supply Chain Council. He evaluated how the degree of SCOR application influenced the success of supply chain management. To measure success, he used three of the earlier mentioned metrics (i.e., costs, time, and quality) and added flexibility. His findings show that the SCOR model application had a significant positive influence on the success of supply chain management. Further, he concludes that the RM application enhances the effectiveness and efficiency of considered information systems development. Still, his findings are based on cross-sectional data and are yet to be verified by a longitudinal study that analyzes the effects of the SCOR model application in a more extended period in certain use cases.

Based on these findings, one can derive that the application of reference models offers various advantages to the RM user. Nevertheless, there are also disadvantages a user has to be aware of before applying RMs. First, the application of RMs may negate an already existing competitive advantage since competitors can gather the same knowledge. Second, the maintenance and especially the adjustment to an enterprise-specific context can be time- and resource-consuming. Last, the application of a complex RM requires high knowledge (Fettke 2008).

In consequence, Fettke argues that the sole existence of an RM does imply neither its value nor its success. It rather depends on the context in which the RM is applied (Fettke 2008). For example, Hars mentions highly regulated domains as a suitable RM application context (Hars 1994). Therefore, the analysis of an RM's intended value is an essential aspect when developing its application design. Such an analysis and its documentation within the RM may mitigate the risk of a diverse value perception between RM designer and user.

MODELING LANGUAGES FOR RMS. Depending on the addressed problem domain, RMs differ in their form of representation. Hence, RMs differ in modeling languages they use to represent the reusable solution. Consequently, there exists no uniform modeling language for representing RMs. However, literature often uses event-driven process chains (Scheer (1998) for modeling RMs as business process models, entity-relation models (Chen 1977) for modeling RMs for standard data structures, or the unified modeling language (Rumbaugh et al. 1998) for RMs that address software engineering.

Nevertheless, the author of this work argues that any language for developing enterprise models may be appropriate when constructing an RM—if the problem domain demands it. For instance, the problem investigation of this thesis reveals that the typical approach of developing reference process models lacks the holistic lens on enterprise's business and IT alignment in a changing business environment. While the vast body of knowledge of the RM research domain provides general guidelines how to construct and apply RMs (see next section), the author claims that they lack preciseness when it comes to developing RMs that aim for specific IS model structures (such as RMs with the structure of EA, see section 3.1). As the KBA in section 4.3 shows, there is an absence of approaches that specifically provide guidelines to develop REAs. As this thesis proposes such an approach, it builds from accepted methods for RM construction, application, and evaluation. The next section summarizes the RM research domain in that regard.

3.2.2 CONSTRUCTION METHODS FOR REFERENCE MODELING

From a life cycle perspective on RMs, IS research distinguishes between the phases of **RM construction** and **RM application** (Fettke and Loos 2006). During RM construction, the RM is developed and prepared for its application by the RM designer. In the application phase, the RM user applies the model to his or her particular use case. This section discusses methods for constructing RMs. Section 3.2.3 presents available approaches for applying RM. For constructing RMs, research discusses two generic strategies. While the deductive approaches derive RMs from generally accepted knowledge, the inductive approaches abstract RMs from individual models to agree on a shared understanding within the RM (Becker and Schütte 1997). Most established RMs have been developed based on deductive approaches (Ardalani et al. 2013). However, inductive RM provides potential because more and more relevant data in terms of logs and concrete information models of organizations are available. Further, inductively developed RMs tend to have a higher degree of detail, are more mature, and seem to be more accepted when it comes to RM application (Rehse et al. 2016). In the following, section 3.2.2.1 presents two methods for conducting deductive RM, while section 3.2.2.2 provides an overview of recent approaches to inductive RM.

3.2.2.1 DEDUCTIVE REFERENCE MODELING

The RM research domain provides numerous methods for RM construction. Fettke and Loos (2004c, p. 17) provide an overview of existing approaches. While some approaches focus on developing certain RM types that concern application mechanisms of the RM at design time—such as configurable reference process models (Becker et al. 2002) or adaptive RM (Delfmann 2006)—others provide more generic methods, e.g., Schütte (1998). For developing REAM, the author primarily used two RM construction approaches as a basis. First, the cyclic procedure model by Schütte (1998) provides a widely-accepted approach that helps to identify general steps when constructing RMs. Second, the method for configurative RM proposed by (Becker et al. 2002) represented the basis for the first version of REAM. The following paragraphs briefly explain them. For a more thorough understanding the author refers to the respective articles.

PROCEDURE MODEL FOR RM CONSTRUCTION BY SCHÜTTE

Schütte (1998) defines a cyclic procedure model, which comprises of five phases: *(i) problem definition*, *(ii) model frame construction*, *(iii) model structure construction*, *(iv) model completion,* and *(v) application*. Figure 17 illustrates the procedure model. The several phases are presenting in the following.

PHASE 1: PROBLEM DEFINITION. The initial phase of the procedure model aims to clarify the concrete objective of the RM. Schütte emphasizes that one shall clarify whether the problem is relevant to the potential users. Therefore, he recommends to investigate the problem domain from different angles and to consult various problem stakeholders. That includes a characterization of the problem domain by delineating the class of organizations addressed by the RM (e.g., define the industry) and related stakeholder groups. Further, this phase clarifies who will construct the RM, i.e., sets up an RM team.

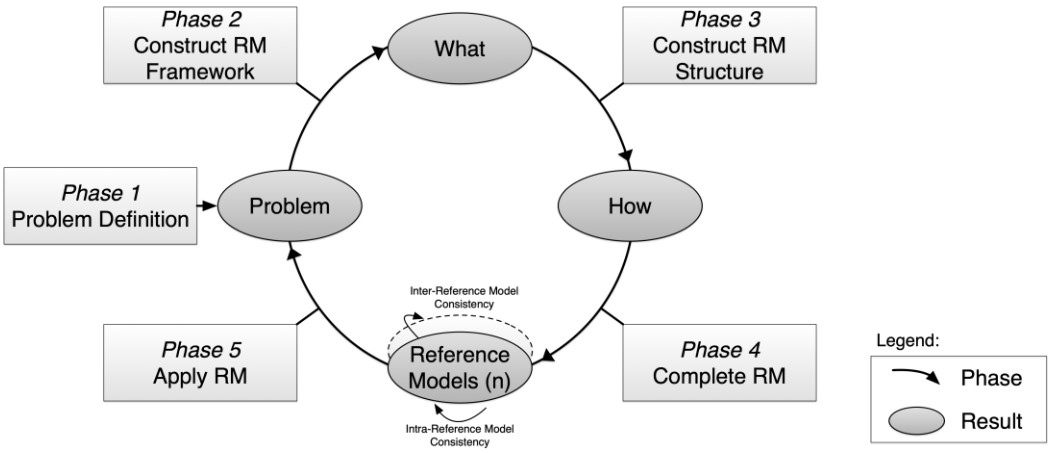


FIGURE 17. RM CONSTRUCTION PROCESS BY SCHÜTTE (1998)

PHASE 2: CONSTRUCT RM FRAMEWORK. The overall objective of the second phase is to define a framework that dictates the subsequent RM construction process. Therefore, Schütte asks the question *"What?"* to include in the envisioned RM. It includes domain-specific and model-specific aspects. From a domain-specific perspective, one shall identify characteristics and their possible values based on the peculiarities of the problem domain. These characteristics help problem stakeholders to apply the resulting RM to their organizational specifics. From the model-specific perspective, phase 2 aims to identify appropriate IS models for addressing the problem domain. For instance, one shall clarify whether either business process models, entity-relationship models, or both are necessary. Schütte recommends to define a "master reference model" that structures this. Here, meta-models of selected model types may be helpful in order to identify model elements and relations the envisioned RM should use.

PHASE 3: CONSTRUCT RM STRUCTURE. This phase fills the RM framework with content. Therefore, Schütte discusses two concrete perspectives: the business process perspective and the data model perspective. After agreeing on an adequate abstraction level of the RM content, both the process and the data perspective evolve separately. Although Schütte does not explicitly state how to acquire the necessary knowledge for this phase, the author of this work understands that he uses a deductive approach for knowledge elicitation. After constructing the several RM perspectives, Schütte further recommends to evaluate the resulting models together with domain experts.

PHASE 4: COMPLETE RM. This phase integrates the RM perspectives the previous phase developed. Schütte requires the RM team to investigate the consistency between the elements within each RM perspective (intra) as well as among the different perspectives (inter). The latter includes naming conventions, but primarily aims to identify relations across the different perspectives. Consequently, this phase results in a consistent RM. Depending on the problem specification, one may enrich the RM with quantitative parameters that help support benchmarking the RM.

PHASE 5: APPLY RM. Schütte acknowledges that the literature does not rigorously cover RM application despite its relevance. However, he does not provide an approach on how to apply RMs. Nevertheless, he discusses different scenarios why problem stakeholders may intend to use an RM. He states that stakeholders use RMs to analyze and improve their organizational structures or apply an RM for constructing enterprise-specific models. For the latter, stakeholders may use configuration mechanisms, which the RM incorporates in its design, or manually adapt the RM to their organizational specifics. After the application of an RM, the cyclic character of Schütte's procedure becomes apparent as insights from the RM application might trigger an alteration of the RM or provides useful feedback for improving it.

CONFIGURATIVE REFERENCE MODELING BY BECKER ET AL.

This approach proposed by Becker et al. (2002) addresses the RM's dilemma among general validity and effort of adjustments. On the one hand, RMs aim to provide globally valid recommendations towards an abstract user group of the problem domain, e.g., a specific industry. On the other hand, a particular RM user adjusts the RM to its specific organizational demands. Consequently, RM users intend to have as few adjustments efforts as possible. In contrast, an RM tries to address the most extensive user group possible.

Becker et al. (2002) propose to solve this conflict by developing configurative RMs. Configurative RMs define rules that determine model adjustments depending on the user enterprise's characteristics. Each value of predefined configuration parameters triggers the instantiation of an appropriate model variant in a certain point of the RM. According to (Becker et al. 2002), configuration parameters are either the enterprise's characteristics (e.g., size) or perspectives on the resulting EA. The process for developing a CRM comprises five phases shorty presented in the following. Figure 18 illustrates it.

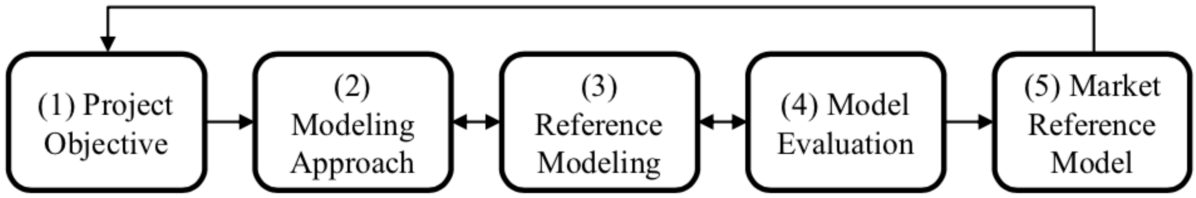


FIGURE 18. CONFIGURATIVE REFERENCE MODELING (BECKER AND KNACKSTEDT 2003)

PHASE 1: PROJECT OBJECTIVE. Likewise to the equivalent phase of Schütte's procedure, the first phase narrows down the RM's scope by clarifying the problem at hand. Although the modeling scope usually is discussed before, it is made explicit in Phase 1. Initially, a broadened view is conceived. For the chosen branch of industry, three aspects are considered:

- To determine which *business units* to cover by the final RM
- To define the relevant *attributes of enterprises* and their possible values in the industry
- To elaborate on *perspectives* that represent different users' views on the model. Becker et al. (2002) distinguish among the dimensions of roles (Zachman 2015), purposes (Frank 1994), and others (e.g., personal competence).

A demand analysis narrows down this broadened view on the problem. It investigates the three aspects and includes a market analysis for existing RMs, relevant enterprises, perspectives, and requirements. The outcome of Phase 1 is a description of the project's objective.

PHASE 2: MODELING APPROACH. The second phase determines the grounded methodology for developing the RM. According to Becker et al. (2002), the modeling approach depends on the modeling project and thus is specific for each project. Further, the modeling approach can build on existing modeling methods like business process modeling. Becker et al. (2002) split the modeling approach into methodical and content-related components. The methodical perspective comprises of RM concepts, their representation, and guidelines for constructing them. By dint of meta-modeling, the concepts are interrelated among each other. Contentwise, Becker et al. distinguish between three components, which differ in their level of detail. The *model framework* structures the relevant system of the RM by functional and content-related aspects. For instance, core, supporting, and management processes, as well as the enterprise's environment, can be categorized employing several elements in a value chain. Each element from the model framework links to *refinement models*, which represent these elements in more detail by dint of specific modeling methods like BPMN[1] or ERM (Chen 1977). Iterative refinement is possible. Within these refinement models, *rules for configuration* are defined. The rules determine how the RM is modified depending on chosen variables like attributes of the enterprises (see Phase 1). By specific adjustment points, the rules for configuration are linked to the models.

PHASE 3: REFERENCE MODELING. This phase applies the modeling approach to the defined problem context. The identified business units from Phase 1 serve as a basis for the development of the model framework, while the perspectives and enterprise characteristics determine the rules of configuration. Meta-models from Phase 2 serve to check the models' formal validity. Becker et al. (2002) recommend two alternatives for the acquisition of knowledge to develop the RM:

(a) existing enterprise-specific models, which can be analyzed, combine and generalized (may need to be externalized by dint of interviews, surveys or observations)

(b) analyzing literature for relevant findings in the problem context

Further, the modeling process usually applies a top-down approach (deduction). Still, the bottom-up modeling processes can help during the development (induction), if detailed models require changes in the model framework.

PHASE 4: EVALUATE MODEL. Becker et al. understand the evaluation phase as an integrated part of model development in Phase 3. Creating new versions of refinement models or the model framework requires formal and content-related evaluation within the modeling process. Checking the alignment between produced models and the prior defined meta-models ensures formal validity. Expert interviews evaluate the content-related validity of the RM. Further, the models need to be analyzed in terms of consistency regarding the defined glossary. Still, Becker et al. stress to audit the resulting complete RM. They propose to apply it to several scenarios—at best to a Becker et al. (2002) real-world customer. Since not every evaluation case will trigger all possible configurations of the model, they recommend a higher amount of use cases. According to the authors, each evaluation use case shall investigate three different types of model dependencies:

- *Configuration*: Checks whether configuration rules provide appropriate model variants depending on the value of the use case's attributes.
- *Function*: Checks content-related consistency within model variants.
- *Domain Knowledge*: Checks modeling guidelines and created hypotheses by third parties in order to ensure applicability to the whole industry from Phase 1.

PHASE 5: MARKET REFERENCE MODEL. The method also defines a fifth phase, which intends to address the marketing of the developed RM. Becker et al. describe how to implement the Four P's of marketing proposed by McCarthy and Perreault (1987): Product, Price, Promotion, and Placement.

3.2.2.2 INDUCTIVE REFERENCE MODELING

While deductive RM derives RMs from commonly-accepted knowledge, inductive RM identifies commonalities in a set of enterprise-specific models and derives an RM by using (semi-)automated mining techniques (Rehse and Fettke 2019, p. 12). Inductive RM exploits the fact that organizations process an increasing amount of IS logs and produce enterprise models on their own. Thus, inductive RMs provide a higher degree of detail, are more mature, and seem to be more accepted when it comes to RM application (Rehse et al. 2016; Ardalani et al. 2013; Fettke 2014).

[1] cf. http://www.omg.org/spec/BPMN/2.0/

However, inductive RM includes the challenges to detect commonalities of organization-specific IS models, their abstraction to the degree that applies to the envision problem domain, and integrating them in a coherent reference model. Recent efforts in the RM research domain build from insights of different ISR fields, such as graph theory, process mining, or natural language processing, in order to accomplish these challenges (Rehse et al. 2016). The current body of knowledge offers different abstraction techniques that describe how to derive the RM content inductively. While the majority of these approaches aim to identify a common practice within the available individual models, some also claim to identify best practices (Scholta et al. 2019). Further, research provides general inductive RM methods that guide RM constructors when conducting inductive RM.

However, the majority of research in this field focuses on the inductive development of reference process models. Thus, they are not directly transferable to the inductive development of REAs (Timm et al. 2018b).

In order to provide general insights into inductive RM, the remainder of this section presents the method by Fettke (2014). This method describes seven phases one shall follow for inductive RM. The artifact of this thesis, REAM, refers to these phases for inductively developing REAs (see section 6.5.4).

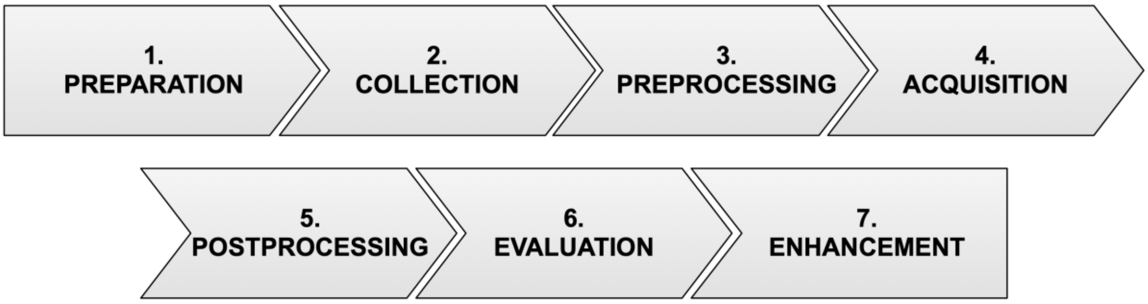


FIGURE 19. PHASES OF INDUCTIVE REFERENCE MODELING (FETTKE 2014)

Figure 19 gives an overview of the seven phases that Fettke (2014) proposes for conducting inductive RM. He defines each phase as follows:

1. **PREPARATION.** Likewise to the deductive construction methods by Schütte (1998) and Becker et al. (2002), the first phase prepares the RM construction. Therefore, the RM's overall objective, related requirements, and underlying modeling conventions shall be defined. Fettke suggest to conduct stakeholder interviews, literature analysis, and the investigation of existing RMs. Further, this phase includes choosing an adequate modeling notation.

2. **COLLECTION.** The second phase aims to collect the several enterprise-specific models. Based on the RM's objective, this phase determines the class of organizations that apply to the problem domain. For instance, this may be potential RM user organizations. Afterward, the RM user defines a representative sample of that class. Therefore, one needs to assess both the access to individual models and the effort to do so. The following collection of individual models may apply any known method for eliciting enterprise models, e.g., participative enterprise modeling (Stirna et al. 2007; Sandkuhl et al. 2014). If available, already existing enterprise models within the various organizations help to decrease the effort of this phase. The results of this phase is a set of individual models from organizations of a particular domain class.

3. **PREPROCESSING**. Before deriving an RM from the set of individual models, this phase harmonizes them regarding the modeling notation and conventions defined in the first phase. That is important, if the previous phase collected enterprise models that already existed and did not match the RM modeling notation. Furthermore, Fettke suggests to analyze the set of models regarding model synsets. These refer to model parts that address the same phenomena. In the end, phase 3 results in a homogenous set of individual models.

4. **ACQUISTION**. This phase derives an RM from the homogenous individual models. Therefore, Fettke distinguishes between two activities: clustering and RM derivation. The former aims to cluster similar individual models into different clusters. For forming clusters, Fettke refers to similarity measure for the modeling notation chosen in phase 1. The latter activity aims actually to derive the RM. Therefore, the RM constructor needs to choose adequate abstraction techniques that identify commonalities within the set of individual models and decides whether or not to integrate these into the RM. As stated earlier, this is a central step of inductive RM. Thus, the chosen abstraction techniques must fit the RM objective. For instance, the majority of available approaches do not provide sufficient means to identify best practice RMs. Section 6.5.4 provides an overview of existing abstraction techniques. Further, Timm et al. (2018b) compare existing approaches regarding their applicability towards REAs. According to Fettke, this phase results in a "*raw RM*."
5. **POSTPROCESSING**. This phase aims to manually post-process the "raw RM" due to the (semi-) automated character of the RM derivation. While there are many possibilities to enhance the "raw RM," Fettke emphasizes two aspects. First, the applied abstraction technique may have eliminated meaningful relationships among RM elements. Second, RM constructors may complement the RM with additional knowledge that evolved by deductive methods, e.g., from expert interviews of related literature. This phase results in a final RM.
6. **EVALUATION**. This phase's objective is to evaluate the final RM regarding its fit to the initial RM objective and other properties, such as completeness or syntactical correctness. Fettke refers to existing approaches for evaluating RMs (see section 3.2.4). He emphasizes the need to involve practitioners and domain experts in this process.
7. **ENHANCEMENT**. Once constructed, the RM shall be maintained continuously. The insights from the evaluation phase, developments of the problem domain, and findings from the RM application may trigger the enhancement of the RM. In the context of inductive RM, this also includes the collection of additional individual models.

With these phases, Fettke (2014) provides a first general approach that guides the inductive development of RMs. However, the method leaves several questions unanswered. First, Fettke does not discuss, in which context an iterative approach to RM is feasible and when one shall prefer it to deductive approaches. Second, the second phase is vague regarding techniques on how to collect individual models. Although this phase is essential for the resulting RM's quality, it lacks providing means that minimize the collection effort or improve the comparability between collected individual models. For instance, what steps shall one follow if there exist no enterprise-specific models and who shall participate in the elicitation effort of individual models? Third, the acquisition phase is not precise, either. There may exist some situations in which particular abstraction techniques fit best. Unfortunately, the method only refers to an abstraction parameter α and a configuration parameter β without defining them. Finally, the author of this work claims that a concrete instantiation of the method depends on the chosen modeling language the RM uses. The inductive development of an REA may require a different toolset and concrete steps than developing reference process models.

A recent approach for inductive RM development—Situational RM Mining (S-RMM)—addresses some of these remarks (Rehse and Fettke 2019). It integrates the approach by Vom Brocke (2006), who distinguishes between RM with reuse (RM application) and RM for reuse (RM construction) and defines design principles for both (see section 3.2.3). Together with a procedure model, S-RMM provides more guidance on how to proceed when inductively constructing RMs. S-RMM first analyzes the situational context of the RM and derives essential design principles from it (right-hand-side of Figure 20). After analyzing further requirements towards the RM, S-RMM suggest matching abstraction techniques for acquiring the RM. Only afterward, the individual input models are elicited. However, the S-RMM still lacks clear guidance for individual model collection and focuses on business process models.

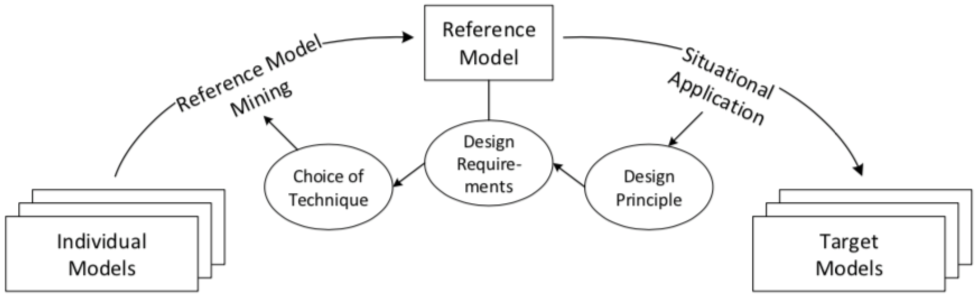


FIGURE 20. MAIN IDEA BEHIND S-RMM (REHSE AND FETTKE 2019)

3.2.3 APPLICATION METHODS FOR REFERENCE MODELING

The majority of research activities in the domain of RM focuses on RM construction, while research regarding RM application is scarce (Fettke and Loos 2004c). Nevertheless, few methodological works exist.

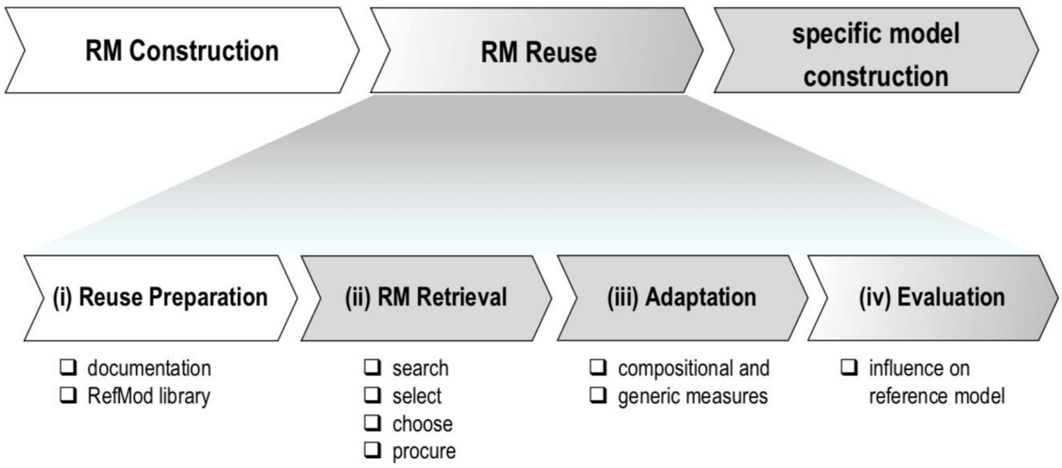


FIGURE 21. RM APPLICATION BASED ON FETTKE AND LOOS (2002A)

Fettke and Loos suggest a procedural model that they attach between the construction and application process and name it “reuse.” As Figure 21 illustrates, the main processes therein are: (i) design of RM reusability, during which the designer makes the RM accessible; *(ii) RM retrieval*, during which the user searches, selects and procures the RM; *(iii) RM adjustment*, where the user might change the RM for his or her specifics; and, *(iv) evaluation*, where both designer and user change feedback of the process, such as problems or experiences. To support the procedure of reuse, the authors characterize RMs by static means: model type, perspective on structure or behavior, and modeling language (Fettke and Loos 2002a).

Based on his procedure for RM construction (see section 3.2.2.1), Schütte (1998) describes how to apply RMs in two different application scenarios from the perspective of the RM user. It requires an RM already prepared for application. Thus, it may help after the reuse procedure from Fettke and Loos. Becker and Knackstedt (2003) provide a procedure model for the application of configurative RM’s (Becker et al. 2002).

DESIGN PRINCIPLES OF REFERENCE MODELS. (Vom Brocke 2006) provides an approach that further concretizes how to incorporate RM application into the construction process of an RM. He defines five design principles for both RM construction and application. From the perspective of the RM user, such principles support the RM adjustment during its application. They represent techniques that help RM users to adjust the RM to their organizational specifics. The method for REA development applies this approach and refers to these principles as *"Adjustment Mechanisms"* (see Table 36 in section 6.2.4). Figure 22 gives a short overview of the five principles that vom Brocke defines. The design principle of configuration relates to the mechanism proposed by configurative RM (Becker et al. 2002).

While the author of this thesis refers to the original article by von Brocke for a comprehensive explanation of the several principles, it is worth mentioning that the effort of integrating the principles in an RM declines in the same order they are enumerated by Figure 22. However, the effort necessary for RM users when using these principles for making adjustments increases in the same order. For instance, the effort for constructing RMs using the configuration principle is very high, while RM users can simply follow these configuration rules when applying the RM. The opposite applies to the analogy principle.

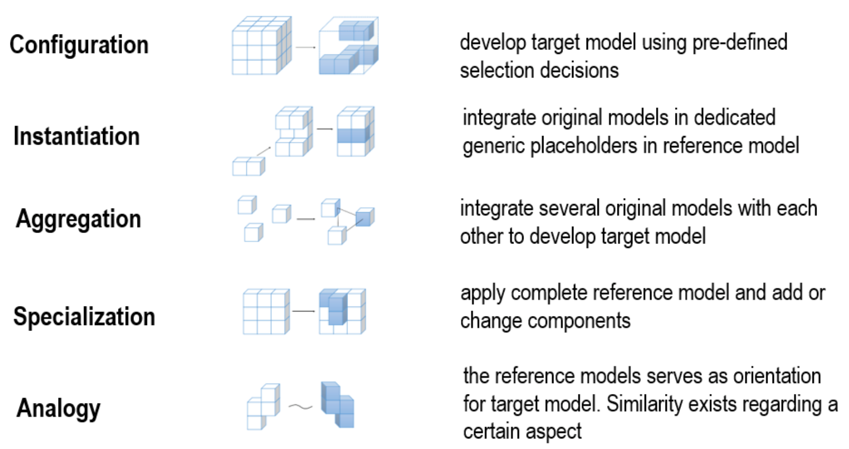


FIGURE 22. DESIGN PRINCIPLES FOR RMS (VOM BROCKE 2006)

Wolf argues that it is hardly possible to develop scientific methods for RM application. He understands it as a communication task between the RM designer and user, who may not instantly comprehend the RM's value (Wolf 2001). Thus, he suggests documenting the intention, context, the addressed problem, and the suggested value. That is in line with the prior depicted argument that the RM application is context-dependent. The author of this work concludes that this may take place in the application preparation of an RM. In line with Wolf, the author argues that it is vital for both the RM designer and the RM user to explicate possible application scenarios (Wolf 2001). Analyzing related literature, the author identified typical application scenarios presented in Table 10. They provide a basis for application scenarios REAM proposes for preparing the application of REAs (see section 6.6.1).

TABLE 10. OVERVIEW OF APPLICATION SCENARIOS FOUND IN THE RM LITERATURE

APPLICATION SCENARIO	DESCRIPTION	SOURCE
Construction of Specific Models	RM user develops a specific model	(Fettke and Loos 2004a; Fettke 2008; Schütte 1998)
IS Development	RM as a development framework	(Fettke and Loos 2006; Fettke 2008; Fettke and Loos 2004a; Höhnel et al. 2006; Becker and Knackstedt 2003)
Consultancy	RM as a consulting artifact	(Fettke 2008)
Knowledge Transfer	RM as means for training	(Fettke 2008; Becker and Knackstedt 2003)
Analysis	RM used to evaluate models.	(Fettke and Loos 2004a; Becker and Knackstedt 2003; Schütte 1998)
Software Procurement	RM support procurement decisions.	(Fettke and Loos 2004a; Höhnel et al. 2006)
Migration Support	RM support migration processes.	(Höhnel et al. 2006)

3.2.4 EVALUATING REFERENCE MODELS

The output of ISR regarding the evaluation of RMs is scarce. Frank (2006a) states that evaluating RMs is an essential and challenging task. Being a specific type of conceptual model, RMs further refer to the claim of reusability and intend to provide economic benefits, which complicates the evaluation effort. As a starting point for evaluating RMs, Frank (2006a, pp. 119–122) therefore refers to evaluation approaches from conceptual modeling (Moody and Shanks 1994; Krogstie 1998; Schütte and Rotthowe 1998) and modeling languages (Lindland et al. 1994; Weber et al. 1997).

While mentioning that a complete objective RM evaluation is hardly feasible, Frank (2006a) proposes a multi-perspective framework to evaluate RMs. Using different perspectives, he aims to foster a more differentiated and balanced judgment of an RM. In concrete, Frank defines the four main perspectives *economic*, *deployment*, *engineering*, and *epistemological*. For each perspective, he identifies evaluation criteria and discusses their importance for evaluating RMs in comparison to conceptual models. Frank emphasizes that this border is somewhat fuzzy and that RM evaluation further depends on the RM's structure (e.g., business process model, EA). The following list summarizes the perspectives' foci presents selected evaluation criteria groups. For additional information (e.g., concrete criteria), the author of this work refers to Frank (2006a).

ECONOMIC PERSPECTIVE. The economic perspective addresses costs and benefits related to the RM application. It primarily addresses a user-oriented perspective, while one could argue that the construction of RM has to meet economic requirements as well. Frank defines three types of users: users that use the RM to develop IS, users that use it for documentation purposes, and users that use it for strategic issues. For this economic perspective, the discusses three main categories: costs (e.g., introductions costs or adjustment costs), benefits (e.g., flexibility or efficiency), and protection of investment.

DEPLOYMENT PERSPECTIVE. The deployment perspective focuses on criteria relevant for those who work with the RM. It concerns the ability and willingness of the RM user and discusses the RM's understandability (e.g., level of detail), appropriateness (e.g., adequate use of known concepts), and attitude (e.g., cultural barriers).

ENGINEERING PERSPECTIVE. The engineering perspective evaluates the RM as a design artifact that has to satisfy a prior defined specification. It concerns the RM's requirement fulfillment and its fit to the intended RM purpose. Frank defines four main aspects: definition (of intended application domains and purposes), explanation (e.g., design rationales, documentation of requirements fulfillment), language features (e.g., level of formalization or supported views), and model features (e.g., correctness or modularization).

EPISTEMOLOGICAL PERSPECTIVE. The epistemological perspective addresses the RM as the output of scientific research. Thus, it focuses on the scientific method applied for RM development. Frank defines four interrelated aspects: evaluation of theories (e.g., core concepts and their real-world correspondence, underlying assumptions), general scientific principles (e.g., abstraction or originality), critical reflection of human judgment (e.g., bias through modeling language familiarity), and reconstruction of scientific progress (e.g., comparison with alternatives).

The author of this work acknowledges that these four RM evaluation perspectives provide a thorough basis for evaluating any type of RM. To complement the evaluation framework with guidance on how to approach RM evaluation, Frank (2006a, p. 137) provides a generic process for conducting RM evaluation. Figure 23 illustrates the five stages of conducting RM evaluation. The process starts with a strategic analysis of the RM's user, i.e., the enterprise that applies it. This analysis aims at anticipating the RM's effect on the enterprise's competitiveness in terms of, e.g., cost reduction, change capabilities. If the user expects a benefit, the second step specifies particular requirements for the RM evaluation that are project-specific. Afterward, the third step selects concrete evaluation criteria from the different generic evaluation criteria from the four evaluation perspectives. It includes choosing the appropriate participants and means to conduct the evaluation. Step four conducts the evaluation. The final step integrates the evaluation results with each other in order to achieve a balanced evaluation.

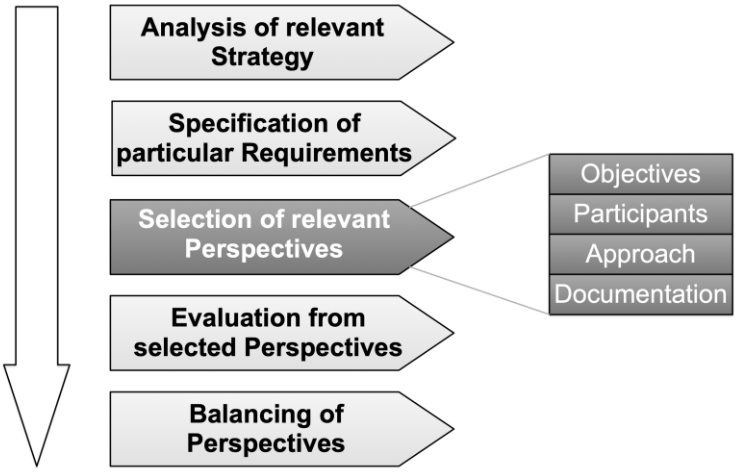


FIGURE 23. A GENERIC PROCESS MODEL FOR RM EVALUATION (FRANK 2006A)

While Frank (2006a) provides a comprehensive overview of aspects to consider when evaluating RMs, his approach lacks describing what evaluation methods to apply when conducting the actual evaluation. Therefore, Fettke and Loos (2003) provide a multiperspective RM evaluation framework. It relates appropriate research methods for RM evaluation with the approach of how criteria have been chosen. Figure 24 illustrates the framework. The authors distinguish between criteria derived from theory and criteria that are specific to a particular evaluation case (left-hand-side). One could argue that theory-driven criteria correspond to Frank's four perspectives, while ad-hoc criteria relate to the second step of Figure 23. Further, they identify both empirical and analytical methods suitable for conducting RM evaluation. The remainder of this work uses both approaches as a basis for defining the evaluation of REAs.

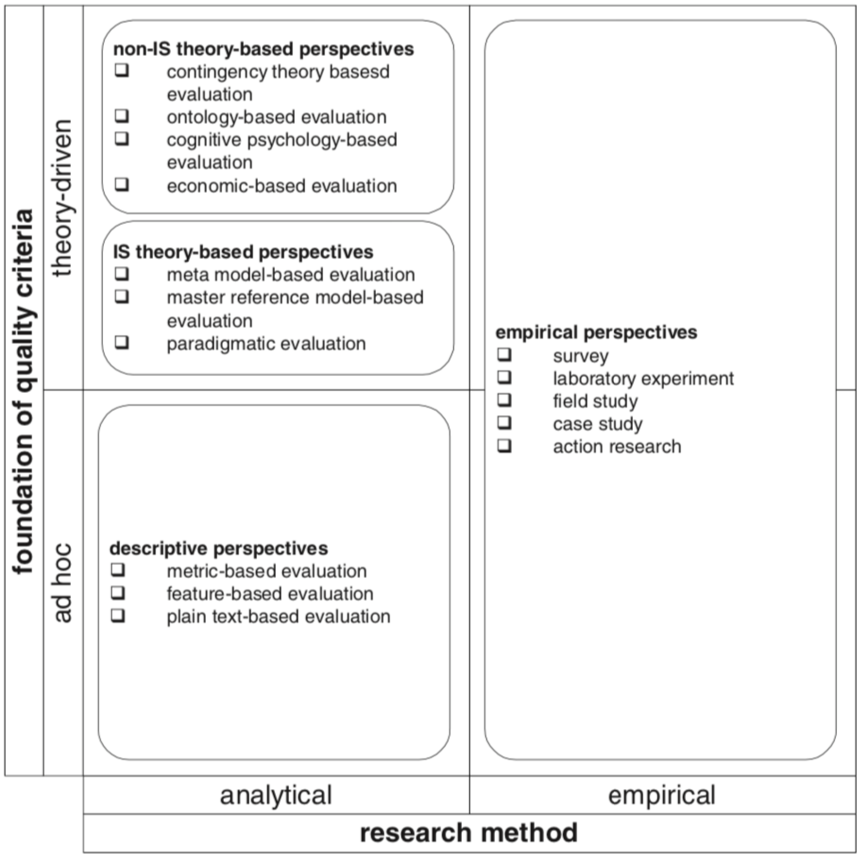


FIGURE 24. FRAMEWORK FOR MULTIPERSPECTIVE EVALUATION OF RMS (FETTKE AND LOOS 2003)

IV. PROBLEM INVESTIGATION

The starting point of this Ph.D. thesis was the problem investigation. As chapter II discussed earlier, this work conducts design science research (DSR), in which the problem investigation represents an essential research phase. The overall objective of a problem investigation is to explicate a practical problem that is of global relevance to a class of problem stakeholders. Therefore, the research problem shall occurr in more than one local practice (Johannesson and Perjons 2014). Further, researchers need to prove that related research did not solve the problem yet. A useful tool to do so is to conduct a thorough knowledge base analysis (KBA) that investigates related research and assesses existing solutions to similar problems regarding their feasibility to the overall research problem (Hevner et al. 2004).

This chapter presents the results of the investigation of two distinct local practices (see section 4.1). Based on their commonalities, section 4.2 derives a global problem statements and investigates its root causes. Results show, that practice demands guidance for developing REAs (REAs) while research lacks providing adequate method support. Afterward, section 4.3 conducts a systematic literature review in order to give an extensive analysis of existing research in the domain of REAs. Finally, section 4.4 summarizes the results of the problem investigation and explicates this thesis' underlying research question.

4.1 INVESTIGATION OF LOCAL PRACTICES

This thesis addresses a practical problem identified during research activities in two distinct local practices. Based on insights from both domains, section 4.2 derives a problem that is relevant in practice. In this context, this section discusses both local practices and their related problem spaces in more detail. Section 4.1.1 investigates problems faced by public utilities (PUs) in the utility industry in the context of structural change. Afterward, section 4.1.2 discusses the challenges of regulatory compliance management in the finance industry.

4.1.1 LOCAL PRACTICE A: STRUCTURAL CHANGES IN THE UTILITY INDUSTRY

A first conjecture of the problem tackled by this work occurred during the initial phase of a research project situated in the German utility industry. The project called ECLORA—a German abbreviation for *"Development of a cloud-based Reference Architecture"*—addressed organizational challenges public utilities (PU) have been facing since national and international regulations such as market liberalization and the preferred usage of renewable energy sources. ECLORA's overall objective was to develop an industry-specific REA which reveals the appropriate utilization of IT landscapes from the perspective of PUs in consequent change processes. In concrete, the REA addressed power supply companies, distribution system operators[1], as well as water suppliers, and wastewater companies. In a joint project structure, the author and an academic research team collaborated with the industrial partner SIV group. The SIV group is an independent software vendor (ISV) located in Rostock, Germany. Among other things, it provides enterprise resource planning (ERP) solutions and business process outsourcing services to PUs from all over Europe. Thus, from a market perspective, the SIV group act as a software provider, service provider, and an IT consultancy. Five SIV employees were active ECLORA project members. In concrete, the SIV's project team consisted of a business analyst, an IT consultant, a software engineer, a solution architect, and an enterprise architect.

ECLORA's agenda kicked off with an online survey. Investigating current and future challenges, it analyzed the state of business and IT alignment and further the awareness of EAM approaches of 53

[1] role for operating regional distribution grids of electricity supply, who plans, builds and maintains distribution infrastructure responsible for regional grid access and integration of renewables, regional grid stability, load balancing and connections to grid users (generators and consumers) at distribution grid level (VDE 2011).

public utilities. Concerning this thesis, the insights from the survey and additional interviews SIV group's experts identified an initial local problem. Therefore, this section looks at this local problem from different angles. The next subsection summarizes recent developments since the liberalization of the energy market and the consequences for PUs in order to get an understanding of the current situation in the utility industry. Subsequently, section 4.1.1.2 presents problems and challenges from the PUs' perspective elicited from the online survey and expert interviews. Before summarizing the characteristics of Local Practice A's problem, section 4.1.1.3 further investigates related IS research literature to justify why this problem is yet unsolved by identifying research gaps.

4.1.1.1 DEVELOPMENTS IN THE EUROPEAN ENERGY MARKET

Over the last two decades, structural change has been dominating European energy markets. In 2006, the European Commission defined three main objectives for future energy policies within the European Union: energy security, competitiveness, and climate change mitigation (European Commission 2006). On this foundation, the European Union agreed to cut greenhouse gas emissions from 1990 by at least 40% until 2030, to increase the proportion of renewables in final energy consumption of the EU to 27%, and to improve energy efficiency by at least 27% (2030 Climate and Energy Policy Framework). To achieve this, subsequent laws and regulations on European and national levels translated these high-level goals into more concrete actions. Their implementation resulted in fundamental structural changes in the European energy markets. Next to regulation, other dimensions drove industrial change in energy markets. Based on the framework of environmental velocity by McCarthy et al. (2010), a study conducted by Deloitte in the US electric power industry identified four additional external drivers for the change in industry: changes on the demand side, new technologic possibilities and trends, increasing demands in product resilience, and an intensified competition driven by new market entrants using innovative business models (Aliff 2013, p. 4). Other authors agree with this systemization. One can further observe that most work consider regulatory, economic, technological, and societal impacts as primary drivers for change in energy markets, as discussed in Kartseva et al. (2004). Hence, the remainder of this section examines the transition process of the German electricity sector by looking from a regulatory, technological, and market perspective. Doing so helps to grasp the context of the local practice at hand, to understand challenges that PUs are facing in this environment, and further underlines the current and future role of information systems in this industry.

REGULATORY CONTEXT: UNBUNDLING AND RENEWABLES RESTRUCTURE GERMANY'S ELECTRICITY INDUSTRY. The Energy Industry Act from 1998 (Bundesrepublik Deutschland 1998) can be seen as a starting point and primary driver of industrial change in the German energy sector. Due to its principles of unbundling and market liberalization, traditional PUs' monopolistic market power dissolved. While it obligated PUs to legally separate grid operations and energy supply into distinct legal bodies, PUs also had to grant new market entrants access to their power networks. The same applied to other related services, such as metering operations or electricity generation. In the end, a categorization of eight different market roles emerged, which resulted in more complex organizational structures (BDEW 2008). In line with the German Climate Action Plan, which aims to reduce greenhouse gas emissions up to 95% by 2050 (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2016), the German government defined the goal to increase the proportion of renewable resources used for the electricity generation to 80% until 2050. Therefore, the Renewable Energy Sources Act (German Federal Government 7/21/2014) regulates the electricity feed-in. It prioritizes electricity generated by renewables and compensates feed-in costs by pre.determined rates. In total, 26 distinctive laws and 33 enactments regulate the German energy market (BMWi 2018). Most recently, the German government is discussing the phase-out plan of coal for electricity generation, which accounted for 36% of Germany's gross electricity generation in 2018 (AGEB 2018). A government-appointed commission estimates a complete phase-out until 2038 feasible (Carrel et al. 2019).

While statistics indicate first achievements (proportion of renewables in gross electricity generation climbed from 14.7% in 2008 to 35.2% in 2018, AGEB (2018)), public debates arose as well. According to Buhl and Weinhold (2012), the German energy turnaround faces several significant challenges. For instance, the integration of renewable energy sources, whose generation is difficult to predict, faces a mismatch between times of supply and demand. Moreover, the production of these energy sources implicates unpopular energy storage installations, which often interfere with regulations regarding environmental protection. Finally, the feed-in and transport of electricity from renewable sources brings along a massive expansion of the electricity grid—not only nationwide, but at international levels as well. This further implies new challenges for optimizing the energy efficiency. Small energy producers with more flexible generation frequencies need to improve the energy production in comparison to the demanded energy in the grid (Kartseva et al. 2004). Moreover, Maubach (2015) ascertains that Germany lacks a holistic approach in energy and climate politics and misses several chances in the context of the energy turnaround. In concrete, he identifies an absence of integration between European and German politics. He points out that the EEG mainly contradicts the European cap and trade program, which aims to reduce carbon dioxide emissions without restricting electricity generation to renewable energy resources. Further, he understands the prioritization of renewable sources as an impediment to market competitiveness. Companies would focus on intensifying building renewable generation plants and ignore possibilities for developing more efficient and sustainable alternatives to skim off subsidies, finally resulting in higher electricity prices for end consumers.

As a conclusion, this regulatory shift forced a prior monopolistic industry towards a technology-driven, competitive, and more consumer-oriented market place (Buhl and Weinhold 2012). Increased competition in most parts of the value chain and the ascending importance of subsidized and volatile renewables asked new questions of the traditional energy grid system and demanded the development of new technologies (Maubach 2015, pp. 60–61; Buhl and Weinhold 2012).

TECHNOLOGICAL CONTEXT: SMART GRIDS AND DIGITALIZATION ENABLE DECENTRALIZATION AND EFFICIENCY. Both research and practice agree that the electricity sector has been and still is facing "its most disruptive period of change" (Aliff 2013, p. 3). A study from PricewaterhouseCoopers identifies digitalization as a critical driver for change in the industry, especially in the areas of grip operations and sales (PWC 2017). In terms of the former, smart grids aim to facilitate renewables feed-in without jeopardizing supply security. New modes of interaction between electricity providers and consumers due to new technologies like smart metering systems characterize the latter (Jagstaidt et al. 2011) as PUs need to offer new customer-oriented services.

Smart grids are intelligent electricity supply infrastructures that use integrated IS to interconnect and control intelligent generators, storage facilities, loads, and network operating equipment in power transmission and distribution networks (German Federal Network Agency 2011). One of their central objectives is to react to local changes in electricity supply and demand in real-time. Thus, smart grinds intend to overcome obstacles regarding load forecasting or generation forecasting (Lampropoulos et al. 2010). Interoperability and standardization are drivers for a successful realization of smart grids and are indispensable for providing demanded services like smart metering, smart mobility, or smart home (Holzamer and Vollmer 2017). Standardization bodies have developed a technical reference architecture for smart grids (Smart Grid Coordination Group 2012) as well as a standard for smart grid gateways (German Federal Government 8/29/2016). The latter represents an interface between the smart grid and metering systems of electricity producers and consumers. Therefore, authorities address system integration and a high degree of cooperation among the various market roles as critical success factors (German Federal Network Agency 2011).

From a general perspective, most literature attaches great importance to IS for enabling change in the electricity sector in general and for the implementation of smart grids in specific. Researchers agree that PUs' IS landscapes will become more complex to implement dicusses requirements (Goebel et al. 2014, p. 30; Kartseva et al. 2004). In the final report of German Federal Ministry for Economic Affairs and Energy's lighthouse project, E-Energy, the authors conclude that IT is particularly vital for controlling the bidirectional and decentralized flow of electricity, enabling real-time data exchange, and digitalizing a significant part of PU's range of function—such as grid management, consumption management, generation management, customer processes or trade (Karg et al. 2014). Nevertheless, Maubach (2015, pp. 71–98) points out that disruptive technologies and innovations have been scarce in the German electricity sector so far. Although smart meters are deemed as a pivotal technology to replace traditional Ferraris meters, Germany had to downgrade a national smart meter rollout plan due to data security issues and a negative cost-benefit analysis (Bundesnetzagentur 2016). While other European countries, like Denmark or France, plan a wide-scale rollout of smart meters by 2020, Germany's Federal Office for Information Security just certified the first Smart Meter Gateway at the end of 2018 (BSI 12/20/2018). Once the new infrastructure exists, Maubach expects that new consumption-sided private and industrial applications will emerge. Furthermore, demand-tailored generating plants and independent consumer-sided electricity cycles will become more and more prevalent (Maubach 2015).

MARKET CONTEXT: TRADITIONAL PUS FACE SIGNIFICANT CHALLENGES IN A DYNAMIC MARKET ENVIRONMENT. The paradigm of unbundling forced traditional PUs to separate their branches into distinct legal entities (Jagstaidt et al. 2011). A single PU may act in several market roles (e.g., grid operator and electricity supplier). This caused more complex and varying organizational structures of market actors. Moreover, it enabled the emergence of new business models combining several roles as well as offering new services. Thus, new and more complex business-to-business partnerships originated, while revenue streams of the sector changed (Kartseva et al. 2004).

Furthermore, the energy turnaround lowered entry barriers to new market actors. Grid operators have to open their infrastructure to competing electricity producers and electricity suppliers. Simultaneously, the role of customers changed. Passive consumers became more informed and aware, while higher competition further strengthened their market power. Accordingly, their requirements towards PUs changed as they demanded new service offerings, such as flexible tariffs (Jagstaidt et al. 2011). Besides, more and more electricity consumers became producers and fed-in small amounts of electricity as photovoltaic panels became more affordable (Lampropoulos et al. 2010). Finally, the turnaround also affected other market actors like ISVs and IT consultancies. From their perspective, PUs demanded for new products and services.

Scheer (2010) supports this and hints that an effective and efficient involvement of traditional PUs has to be one essential objective in order to lead the German Energy market to an energy generation rate of 80 percent renewables. In this context, the structural changes in the energy market simultaneously determined new requirements for business processes and IT systems of PUs (Appelrath and Chamoni 2007). The unbundling of market roles forced the distribution of prior internal business processes to manifold enterprises. The orchestration of these business processes, such as meter data transmission, grid usage billing, consumer and supplier processes, or data transmissions, is a non-trivial task, because PUs needed to adapt their business architecture and implement new interfaces that support data exchange with other market actors (BDEW 2008). Next to a change of organizational structure, the increasing competition in the sector additionally required traditional PUs to adapt their business models (Maubach 2015). Even more so, new technologies and new market entrants forced them to improve their organizational efficiency and effectiveness (Appelrath and Chamoni 2007; González Vázquez et al. 2012).

In sketching future markets of the electricity sector, Eßer et al. (2007) summarize several challenges PUs face. While their success depends on higher quality of services, transparency, and customer care, they simultaneously need to reduce their tariffs in order to stay competitive. The authors conclude a transformation from customer-oriented processes to market-oriented processes, where electricity is not a commodity anymore due to society's and politics' growing awareness regarding environmental pollution. This further means that PUs need to implement market-focused innovation into their legacy structures rather than continuing a hitherto approach that only addressed efficiency optimization concerning the production of electricity (Maubach 2015). Thus, PUs have to be aware of their current business processes' cost structures. So far, PUs tend to miss opportunities that open up during market changes. Today, the private sector dominates the business of electricity production from renewables, because established PUs did not adapt in time. Maubach (2015, p. 114) asserts that the same may happen for current business opportunities like smart home products, smart meter services, or other consumer-centered services. To conclude, PUs have to develop new business capabilities in order to realize the demanded transformation of their value chains, as has been the case in the telecommunications sector too (Czarnecki et al. 2013b).

In order to cope with this industrial shift, Jagstaidt et al. (2011) observe the intense involvement of IS, mainly due to the extreme increase of internal and external data exchange. Likewise, the necessary information originates from heterogeneous sources in variable quality, sometimes even n paper (González Vázquez et al. 2012). As a result, Kopetzki and Wassermann (2014) identify a successful realization of increasingly high requirements towards the IT landscapes of PUs as a critical success factor. The above statements are in line with the research of energy informatics. Here, Watson et al. (2010) and especially Califf et al. (2012) understand appropriate IS usage as a vital ingredient for successful industrial change in the energy sector.

4.1.1.2 PROBLEMS AND CHALLENGES IN THE UTILITY SECTOR FROM AN IS PERSPECTIVE

Described developments and challenges have critical influences on PUs' operative and strategic business. Overcoming these obstacles means to tie up resources. Depending on an organization's size and structure, this may be a non-trivial effort. According to the Federal Bureau of Statistics, 71.3% of all enterprises in the German energy sector are small and medium-sized enterprises[1] (SME) (Gude 2018). While SMEs represent the majority in this sector, they only employ 12.8% of the sector's workforce and share less than 4% of the sector's total revenue (Söllner 2014). These statistics reveal that PUs generally enter very high capital expenditure on property. As shown in the previous section, PUs still need to stay competitive with new market entrants while investing in their organizational change and need to evolve their IT landscapes. This work conjectures that German SME PUs demand for support regarding their organizational change. These recent developments require the alignment of PUs' business and IT landscapes. As depicted earlier in section 3.1, EAM offers tools and methods that meet such a demand.

SURVEY DESIGN: CURRENT STATE OF EAM IN SME PUS. Based on these considerations, this chapter presents the results of an online survey conducted during the ECLORA project's preparations. It investigated the state of the art of EAM in SME PUs. The research team chose this method since surveys provide a simple approach to retrieve a high amount of information in a standardized way (Robson and McCartan 2016). Assuming that EAM supports SME PUs in overcoming current challenges, the survey intended to poll practitioners from SME PUs in order to answer the following questions:

- *Are SME PUs aware of EAM? How do they assess EAM's benefits?*
- *What is the current state of business and IT alignment at PUs?*

[1] According to the European Commission, SMEs are defined as enterprises with less than 500 employees and not more than 50 million € annual revenue. (2003/361/EC)

➢ *Is there a demand for a REA in the utility industry?*

The researchers followed the guidelines by Robson and McCartan (2016) for designing the questionnaire and conducting the survey. After revising the questionnaire, partners from the SIV group conducted a pre-test. The improved and condensed questionnaire was uploaded to the platform *SoSci Survey*[1]. The project partner SIV.AG distributed the link to their PU customers. In the end, 53 complete questionnaires were submitted. With the export functionality of the *SoSci Survey* (in CSV-format), the data was analyzed using SPSS[2] by IBM (Cammin et al. 2015). Next to an introductory part, the questionnaire contained six parts: *General Information (Part A)* focused on the responding enterprise, its size, market role in the utility industry, and the respondents' position. *Corporate Management and Organization (Part B)* referred to knowledge and experiences in EAM as well as EAM's current integration and its general importance for the utility enterprise. *Strategy (Part C)* captured the transparency of the enterprise's strategy, identified core processes as well as Business Process Outsourcing (BPO) activities. *Operation (Part D)* enquired about the enterprise's current IT landscape, its alignment to business and strategy, and the respondents' satisfaction with current IT support. *Monitoring (Part E)* inquired whether PUs implemented processes for updating IT and business with operative and strategic changes. *Development and Forecast (Part F)* identified future actions regarding EAM and asked for the expected value of implementing EAM.

SURVEY RESULTS: PUS DEMAND FOR SUPPORT TO CONTROL BUSINESS-IT ALIGNMENT. The survey's results provided several implications for this thesis. To summarize, the survey confirmed and concretized problems and challenges that occurred using EAM from the perspective of German PUs and revealed a demand for an REA in the utility industry. Before discussing derived implications, this section presents the survey's results. Therefore, the questionnaire's structure guides the presentation. The section primarily focuses on the results of the survey that contribute to the problem investigation of this thesis. For a more comprehensive presentation of results, the author refers to Timm et al. (2015b).

Responding PUs (Part A): A central aspect was to investigate the organizational structure of the PUs. Therefore, the respondents were able to choose from nine different market roles from BDEW (2008). Since multiple answers were possible, 25 different combinations of market roles occurred in the pool of responding enterprises. Almost half of the market role combinations had less than a 5% share of the total amount of combinations. That fact indicates a high degree of diversification in the utility industry. Figure 25 illustrated this.

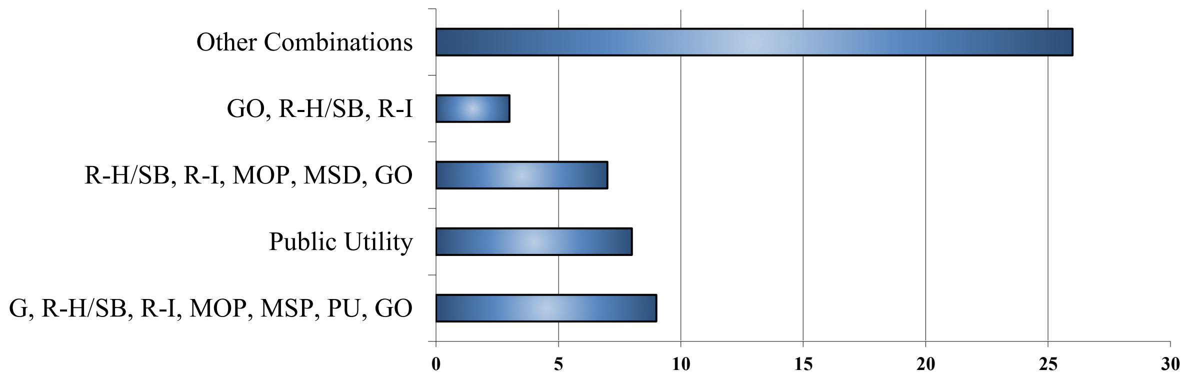


FIGURE 25. COMBINATION OF MARKET ROLES[3] IN PERCENTAGE STATED

[1] https://www.soscisurvey.de/
[2] http://www-01.ibm.com/software/de/analytics/spss/
[3] G- Generator, GO - Grid Operator, MOP - Metering Point Operator, MSP - Metering Service Provider, PU - Public Utility, R-H/SB - Retailer for Households and Small Businesses, R-I - Retailer for Industry

Experience with and Expectations towards EAM (Part B): None of the respondents rated themselves as an expert in EAM practice. Based on all respondents, the majority (61%) was inexperienced with EAM. Still, 72% of the IT respondents assess themselves at least as beginners. In contrast, only 39% of the management respondents considered themselves as beginners. One can derive that respondents from IT departments are most aware and experienced in EAM in the industry. Interestingly, still 50% of the management rated EAM as essential or very important for organizational success, while 82% of the IT department agreed. In contrast to the missing experience of EAM, one-third of every identified department rated EAM as necessary. This result is remarkable when contrasting the level of experience to the assessment of EAMs importance. Figure 26 visualizes this. The available data set allows the conclusion that with increasing experience of EAM, respondents become more aware of EAM's benefits.

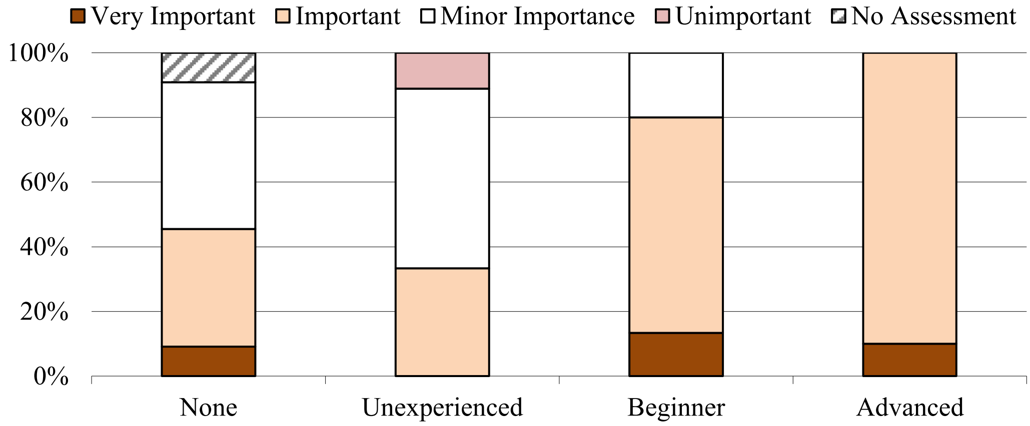


FIGURE 26. IMPORTANCE OF EAM BY LEVEL OF EXPERIENCE

Respondents stated that they had no managerial support for EAM because EA frameworks like TOGAF were too complicated, and EAM in general would be too cost-intense and time-consuming. These statements lead to two conjectures. First, there is a lack of EAM solutions or frameworks tailored for SME PUs. Second, there is a need for a domain-specific EAM solution tailored to the challenges of the utility industry. The statistic of EA Framework usage confirms the former conjecture. The majority of the respondents (77%) did not make a declaration regarding used EA Frameworks. While only 5.7% of the respondents mentioned COBIT or TOGAF, 15.1% stated ITIL. Discussing the responses regarding EAM's benefits speaks for the validity of the second conjecture. A considerable percentage of respondents stated overcoming complexity (45.3%) and tool support for business process management (41.5%) as a central benefit. Further, 35.8% stated that decision support for strategic projects and investments are promising benefits by EAM activities. Likewise, advantages like quality management and the review of IT systems (32.1%) and applications (30.2%) were mentioned. In order to get more insights, the respondents had to state their feelings about the following three statements: *(1) Acquisitions and fusions force the harmonization of heterogeneous IT landscapes, (2) Movements like Cloud Computing, Offshoring or Outsourcing lead to a distributed IT landscape. (3) Regulations and laws cause an increasing IT complexity.* The agreements for these statements were measured using a Likert scale (Norman 2010). The majority agreed to all three statements by choosing at least "agree." In conclusion, all these three aspects seem to characterize current challenges in the utility industry, and implementing EAM programs would provide means to overcome them.

Documentation (Part C): The majority of the respondents (70%) assessed their corporate strategy as documented, of which only 49% stated it as available for every employee, while in 17% of the cases, the corporate strategy was undocumented. Further, 81% stated that business goals were documented (Sandkuhl et al. 2014). The responses regarding core process documentation reflect these figures (84.9%), although only in 53.3% of the cases these were available to the employees. More interestingly, the majority of respondents were unsatisfied with the core processes' IT support. Although 91% confirmed IT support of these processes, only a minority (22%) deemed it as sufficient in terms of information and resource provision. It seemed that there was a need for optimizing IT support of the core processes. This statement is supported when contrasting the degree of IT support and the provision of information and resources.

Business and IT Alignment (Part D+E): The results in this part did not verify the need for improvement of IT support identified in Part C. While 47.2% of the respondents stated a complete collaboration between IT and functional departments, 49.1% said the collaboration partially existed. Contrasting these results with the questions from Part C did not provide an explanation, why information and provision of resources is lacking. A conclusion of these results may be that even with high degree of collaboration of IT and business, the IT support and resource provision are not automatically satisfying. Thus, as an assumption, the practice of IT and business collaboration might not be optimal and need to be improved. As EAM programs capture organizational change, monitoring activities play a central role. Changes in business processes or responsibilities may have a direct impact on operational business and, thus, need to be identified in order to adjust the EA (Ahlemann et al. 2012). In Part E, 47% of the surveyed enterprises neither appointed a single person nor implemented a department responsible for this interface activity between IT and business. Only 25% of the enterprises named a responsible role, while 11% assigned a department for this. Consequently, most of the enterprises updated their corporate strategy, IT strategy, and core processes in irregular intervals. While 40% update their strategy on demand, about 60% analyze their IT strategy and core processes when required.

Improvement Potentials (Part F): Regarding the need for better IT support of business process, only 25% mentioned to be satisfied with the current situation. More than 50% were unsatisfied with several IT systems. Respondents assessed billing systems, customer relationship management systems, and document management systems as too complex. Further, the respondents enumerated business processes that would benefit from more effective IT and business alignment. They especially expected billing processes (23%), end-consumer processes (20%) as well as controlling processes (15%) and energy data management (14%) to benefit from better IT support. To contrast this with the potentials, the questionnaire asked respondents to state their expectations towards a feasible EAM, which resulted in the following enumeration:

- *more effective utilization of resources* (53%)
- *detection of demand for action and optimization* (49%)
- *enhancement of business-IT alignment* (43%)
- *analysis tool to understand relationships and dependencies in the enterprise* (36%)
- *reduction of IT costs* (32%)

IMPLICATIONS FOR THE LOCAL PRACTICE. While PUs are primarily inexperienced in EAM, only respondents from IT departments seem aware of the concepts and benefits of EAM. Nevertheless, the majority considers EAM as an essential tool for enabling corporate success and overcoming complex tasks apparent in current industry developments. However, most respondents assessed EAM endeavors as too complicated, resource-, and time-consuming to implement. In consequence, the study identified only a few EAM initiatives at PUs', which may explain why the minority of respondents state a sufficient degree of business and IT alignment. Besides, acquisitions and fusions in the sector endanger harmonization of heterogeneous IT landscapes of PUs, as do recent business process outsourcing decisions and numerous regulatory requirements.

In contrast to these observations, one can conclude a demand for a domain-specific REA using EAM concepts and approaches tailored to the needs of PUs. The given results agree with this conclusion. The majority of respondents names EAM as a potential means to improve their core-processes' IT support, to reduce overall IT costs, or to optimize their increasingly IT-driven organizational structures. Still, the results indicate that such a domain-specific REA has to be applicable for addressed PUs. In this regard, the high diversification of market roles in the utility sector (which implies variations of underlying business models and, thus, core processes) seems to be a vital factor. Consequently, a demanded REA for PUs should provide configuration mechanisms depending on a PU's market roles and appropriate means for REA users for applying it. Furthermore, the results hint that a domain-specific REA shall base on an overall structure problem stakeholders agree upon. Next to these insights, the survey also collected data from the PUs for defining such an REA structure.

After the analysis of the survey, three domain experts from the project's industrial partner SIV group evaluated the results regarding their industrial experience and knowledge. As their roles ranged from EAM project manager and enterprise architect to IT consultant, they were able to evaluate the survey's representativeness and reliability. The experts agreed with the results since the findings reflected their experience in providing ERP systems and business process outsourcing services to PUs. Overall, they stressed that the majority of PUs exhibits a low maturity in terms of EAM due to prior static legacy structures that cemented themselves in the era of monopolistic markets.

4.1.1.3 INVESTIGATING RESEARCH ON INFORMATION SYSTEMS FOR POTENTIAL SOLUTIONS

This section investigates the role of IS in the utility industry as stated in IS research, summarizes addressed research objectives, and discusses related work from an EAM perspective. While most literature in the context of the energy turnaround and IS research focuses on the technical realization of decentralized electricity generation, load forecasting, or flexible price calculation, Califf et al. (2012) emphasize that the role of IS also needs to be considered from the perspective of business organizations, and therefore especially PUs. Other authors agree and claim that PUs' IT landscapes become increasingly complex and, therefore, require more integrated solutions as well as industry-wide standardizations (González Vázquez and Appelrath 2010; Kopetzki and Wassermann 2014; Goebel et al. 2014). As an illustration, González Vázquez et al. (2012) identify more than 80 different information sources necessary to develop an appropriate information system for the utility industry. Likewise, the amount of operational data rises. Consequently, requirements towards PUs' data management increase as reports from the German lighthouse project "E-Energy" confirm (Karg et al. 2014).

As the role of IS in the utility industry is of growing importance, this manifests in research interests from the IS research domain. There is a consensus that information systems are at the core of a successful transformation to overcome the current industrial challenges (Watson et al. 2010). Further, Lampropoulos et al. (2010, p. 3) and Karg et al. (2014) deem IS as a key to facilitate communication among suppliers, producers, consumers, and other market roles. Therefore, Winkels et al. (2007, p. 388) systemize IT related requirements to enable a decentralized energy management system, which they propose at the core of market interaction. In recent standardization efforts, the German Federal Offices for Information Security (BSI) and Economic Affairs and Energy (BMWi) identify five pillars that drive the digitalization of the utility industry: smart metering, smart grid, smart mobility, smart home, and smart services (Holzamer and Vollmer 2017). Research primarily investigates the former two. A plethora of research analyzes the role of IS in realizing real-time grid operations in the era of volatile renewable energy sources (Uslar et al. 2019). Here, interoperability, demand/supply forecasting, the architecture of the grid's infrastructure, and security aspects are investigated (Goebel et al. 2014; Lampropoulos et al. 2010, p. 7). In the frame of an EU Mandate, the Smart Grid Coordination Group developed a technical reference architecture model (called SGAM – Smart Grids Architecture Model) that represents information flows among smart grid stakeholders (Smart Grid Coordination Group 2012). Based on this, the "E-Energy" project used the results from six model regions to derive a reference architecture that relates empirical knowledge to the SGAM (Irlbeck and Koutsoumpas 2015). In this context, IS research identifies numerous adoption barriers and problems that occur when implementing such complex IS systems at PU level. Next to the barriers of switching costs or collective action dilemma (Schwister and Fiedler 2015), Dedrick et al. (2015, p. 26) claim that *"utility companies need to develop new technology skills in areas such as systems integration, networking, security, and data analytics*." The implementation of smart metering is a good showcase for this. Based on a literature review, Krüger and Teuteberg discuss the increasing amount of operational data that needs to be processed when implementing smart metering services (Krüger and Teuteberg 2015, p. 1181). Vukmirović et al. (2010) provides a smart metering architecture that tackles this problem. This builds on work by Jagstaidt et al. (2011), who argues that smart metering technologies are only successful when implemented on all EA layers. Furthermore, most recent IS research analyzes consumer adoption to new technologies. While some authors primarily identify positive reactions towards smart meter technologies (Fürst et al. 2018), others hint at issues like data privacy that need to be considered consumer-wise (Warkentin et al. 2017).

There just has been little activity in IS research, which addresses a holistic approach to overcome the stated challenges for PUs from an EAM angle. Few articles present the development of a PU-specific EAM (Gorski 2018; Kallgren et al. 2009). In the context of implementing smart grid technologies in PUs IT landscapes, several articles suggest using EAM methods to integrate grid operators with smart grid networks (Trefke and Danekas 2012; Postina et al. 2010). Some authors present initial results of EAM initiatives of smart grid integration (Trefke and Danekas 2012; Parra et al. 2014). However, most research focuses on parts of EAM's scope and proposes recommendations to PUs for adopting to the industrial change. For instance, Vázquez et al. identified 11 reference models for information systems development in the energy sector (González Vázquez et al. 2012). In another article, they propose a catalog for reference models in order to agree on a common terminology (González Vázquez and Appelrath 2010). Felden and Buder (2012) develop a RM deriving practical guidance for strategic asset management for utilities. They aim to integrate business and technical artifacts in order to enhance decision support in business intelligence systems. From a business process perspective, Deindl et al. (2010) provide a reference process map for PUs spanning from sales and trade processes to technical processes.

While IS research does not provide a complete picture for PUs from an EAM perspective, the majority of related work agrees with this work's previous findings that there is a need for a domain-specific REA. On the one hand, both research and government reports agree that a complete EAM perspective is necessary. So does a success factor analysis conducted at Danish PUs reveal the importance of a holistic EA approach in this field (Khisro and Sundberg 2018). Further, a recent report of the German Ministry for Energy states that digitalization will concern all layers and phases of value creation, including data and IT perspectives (BMWi 2016, p. 145). On the other hand, a lot of IS research articles consider reference models as an appropriate means to support PUs in their transformation. Based on his IT-related requirements, Winkels et al. (2007, pp. 389–390) propose reference models for their realization. Krüger and Teuteberg (2015, p. 1181) include RM in their research agenda for a successful implementation of smart meter technologies. However, reference models that are applicable, scientifically developed, and capture all necessary EA layers are scarce (González Vázquez and Appelrath 2010, p. 322). Not only does the final report of the "E-Energy" project recognize this lack of methodological support for a coherent Smart Energy Reference Architecture (Karg et al. 2014; Irlbeck et al. 2013). Also, authors from similar endeavors like the telecommunications industry understand that the utility industry would benefit from an REA solution (Czarnecki et al. 2013a).

4.1.1.4 SUMMARY: LOCAL PROBLEM A AND RELATED RESEARCH GAPS

This chapter investigated the characteristics of Local Practice A. After presenting industry developments since the market liberalization, the chapter reported on results from an online survey, which revealed that PUs are overwhelmed with the challenges they face. New regulatory requirements, technological innovations (e.g., smart meters) accompanied by the need for digital transformation, increasing market competitiveness, and the dissolution of monopolistic power structures force PUs to transform their organizational structure not only at business level, but also from an IS perspective. One central finding of the survey is that while most PUs state to document their business processes properly, they lack an appropriate alignment with their IT architecture in the majority of the cases. Although they consider EAM as an effective means to overcome this, they lack in resources and knowledge to implement holistic EAM initiatives since known EAM approaches are understood to be too complicated, time-, and cost-intense. As a conclusion, the survey identifies the need for a domain-specific reference model, which would capture how each of the PUs' EA layers are affected by current challenges and provides best practice approaches to overcome them.

Recent IS research in the problem domain supports the demand for such an REA, as section 4.1.1.3 discussed earlier. While most research activities focus on technological solutions to facilitate a smart grid in the age of volatile renewable energies, only a few articles focus on consequences for PUs. However, there is a consensus that change requirements affect all EA layers. Although literature suggests several reference models in this regard, there is an absence of such a holistic approach and a lack of methodological support.

To conclude, the problem of Local Practice A is that PUs need support in their organizational change processes from business and IS perspective, but are lacking capacities to implement individual EAM programs from scratch. An REA tailored to their needs does not exist. In order to cover PUs' demands, a solution shall apply to all possible market roles of the domain. Therefore, such an REA shall be configurable regarding the PUs' market role. Furthermore, the experts from the SIV group remarked that one challenge is to gather the appropriate knowledge for REA development. While they understand that domain-specific knowledge is available, they claim that this will not be of a sufficient level of detail in order to achieve deep insights regarding EA related aspects like data structures or IT usage. Consequently, a central task to achieve an applicable REA is to elicit practical knowledge for REA development. Moreover, the experts agreed that the problem stakeholders not only encompass the PUs in their numerous combinations of market roles. Likewise, other market actors, such as IS vendors and business process outsourcing providers, would share the above-stated challenges and would benefit from a domain-specific REA.

4.1.2 LOCAL PRACTICE B: REGULATORY COMPLEXITY IN FINANCIAL SERVICES

The second Local Practice B is the financial industry. The author investigated it during the COFIN research project between 2016 to 2018. The initial problem situation of COFIN shared commonalities with the problem from Local Practice A (see section 4.1.1). This similarity suggested a global relevance of the problems at hand and provided the basis to derive a global problem of general interest (see section 4.2).

COFIN—a German abbreviation for "*Compliance Organization in Financial Institutes*"—addressed the financial industry's lack of a holistic regulatory compliance management (RCM) and the growing role of information systems in the domain. Therefore, COFIN aimed to go beyond the analysis of legal texts and expert knowledge in order to suggest realization guidelines for financial institutes. Instead, the COFIN's objective was to develop a RM that builds on institutes' practical knowledge, identifies effective practices, and uses EAM concepts to capture regulation's impact from business, data, and application perspectives. This approach intended to prevent banks from implementing isolated and deadline-driven compliance programs. It further wanted to support them in analyzing generically formulated laws and reveal their consequences for institutes. Therefore, the project aimed to develop an REA that primarily addresses financial institutes and vendors of compliance software, but also supports IT consultancies, auditors, or even the regulator itself in order to harmonize all participating stakeholders' interests.

COFIN originated from a working group of the German IT-association *bitkom*[1]. The working group consisted of ten ISVs and IT consultancies from the regulatory compliance domain in the financial services industry. While the working group financed the project, bitkom took responsibility for project organization. The author acted as one of the five members of the project team[2]. In this context, the author was responsible for the methodological approach and the development of the REA. In concrete, method design meant to develop strategies to elicit practical knowledge from institutes, make it comparable, derive an REA from it, and design an appropriate evaluation.

In order to make the investigations of both local practices comparable to each other, the remainder of this section uses the same structure as the previous regarding local practice A (section 4.1.1). While section 4.1.2.1 summarizes general recent developments in regulatory compliance in the financial sector, section 4.1.2.2 presents concrete problems the author observed in the early phase of COFIN. Section then 4.1.2.3 discusses the current state of IS research and compares it to identified problems. In the end, section 4.1.2.4 provides a summary of the local problem.

4.1.2.1 DEVELOPMENTS IN THE REGULATION OF FINANCIAL SERVICES

After the global financial crisis in 2007, the G20 nations agreed to reform the global financial markets. Five years later, the Financial Times described the reactions to this agreement in the financial sector as a 'tsunami' of regulations (Ricketts 2013). Regulators of the European Union responded to G20's agreements by a plethora of regulations addressing financial institutes. The amendment of the KWG by the CRD-IV Implementation Act adopted in 2013, the repeatedly revised Minimum Requirements for Risk Management (MaRisk) (BaFin 2017), or the Minimum Requirements for Compliance (MaComp) (BaFin 2018a) are just the tip of the iceberg. The inclusion of international regulatory contexts, such as guidelines from the European Supervisory Authorities (ESAs)[3] or the Foreign Account Tax Compliance (FATCA)[4], as well as concrete compliance domains like anti-money laundering (AML) or counter-terrorist financing (CTF), represent a vast need for action from the perspective of financial institutes[5]. In figures, the Federal Financial Supervisory Authority (BaFin) provides an overview that lists a total of 39 relevant laws and 80 regulations as "most important legal bases" (BaFin 2018b). In the period from the calendar years 2017 to 2019 alone, there are 36 regulatory deadlines for 18 different regulations in the European legal area (Mellon 2017). For these deadlines, regulatory authorities demand an individual state of realization, while they fail to give concrete guidelines for correct implementation in the majority of the cases. As an example, AML programs require implementing organizational functions like hazard analysis, customer identification, further customer due diligence, prevention mechanisms, and reporting duties (European Union 2018). Although these functions' success highly relies on integrated data structures of a financial institute's customer base, an immense amount of transactional data, and sophisticated monitoring and prediction tools, regulation lacks in addressing these aspects.

The increasing number of regulations forces financial institutes to implement a coherent Governance, Risk, and Compliance (GRC) program (Abdullah et al. 2010). Racz et al. (2010) define GRC as an "*integrated, holistic approach […] ensuring that an organization acts ethically correct and in accordance with its risk appetite, internal policies and external regulations through the alignment of strategy, processes, technology and people*". The compliance function of an institute herein has the objective to identify relevant regulatory requirements and to facilitate adherence to these obligations (Mills 2008).

[1] see https://www.bitkom.org/Themen/Digitale-Transformation-Branchen/Banking-Finance/Forschungsprojekt-IT-gestuetzte-Compliance-im-Finanzsektor-2.html for more infomation (accessed 17/04/19)
[2] the project team consisted of two researchers from the University of Rostock and three from the Berlin based Institute for Regulatory Management
[3] see https://www.bafin.de/EN/RechtRegelungen/Leitlinien_und_Q_and_A_der_ESAs/Leitlinien_und_Q_and_A_der_ESAs_node_en.html, accessed 12/04/19
[4] see www.treasury.gov, accessed 12/04/19
[5] see https://www.bafin.de/SharedDocs/Veroeffentlichungen/EN/Aufsichtsrecht/Gesetz/GwG_en.html, accessed 12/04/19

This task is called regulatory compliance management (RCM). Kharbili (2012, p. 24) defines RCM as the management "*…of ensuring that enterprises (data, processes, organization, etc.) are structured and behave in accordance with the regulations that apply, i.e., with the guidelines specified in the regulations*." In summary, the regulatory framework is becoming increasingly complex, and its dynamism is ascending. Likewise, regulatory requirements are expanding to more addressees, including organizations beyond the financial domain. Moreover, the penalty system of regulatory authorities prevents effective implementation of laws from a more holistic and systematic perspective and forces institutes to act deadline-driven.

GRC and, in particular, RCM should aim to comply with complex regulatory obligations from a holistic perspective. The question arises, how financial institutes accomplish the required enterprise-wide RCM. In the context of the Sarbanes-Oxley-Act, Wagner and Dittmar (2006) observed that a thorough implementation of RCM achieved side-benefits like process standardization or consolidation. Further, Gozman and Currie (2015) value a mature GRC as a new value-adding capability since institutes can offer it to third parties as a consulting service. Consequently, using EAM to capture regulatory impacts on these different perspectives may arguably be a sensible approach. Volonino et al. (2004) highlight that holistic RCM affects an organization from different perspectives. In contrast to merely complying with specific rules, it is about developing an integrated approach by identifying both all relevant organizational elements and the relationships among them.

In reality, however, financial institutes tend to implement isolated compliance solutions due to short-term deadlines set by regulators (Gozman and Currie 2015). When observed from an EAM perspective, most regulations require an implementation that goes beyond alterations at institutes' business level. More often, implementations at data and application levels are especially crucial to meet regulatory requirements. Studies reveal that the multitude of requirements in conjunction with short deadlines means that financial institutes are unable to implement holistic RCM and are increasingly resorting to external IT solutions (Gozman and Currie 2015). This development presents the IT industry with a significant challenge. ISVs must develop IT-supported solutions and application scenarios that are audit-proof to regulatory requirements. However, institutes still need to establish a holistic regulatory compliance management system.

The German Central Bank also focuses on these developments. In his speech at the "20th Banking Symposium of the European Center for Financial Services", Dr. Andreas Dombret—in the Board of managing directors of the Central Bank until May 2018—called for the reduction of operational burdens as the primary goal for the further development of banking regulation (Dombret 9/7/2016). He also notes that regulatory complexity is leading to entry barriers and can, therefore, impair the competitive dynamism and innovative ability of the industry. Also, increasing complexity would lead to increasing supervisory expenditure on the part of BaFin. In recent years, the principle of proportionality is under discussion. Therefore, the so-called "level playing field" approach aims to impose regulatory requirements on financial institutes with their inherent systemic risk. This would result in a regulatory framework, where "less significant" banks (e.g., thrift institutes) and system-relevant banks are addressed differently from a regulatory perspective (Felix Hufeld 9/22/2017; Ilchmann and Richter 2016).

4.1.2.2 PROBLEMS AND CHALLENGES OF FINANCIAL REGULATORY COMPLIANCE

After the prior section presented general developments in the domain of RCM, this section reports on industry-related research activities as part of the problem investigation of Local Practice B. The author conducted them in the early stages of the COFIN research project. In total, three different sources provided input for a thorough understanding of the problem at hand. First, in an expert interview, the author consulted two RCM practitioners[1], who reported on both their experiences from their work-practice in a leasing institute and findings from a previous project on AML. Second, the working group of the ten ISVs and IT consultancies formed a focus group that guided the project's direction by sharing their industry-related experience and giving feedback to interim results. In an initial focus group meeting, the author learned the perspective of IT solutions providers in the field of practice. Third, the COFIN project team conducted telephone interviews with four different German banking federations. The author analyzed the interviews' transcripts in order to gather more insights on the problem from the lenses of financial institutes.

The first activity took place in the scope of two project preparation meetings. The experts provided insights on their experience regarding regulatory practice. They agreed with earlier mentioned statements regarding RCM saying regulatory requirements become increasingly complex, dynamic, and affect institutes on both business and IS level while supervisory bodies fail to provide clear, coherent means to implement them at institutes. They further claimed the infeasibility to develop a holistic RCM approach that only considers regulatory texts as a knowledge base. Instead, the development of holistic RCM would also have to incorporate experience on how to translate regulatory requirements effectively into a coherent RCM program. Moreover, the experts reported on an earlier project that had the aim to develop a best practice description for performing case management for AML programs in large banks. Together with the German bank association and a private university in the field of GRC as partners, the project resulted in a best practice recommendation certified by the supervisory authority in Germany. It covered organizational roles, process descriptions, and aids, such as lists of embargo countries for realizing AML programs. The experts described the following core insights:

- it is feasible to develop the best practice descriptions based on established practices in the domain,
- financial institutes are willing to apply guidance that is based on practical experience and found them beneficial,
- there is a need for integrating an IT perspective into the best practices to ease the implementation.

The following activity took place in January 2016. The focus group meeting discussed the integration between different IT solutions in the compliance field, the effects of changed or new regulations on these solutions, and the current demand of financial institutes as perceived by the group. The author and the remaining research team took notes during the meeting, captured flipchart and whiteboard content, and collected slide decks the participants contributed to the meeting. The main conclusions were that the vendors looked for mechanisms to improve their products' robustness against changing regulations, expect new business opportunities in the regulatory technology domain by integrating different tools along the value chain, and want to use existing data for learning. Further, the ISVs felt a substantial demand from their clients for an enhanced integration of RCM processes and tools. In discussions regarding a potential solution for a holistic RCM, all ISVs agreed that regulation affects institutes on all EAM related layers. They concretized that a solution should especially investigate regulatory impacts on business, data, and application layer[2].

The third source of practical insights were interviews with three federations from German credit institutes and one from the financial services domain. They confirmed that financial institutes are frequently lamenting an absence of better RCM related approach. Besides, they mentioned concrete compliance domains, where they perceive an increasing demand for support. The core findings were that German banking federations demanded more support in the regulative topics of AML, Customer Identification (also "Know Your Customer," abbr. KYC), and Fraud Prevention. In concrete, they stated a lack of systematic implementations of these regulatory topics without appropriate IT support.

[1] both experts were part of the COFIN project team. One expert is board member of the financing company, the other is ist
[2] see the architectural layers of the TOGAF framework as they are presented in section 3.1.3.2

After discussing recent developments in Local Practice B and validating these observations with different stakeholders, the following list of statements summarizes the domain of RCM in financial services from a practitioners' perspective:

- the majority of financial institutes conduct a deadline-driven RCM approach that results in regulatory implementations, which are isolated from one another and result in inefficient and ineffective RCM programs,
- practitioners identify a potential of synergies and demand a coherent and holistic RCM approach,
- regulatory requirements address different perspectives of the institutes' architecture, while mainly driving change at business, data, and application levels,
- a holistic RCM approach shall be resilient towards regulatory changes,
- regulatory texts are insufficient in order to develop an effective holistic RCM approach; practitioners agree that practical knowledge is essential to derive effective practices on how to implement regulatory requirements
- the domain lacks a body of practical knowledge that enables the development of a holistic RCM

4.1.2.3 CURRENT STATE OF IS RESEARCH IN FINANCIAL REGULATORY COMPLIANCE

The results from the previous two sections discussed recent developments and RCM related challenges as perceived in practice. In order to gain insights from a scientific lens, this section compares the above-listed problem characteristics against the current state of IS research activities in financial services compliance.

In order to identify relevant related literature, the author searched the Scopus and Google Scholar databases for peer-reviewed articles. This identified meta-reviews and literature analyses in the field of RCM from an IS perspective. Analyzing the results from Akhigbe et al. (2015) and Cleven and Winter (2009) helped to get an overview of current research activities and to identify first articles that are closely related to Local Problem B. Afterwards, the author further searched for "*regulatory compliance,*" "*compliance management*" and "*finance**" in combination with "*information system**" and "*enterprise architecture*." After assessing the results, for- and backward search was conducted on relevant articles, as suggested by Webster and Watson (2002). The author included all articles that approached RCM topics from an IS perspective. The remainder of this section summarizes the findings and concludes requirements research stated in terms of holistic RCM.

There exist numerous systematic literature reviews and meta-analyses in IS research on RCM. Akhigbe et al. (2015) analyze the results of fourteen literature reviews that focus on RCM from the perspectives of business processes. As a result, they require future IS research to focus on real-life regulatory compliance scenarios and compliance enactment tasks, i.e., mechanisms to react to violation occurrences to re-establish compliance dynamically. Cleven and Winter (2009) focus on a broader and more aggregated perspective by including articles beyond business process management. Using the concept of EAM for their theoretical framework, they map the identified articles to the several EA layers. Their work reveals that there exists no holistic approach covering all EA layers. Abdullah et al. (2010) use expert interviews and a literature review to identify gaps between industry challenges and research solutions in RCM. They derive the need for benchmark studies, reference models, and knowledge of appropriate IT support. Volonino et al. (2004) highlight that holistic RCM has to be considered enterprise-wide and is beyond merely complying with specific rules. In contrast, it was about developing an integrated approach by identifying all relevant organizational elements and the relationships among them. In reality, financial institutes tend to implement isolated compliance solutions due to short-term deadlines set by regulators (Gozman and Currie 2015). The question arises, how to realize such a holistic and enterprise-wide RCM.

One topic of interest of IS research in RCM is compliance modeling, where legal requirements are identified (Kharbili 2012). Boella et al. understand methods from the discipline of requirements engineering as appropriate in this field. They think research lacks mechanisms for understanding legal reasoning and demand a dialogue among legal and industry experts (Boella et al. 2014). Further, Ghanavati et al. provide a method that enables the extraction of legal requirements from regulations and articulates them in a “Legal GRL” (goal-oriented requirements engineering language), which they use for compliant software development (Ghanavati et al. 2014).

Other prevalent research disciplines in RCM are ontologies and semantic web technologies. Abi-Lahoud et al. suggest using the language specification ‘Semantics of Business Vocabulary and Business Rules’ (SBVR) together with the knowledge of subject matter expert to interpret and represent regulatory statements in a common vocabulary (Abi-Lahoud et al. 2014). Further, Abdullah et al. present a cross-industry ontology for the RCM domain and see various application scenarios of it (Abdullah et al. 2016). In a more applicable approach, Elgammal and Butler use SBVR to develop a “Compliance Management Knowledge Base,” which incorporates structured knowledge from regulation, business, and compliance contexts. On this basis, they present a compliance rule manger (Elgammal and Butler 2015). Likewise, Ford et al. present an approach that automatically compares ontology-based rules (representing regulatory requirements) with operative data from financial organizations and generates compliance reports (Ford et al. 2016). Butler et al. provide a software prototype for RCM change management that supports financial organizations in change identification on compliance-related matters (Butler et al. 2015).

The articles discussed above provide technical insights from the IS research discipline in the RCM domain. Some contributions focus on the regulatory impact on organizational and operational structures. Boella et al. identify the need to map legal interpretations with business rules and processes and introduce a web-based knowledge management system called Eunomos (Boella et al. 2013). On Eunomos, researchers and practitioners map different law interpretations to processes and rules. The authors define a procedure for financial institutes to use it and provide an example with the MiFID directive. Kahrbili introduces a conceptual framework for RCM in the domain of business process management (Kharbili 2012). Becker et al. discuss how RM methods can be used by financial organizations to meet prior defined legal requirements (Becker et al. 2010). Still, they only provide a methodical sketch for the compliance reporting domain. Timm et al. go one step further and develop a reference process model for customer identification in the context of anti-money laundering directives (Timm et al. 2016a). The RM defines essential steps a financial organization should perform in order to be compliant with current laws and also states the process data necessary to do so. The authors focus on the internal behavior of organizations in RCM. However, since using a deductive approach, their RM is based on statements from legal texts or literature and may differ from actual real-life behavior of organizations as demanded by Akhigbe et al. (2015). Schlosser et al. (2014) present another reference model. They use a functional RM for business rules management for better Business-IT alignment by defining requirements for rule-based IS solution in the regulatory context. On a more global perspective, Foorthuis and Bos provide a strategical framework for implementing compliance means in an organization (Foorthuis and Bos 2011). Unfortunately, the high-level approach lacks concrete means of implementations. Further, Gozman and Currie emphasize the importance of means like early engagements between software vendors and compliance managers or holistic data management (Gozman and Currie 2014). By conducting a long-term study with several financial institutes, they derive eight IS capabilities for the implementation of a holistic GRC initiative (Gozman and Currie 2015). Their capability framework agrees with COFIN’s identified demand for a holistic RCM approach. Likewise, it emphasizes the vital role of information technology (IT) in the context of RCM.

In conclusion, the following statements summarize the current state identified in IS research:

- There is a need to include practical knowledge from financial institutes in RCM solutions (Abdullah et al. 2010; Akhigbe et al. 2015).
- There is no holistic approach for RCM realization from the perspective of EAM (Cleven and Winter 2009).
- The literature agrees that reference models support the implementation of holistic RCM (Akhigbe et al. 2015; Cleven and Winter 2009).
- The support of IS needs to be made more transparent in order to enable IT-supported RCM (Abdullah et al. 2010).

4.1.2.4 SUMMARY: LOCAL PROBLEM B AND RELATED RESEARCH GAPS

This section investigated the characteristics of Local Practice B. After presenting industry developments since the financial crisis in 2007, the section reported on the domain's recent problems, which bases expert interviews, a focus group, and telephones interviews. In short, practitioners agree that the regulatory system prone to ineffective and isolated implementation of critical regulatory requirements from the perspective of financial institutes. Although all stakeholders highlight the importance of a holistic RCM, inaccurate legal texts, insufficient knowledge, and a high rate of deadlines cause isolated and cost-intensive compliance programs. Current IS literature verifies the author's findings ascertained from practice. It further stresses the importance of IT systems that support the realization of RCM programs. Although the presented body of knowledge provides an initial EAM perspective on the problem, no holistic RCM approach is available. However, literature asks future endeavors to combine requirements from legal texts, generally accepted domain knowledge, and practical experience in order to develop domain-specific solutions—for instance, in the form of enterprise models—that support stakeholders to implement RCM programs on business, data, and IT level. In summary, one can conclude that practice and research agree on a need for a holistic RCM. Based on prior elaborations, the author suggests a RM that uses EAM concepts as a sensible solution.

4.2 GLOBAL PROBLEM AND ROOT CAUSE ANALYSIS

Based on the previous chapter, the next paragraphs will compare the investigations of both local practices, discuss their similarities, and will derive a global problem of general interest. Afterward, the relevance of the global problem is justified, as are the related problem stakeholders. In order to grasp the reason for the problem's existence, this chapter discusses the two root causes that represent the problem's core and shall be a starting point for any potential design solution. The final part of this section relates the problem to the research domains EAM and RM and discusses how they will contribute to solving it.

4.2.1 PROBLEM STATEMENT

The following Table 11 revisits the previous sections and summarizes the two local practices regarding selected aspects. As DSR demands it (Johannesson and Perjons 2014), these help to derive a global problem and enables to provide a distinct description of it. Next to a summary of the local problems, the table compares their origins and identifies relevant problem stakeholders. Further, it clarifies the role of IS in the problem context, summarizes the identified challenges, and compares them with available solutions from IS research literature. For a more profound investigation of the local practices, the author refers to section 4.1.

TABLE 11. SUMMARY OF LOCAL PRACTICES

ASPECT	LOCAL PRACTICE A (UTILITY INDUSTRY)	LOCAL PRACTICE B (FINANCIAL INDUSTRY)
Problem Summary	The utility industry lacks a solution that supports PUs in transforming their legacy organizational structures regarding changes in regulation and market. These transformation processes affect both PUs' business and IT architectures.	Financial Institutes need support in implementing an RCM that is characterized by integrating prior isolated compliance programs and capturing effects of regulation from an IT perspective aligned with organizational implementation.
Origin of the Problem	• Regulation: Market Liberalization, renewable energy act • Integration of new technologies like Smart Meters and Smart Grid • Market Changes: dissolution of monopolistic structures, lower entrance barriers	• Regulation: plethora of regulatory requirements • absence of concrete means to realize regulatory requirements • regulatory bodies force deadline-driven implementation
Problem Stakeholders	• Public Utilities (PUs; mainly SMEs) that occupy different combinations of the market roles • IS vendors • Business Process Outsourcing Providers	• Financial Institutes • IS vendors • IT consultancies
Role of IS	• IS perceived at the core of transformational processes • PUs' IT landscape becomes increasingly complex and heterogeneous • increasing amount of data to be processed	• almost all regulations go beyond the implementation of new compliance processes but rather concern data and IT architecture of financial institutes • effective and efficient compliance processes highly rely on IT systems (e.g., for fraud pattern detection)
Practice: Challenges	• SME PUs overwhelmed with need for organizational transformation • PUs lack an appropriate alignment of business and IT architectures • although PUs consider EAM as a useful tool, they assess it as too complicated, cost-, and time-intense to build EAM initiatives from scratch • experts state that necessary knowledge is not available	• isolated implementation of regulatory requirements predominant • institutes need support in holistic RCM that is resilient towards future regulatory change • need for practical knowledge since practitioners rate regulatory texts as an insufficient source of information • body of practical knowledge unavailable
ISR: available solutions	• majority of research activities concerns smart grid technologies and the integration of volatile renewables in the energy value chain • IS research agrees that changes affect all layers of PUs • related work develops reference models, but lacks a complete EA perspective • IS lacks methodological support for such a holistic reference model	• research agrees on reference models for RCM realization • empirical studies demand analysis of practical knowledge from financial institutes • research identifies the absence of a holistic RCM approach from the perspective of EAM • the support of IS needs to be made more transparent in order to enable IT-supported RCM

There exist similarities between the two problem contexts. In both cases, changes in an industrial environment pose certain groups of organizations with the challenges to cope with them. While these changes are different for each industry, practice and research in both domains agree that they affect the alignment of business and IT architectures of the respective addressees, i.e., financial institutes or PUs. After investigating the current situation in practice, one can observe that both groups of organizations fail to react appropriately due to case-specific reasons. Furthermore, domain experts lament an absence of detailed knowledge that helps these organizations to analyze how industrial changes affect them and to implement them on all levels of concern (i.e., business or IT perspective). By addressing a holistic approach, the author intends to understand how business, data, and IT perspectives are affected, how they relate to each other, and how that knowledge can then inform organizations about best practices to implement change.

The research fields of EAM and RM provide appropriate tools for such an effort (see chapter III). As section 4.2.4 will discuss in more detail, methods from EAM holistically capture business and IT perspectives of organizations, while RM methods help constructing IS models that provide solutions for a particular problem domain. These considerations form the basis for the problem statement that underlies this thesis. The remainder of this section discusses the global problem's relevance and studies its underlying root causes.

PROBLEM STATEMENT OF THIS THESIS
REFERENCE MODELS, ESPECIALLY REFERENCE ENTERPRISE ARCHITECTURES (REA), SUPPORT ENTERPRISES OF A PARTICULAR PROBLEM DOMAIN TO OVERCOME THE CHALLENGES OF INDUSTRIAL CHANGE. REAS PROVIDE A SOLUTION FOR AFFECTED ENTERPRISES BY INTEGRATING BOTH BUSINESS AND IT PERSPECTIVES IN THE CONTEXT OF THAT CHANGE. FURTHER, THEY OFFER MEANS HOW THESE ENTERPRISES CAN REUSE THAT KNOWLEDGE. HOWEVER, PRACTICE LACKS METHODOLOGICAL GUIDANCE HOW TO DEVELOP REAS SYSTEM-ATICALLY.

As can be seen from the prior elaborations, the problem is relevant in at least two concrete local practices. Furthermore, the author learned about other related practices in the course of his DSR project. For instance, developments in the telecommunications industry show some similarities. Here, new technologies and an increasing competitiveness force market actors to transform their strategies, business processes, data, and application landscapes (Czarnecki and Dietze 2017c). Hence, the author claims that the above problem statement is of general interest, as demanded by Johannesson and Perjons (2014).

4.2.2 PROBLEM STAKEHOLDERS OF PRACTICES

While the industrial changes in the different problem contexts affected different groups of organizations, three general problem stakeholders turned out to be relevant from a global perspective. The first stakeholder group consists of the *organizations* directly affected by this change. They are at the center of the global problem as industrial change primarily addresses them. The second stakeholder group considers all different *business partners* of these organizations. Industrial change may affect them directly or indirectly, too. For instance, ISVs need to align their software products' interfaces in compliance with the latest data exchange formats. Likewise, BPO providers should ensure that they execute business processes according to frequently changing legal requirements. The author further considers business and IT consultancies in this second stakeholder group as they might require updating their domain knowledge in a short time to ensure their competitiveness. Especially since this work's problem statement regards towards change processes addressing both business and IT processes, these business partners play an essential role in the development of an appropriate solution. As a third and last group of problem stakeholders, the author considers *governmental or instituteal bodies*. For instance, governmental institutes regularly enact new laws, which force the industrial change. Moreover, industry-specific federations may be involved since they aim to support their members in organizational development and industry-wide cooperation.

These groups of problem stakeholders emerged during the different research activities of the problem investigation. While the list represents the authors' interpretation based on the two local practices, all identified stakeholders occurred in the problem contexts and were involved in the research projects. Table 12 makes this more transparent. In the context of the two research projects ECLORA and COFIN, the author interacted with these stakeholders, as documented in the table. The respective stakeholders of both local practices provided different perspectives on the problems at hand. These insights validated the importance of the problem, as documented in the respective section 4.1.1 and section 4.1.2.

TABLE 12. STAKEHOLDERS OF PRACTICES

LOCAL PRACTICE	STAKEHOLDER GROUP	INVESTIGATION METHOD
Local Practice A: Public Utilities	Affected Organizations: four SME Public Utilities	Modeling Workshops and Interviews
	ISV, consultancy, and BPO Provider: SIV group	project partner, expert interviews
Local Practice B: Regulatory Compliance in Financial Services	Affected Organizations: financial institutes	telephone interviews, modeling workshop
	ISVs and IT consultancies: bitkom working group 'financial services compliance	focus group, expert interviews
	governmental or instituteal bodies: four banking federations	telephone interviews

In conclusion, this list of stakeholder groups neither intends to be complete nor mandatory for each practice related to the global problem. Instead, the author provides it in order to grasp a complete understanding of potential industrial actors affected by such problem contexts. However, the constellation of relevant market actors may differ between different local practices.

4.2.3 ROOT CAUSE ANALYSIS

While the prior sections provided the problem statement and its involved problem stakeholders, the next step was to identify the problem's underlying root causes. As presented earlier section 2.1.2, identifying root causes aims to identify phenomena that cause it, helps to decompose it further into aspects a possible solution has to address, and avoids a solution from only tackling a problem's symptoms (Rittel and Webber 1973, p. 165). From the author's understanding, the most important source for such root causes are the problem stakeholders. Therefore, the author used different points of time during the problem investigation and even during subsequent DSR activities to analyze the domain knowledge of project partners and translated it into root causes. Before, a fishbone diagram helped to identify and document different categories for potential causes. This list of categories then served as a basis to investigate the local practices for root causes. The list consisted of the following categories:

(i) specific market dynamics cause industrial change (e.g., technological trends)
(ii) the legal environment around the industry
(iii) the capabilities of affected organizations to understand the consequences of change
(iv) the absence of knowledge necessary to identify possible solutions for implementing these changes
(v) communication and cooperation among stakeholders

During this DSR project and after consultation with several problem stakeholders, the author eliminated categories (i) and (ii). Although market dynamics or regulatory requirements might trigger the need for industrial change in a concrete problem case (as seen in both local practices discussed earlier), stakeholders and the author agreed that a particular trigger for change does not qualify as a root cause. While disruptive technologies or a new legal framework may cause industrial change, one cannot dismiss the possibility that the same systematic approach enables implementing change in both cases. Likewise, category (v) did not qualify for a root cause, either. Experts and surveyed organizations from both local practices mentioned a need for improved cooperation among involved stakeholders. In Local Practice B, financial institutes desired better cooperation on the part of regulatory authorities and auditing companies.

In contrast, long-term research projects situated in the domains of both local practices showed that cooperation does exist (Karg et al. 2014). Discussions with members of the focus group from Local Practice B then hinted that—although there may exist room for improvement of stakeholder cooperation—this may be a side effect of the fact that no systematic approach exists. In the end, this step of the problem investigation identified two root causes related to categories (iii) and (iv). Table 13 summarizes them and relates them to the research methods conducted to elicit them during the two research projects ECLORA and COFIN.

In the early phase of this DSR project, the domain experts and responding PUs from Local Practice A agreed that within the problem domain, no undertakings existed that envisioned to develop a RM capturing a complete picture of best practices for PUs after the market liberalization and revealing the role of IT landscapes. All parties lamented the absence of an overall approach to providing such a solution. Reports of the E-Energy project further strengthened this observation, which reflected on their procedure and explicitly stated an absence of a methodological basis (Karg et al. 2014). In Local Practice B, the author identified a similar situation. Although participants of the focus group were experts from

ISVs and consultancies, an approach to develop models that capture the dependencies among business and IS levels was absent. Relevant IS research literature in the domain confirmed this observation, as documented in section 4.1.2.3. In conclusion, the author identifies the absence of appropriate methodological support as RC1 of the problem statement.

In both practices, the stakeholders described the lack of depth in knowledge as one central problem. While in Local Practice A is characterized by an absence of available information regarding business processes and supporting IS, Local Practice B primarily lacks necessary data structures for a holistic solution. In both cases, the stakeholders complained about an insufficient detail of available general knowledge. In consequence, the impediment for success was to gather knowledge from practice, and the author formulated RC2.

TABLE 13. IDENTIFIED ROOT CAUSES OF THE PROBLEM

ROOT CAUSE	DESCRIPTION	SOURCE
RC1	Organizations lack methodological support to capture the impact of industrial change from business, data, and IS perspectives, as these endeavors are complex and resource-intensive.	**ECLORA:** • Expert Interviews (ISV experts), • Survey (SMEs), • Literature (E-Energy) **COFIN:** • Focus Group (ISV experts, IT consultants), • Literature
RC2	Detailed knowledge for such endeavors is seldom available in explicit form, since most companies fall short on documenting beyond business processes and further tend to implement isolation solutions.	**ECLORA:** • Expert Interviews (ISV experts), • Survey (SMEs), **COFIN:** • Focus Group (ISV experts, IT consultants), • Literature

4.2.4 GLOBAL PROBLEM IN THE CONTEXT OF RELATED RESEARCH DOMAINS

According to Johannesson and Perjons (2014), a solution to a design problem has to address the problem's underlying root causes. Therefore, this section first relates the identified problem statement to contributing IS research domains. In concrete, it will shortly argue why the author understands EAM and RM as an appropriate means to address RC1 and RC2. For reasons of conciseness, the following paragraphs only present established knowledge from the two domains that support this argumentation. The author refers to the first part of this thesis, where chapter III discussed concepts, methods, and current research insights from RM and EAM.

From a solution design perspective, addressing RC1 implies considering three aspects. First, a possible solution needs to provide the means to capture the impact of industrial change in a holistic picture. As depicted earlier, such a holistic picture means comprehending the need for organizational change from business, data, and IT perspective as well as the dependencies among these perspectives. Second, RC1 points out that a solution shall provide a systematic approach to gather reliable knowledge for the holistic picture. Third, the application of the holistic picture shall be feasible for the organizations affected by the industrial change.

Concerning the first aspect of RC1, IS literature understands EAM to be an effective means. In general, EAM is a management discipline to provide a coherent understanding of an enterprise by aligning goals, roles, processes, and IT alignment (Op't Land et al. 2009; Winter 2014). Several authors agree that EAM is a powerful tool to overcome external pressures inflicted by environmental changes (Lankhorst et al. 2017; Greefhorst and Proper 2011; Gong and Janssen 2019) and to implement faster strategic change (Ahlemann et al. 2012). There further exist empirical studies that attribute EAM with the following benefits:

- the dissolution of information silos (Aier et al. 2011),
- fewer inconsistencies and redundancies through transparent IT functionalities (Aier et al. 2011),
- EA models lead to a better understanding of complex interactions of business operations, technical systems supporting them, information technology, information flows in comparison to traditional documentation available in organizations (Franke et al. 2018)

Regarding the latter two aspects of RC1, IS research provides methods developed in the domain of RM. As a RM is defined to provide a reusable IS model that incorporates recommending practice for a specific group of stakeholders in a particular problem domain (Thomas 2005). IS researchers do agree that the principal value of reference models is to make the design and development of information systems more efficient and effective (Schütte 1998; Fettke and Loos 2004c). Some research provides economic metrics that concretize this, as they attribute reference models with a decrease in costs due to the reusability, a decrease of modeling time for enterprise-specific models, an increase of the IS quality, a competitive advantage, and a decrease in modeling risk (Becker and Knackstedt 2003; Fettke and Loos 2006). Although IS research lacks empirical evidence for these claims, researchers agree on them.

The second root cause RC2 shows that—next to a methodological approach—available explicit knowledge is absent. The research domain of EAM suggests several techniques to elicit EAM relevant practical knowledge from involved stakeholders or IT systems holding it and structure it in an EA model. Next to typical interview techniques, participative enterprise modeling is an established method to not only define process models or enumerate utilized IT systems, but rather to make their interdependencies transparent by bringing different problem stakeholders together (Stirna et al. 2007). These possibilities still lead to the challenge of using a sufficient and reliable quantity of practical knowledge to derive a model that represents universally valid and reusable knowledge. The RM domain recently proposes methods to derive IS models that capture best practices based on a body of practical knowledge (Rehse et al. 2016). While this research stream (cf. inductive RM in section 3.2.2.2) is still immature and primarily focused on business process models, it is worth exploring when designing a possible solution.

To conclude, the research domains of EAM and RM are arguably appropriate starting points for a more detailed KBA. Consequently, the following chapter will report on the results of a systematic literature review (SLR). The review aims to discover available solutions that contribute to a potential solution for this work's problem. Since the above elaborations identified RC1 and RC2, the next chapter analyzes the existing body of knowledge that combines concepts and methods from EAM and RM. Therefore, the subsequent SLR will synthesize recent insights on REAs and how to develop them.

4.3 KNOWLEDGE BASE ANALYSIS—A SYSTEMATIC LITERATURE REVIEW

As the previous sections investigated, this thesis addresses the problem of providing methodological support to develop a domain-specific REA that originates from practical knowledge elicited in the respective problem domain (cf. root causes established in Table 13). Before developing a solution to this problem, this section aims to analyze the current body of knowledge for potentially reusable solutions (Johannesson and Perjons 2014, p. 94). During a first explorative literature search, the author recognized that—while there exists a plethora of knowledge for developing reference models (see chapter III)—research seems to lack methodological guidance tailored to develop REAs. However, some articles hinted at an increasing research interest in developing reference models for architectural description in general (Cloutier et al. 2009) or enterprise architectures in specific (Czarnecki and Dietze 2017c). In order to analyze and structure the existing body of knowledge in more detail, this chapter conducts a systematic literature review (SLR). The overall objectives of the SLR are (i) to structure recent research insights in the domain of REA, (ii) to identify research gaps concerning the thesis' problem, and (iii) to reveal existing knowledge that may support the design of a potential solution.

Although this chapter presents the SLR's process and its findings in a linear way, the SLR process iteratively spanned in different phases over multiple years. During this process, four input factors influenced the presented SLR. First, the starting point of the SLR was a literature search conducted in the spring of 2016. At that point, the author just finished investigating Local Practice A (see section 4.1.1). Hence, the problem investigation was still in progress. A full-text review of the search results identified ten relevant articles and analyzed them systematically. Meanwhile, the author continued the problem investigation participating in the research project described in Local Practice B (see section 4.1.2). Second, an SLR was published by Sanchez-Puchol and Pastor-Collado (2017) in the proceedings of the 11th Mediterranean Conference on Information Systems in Genoa, Italy. Their work reviewed IS research on *"enterprise reference architectures"* and focused on some aspects that match the purpose of this SLR. Nevertheless, the review's scope was too broad to discover available methods for REA development. As this section will reveal, it further missed some critical literature in the domain while it also included general EA literature, which might distort the review's conclusions. Third, during the period from 2017 to 2019, the author identified additional relevant articles and collected them in a separate literature database. The author identified them at IS conferences, discussions with colleagues, or recommendations of platforms, such as *researchgate*[1]. Fourth and last, the author conducted a second SLR in 2019. The rationale behind this decision was that (a) the SLR published by Sanchez-Puchol and Pastor-Collado (2017) identified a slightly increasing research interest in the field of REA and (b) the author recognized additional relevant publications after 2017. The remainder of this chapter will document this second SLR in detail, which resulted in 27 relevant papers in total. However, the selection process provides transparency in which articles of the final set originated from which of the four stated input factors. In doing so, the chapter complies with the SLR's claim to be reproducible (Fink 2010).

The remaining structure of this chapter follows the five phases, as proposed in the framework for literature reviewing by Vom Brocke et al. (2009). After section 4.3.1 first presents how this SLR instantiated these five phases, section 4.3.2 argues about the SLR's detailed scope and its underlying research questions. Section 4.3.3 then presents the developed conceptual framework forming the basis to analyze the knowledge base. Afterward, section 4.3.4 describes the paper selection process before section 4.3.5 discusses the results of the paper synthesis of the 27 identified articles. On this basis, section 4.3.6 assesses the findings from the knowledge base analysis (KBA) concerning the research problem in order to derive research gaps. Finally, these will inform the design of a potential solution and, thus, provide input to formulate the research question of this work.

4.3.1 STRUCTURING THE SLR

Before presenting the results of the SLR, this section shortly summarizes the procedural approach of the literature review. While section 2.2.3 established the methodological basis for conducting SLRs, this section documents the concrete actions taken in the different phases of this thesis' SLR.

As discussed in the research design (see chapter II), Vom Brocke et al. (2009) distinguish five phases for conducting literature reviews: *(i) definition of review scope, (ii) conceptualization of topic, (iii) literature search, (iv) literature analysis and synthesis,* and *(v) research agenda*. The rationale behind choosing this procedure was that the approach explicitly states a phase for developing a conceptual framework before literature search. Although the final version of that framework evolved during the general SLR process, it helped not only translating RQs into more specific review aspects for the literature analysis, but also supported the decision process during the paper selection. Figure 27 visualizes how this SLR conducted the five phases. In order to make the process of this SLR more replicable, the figure structures the phases into several steps representing the concrete actions taken in the respective

[1] see https://www.researchgate.net/ (accessed 09/07/19)

phase. As indicated in the figure, these originated from the guidance of other theoretical work on SLR in the IS discipline, such as Bandara et al. (2015), Kitchenham (2004), or Webster and Watson (2002).

Vom Brocke et al. (2009) assess **phase (i)** as an essential step in conducting literature reviews. Here, the reviewers shall concretize the review's scope in order to clarify its intentions and to bear implications for the later search process and accompanying decisions. Beforehand, the approach at hand integrated *step 1* that discusses the actual need to conduct an SLR in the first place, as is discussed by Petticrew and Roberts (2006), Okoli (2015) and Kitchenham (2004). Therefore, the author searched for similar SLRs and analyzed them regarding this SLRs overall objective (see above).

Section 4.3.2 presents these results and argues that, while Sanchez-Puchol and Pastor-Collado published an akin SLR in 2017, a complementary SLR in the light of this thesis is necessary. Subsequently, in *step 2*, the section then concretizes the SLR's scope by applying the taxonomy for literature reviews proposed by Fettke (2006). That taxonomy defines characteristics of SLRs in the domain of IS research and builds on prior published taxonomies, such as the one from Cooper (1988). After making the SLR's intentions transparent, step 2 further defines its underlying research questions. Kitchenham (2004, p. 11) says that the review of a Ph.D. thesis shall identify the current state of knowledge in the respective domain and concretize where the proposed research fits into the analyzed body of knowledge.

Before searching for relevant literature, **phase (ii)** shall lay a broad conception of the topic, which includes central concepts of the review's scope and aspects that translate the intentions of prior defined RQs into specific analysis aspects (Vom Brocke et al. 2009). Therefore, *step 3* aims to identify what concepts to address during the literature analysis. The starting point for this step was the problem statement, the identified root causes RC1 and RC2 (see section 4.2.3), and the conceptual matrix used by the related SLR (Sanchez-Puchol and Pastor-Collado 2017) found during step 1. Comparing the matrix with the intentions of the RQs from step 2, the output of step 3 was a list of relevant concepts that guided data extraction during step 8. In order to put these concepts into a clear framework, *step 4* structured them in a conceptual framework. Therefore, the RQs, as well as elaborations from chapter III guided its overall structure. As a result, this phase ensured the SLR at hand followed a concept-centric approach, as proposed by Webster and Watson (2002). From a coding perspective, the conceptual framework consisted of deductively elicited codes at that moment in time (Bandara et al. 2015). However, while extracting the data later during step 8, these codes were further refined inductively. Section 4.3.3 presents the resulting conceptual framework.

After clarifying the scope and concepts under investigation, Vom Brocke et al. (2009) define the search process in **phase (iii)**. While the authors recommend to start searching for articles in fitting journal outlets, relevant databases using appropriate keywords, and performing back- as well as forwards searches of identified relevant articles, this SLR follows the steps of Kitchenham (2004) to perform the literature search. The rationale behind that decision was that the author understands Kitchenham's approach to be more precise in terms of traceability. The following three steps guided the process of phase (iii). *Step 5* develops an overall search strategy. This included identifying appropriate literature databases indexing articles from the associated domains of EA and RM as well as specific journals and conference proceedings. Moreover, the step conducted initial test searches to populate an appropriate search term. These searches iteratively adjusted the search term adding keywords from relevant articles identified during the process. Simultaneously, a first list of inclusion and exclusion criteria for the later paper selection step evolved. As suggested by Kitchenham (2004), using a review protocol helped to document the findings of this step. After finalizing the search term, *step 6* conducted the actual search. Due to the seemingly immature nature of the REA domain (Sanchez-Puchol and Pastor-Collado 2017), the SLR at hand uses a topic-oriented search strategy (Webster and Watson 2002, p. 16).

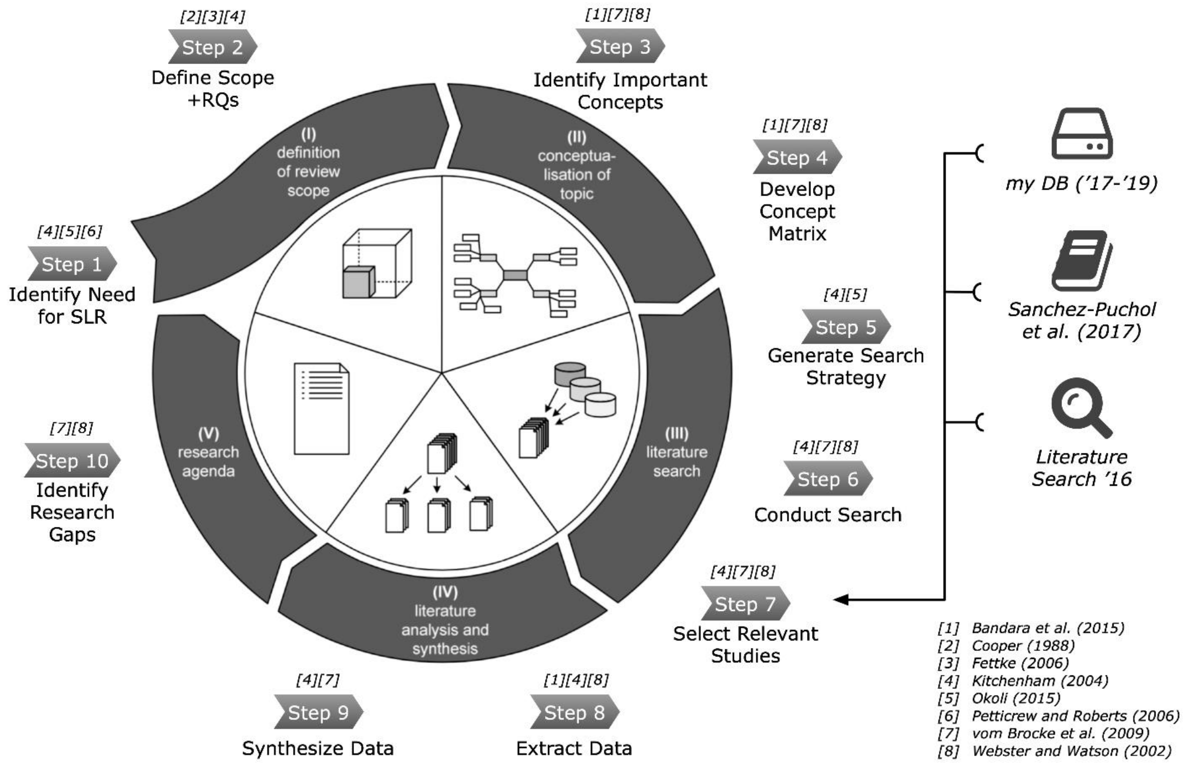


FIGURE 27. SLR PROCESS ADAPTED FROM VOM BROCKE ET AL. (2009)

Consequently, the literature did not focus on particular research outlets, such as specific journals or conferences, but applied the search term on the databases Scopus[1], Google Scholar[2], and SpringerLink[3]. Subsequently, *step 7* selected relevant articles from the data set retrieved during the previous step. Based on the RQs and the developed conceptual framework, the data set of articles passed several rounds of selection, as section 4.3.4 documents. During these selection rounds, the initial list of exclusion and inclusion criteria grew inductively (Kitchenham 2004; Okoli 2015). In addition to the articles retrieved in step 6, the other three sets of articles collected during the Ph.D. project passed this selection process. As explained above in section 4.3, these were the references from Sanchez-Puchol and Pastor-Collado (2017), the search conducted in 2016, and the literature database accumulated during 2017 and 2019. Figure 27 indicates this on the right-hand side. After selecting relevant articles, step 7 further conducted a back- and forward search for each identified article, as proposed by Webster and Watson (2002). In order to minimize bias of the review, articles relating to the same study or set of data were merged into one unit of analysis for the data extraction during phase (iv) (Kitchenham 2004, p. 23). Section 4.3.4 reports on the literature search by providing the final search term, presenting the data retrieved, and explaining the selection process in detail, including the search conducted in 2016.

For literature analysis and synthesis in **phase (iv)**, Vom Brocke et al. (2009) suggest using a topic-centered approach (Webster and Watson 2002). Therefore, this phase covered two subsequent steps. S*tep 8* iteratively extracted data for each unit of analysis from phase (iii) regarding the review aspects covered by the conceptual framework from phase (ii). A unit of analysis was either an article identified during the selection process or a merged sample of articles relating to the same study or data set. A review aspect relates to the codes defined in step 4. During the data extraction, the author made different observations. While a unit of analysis could contribute to a specific review aspect or not, it sometimes occurred that it provided very detailed information for one review aspect. In some cases, the author

[1] see https://www.scopus.com/ (accessed 16/07/19)
[2] see https://scholar.google.de/ (accessed 16/07/19)
[3] see https://link.springer.com/ (accessed 16/07/19)

decided to divide these review aspects into sub-codes, if that unit of analysis provided enough information. In other cases, the author extended the conceptual framework by a new review aspect because the discovered concept added value for answering an RQ. Thus, next to the data extraction, step 8 also inductively extended the codes and sub-codes of the conceptual framework from phase (ii).

After the extraction process, *step 9* synthesized the extracted data in order to answer the review's RQs. Therefore, the author performed a descriptive synthesis using the conceptual framework populated with the data from the units of analysis (Kitchenham 2004, p. 24). Section 4.3.5 summarizes these findings regarding the several RQs. On this basis, the last **phase (v)** of the SLR aims to derive a research agenda Vom Brocke et al. (2009). According to Webster and Watson (2002), the resulting agenda shall provide more insightful questions for future research in the topic under investigation. In the case of this SLR, *step 10* intended to summarize knowledge that is potentially reusable for a solution design for the prior identified research problem. Further, it intends to unfold research gaps in the development of REAs a solution shall address.

4.3.2 PHASE I: DEFINING THE SLR SCOPE

This section presents the results of the two steps of phase (I). Doing so, it argues why a new SLR was necessary in the light of this work, provides the SLR's scope, and defines the underlying research questions (RQs). Before discussing the SLR's necessity, this section shortly presents its overall purpose. The SLR builds on the findings from the theoretical foundation in chapter III and the problem investigation from section 4.2. The overall intention is to analyze current IS research activities from the research fields of EAM and RM regarding available solutions that address the identified root causes of the problem statement. Hence, the objective of the SLR is to identify approaches and insights for REA development. In concrete, the SLR analyzes if the body of knowledge provides means for methodological support (RC1) and knowledge elicitation (RC2) in the context of REA development. Therefore, the SLR intends to provide insights regarding the following aspects:

- **ASPECT 1:** How does current IS literature define REAs?
- **ASPECT 2:** What approaches in the domain of REA development exist, and how can they be reused to design a solution? Does literature distinguish between methods for REA construction and application?
- **ASPECT 3:** How does related work elicit knowledge for REA development?
- **ASPECT 4:** How does related work structure and document REAs?
- **ASPECT 5:** What gaps in current IS literature do exist in the domain of REA development?

According to Kitchenham (2004, pp. 6–7) and Okoli (2015), identifying gaps in current research is a valid reason to perform an SLR. Webster and Watson (2002, p. 14) say that one can conduct SLRs either in mature research domains or emerging ones. The SLR at hand relates to the latter and, therefore, aims to give the field of REA an initial structure.

STEP 1: IDENTIFY THE NEED FOR THE SYSTEMATIC LITERATURE REVIEW. As discussed in section 4.3.1, one should assess the actual need for an SLR before conducting such a resource-intense endeavor. Most guidelines for conducting SLRs therefore recommend starting to search for available SLRs that relate to the topic under investigation. Thus, the author searched for related SLRs. First, he utilized search term covered the three domains of *reference modeling*, *enterprise architecture management,* and *literature review*:

```
(reference NEAR/3 ("enterprise architecture" OR "enterprise model"
OR architecture))
AND
("literature review" OR "literature analysis")
```

Since the main objective was to identify SLRs regarding reference models that use EA structures, the term searched for results that used the term "reference" in the proximity of "(enterprise) architecture" or "enterprise model." Using that query excluded the research that focuses, for instance, on reference process models (see chapter III). In order to limit results not only to SLRs, the second part of the search term contained the synonyms *"literature review"* and *"literature analysis."* Second, the author applied the search term to four databases: Scopus, Google Scholar, ACM DL[1], and SpringerLink[2]. For each search, the search term was adjusted towards the database's syntactic specifics and applied to title, abstract, and keywords. Table 14 illustrates the database-sensitive search terms and documents the number of retrieved articles. The author performed the search in May of 2019.

TABLE 14. SEARCH RESULTS PER DATABASE FOR IDENTIFYING RELATED SLRS

DATABASE	SEARCH STRING	#RESULTS	#RELEVANT
Scopus	`(reference W/3("enterprise architecture" OR "enterprise model" OR architecture)) AND ("literature review" OR "literature analysis")`	26[3]	0
Google Scholar[4]	`(intitle:(reference AROUND(3) (enterprise AROUND(3)(architecture OR model))) AND (intitle:"literature review" OR intitle:"literature analysis")`	14	1
ACM DL[5]	`acmdlTitle:("reference enterprise architecture" OR "enterprise reference architecture" OR "reference enterprise model")`	1	0
Springer Link[5]	`("reference enterprise architecture" OR "enterprise reference architecture") AND ("literature analysis" OR "literature review")`	39	0
	Σ	**80**	**1**

For each item, the metadata and abstracts were stored in an excel table, using the CSV-export provided by the respective database. Each retrieved item passed through a title and abstract review and—in cases of uncertainty—the author scanned the full text. From the total of retrieved 80 articles, only one item related to the purpose of this SLR and, thus, was relevant: Sanchez-Puchol and Pastor-Collado (2017). The most common reason for exclusion was that the items did not provide a literature review in the first place. Further, the majority of items lacked a concrete focus on EA concepts. For instance, they developed reference software architectures or reference process models. While some retrieved articles provided insights in developing REAs, these lacked a literature analysis but focused on specific REA applications.

Kitchenham (2004, p. 9) does explicitly state that a new and appropriate SLR of quality, which addresses the same scope of the current SLR endeavor, dismisses the need for a new SLR. Consequently, one might assume that the availability of the SLR by Sanchez-Puchol and Pastor-Collado (2017) dismisses the necessity of this thesis' SLR. However, following this argumentation requires assessing the

[1] *Association for Computing Machinery Digital Library; see https://dl.acm.org/ (accessed 17/07/2019)*

[2] Although Scopus in fact indexes articles from SpringerLink, Springer states that Elsevier Scopus might make editorial decision that lead to not indexing all their articles. Thus, one cannot guarantee that all articles are found using scopus (see https://www.springer.com/gp/computer-science/lncs/information-on-abstracting-and-indexing/799288).

[3] Scopus also listed Journal Issues or Conference Proceeding. These numbers present the amount of results cleaned up regarding to this.

[4] The operators for this query were ajdusted using the guide from https://ahrefs.com/blog/google-advanced-search-operators/ (accessed 11/05/19)

[5] as ACM DL and SpringerLink lack a mature search interface, the search was restricted to the search query as indicated

quality of their SLR and comparing its scope with the SLR at hand. Therefore, the author assessed whether the SLR by Sanchez-Puchol and Pastor-Collado (2017) provides insights that answer the above stated RQs. Further, the section evaluates its overall quality using guidelines for critically appraising review articles (CRD 2009). On this basis, the author argues whether this KBA needs a new SLR from scratch, or the work by Sanchez-Puchol and Pastor-Collado (2017) already provides the depths that are sufficient for this section's purpose. In concrete, the author analyzed the related SLR regarding its objectives, the checklist from (CRD 2009), and the results presented in comparison to this work's scope. Deciding whether to perform an additional SLR more transparent, the subsequent paragraphs discuss similarities as well as differences between the SLR by Sanchez-Puchol and Pastor-Collado (2017) and this work. Thereby its qualities and flaws are exposed. The remainder of this section will refer to the SLR as "rSLR" (i.e., related SLR).

The main goal of the rSLR is to *"identify, organize, and classify high-quality studies addressing knowledge related to the topic of ERA"* (Sanchez-Puchol and Pastor-Collado 2017, p. 2). The authors use the term "enterprise reference architectures" (ERA), while they address the same concept as an REA. For means of comprehensibility, this work refers to both using "REA." The rSLR intends to contribute to a better understanding of the field of REAs and aims to provide directions for plausible future research opportunities of the topic. Its analysis framework builds on four RQs, which investigate (i) the notion of REAs, (ii) REA adoption in practice, (iii) REA design, implementation and management, and (iv) the impact of REAs. This section shortly summarizes the rSLR's results regarding these RQs and compares them to the above-mentioned review aspects.

In order to synthesize the data of discovered REA related literature, the rSLR develops a conceptual matrix that structures each RQ into several codes. In their data synthesis regarding *(i) the notion of REAs*, the authors provide an overview of available definitions. While they point out that there exist no commonly accepted definitions, they identify the definition provided by Harmsen van der Beek, Wijke ten et al. (2012) as the most concrete. Further, they expose contrary definitions, which they delineate from their conception of REAs, such as the one by Fattah (2009). The rSLR provides a comprehensive list of building blocks for REAs claimed by identified literature to concretize the REA concept (Sanchez-Puchol and Pastor-Collado 2017, p. 10). Their results regarding *(ii) REA adoption* in practice distinguish between adoption factors, success factors, stakeholders, and uses. By extracting critical success factors from their data set, the authors provide a first step towards a management approach for REAs, e.g., ownership or maintenance aspects of REAs. They further enumerate potential usage scenarios for REAs and discuss adoption factors deduced from the data set. However, the significance of these results remains a doubt. Although the rSLR provides a sensible list of adoption factors for REAs, it remains unclear whether these factors are drivers that cause the need to develop an REA, or they determine when organizations are likely to apply an available REA (e.g., regulatory changes and mergers/acquisitions respectively). Their list of usage scenarios is mostly owing to one source that investigates the EAM usage in general (Niemi and Pekkola 2017). Thus, the author of this work questions their transferability to the concept of REA. In order to address its third RQs *(iii) REA design, implementation, and management approaches*, the rSLR analyzes the data set for REA design, mapping, and selection methods. While the authors register that available approaches for REA development agree in combining theoretical and practical knowledge, they do not expand on this aspect any further. They identify only a few articles that focus on methodological work[1] and derive a need for prescriptive knowledge for REA development and formulate first demands towards methodological support, such as REA model construction or application models to compare a concrete EA solution with an REA (Sanchez-Puchol and Pastor-Collado 2017, p. 11). Concerning the *(iv) impact of REAs*, the rSLR subdivides the aspect into benefits when applying REAs and empirical work in general. While the synthesis presents an extensive list of

[1] The rSLR identified five articles for their third RQ, from which three were published by the author of this thesis.

REA benefits, it highlights a lack of empirical evidence behind it. These findings agree with research from the domain of RM, where, although research agrees on the different benefits that come with applying reference models, almost no work exists proving their validity (Timm 2018a).

Comparing these results with the five aspects enumerated at the beginning of this section, one can conclude that the overall objective of the SLR by Sanchez-Puchol and Pastor-Collado (2017) matches with the objective of this KBA. The results of all RQs inform a potential artifact that addresses the problem statement elaborated in section 4.2.1. Especially rSLR's findings regarding the notion of REAs, its core components, critical success factors, and benefits are helpful to design methodological support for REA development. Furthermore, the authors point out that future research in the REA field should provide prescriptive knowledge in order to improve the research field's maturity. This finding underlines the relevance of this thesis as it addresses the need for method support for REAs. However, the rSLR does not cover some very relevant aspects of this KBA. In concrete, the rSLR misses analyzing how related work elicits and uses practical knowledge to construct REAs and how research designs REAs in detail. Further, some articles from the rSLR's data set provides insights the authors did not integrate in their synthesis. For instance, Czarnecki and Dietze (2017a) report on how they combined RM and EAM methods to develop an REA for the telecommunications industry.

Looking from the perspective of 2019, the author argues that this chapter would benefit from updating the rSLR. The argumentation refers to the CRD's checklist for quality literature reviews (CRD 2009). Hence, this work assesses the rSLR's quality regarding its search process in general, the paper selection process and its documentation, and data extraction and synthesis.

Overall Search Process. The rSLR uses a high diversity of relevant sources to employ the search term, which ensures to cover a wide range of potential outlets. Further, the authors' decision to relax their publication type exclusion criteria and to include books, a master thesis, and an expert's blog post is reasonable (Sanchez-Puchol and Pastor-Collado 2017, p. 6). Nevertheless, the employed query seems to have room for improvement. The authors searched within title, abstract, and keywords for the exact phrases *"enterprise reference architecture"* or *"reference enterprise architecture."* To the knowledge of the author, the search term is quite restricting. As the rSLR pointed out, the literature lacks a well-established definition of the REA concept. Thus, there might exist related work that uses other terms than the above mentioned to describe the same concept. For instance, a well-documented REA is provided by Czarnecki and Dietze (2017c), while they use the term *"reference architecture."* Moreover, the rSLR searched in April 2017. Thus, there are two years between the rSLR and this KBA. As shown later, relying on the rSLR's literature base might miss relevant knowledge published between 2017 and 2019.

Paper Selection & Result Documentation. The rSLR documents its selection process in a very transparent manner. The authors show the number of retrieved articles per literature source and review cycle and enumerate used criteria for in- and exclusion. Further, they perform a back- and forward search that added ten relevant articles. However, some room for improvement exists. Six articles of their identified articles solely focus on EA research and do not cover REAs. Using these in a literature basis of overall 20 research items will distort the data synthesis and, thus, might lead to misinformed conclusions.

Data Extraction & Synthesis. The rSLR provides a very transparent data extraction. Their synthesis builds on a conceptual matrix that evolved from the defined RQs. The authors use a deductive-inductive mixed approach to identify the codes of the matrix. For categorizing descriptive information, they used known taxonomies, e.g., the taxonomies by Recker (2013) for utilized research methodologies. Although one might cast doubt on some of the used codes (see above), the resulting matrix provides a first structure of the REA domain and, thus, contributes to the body of knowledge.

Petticrew and Roberts (2006, p. 28) argue that a SLR is not appropriate, if: (i) other SLRs are already available; (ii) there exist only a limited amount of primary studies in the area; (iii) only vague RQs can be asked; (iv) the estimated value created by the SLR does not justify the effort for conducting it. Concerning (i) and (ii), a new standalone SLR might not be appropriate for this Ph.D. thesis since the SLR presented by Sanchez-Puchol and Pastor-Collado (2017). However, analyzing the rSLR, it only answers some aspects of this KBA and seems to omit relevant literature that is important to develop an informed solution for the global problem of this thesis. Consequently, this SLR builds on the rSLR and extends it. Therefore, this KBA conducts a new search, adjusts the conceptual matrix from the rSLR, and presents a new data synthesis. In this way, it aims to minimize SLR's effort.

STEP 2: DEFINE SCOPE AND RESEARCH QUESTIONS (RQS) OF THE SLR. Before concretizing its underlying RQs, this section explicates the intentions of this SLR using the morphological box for literature reviews in IS research, which is proposed by Fettke (2006, p. 259). Table 15 shows eight characteristics of an SLR. From a general perspective, this SLR explicitly aims to integrate knowledge created in the IS domain for REA development, meaning that the SLR focuses not only on precisely stated research outcomes, but also on used or developed theories in related work as well as on documented experiences, e.g., while applying a developed REA in practice. Since relevant literature will provide knowledge in the form of design artifacts (methods or models), conceptual work, or case studies, this SLR will result in insights based on natural language. Doing so, the SLR will present the identified knowledge from a neutral perspective. As will be shown in section 4.3.4, it follows an exact selection process that aims to identify all relevant research articles relating to the domain of REAs and contribute to the problem statement and its related root causes identified in section 4.2.3. Hence, the selection process uses using a comprehensive list of exclusion and inclusion criteria. Overall, the SLR intends to derive a research agenda that guides the artifact developed in the thesis and hints at other open research directions. Thus, it addresses scholars from the research domain of RM and EAM.

TABLE 15. CHARACTERIZATION OF THIS SLR BASED ON FETTKE (2006)

<table>
<tr><th colspan="2">CHARACTERISTIC</th><th colspan="6">CATEGORY</th></tr>
<tr><td colspan="2">Type</td><td colspan="3">natural-language</td><td colspan="3">statistical</td></tr>
<tr><td colspan="2">Focus</td><td>research outcomes</td><td colspan="2">research methods</td><td colspan="2">theories</td><td>applications</td></tr>
<tr><td rowspan="2">Objective</td><td>Formulation</td><td colspan="3">non-explicit</td><td colspan="3">explicit</td></tr>
<tr><td>Content</td><td colspan="2">integration</td><td colspan="2">criticism</td><td colspan="2">central aspects</td></tr>
<tr><td colspan="2">Perspective</td><td colspan="3">neutral</td><td colspan="3">position</td></tr>
<tr><td rowspan="2">Literature</td><td>Selection</td><td colspan="3">non-explicit</td><td colspan="3">explicit</td></tr>
<tr><td>Coverage</td><td>seminal articles</td><td colspan="2">representative</td><td colspan="2">selective exhaustive</td><td>exhaustive</td></tr>
<tr><td colspan="2">Structure</td><td colspan="2">historical</td><td colspan="2">conceptual</td><td colspan="2">methodological</td></tr>
<tr><td colspan="2">Audience</td><td>general public</td><td colspan="2">practitioners</td><td colspan="2">general scholars</td><td>specialized scholars</td></tr>
<tr><td colspan="2">Research Agenda</td><td colspan="3">non-explicit</td><td colspan="3">explicit</td></tr>
</table>

As enumerated above, this SLR intends to analyze the body of knowledge regarding five aspects based on this thesis' problem investigation (see p.96). In order to address these, the SLR at hand intends to answer the following RQs:

- ***RQ1: How does research in this field denote the notion of REAs?***

This RQ aims to align the conceptual basis of this work with related research. It builds on the knowledge established in Sanchez-Puchol and Pastor-Collado (2017). Answering this RQ includes analyzing identified related work regarding definitions of the REA term, drivers that cause the need of an REA, or characteristics that describe an REA. The results will help to inform REAM by concretizing requirements towards its output.

- ***RQ2: What methodological support for REA exist in related work?***

As pointed out in RC1 (see pp.90), methodological support is a crucial component in order to develop a solution for the global problem. Hence, this RQ focuses on analyzing the methodological basis related work applies or develops in the context of REA development. According to the general RM lifecycle, such methods may relate to REA construction or application. In comparison to Sanchez-Puchol and Pastor-Collado (2017), who only stated articles that explicitly provide methodological artifacts, answering this RQ will also include insights, procedures, or guidelines other authors document or reflect on while developing an REA. For instance, while Czarnecki and Dietze (2017c) do not provide essential methodological guidance on how to develop REAs, they still document their construction and application process. Such insights help to define steps for an REA method.

- ***RQ3: How to structure and document a REA?***

While RQ1 focuses on defining and conceptualizing an REA, RQ3 aims to analyze related work on how to documented and structure an REA. Next to aspects like used modeling language, applied EA frameworks, and covered EA layers, this includes how to integrate domain-specific aspects in the REA model or how REA documentation supports the REA's application in practice.

- ***RQ4: How to elicit and integrate the combination of both practical and theoretical knowledge during the REA development?***

Concerning RC2, a potential solution needs to address is to provide guidance eliciting the appropriate knowledge that forms the REA. As elaborated in the problem investigation (see pp.90), relevant practical knowledge is rarely available and, thus, needs to be elicited. Thus, RQ4 focuses on how related work does elicit knowledge, what elicitation methods it utilizes, and how it uses this knowledge to construct the REA.

4.3.3 PHASE II: CONCEPTUALIZATION OF THE SLR TOPIC

Before searching for relevant research articles, phase (ii) developed a conceptual framework that guided the data extraction during phase (iv). This is in line with the argumentation of Webster and Watson (2002, p. 16), who identify literature reviews as concept-centric and recommend using a conceptual matrix that structures the data extraction of each unit of analysis.

STEP 3 + STEP 4: IDENTIFYING CONCEPTS AND DEVELOPING CONCEPTUAL FRAMEWORK. After identifying relevant concepts in step 3, step 4 developed the conceptual framework using the RQs from above to form its structure. For reasons of brevity, this section condenses the results of these two steps in the following paragraphs.

The input of the conceptual framework was twofold. On the one hand, the author analyzed the conceptual matrix from Sanchez-Puchol and Pastor-Collado (2017) regarding the SLR's intentions and RQs. On the other hand, the elaborations from chapter III introduced essential concepts from the two related research domains EAM and RM. As Bandara et al. (2015, p. 167) recommend, this deductive coding approach helps to keep the codification process for the conceptual framework efficient. Section 4.3.5 will discuss how the data extraction inductively divided the codes of the initial framework into several sub-codes as they emerged during phase (iv). Figure 28 visualizes the resulting conceptual framework, its high-level categories with the identified codes, and indicates the origins of the codes.

In order to deduce available knowledge regarding the notion of REAs (RQ1), the SLR analyzes each identified study for definitions of the REA concept it elaborates or cites. Some studies might systematize the REA notion providing conceptual models or taxonomies to do so. Further, RQ1 intends to identify drivers triggering the need for an REA in a specific domain, stakeholders that might be involved in constructing or applying the REA, as well as the benefits an REA can deliver. Also, analyzing literature regarding building blocks of an REA enhances grasping its notion in more detail. For structuring the methodological support (RQ2), the framework distinguishes between methods or procedures the several studies followed or provided regarding REA construction and application. Moreover, particular focus lies on how related work evaluates a developed REA. Since an REA primarily uses the structure of EA models (RQ3), the framework will investigate related work regarding utilized EA frameworks, covered EA layers, and applied modeling languages for REA representation. Furthermore, it will identify problem domains (or industries) addressed by the studies. Beyond this, the SLR searches for other means of documenting an REA, if stated so. Finally, the SLR examines how research uses theoretical and practical knowledge to form the REA (RQ4). Therefore, the framework gathers data about used knowledge sources, elicitation techniques, as well as the reasoning process behind integrating knowledge into the REA. Next to the concept-centric codes, the framework additionally extracts metadata for each article. Next to authors, publication year, publication type, and outlet, it also analyzes utilized research methodology, and the overall research topic. During the selection process in phase (iii), the author recognized that some articles with a focus on reference architectures (RA) in general still contribute to the concept of REAs. In conclusion, the framework also categorizes whether an article lays focus on REA or RA in general.

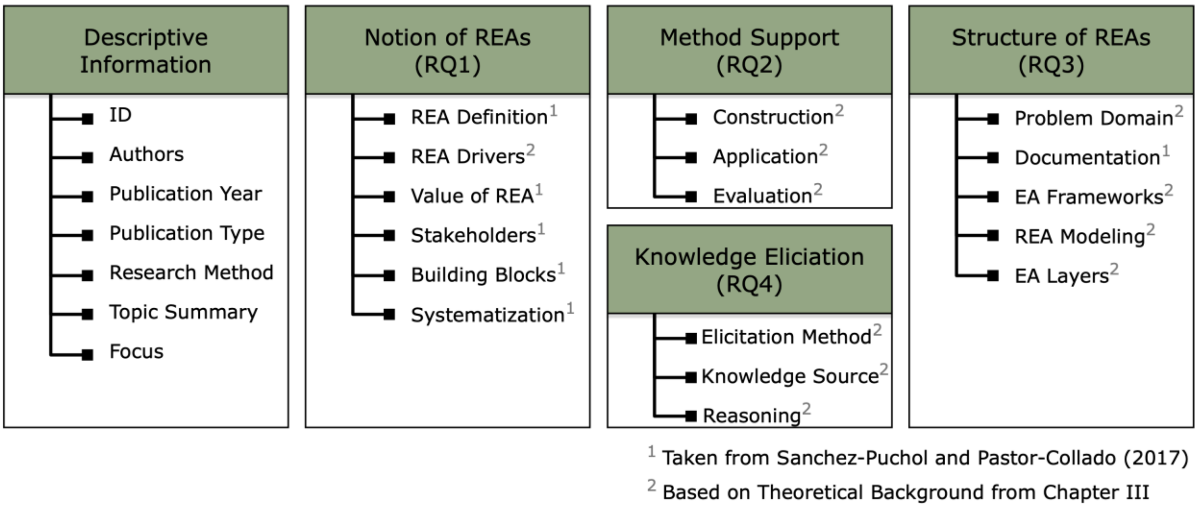


FIGURE 28. CONCEPTUAL FRAMEWORK FOR THE SLR

4.3.4 PHASE III: LITERATURE SEARCH AND SELECTION

This section summarizes the results of steps 5, 6, and 7. While step 5 concerns the chosen research strategy, steps 6 and 7 two reveal the results of the actual search and makes the decisions transparent what retrieved articles were in- or exclude and why. As indicated at the beginning of this chapter, the paper selection process built on several inputs. Next to the search conducted in June 2019, a literature search conducted in 2016, a literature base accumulated during 2017 and 2019, and the references from Sanchez-Puchol and Pastor-Collado (2017) formed the resulting literature database, from which the author selected relevant studies. Although this section focuses on the search conducted in 2019, it shortly reports on the results from the search conducted in 2016 as well.

STEP 5+ STEP 6: GENERATE SEARCH STRATEGY AND CONDUCT SEARCH. In 2016, a first search for REA related articles followed recommendations from Kitchenham (2004). Kitchenham recommends identifying appropriate research outlets that publish quality studies in the domain under investigation. Since the field of REA is an understudied research field (Sanchez-Puchol and Pastor-Collado 2017), no existing research outline qualified for this criterium to the knowledge of the author. Consequently, the authors decided to perform the search on high-ranked research outlets (including both journals and conference proceedings). Using well-known rankings, the author included all A or B ranked conference and journals, whose scope either addressed enterprise modeling or IS management[1,2]. This resulted in a list of 65 research outlets. After some initial search tests, the author conducted a first search for each of these research outlets. Doing so, all journals and conference proceedings were grouped by a database that indexes the respective outlet. In the end, this included using Scopus, AISeL[3], EBSCOhost[4], ACM DL, IEEExplore[5], and SpringerLink. The first row of Table 16 shows the first search query (S1), which combined two word groups for retrieving relevant paper. While the first group used synonyms for the term REA, the second required articles to provide either methods or practical experiences in the field. The query was the result of the initial search term and additional terms occurring in articles assessed relevant during the initial search. Applying the query to each of the 65 outlets retrieved only 31 articles. From these, none contributed to the domain of REA and, thus, the search resulted in no relevant paper. However, to the knowledge of the author there existed relevant research. Consequently, the search query term was relaxed regarding its requirements. The second search query (S2) divided the first word group into combined synonyms of the domains RM (e.g. “reference”, “template”, or “blueprint”) and enterprise architecture (e.g. “enterprise modeling”, “enterprise architecture”). The search of S2 retrieved 1564 articles, from which the majority (1258) occurred on SpringerLink. This high amount of articles is due to the absence of an advanced search interface, since Springer does not allow nested search queries on abstracts. However, these were included to the result database of the search from 2016. Below, the documentation of step 7 explains how these 1564 articled were filtered.

While the search in 2016 focused on a broader scope, the author was able to draw on a more accurate picture of the research field due to a more sophisticated understanding of the thesis’ global problem statement in 2019. Since the research outlet-based search from 2016 required more effort than database-based search and did not provide significant benefits in return, the author decided to perform the third search (S3) on the literature databases with the most promising retrieved sources after S2. Thus, S3 applied the search term to Scopus, Google Scholar, and Springer Link and retrieved 95 articles in total. In comparison to S1 and S2, the search term S3 focused on core concepts of an REA and used the *“NEAR”* operator to combine them. As of the time of the search, the author learned that many authors of related work did not use the terms “reference enterprise architecture” or “enterprise reference architecture” (as search for in Sanchez-Puchol and Pastor-Collado, (2017)) and tend to use very different combinations of the term “reference model” and “enterprise architecture” (or “enterprise model”). After performing the paper selection (see below), the author decided to follow the suggestion by Vom Brocke et al. (2009) and Webster and Watson (2002) to perform a back- and forwards search on the resulting set of relevant articles in order to ensure the highest possible coverage of relevant work.

TABLE 16. SEARCH TERMS USED IN SLR

ID	DATE	FIELDS	SEARCH TERM	RESULTS
S1	18-03-2016	Title, Abstract, Keywords	*("reference enterprise architecture" OR "enterprise reference architecture" OR "reference enterprise model*" OR "enterprise reference model*" OR "enterprise architecture blueprint" OR "domain-specific enterprise architecture" OR "domain specific enterprise architecture")* ***AND*** *(develop* OR "procedure model*" OR "experience*" OR method* OR approach* OR research* OR framework)*	31
S2	14-04-2016	Title, Abstract, Keywords	*("reference model*" OR reference OR adapt* OR blueprint OR template OR "best practice*" OR "domain-specific" OR "domain specific" OR sector* OR industr* OR branch* OR "reference architecture")* ***AND***	1564

[1] For Journals, the VHB Jourqual Ranking 3 was used (partial rating for IS outlets): https://vhbonline.org/en/service/jourqual/vhb-jourqual-3/teilrating-wi/ (accessed 24/07/2019)
[2] For Conferences, the CORE rating was used: http://www.core.edu.au/ (accessed 24/07/2019)
[3] Association for Information Systems eLibrary: https://aisel.aisnet.org/ (accessed 25/07/2019)
[4] library of EBSCO Information Services: https://search.ebscohost.com/login.asp/ (accessed 25/07/2019)
[5] digital library of IEEE: https://ieeexplore.ieee.org/ (accessed 25/07/2019)

ID	DATE	FIELDS	SEARCH TERM	RESULTS
			("enterprise architecture" OR "enterprise model" OR "enterprise system*" OR "organization* architecture" OR "organization* model*" OR "reference architecture")* ***AND*** *(develop* OR "procedure model*" OR "experience*" OR method* OR approach* OR research* OR framework)*	
S3	13-05-2019	Title, Abstract, Keywords	*reference NEAR/3 (architecture* OR model*) NEAR/3 enterprise* ***AND*** *PUBYEAR > 2016*	95

STEP 7: SELECT RELEVANT STUDIES. The results of S2 and S3, together with the references from Sanchez-Puchol and Pastor-Collado (2017) and the author's accumulated literature database, formed the input literature set for the selection process. As Figure 29 illustrates, each of these inputs traversed multiple selection steps, including abstract and full-text review, and duplicate elimination. Afterward, a set of 35 relevant articles emerged, which consisted of 27 articles from S2, S3, the rSLR, and an additional eight relevant articles from the accumulated literature database. The latter skipped the first selection steps as they were already carefully read during the period, in which the author accumulated them. Although Sanchez-Puchol and Pastor-Collado (2017) identified 20 relevant articles in their SLR, the author only included 17 for the selection process, since the remaining were publications of the author himself. For the resulting 35 articles, the author performed a back- and forward search, using the instructions from Webster and Watson (2002, p. 16). This activity identified five additional articles. As Table 18 shows, the author identified four groups of articles that were either part of the same study or used the same data set for their findings. According to Kitchenham (2004, p. 23), these were merged into a coherent unit of analysis, resulting in 31 articles that went through the data extraction during phase (iv). During the data extraction in step 8, the author excluded four further studies because they did not contribute to answering the SLR's RQs.

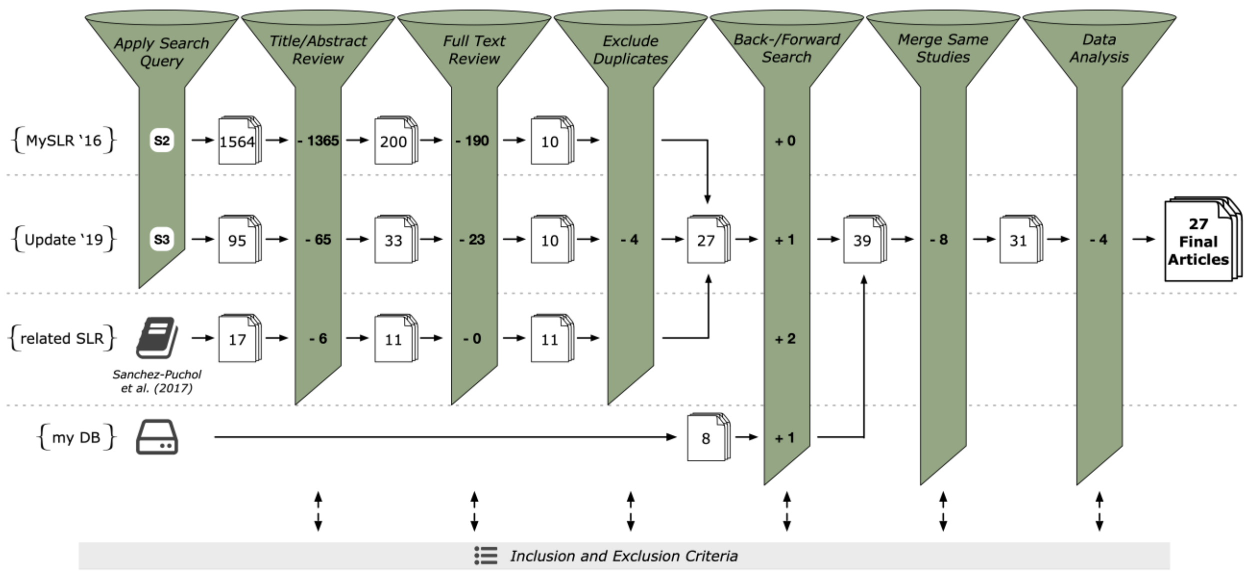


FIGURE 29. PAPER SELECTION PROCESS

In each selection step, the author decided whether an article would pass or not. Such a decision used inclusion and exclusion criteria. Before the first selection step, the author defined a list of generic inclusion and exclusion criteria. This list formed the basis for each decision. During the selection process, this list grew as the author learned about the research contributions and then decided whether they fit to the SLR's scope. While assessing the articles' relevance for the SLR, the author identified further aspects of why to include or exclude articles. For instance, at the start of the SLR, the author intended to automatically exclude articles that concentrate on reference architectures from a more generic perspective (Cloutier et al. 2009). After reading full-text, the author decided that these articles are relevant since they contribute a theoretical fundament to understand the notion of REAs. In addition, many seemingly relevant articles only focused on software reference architectures and, thus, the author excluded them. Table 17 enlists the resulting inclusion and exclusion criteria. In contrast, the author relaxed the selection in terms of publication type. While initially blog posts or white paper were excluded, the SLR included two blog posts from known authors of the EA domain (Lankhorst 2014), two Ph.D. theses, a master thesis, and one DIN standard.

TABLE 17. LIST OF EXCLUSION AND INCLUSION CRITERIA (GENERIC CRITERIA IN ITALIC)

	INCLUSION CRITERIA	EXCLUSION CRITERIA
Generic	+ *the article is of scientific rigor*	– *the article is an editorial, position paper, keynote, opinion, tutorial summary, introduction to conference proceedings, workshop summary, poster or panel* – *the article is written in another language than English or German*
Accumulated	+ an REA is developed + an REA is applied in practice + a RM is developed which covers perspective related to EA (e.g. considers business architecture but also information or application architecture) + theoretical work on Reference (Enterprise) Architecture concepts + cross-industry reference models that use EA concepts	– domain-specific EA frameworks (sometimes using "reference" term) – reference process models that solely focus on business processes – reference software architectures – technical reference architectures – organization-specific EA endeavors – reference models that guide EA management activities

TABLE 18. MERGED STUDIES (S = STUDY ID, Δ = NUMBER OF EXCLUDED ARTICLES)

	S	ID	REFERENCE	TITLE	Δ	REASON
Group 1	S1	1a	**Aulkemeier et al. (2016b)**	**A Service-Oriented E-Commerce Reference Architecture**	-1	1b provides an application case of 1a
		1b	Aulkemeier et al. (2016a)	A pluggable service platform architecture for e-commerce		
Group 2	S3	3a	**Czarnecki and Dietze (2017c)**	**Reference architecture for the telecommunications industry**	-4	3a is a research book that is based on all related research articles (e.g., 3b-3e)
		3b	Czarnecki et al. (2013b)	Reference process flows for telecommunication companies: An extension of the eTOM model		
		3c	Czarnecki (2016)	Design und Nutzung einer industriespezifischen Referenzarchitektur für die Telekommunikationsindustrie		
		3d	Czarnecki and Dietze (2017b)	Domain-Specific Reference Modeling in the Telecommunications Industry		
		3e	Czarnecki and Spiliopoulou (2012)	A Holistic Framework for the Implementation of a Next-Generation Network		
Group 3	S7	7a	Muller (2008)	Right Sizing Reference Architectures - How to provide specific guidance with limited information	-1	7b builds on the theoretical knowledge developed in 7a and includes a case study
		7b	**Muller and van de Laar (2009)**	**Researching Reference Architectures and their relationship with frameworks, methods, techniques, and tools**		
Group 4	S12	12a	Nakagawa et al. (2012)	RAModel: A RM for Reference Architectures	-1	12b builds on 12a and provides more insights
		12b	**Nakagawa et al. (2014)**	**Consolidating a Process for the Design, Representation, and Evaluation of Reference Architectures**		
Group 5	S16	16a	**Sánchez-Puchol and Pastor-Collado (2018b)**	**First in-depth analysis of enterprise architectures and models for higher education institutes**	-1	in correspondence, the authors confirmed that 16a is an improved version of 16b
		16b	Sánchez-Puchol and Pastor-Collado (2018a)	A critical review on reference architectures and models for higher education institutes		

In the end, phase (iii) resulted in a final set of 27 studies that contributed to at least one of the RQs discussed earlier (see section 4.3.2). Before it discusses the SLR's findings of each RQ using the filled conceptual matrix from phase (ii), the next section will summarize the descriptive information of the final set of 27 studies.

4.3.5 PHASE IV: DATA EXTRACTION AND SYNTHESIS

After identifying relevant studies, phase (iv) aimed at extracting all relevant data from these using the prior established conceptual framework (step 8), synthesizing these findings, and answering the four RQs (step 9). In step 8, each of the 27 selected studies served as a unit of analysis. While the merged groups from Table 18 represented one unit of analysis, all members of the group were analyzed. As section 4.3.3 discussed, sub-codes inductively emerged for most aspects of the framework during the data extraction in step 8. For capturing the relevant knowledge, the author used *Citavi*[1]. The author stored the relevant aspects of the studies using the tool's knowledge item functionality grouping each knowledge item to the appropriate category from the conceptual framework. After completing this process, the author grouped the items from the respective category according to their content. The resulting groups formed sub-codes of the framework's categories. Table 19 shows a high-level perspective on the final conceptual frameworks. It summarizes how each unit of analysis contributed to the RQs and their respective categories and subcodes.

Before the remaining sections of this chapter summarizes the results of the data synthesis for each RQ, the following paragraphs analyze the descriptive information of the 27 studies. Next to authorship and publication year as well as a short topic summary, Table 19 documents each study regarding its publication type, its focus on the REA domain, and employed research method. For reasons of comparability, we use the taxonomy for research methods as used by Sanchez-Puchol and Pastor-Collado (2017), which borrows from the taxonomies from Recker (2013) and Bandara et al. (2015). A study's focus on the REA domain may relate to either REA in specific or RAs in general. If relevant, the author specified what kind of contribution the study proposes, i.e., a method of concrete REA model. Looking Table 19, one can analyze certain aspects of the descriptive data obtained. Thus, this section will investigate insights regarding the studies' year of publication, the authors, the focus they take in relation to the REA domain, and research methods they utilize.

In their SLR, Sanchez-Puchol and Pastor-Collado (2017) identify a slightly sustained increase of publication activity in the REA domain. Although the total number of relevant studies published is still small, Figure 30 supports this observation. As the figure reveals, the majority (13 studies) of identified studies were published in 2017 or 2018. The figure further indicates a growing research interest in REAs within the IS domain. The figure further visualizes the types of outlets. Next to some theses, blog post, or industrial standards, the majority of studies contributed to conference proceedings (11 studies), journals (8 studies), or scientific books (2 studies). Especially the increasing interest of IS-related conference proceedings might argue for the REA's increasing importance. Nevertheless, these numbers indicate that the domain of REA is still a very immature research domain. As the next sections will show, many open research questions support this. In total, 68 distinct authors wrote the 27 studies. Interestingly, only six of them authored two studies: Alina Chircu, Eldar Sultanow, Gerrit Muller, Jos Trienekens, Maria-Eugenia Iacob, and Paul Grefen. This vast diversification further speaks for the domain's immaturity.

[1] Citavi is a program for reference management and knowledge organization published by Swiss Academic Software. See https://www.citavi.com/en for more information.

TABLE 19. FINAL LIST OF INCLUDED STUDIES FOR KBA

ID	AUTHOR + YEAR	PUBTYPE	FOCUS[1]		TOPIC	METHOD[2]
S1	Aulkemeier et al. (2016b)	Journal	REA	D	REA for E-Commerce Systems providing integrated IT support for different sales channels	DSR
S2	Cloutier et al. (2009)	Journal	RA	T	Conceptualization of Reference Architectures	C
S3	Czarnecki and Dietze (2017c)	Book	REA	D	Book on an REA for the Telecommunications Industry with real-world examples and a concrete REA model	DSR
S4	Fattah (2009)	Conference	REA	T	Classification of REAs	C
S5	Kotzampasaki (2015)	Mater Thesis	REA	M	Process and Toolkit for Selecting REAs	DSR
S6	Lankhorst (2014)	Blog Post	REA	T	Value of REAs	NA
S7	Muller and van de Laar (2009)	Conference	RA	T	Notion of RAs in comparison to architectural frameworks, RA structure and development	MX: [C, QL (Case Study)]
S8	Tambouris et al. (2014)	Journal	REA	D	Development of a requirements set towards an REA for eGov Public Service Provision	QL (SLR)
S9	Harmsen van der Beek, Wijke ten et al. (2012)	Conference	RE	T	Definition and Conceptual Model for REAs	C
S10	Iacob et al. (2013)	Journal	REA	D	REA for a fuel-based Logistics Carbon Management System	DSR
S11	Janssen and Cresswell (2005)	Conference	REA	D	REA for Local Government	QL (Action Research)
S12	Nakagawa et al. (2014)	Conference	RA	M T	Notion of RAs and Procedure for RA Development	DSR
S13	Pang (2015)	Blog Post	REA	T	Overview of Types of REA	NA
S14	Reidt et al. (2018)	Journal	RA	T	Definition and Systematization of RAs	C
S15	Adwan (2018)	Conference	REA	D	REA for Smart City focused in Application and Technology Architecture	QL (SLR, interview, content analysis)
S16	Sánchez-Puchol and Pastor-Collado (2018b)	Journal	REA	T	Framework for Comparison of REAs in Higher Education Domain	MX: [QL (content analysis),C]
S17	Heidel et al. (2017)	DIN Standard	REA	D	RA for Cyber-Physical Systems	NA
S18	Baloyi and Kotzé (2018)	Conference	REA	D	REA for Data Privacy in Cyber-Physical Systems	DSR (unspecified)
S19	Rodriguez (2018)	Ph.D. Thesis	RA	D	RA for Health Care	DSR (unspecified)
S20	Ghahramany Dehbokry (2017)	Ph.D. Thesis	REA	D	REA for Small and Medium-Sized Enterprises with Focus on Business Architecture	DSR
S21	Gill et al. (2017)	Journal	REA	D	REA for E-contracts	DSR
S22	Nardello et al. (2017)	Journal	REA	D	Application of RAMI from S17	DSR
S23	Sultanow et al. (2018)	Conference	REA	D	REA for Pharma, Health Care, and Life Sciences	C
S24	Naranjo et al. (2018)	Conference	REA	D	REA for Developing Collaborative Software Production Teaching-Learning Environments	DSR
S25	Chircu et al. (2017)	Conference	REA	D	REA for Digitalization in Pharma Industry	C
S26	Angelov et al. (2008)	Conference	RA	M	Method for Evaluating RAs	MX: [QL (Case Study), C]
S27	Trefke (2012)	Book Chapter	RA	T M	Development of RAs	C

[1] **Focus**: D: Development | M: Methodological Support | T: Theory Development

[2] **Method**: C: Conceptual Work | DSR: Design Science Research | QL: Qualitative Research | QT: Quantitative Research | MX: Mixed Methods | NA: Not Assigned

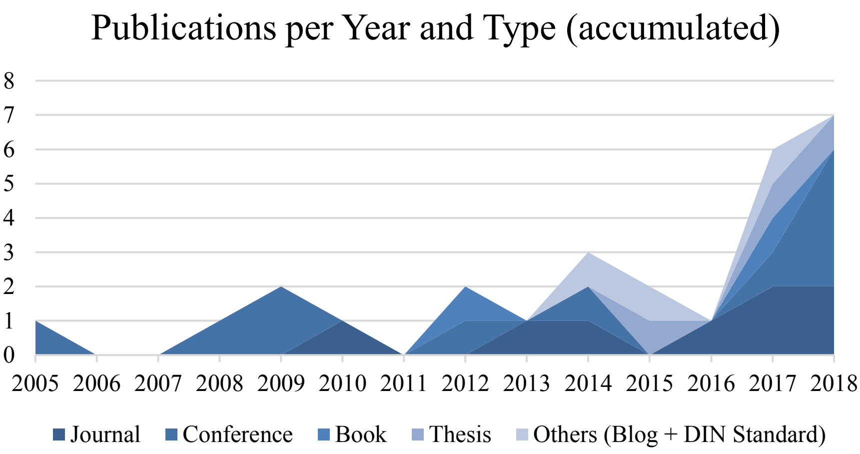


FIGURE 30. STUDIES PUBLISHED PER YEAR AND PUBLICATION TYPE

In order to get a better overview of the topics covered by the identified studies, Table 19 categorizes each study regarding its focus. First, the author analyzed whether a study at hand investigated RA in general or concretely addresses REAs. Second, it was possible to relate each study to one of the contribution types (i) development, (ii) method support, or (iii) theory. A study qualified for (i) as soon as it provided experience in constructing or applying a concrete RA or REA. Once it thereby provided methodological guidance, i.e., how to construct an REA, the author further related it to (ii). Moreover, some contributions were theoretical or aimed to provide general conceptualization of the topic. Thus, they either provided definitions of relevant concepts in the RA/REA domain (Cloutier et al. 2009) or put them into a clear conceptual framework to concretize the notion of REAs (Harmsen van der Beek, Wijke ten et al. 2012). In this case, they matched (iii). Figure 31 illustrates how the 27 studies spread across these categories. Each bar shows the distribution regarding the three contribution categories, while the two shades of blue indicate the focus on either RA or REA. As already depicted by Table 19, two studies contributed to more than one contribution type. Looking at Figure 31 reveals that most studies report on the development of REAs. Furthermore, the amount of research with a focus on theory balances between REA and RA related work. Two further observations stand out. First, only the study by Rodriguez (2018) develops a RA. Second, although the identified body of knowledge exhibits much experience in developing REAs, only one work provides actual methodological support for doing so (Kotzampasaki 2015). However, Kotzampasaki provides a method to select an appropriate REA available, but does support neither the development nor the application of REAs in concrete. Nevertheless, the three studies that focus on RAs in general might provide valuable insights for an REA development method. Moreover, the experiences shared in the 15 studies that develop a RA or REA will be helpful, too. Their contributions are discussed in the remaining sections in more detail.

Finally, Figure 32 shows the distribution of utilized research methods between the studies under investigation. The studies that utilized mixed methods related to either DSR, conceptual work, or qualitative research. While three studies did not follow a particular research method, that is the two blog posts and the industrial standard, the majority of studies used either DSR or a conceptual approach. Most studies focusing on theory building (see Figure 31) used a conceptual approach. For REA development or method construction, authors primarily used DSR. Additionally, some authors deployed qualitative methods like action research or content analysis to develop a specific REA. From these results, one can derive that REA research concentrates on providing research artifacts, primarily focusing on REA models, but also methods. Being a central characteristic of DSR, it confirms the methodological approach behind this thesis.

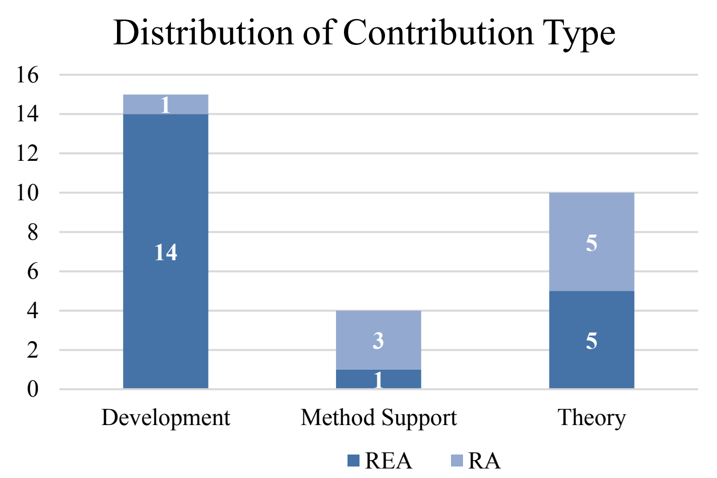


FIGURE 31. DISTRIBUTION OF THE STUDIES' FOCUS ON THE REA DOMAIN

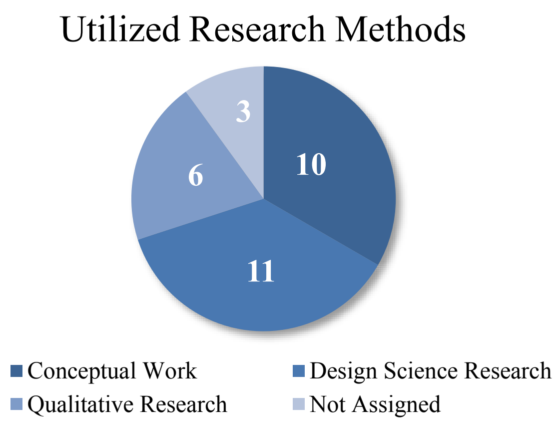


FIGURE 32. UTILIZED RESEARCH METHODS

4.3.5.1 RQ1: HOW DOES RESEARCH IN THIS FIELD DENOTE THE NOTION OF REAS?

In order to clarify how IS research defines the REA term, the SLR analyzed the 27 studies regarding six categories, as elaborated by Figure 28: REA definition, REA value, stakeholders of REA, REA building blocks, systematizations of REA, and REA drivers. Except for S1 (see Table 19) all studies covered at least one category. Most studies contributed to REA definition (17 studies) and REA drivers (16 studies). For most categories further sub-categories emerged during data analysis, Figure 33 visualizes the distribution of sub-categories in a treemap.

The treemap's intention is twofold. On the one hand, it summarizes all sub-categories identified during data analysis for RQ1. On the other hand, it reveals how often related work discussed each (sub)-category. Since included studies focus on either generic RAs or REAs in concrete, some sub-categories refer to this distinction in order to avoid a biased data synthesis on the topic. While the majority of studies provided (or referred to) a definition of the REA concept and discussed its characteristics, only five studies systematized the REA research field by developing taxonomies or conceptual models. The author divided the category "definition" into four sub-categories. Depending on their focus (RA or REA), most studies provided a concrete definition.

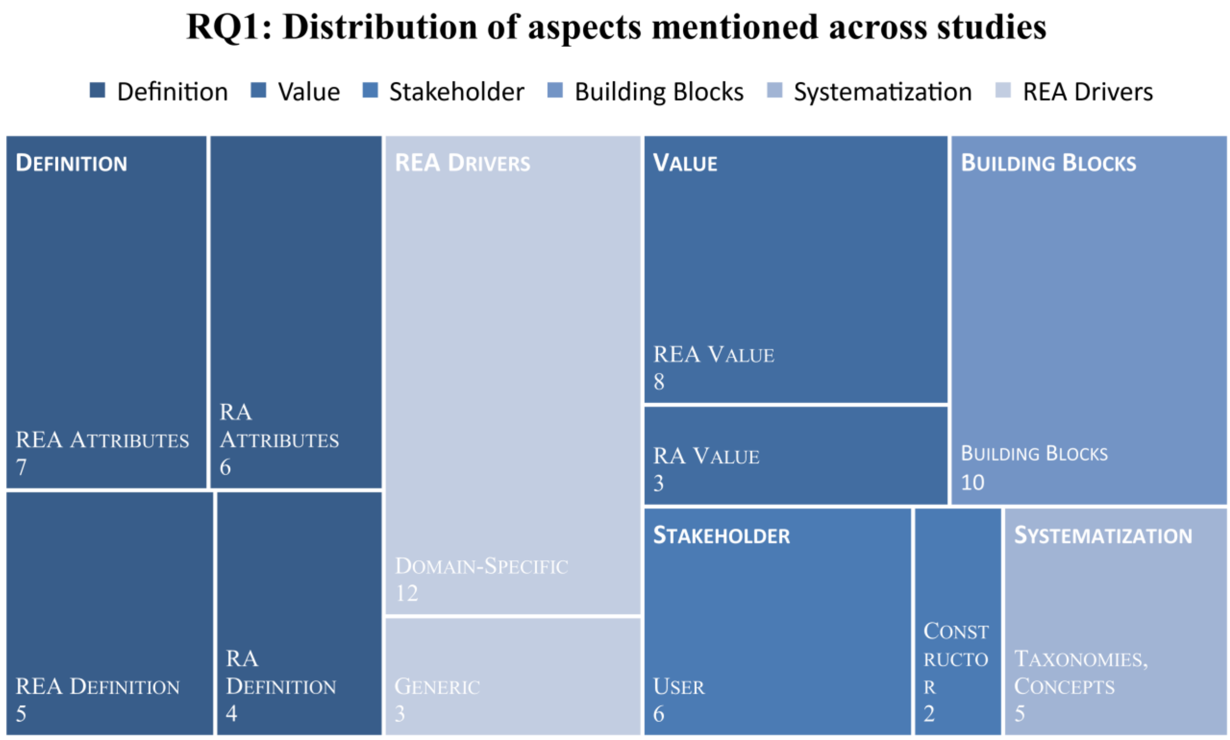


FIGURE 33. OVERVIEW ON TOPICS COVERED BY IDENTIFIED STUDIES REGARDING REA NOTION

Further, the SLR captures the different characteristics mentioned in some studies. Moreover, studies frequently discuss factors that create a need for REA. As most of them focus on RA/REA development (cf. Figure 31), this is no surprise. Most studies state factors that caused the development of an REA or RA. In contrast to the relative high clarity regarding such factors, there is an absence of empirical evidence of REAs' value. While some studies use theory to derive the value of generic RAs (Cloutier et al. 2009; Muller and van de Laar 2009), others build from practical experience to deduce case-specific values of REAs (Czarnecki and Dietze 2017c; Harmsen van der Beek, Wijke ten et al. 2012). Some studies also report on stakeholders involved in the REA development process, enumerating stakeholders during the REA construction (constructor) or application (user). Ten studies state building blocks that compose an REA.

Although the majority of the identified studies agree upon the general characteristics of RAs and REAs, there is no commonly accepted definition regarding these terms. In most cases, authors understand REAs to be a particular type of RAs. Thus, to grasp the notion of REAs, one has to start investigating the nature of RAs in general. Therefore, this section synthesizes the knowledge regarding RAs and its characteristics before focusing on the concept of REAs. The remainder of this section then discusses the results regarding the remaining topics shown in Figure 33.

DEFINITIONS ON THE TERM *REFERENCE ARCHITECTURE* AND CORRESPONDING CHARACTERISTICS. Although many RAs exist, Nakagawa et al. (2012, p. 297) note a lack of understanding regarding the precise nature of a RA and the components it encompasses. While seven studies contribute to the general understanding of the term "Reference Architecture," four provide an explicit definition. Table 20 enlists these definitions. The author only included definitions when the respective study explicitly stated them as one.

While S2 and S12 define RAs from a more general perspective, S14 and S27 provide more details on characteristics that constitute RAs. Essentially, all definitions agree that a RA supports the development of architectures for a specific domain. Thus, a RA is an abstract architecture and addresses an application domain providing reusable knowledge. Users instantiate a RA to construct a concrete architecture. While still open to interpretation, S2 and S14 hint that knowledge is rooted in existing architectures of the problem domain. S2 further states that a RA provides a futuristic lens on the domain. However, there is no consensus on the structure of RAs. S14 understands a RA as a framework that combines a technical perspective with domain-specific expertise. S27 describes RAs as systems consisting of elements that interrelate with each other and its environment. From a reuse-oriented perspective, S2 and S27 state that a RA requires a continuous development over time, as their definitions mention its evolutionary character. Finally, S27 considers user acceptance as a prerequisite for RA reuse.

TABLE 20. DEFINITIONS FOR THE RA CONCEPT AS PRESENTED IN THE IDENTIFIED LITERATURE

	ID	SOURCE	DEFINITION
RA	S2	Cloutier et al. (2009, p. 4)	*„Reference Architectures capture the* ***essence of existing architectures****, and the* ***vision of future needs*** *and evolution to provide* ***guidance*** *to assist in* ***developing new system architectures****."*
	S12	Nakagawa et al. (2012, p. 298)	*„...a reference architecture is an architecture that encompasses the knowledge regarding how to* ***design concrete architectures of systems*** *of a* ***given application domain****."*
	S14	Reidt et al. (2018, p. 903) (translated from German)	*„A reference architecture is an abstract architecture designed to make it easier for people to develop systems, solutions and applications by providing knowledge and a framework for development. The relationship between reference architecture and concrete architecture is characterized by the fact that* ***the object or content of the reference architecture is (re-)used in the construction of the concrete architecture*** *of the respective system to be developed. The reference architecture* ***has a technical focus, but combines it with the corresponding expertise of the respective domain****. Through its characteristics and content, it forms a* ***common framework*** *for the detailed discussions of all* ***stakeholders*** *involved in the development."*
	S27	Trefke (2012, p. 17) (translated from German)	*„A reference architecture describes the* ***structure of a system with its element types and structures as well as their interactions with each other and its environment****. This determines restrictions regarding the instantiation of the architecture. Individual peculiarities are abstracted and thus* ***a reference architecture is characterized by general validity in a special domain****. With a reference architecture the* ***construction of further architectures can be supported*** *using the functional requirement of the reference architecture. This can also include the definition of* ***guidelines for use, evolution and responsibilitie****s. In addition, a reference architecture has a* ***recommendation character*** *that is based on experience as well as broad* ***user acceptance*** *and recognition."*

In supplement to these definitions, six studies explicitly state characteristics of RAs and add to the picture of its notion. Including the aspects mentioned in the above RA definitions, Table 21 gives an overview of all characteristics. It is no surprise that authors relate the three main characteristics of reference models—i.e., reuse, recommendatory character, and universal validity (cf. chapter III) —to RAs. The majority emphasizes that RA's success highly depends on its user acceptance, as its development is feedback-based. Consequently, a RA needs to evolve even after its development. Although they agree on a RA's domain-focus, most studies stress that RAs differ in their level of abstraction in such a domain, stating that some RAs may even have an industry-independent scope.

Further, the diversity of RA's stakeholders highly depends on its scope. Interestingly, some authors agree that RAs are abstractions of existing architectures, while others see them as blueprints that possess a futuristic lense, too. Moreover, the authors claim that RAs shall cover appropriate domain-specific knowledge next to technological details. In this context, Cloutier et al. (2009, p. 6) assert that only the integration of technological architecture, business architecture, and customer context can form a RA. However, it remains unclear whether a RA needs to be complete, technology-neutral, and how it shall be structured or represented. The author agrees with Cloutier et al. (2009, p. 6) as they state that each RA shall align with the mission, vision, and strategy of the problem domain's stakeholders. Starting there will then determine the RA's characteristics, such as level of abstraction, necessary knowledge, stakeholders, or technological neutrality.

TABLE 21. RA CHARACTERISTICS STATED BY STUDIES

RA CHARACTERISTICS	SOURCE
RA is Reuse-Oriented	S2, S7, S14, S26, S27
RA is Domain-Specific	S2, S7, S14, S26, S27
RA is mined from existing architectures (based on concepts proven in practice)	S2, S7, S14, S27
RA has a recommendatory character	S2, S7, S14, S27
RA is feedback-based and its success depends on user acceptance	S2, S14, S26, S27
RA are universally valid (or complete subsuming all necessary functionality regarding the problem domain)	S5, S14, S26, S27
RA provides futuristic vision	S2, S26, S27
RA combines technical with domain-specific knowledge (incl. business or customer perspective)	S2, S7, S14
RA differs regarding its level of abstraction	S14, S26, S27
RA evolves over time	S2, S27
RAs address different user groups	S5, S26
RA defined as a framework	S14
RA represented as a model	S27
RA is strongly linked to the domain-specific mission/vision/strategy	S2
RA is minimal focusing on functionality common to all stakeholders	S5
RA is technologically neutral	S14

DEFINITIONS ON THE *REA TERM* AND CORRESPONDING CHARACTERISTICS. Identifying the research domain of REAs as a still immature research field, Sanchez-Puchol and Pastor-Collado (2017, p. 9) find out that most studies contribute to the notion of the REA concept by providing definitions, characteristics, or conceptual frameworks. Although there is no commonly accepted REA definition, five studies provide definitions enlisted in Table 22. The table further highlights the essential aspects stated by the definitions.

TABLE 22. DEFINITIONS FOR THE REA CONCEPT AS PRESENTED IN THE IDENTIFIED LITERATURE

	ID	SOURCE	DEFINITION
REA	S4	Fattah (2009, p. 3)	*„An ERA is a **blueprint for the Solution Architecture** of a number of potential projects **within an organisation** that embodies the **EA principles, policies, standards and guidelines**. In other words, an ERA is a Solution Architecture with some of the Architectural Decisions already made and others left open.“*
	S6	Lankhorst (2014)	*„Reference architectures are **standardized architectures** that provide a **frame of reference for a particular domain, sector or field of interest**.“*
	S9	Harmsen van der Beek, Wijke ten et al. (2012, p. 99)	*„An ERA is a **generic EA for a class of enterprises**, that is a coherent whole **of EA design principles, methods and models** which are used as **foundation in the design and realization of the concrete EA** that consists of three coherent partial architectures: **the business architecture, the application architecture and the technology architecture**.“*
	S10	Iacob et al. (2013, p. 728)	*„ ...we infer that a reference architecture [...] (1) is a **generic architecture** of the components of a system that provides functionality for the management of carbon emissions in the transportation sector; (2) provides a map of its possible **relationships to and interfaces with both the business and the technological environment**; and (3) is **based on best practices**.“*
	S24	Naranjo et al. (2018)	*„An Enterprise Reference Architecture (ERA) is a **generic solution model for the parts of a class of enterprise or domain**. An ERA includes principles, policies, architectural views, requirements, ontologies, standards, conceptual reference models and/or guidelines for designing enterprise concrete architectures; i.e., an ERA is an enterprise architecture with some **architectural decision already made and others left open**. In other words, an ERA generalizes solutions by **abstracting and aggregating the available knowledge** about a specific class of enterprise or domain in order to **improve the quality and effectiveness of the architect's work**.“*

Although S10 provides an REA definition for the carbon industry, Table 22 includes it because it provides REA aspects that apply to REAs in general, too. Taking a closer look at the five definitions, one can identify both similarities and differences. At first glance, definitions for RA and REA appear quite similar. Likewise to RAs, all definitions describe an REA to be domain-specific and of generic nature, from which users can deploy concrete architectures. Equally, the studies state that content provided by the REA originates from practical knowledge (S24) and may represent best practices (S10).

In contrast to RA, REA definitions differ regarding its level of abstraction. Supported by Janssen and Cresswell (2005), S4 understands an REA as a blueprint that is developed within one organization and is later reused by its different departments. However, the majority of studies agree that an REA has a broader scope that considers groups of organizations sharing the same problem domain or even industry sector (S6, S9, and S24). The core difference between RAs and REAs is that definitions stress that REAs relate to the domain of EAM. Thus, it uses principles, methods, and modeling standards from the EAM research domain (S4, S9, S24) and shall cover relevant EA layers like business, application, and technology architecture (S9, 24, cf. chapter III). According to Tambouris et al. (2014, p. 992), a RA can represent an essential part of an REA as it has a more technological focus. In contrast to this, S9 argues that an REA is a special type of RA, but is—in comparison to software RA (SRA)—less investigated. Further, they claim that definitions regarding SRAs are not applicable to REAs as their focus restricts to software elements, systems, and data flows. Trefke (2012, p. 19) agrees with this describing REAs as special types of RAs.

Comparing the attributes studies are ascribing to REAs, similarities between RA and REA become even more apparent. Table 23 summarizes characteristics studies relate to REAs. Similar to RAs, the literature describes REAs as the knowledge aggregation from a particular domain, which is reused by different entities of that domain. Further, an REA is characterized by its level of abstraction (e.g., sector or whole industry), level of coverage (certain business functions or complete organizational scope), and level of knowledge aggregation (generalized to detailed REA elements). In terms of abstraction level, Tambouris et al. (2014, pp. 992–993) claim that an REA can be related to the concept of "industry-architecture" as proposed by the TOGAF Architecture Continuum (The Open Group 2011, p. 464). Naranjo et al. (2018) say that an REA's content—and thus its level of abstraction, aggregation, and coverage—depends on both its problem context and its concrete objective. Identified studies stress REAs' strong relation to practical experience as REA's application success highly depends on effective knowledge transfer. As discussed earlier, the central difference to RAs is that REAs combine methods from EA research with the concept of RA in general. Thus, the author concludes that the general characteristics of RAs can be ascribed towards REAs as well.

TABLE 23. REA CHARACTERISTICS STATED BY STUDIES

REA CHARACTERISTICS	SOURCE
REA is characterized by its level of abstraction	S4, S8, S24, S25
REA relates to a particular problem domain (industry, sector, field of interest, …)	S6, S9, S13, S25
REA shall be easy to reuse for concrete solution architecture development	S4, S6, S13
REA is characterized by its level of coverage	S4, S24
REA combines elements from EA and RA domain	S9, S25
REA content shall relate to practical expertise	S4
REA application highly depends on effective knowledge transfer	S4
REA abstraction level can be related to the TOGAF Archictecture Continuum	S8
REA is characterized by its level of knowledge aggregation	S24
REA content depends on its context and objective	S24

THE VALUE OF *REFERENCE ARCHITECTURES* AND *REFERENCE ENTERPRISE ARCHITECTURES*. A high number of studies further discussed the value of RA and REA. Discussing the value of their developed REA for the telecommunications industry, Czarnecki and Dietze (2017c, p. 74) refer to Böhmann et al. (2007) as they point out that one can only observe an REA's real value can only after applying it in a real-world use case. In this context, Cloutier et al. (2009, p. 24) claim a lack of insights as they state an absence of necessary data in this regard. However, from eleven studies that discuss the value of either RAs or REAs three (S2, S5, and S9) derive their insights from practice (mainly expert interviews) and three others (S19, S20, S22) even conclude RA/REA values from concrete applications of the developed RAs or REAs. Table 24 enumerates all value contributions the several studies mention—distinguishing between RA value and REA value. The list reveals that values ascribed to RAs are very general. Interestingly, all benefits of RAs apply for REAs as well. This observation supports the above-made statement that an REA is a special type of RA. Further, studies relating to REAs' value identify some concrete benefits (e.g., training of employees or regulatory compliance) as they rely on concrete REA application use cases.

TABLE 24. RA AND REA VALUE IDENTIFIED IN THE LITERATURE BASE

RA VALUE	SOURCE
knowledge transfer and communication improvement[1]	S2, S7
cost reduction[1]	S2, S19
interoperability improvement[1]	S2, S7
shorter development cycles[1/2]	S2
risk mitigation[1]	S2
quality improvement[1]	S2

REA VALUE	SOURCE
common understanding and communication improvement[1/2]	S5, S6, S9, S20, S22, S23, S25
higher efficiency of EA initiatives (time, costs)[1]	S3, S5, S9, S25
quality improvement of EA initiatives	S3, S5, S9
supporting transformation process of EA[2]	S5, S20
interoperability improvement (e.g. to other organizations)[1]	S5, S6
more efficient decision making processes	S5, S9
risk mitigation[1]	S5, S6
facilitating regulatory compliance	S6, S23
improving understanding of impacting external factors[2]	S20, S23
cost reduction of EA initiatives	S5
benchmarking with industry	S6
facilitating employee training[2]	S22

From an REA perspective, there seems to be a consensus in the literature that applying REAs improves the establishment of a common understanding of the problem domain at hand. That is because most authors understand an REA to provide a taxonomy or vocabulary of that domain (Cloutier et al. 2009, p. 11; Harmsen van der Beek, Wijke ten et al. 2012, p. 107; Kotzampasaki 2015, p. 19; Chircu et al. 2017, p. 2044). Based on this shared knowledge, above studies argue and prove that applying an REA improves the communication of the different stakeholders involved in EA initiatives, which further results in the improvement of the EA program's overall quality (Czarnecki and Dietze 2017c, p. 76; Kotzampasaki 2015, p. 13; Harmsen van der Beek, Wijke ten et al. 2012, p. 96). Two or fewer studies only covered the remaining benefits of the REA application. Nevertheless, the author recognized that several studies stated the importance to include best practices in REAs in order to deliver stated benefits (Harmsen van der Beek, Wijke ten et al. 2012, p. 107; Lankhorst 2014; Cloutier et al. 2009, p. 11). This implies a need to include practical knowledge when constructing REAs, which is in line with the results of this work's root cause analysis (cf. RC2 in section 4.2.3).

THE STAKEHOLDERS OF *RAS* AND *REAS*. As illustrated during the elaboration of the two local practices earlier in section 4.2, the development context of REAs can be highly diverse. Thus, the different groups of stakeholders involved in REA development or interested in its usage might differ from case to case. However, the author investigated whether the 27 studies explicitly state or agree on particular stakeholder groups that shall be involved in the REA construction process. Moreover, the author looked for common stakeholder groups that are targeted by the RAs and REAs as potential users. While it is essential to identify the right mix of stakeholders involved in developing the REA, the same applies when it comes to being aware of a REA's potential users from the beginning. The RM research domain agrees that an REA's intended use affects its construction process (Vom Brocke 2006). Thus, to provide a method for REA development, it is vital to know about common REA user groups as well.

[1] REA value derived from domain experts
[2] REA value derived from concrete RA/REA application

In contrast to the prior aspects that are covered to grasp the notion of REAs, there was no difference made whether studies referred to RA or REAs—only one study (S26) focusing on RAs discussed stakeholders. Table 25 enlists all identified stakeholder groups the studies named. From a general perspective, the only study that investigated REA stakeholders with some detail was S9. Interviewing IT and EA experts, they derived four user groups of REAs and their need why to use REAs (Harmsen van der Beek, Wijke ten et al. 2012, pp. 106–107). While they distinguish between enterprise architects and managers of an organization from the problem domain, Table 25 summarizes them into the group *"enterprises operating in the problem domain."* Looking at the findings, one can see that studies agree that both enterprises and software vendors are typical REA users, while there is no consensus regarding the stakeholders involved in the construction process of REAs. Although the sample size of this data is small, the author concludes that defining the REA development team is a task, which highly depends on the specific case. Angelov et al. (2008, pp. 229–230) agrees, claiming that there is no coherent stakeholder group applying to all REAs as it is domain-specific. In conclusion, one can derive that an REA shall consist of a step that investigates its stakeholders. While this list has no claim to completeness, it may provide a good starting point for stakeholder groups this REA method step can build from.

TABLE 25. STAKEHOLDERS MENTIONED BY THE IDENTIFIED STUDIES

STAKEHOLDERS DURING REA CONSTRUCTION	SOURCE	POTENTIAL USERS OF REAS	SOURCE
decision-makers of the domain	S11	enterprises operating in the problem domain	S3, S5, S9, S24, S25, S26
process owners of the domain	S11	independent system vendors (ISVs)	S3, S9, S25, S26
technology experts of the domain	S11	consulting firms	S3
standardization organizations	S24	auditing firms	S9
research group	S24		
group of enterprises of the domain	S24		

BUILDING BLOCKS OF REAS. In their SLR, Sanchez-Puchol and Pastor-Collado (2017) identify a list of building blocks of an REA. As earlier elaborations revealed, this work extended the body of knowledge of that SLR (cf. Figure 29). Consequently, this section analyzes this extended knowledge base in order to update the list of building blocks. Therefore, Table 26 lists the identified building blocks. While some of them have been adopted directly from the respective studies, others were merged into one building block as the author interpreted them to focus on the same aspect. In this manner, the author defined the aggregated building blocks *common vocabulary*, *REA model*, *REA application model*, and *REA scope*. The respective brackets state the aggregated concepts. Overall, there seems to be a consensus on the main building blocks an REA shall cover. A REA shall provide a model, which covers all EA layers that are necessary for the respective REA scope. Further, this model is considered to rely on an appropriate EA framework like TOGAF, which provides a proven architectural structure the REA can build from. The model uses reusable architectural patterns and provides different viewpoints covering different perspectives on the problem domain. Interestingly, the building block that occurred most is a common domain-specific vocabulary, which may be provided in terms of typology, taxonomy, glossary, or ontology. Comparing this to the findings documented in Table 24, this is no surprise as the majority of studies identify the establishment of a common understanding and communication improvement as a central value offered by REAs. What also catches the eye is that many studies stress the importance of best practices a REA shall provide in order to offer value. Moreover, the author identifies a need for a REA to make its objective and addressed stakeholders explicit, to formulate adequate requirements the REA shall meet as well as its evaluation against them, and to provide guidance how to apply the REA in concrete application cases. Also, some studies highlight that a REA shall reuse available technical (or other) standards of the problem domain in order to ensure user acceptance. Only very few authors state that an REA shall be throughly documented and if so, there is no clarity what a REA documentation shall look like. Here, the author identifies a lack of existing knowledge.

TABLE 26. BUILDING BLOCKS IDENTIFIED IN STUDIES

BUILDING BLOCKS OF REAS	SOURCE
domain-specific common vocabulary (e.g., taxonomies, ontologies, or typologies)	SLR1, S2, S3, S6, S9, S12, S14, S24
architectural structure that builds on EA frameworks	SLR1, S3, S8, S12, S14, S19, S20, S24
REA model (reusable architectural patterns, viewpoints)	SLR1, S2, S6, S14, S20, S24
best practices from problem domain	SLR1, S2, S6, S12, S14
REA application model (REA->concrete EA, design principles)	SLR1, S2, S14, S20, S24
REA requirements	SLR1, S8, S19, S24
references to technical or business standards	SLR1, S2, S12, S24
REA scope (common architectural vision / business purpose / stakeholders)	S2, S12, S19, S24
appropriately detailed documentation	SLR1, S12, S19
architectural sub-domains / problem domain perspectives	SLR1, S3
roadmap for transformation	S2
end-to-end processes spanning the REA	S3

SYSTEMATIZATIONS OF REFERENCE ENTERPRISE ARCHITECTURES. Since authors agree that the field of RA and REA is a research domain of low maturity, it is no surprise that only five studies systematize concepts or types of either RA or REA. Structuring the concept of RAs, Angelov et al. (2008, p. 227) distinguish between a "Futuristic" and "Practice" RA (FRA and PRA). While FRAs are research-driven and aim to foresee essential design principles of a specific domain for the future, PRAs build on accumulated practical experience in a domain. Regarding the design process, the authors claim that the former follows a more "top-down" approach, while the latter primarily emerges "bottom-up." Angelov et al. (2008, p. 228) understand that these two types have differences concerning their origin and goals. PRAs originate from descriptive knowledge and aim to provide prescriptive knowledge to support more efficient system development. In contrast, FRAs originate from prescriptive knowledge provided by research and—as the authors claim—aim to provide descriptive knowledge of novel functionalities.

In order to sharpen the understanding of RAs, Nakagawa et al. (2012, p. 300) propose the *"RA-Model"* that identifies central elements of them. Analyzing related work from the software architecture domain, the authors identify elements of RAs and cluster them into the groups *(i) domain*, *(ii) application*, *(iii) infrastructure*, and *(iv) crosscutting elements*. While elements from (i) refer to aspects that impact the RA from the outside (e.g., regulation), group (ii) contains elements that provide an understanding of the RA itself (e.g., its goals, requirements, or necessary data). Since Nakagawa et al. (2012, p. 300) understand RA as the basis for implementing software systems, group (iii) refers to elements that help to build it (e.g., software/hardware elements or guidelines). Finally, group (iv) aggregates elements that spread across the first three groups, like communication aspects or a common vocabulary.

Next to work that focuses on RAs, three studies systematize the concept of REAs. Fattah (2009, pp. 1–2) classifies REAs by the dimensions coverage and abstraction. Concerning the former, an REA might cover all EA related aspects (i.e., from strategy to technology layer) and all domain-specific topics. In contrast, an REA might only focus on certain EA layers and a specific aspect of the domain. The level of abstraction refers to how concrete or specific an REA is regarding its problem domain. Fattah (2009, p. 5) distinguishes between the abstraction levels *conceptual*, *generic*, *industry*, and *enterprise* (from abstract to specific) and proposes a hierarchy regarding these levels. In contrast to the author of this thesis, he understands an REA to relate to the enterprise-specific abstraction level. In line with others (cf. (Sanchez-Puchol and Pastor-Collado 2017; Harmsen van der Beek, Wijke ten et al. 2012) the author classifies REAs at industry level as an REA aims to be reused by different enterprises from the same problem domain. The global problem identified in section 4.2 supports this decision. Investigating available REAs in the higher education domain, Sánchez-Puchol and Pastor-Collado (2018b, p. 36) develop a criteria framework to make existing REAs comparable with each other. The authors define attributes and cluster them into four groups. Figure 34 shows the framework. Next to attributes concerning REA identification, the framework divides the characterization of REAs into *general scope*, *structure & content*, and *practical use*. An REA's scope addresses its overall objective, the origin of its knowledge, level of detail, and universality regarding possible stakeholders. Structure- and content-wise, the authors characterize REAs by the EA layers they cover, architecture principles or model notations they utilize, and its documentation. Furthermore, they consider domain-specific dimensions to be important as well—they define dimensions for the higher education domain. In order to assess an REA's practical use, the framework analyzes the REA's evaluation and its barriers regarding accessibility. Moreover, it investigates whether it provides guidelines that support its efficient and effective application in practice.

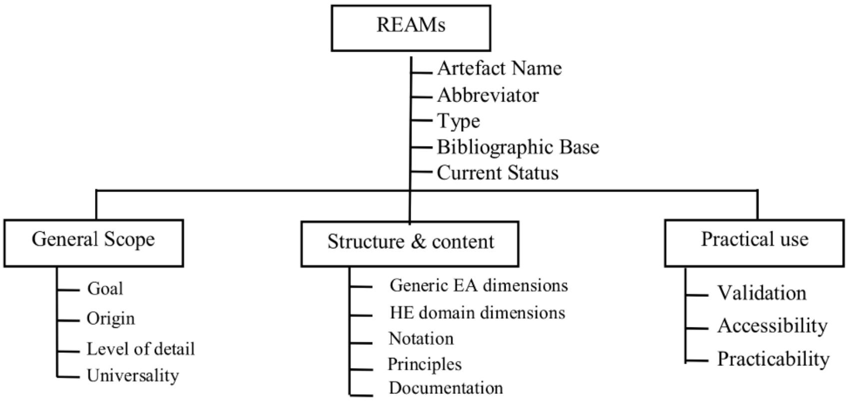


FIGURE 34. CRITERIA FOR REAS (SÁNCHEZ-PUCHOL AND PASTOR-COLLADO 2018B, P. 36)

Providing a broader angle on REAs, Harmsen van der Beek, Wijke ten et al. (2012, p. 101) provide a conceptual model that puts different concepts of REAs in relation to each other. As Figure 35 illustrates, the authors structure their conceptualization using two axes. The vertical axis distinguishes between concrete and abstract concepts, while the horizontal spans from real-world concepts to their representations (or models). Further, the conceptualization defines activities that enable the transformation of real-world concepts into their representative form and vice versa. On a concrete level, an EA represents relevant aspects of a specific real-world enterprise using architecting activities utilizing accepted EA frameworks. On an abstract level, Harmsen van der Beek et al. understand REAs as representations of a certain class of enterprises from the real world. Transformational activities are restricted to the design and maintenance of the REA as realization only takes place on the concrete level. The design of REAs also includes using EA frameworks. If a concrete enterprise belongs to the class addressed by an REA, it can use that REA for its transformational processes.

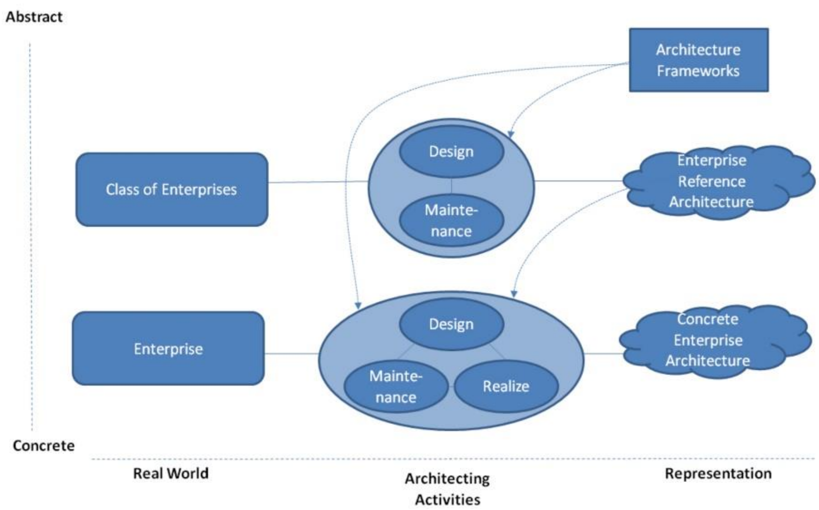


FIGURE 35. CONCEPTUAL FRAMEWORK ON REAS (HARMSEN VAN DER BEEK, WIJKE TEN ET AL. 2012, P. 99)

Although REA related research provides just a small number of conceptual work, some of it will inform a method for REA development. Using the distinction between FRAs and PRAs might be helpful in a stage of REA development where stakeholders need to concretize the scope of the REA. Relating to one of each type—or even a hybrid of them—is a good starting point to define the knowledge base the REA shall build from, which then further helps to develop a strategy for eliciting the necessary knowledge. Although it encompasses a focus on software RAs, the author understands the RAModel proposed by Nakagawa et al. (2012, p. 300) to be adaptable to the concept of REAs. Especially elements from the groups (i) and (iv) seem to be directly reusable to conceptualize REAs. Nevertheless, the groups (ii) and (iii)—relating to application and infrastructure—should be reexamined and adjusted to the specifics of the EA domain. For instance, instead of considering elements that support software implementations, the REA shall focus on different EA layers and provide different architectural viewpoints. Here, the criteria framework proposed by Sánchez-Puchol and Pastor-Collado (2018b, p. 36) seems appropriate to tailor the RAModel to REA specifics. Although developed in the higher education domain, all of its attributes are generalizable to other domains. Moreover, the conceptualization by Harmsen van der Beek, Wijke ten et al. (2012, p. 101) provides a good frame to put REAs into context. The conceptualization is in line with the author's understanding of the REA that emerged while investigating the local practices. However, the level of abstraction probably is not as rigid as the conceptualization from Figure 35 might imply. Therefore, the levels of abstraction proposed by Fattah (2009, p. 5) could be a good starting point.

DRIVERS OF REFERENCE ENTERPRISE ARCHITECTURES. The majority of the studies state the forcing drivers that triggered REA or RA development—either from a general or case-specific perspective. While three studies (S2, S6, and S14) provide generic drivers from literature or expert knowledge, the majority (S3, S8, S9, S15, S17-S23, and S25) reports on the drivers that caused the development of the REAs these studies present. In their theoretical work, Cloutier et al. (2009, p. 5) identify two universal forces that motivate RA development across all domains: increasing complexity of (socio-technical) systems and increasing dynamics and need for integration within these systems. After analyzing all drivers stated in the body of knowledge, the author recognized that all stated drivers for REA relate to either of the two universal forces proposed by Cloutier et al. (2009, p. 5). Based on this observation, Table 27 investigates two aspects. On the one hand, it reveals how these two forces occur across the different problem domains. On the other hand, it investigates whether different domains indicate special needs to encourage REA development based on the available data.

TABLE 27. REA DRIVERS STATED IN STUDIES IN RELATION TO THE RESPECTIVE DOMAIN[1]

	REA DRIVER	**CPS**			**ECON**	**EGOV**	**TEL**	**SME**	**FIN**	**HEALTH**			**SMC**	**GENERIC**		**LP-A**	**LP-B**
		S17	S18	S22	S21	S8	S3	S20	S9	S19	S24	S25	S15	S6	S14		
complexity	need for holistic data security concept		•														
	increasing network of business partners				•		•									•	
	increasing complexity of products						•										
	lack of business and IT alignment					•			•							•	•
	need to stay competitive							•								•	
	need for cost reduction						•									•	•
	EA initiatives too resource-intense													•		•	
dynamics and	lack of interoperability			•						•	•	•	•			•	•
	need for standardization	•													•	•	•
	increasing compliance requirements								•							•	•
	inconsistent data models								•								•
	long lead times during change implementation								•								
	disrupting technologies						•									•	

[1] CPS = cyber phisical systems | eCon = e-Contracting | eGov = e-Government | Tel = Telecommunications Indsutry | SME = small and medium-sized enterprises | Fin = Financial Industry | Health = Healthcare, Pharma Industry | SmC = Smart City

Although the results shown in Table 27 are not representative due to the small sample size, one can still make several observations. First, the distribution of REA drivers validate both generic forces defined by Cloutier et al. (2009, p. 5) as they more or less uniformly span across them. Second, there is no typical pattern regarding concrete REA drivers that is relevant for every domain. REA initiatives from different domains address different issues regarding complexity and dynamics. While studies from the health domain focus on interoperability issues, REA initiatives from the telecommunications, CPS, and financial industry address several different aspects simultaneously. Third and last, the lack of interoperability occurred most frequently. Overall, the results show that while there is a consensus on the two universal forces system complexity and dynamics, the need for an REA can be manifold. The author argues that one shall identify the driver at the beginning of an REA development process in order to focus on the needs elicited from practice.

Comparing the list of REA drivers to the characteristics of the local practices analyzed in section 4.2, the author argues that both Local Practice A and B reveal a need for an REA. As shown on the right side of Table 27, the utility industry and the financial institutes face several of the enumerated issues. Consequently, the author derives that both use cases arguably qualify for the development of an REA to resolve these issues.

4.3.5.2 RQ2: WHAT METHODOLOGICAL SUPPORT FOR REA EXIST IN RELATED WORK?

One of the central contributions of this thesis is to provide prescriptive knowledge that supports the development of an REA. Therefore, answering RQ2 reveals the current knowledge regarding method support for REA development and identifies open research questions within the IS domain. To do so, the author analyzed the 27 studies regarding methodological support for REA contruction, application, and evaluation. Distinguishing between these three categories resulted from the theoretical background in chapter III. For all categories, further sub-categories emerged during data analysis. Figure 36 visualizes the distribution of sub-categories in a tree map.

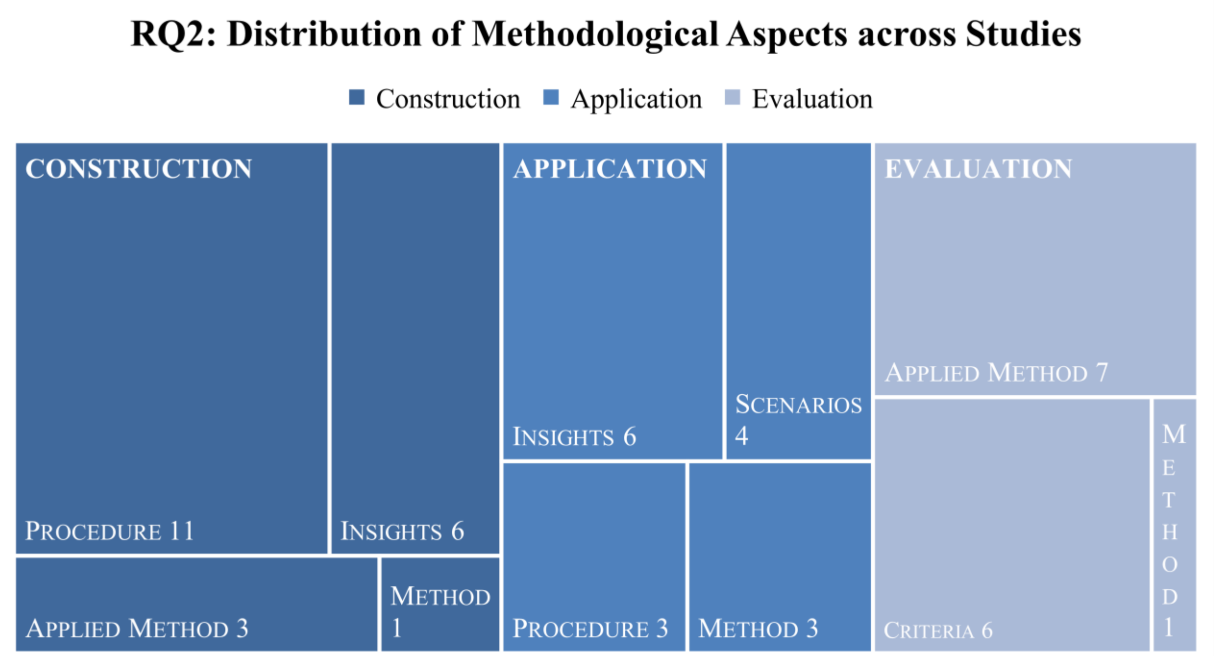


FIGURE 36. OVERVIEW ON TOPICS REGARDING METHODOLOGICAL SUPPORT FOR REA

The author investigated whether studies provided methods for REA construction, application, or evaluation. Since the majority of studies did neither provide nor follow an REA method, the author further captured essential steps these studies documented for both constructing and applying the REA—

if explicitly stated by the respective authors. Especially the studies providing theoretical work provided a more general perspective on REA development and, thus, contributed with some insights or gave certain guidelines. Moreover, some studies applied methods for REA development. In terms of REA evaluation, the author identified several criteria studies used to evaluate REAs.

While the results of the analysis build a basis to develop a method for REA development, the literature states a lack of methodological support for REA development. Tambouris et al. (2014, p. 992) bemoan an absence of comprehensive methods and techniques for REA development. Likewise, Nakagawa et al. (2012, p. 297) point out that most efforts are characterized by an ad-hoc approach when constructing REAs. Only Harmsen van der Beek, Wijke ten et al. (2012, p. 102) argue that EA frameworks would offer guidance for REA development. The author disagrees, as EA frameworks solely focus on EA endeavors at an enterprise or project level. The remainder of this section summarizes the results for REA construction, application, and evaluation separately. The findings support the argument that using EA frameworks is only one aspect of REA development.

CONSTRUCTING REAS: GENERAL INSIGHTS, METHODS, AND SUGGESTED DEVELOPMENT STEPS. In the end, 17 studies contributed to the REA construction category. Although there exists no method tailored to the construction of REAs, six studies (S2, S3, S6, S7, S12, and S24) provide general statements that help to prepare REA endeavors. Cloutier et al. (2009, p. 7) and Muller (2008, p. 2052) stress that the development of REAs strongly relies on feedback from practice during several evolutionary development iterations. Lankhorst (2014) goes one step further and argues that the development of REAs should be based within the community of the problem domain, which is in line with the user-oriented understanding of the RM notion (cf. chapter III). According to Nakagawa et al. (2014), the REA development should go hand in hand with a profound terminology for the problem domain, which has to be developed if not available.

Concerning knowledge elicitation, studies make different statements. While Naranjo et al. (2018) claim that the REA context terminates whether to use a bottom-up or top-down (or hybrid) approach, Cloutier et al. (2009, p. 7) argue to abstract REAs from existing architectures. In order to ensure the success of an REA development endeavor, Muller (2008, p. 2052) brings up the importance of a sound resource budgeting within the development team and says that REAs should rely on appropriately chosen EA frameworks established in the domain. Likewise, he hints at the risk of over-detailing the REA and assesses the decision of finding the appropriate level of detail as important as it is difficult. Therefore, he introduces the "abstraction diabolo," saying an REA's level of detail depends on the number of addressed systems from the problem domain and the necessary number of components of these systems Muller (2008, p. 2050). Finally, Czarnecki and Dietze (2017c, p. 10) claim that one could use methods from the research domains IS modeling, EAM, and RM. However, as related work shows, these methods fail to meet the specific needs of REA and, thus, only serve as starting points for an REA method.

The study provided by Nakagawa et al. (2014) is the only one that provides a comprehensive method—called ProSA-RA. Although it intends to develop RAs in general, ProSA-RA contributes to the design of an REA development method. The fact that other studies from the available sample apply it to develop REA hints at its relevance (Rodriguez 2018). The four-step approach builds on the RA-Model presented in section 4.3.5.1 from the same authors (Nakagawa et al. 2012). The method defines the several steps, their process flow, the resulting information flow, and involved stakeholders (see Figure 37). In step 1, ProSA-RA collects knowledge from the domain necessary to develop the RA. This knowledge includes publications, software systems, people from the domain, domain ontologies, and related reference models. Activities of this step, therefore, also include actions to elicit that knowledge as well as system requirements. Step 1 also aims to establish a common terminology of the domain. To concretize these findings, the authors suggest utilizing the RAModel for the documentation of necessary

RA elements. Afterward, step 2 identifies the necessary domain concepts. Therefore, it identifies requirements towards the RA based on prior elicited system requirements. These concepts build the basis for step 3. It builds the architectural description as the RAModel can be applied as a general framework. Although ProSA-RA provides guidelines to develop architectural views, these strongly relate to software architectures (e.g., source code views) and, thus, are not covered here. Nonetheless, the REA method will use a viewpoint approach, too. Finally, step 4 evaluates the RA using a checklist-based approach FERA (Framework for Evaluation of Reference Architectures). Here, domain experts and software architectures act as reviewers that answer structured questionnaires based on these checklists. To show ProSA-RAs applicability, the authors apply it in a real-world case scenario.

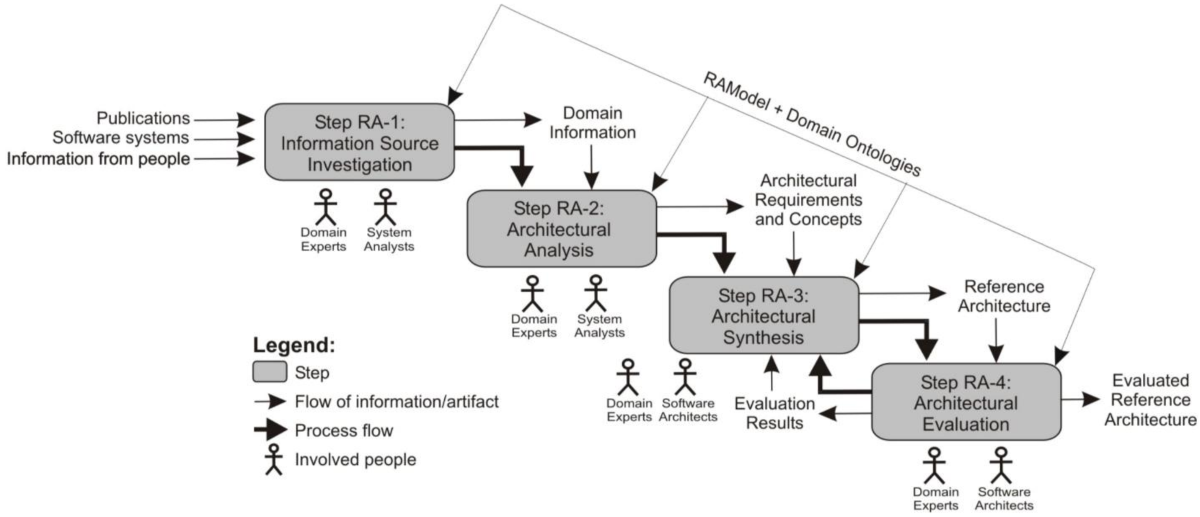


FIGURE 37. PROSA-RA METHOD PROPOSED BY NAKAGAWA ET AL. (2014)

Amongst the other studies, only three use a dedicated method when developing the REA. As said before, Rodriguez (2018) instantiates ProSA-RA. The REA for the telecommunications industry presented in Czarnecki and Dietze (2017c, pp. 74–76) apply Schütte's (1998) general RM method introduced in chapter III. While the authors show that Schütte's approach applies to REA development as well, analyzing their documentation reveals that it needs more concrete activities tailored to REA specifics, in order to come up with an REA. Therefore, the author investigated all studies regarding activities they conducted during their REA development. Naranjo et al. (2018) apply this pragmatic approach by deriving a four-step approach from it.

Eleven of the studies contributed to REA construction. While some studies identify actions for REA development from a more prescriptive standpoint (Trefke 2012, p. 29), the majority explicitly explains steps how an REA or RA was developed (Ghahramany Dehbokry 2017, p. 16; Aulkemeier et al. 2016a, p. 472; Czarnecki and Dietze 2017c, pp. 115–119). Interestingly, although 15 of all 27 studies present an REA, three of them miss to document the development procedure (Nardello et al. 2017; Sultanow et al. 2018; Chircu et al. 2017).

During the analysis, the author annotated every text passage that described a development step using the knowledge item functionality of the Citavi reference management tool. After aggregating the resulting list of development steps, the author defined two clusters, to which each of the twelve resulting steps relates. Table 28 presents the results of this analysis. Although the grouping of the steps may be biased by the author's knowledge and is open for discussion, it helps to provide an initial structure of REA development steps.

The first cluster *preparation* intends to capture all activities before any information for REA development is collected or even used to construct the REA. It appears that defining requirements towards the resulting REA is an essential step since five studies explicitly state it. Further, the authors report that it was helpful to identify problem-specific domains and put them in a structural overview in order to improve the understanding of the problem domain. Interestingly, only one study states that it determined the REA scope in the beginning. Another study outlined possible application scenarios before the construction process started.

The second cluster *REA construction* then includes all steps that relate to knowledge elicitation and architecture development mentioned by the authors. The distribution of studies related to the steps seem to be in line with the observation of Nakagawa et al. (2012, p. 297) that most studies use an "ad-hoc" approach. The highest consensus lies in the steps to search for reusable reference models and to investigate the current landscape of IS artifacts in the domain. To the surprise of the author, no study reflected on the process of how to decide what knowledge elicited from practice or theory is used by the resulting REA model. Overall, the identified activities build a compelling initial basis for an REA development method.

TABLE 28. REA DEVELOPMENT STEPS CLUSTERED REGARDING PREPARATION AND CONSTRUCTION

	STEPS FOR REA DEVELOPMENT	SOURCE
REA PREPARA-	set the scope of the REA	S20
	identify REQ towards the REA (elicitation, documentation, validation)	S8, S11, S17, S20, S27
	develop potential application scenarios before REA construction	S27
	identify architectural domains of problem space	S3, S21, S24, S27
	develop a structural overview of the problem domain in an initial model	S11, S24, S27
REA CONSTRUCTION	identify relevant reference models that are available within the domain	S1, S17, S18
	elicit knowledge from the domain's business perspective	S10
	elicit knowledge regarding the domain's IS landscape	S1, S10, S27
	make data from different sources comparable	S15
	abstract reference elements form data	S24
	structure REA using architectural views	S24
	define end-to-end processes that interrelate EA layers and domains	S3

APPLYING REAS: GENERAL INSIGHTS, APPLICATION SCENARIOS, AND METHODS. In contrast to constructing REAs, only eleven studies reported on applying REAs. From these, the majority only shared general insights regarding REA application. Looking at how studies distribute among the sub-codes insights, procedures, methods, and scenarios, one can derive that research lacks coverage on REA application (see Figure 36). This is in line with observations made by Sanchez-Puchol and Pastor-Collado (2017, p. 12), who identify a lack of methodological support and empirical insights regarding REA application. However, this section summarizes the results of the data analysis in this aspect, as they inform the design of this work's artifact. After discussing the general insights found in the literature, the author summarizes the stated application scenarios of REAs and synthesizes application procedures and methods presented in the studies.

From a general perspective, Sanchez-Puchol and Pastor-Collado (2017) claim that the uses of EA apply to REAs as well. The authors present success factors for REA application: clear ownership of the REA and appropriate REA sponsorship on the constructor-side, organizational commitment, and enforcement on the user-side. In addition to this, Czarnecki and Dietze (2017c, p. 76) stress the need to distribute the REA among industry actors appropriately, to use the multiplier effect of ISVs and system integrators, to provide case-examples of real-life application projects, and to provide trainings and support for REA application. Cloutier et al. (2009, p. 12) and Lankhorst (2014) second the latter, stating that a successful application depends on the quality of REA documentation provided to the user. Looking from a user-oriented standpoint, Heidel et al. (2017, pp. 56–59) point at the various needs demanded by the different stakeholders of the problem domain.

Consequently, the REA has to find the trade-off between general validity and customizability—known as the RM dilemma (cf. chapter III). Experts understand REA to be useful at any point in time during an EA project (Kotzampasaki 2015, p. 19). However, Harmsen van der Beek, Wijke ten et al.

(2012, p. 106) found that only a few practitioners have experience with REA application. The authors recommend REAs to make as much use of methods provided by known EA frameworks as possible since they are familiar to most practitioners. Czarnecki and Dietze (2017c, p. 10) state that approaches from both RM and enterprise transformation provide useful tools for planning an REA application.

Only four studies report on application scenarios for their REAs. Comparing REA application with the transformational process, Czarnecki and Dietze (2017c, pp. 226–230) distinguish between strategic (e.g., impact on business areas), technical (e.g., impact of retiring legacy systems), and operational transformation (e.g., the impact of automation) triggered by REAs. They exemplify each scenario and relate potential stakeholders (e.g. chief officers) to them. Based on the replies of enterprise architects in an interview study, Harmsen van der Beek, Wijke ten et al. (2012, p. 107) claim that REA can be used for communication support among different domain stakeholders, to support the scoping and design of EA projects, to support IT landscape planning, and to conduct review processes against existing EAs. Moreover, Iacob et al. (2013, p. 736) show how to implement technical components based on an REA using model-driven development. Likewise, Aulkemeier et al. (2016a) apply the REA from Aulkemeier et al. (2016b) using prototyping in order to support a cloud-based transformational project.

Three studies recommend specific steps to consider for the application of an REA. One can derive that the awareness of an REA's possible usage scenarios is an essential success factor. Thus, Ghahramany Dehbokry (2017, p. 16) includes the definition of application scenarios as a step within the REA construction. Moreover, the REA team should define an appropriate distribution strategy—e.g., providing it online (Tambouris et al. 2014, p. 1007). Furthermore, some studies utilize the design patterns for RM defined by (Vom Brocke 2006) as they apply REAs using instantiation, aggregation (Heidel et al. 2017, 25-27), and specialization (Ghahramany Dehbokry 2017, p. 120).

Although the results of the SLR reveal an absence of a method for REA application, three studies propose some methodological guidance. While Czarnecki and Dietze (2017c, pp. 77–78) and Rodriguez (2018) define an application method for the REAs they present. Kotzampasaki (2015, p. 32) proposes a method that supports architects to identify the appropriate REA for a specific problem. Kotzampasaki provides a method guiding an architect to identify fitting REAs and supports this process by dint of an REA selection toolkit. The toolkit intends to provide an REA database, from which the architect can choose an REA based on predefined criteria. While the approach comes with the risk that REA designers have to make the necessary information available to the platform, it provides insights from the perspective of REA users. Furthermore, the author recognizes parallels to the approach by Fettke and Loos (2002b), who suggest a catalog-based approach to make the plethora of reference models systematically accessible to potential users.

After finding an appropriate REA, authors agree that applying REAs at the organization is a very resource-consuming task. In order to support the users of the reference architecture for healthcare supportive home systems (HomecARe), Rodriguez (2018) defines a process of how to instantiate the HomecARe. The method distinguishes between determining the application context (*domain analysis*), defining requirements towards the application (*architectural analysis*), identifying candidate architectural solutions (*architectural synthesis*), and evaluating these results (*architectural evaluation*). For each step, the method defines inputs, reusable artifacts of the REA, and outputs. The work by Czarnecki and Dietze (2017c, pp. 77–78) provides the best documentation for applying REAs. As Figure 38 visualizes, the authors define six steps to implement an REA within an organization. While the first and second steps have parallels with the selection process by Kotzampasaki (2015, p. 32), step three and four select relevant parts of chosen REAs, customize them, and possibly synthesize them in an application model. At this point, Czarnecki and Dietze (2017c, pp. 77–78) argue that a solution model (implemented at the organizational level) may require more than the application is able to provide (e.g., in terms of level of detail). Thus, the fifth step of the REA application asks the user to develop further solutions to close this gap. Implementing the resulting solution model solves the initial problem. Next to this procedure, the authors further provide users with an architecture solution map that supports structuring the task related to the REA application. In total, the approach defines eight key elements, such as architecture diagnostics, strategic alignment, or change management. Furthermore, the authors report on several real-world cases that document their different application specifics.

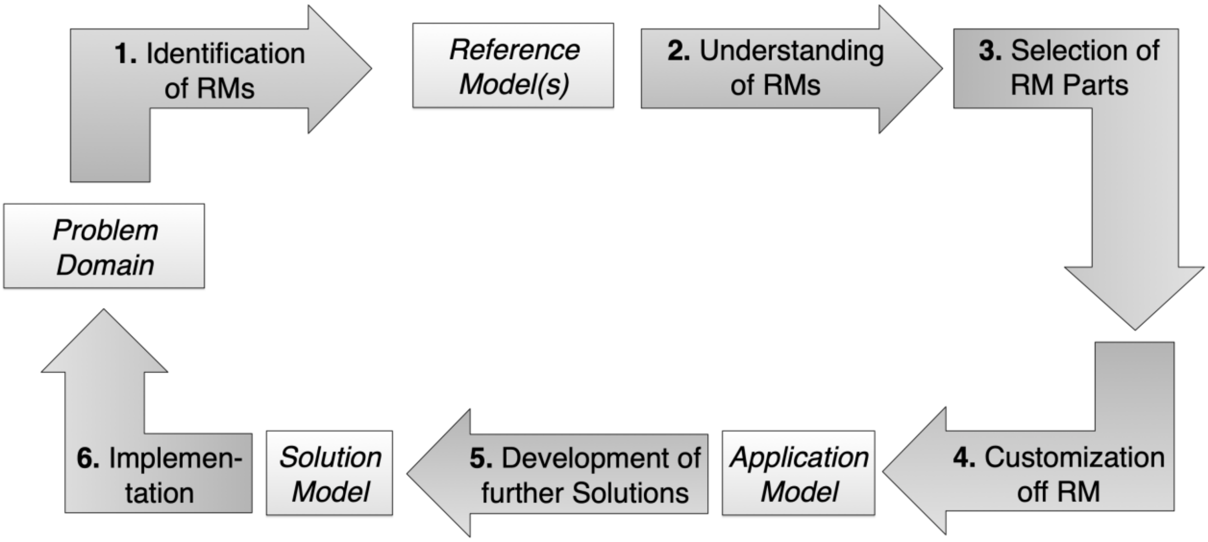


FIGURE 38. RM USAGE OF THE TELCO REA (CZARNECKI AND DIETZE 2017C, P. 77)

EVALUATING REAS: USED METHODS AND CRITERIA. As the previous sections have shown, many diverse factors determine an REA's success. However, Figure 36 shows that REA evaluation receives the least attention. In total, only seven studies report on how they applied REA evaluation. While some of these also discuss criteria they investigated during the evaluation, others provide small lists of criteria they deem essential for REA evaluation from a theoretical perspective. From the sample of 27 studies, a total number of eleven contributed to this category. This observation reveals a research gap in the REA domain, especially because many authors state that REAs shall evolve over many feedback loops (Muller 2008, p. 2052) and that its acceptance in practice strongly depends on proven concepts incorporating the REA (Cloutier et al. 2009, pp. 7–8).

On the one hand, the absence of research focusing on REA evaluation might be due to the reported low maturity of REA research in general. On the other hand, Angelov et al. (2008, pp. 231–232) point out that an evaluation of REAs is a very resource-consuming endeavor since both the generic nature of REAs and the diverse application scenarios of an REA require evaluation. This task becomes even harder when evaluating REAs that claim to make future-oriented recommendations.

One study from the sample discusses method support for RA evaluation. Angelov et al. (2008, pp. 237–238) analyze the architectural trade-off analysis method (ATAM) (Mugurel T. Ionita et al. 2002) regarding its applicability and suggests ways to adapt it in order to conduct RA evaluation, that is the identification on evaluation participants and appropriate evaluation scenarios. Further, they propose aspects for RA evaluation that extends ATAM. First, Angelov et al. recommend comparing the RA with best practice architectures existing in the domain in order to validate the RA's completeness. Second, the approach evaluates the applicability of RAs by testing it after defining different application contexts. Third and last, Angelov et al. (2008) suggest testing a RA's buildability by showing how specific components of the model are instantiated in real scenarios, for instance, using prototyping as Aulkemeier et al. (2016a) do. Although this approach focuses on evaluating RAs, especially the first two ATAM extensions might be helpful for REA evaluation. Moreover, the author of this work understands the scenario-based evaluation approach to be feasible for REAs as well.

While the work by Angelov et al. (2008) contributes to REA evaluation from a methodological stance, other studies provide further insights regarding what criteria to evaluate an REA against and research settings to use for an evaluation. Therefore, the author analyzed all studies that conducted an evaluation, focusing on evaluation criteria investigated and research methods utilized. Summarizing the results, Table 29 enables the following observations. The studies mentioned nine different criteria when evaluating REAs. According to data used in this SLR, authors understand REAs' *completeness* (that is its fidelity with the problem domain), its *ease of use*, and its *customizability* as essential criteria. Kotzampasaki (2015, pp. 18–19) further argues for evaluating an REA's up-to-dateness, comprehensibility, availability, and the ease of maintaining the REA. Others mention model buildability (Angelov et al. 2008, pp. 237–238) and minimality (Ghahramany Dehbokry 2017, p. 122) as additional criteria.

All criteria mentioned relate to either qualities ascribed to information models (e.g., correctness or minimality), qualities of reference models (customizability, up-to-dateness, or availability), or software engineering (ease of use, maintainability, or buildability). Depending on the nature of the REA at hand, these domains seem to provide some useful tools for evaluating REAs.

TABLE 29. UTILIZED RESEARCH METHODS FOR REA EVALUATION AND INVESTIGATED CRITERIA

EVALUATION CRITERIA	SOURCE
completeness (fidelity with domain)	S12, S18, S20, S26
ease of use	S5, S12, S18, S20
customizability	S3, S5, S12
up-to-dateness	S5
comprehensibility	S5
availability	S5
maintainability	S5
minimality	S20
buildability	S26

RESEARCH METHODS	SOURCE
case study research	S1, S19, S20
expert interview	S18, S20
prototyping	S1, S10
checklist-based review	S8
group sessions	S11

In addition to investigated evaluation criteria, Table 29 also enlists the research methods utilized by the studies. Three studies applied the REA in a real-world setting using case study research. Others validated the REAs with the help of domain experts using interview studies, group sessions, or even a checklist-based review with the participants. In two cases, the authors performed prototyping building an instantiation of the REA using model-driven development methods. In most cases, the evaluations focused on a particular part of the REA to illustrate its validity. This observation corresponds with the Angelov's statement saying that REA evaluation is scenario-specific. Furthermore, the fact that all studies but S10 evaluate the REA in real-world settings or consult domain experts reaches a consensus with the user-oriented perception of reference models, which highlights that a reference model's acceptance in practice determines its validity (Thomas 2005).

4.3.5.3 RQ3: HOW TO STRUCTURE AND DOCUMENT AN REA?

REAs are complex artifacts, address different user groups, and often represent a vast body of knowledge. Thus, while being at its core, the information model visualizing the REA itself is not the sole REA component. As discussed in section 4.3.5.1, the studies identify many different building blocks an REA shall provide. Consequently, RQ3 analyzes the 27 studies in terms of how they approach the REA structural composition. Therefore, this SLR investigated how authors documented the REAs' content (*REA documentation*) if they use *EA frameworks*, *modeling languages*, and the *EA layers* the several studies addressed. Figure 39 illustrates what subcodes evolved after data analysis and shows how many studies contributed to the respective subcodes using a treemap.

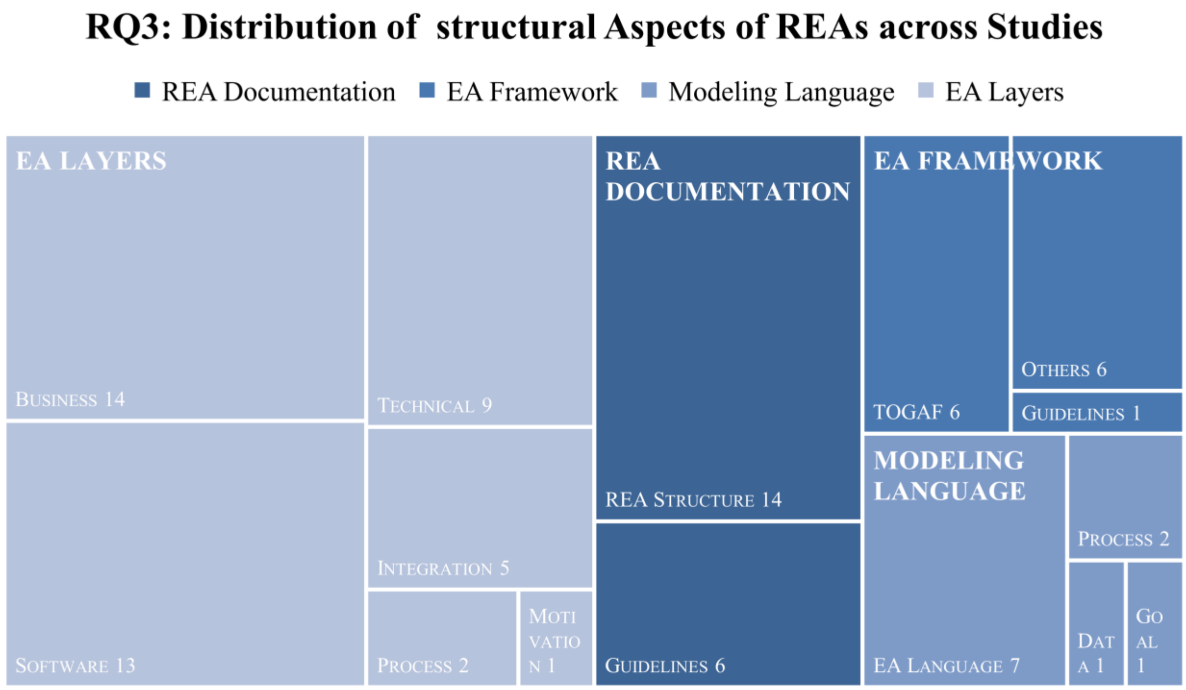


FIGURE 39. OVERVIEW ON TOPICS COVERED REGARDING REA STRUCTURE AND DOCUMENTATION

DOCUMENTING REAS: GUIDELINES AND INSIGHTS FROM DEVELOPED REAS. The author analyzed the 15 studies that present either RA or REA development (cf. Figure 31). Since there is neither a coherent definition of the REA concept nor exists a commonly accepted REA development approach, it is no surprise the author did not identify a consistent approach of REA documentation across the 15 studies. Although six studies (more or less thoroughly) reflect on guidelines for REA documentation, no approach supports sound REA documentation. Improving a RA's comprehensibility, Cloutier et al. (2009, p. 9) recommend decomposing them into logical units. A logical unit can relate to either utilized technical frameworks (e.g., EA frameworks) or domain-specific aspects (Cloutier et al. 2009, p. 10; Sánchez-Puchol and Pastor-Collado 2018b, p. 36). In this context, Trefke (2012, p. 27) stresses that REAs shall provide a hierarchical structure using architectural viewpoints. Content-wise, Janssen and Cresswell (2005, p. 3) point out that REA constructors have to find the appropriate level of abstraction in order to ensure the REA's value. Their suggestion aligns with the practice-oriented stance by Pang (2015), who suggests the guideline to provide the so-called "one-pager" for each EA layer covered by the REA.

Unfortunately, the 15 studies provide documentation for their RA or REA in varying levels of detail. Although they develop an REA, Janssen and Cresswell (2005) do not discuss its structure. However, Table 30 tries to compare them with each other in terms of REA documentation and structure. To make the comparison feasible, Table 30 analyzes whether the studies provide information regarding REA building blocks identified earlier at the end of section 4.3.5.1. Therefore, the author uses the building blocks from Table 26 that were mentioned by more than one study and focused on structural or documentation-related aspects. Thus, the building blocks "best practice," "transformation roadmap," and "end-to-end process" were not used. While Czarnecki and Dietze (2017c) only mention the latter two, the author excluded the former because "best practice" is hardly a well-understood concept in the RM domain (Scholta et al. 2019).

The results presented in Table 30 emerged as follows. Based on the available data, i.e., the articles enlisted in Table 19, the author decided whether a study documented the REA regarding the several building blocks. In doing so, the author recognized different levels of documentation quality among the studies. For instance, Tambouris et al. (2014) provide a thorough definition of requirements, while others only shortly summarized general REA requirements without referring to them later on. (Naranjo et al. 2018; Ghahramany Dehbokry 2017; Adwan 2018). To make such differences transparent, the author used three different symbols for each cell:

– the approach does not cover the building block
○ the approach partially covers the building block (e.g., S1 and S3 present essential concepts of the domain but do not provide a taxonomy; S20 and S24 do discuss general requirements but do not make them explicit)
● the approach covers the building block

Although this approach leads to some interesting insights, the author points out that it comes with some limitations, too. First, the author's subjective conclusions bias the analysis. Second, the available data may not represent the actual data existing for the several REAs and, thus, some REAs might provide more documentation aspects than shown in Table 30. However, the author argues that these limitations are acceptable since this comparison has no claim to completeness and instead aims to provide general insights on REA documentation.

TABLE 30. COMPARING DOCUMENTATION OF DEVELOPED REAS TO REA BUILDING BLOCKS

BUILDING BLOCKS FOR DOCUMENTATION	S1	S3	S8	S10	S11	S15	S17	S18	S19	S20	S21	S22	S23	S24	S25
(B1) REA Scope Definition	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
(B2) REA Requirements Elicitation	-	●	●	-	●	○	●	-	●	○	-	-	-	○	-
(B3) Domain-Specific Vocabulary	○	○	-	○	-	-	○	-	-	○	●	-	-	-	-
(B4) Used Framework	●	●	●	●	-	●	●	●	-	●	-	-	●	●	●
(B5) Viewpoint Structure	-	●	-	○	-	○	-	-	●	●	-	●	●	●	-
(B6) Domain-Specific Viewpoints	●	●	-	-	-	-	●	●	●	●	○	-	●	●	●
(B7) Reuse Industry Standards/RefMods	●	●	-	-	-	-	●	●	●	-	-	●	●	●	-
(B8) Application Support (DPs[1], Guidelines)	-	○	-	○	-	-	●	-	●	●	-	●	-	-	-

Looking at the results of Table 30, one can make several observations. First, the vast majority of REAs thoroughly documented on their scope (B1) and based their structure on a known EA framework (B4). Hence, one can derive that a clear REA objective and an underlying EA framework is a mandatory REA aspect. Second, many studies included standards and reference models identified in related work (B7). In some cases, no appropriate reference models or standards existed, but most studies discussed this aspect. Hence, each REA development endeavor should include a search for reusable reference models or standards. Third, the results indicate a lack of documentation efforts in terms of a common domain-specific vocabulary (B3), a coherent REA viewpoints structure (B5), and application support (B8). This finding is especially surprising since most studies that discussed REAs' building blocks mentioned these as necessary (cf. Table 26).

Interestingly, many authors used domain-specific aspects to structure the REA on a high level of abstraction in combination with EA layers provided by the used EA framework. However, most studies did lack to provide more information on a more granular level. As an example, S10 only uses an overall layered ArchiMate view, while S15 discusses only the content of the different EA layers without referring to architectural viewpoints at all. The author raises the question of whether there is a missing guidance for appropriate EA viewpoint design. The same seems to be valid for the application of an REA as only four REA cover it in their approach. The REA for the telecommunications industry presented by S3 appeared to provide the most sophisticated documentation and might be worth a further look when designing an REA method. Overall, the comparison shows that although REA literature seems to steer

[1] DP = Design Principles

towards a consensus regarding REA structure and documentation, the research domain still lacks in providing clear guidance in putting this knowledge into practice.

REA STUDIES: USED EA FRAMEWORKS, MODELING LANGUAGES, AND COVERED EA LAYERS. Next to the REA documentation and structure, RQ3 also investigates to what EA frameworks, EA layers, and modeling language 15 studies relate. In terms of applied EA frameworks and modeling languages, Figure 39 already provides the data synthesis. Muller (2008, p. 2053) claim that any REA shall refer to an EA framework as they represent a deep body of knowledge, and some domains even use them as a standard. Thus, potential users of an REA are familiar with its structure, such as EA layers, viewpoint structure, or model elements. From nine studies that explicitly stated to have used an EA framework, five used TOGAF. Only the Zachman Framework was also used more than once. The remaining frameworks, BAWG, RM-ODP, SGAM, and FEAF, were applied only once. Studies chose them because they provide EA concepts tailored to a specific industry, such as the Smart Grid Architecture Model for the utility industry. Only Ghahramany Dehbokry (2017) combined several frameworks: TOGAF, BAWG, and Zachman. Interestingly, six studies (S3, S11, S19, S21, S22, S25) did not refer to any EA framework.

Since the majority of studies followed TOGAF, it is no surprise that most REAs used ArchiMate for model representation (six times). However, Adwan (2018) used ArchiMate, although the author followed the FEAF framework. UML4ODP (S24) and SoaML (S19) are the other two used architectural languages. Some authors approached model representation by combining modeling standards. For instance, Czarnecki and Dietze (2017c) used UML for data modeling and BPMN as a process model notation. Rodriguez (2018) provided an approach by combining GORE for goals modeling with BPMN and the SoaML notation. However, from this set of data and the consensus between most authors, the author concludes that an REA shall follow a coherent modeling approach if feasible.

The last question covered by RQ3 is how approaches span over the different EA layers that exist. The author examined the studies regarding the layers that their REA or RA addressed. The author used the well-accepted delineation of essential EA layers proposed by Winter and Fischer (2006) in order to ensure comparability. As their approach does not cover a motivational layer, the author added it as another dimension on top. The author argues that the motivational layer helps to represent an REA's scope and purpose. Figure 40 reveals how the REAs developed by the 15 studies distribute over these six EA layers.

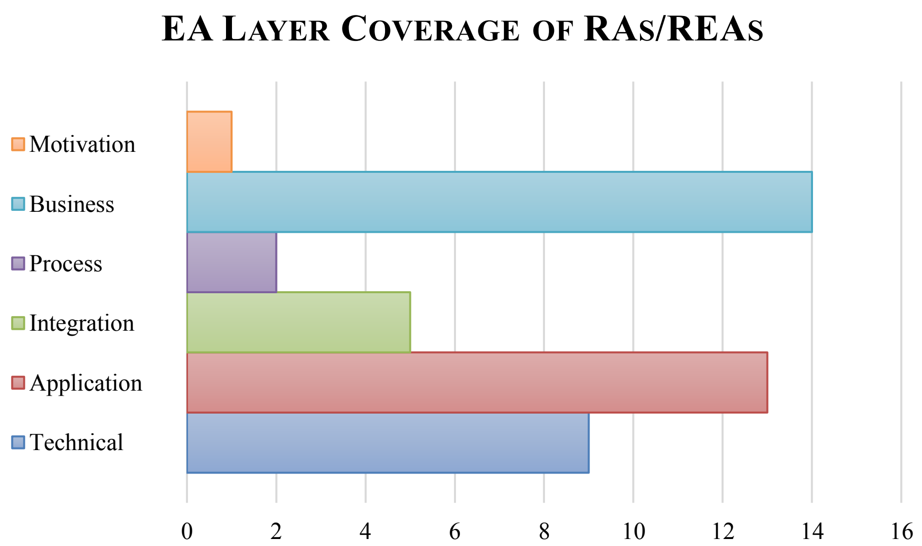


FIGURE 40. EA LAYERS COVERED BY STUDIES

For each study, the author decided which of the six EA layers is addressed based on the data provided by the respective articles. As Figure 40 shows, the majority of approaches focused on business, application, and technical layers. While some EA frameworks like TOGAF distinguish between data and application layer, Winter and Fischer (2006) aggregate these two in the application layer. Hence, if a study covered the data layer, the author counted this as a contribution to the application layer. Overall, the results reach a consensus with theory, where Cloutier et al. (2009) demand a RA to cover at least the triangle of technical, business-related, and customer-related (i.e., domain specifics) aspects. Further, it seems that the problem domain requires the REA to cover other layers as well.

4.3.5.4 RQ4: KNOWLEDGE ELICTATION DURING THE REA DEVELOPMENT?

The elicitation of appropriate domain-specific knowledge and its synthesis into an REA is a central task when developing REAs. To understand and compare current insights in the RA and REA domain, RQ4 investigates what research methods studies applied to elicit relevant knowledge, what kind of knowledge they used, and whether the authors used deductive, inductive reasoning, or both to derive an REA. While the author conducted this analysis on the 15 studies that developed either a RA or REA, other studies provided some general guidelines in this regard.

Cloutier et al. (2009, p. 7) and Muller and van de Laar (2009) agree that knowledge used for REA development originates from both explicitly and implicitly available knowledge. While explicit knowledge often occurs in documentations or event logs of existing systems (e.g., a concrete architecture solution of an organization), implicit knowledge may lie in the experience of domain experts Muller and van de Laar (2009). Concerning their distinction between futuristic and practice RAs (FRA and PRA), Angelov et al. (2008, p. 228) argue that PRAs emerge from descriptive knowledge while FRAs rely primarily on prescriptive knowledge. Hence, depending on an REA's purpose, the appropriate type of knowledge may differ. From a methodological perspective, all these authors agree to use expert interviews, document analysis, or observations as elicitation approaches. Muller and van de Laar (2009) further discuss that formats such as interactive workshops with several domain experts might be fruitful and are subject to further research. Relating to deductive and inductive strategies for RM (cf. chapter III), Cloutier et al. (2009, p. 7) claim that REA development is mainly a mining effort and, thus, requires inductive reasoning techniques. However, other authors also consider deductive reasoning as a valid strategy, not least because many relevant knowledge only exists implicitly in experts' experience. Muller and van de Laar (2009) add that combining deduction and inductive might contribute to the acceptance of an REA.

To investigate whether actual REA development endeavors reflect these guidelines, the remainder of this section analyzes them regarding the categories elicitation method, knowledge sources, and reasoning approach. Figure 41, Figure 42, and Figure 43 illustrate the results using pie diagrams. To make elicitation methods comparable, the author utilized the taxonomy of data collection methods from Johannesson and Perjons (2014, pp. 55–61), who distinguish among questionnaires, interviews, focus groups, observations, and documents.

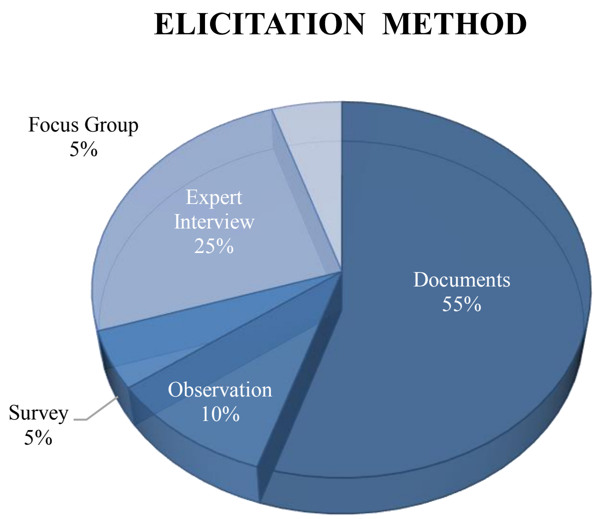


FIGURE 41. ELICITATION METHODS USED BY STUDIES

As Figure 41 illustrates, the majority of studies used document analysis to elicit relevant knowledge to develop REAs. Most of these eleven studies analyzed different kinds of information sources. All except one analyzed academic literature. Many systematically investigated industry-related information, e.g., by conducting a market analysis of IT providers (Aulkemeier et al. 2016b), consulting industry reports (Adwan 2018), or consulting existing reference models (Czarnecki and Dietze 2017c). In two studies, authors conducted an SLR to elicit knowledge (Tambouris et al. 2014; Aulkemeier et al. 2016b). Every fourth study utilized expert interviews. While most endeavors consulted practitioners from affected organizations, others also interviewed IT consultants (Chircu et al. 2017), EA experts (Ghahramany Dehbokry 2017), or IT experts (Adwan 2018). In one study, the REA was even developed with the help of several focus group meetings (Janssen and Cresswell 2005). Unfortunately, the authors do not share their experiences in this regard. Two REAs use from knowledge elicited through observation (Janssen and Cresswell 2005; Czarnecki and Dietze 2017c). In both cases, the authors accompanied different projects in the problem domain and used their observations to contribute to the REA design. Finally, (Iacob et al. 2013) survey service providers of the respective problem domain to gain insights on the structure of their application architectures. Overall, this widespread utilization of the elicitation method among the quite a small data set of 15 REA projects hints that a variety of methods is feasible for REA development. Besides, a combination of document analysis and method to gather practical experience seems to be an accepted approach across the studies.

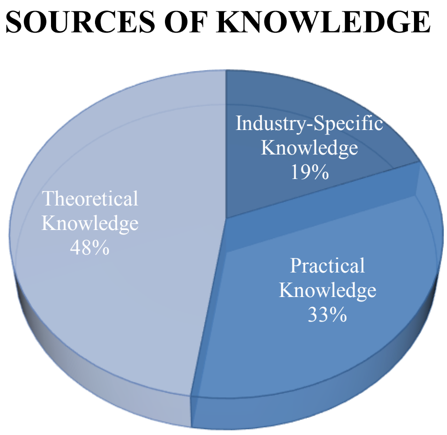


FIGURE 42. KNOWLEDGE SOURCES USED BY STUDIES

Figure 42 confirms the above observation when looking at the types of knowledge the studies used. The figure distinguishes between theoretical, practical, and industry-specific knowledge. As depicted earlier, the majority of studies combined different types of knowledge sources. Only three studies solely relied on theoretical knowledge by deriving REAs from knowledge communication through academic publications (Tambouris et al. 2014; Gill et al. 2017; Naranjo et al. 2018). Every third approach also included practical knowledge. Here, the author decided to aggregate knowledge authors gathered in practice, such as information based on expert knowledge, use cases, or surveys. Interestingly, all REA approaches that use practical knowledge combined it with theoretical knowledge. In contrast to practical knowledge, the author defined "industry-specific knowledge" as domain-related insights authors did not elicit themselves, but gathered, for instance, using document analysis. It mainly represents information like available reference models, industry reports, but also information gathered via online resources. Although this kind of knowledge is solely not sufficient for REA development, the studies by (Czarnecki and Dietze 2017c; Adwan 2018; Iacob et al. 2013) show that it can complement theoretical and practical knowledge.

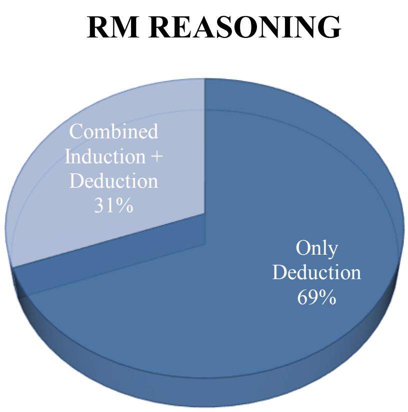


FIGURE 43. REASONING APPROACHES USED BY STUDIES

Depending on how and what kind of knowledge an REA endeavor elicits, different means of reasoning are necessary. Figure 43 visualizes whether studies used inductive or deductive reasoning (see chapter III). All of the 15 studies used deductive reasoning for REA development. In four cases, the authors applied an approach combining deduction with inductive reasoning. For instance, Czarnecki and Dietze (2017c) used deduction for initially developing the REA, and inductively revised it from the several application use cases. Iacob et al. (2013) deductively developed the business layer using expert knowledge and built the application layer from the survey results using inductive reasoning. However, none of these four approaches report how they conducted the inductive reasoning. Being a current research topic in reference process modeling (cf. chapter III), this remains an open research question for REA development, too. Overall, the author concludes a consensus among studies to reuse as many existing knowledge as possible, if available. Nevertheless, inductive reasoning might be necessary or even beneficial for the success of an REA, although the data sample does not provide any insights to confirm this statement.

4.3.6 PHASE V: RESEARCH AGENDA FOR REA DEVELOPMENT

After section 4.3.5 discussed the SLR results in detail, the following paragraphs summarize the five findings the KBA made in the REA research domain. Afterward, section 4.4 puts these in context with the problem investigation from sections 4.1 and 4.2. On that basis, the author derives a research question that will guide the remainder of this work.

SLR FINDING 1: LOW MATURITY OF REA RESEARCH DOMAIN. The findings of this SLR confirmed statements concluded by Sanchez-Puchol and Pastor-Collado (2017), who conducted a similar SLR in 2017. As section 4.3.5.1 reveals, there is no definition of the REA notion used across literature. Also, research lacks clarity on the value of REAs as studies have varying perspectives on its benefits without backing their views with empirical data. However, Figure 30 indicates an increasing research interest on the REA topic. At the same time, authors seem to steer towards a consensus regarding REA characteristics, as Table 23 illustrates. Furthermore, some theoretical work exists that tries to grasp the REA notion by explicating first definitions on the term (cf. Table 22) and providing conceptualizations (cf. Figure 35). The author argues that a method for developing REAs can build from this knowledge base.

SLR FINDING 2: LACK OF METHODOLOGICAL GUIDANCE FOR CONSTRUCTING REAS. As results from section 4.3.5.2 show, no method exists that guides REA construction. Only Nakagawa et al. (2014) provide the approach *ProSA-RA* to develop RAs. Unfortunately, this approach is hardly applicable to REA development due to REA's specific characteristics and necessary building blocks (cf. section 4.3.5.1). However, ProSA-RA's four steps, such as information source investigation or evaluation, will still inform of an REA method to a certain degree. Furthermore, a more detailed analysis of the 15 studies that developed REAs revealed steps for REA construction, on which most authors agree (cf. Table 28). Although research understands a sound viewpoint structure of REAs as essential, authors often miss to report how they did so. Interestingly, authors understand REA evaluation as crucial as they neglect it in their work. Some studies hint at scenario-based real-world settings as appropriate means for evaluation. Finally, there exists no clarity regarding the organizational aspects of managing REA development. Very few authors cover typical roles and stakeholders involved in the construction process. Overall, it seems that research would benefit from a method tailored to REA structures since there seems to be an increasing interest in this topic.

SLR FINDING 3: KNOWLEDGE ELICITATION AND REASONING FOR REA. The analysis discovered a diverse combination of elicitation methods used for knowledge elicitation among REA endeavors. It appears that most authors deploy an ad-hoc approach for gathering information as studies miss to explain their method choices. Moreover, almost no study reports on how the gathered knowledge contributed to the resulting REA, especially when authors use inductive reasoning. This should be a mandatory aspect to discuss. While they agree on the benefit of inductive REA development, only a few studies apply inductive techniques, and even these do not describe how they proceeded in detail. The author understands that this is due to a lack of available inductive approaches tailored to REA structures. Furthermore, it seems that the choices regarding knowledge types and utilized elicitation methods strongly depend on an REA's scope. The different REA endeavors mostly elicited a combination of theoretical, practical, and industry-specific knowledge using several sources. The author sees knowledge elicitation and its reasoning as a central task during REA construction and, hence, it should be a core aspect of a method for REA development.

SLR FINDING 4: LACK OF CONTRIBUTIONS FOR REA APPLICATION. REA research is in line with the user-oriented perspective on RM (Thomas 2005). Authors agree that reusability is a core characteristic of REAs. However, the minority reports on concrete REA applications, which might be the reason why no empirical evidence for REA value exists (cf. section 4.3.5.1). While some studies provide procedures for REA application in their specific cases, research lacks a systematic approach for it. Because there are many diverse reasons why to apply an REA, some authors recommend defining concrete application scenarios to provide more clarity for potential users. Regarding this, results reveal that predefined application scenarios influence the development and content of an REA. Hence, the author concludes to integrate the application design into the REA construction process since the REA content shall address the intentions of potential users. Available approaches fail to address this aspect. Furthermore, research asks for insights regarding evolutionary aspects of REAs. Authors argue that REAs will evolve as their context might change in time.

SLR FINDING 5: ABSENCE OF COHERENT REA DOCUMENTATION GUIDELINES. The last field of action addresses documenting the REA. Because it serves as the basis for REA application projects, the author understands a detailed and sound documentation as a critical success factor of REAs. Although the majority of authors understand them as important aspects, the minority of studies report on a common vocabulary, coherent viewpoint structure, or application support in their REA documentation. On the contrary, studies report on their scope, EA frameworks used, standards/reference models deployed, and provide domain-specific perspectives on the REA. In conclusion, the methodological support of REA development should provide practices on how to document the REA.

4.4 SUMMARY OF PROBLEM INVESTIGATION

Johannesson and Perjons (2014) claim that a valid DSR problem shall be of general interest. Further, it is challenging, and lacks available solutions applicable to it. Next to designing the actual artifact, Hevner (2007) introduces the relevance and rigor cycles—relating to general interest and available knowledge, respectively. The relevance cycle analyzes a DSR project's application context. One of its objectives is to explicate a global problem in this context and derive requirements towards a solution. Earlier, sections 4.1.1 and 4.1.2 analyzed two local practices from distinct industries that share a similar problem, on which section 4.2 derived a global problem from it.

Further, section 4.2.3 identified two root causes of that global problem (cf. Table 13). In order to ensure that a possible solution is not a routine design and adds to the available knowledge base, the rigor cycle analyzes existing research to confirm scientific rigor (Hevner 2007). Therefore, the author conducted a systematic literature review in section 4.3, which investigated current research in the related research domains (cf. section 4.2.4). By revealing five SLR findings (cf. 4.3.6), the results show that no solutions for the global problem exist. The remainder of this section discusses the global problem in the context of the SLR findings and derives a research question that will guide this work.

Earlier, section 4.2 identified the global problem that in different industries, groups of organizations face significant changes that affect their internal structures. While these changes can be manifold (e.g., technological developments or dynamic regulations), they often force organizations to revise their business and IT management holistically. Further investigations with stakeholders of two concrete local practices have shown that organizations lack methodological guidance to capture the actual impact of such changes, while necessary knowledge is rarely available in explicit form. Table 31 revisits these two root causes and summarizes its requirements towards a possible solution. It relates them with the findings of the SLR from section 4.3. In doing so, the table summarizes aspects the investigated knowledge base contributes to overcome the respective root cause. Further, it relates them with the SLR findings presented in section 4.3.6.

Table 31 divides each root cause into specific requirements a possible solution should meet in order to provide an appropriate solution for the global problem. A solution shall provide method support for REA construction and application as well as a management perspective behind such a method to resolve RC1. As SLR FINDINGS 2 and 4 depicted earlier in section 4.3.6, the investigated knowledge does not provide methods for either REA construction nor for REA application. However, related work provides some knowledge a solution should reuse. The third column of Table 31 enumerates this reusable knowledge and links to the respective section of the data synthesis of the SLR.

Nevertheless, this knowledge only provides initial insights to design a method tailored to REA development. Moreover, RC2 demands the method to provide means of knowledge elicitation, reasoning about this gathered knowledge, and guidelines to design an appropriate and well-documented REA structure from the perspective of potential users. In this regard, SLR FINDING 3 reveals an absence of guidelines on what knowledge to elicit using what methods for REA development. Especially in terms of approaches to derive an REA from a data set, research is scarce. Moreover, SLR FINDING 5 reveals that there exists no consensus among literature on how to accurately document and structure a resulting REA.

To conclude, a solution that tackles the global problem identified in section 4.2.1 needs to contribute to all these four SLR findings, as indicated by the last column of Table 31. The author argues that there exists sufficient knowledge on the REA notion. Thus, this work will build on the conceptual knowledge on the REA term and reuse definitions and conceptualization presented in section 4.3.5.1, although SLR FINDING 1 still postulates a low maturity of the REA domain. Furthermore, SLR results showed that research domains RM and EAM are appropriate as authors used REAs to overcome similar problems (cf. Table 27) and followed the same research methodologies as this thesis in doing so (cf. Figure 32).

TABLE 31. ROOT CAUSES IN THE CONTEXT OF KNOWLEDGE BASE ANALYSIS RESULTS

ROOT CAUSE	REQUIREMENTS	REUSABLE KNOWLEDGE	SLR FINDINGS
RC1 Organizations lack methodological support to capture the impact of industrial change from business, data, and IS perspectives, as these endeavors are complex and resource-intensive.	method support for REA construction	conceptual knowledge of REAs (cf. section 4.3.5.1)	SLR Finding 2
		building blocks of an REA (cf. Table 26)	
		procedural insights of REA endeavors (cf. Table 28)	
		ProSA-RA method (cf. Figure 37)	
	method support for REA application	scenario-based application (cf. p.123)	SLR Finding 4
		case-specific application procedures (cf. p.123)	
		evaluation criteria (cf. Table 29)	
	management approach for REA method	involved stakeholders (cf. Table 25)	SLR Finding 2 SLR Finding 4
RC2 Detailed knowledge for such endeavors is seldom available in explicit form, since most companies fall short on documenting beyond business processes and further tend to implement isolation solutions.	means for knowledge elicitation	mix of theoretical, practical, and industry-specific knowledge sources (cf. Figure 42)	SLR Finding 3
		variety of elicitation methods feasible (cf. Figure 41)	
	knowledge reasoning	combination of deduction and induction (cf. Figure 43)	SLR Finding 3
	well documented REA structure	essential EA layers (cf. Figure 40)	SLR Finding 5
		domain-specific viewpoints (cf. Figure 39)	

Based on these findings, the author derives the research question (RQ) that guides the remainder of this thesis. It relates to each of the SLR findings of the current knowledge base in the REA domain in order to result in a method that resolves both root causes RC1 and RC2. As previous sections have shown, the research question bases on scientific rigor and of general interest to the problem domain. Furthermore, its overall purpose decomposes into several aspects that guide the next chapters of the thesis.

RESEARCH QUESTION OF THE THESIS:

HOW TO PROVIDE METHODOLOGICAL SUPPORT FOR SYSTEMATICALLY CONSTRUCTING AND APPLYING DOMAIN-SPECIFIC REAS?

- ❖ **ASPECT 1:** What requirements exist towards an REA method?
- ❖ **ASPECT 2:** How to adjust RM methods to the EA domain in order to define a method for developing REA?
- ❖ **ASPECT 3:** What knowledge is necessary for REA construction? How to elicit this knowledge? How to derive an REA from it?
- ❖ **ASPECT 4:** How to accurately document and structure an REA?
- ❖ **ASPECT 5:** How to support effective case-specific REA application?
- ❖ **ASPECT 6:** What stakeholders participate in what phase of the REA development?

The best way to prove that a problem is challenging in terms of (Johannesson and Perjons 2014) is to relate the problem at hand regarding characteristics of so-called "wicked problems," as discussed earlier in section 2.1.2. The author claims that it is a non-trivial task to answer the above stated RQ. Investigating both local practices highlighted the complexity of the problem and showed that problem stakeholders benefit from a solution. Related research agrees that methodological support for REA development does not exist yet. Moreover, the results of the SLR hint that a complete method support will cover many diverse topics as the conceptual framework from section 4.3.3 shows. Also, the findings of this chapter indicate that a potential solution shall evolve using real-world settings. Given the long period an REA construction requires, the task to develop a valid and sound development method becomes even more challenging. Overall, the author argues that the problem underlying this thesis qualifies for a DSR project.

After this chapter presented the results of the problem investigation to derive the thesis' research question, the next chapter elaborates requirements towards an REA method before chapter VI presents the final artifact.

V. REQUIREMENTS TOWARDS A REFERENCE ENTERPRISE ARCHITECTURE METHOD

Based on the global problem explicated in the previous chapter (see section 4.2) and the analysis of solutions available in the knowledge base (see section 4.3), this chapter elaborates requirements that apply towards a possible solution to answer the research question developed in section 4.4. The content of this chapter represents the results of the second phase, "define objectives of a solution" in Peffers et al. (2007) DSR process.

Therefore, the remainder of this chapter structures as follows. Based on the results of the problem investigation and SLR, section 5.1 outlines the artifact that is appropriate as a possible solution for the explicated problem. It puts the artifact type choice in the context of the results of the previous chapter and gives a high-level overview of the artifact itself. Afterward, section 5.2 describes the requirements selection process before section 5.3 presents the final list of requirements elicited. In the end, section 5.4 shortly summarizes the results of this DSR step.

5.1 THE ARTEFACT: A METHOD TO SUPPORT REA DEVELOPMENT AND APPLICATION

In order to outline the artifact, Johannesson and Perjons (2014, p. 105) suggest to choose an artifact type that is appropriate to the explicated problem. In section 4.3.6 of the KBA, the author identifies a need for methodological support for REA development. In consultation with possible types of DSR artifacts (see Table 1 in section 2.1), the author defines the DSR artifact type *method* appropriate in order to design a potential solution for the problem explicated in section 4.2.

Based on this choice, the author shortly outlines the envisioned REA method. First, the KBA identified the need for methodological support for REA development as one of the problem's root causes (cf. RC1 in Table 13). Hence, the REA method's primary objective is the construction and application of a domain-specific REA model. Consequently, applying the REA method in a specific case supports the creation of an REA model for that domain. In concrete, applying a proposed method for REA development in Local Practice A, it shall result in an REA model that supports small and medium-sized public utilities in overcoming structural changes in the utility industry. Also, its application in Local Practice B would results in an REA model that enables financial institutes to implement holistic regulatory compliance management (see chapter IV).

Second, problem stakeholders from the different local practices agreed on the necessity to combine theoretical and practical knowledge in a domain-specific REA while they lamented about the absence of available practical knowledge (cf. RC2 in Table 13). Thus, a method for REA development can guide the user eliciting such knowledge. It further provides means how to reason about it in order to derive an REA model that represents current state knowledge of the respective domain.

Third, as chapter III and insights from the KBA concluded, such prescriptive knowledge should provide a structured approach in order to delineate logically or chronologically separated tasks from each other. A modular approach may be feasible by dividing actions of the REA method into logical units that address distinct tasks, use defined inputs, and produce specific outputs. For instance, the REA method shall encompass both REA construction and application. Both represent different units of action and may divide into smaller units as well.

Fourth, the REA method shall reuse existing approaches and actions identified in section 4.3. Further, methods from EAM and RM disciplines may inform the structure and content of the artifact, e.g., in terms of generic steps necessary for RM development.

Fifth and last, the KBA also identified research gaps the REA method needs to address in order to provide a satisfactory solution (see section 4.3.6). For instance, the REA method needs to provide means to integrate deductive and inductive reasoning techniques when deriving an REA model or shall prescribe minimum requirements for sound REA model documentation.

In conclusion, this Ph.D. thesis envisions designing a method that supports REA development—from now on, referred to as the REA method (in short REAM). In doing so, REAM shall provide systematic and feasible guidance for constructing and applying a domain-specific REA. Therefore, REAM shall integrate deductive and inductive reasoning using theoretical and practical knowledge. Based on these considerations, the following section reflects on the process used to identify requirements towards REAM before section 5.3 presents these.

5.2 DESCRIBING THE REQUIREMENTS ELICITATION PROCESS

When presenting its requirements, a DSR project shall be transparent regarding their identification. The author ensures this by reflecting on the elicitation process, the stakeholder involvement, and the literature review (Johannesson and Perjons (2014, p. 108). However, Peffers et al. (2007, p. 55) do not describe particular activities a DSR project shall follow for requirements elicitation. Hence, the author followed a process informed by other theoretical work from the requirements engineering domain in general and other DSR methodologies in specific. Figure 44 visualizes the overall process.

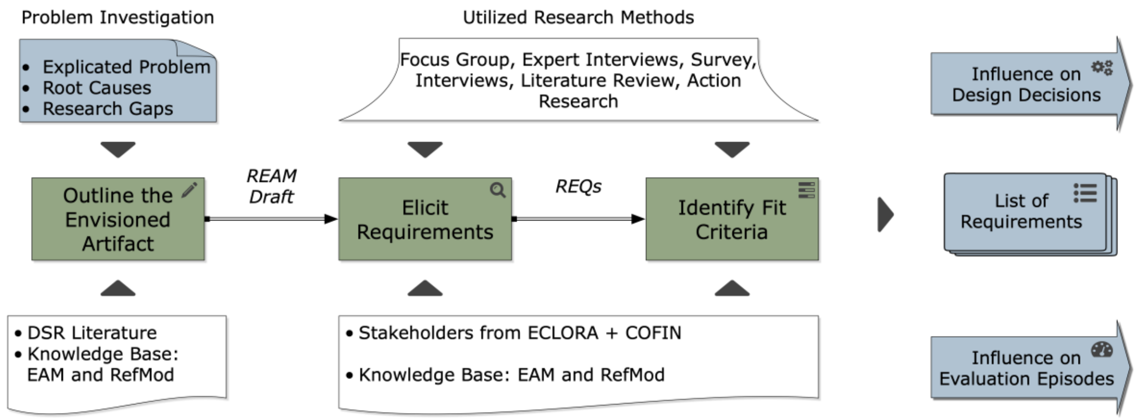


FIGURE 44. REQUIREMENTS ELICITATION PROCESS

The center of the figure represents the three logical steps the author conducted during requirements elicitation. While section 5.1 discussed the overall outline of REAM, this and the next section presents the results of the second and third step. The figure further shows what inputs and outputs each elicitation step used (top left and right corner). It then delineates the research methods the author used for requirements elicitation (top of figure), and the knowledge consulted in each step (bottom of figure). The first two steps of the process reuse the two steps defined by Johannesson and Perjons (2014, p. 104). Based on the findings of the previous chapter, that is, the explicated problem, its related root causes, and the derived research gaps in the knowledge domain—section 5.1 drafted REAM using artifact types from DSR literature and concerning the research context of EAM and reference modeling. The resulting REAM draft built the foundation to elicit requirements towards REAM by investigating the local practices of the DSR project and investigating related research (Hevner 2007, p. 3). Thus, the requirements section 5.3 presents originated from different sources. Therefore, the author used different research methods as enumerated in Figure 44.

Consequently, investigating the different sources resulted in several sets of requirements. Afterward, the author aggregated the different sets of requirements. In this way, a final set of requirements evolved. In the case of disagreements or conflicting requirements, the author consulted involved stakeholders to resolve them. These activities resulted in a final list of requirements. In line with the requirements engineering domain, this list contains both functional and non-functional requirements (Glinz 2007, p. 21;

Pohl 2010, pp. 19–21; Johannesson and Perjons 2014, p. 103). As the nature of non-functional requirements is not precise (Chung and Do Prado Leite 2009, p. 366), the author further related non-functional requirements to either structural or environmental requirements (Johannesson and Perjons 2014, p. 109).

The essential reason to define requirements is not only to steer the design process in the correct direction. Requirements also provide means to evaluate whether the proposed artifact poses a solution to the explicated problem. Therefore, one needs to know in what circumstances the artifact meets its requirements or not before evaluating it. To overcome this, Robertson and Robertson define the concept of fit criteria. A fit criteria is *"a quantification or measurement of the requirement such that you are able to determine if the delivered product satisfies, or fits, the requirement"* (Robertson and Robertson 1999, p. 392). Consequently, the author defined the third step of the requirements elicitation to identify fit criteria for each requirement. While some non-functional requirement relate to a specific scale of measurement (e.g., execution time), there are no such scales for the majority of requirements—especially for functional requirements as they are either completed or not (Robertson and Robertson 1999, pp. 168–169). Whether an artifact meets its requirements mostly depends on the satisfaction of an authority involved, which could be a problem stakeholder, data source, or system. The author argues that defining such fit criteria improves the understanding of the elicited requirements and, thus, informs the design process. Moreover, the fit criteria build a foundation for designing the evaluation of the artifact in the later stages of the DSR project.

To summarize, the elicitation of requirements towards a REAM produced the following outputs: an outline of the artifact, a list of functional and non-functional requirements, first insights regarding the artifact design based on the requirements, and an initial evaluation design based on identified fit criteria.

As stated earlier, the process in Figure 44 represents a logical rather than a chronological order of activities during the second DSR phase. Although the author started to elicit requirements after an initial problem explication (investigating Local Practice A, see section 4.1.1), the final list of requirements is a result of an iterative process. Some requirements changed during the design of REAM because the author's comprehension of the problem domain iteratively improved. The need for other requirements occurred during the design process. While the former requirements group evolved using a problem-oriented approach, the latter evolved from a solution-oriented perspective (Braun et al. 2015, p. 139). Such an approach is in line with requirements engineering literature that says requirements evolve, and developers seldomly identify a complete requirements set before the design process (Robertson and Robertson 1999, p. 3). In the context of method development, Henderson-Sellers et al. (2014, pp. 65–66) claim that one cannot foresee all method requirements. In order to provide transparency, section 5.3 documents the time of elicitation for each requirement and how it evolved.

As depicted earlier, requirements originated from different sources. According to DSR literature, the author investigated the problem space, i.e., the two local practices, as well as related research literature. In the specific context of this thesis, the author identified four concrete requirement sources. First, Johannesson and Perjons (2014, p. 105) suggest that functional requirements shall be related to addressed root causes. Thus, the two *(i) root causes* of the global problem identified in section 4.2 represent a central source for functional requirements.

Second, one shall survey potential users of the envisioned solution in order to derive requirements. Therefore, the author consulted the several stakeholder groups identified during the problem investigation (see section 4.2) to elicit requirements based on the *(ii) stakeholders' interest*s. One could argue that (i) and (ii) represent similar sources since the identification of the global problem relies on findings made in the local practices, which involves the several problem stakeholders as well. However, the author uses this differentiation to separate requirements that directly originated from a fully understood problem space from requirements that evolved during the late design stage of the artifact based on stakeholders' improved understanding of the method's functionality. For instance, the design and evaluation of REAM involved the participation of different stakeholders using, among others, validation workshops, where domain experts evaluated the REA developed by a first version of REAM. During these multiple workshops, the stakeholders agreed that REAM should produce an REA documentation that also includes defined application scenarios of the REA.

Third, the identification of artifact requirement shall always be related to existing research since similar solutions can inform the specifics of a desired solution (Johannesson and Perjons 2014, p. 106). Thus, the *(iii) knowledge base* from section 4.3 served as a third source for requirements. Fourth and finally, comparing results from the KBA and root cause analysis revealed several research gaps. On this basis, section 5.1 outlined the envisioned artifact of this DSR project—identifying method as an appropriate artifact type and drafting its overall structure. According to DSR literature, different artifact types call for different evaluation criteria (Johannesson and Perjons 2014, pp. 109–111; Gregor 2006, p. 629). Consequently, the *(iv) outlined artifact* represents a fourth source for requirements towards REAM. Figure 45 visualizes these four different requirement sources and their context. The white boxes indicate the chapters of this work that covered the respective source. While the author derived the sources (i), (ii), and (iii) from the global problem and identified research gaps, source (iv) relates to the stakeholders of both local practices.

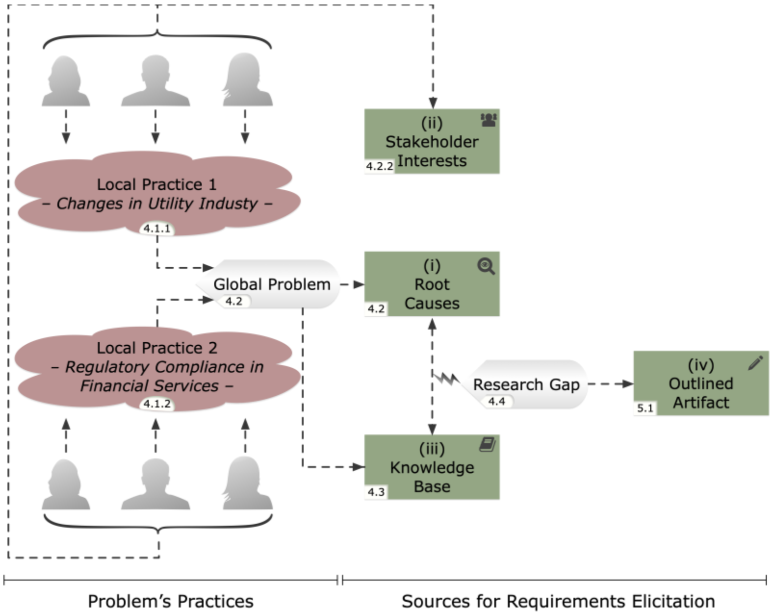


FIGURE 45. SOURCES USED FOR ELICITING REQUIREMENTS TOWARDS REAM

Based on this systematization, the author conducted several activities to elicit requirements from the different sources. To understand how the final list of requirements evolved, one has to understand the iterative process underlying this DSR project (see section 2.1.2 for the chronological perspective on the DSR project). Therefore, the following paragraphs document the activities for requirements elicitation by dividing the process into three phases of requirements elicitation—early, development, and late phase. The *early phase* relates to the beginning of the ECLORA project, where the DSR project initially occurred. It further captures all activities taken before the author developed the initial version of REAM, including eliciting requirements from the sources (iii) and (iv). The *development phase* addresses the period of the DSR project that designed a first REAM version and provided its evaluation in LP-A. It further considers the first activities during the COFIN project because they improved the author's understanding of the problem space. Finally, the *late phase* relates to all research activities the author conducted, starting with the design of the third REAM version. In this way, gained insights enhanced the understanding of existing requirements or identified the need to specify new ones (e.g., FREQ5 in Table 33).

This chronological viewpoint on requirements elicitation intends to provide transparency on how the requirements' maturity increased over time. Three dimensions specification, representation, and agreement Pohl (1994, p. 246) proposes for requirements engineering concretize this maturity. They represent the goals one shall achieve in order to guarantee the quality of specified requirements. As section 5.3 presents the final list of requirements, it also reflects on these dimensions to argue about the requirements' correctness in the context of the global problem.

REQUIREMENTS ELICITATION DURING EARLY PHASE. As chapter IV described earlier, the need for a REAM first occurred at the beginning of the ECLORA project (see section 4.1.1). At that point, the author conducted an initial problem investigation and studied related work for available solutions. Since the findings indicated the problem's relevance, the author performed the first activities to elicit requirements towards a REAM. Some of these were the ones that investigated the problem domain. In concrete, the findings from the survey of 53 small- and medium-sized PUs (see section 4.1.1.2) and expert interviews with three domain experts from the project partner SIV group resulted in an initial list of requirements towards REAM.

Furthermore, investigating literature on reference models for the utility domain augmented this first list of requirements. Since the author defined the envisioned artifact type to be a method, he also investigated DSR literature regarding non-functional requirements that apply to methods. Therefore, the author analyzed the following articles to identify an initial list of non-functional requirements relevant for REAM:

- *Johannesson and Perjons (2014, pp. 109–111):* The authors enlist generic qualities that can be used as an inspiration or validation for requirements elicitation DSR projects. They identify three structural, nine usage, three management, and eleven generic qualities that may relate to a requirement.
- *Checkland and Scholes (1999):* The authors propose an evaluation framework that includes the five high-level qualities efficacy, effectiveness, efficiency, elegance, and ethicality.
- *Gregor (2006, p. 629):* The author defines completeness, simplicity, consistency, ease of use, and quality of results as evaluation criteria for method development in DSR.
- *March and Smith (1995, p. 261):* The authors consider operationality, efficiency, generality, and ease of use as metrics to evaluate methods.
- *Robertson and Robertson (1999, pp. 112–136):* The authors suggest eight categories of non-functional requirements.

The author used the resulting list of non-functional requirements as an inspiration to concretize observations made at the local practices in the form of requirements. The upper part of Table 32 enlists the requirements identified at the early stage.

REQUIREMENTS ELICITATION DURING DEVELOPMENT PHASE. After designing an initial version of REAM method, the author applied it in the context of Local Practice A, i.e., the ECLORA project. Since the author was responsible for the method application, he performed action research that both produced an REA for PUs and observed additional requirements from the problem stakeholders. For instance, domain experts from SIV involved in the project required REAM to produce interim results during the time-consuming development process of the REA that also shall be accessible by either open-source tools or office products. As another activity during the REA development in the ECLORA project, the author participated in several modeling workshop at PUs, in which he gathered practical knowledge together with domain experts from SIV. During these workshops, additional requirements towards REAM occurred, as Table 32 enlists them below. After applying REAM in Local Practice A, several research activities during the beginning of the COFIN project elicited further requirements towards REAM. Assection 4.1.2 described earlier, a focus group of nine ISVs from the financial regulatory compliance domain supervised the research project's progress. During the initial meeting of the focus group, the participating author took notes during the meeting, captured flipchart and whiteboard content, and collected slide decks the participants contributed to the meeting. The ISVs stated four requirements as enlisted in Table 32. To further capture the perspective of financial institutes, the project team conducted interviews with representatives from four different German banking federations. Next to stating challenges in current topics of financial regulation (such as anti-money laundering or customer identification), the interviewees discussed the need for a holistic regulatory compliance management from the perspective of financial institutes. These activities resulted in two requirements (see Table 32). Finally, an updated systematic literature review in the related knowledge base identified another requirement, while it also validated requirements elicited before.

TABLE 32. ELICITING INITIAL REQUIREMENTS TOWARDS REAM

	SOURCE	STAKEHOLDERS	ELICITATION ACTIVITY	ID	IDENTIFIED REQUIREMENTS
EARLY PHASE	Global Problem & Root Causes	LP-A: SME PUs	Survey with 53 PUs	R1	REAM shall extend existing Reference Modeling Methods to construct REAs.
				R2	REAM shall produce an REA that helps PUs to understand the influence of industrial change on their business and IT structure.
		LP-A: ISV	Expert Interviews (project manager, enterprise architect, IT consultant)	R3	REAM shall elicit and analyze knowledge from practice in order to capture common and best practices in the problem domain.
	Knowledge Base	-	Literature Review (Reference Models in Utility Domain)	R4	Method shall extend the Configurative Reference Modeling method by Becker et al. (2002) for EA structures.
				R5	The method shall integrate deductive and inductive reference modeling.
	Outlined Artifact	-	Review DSR Literature	R6	REAM shall be of coherent structure.
				R7	REAM's structure shall be modular.
				R8	REAM shall be comprehensible.
				R9	REAM shall be effective (produce domain-specific REA).
				R10	REAM shall clarify its operational environment.
				R11	Applying REAM shall produce traceable outputs.
DEVELOPMENT PHASE	Stakeholders Interests	LP-A: ISV	Action Research (ECLORA project)	R12	The steps of REAM shall produce relevant interim results.
				R13	The output of REAM shall be accessible via open source or known office products.
		LP-A: SME PUs	Action Research (modeling workshop)	R14	REAM shall analyze domain-related aspects such as industry-specifics that guide the REA structure.
		LP-B: ISVs	Focus Group (COFIN project)	R15	REAM outputs shall be easily accessible.
	Global Problem & Root Causes	LP-B: ISVs	Focus Group (COFIN project)	R16	The produced REA for LP-B shall reveal interrelations among processes, data structures, and IT systems in the regulatory compliance domain.
				R17	The REA produced for LP-B shall combine regulatory requirements with knowledge from their actual practical implementations.
				R18	The content of REA constructed for LP-B shall correspond with regulatory requirements and related concepts.
		LP-B: Financial Institutes	Telephone Interviews (Banking Federations)	R19	The REA produced for LP-B shall be representative for financial institutes in the German legal sphere.
				R20	REAM shall provide means to apply the REA in practice.
	Knowledge Base	-	Systematic Literature Review	R21	REAM shall span both the construction and application of the REA developed by its instantiation.
LATE PHASE	Stakeholder Interests	LP-B: ISVs, Financial Institutes	Action Research (COFIN project)	R22	REAM shall provide means to tailor the application of an REA to its application context.
		LP-B: ISVs, IT consultants	Expert Interview (during validation workshops)	R23	REAM shall provide a transparent process on how to apply an REA in practice.
				R24	The structure of the produced REA shall follow domain-specific taxonomies and conceptualizations.

REQUIREMENTS ELICITATION DURING LATE PHASE. This phase relates to all activities starting from the design process of REAM's third version. Especially during the application of the method in Local Practice B, i.e., the development of an REA for holistic RCM (see chapter VII). In concrete, two research activities lead to adjustments and additions of the requirements portfolio existing at that time. On the one hand, the author conducted action research applying REAM in the context of the COFIN project. Since REAM demanded to elicit knowledge from practice, i.e., interviewing compliance managers of financial institutes, and making design decisions together with project partners, i.e., domain experts from ISVs, the author identified new requirements that emerged towards REAM. On the other hand, the author evaluated REA that resulted from the method application using validation workshops, in which the author interviewed practitioners from the problem domain regarding the REA's correctness and applicability (see chapter VII). These activities revealed new requirements that primarily address the application of an REA in practice—as requirements define at the bottom of Table 32 show.

5.3 THE REQUIREMENTS PORTFOLIO OF REAM

After identifying the list of requirements during the different phases of the DSR project, this chapter presents their harmonization into a final list of requirements towards REAM. Doing so, it discusses the following aspects for each requirement:

- **Rationale**: Next to its description, the author explains the rationale behind the defined requirement.
- **Type**: Each requirement is either functional or non-functional. For non-functional requirements, the author uses the systematization as proposed by Johannesson and Perjons (2014) and relates them to constructs of quality.
- **Source:** As discussed in section 5.2, each requirement originated from at least one of the sources root causes, stakeholders interests, outlined artifact, or knowledge base.
- **Elicitation Method**: The various activities for requirements elicitation used several research methods in the early, the development, and the late phase of the DSR project.
- **Related initial requirements**: Each requirement relates to at least one initially elicited requirement from Table 32. In most cases, the author formulated a final requirement based on the agreement of stakeholders from both local practices.
- **Time Aspect:** The author explains how requirements evolved during the DSR project. This aspect further assesses the requirements' level of specification, agreement, and representation, as defined by Pohl (1994, p. 246).
- **Fit Criteria:** The chapter defines fit criteria for every requirement relating them to appropriate authorities, whose demands have to be satisfied.
- **Design Decisions:** As they influence the design of the proposed artifact, the author summarizes what design decisions have been made based on the particular requirements.
- **Evaluation Design:** Akin to the previous aspect, the chapter derives how to design the evolution in order to assess the fit of the particular requirements.

The remainder of the chapter presents the final list of requirements as follows. Table 33 enumerates the eight requirements that resulted from the elicitation process. It relates them to the aspects requirement type, source, elicitation methods, and the initial requirements from Table 32, from which they originate. Afterward, the author describes each requirement in detail by providing its rationale, discussing its time aspects, identifying its fit criteria, and reflecting on its influence on design decisions and evaluation design. Table 33 provides a high-level perspective on the requirements and the sources from which they originated.

Comparing the final requirements from Table 33 with the initial list of Table 32, one recognizes that all final requirements evolved from at least two different sources throughout the DSR project. R8 is the only initial requirement that was discarded for the final requirements set. The author understands the importance of evaluating a proposed method regarding its usability in general and its comprehensibility as defined by Johannesson and Perjons (2014, p. 110) in concrete. However, the long time-span of applying REAM by various independent method users made a rigorous evaluation of this requirement unfeasible in the scope of a Ph.D. project. Furthermore, applying REAM implies the collaboration of different problem domain stakeholders, which adds to the effort of such an evaluation. Therefore, the author decided to focus on REAM's effectiveness and quality of output. The final list of requirements reflects on this.

TABLE 33. FINAL LIST OF REQUIREMENTS TOWARDS REAM

	ID	REQUIREMENT	RELATED CONCEPT	SOURCE	ELICITATION METHODS	INITIAL REQS
FUNCTIONAL	FREQ1	Method that produces RM using EA Structures	-	Root Cause 1, Knowledge Base	survey, literature analysis, focus group	R1, R4, R16
	FREQ2	Cover the complete Reference Modeling Lifecycle	-	Root Cause 1, Knowledge Base	interviews, systematic literature review	R20, R21
	FREQ3	Analyze practical knowledge in combination with generally accepted knowledge	-	Root Cause 2, Knowledge Base	expert interviews, telephone interviews, systematic literature review, focus group,	R3, R5, R17, R19
	FREQ4	Integrate Domain-Specific Aspects	-	Root Cause 2, Stakeholders' Interests	action research, focus group, expert interviews	R14, R18, R24
	FREQ5	Design Reference Enterprise Architecture for Reuse	-	Stakeholders' Interests	action research, expert interviews	R22, R23
NON-FUNC-	NFREQ1	Coherent and Modular Method Structure	coherence, modularity	Outlined Artifact	literature analysis	R6, R7
	NFREQ2	Applicability of produced REA	effectiveness, quality of output	Root Cause 1, Outlined Artifact,	survey, literature analysis, telephone interviews	R2, R9, R19
	NFREQ3	Artifact Trace and Tool Support	operational environment, traceability	Outlined Artifact, Stakeholder's Interests	literature analysis, action research, focus group	R10, R11, R12, R13, R15

FREQ1: METHOD THAT PRODUCES A RM USING EA STRUCTURES. REAM shall be a stand-alone method that enables the domain-independent development of a RM that uses the structure of enterprise architectures.

- ❖ **RATIONALE:** REAM shall produce a RM to reveal the dependencies and relationships among business activities, data, and necessary information systems in a particular problem domain.
- ❖ **TIME ASPECT:** At the early state of this DSR project, i.e., at the beginning of the ECLORA cycle, FREQ1 did not require REAM to be a stand-alone method. Based on RC1, this FREQ1 was rather vague since the problem-oriented elicitation approach only hinted to provide methodological support for REA development. The author refined FREQ1 after the ECLORA cycle. At that stage, FREQ1 envisioned REAM to be an extension of an existing method for RM construction: the method for configurative RM by Becker et al. (2002). After the demonstration of REAM during the ECLORA Cycle, the author observed that adjusting the approach by Becker et al. (2002) to EA structures was not sufficient. During the COFIN cycle, discussions with the experts of the focus group from Local Practice B and the results of the interviews with banking federations revealed the need to change FREQ1. In consequence, the author learned that REAM should be a stand-alone method, which employs appropriate approaches from the RM domain. This was due to the following reasons:

- the configurative RM approach is tailored to one specific mechanism for RM application, i.e., configuration (cf. FREQ5),
- it defines no specific activities to construct a RM based on practical knowledge (cf. FREQ3),
- it primarily focuses on RM construction (cf. FREQ2), and
- adjustments necessary to develop reference models using EA structures have been significant, which qualifies REAM to be a new method (this REQ1).

- **FIT CRITERIA:** REAM's produced REAs shall conform to standards from the EA research domain. That is, it shall use accepted notation standards and cover all appropriate EA related layers. Hence, the method's output, i.e., the domain-specific REA, shall comply with these EA standards.
    - **AUTHORITY:** EA Knowledge Base, Enterprise Architects
- **INFLUENCE ON DESIGN DECISIONS:** FREQ1 had two implications for the design process of REAM:
    - REAM shall use appropriate EA standards that support REA modeling
    - REAM shall include how to select appropriate EA aspects and layers
- **INFLUENCE ON EVALUATION DESIGN:** As a general implication for the evaluation design, FREQ1 demanded it to validate the output of REAM with EA experienced domain experts regarding its conformance with EA standards.

FREQ2: COVER THE COMPLETE RM LIFECYCLE. REAM shall guide the user regarding the phases REA construction, application, and the application feedback to the produced REA.

- **RATIONALE:** This requirement relates to the user-oriented perspective on the concept of reference models established by Thomas (2005) and Vom Brocke (2006). Since a reference models’ value depends on the user’s perception of its applicability, REAM shall cover the application and feedback phases as well.
- **TIME ASPECT:** Based on findings during the initial COFIN cycle and a more profound systematic literature review, the author defined this requirement. For instance, interviewees from the banking federations were keen on the idea of developing an REA for holistic RCM, but were doubtful whether financial institutes could apply it. At that time, REAM and its demonstration focused on REA construction. The author learned that the method should extend its scope to the application and application feedback of the REA. This extension intends to support method users in developing strategies for continuous REA maintenance.
- **FIT CRITERIA:** REAM shall conform to its users' demands to successfully construct an REA, apply it in practice, and update the REA based on feedback from the application.
    - **AUTHORITY:** Users of the resulting REA, REAM users
- **INFLUENCE ON DESIGN DECISIONS:** FREQ2 had two implications for the design process of REAM:
    - REAM shall define components for REA construction, REA application, and Application Feedback

- REAM shall include potential users during appropriate steps of the REA construction process.

❖ **INFLUENCE ON EVALUATION DESIGN:** The author shall evaluate all components of REAM in at least two naturalistic settings.

FREQ3: ANALYZE PRACTICAL KNOWLEDGE IN COMBINATION WITH GENERALLY ACCEPTED KNOWLEDGE. REAM shall combine deductive and inductive approaches. This ensures the reuse of available domain-specific knowledge (e.g., using domain-specific generally accepted and relevant knowledge) as well as the integration of newly acquired knowledge from practice. For the latter, REAM shall guide to elicit knowledge from practice and to derive universally valid practices.

❖ **RATIONALE:** REAM shall guarantee that the constructed REA offers an appropriate level of detail regarding its problem domain. As the several requirements elicitation activities revealed, detailed domain knowledge is rarely available. Thus, REAM also shall acquire new domain knowledge from involved problem stakeholders.

❖ **TIME ASPECT:** As the KBA revealed, the construction of a practical RM should use both deductive and inductive approaches, in order to benefit from their strengths and mitigate their risks. Therefore, the author this requirement at the early phase of the DSR project. Further activities in the ECLORA project confirmed this assumption. During the beginning of the ECLORA cycle, the experts of the SIV group stated that a procedure of the REA development should use generally accepted domain-specific knowledge (e.g., domain-specific business areas or data exchange formats). However, the experts agreed that this knowledge presumably would not be of a sufficient level of detail in order to achieve deep insights regarding EA related aspects like data structures or IT usage. The practitioners from Local Practice B verified this, too. The author improved his understanding of this during the COFIN project, which led to a more concretized requirement specification. First, the author acknowledged that the method should provide different means for eliciting practical knowledge. Second, the method should analyze available approaches for inductive RM for their applicability to EA models and provide necessary adjustments.

❖ **FIT CRITERIA:** The knowledge represented by the resulting REAs shall conform to existing knowledge and phenomena in the respective problem domains' practices.

- **AUTHORITY:** Domain knowledge from REA development context, Domain Experts

❖ **INFLUENCE ON DESIGN DECISIONS:** FREQ3 had two implications for the design process of REAM:

- REAM shall include steps that provide means to elicit relevant practical and theoretical knowledge of the REA domain.
- The author shall analyze methods for inductive RM regarding their applicability to EA structures.

❖ **INFLUENCE ON EVALUATION DESIGN:** Domain experts, who possess knowledge regarding all addressed EA layers, shall evaluate REAM's output regarding its level of detail and representation of practical domain knowledge.

FREQ4: INTEGRATE DOMAIN-SPECIFIC ASPECTS. REAM shall provide an approach to incorporate domain-specific aspects for the final R-EA structure. Since REAs apply to different contexts, the produced REA shall, for instance, follow domain-specific taxonomies or information models.

- ❖ **RATIONALE:** REAM shall incorporate domain-specific systematizations of knowledge to ensure the resulting REA's relevance in the respective problem domain and to increase potential users' acceptance of the REA models' structure.
- ❖ **TIME ASPECT:** FREQ4 did not directly evolve from the problem characteristics. The author discovered it during the artifact design in the late phase. During his involvement in eliciting practical knowledge by dint of modeling workshops at companies from Local Practice 1, the author observed that REAM should address the elicitation of domain-specific content in the REA. In consequence, this meant for the method design to address the elicitation and integration of domain-relevant aspects during the REA development process. Expert interviews with senior consultants of Local Practice B agreed with FREQ4 as they even considered it as a critical success factor for an REA's acceptance by its users.
- ❖ **FIT CRITERIA:** The structure and presentation of REAM's output shall conform to systematizations and concepts known within the respective problem domain.
    - **AUTHORITY:** REA users, domain experts
- ❖ **INFLUENCE ON DESIGN DECISIONS:** FREQ4 had one implication for the design process of REAM:
    - REAM shall integrate actions that consider such domain-specific aspects during the REA construction
- ❖ **INFLUENCE ON EVALUATION DESIGN:** Domain experts and REA users shall evaluate the appropriateness of used domain-specific in resulting REA structures.

FREQ5: DESIGN REFERENCE ENTERPRISE ARCHITECTURE FOR REUSE. The method shall give clear guidance on how to design an applicable REA. Thus, the output of the method should be an REA that provides different means for adjusting it for domain-specific application scenarios.

- ❖ **RATIONALE:** Its applicability to practice is a central success factor for reference models. Thus, REAM shall give a clear definition of REA application criteria in order to facilitate the best applicability for stakeholders of the respective problem domain.
- ❖ **TIME ASPECT:** FREQ5 evolved during the late phase of the DSR project (see Table 32 and Table 33). During the COFIN cycle, the author observed that the configuration mechanism is not sufficient for a universally valid REAM. Similar to FREQ1, the decision to define REAM as a stand-alone method triggered the specification of FREQ5. In consequence, REAM should support the configuration mechanism proposed by Becker et al. (2002) as one of several other adjustment techniques for RM application (as proposed by Vom Brocke (2006)). This motivated the author to investigate other adjustment techniques and to assess their feasibility with EA model structures. During one focus group meeting, where domain experts evaluated a first version of the REA for Local Practice B, the stakeholders agreed upon the importance of well-defined application scenarios for an REA's acceptance in the domain.
- ❖ **FIT CRITERIA:** The application scenarios produced by REAM shall conform to the needs of its respective development context.
    - **AUTHORITY:** REA users, domain experts

- **INFLUENCE ON DESIGN DECISIONS:** FREQ5 had two implications for the design process of REAM:
    - REAM shall provide means to guide method users in developing application scenarios tailored to specific REA usage contexts.
    - The author shall investigate the design principles proposed by Vom Brocke (2006) regarding their applicability towards EA structures.
- **INFLUENCE ON EVALUATION DESIGN:** FREQ5 had two implications for the evaluation design of REAM:
    - The author shall evaluate the application scenarios produced by REAM with domain stakeholders and REA users.
    - The author shall apply an REA using different application scenarios and design principles to evaluate their effectiveness.

NFREQ1: COHERENT AND MODULAR METHOD STRUCTURE. The method should provide a coherent and modular structure. Thus, all parts of the method should be logical, orderly, and consistently related to each other. Further, it shall consist of loosely-coupled parts, i.e., not all parts may be mandatory during method execution, and can be recombined with each other depending on the method execution's context.

- **RATIONALE:** REAM shall support different ways of execution to enable its applicability in different application contexts, while REAM's logic and related concepts remain consistent.
- **TIME ASPECT:** As documented in Table 32 and Table 33, this requirement evolved as soon as the author defined the artifact type of this DSR project. After consulting the DSR literature, the author identified the constructs coherence and modularity as essential characteristics of REAM. Requirements elicited during the later phases of the DSR supported this. As FREQ2 demands REAM to span the complete RM lifecycle, the author derived the need for REAM to provide a modular yet coherent method.
- **FIT CRITERIA:** REAM shall be executable in different usage scenarios by the method users.
    - **AUTHORITY:** REAM users
- **INFLUENCE ON DESIGN DECISIONS:** NFREQ1 had two implications for the design process of REAM:
    - REAM shall follow an appropriate method conceptualization defining task-specific method modules or components.
    - REAM shall define a precise method framework that defines entry points, inputs, outputs, and execution paths in order to provide a consistent structure.
- **INFLUENCE ON EVALUATION DESIGN:** The author shall evaluate REAM in different formative settings using different execution paths. Doing so, insights from these evaluation episodes will enhance the overall method structure.

NFREQ2: APPLICABILITY OF PRODUCED REA. The execution of REAM shall produce desirable results. In concrete, an execution of REAM shall produce a domain-specific, which REA stakeholders of the problem domain apply it in their organizational context.

❖ **RATIONALE:** REAM's shall produce REAs that are accepted and applied in practice.

❖ **TIME ASPECT:** This non-functional requirement first evolved at the beginning of the Ph.D. project. Elicitation activities in later phases of the project validated it. The overall objectives in both local practices were the systematic REA development that is applicable by stakeholders of both problem domains. In Local Practice A, the responding PUs of the survey demanded the REA to improve stakeholders' understanding of industrial changes on their business and IT structures. In Local Practice B, the experts of the focus group stated that a developed REA's success highly depends on the feasibility of its application. These observations are in line with the user-oriented definition of reference models.

❖ **FIT CRITERIA:** REAM shall produce outputs that are relevant to domain stakeholders and applied in practice.

- **AUTHORITY:** REAM users

❖ **INFLUENCE ON DESIGN DECISIONS:** This requirement had no direct influence on the design decisions.

❖ **INFLUENCE ON EVALUATION DESIGN:** The author shall evaluate REAM in a naturalistic setting.

NFREQ3: ARTIFACT TRACE AND TOOL SUPPORT. Potential users of REAM may work in a variety of business contexts—such as IT consultants, IS researchers, or employees of authorities. REAM's tool support, therefore, should primarily consist of open source and office tools, since one can assume that such software is available to the majority of these users. The method shall provide mechanisms for proper documentation of produced results and project advances.

❖ **RATIONALE:** REAM shall integrate with its users' typical business environments and shall support users in documenting their results throughout the execution.

❖ **TIME ASPECT:** During a focus group meeting in the context of Local Practice B and the process of REA development for Local Practice A, the author observed that interim results during the REA development process were vital for two reasons. First, to reach a common understanding of the progress among involved stakeholders. Second, to enable informed design decisions in the development process. Stakeholders from both local practices voted to use open source or office-alike tools as often as possible. All stakeholders of both practices stressed to avoid costly software packages like special EAM tools when possible. Furthermore, DSR literature states that the history of documentation during the method execution is a known quality criteria for method development. Consequently, the author defined this non-functional requirement related to the constructs of traceability (Johannesson and Perjons 2014, p. 110) and operational environment (Robertson and Robertson 1999, p. 123).

❖ **FIT CRITERIA:** REAM shall be executable with typical office software products and open source tools.

- **AUTHORITY:** REAM users

❖ **INFLUENCE ON DESIGN DECISIONS:** NFREQ3 had two implications for the design process of REAM:

- REAM shall clearly define the inputs and outputs of the several method activities.
- REAM shall define how to represent these interim results, suggesting appropriate tools.

❖ **INFLUENCE ON EVALUATION DESIGN:** The author shall evaluate REAM's operational environment and traceability in a naturalistic scenario.

Before the next section summarizes the results of the requirements elicitation process, the last paragraph of this section reflects the final set of requirements towards REAM in the context of the three goals of requirements engineering, as defined by Pohl (1994, p. 246). The author claims that requirements engineering shall aim to arrive at a desired output that is characterized by a complete specification of requirements, transform informal into formal representations, and gain an agreement among all involved stakeholders. Pohl defines three dimensions that represent the fulfillment of these goals accordingly: specification, representation, and agreement. For each dimension, Pohl provides strategies that help to transform an initial input of requirements towards a desired state of requirements. The next paragraphs summarize the activities of this thesis' requirements elicitation process in the context of these three dimensions in order to argue about the validity of the final requirements set. The author understands the specification and agreement dimensions as relevant for a rigorous requirements elicitation towards REAM. Thus, the remainder of this section discusses their fulfillment.

However, the author argues that Pohl's interpretations of the representation dimensions do not necessarily apply to the development of IS methods. This dimension aims to transform natural expressions of requirements (informal) into formal representation languages, such as first-order logic, and, thus, focuses on system development. Since this thesis designs a method, formal representations may not be a reasonable goal when it comes to representing requirements. Still, the author represented each requirement using the same structure.

In order to arrive at a complete state of requirements specification, Pohl suggests using knowledge from the problem domain, reusing specific knowledge already established by existing similar research, and validating elicited requirements. For the identification of requirements that base on a common view, Pohl suggests to capture the perspectives, to dissolve disagreements among stakeholders, and to coordinate communication among the different stakeholders.

First, revisiting the requirements elicitation process discussed in section 5.2 shows that the author gathered information from different stakeholders of two distinct local practices. Using different research methods, the author ascertained the demands from the perspectives of different affected organizations (interviewing enterprise architects, caseworkers, and management levels), (IT) consultants from ISVs, and federations active in the local practices. As Table 33 illustrates, the different stakeholders from both domains agreed on every requirement. Comparing the viewpoints of the stakeholders ensured that the requirements do represent neither the personal view of the author nor isolated perspectives from single problem stakeholders.

Instead, the heterogeneity of considered perspectives improved their relevance to the global problem.

Second, the author investigated related work in both local practices for similar research and conducted a systematic literature review, which revealed research gaps in the domain of REA development and application. As Table 33 shows, both domain and specific knowledge contributed to the elicited requirements. For instance, knowledge gathered from the RM and DSR literature contributed to the specification of FREQ2, FREQ3, and the NFREQs.

Third, this chapter discusses a chronological order of activities for requirements elicitation, which the author distinguished into early, development, and late phase (cf. Table 32). This iterative process ensured the assessment of the requirements' completeness. While the author reformulated some initially elicited requirements (FREQ1, FREQ3), some research activities identified new requirements (FREQ2, FREQ5) in the course of this process.

5.4 SUMMARY OF REQUIREMENTS ELICITATION

This chapter presented the results of the DSR project's second phase, i.e., defining the objectives of the solution. In this context, this summary reflects the results in the light of the guidelines for defining DSR requirements formulated by Johannesson and Perjons (2014, p. 108). The authors demand DSR authors to specify the artifact under consideration, to justify each requirement, and to describe their identification process. Based on the results of the problem investigation and systematic literature from chapter IV, this phase had several objectives. First, section 5.1 discussed the outline of the artifact the author considers as a possible solution. Investigating different types of DSR artifacts, the author decided to design a method that guides the development and application of REAs (REAM). Second, section 5.2 documents the process the author followed to elicit requirements towards REAM and presents a list of initial requirements. The author distinguishes between three phases of the DSR project, during which requirements evolved. In each phase, different research method were utilized that investigated the different perspectives of problem stakeholders from both local practices. From retrospect, the requirements originated from the problem's root causes, additional stakeholders interests, the specific characteristics of the artifact's type, or the available knowledge base. Third and last, section 5.3 harmonizes the initial requirements to a set of five functional and three non-functional requirements. The author specifies each requirements regarding predefined aspects like its rationale, evolution over time, fit criteria, or elicitation method. Figure 46 provides a high-level summary on the final set of requirements in relation to the sources, from which they originated.

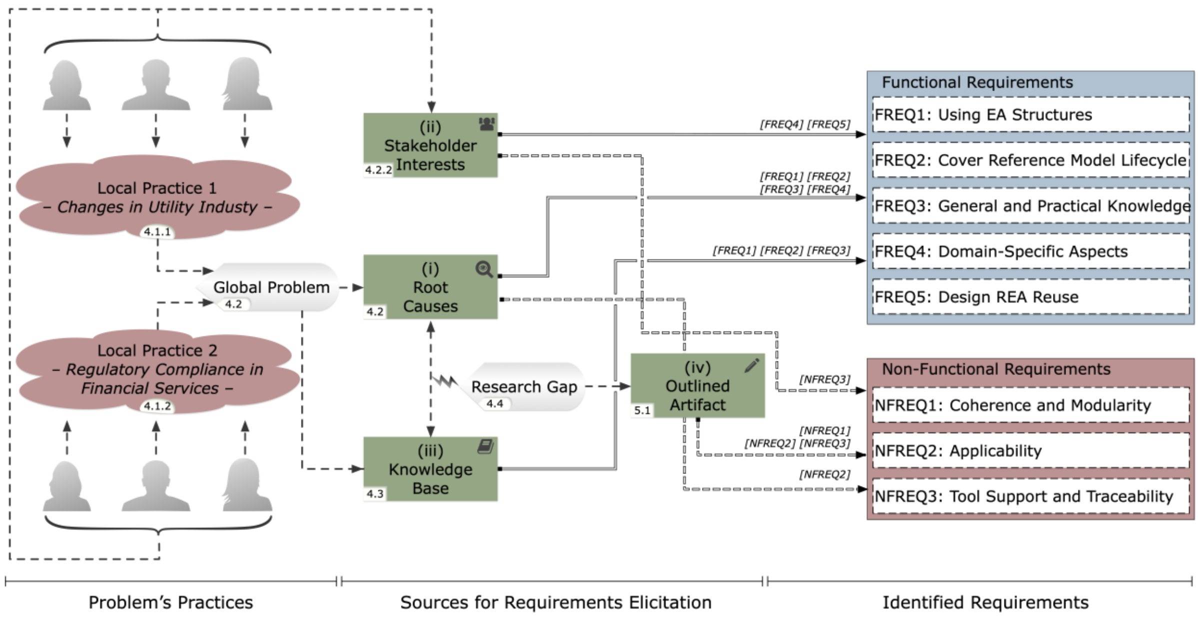


FIGURE 46. SUMMARY OF REQUIREMENTS ELICITATION PROCESS FOR REAM

Next to the requirements towards REAM, this DSR phase further provides a foundation for decisions during the solution design phase and artifact evaluation. On the one hand, most requirements inform the author about central tasks REAM shall accomplish, how it shall be structured, and what qualities to expect from the output REAM produces (i.e., a domain-specific REA). On the other hand, the author derives that the evaluation design of REAM shall include several formative iterations that idealistically take place in naturalistic settings. Overall, the author argues that this chapter conforms to the earlier enumerated guidelines for requirements elicitation, as formulated by Johannesson and Perjons (2014, p. 108).

VI. REAM—A METHOD REFERENCE ENTERPRISE ARCHITECTURE DEVELOPMENT

This chapter presents the artifact of this Ph.D. thesis, a method for developing REAs—in short, REAM. After chapter IV defined this work's addressed problem statement and derived the overall research question, chapter VI identified and formulated requirements towards a possible solution. REAM evolved through several build-evaluate cycles.

The content of this chapter presents the **final version of REAM**. For a detailed documentation of REAM's evolution, the author refers to chapter VII. There, the author reports on the evaluation of REAM and presents its intermediate method versions.

The remainder of this chapter is structured as follows. Section 6.1 presents REAM's overall structure, before section 6.2 provides an initial overview of REAM's approach, its users, and important concepts. To improve REAM's comprehensibility, section 6.3 introduces a running example that accompanies the detailed REAM documentation. Subsequently, sections 6.4, 6.5, and 6.6 present the different method phases that aggregate REAM. Each of these sections documents the particular method components of REAM and illustrates their application by dint of the running example. Finally, section 6.7 reflects on REAM design. It discusses its underlying design rationales and documents the knowledge it reuses from the prior investigated knowledge base.

6.1 CONCEPTUALIZING AND DOCUMENTING REAM

REAM uses the method conceptualization proposed by Goldkuhl et al. (1998). As presented in section 2.2.1, this conceptualization identifies several parts of an IS method: perspective, framework, method components—consisting of procedure, notation, and concepts—and cooperation forms. During the design process of REAM, the author adjusted some of the conceptualization's aspects to the specifics of REAM. This section shortly describes these adjustments and uses the final conceptualization of REAM to define a documentation template in order to present REAM systematically.

Next to the existing concepts of Goldkuhl et al. (1998), REAM makes following adjustments to structure the method. First, the ten method components (from here on states as "components") relate to one of three REAM *phases*. These phases represent different stages of a reference model's lifecycle (see chapter III). Section 6.2 explains these three stages in more detail.

Second, REAM uses a sequence of *steps* to present the procedure of each component. Steps divide an component's overall objective into distinct activities to accomplish these objectives. For each component, REAM defines an execution path of its several steps.

Third, REAM defines *inputs* and *outputs* for each step. Such an in- or output represents concepts produced or used by a particular step of REAM. Section 6.2.3 gives a holistic overview of all concepts used by REAM and documents, which steps produces, uses, or refines them.

Fourth, REAM further introduces *guidelines* for each component. While REAM provides descriptions of how to conduct each step, the various evaluation cycles of this DSR project revealed some best practices that help REAM users while executing REAM. The end of each component section provides a list of guidelines. These guidelines relate to a specific step of that component.

Based on these considerations and adjustments, the remainder of this chapter structures REAM using the following documentation template. It focuses on REAM from three perspectives. The *method perspective* documents REAM's overall purpose and perspective on the problem space it addresses (see section 6.2.1). Moreover, it presents the overall method framework of REAM, which defines how to execute the several method components (see section 6.2.2). Further, it presents cooperation forms for applying REAM (see section 6.2.3). Finally, it defines all concepts used by REAM and provides their interrelations among each other (see section 6.2.3). The *phase perspective* explains the purpose of each REAM's three phases. Furthermore, it discusses the context of each REAM phase and how their corresponding components are related to each other (e.g., see section 6.3). The *component perspective* then presents each component of REAM in detail. For each component, it discusses their objective, necessary concepts, and the particular procedure (e.g., see section 6.4.1). As an component's procedure consists of several steps, each step is explained by documenting its input, step description, output, recommended methods, utilized tools, and notation (e.g., see section 6.4.1.2). Figure 47 summarizes this documentation template of REAM.

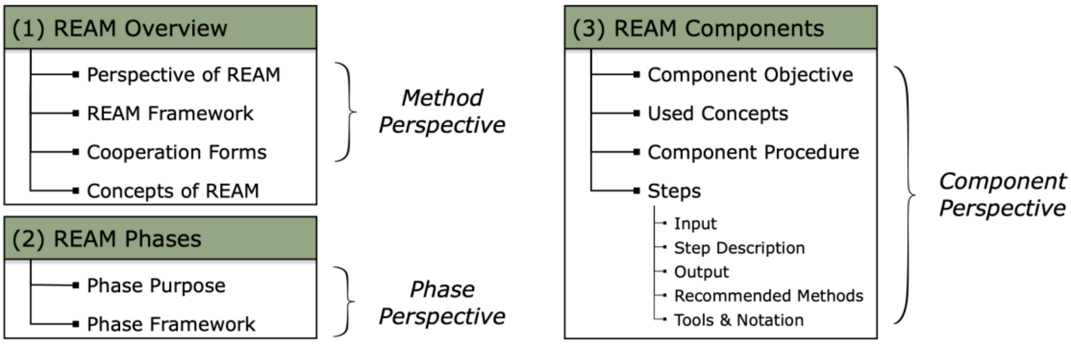


FIGURE 47. REAM DOCUMENTATION TEMPLATE

6.2 OVERVIEW OF REAM AND ITS METHOD COMPONENTS

This section gives a high-level overview of REAM. In concrete, its subsections relate each to one of the three method perspectives (see section 6.4). After section 6.2.1 presents REAM's overall purpose and discusses its concrete perspective by revisiting previously defined requirements, section 6.2.2 presents the method framework of REAM. Subsequently, section 6.2.3 explains the cooperation forms necessary to apply the method. Finally, section 6.2.4 defines all concepts that are used by REAM.

6.2.1 INTRODUCTION TO REAM—PURPOSE AND PERSPECTIVE

The overall purpose of REAM is to provide methodological support for developing Reference Enterprise Architectures (REA). REAM applies to problem domains that relate to the overall problem statement of this thesis (cf. sectionss 6.4 - 6.6). This is the case in problem domains, in which a group of stakeholders faces organizational changes that affect different aspects of the architectural structures, i.e., business, information, application, and technology architectures. REAM produces an REA that provides solutions for these stakeholders by presenting practices to overcome stated challenges. Therefore, REAM's purpose addresses the following aspects derived from requirements defined in chapter IV:

- REAM's output—the REA—is a RM for the problem domain that uses enterprise architecture structures (FREQ1)
- REAM not only guides constructing the REA, but also guides REAM user to prepare the REA for its practical application (FREQ2, FREQ5)
- REAM analyzes implicit practical knowledge and provides means how to integrate them in the resulting REA (FREQ3, FREQ4)

Before the next section presents REAM's overall framework, Figure 48 presents the definition of the "Reference Enterprise Architecture" term used by REAM. It builds from the findings of section 4.3 and the author's experience gained while designing REAM. The definition builds from the work of (Harmsen van der Beek, Wijke ten et al. 2012, p. 99) and definitions from the RM research domain (see section 3.1). Thus, the three main characteristics of a reference model—i.e., generalizability, recommendatory character, and reuse—apply to REAs as well. In contrast to the REA definition found in current research, this definition also emphasizes the reusability aspect of the REA. Next to the definition, Figure 48 further enlists what characteristics REAM ascribes to the REA and the building blocks it understands at an REA's core (cf. Table 26).

Reference Enterprise Architecture

An REA is a specific type of a reference model that uses the structure of enterprise architectures (EA). It addresses a concrete problem that affects a class of organizations regarding their business and IT structures. The REA structures domain-specific knowledge in a coherent EA model, represents a generalized solution for the problem, and provides means for organizations to apply that model in their practices.

Characteristics of REAs:

- REAs highly depend on the context of the addressed problem
- the structure of REAs is based on an EA framework and consists of several architectural layers necessary to address the problem holistically
- REAs derive solutions from practical knowledge of the domain
- REAs can be applied in different scenarios offering different benefits to the respective REA user
- the scope, content, or structure of REAs may change over time as their context may change

Building Blocks of REAs:

- an architectural description that uses and appropriate EA modeling language
- a domain-specific dictionary that defines important terms
- an application design that defines how a REA is applied in which contexts and by whom
- a documentation that explains the REA in appropriate detail

FIGURE 48. DEFINITION OF REA TERM, ITS CHARACTERISTICS, AND BUILDING BLOCKS

6.2.2 A FRAMEWORK FOR EXECUTING REAM

According to Goldkuhl et al. (1998), a method framework represents the structure and interrelations between its several components. Hence, REAM framework documents in what order to execute the ten REAM components. Figure 49 visualizes the overall method framework of REAM. As depicted earlier, REAM consists of three different phases that cluster the components. Each phase refers to a distinct group of questions one needs to ask in the context of REA development.

PHASE (A): PREPARING REA DEVELOPMENT:

- *What is the scope of the REA (addressed problem, domain, stakeholders)?*
- *What requirements exist towards the REA?*
- *What knowledge is available to develop the REA?*

PHASE (B): REA CONSTRUCTION:

- *How shall the REA be structured?*
- *What available knowledge shall an REA reuse?*
- *How to elicit appropriate knowledge for the REA?*
- *How to construct an REA Model?*

PHASE (C): REA APPLICATION:

- *How to prepare the application of an REA?*
- *How to evaluate the REA?*
- *How to keep the REA up-to-date?*

The center of Figure 49 shows the three REAM phases and the components they contain. Further, it presents a general execution flow. Each phase produces several outputs. The left side of the framework indicates additional concepts that influence the REA execution. *Phase (A): PREPARING REA DEVELOPMENT* investigates the PROBLEM DOMAIN the REA. It is usually triggered by a specific problem that relates to one or various possible drivers for REA (cf. Table Table 27). Phase (A) further develops an initial strategy on how to construct the REA, which forms the basis for Phase (B). The REA PORTFOLIO documents that strategy. On this foundation, *Phase (B): REA CONSTRUCTION* defines five components dedicated to the actual construction of the REA. The phase includes setting up an overall REA Framework, defining its structure, eliciting necessary knowledge, and developing an REA model. Whether to use deductive or inductive reasoning, Phase (B) relies on previously identified REUSABLE KNOWLEDGE, ELICITATION NEEDS, and REA REQUIREMENTS. The actual REA and its model representation is the central output of Phase (B). In *Phase (C): REA APPLICATION*, the REA is complemented by an REA APPLICATION DESIGN, which shows PROBLEM STAKEHOLDERS the modi operandi how to apply the REA in practice. Phase (C) evaluates the REA and points out means to maintain the REA over time. If possible, REAM user shall evaluate the REA whenever applied in practice. Thus, Phase (C) also identifies MEANS OF IMPROVEMENT, which may trigger any of the previous REAM phases and components.

The right side of Figure 49 visualizes feedback loops that may occur while executing REAM. They represent situations in which the execution of one component generates knowledge that causes the execution of an already executed component. New knowledge may identify the need to alter previously produced REAM concepts. For instance, the evaluation of the REA in Phase (C) reveals that the REA STRUCTURE needs to be adjusted. This may cause an additional alteration of REAM COMPONENT 4. In general, REAM does not restrict the method user to a predefined list of such feedback loops since they may occur at any time while applying REAM. However, it provides a set of typical feedback loops observed by the author. Figure 49 indicates them as *(I) – (IV)*:

(I) COMPONENT OF PHASE (B) TRIGGERS COMPONENT OF PHASE (A):

- Knowledge elicitation of COMPONENT 5 or COMPONENT 6 results in an improved understanding of the PROBLEM DOMAIN and requires a redefinition of the SPECIFIED PROBLEM and PROBLEM DOMAIN (COMPONENT 1).

(II) COMPONENT OF PHASE (B) TRIGGERS COMPONENT OF PHASE (B):

- Completing the REA MODEL in COMPONENT 7 identifies the need to restructure the REA. Thus, COMPONENT 4 is conducted again.
- After conducting COMPONENT 5, it may become apparent that available knowledge does not suffice to meet the REA REQUIREMENTS. Thus, COMPONENT 6 is executed, too.

(III) COMPONENT OF PHASE (C) TRIGGERS COMPONENT OF PHASE (B):

- The results of COMPONENT 9 identify the need to structure the REA using additional architecture viewpoints on the REA and, thus, trigger COMPONENT 4.
- The results of COMPONENT 9 indicate the need to captured more detailed aspects of the REA. Hence, another ABSTRACTION TECHNIQUE is used in COMPONENT 6.

(IV) COMPONENT OF PHASE (C) TRIGGERS COMPONENT OF PHASE (A):

- The results of COMPONENT 9 identify new REA REQUIREMENTS and, thus, trigger COMPONENT 1.
- Identified changes of the REA's context (COMPONENT 10) require a new analysis of PROBLEM STAKEHOLDER affected by the SPECIFIED PROBLEM (COMPONENT 1).

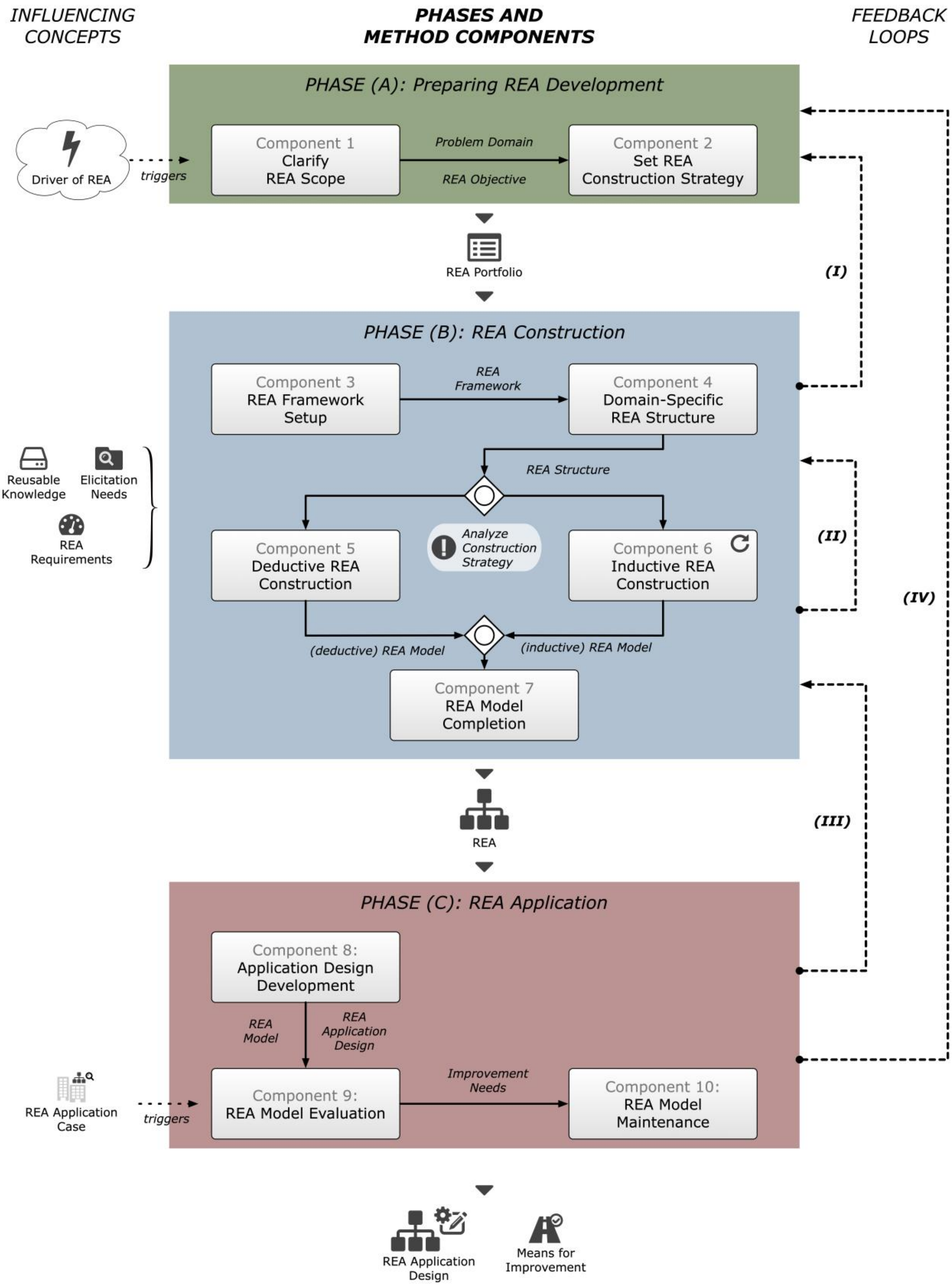


FIGURE 49. REAM METHOD FRAMEWORK

6.2.3 COOPERATION FORMS OF REAM

According to Goldkuhl et al. (1998), IS methods shall define cooperation forms that clarify who asks the questions dictated by the method components' procedures. The authors relate this to roles that perform the method execution. Further, the several parts of a method may utilize different forms of cooperation, such as interviews or brainstorming sessions. To document these aspects appropriately, REAM uses an approach that defines cooperation forms from two perspectives:

(i) skills necessary to perform the different steps defined by REAM's method components, and

(ii) recommended research methods for each step of REAM that represent forms of cooperation. The following paragraphs discuss these two perspectives.

REAM is designed to be executed in a project setting. Thus, REAM recommends to form a project team for successful method execution. The remainder of this work refers to this as the REA Team. The REA Team consists of different roles that possess a particular set of skills necessary to apply REAM. Typically, any project team needs a project manager with project managerial skills. As this applies to any project team, REAM refers to standard project management literature for the identification of project-generic roles and skills. On this basis, the method defines a list of skills the REA Team shall possess across their project members. They relate to two general skill groups.

DOMAIN-DEPENDENT SKILLS. These skills refer to the industry or problem domain, to which the REA applies. Hence, depending on the respective context of an REA project, there may exist additional domain-dependent skills necessary to apply REAM. However, REAM defines the following generic skills for this group:

- ❖ **[SK1] expert knowledge of the problem domain:** broad and long-term professional experience in the domain or industry. That includes a thorough understanding of relevant value networks and market structures; profound knowledge regarding dominant organizational structures, central business processes, or IT landscapes.
- ❖ ***[SK2] professional network [optional]*:** some REA Team members shall have access to a business network within the problem domain. If possible, this may span over all relevant stakeholders of the envisioned REA or different industrial associations existing in the domain.

SKILLS REGARDING EAM AND ENTERPRISE MODELING. Most components require skills that relate to the domain of EAM and enterprise modeling. REAM advises to form an REA Team, in which several different actors possess the following skills:

- ❖ **[SK3] EAM EXPERTISE:** extensive understanding and experience of EAM methods, existing EA frameworks, modeling languages, appropriate tool support, and an understanding of how to put EA concepts into practice. Ideally, REAM recommends professional experience as an enterprise architect[1].
- ❖ **[SK4] ENTERPRISE MODELING EXPERTISE***:* expertise and experience in conducting enterprise modeling. That includes experience in eliciting necessary knowledge, such as participatory enterprise modeling (Stirna et al. 2007), the modeling process itself, and the professional use of modeling tools.
- ❖ **[SK5] QUALITATIVE RESEARCH EXPERIENCE:** conduction of qualitative research with scientific rigor. Especially, conducting expert interviews, setting up focus groups, surveys, or multi-day workshops is essential. In some cases, this may require quantitative research methods, as well.

[1] the head of an EAM initiative in an organization. He or she ensures the completeness and quality of the architecture from a cross-departmental perspective (Wißotzki et al. 2017).

TABLE 34. OVERVIEW OF SKILLS, METHODS, AND USER INVOLVEMENT FOR REAM

COMPONENT		COMPONENT STEP		SK1	SK2	SK3	SK4	SK5	USER?	RESEARCH METHODS[1]
1	CLARIFY REA SCOPE	1A	Analyze Problem	X	X	X		X	☑	*EI, FG, LR, S*
		1B	Define the Problem Domain of the REA	X	X			X	☑	*EI, FG, LR, S*
		1C	Identify Stakeholders and their needs	X	X			X	☑	*EI, FG, I, LR, S*
		1D	Derive Objectives of the REA	X		X	X			*RE*
		1E	Set up REA Development Team	X	X	X	X	X		*PM*
2	SET REA CONSTRUCTION STRATEGY	2A	Identify Application-Centered Aspects	X	X	X		X	☑	*EI, FG, IS, LR, S*
		2B	Identify Construction-Centered Aspects			X	X			
		2C	Search for previous work in Problem Domain	X				X		*EI, LR*
		2D	Define REA Portfolio			X				
3	REA FRAMEWORK SETUP	3A	Choose appropriate EA Framework			X	X	X		*LR*
		3B	Define REA Modeling Notation			X	X			
		3C	Clarify REA Tool Support			X	X			
		3D	Define REA Framework			X	X			
4	DOMAIN-SPECIFIC REA STRUCTURE	4A	Decide on naming conventions	X				X		*DA, EI, FG, LR*
		4B	Define High-Level Structure of REA	X		X	X		☑	*FG, PEM*
		4C	Evaluate High-Level REA Structure	X		X		X	☑	*EI, S*
5	DEDUCTIVE REA CONSTRUCTION	5A	Analyze Reusable Knowledge	X		X		X		*DA, EI, FG, LR*
		5B	Elicit Implicit Knowledge Base	X	X	X		X	☑	*EI, FG, PEM*
		5C	Deduce REA Model			X	X			
		5D	Evaluate Model	X				X		*EI, PEM*
6	INDUCTIVE REA CONSTRUCTION	6A	Choose Organization Sample		X			X		
		6B	Define Collection Scope	X		X	X			*Q*
		6C	Approach Organizations		X				☑	
		6D	Collect Individual Models				X	X	☑	*IS, PEM*
		6E	Harmonize Individual Models				X			
		6F	Choose Abstraction Techniques	X		X	X			*LR, SD*
		6G	Acquire REA Model				X			
		6H	Post-process REA Model	X		X	X			
		6I	Evaluate Model	X		X		X	☑	*EI, FG, S*
7	REA MODEL COMPLETION	7A	Develop Integrated REA Model				X			
		7B	Check and Complete Interrelations			X	X			
		7C	Check and Complete Naming Conventions	X			X			
		7D	Check and Complete Documentation	X		X	X			
		7E	Enrich Data depending on the REA scope			X	X			
8	APPLICATION DESIGN DEVELOPMENT	8A	Define REA Value	X		X				
		8B	Specify REA Application Scenarios	X		X				
		8C	Define REA Application Design	X		X				
		8D	Disseminate REA Model	X	X					
		8E	Develop REA Communication Material	X		X	X			
9	REA MODEL EVALUATION	9A	Define Evaluation Strategy	X		X				
		9B	Conduct Model-Centric Evaluation					X	☑	*EI, FG, S*
		9C	Conduct User-Centric Evaluation	X				X	☑	*AR, CS, IS, O*
10	REA MODEL MAINTENANCE	10A	Define Maintenance Plan	X		X				
		10B	Re-Investigate Problem Domain	X	X			X	☑	*EI, FG, LR, S*
		10C	Derive Means for Improvement	X			X			

As indicated above, the concrete composition of an REA Team highly depends on the context of the project itself. Table 42 in section 6.4.2.1 presents an example of such an REA Team. There the project team of a real-world project for REA development (cf. section 6.3) is discussed and gives insights on how to instantiate such an REA Team.

[1] **Research Methods**: AR: Action Research | CS: Case Study | DA: Document Analysis | EI: Expert Interviews | FG: Focus Group | IS: Interview Study | LR: Literature Review | O: Observation | PEM: Participative Enterprise Modeling | PM: Project Management Methods | Q: Questionnaire | RE: Requirements Engineering | S: Survey | SD: Software Development

In addition to this set of required skills, REAM provides recommendations on what research methods to utilize when performing specific steps. That intends to support REA Teams when executing the several component s of REAM. For each step documentation, REAM provides a list of recommended research methods to apply (if appropriate). Table 34 provides an overview of what component and step requires which of the above-enlisted skills and what research methods a user shall use while executing it. Furthermore, it indicates what parts of REAM require the involvement of potential REA users.

6.2.4 CONCEPTS USED BY REAM

Goldkuhl et al. (1998) argue that a thorough description of an IS method requires the definition of concepts used within that method. Specific activities of the method components address particular phenomena. A concept encapsulates these phenomena. Thus, this section gives an overview of the concepts used by REAM.

REAM summarizes the concepts into eight high-level concept groups. These concept groups relate to one or more REAM phase (see section 6.2.1), in which they are produced and used. Each group focuses on different aspects of REA development. Table 35 presents these concept groups, provides their definition, and refers to REAM Phase that focuses on them.

TABLE 35. HIGH-LEVEL CONCEPT GROUPS OF REAM

CONCEPT GROUP	DEFINITION	BY PHASE
REA SCOPE	The REA SCOPE represents the overall reasons behind the REA endeavor. It consists of the SPECIFIED PROBLEM, the PROBLEM DOMAIN, and the concerned PROBLEM STAKEHOLDERS with their STAKEHOLDER NEEDS. Further, it encompasses the REA OBJECTIVE, derived REA REQUIREMENTS. Moreover, the REA SCOPE is related to REA TEAM.	PHASE (A)
REFERENCE ENTERPRISE ARCHITECTURE (REA)	The REA groups all concepts that represent the Reference Enterprise Architecture. It encompasses the REA FRAMEWORK, REA STRUCTURE, the REA MODEL itself, its REA DOCUMENTATION, and the REA PORTFOLIO.	PHASE (A) + PHASE (B)
REA MODEL	The REA MODEL is part of the REA and represents the architectural description of the REA. It operationalizes the REA FRAMEWORK. The model stores all elements and relations in a model repository. Based on the REA STRUCTURE, it visualizes the different perspectives on the REA by dint of the defined architecture viewpoints. During REAM execution, different versions of the REA MODEL are constructed: (initial), (deductive), (inductive), and (integrated) REA MODEL.	PHASE (B)
REA KNOWLEDGE BASE	The REA KNOWLEDGE BASE groups the different concepts that represent knowledge. That knowledge is either created by REAM or reused.	PHASE (A) + PHASE (B)
REA EVALUATION	The REA EVALUATION focuses on concepts that are used to evaluate the REA MODEL. That includes the EVALUATION STRATEGY and EVALUATION CRITERIA.	PHASE (C)
REA MAINTENANCE	The REA MAINTENANCE encompasses the concepts that keep the REA current regarding contextual changes and put previously identified IMPROVEMENT NEEDS into action. It consists of the MAINTENANCE PLAN and MEANS FOR IMPROVEMENT.	PHASE (C)

As their definitions indicate, each concept group aggregates further concepts that represent a concrete phenomenon relevant to specific steps of REAM. In some cases, these aggregated concepts compose other concepts as well (e.g., REA MODEL). To illustrate this, Figure 50 gives an overview of these aggregation relations among REAM's concepts.

Figure 50 shows the six high-level REAM concepts defined in Table 35 and reveals the concepts they aggregate. All concepts presented in grey boxes further aggregate different concepts. For instance, the REA MODEL, which is part of the REA, aggregates the Deductive REA and the Inductive REA. The latter consists of concepts that are related to inductive REA construction in component 6 of REAM Phase (B). Table 36 defines each of the total 34 concepts and relates them to the steps in produce, use, and refine them.

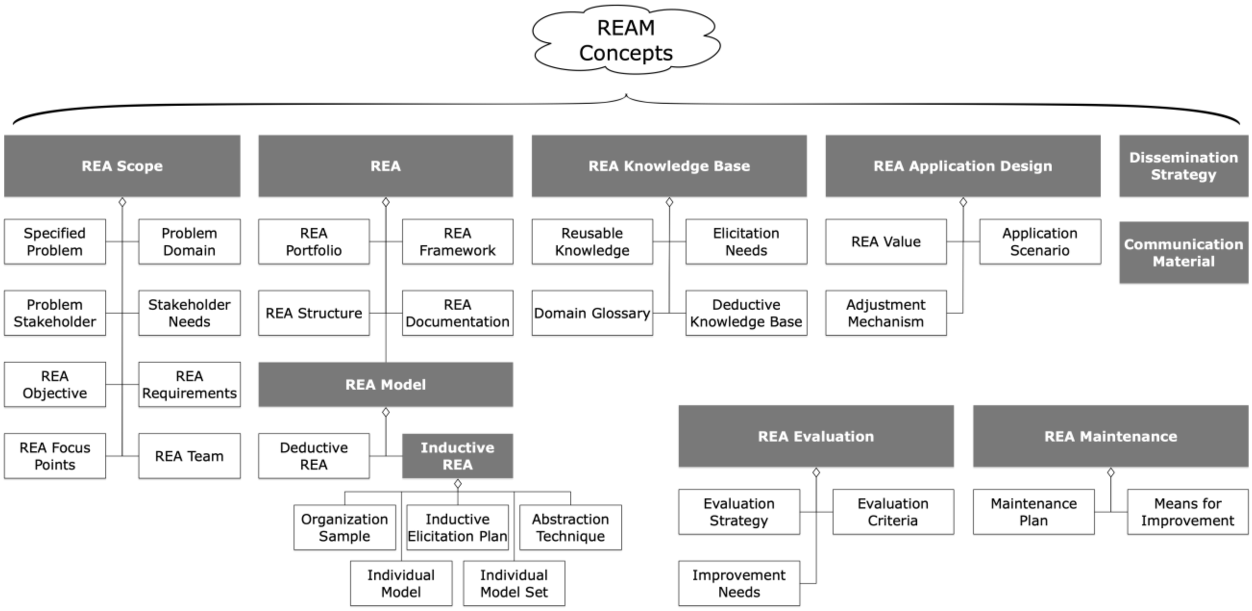


FIGURE 50. OVERVIEW OF REAM CONCEPT GROUPS AND THEIR COMPOSING CONCEPTS

TABLE 36. DETAILED EXPLANATION OF ALL CONCEPTS USED BY REAM

GROUP	CONCEPT	DEFINITION	PRODUCED	USED	REFINED
REA SCOPE	**SPECIFIED PROBLEM**	The SPECIFIED PROBLEM explicates a particular problem in a specific domain. It relates to REA drivers and relates to several EA layers.	STEP 1A	STEP 1B, 1C, 1D	
	PROBLEM DOMAIN	The PROBLEM DOMAIN defines the domain of the SPECIFIED PROBLEM concerns. Therefore, it identifies affected industries as well as affected business areas of these industries.	STEP 1B	STEP 1C, 1E STEP 2C, 2D STEP 4A STEP 5A, 5B STEP 10A, 10B	
	PROBLEM STAKEHOLDER	PROBLEM STAKEHOLDERS are organizations active in the PROBLEM DOMAIN share the SPECIFIED PROBLEM. They can either be directly or indirectly affected by the SPECIFIED PROBLEM.	STEP 1C	STEP 1D, 1E STEP 2A, 2D STEP 6A STEP 8A, 8B	
	STAKEHOLDER NEEDS	STAKEHOLDER NEEDS are demands or interests in the context of the SPECIFIED PROBLEM.	STEP 1C	STEP 1D, 1E STEP 2A, 2D STEP 8A, 8B	
	REA OBJECTIVE	The REA OBJECTIVE represents the overall goal of the REA initiative. It is formulated based on the SPECIFIED PROBLEM. Therefore, it translates the problem-oriented perspective of the SPECIFIED PROBLEM into a solution-oriented formulation.	STEP 1D	STEP 1E STEP 2B, 2C STEP 8A, 8B STEP 9A	
	REA REQUIREMENTS	REA REQUIREMENTS are conditions or capabilities that must be met or possessed by the REA to satisfy the REA OBJECTIVE (based on IEEE Standard 610-12-1990). In the context of an REA, an REA REQUIREMENT may focus on structural, domain-specific, construction-oriented, application-oriented, documentation-oriented, or collaboration-oriented aspects.	STEP 1D	STEP 2B-2D STEP 5D STEP 6I STEP 9A STEP 10B, 10C	STEP 10B
	REA TEAM	The REA TEAM consists of several people that are responsible for realizing the REA OBJECTIVE under the given REA REQUIREMENTS. The members shall possess skills related to EAM, enterprise modeling, qualitative research methods, and expert knowledge in the PROBLEM DOMAIN (or have access to a professional network in the Problem Domain).	STEP 1E		

GROUP	CONCEPT	DEFINITION	PRODUCED	USED	REFINED
	REA FOCUS POINTS	REA FOCUS POINTS identify focal aspects the REA MODEL construction shall concentrate on. Depending on the REA OBJECTIVE, derived REA REQUIREMENTS, and APPLICATION SCENARIOS, these aspects guide the REA TEAM during content-wise or structural decisions. The REA FOCUS POINTS also influence decisions regarding what knowledge shall be elicited.	STEP 2B	STEP 2D STEP 4B	
REA	**REA PORTFOLIO**	The REA PORTFOLIO summarizes the knowledge gathered during PHASE (A) of REAM concisely. Therefore, it summarizes the REA SCOPE, an outline of the REA, necessary knowledge for construction, and sketches the REA application.	STEP 2D	STEP 3A-3D STEP 6A STEP7D STEP 8D, 8E	
REA	**REA FRAMEWORK**	The REA FRAMEWORK structures the architectural description of the REA. Therefore, it defines the EA framework and the EA modeling language used by the REA as well as utilized tool support. These may be adjusted to the REA specifics, regarding addressed EA layers or used elements.	STEP 3A	STEP 4B STEP 5C	STEP 3B-3D
REA	**REA STRUCTURE**	The REA STRUCTURE uses architecture viewpoints that form the structure of the REA MODEL. The REA STRUCTURE consists of a horizontal (domain-specific) and vertical (EA-based) perspective.	STEP 4B	STEP 4C STEP 5A-5C STEP 6B STEP 7A, 7D	STEP 4C
REA	**REA MODEL (+)**	The REA MODEL represents the architectural description of the REA. It operationalizes the REA FRAMEWORK. The model stores all elements and relations in a model repository. Based on the REA STRUCTURE, it visualizes the different perspectives on the REA by dint of the defined architecture viewpoints. During REAM execution, different versions of the REA MODEL are constructed: (initial), (deductive), (inductive), and (integrated) REA MODEL.	STEP 4B	COMPONENT 5-10	COMPONENT 5-10
REA	**REA DOCUMENTATION**	The REA DOCUMENTATION provides descriptions and explanations of the REA MODEL'S elements, their structure, or the overall construction pro	STEP 7B		
REA MODEL	**DEDUCTIVE REA**	The DEDUCTIVE REA represents the deductively developed parts of the REA MODEL. It results from deductive reasoning. It consists of elements and relations identified in the DEDUCTIVE KNOWLEDGE BASE and represents it based on the REA FRAMEWORK.	STEP 5C	STEP 7A	STEP 5D
REA MODEL	**INDUCTIVE REA (+)**	The INDUCTIVE REA represents the inductively developed parts of the REA MODEL. It further encompasses the concepts necessary for inductive REA construction. In contrast to deductive reasoning, inductive reasoning requires eliciting comparable INDIVIDUAL MODELS, from which an REA can be derived using ABSTRACTION TECHNIQUES. That further includes an ORGANIZATION SAMPLE for the elicitation and an INDUCTIVE ELICITATION PLAN.	STEP 6G	STEP 6H, 6I STEP 7A	STEP 6H, 6I
REA KNOWLEDGE BASE	**REUSABLE KNOWLEDGE**	In the context of the REA, REUSABLE KNOWLEDGE relates to knowledge that is available in explicit form and relates to the REA OBJECTIVE. That may be existing reference models, industry standards, taxonomies, or research literature.	STEP 2C	STEP 2D STEP 5A	
REA KNOWLEDGE BASE	**ELICITATION NEEDS**	ELICITATION NEEDS represent the gap between the necessary knowledge for REA development and identified REUSABLE KNOWLEDGE. That gap may occur in the case the REUSABLE KNOWLEDGE does not cover the knowledge needed to meet the REA REQUIREMENTS.	STEP 2C	STEP 2D STEP 5B STEP 6B	
REA KNOWLEDGE BASE	**DOMAIN GLOSSARY**	The DOMAIN GLOSSARY is a central document that enlists domain-specific concepts and their definitions. Thus, it stores domain knowledge and provides naming conventions for the REA MODEL.	STEP 4A	STEP 5C STEP 7A, 7C	

GROUP	CONCEPT	DEFINITION	PRODUCED	USED	REFINED
	DEDUCTIVE KNOWLEDGE BASE	The DEDUCTIVE KNOWLEDGE BASE represents the domain-specific knowledge used to deduce an REA MODEL. It may refer to existing knowledge such as industry standards or existing reference models	STEP 5A	STEP 5C	STEP 5B
INDUCTIVE REA	ORGANIZATION SAMPLE	The ORGANIZATION SAMPLE defines organizations that participate in the inductive REA study. The organizations relate to PROBLEM STAKEHOLDERS of the PROBLEM DOMAIN. From each of these organizations, an INDIVIDUAL MODEL is developed.	STEP 6A	STEP 6C, 6D	STEP 6C
	INDUCTIVE ELICITATION PLAN	The INDUCTIVE ELICITATION PLAN defines a systematic approach to plan the scope, organization, and procedure for the inductive REA construction. It ensures the comparability of elicited INDIVIDUAL MODELS of participating organizations from the ORGANIZATION SAMPLE.	STEP 6B	STEP 6C, 6D	
	INDIVIDUAL MODEL	An INDIVIDUAL MODEL represents the current state of affairs of a specific organization according to the INDUCTIVE ELICITATION PLAN. The results are structure using the REA FRAMEWORK, that is, using the predefined modeling language and REA STRUCTURE.	STEP 6D		
	INDIVIDUAL MODEL SET	The INDIVIDUAL MODEL SET consists of all INDIVIDUAL MODELS that have been developed by a single inductive REA study.	STEP 6D	STEP 6E-6G	STEP 6E
	ABSTRACTION TECHNIQUE	An ABSTRACTION TECHNIQUE defines a set of rules that prescribe how to generate an REA MODEL from the INDIVIDUAL MODEL SET. Therefore, it uses the concepts of elimination and aggregation.	STEP 6F	STEP 6G	
REA APPLICATION DESIGN	REA VALUE	The REA VALUE defines what kind of benefits an application of the REA offers to a certain PROBLEM STAKEHOLDER.	STEP 8A	STEP 8B	
	APPLICATION SCENARIO	An APPLICATION SCENARIO explicates a specific way how the REA can be applied. It encapsulates a homogenous group of STAKEHOLDER NEEDS and provide means how to apply the REA accordingly. It is specified by a description, which formulates an REA usage intention, and relates to the offered REA VALUE, PROBLEM STAKEHOLDERS, their STAKEHOLDER NEEDS, and the dimension of REA application. In some cases, an APPLICATION SCENARIO further uses case-specific ADJUSTMENT MECHANISMS.	STEP 2A	STEP 2B, 2D STEP 8B, 8C	STEP 8B
	ADJUSTMENT MECHANISM	An ADJUSTMENT MECHANISM represents a set of rules that define what construction activities to take in order to derive a user-specific EA model from the REA MODEL. The choice of ADJUSTMENT MECHANISMS influences the construction process of the REA MODEL. This concept relates to the five design principles defined by Vom Brocke (2006).	STEP 2A	STEP 2D STEP 6B STEP 7E STEP 8C	STEP 8C
REA EVALUATION	EVALUATION STRATEGY	The EVALUATION STRATEGY defines a plan on how to evaluate the constructed REA MODEL. Therefore, it defines Evaluation Methods, EVALUATION CRITERIA, and Participants of the evaluation.	STEP 9A	STEP 9B, 9C	
	EVALUATION CRITERIA	EVALUATION CRITERIA define the aspects to focus on during the evaluation of the REA MODEL. REAM distinguishes between criteria that focus on the model itself (model-centric evaluation) and criteria that focus on a user-centric perspective (user-centric evaluation).	STEP 9A	STEP 9B, 9C	

GROUP	CONCEPT	DEFINITION	PRODUCED	USED	REFINED
	IMPROVEMENT NEEDS	IMPROVEMENT NEEDS represent all kinds of flaws identified during the evaluation of the REA MODEL. Their consequences may range from minor adjustments (e.g., adding a new element) to significant updates of the REA MODEL (e.g., expanding the REA Structure by a new domain-specific aspect).	STEP 9B	STEP 10C	STEP 9C
REA MAINTENANCE	**MAINTENANCE PLAN**	The MAINTENANCE PLAN determines under which circumstances and in what frequency one shall evaluate the REA shall. That ensures the REA is up-to-date.	STEP 10A		
	MEANS FOR IMPROVEMENT	A MEANS FOR IMPROVEMENT translates a specific IMPROVEMENT NEED into action in order to overcome it and update the REA MODEL accordingly. As a result, a MEANS FOR IMPROVEMENT defines what REAM Component and Step to re-iterate in order to meet the respective IMPROVEMENT NEED.	STEP 10C		
-	**DISSEMINATION STRATEGY**	The DISSEMINATION STRATEGY defines how to distribute the REA to potential REA users. That may span from open-source business models to a certification approach.	STEP 8D		
-	**COMMUNICATION MATERIAL**	The COMMUNICATION MATERIAL consolidates all information about the REA that provided to potential REA users, such as an overview of the REA MODEL, the benefits of REA application, or summarizing example case studies.	STEP 8E		

Different versions of the REA Model evolve while executing REAM. They are results from the different stages of Phase (B) REA CONSTRUCTION. Table 37 shortly enlists the different versions of the REA Model produced throughout REAM execution, explains them, and states them to the several steps that produce them.

TABLE 37. REA MODEL VERSIONS THROUGHOUT EXECUTING REAM.

REA MODEL VERSION	DESCRIPTION	PRODUCED BY
(initial) REA MODEL	The (initial) REA MODEL is the first version of the REA MODEL. It initializes the viewpoints of the REA STRUCTURE.	STEP 4B
(deductive) REA MODEL	The (deductive) REA MODEL is a version of the REA MODEL that results from deductive reasoning. It consists of elements and relations identified in the DEDUCTIVE KNOWLEDGE BASE and represents it based on the REA FRAMEWORK.	STEP 5C
(inductive) REA MODEL	The (deductive) REA MODEL is a version of the REA MODEL that results from inductive reasoning. It is based on the REA FRAMEWORK. Its content is the result of applying the ABSTRACTION TECHNIQUE to the INDIVIDUAL MODEL SET.	STEP 6G
(integrated) REA MODEL	The (integrated) REA MODEL aggregates all single parts of the REA MODEL that have been developed by REAM application so far.	STEP 7A

6.3 RUNNING EXAMPLE: A REFERENCE COMPLIANCE ORGANIZATION

The main scope of this chapter is to present REAM. In order to support its comprehensibility, a running example accompanies its description. After presenting one of the three REAM Phases, an additional chapter will discuss how a real-world project applied the corresponding components. These chapters will provide an extract of the project's results and use the structure of the respective REAM Phase to maintain traceability.

The running example is the research project that relates to this thesis' underlying Local Practice B, i.e., the financial services compliance. For a detailed discussion of the project's context, this section refers to section 4.1.2. The project's overall objective was to develop an REA that provides a holistic approach to regulatory compliance management—the Reference Compliance Organization (RCO). Therefore, the RCO had to analyze practical knowledge, identify effective practices, and use EAM concepts to capture regulation's impact on financial institutes from business, data, and application perspectives. The project originated from a working group of the German IT-association bitkom, which consisted of ten ISVs and IT consultancies from the financial services compliance domain. While the working group financed the project, bitkom took responsibility for the project organization. The author acted as one of the five members of the project team. He was responsible for both the methodological approach as well as the development of the RCO. Therefore, REAM was applied, as discussed in section 6.4.3, section 6.5.6, and section 6.6.4.

6.4 PHASE (A): PREPARING REA DEVELOPMENT

The first phase of REAM has two primary purposes:

(i) establish a clear and sophisticated scope of the REA endeavor
(ii) envision the outcome of the REA and identify high-level content it shall capture

In order to achieve these objectives, PHASE (A) consists of COMPONENT 1 and COMPONENT 2. Figure 51 illustrates the extract from REAM method framework. It shows the execution path of them. The remainder of this chapter describes them using the template for component documentation. After explaining both COMPONENT 1 and COMPONENT 2, the chapter further exemplifies their application in practice by illustrating their respective results of applying REAM in the running example.

Each REAM iteration shall start with the components of PHASE (A) since their results are vital for a successful REA development. During the application REAM, new insights might trigger adjustment of results produced by Phase (A). For instance, the REA construction in COMPONENT 5 and COMPONENT 6 might reveal new knowledge that triggers the formulation of additional REA REQUIREMENTS (cf. COMPONENT 1) or identify new relevant APPLICATION SCENARIOS of the REA (cf. COMPONENT 2). Consequently, any activity from either PHASE (B) or PHASE (C) of REAM might prompt the REA Team to revisit the results produced in PHASE (A).

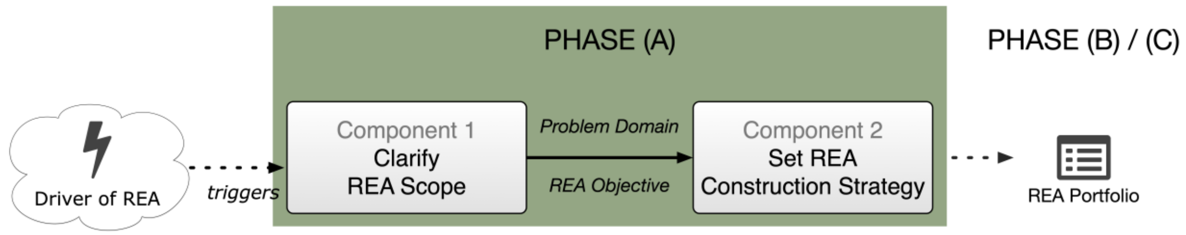


FIGURE 51: OVERVIEW ON PHASE (A) PREPARING REA DEVELOPMENT

6.4.1 COMPONENT 1: CLARIFY REA SCOPE

This component's overall objective is to define the overall scope of the REA development project. That includes a detailed analysis of the problem in order to comprehend and structure its causes. Furthermore, the component defines the REA TEAM, the addressed PROBLEM DOMAIN, addressed PROBLEM STAKEHOLDERS, and STAKEHOLDER NEEDS. On this basis, it derives the overall REA OBJECTIVE and defines concrete REA REQUIREMENTS.

6.4.1.1 COMPONENT 1: USED CONCEPTS

Table 38 explains all concepts that COMPONENT 1 uses. In order to investigate the scope of the REA project, this component defines the concrete problem(s) that underlies the REA endeavor and relates to a specific PROBLEM DOMAIN. That includes identifying PROBLEM STAKEHOLDERS and their corresponding STAKEHOLDER NEEDS in that problem space. Afterward, the component translates this domain-specific information into an REA OBJECTIVE. It guides the REA development and defines REA REQUIREMENTS to achieve the REA OBJECTIVE.

TABLE 38. CONCEPTS USED IN COMPONENT 1: CLARIFY REA SCOPE

INPUT	OUTPUT
REA Driver	SPECIFIED PROBLEM
	PROBLEM DOMAIN
	PROBLEM STAKEHOLDER
	STAKEHOLDER NEEDS
	REA OBJECTIVE
	REA REQUIREMENT
	REA TEAM

6.4.1.2 COMPONENT 1: PROCEDURE AND NOTATION

Component 1 CLARIFY REA SCOPE consists of five sequentially executed steps. Figure 52 visualizes this process. It is mandatory to execute COMPONENT 1 at the beginning of each REA development project. Additionally, there might be points of time during REA construction or application, which cause an alteration or concretization of the REA SCOPE. For instance, the elicitation of knowledge in *Components 5 and 6* during Phase (B) could cause an alteration of the PROBLEM DOMAIN definition, if it becomes apparent that the domain borders are too narrow or too broad.

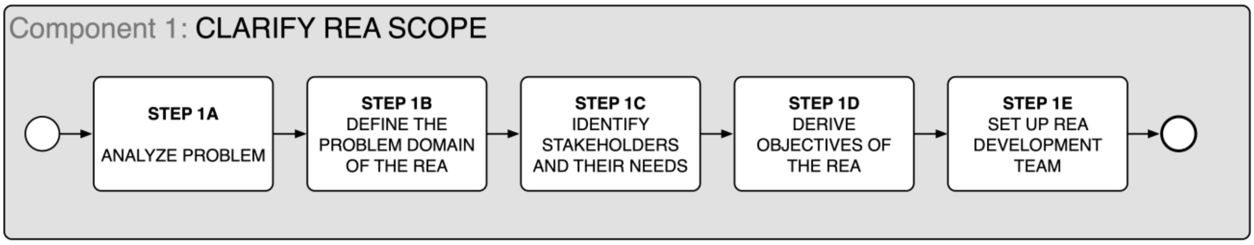


FIGURE 52. PROCEDURE OF METHOD COMPONENT 1: CLARIFY REA SCOPE

STEP 1A: ANALYZE PROBLEM

INPUT: An observed or identified need that triggers the REA project. While it might already be specified, it can also be unstructured.

STEP DESCRIPTION: The first STEP 1A of REAM is to specify the problem and its related domain. Therefore, it is essential to use different sources for problem analysis in order to validate the need for an REA. Thus, the overall goal of STEP 1A is to make an unstructured REA need explicit and to document it in the form of a SPECIFIED PROBLEM. This step is essential for all RM endeavors. Consequently, REAM does not deviate from known RM methods in this regard. However, since REAM produces REAs, the specified PROBLEM shall relate to EAM related topics. In order to identify whether the problem qualifies for REA, REAM requires it to relate to the following characteristics:

- The SPECIFIED PROBLEM does relate to more than one of the essential EA Layers (Winter and Fischer 2006).
- The SPECIFIED PROBLEM relates to at least one of the generic drivers for REA development *"complexity"* and *"dynamics and integration"* and the specific REA drivers related to them (see Table 27)

- The benefits of EAM seem appropriate to solve the SPECIFIED PROBLEM driving the REA development (Lankhorst et al. 2017).

OUTPUT: A SPECIFIED PROBLEM, which concretizes why an REA is necessary.

RECOMMENDED METHODS: Schütte (1998, pp. 189–206) suggests to use a multitude of perspectives for investigating the underlying problem. On the one hand, this includes investigating different organizations that share the SPECIFIED PROBLEM. On the other hand, one shall consider both the perspective of the REA designer and potential users of the REA. Consequently, STEP 1A suggests investigating the problem using a mix of different methods such as expert interviews, (online) surveys, focus groups, or literature reviews.

TOOLS AND NOTATION: The SPECIFIED PROBLEM shall be stored in a central document.

STEP 1B: DEFINE PROBLEM DOMAIN OF THE REA

INPUT: SPECIFIED PROBLEM (from STEP 1A)

STEP DESCRIPTION: STEP 1B defines the domain related to the SPECIFIED PROBLEM. While some REAs address a particular group of market roles in a specific industry, others address every organization of an entire industry. In some cases, REAs address a problem that spans numerous industries (cross-industry). As a result, this step clarifies the exact PROBLEM DOMAIN and provides first insights regarding potential REA users. To define the PROBLEM DOMAIN, one needs to address two perspectives:

(a) **Domain perspective**: What domain or industry does the REA address?
(b) **Functional perspective**: Does the REA span over each function (across the value chain) or does it address a particular function in the addressed domain (e.g., supply chain management)

To clarify (a), existing systematizations help to demarcate the PROBLEM DOMAIN of an REA. Research identifies different layers of abstraction an REA can relate to (Wiermeier and Haberfellner 2007; Fattah 2009, p. 5):

- cross-industry REA: REA spans over several industries (e.g., Supply Chain Management)
- industry-specific REA: REA addresses the problem of a concrete industry (e.g., automotive)

In order to clarify (b), one shall consult domain experts in order to identify functions or processes that are affected by the SPECIFIED PROBLEM.

OUTPUT: PROBLEM DOMAIN

RECOMMENDED METHODS: Similar to STEP 1A, STEP 1B suggests using a mix of different methods such as expert interviews, (online) surveys, focus groups, or literature reviews.

TOOLS AND NOTATION: This Step does not use specific notations or tools. The PROBLEM DOMAIN shall be documented together with the SPECIFIED PROBLEM.

STEP 1C: IDENTIFY STAKEHOLDER AND THEIR NEEDS

INPUT: SPECIFIED PROBLEM (from STEP 1A), PROBLEM DOMAIN (from STEP 1B)

STEP DESCRIPTION: STEP 1C analyzes the PROBLEM DOMAIN and identifies PROBLEM STAKEHOLDERS that act within the PROBLEM DOMAIN and share the SPECIFIED PROBLEM. In most cases, PROBLEM STAKEHOLDERS are organizations that are either directly (e.g., public utilities in LP-A; c.f. section 4.1.1) or indirectly affected by the SPECIFIED PROBLEM (e.g., ISVs in Local Practice A). Although the type and number of relevant PROBLEM STAKEHOLDERS is very case-specific, the KBA in section 4.2.4 revealed a list of PROBLEM STAKEHOLDERS for REAs mentioned in related literature (c.f. Table 25):

- organizations directly affected by the SPECIFIED PROBLEM in the PROBLEM DOMAIN
- independent system vendors (ISVs), who provide IT solutions to these organizations
- consulting firms, whose customers are either these organizations or ISVs
- auditing firms (e.g., if regulatory aspects are a cause for the SPECIFIED PROBLEM)
- industrial federations that act on the organizations' behalf
- standardization organizations that aim to be up-to-date regarding the SPECIFIED PROBLEM
- cooperation of such organizations in industry-specific consortia

For each of these identified PROBLEM STAKEHOLDERS, STEP 1C further analyzes their concrete needs concerning the SPECIFIED PROBLEM. While in most cases, the PROBLEM STAKEHOLDERS' interest is clear and one only has to explicate it, STEP 1C suggests eliciting the STAKEHOLDER NEEDS using methods such as telephone interviews, online surveys, or expert interviews. In order to identify the correct STAKEHOLDER NEEDS, it might be helpful to base this elicitation to the list of values, which related research ascribes to REAs (c.f. Table 24):

- understanding of the problem space and its interrelations on architectural layers
- improvement of communication (e.g., to regulators, business partners, other management levels)
- increasing the efficiency of EA initiatives
- supporting the transformational processes of EA development
- improvement of interoperability (intra and inter)
- more efficient decision-making processes
- risk mitigation
- cost reduction of EA initiatives

Thus, STEP 1C enhances the understanding of the PROBLEM DOMAIN by a list of DOMAIN STAKEHOLDERS that are related to their specific STAKEHOLDER NEEDS.

OUTPUT: PROBLEM STAKEHOLDERS, STAKEHOLDER NEEDS

RECOMMENDED METHODS: Literature Reviews, Expert Interviews, Focus Group, Survey, Interview

TOOLS AND NOTATION: This Step does not use specific notations or tools. However, the results of this step shall be documented together with the PROBLEM DOMAIN and SPECIFIED PROBLEM. Therefore, it might be useful to document PROBLEM STAKEHOLDERS and STAKEHOLDER NEEDS in a tabular form within this document.

STEP 1D: DERIVE OBJECTIVES OF THE REA

INPUT: SPECIFIED PROBLEM (from STEP 1A), PROBLEM STAKEHOLDERS, STAKEHOLDER NEEDS (from STEP 1C)

STEP DESCRIPTION: Based on the results from previous steps, STEP 1D derives the overall REA OBJECTIVE. It directly relates to the SPECIFIED PROBLEM and shall be precisely defined. The REA OBJECTIVE represents the overall goal of the REA initiative. In order to put it into means of action, STEP 1D further defines REA REQUIREMENTS. One can derive them from the REA OBJECTIVE, PROBLEM STAKEHOLDERS, and their STAKEHOLDER NEEDS. As there might exist many PROBLEM STAKEHOLDERS with different needs, it might be necessary to prioritize the elicited REA REQUIREMENTS and to decide which relate to the REA OBJECTIVE.

The requirements guide the construction of the REA later on in the process. Thus, it is vital to address different perspectives of the envisioned REA. The following list provides aspects one shall consider when defining REA Requirements, although the list does not claim to be complete:

- Structural aspects of the envisioned REA: What EA layers and elements are essential to reach the REA objective?
- Domain-specific aspects: What perspectives are necessary from a domain-centric viewpoint?
- Scope of the REA: Do any geographical, regulatory, or instituteal restrictions exist towards the REA?
- Tool and collaboration perspective: What requirements exist regarding the tool support during both REA construction and REA application phase? How can collaboration be enabled effectively?
- Construction-oriented requirements: What requirements do exist regarding the knowledge used for REA construction? What level of detail is adequate for the anticipated REA?
- Application-oriented requirements: What user demands exist for applying the REA?
- Documentation-oriented requirements: What requirements exist towards the documentation of the REA (storage, accessibility, means of representation)?

While it is vital to identify REA REQUIREMENTS in the preparation phase, a clearer picture of these requirements might emerge during the REA construction phase. Consequently, it may be necessary to revisit STEP 1D in the course of the REA development in order to clarify, change, dismiss, or add requirements.

OUTPUT: REA OBJECTIVE, REA REQUIREMENTS

RECOMMENDED METHODS: Methods and Guidelines from the research domain of requirements engineering. (Robertson and Robertson 1999; Pohl 2010; Sommerville 1997)

TOOLS AND NOTATION: While this step does not use specific notations or tools for documenting the REA OBJECTIVE and REA REQUIREMENTS, it recommends to record it in a document, which stores both the objective as a statement and the requirements in a tabular form. Further, each requirement shall be related to the group of PROBLEM STAKEHOLDERS and their respective STAKEHOLDER NEEDS in order to track its origins.

STEP 1E: SET UP REA DEVELOPMENT TEAM

INPUT: PROBLEM DOMAIN (from STEP 1B), PROBLEM STAKEHOLDERS, STAKEHOLDER NEEDS (from STEP 1C), REA OBJECTIVE (from STEP 1D)

STEP DESCRIPTION: As the development of an REA is both knowledge and time-intense, one needs to set up a competent team that collaborates in a project-like environment. Thus, STEP 1E aims to set up the REA TEAM. It consists of different roles, each possessing different sets of skills. These skills shall align to the prior identified REA OBJECTIVE and the REA REQUIREMENTS. Thus, the REA TEAM is case-specific to the respective PROBLEM DOMAIN and REA OBJECTIVE. However, there exist several skills that are mandatory in the REA TEAM:

- expertise and experience in the EAM domain (EA framework(s), EA notations)
- expertise and experience in conducting enterprise modeling and related elicitation techniques such as participatory enterprise modeling (Stirna et al. 2007)
- expertise and experience in conducting qualitative research (e.g., interviews, surveys)
- expert knowledge of the PROBLEM DOMAIN
- professional networks and access to the PROBLEM STAKEHOLDERS (e.g., to industrial associations or concrete stakeholders)

In conclusion, the REA TEAM shall consist of members that possess either knowledge and experience of the PROBLEM DOMAIN or come from a methodological background regarding EAM and research methods aside from traditional project management skills. Table 25 enlists further roles that may participate in the REA TEAM.

OUTPUT: REA TEAM

RECOMMENDED METHODS: Since the development of an REA takes place in a project-like setting, it might be useful to consult methods and tools from the project management discipline.

TOOLS AND NOTATION: STEP 1E does not use any specific tools or notations. However, it might be useful to set up a project plan and steer REAM execution with the help of project management tools such as Gantt charts. For reasons of conciseness, REAM refers to the above-referenced literature.

GUIDELINES FOR COMPONENT 1 CLARIFY REA SCOPE

STEP 1A

- ✓ CONSULT TABLE 27 IN SECTION 4.3.5.1 FOR POSSIBLE PROBLEMS THAT DRIVE REA DEVELOPMENT. ALTHOUGH THAT LIST DOES NOT CLAIM TO BE COMPLETE, COMPARING THE SPECIFIED PROBLEM TO REA DRIVERS ACKNOWLEDGED IN LITERATURE HELPS TO ENSURE THE PROBLEM'S RELEVANCE TO REA DEVELOPMENT.
- ✓ USE DIFFERENT SOURCES TO IDENTIFY THE SPECIFIED PROBLEM IN ORDER TO ESTABLISH A CLEAR PICTURE OF ITS ROOT CAUSES.

STEP 1C

- ✓ CONSULT DOMAIN EXPERTS IN ORDER TO IDENTIFY AN INITIAL LIST OF PROBLEM STAKEHOLDERS.
- ✓ ELICIT STAKEHOLDER NEEDS FROM MULTIPLE STAKEHOLDERS FROM THE SAME GROUP.
- ✓ REVISIT THE RESULTS OF SEPT 1C FROM TIME TO TIME. RELEVANT STAKEHOLDERS AND THEIR NEEDS REGARDING AN REA MIGHT CHANGE OVER TIME. THAT CAN BE DUE TO AN ADVANCED UNDERSTANDING OF THE SPECIFIED PROBLEM FROM THE PERSPECTIVE OF THE REA DEVELOPMENT TEAM, BUT ALSO DUE TO A COMPLETE COMPREHENSION OF THE POSSIBILITIES AND BENEFITS AN REA CAN OFFER FROM STAKEHOLDER'S VIEWPOINT.

STEP 1D

- ✓ USE MULTIPLE SOURCES FOR REQUIREMENTS ELICITATION, SUCH AS DIRECTLY AFFECTED PROBLEM STAKEHOLDERS, DOMAIN EXPERTS, RELEVANT LITERATURE, AND RESEARCH.
- ✓ EVALUATE THE REA REQUIREMENTS WITH DIFFERENT STAKEHOLDERS.
- ✓ REVISIT THE RESULTS OF STEP 1D DURING THE REA CONSTRUCTION PHASE. SINCE SOME ASPECTS OF THE REA BECOME MORE EXPLICIT DURING THE REA CONSTRUCTION PHASE, NEW OR MORE ADVANCED INSIGHTS REGARDING REQUIREMENTS CAN UNFOLD.
- ✓ THE CONCEPTS OF FUTURISTIC AND PRACTICAL RAS PROPOSED BY ANGELOV ET AL. (2008, P. 226) CAN BE CONSULTED TO NARROW THE REA SCOPE AN, THUS, THE REA OBJECTIVE.

6.4.2 COMPONENT 2: SET REA CONSTRUCTION STRATEGY

The rationale behind Component 2 is to agree on an overall construction strategy for the REA development. It intends to guide REAM users to conduct the remaining two REAM phases. Therefore, REAM requires its users to clarify specific characteristics of the envisioned REA. For instance, it identifies potential APPLICATION SCENARIOS from the perspective of REA users, the REA's level of granularity, the general availability of necessary knowledge and resources, or the need for best or common practice. As REAM application progresses over time, the results of COMPONENT 2 may change due to an improved understanding of the PROBLEM DOMAIN at the later stages of the project.

6.4.2.1 COMPONENT 2: USED CONCEPTS

Table 39 explains all concepts that COMPONENT 2 uses. Based on the results of the previous component, Component 2 derives initial APPLICATION SCENARIOS that aim to guide the REA design from that point on. It defines ADJUSTMENT MECHANISMS that sketch how future REA users can deploy the REA in their practice. COMPONENT 2 defines an REA PORTFOLIO that emphasizes REA FOCUS POINTS and summarizes REUSABLE KNOWLEDGE and identified ELICITATION NEEDS.

TABLE 39. CONCEPTS USED IN COMPONENT 2: SET REA CONSTRUCTION STRATEGY

INPUT	OUTPUT
PROBLEM DOMAIN	APPLICATION SCENARIOS
PROBLEM STAKEHOLDER	ADJUSTMENT MECHANISMS
STAKEHOLDER NEEDS	REA FOCUS POINTS
REA OBJECTIVE	REUSABLE KNOWLEDGE
REA REQUIREMENT	ELICITATION NEEDS
	REA PORTFOLIO

6.4.2.2 COMPONENT 2: PROCEDURE AND NOTATION

As explained above, COMPONENT 2 aims to set the cornerstone for the REA construction phase. The REA PORTFOLIO is the central output of COMPONENT 2. It is the central document that can be understood as an executive summary for the REA TEAM as it summarizes essential aspects to consider while constructing the REA. It builds from the results of COMPONENT 1 (see. section 6.4.1). In order to define the REA PORTFOLIO, Component 2 consists of four steps, as Figure 53 illustrates. In the beginning, STEP 2A identifies possible APPLICATION SCENARIOS that later guide the construction phase of the REA development. Afterward, one may execute STEP 2B and STEP 2C simultaneously. While the former defines REA FOCUS POINTS for the construction, the latter investigates whether there exists REUSABLE KNOWLEDGE in the PROBLEM DOMAIN, and identifies ELICITATION NEEDS. STEP 2D aggregates all previous outputs in the REA PORTFOLIO.

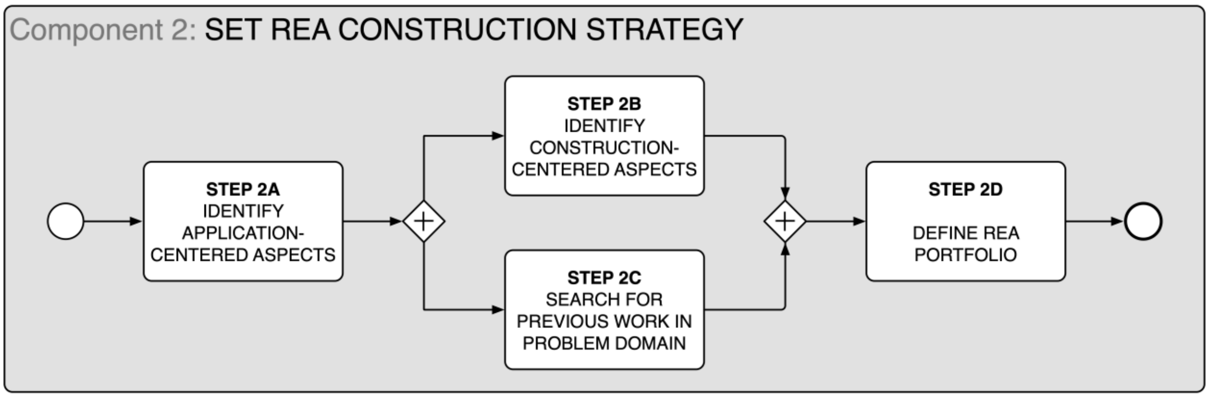


FIGURE 53. PROCEDURE OF METHOD COMPONENT 2: SET REA CONSTRUCTION STRATEGY

STEP 2A: IDENTIFY APPLICATION-CENTERED ASPECTS

INPUT: PROBLEM STAKEHOLDERS, STAKEHOLDER NEEDS (from STEP 1C)

STEP DESCRIPTION: STEP 2A defines possible APPLICATION SCENARIOS. First, for each PROBLEM STAKEHOLDER, possible APPLICATION SCENARIOS are elicited and related to their previously identified STAKEHOLDER NEEDS. REAM suggests to conduct interviews with appropriate representatives from each stakeholder group.

Second, one shall consolidate these APPLICATION SCENARIOS resulting in a list of distinct APPLICATION SCENARIOS groups. Although there may exist a plethora of different APPLICATION SCENARIO types, REAM enumerates several generic one:

- build completely new EA based on REA (e.g., startups, M&As, restructuring)
- transform existing EA based on REA (digitization projects, organizational development)
- check, evaluate, or update existing EA based on REA (regular organizational development)
- conformance of EA to REA (e.g., via certification) is used as audit documentation (external audits, regulatory audits) or tool for conducting audits (with business partners)

Czarnecki and Dietze (2017c, pp. 226–230) define three generic types for applying REAs. Endeavors to use an REA in practice either have a strategic (e.g., apply to specific business areas, customer segments, locations), technical (e.g., support application upgrades, retiring legacy systems, facilitate consolidation plan), or operational orientation (e.g., enable automation or outsourcing).

Third, STEP 2A documents each of these scenarios by relating it to associated PROBLEM STAKEHOLDERS and STAKEHOLDER NEEDS as well as their intention on how to apply the envisioned REA. ADJUSTMENT MECHANISMS capture the latter aspects. They represent the ways of how practice applies REA. That includes the ADJUSTMENT MECHANISMS used to derive a target Model from the REA. Moreover, this may include specific requirements towards the REA application design as well as the necessary knowledge to be stored in the REA. The five design principles defined by Vom Brocke (2006)—*Configuration, Instantiation, Aggregation, Specialization, and Analogy*—help to identify such mechanisms. The following list provides some considerations regarding each of them and in what circumstance it might be reasonable to apply them:

Configuration:

Considerations for REA Application:

- REA Team shall carefully investigate the need for configuration since the implementation costs are very high (Vom Brocke 2006)

Recommended circumstances:

- suitable, if the REA addresses a whole industry and all its related Problem Stakeholders
- the REA Team has a thorough understanding of the market structures and can define metrics that demarcate addressed Problem Stakeholders (Becker et al. 2002, p. 38)
- the REA Team can identify appropriate configuration rules
- this Adjustment Mechanism requires an information base for REA construction. Thus, most cases require to construct the REA using Component 6.

Instantiation:

Considerations for REA Application:

- applies to REAs
- while the author recommends to embed instantiations within the REA Model, REA users might perceive some REA elements to be too generic as well and adjust them on their own

Recommended circumstances:

- available information indicates potential for instantiation
- high diversity of Problem Stakeholders
- alternative instantiations are known to the REA Team. That is likely only the case when applying inductive REA construction.

Aggregation:

Considerations for REA Application:

- vertical and horizontal aggregation theoretically possible for REAs (see Figure 58)
- vertical aggregation not feasible since the interrelations among EA layers quintessence of REA
- horizontal aggregation is feasible as different Problem Sub-Domains can be reused separately

Recommended circumstances:

- the Problem Domain can be divided into several sub-domains that are not closely related to each other (see horizontal REA Structure in Figure 58)

Specialization:

Considerations for REA Application:

- during the abstraction of individual model sets in Component 6, information about the specific instantiations about a generic model elements (or element groups) can be stored and reused by the REA user

Recommended circumstances:

- high diversity of Problem Stakeholders that require specialization of REA Model elements to their specifics
- REA Team possesses knowledge where generic elements or element groups exist
- previous REA Model applications indicate the need for specialization in certain parts of the REA Model

Analogy:
Considerations for REA Application:
- possible analogies to other domains than the Problem Domain addressed by REA shall be documented separately
- observations in this regard may then be useful to other potential REA users from other domains

Recommended circumstances:
- identify parts of the REA that can be generalized to other Problem Domains or industries

The insights gained during this step might trigger an update of the REA REQUIREMENTS in STEP 1D.

OUTPUT: APPLICATION SCENARIOS, ADJUSTMENT MECHANISMS

RECOMMENDED METHODS: Literature Reviews, Expert Interviews, Focus Group, Survey, Interview

TOOLS AND NOTATION: STEP 2A does not use any specific tools or notations. However, REAM recommends to documented all APPLICATION SCENARIOS in a tabular form that relates them to all concepts, as explained above.

STEP 2B: IDENTIFY CONSTRUCTION-CENTERED ASPECTS

INPUT: REA OBJECTIVE, REA REQUIREMENTS (from STEP 1D), APPLICATION SCENARIOS (from STEP 2A)

STEP DESCRIPTION: STEP 2B translates REA OBJECTIVE, REA REQUIREMENTS, and APPLICATION SCENARIOS into central aspects, on which the envisioned REA should concentrate. These aspects will inform the REA construction phase as it guides the REA TEAM when acquiring relevant knowledge or modeling the REA. REAM defines these aspects by dint of REA FOCUS POINTS. Asking the following questions can help to identify them:

- What EA layers to focus on (e.g., focus on business, data, and application layer)?
- What are EA components necessary to include in the REA in order to meet the REA REQUIREMENTS? (e.g., focus on application interfaces, data structures, or responsibilities)
- What perspectives on the envisioned REA help to facilitate the anticipated APPLICATION SCENARIOS (e.g., provide viewpoints that focus on data integration in different domain functions)?

OUTPUT: REA FOCUS POINTS

RECOMMENDED METHODS: Conducting STEP 2B does not require specific methods.

TOOLS AND NOTATION: STEP 2B does not use any specific tools or notations. However, REAM recommends document the identified REA FOCUS POINTS in a central document. They shall be related to either the REA OBJECTIVe, specific REA REQUIREMENTS, or APPLICATION SCENARIOS, from which they originated.

STEP 2C: SEARCH FOR PREVIOUS WORK IN PROBLEM DOMAIN

INPUT: PROBLEM DOMAIN (from STEP 1B), REA OBJECTIVE, REA REQUIREMENTS (from STEP 1D)

STEP DESCRIPTION: STEP 2C analyzes existing knowledge from the problem domain that is reusable for the REA construction phase. That might be any relevant knowledge already accessible to the REA TEAM. However, STEP 2C also includes conducting a structured search of available knowledge within the PROBLEM DOMAIN that relates to the REA OBJECTIVE. Therefore, the REA TEAM shall consider the following resources when searching for REUSABLE KNOWLEDGE:

- Reference Models (any kind of, e.g., reference process models, reference data models)
- Industry Standards (certifications or de-facto standards)
- Taxonomies or systematizations (e.g., from white papers)
- peer-reviewed research in the PROBLEM DOMAIN (not necessarily EA related but focusing on technical or business aspects only)

After identifying REUSABLE KNOWLEDGE, STEP 2C further compares it to the REA REQUIREMENTS in order to detect knowledge gaps, which still exist in the PROBLEM DOMAIN in order to construct the REA. On this basis, the REA TEAM clarifies the necessary knowledge. While some knowledge might be already existing in an implicit form (e.g., the domain knowledge of domain experts), others might need to be further elicited from practice in organizations. STEP 2C documents this by defining ELICITATION NEEDS for the REA construction phase.

OUTPUT: REUSABLE KNOWLEDGE, ELICITATION NEEDS

RECOMMENDED METHODS: There exist many methods that support the identification of REUSABLE KNOWLEDGE. While *expert interviews* help to identify relevant standards or known reference models in the PROBLEM DOMAIN, a method for conducting *systematic literature reviews (SLR)* help to grasp the state-of-the-art in the research literature. If relevant research outlets (domain-specific journals or conference) are known, REAM recommends to use the approach suggested by Kitchenham (2004). Otherwise, REAM suggests using the procedures proposed by Vom Brocke et al. (2009) or Webster and Watson (2002) as they are more of an explorative nature.

TOOLS AND NOTATION: Next to documenting the results of STEP 2C in a structured manner, REAM recommends to use a reference management and knowledge organization tool. That is especially vital when conducting an SLR in order to manage sources and organized knowledge provided within the articles.

STEP 2D: DEFINE REA PORTFOLIO

INPUT: PROBLEM DOMAIN (from STEP 1B), PROBLEM STAKEHOLDER & STAKEHOLDER NEEDS (from STEP 1C), REA OBJECTIVE & REA REQUIREMENTS(from STEP 1D), APPLICATION SCENARIOS & ADJUSTMENT MECHANISMS (from STEP 2A), REA FOCUS POINTS (from STEP 2B), REUSABLE KNOWLEDGE & ELICITATION NEEDS (from STEP 2C)

STEP DESCRIPTION: Based on previous elaborations, STEP 2D defines an REA PORTFOLIO. It revisits all the results from COMPONENT 1 and COMPONENT 2 and summarizes necessary information that is relevant for PHASE (B) REA construction. The rationale behind this step is to reassess the so far produced REAM outputs and to provide them in a concise reference document that guides the construction process further on. Figure 54 illustrates of what information the REA Portfolio shall consist.

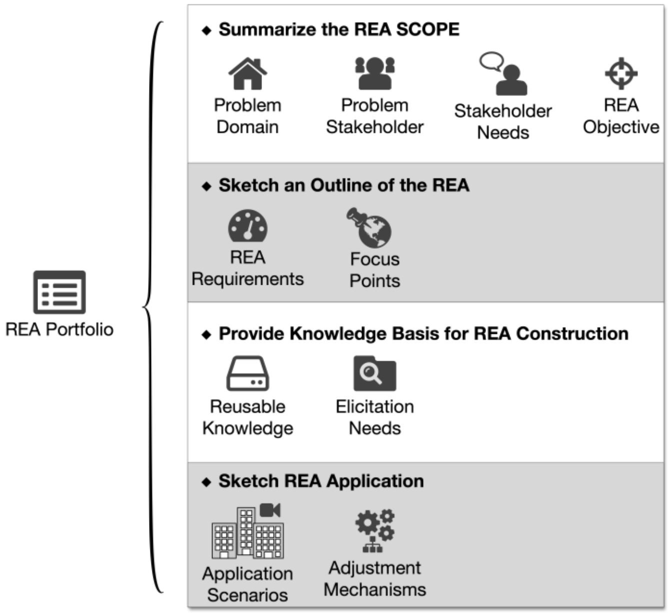


FIGURE 54. REA PORTFOLIO AND THE CONCEPTS IT CONSISTS OF

OUTPUT: REA PORTFOLIO

RECOMMENDED METHODS: Conducting STEP 2D does not require specific methods.

TOOLS AND NOTATION: STEP 2D does not use any specific tools. For documenting the REA PORTFOLIO, REAM recommends storing it in a central document that is easily accessible by all members of the REA Team.

GUIDELINES FOR COMPONENT 2 SET REA CONSTRUCTION STRATEGY

STEP 2A

- ✓ APPLICATION SCENARIOS REPRESENT WAYS OF APPLYING THE REA IN PRACTICE AND ARE ASSOCIATED WITH DIFFERENT BENEFITS THAT COME WITH REA APPLICATION. THEREFORE, THE CONSOLIDATED REA VALUES IN TABLE 24 IN SECTION 4.3.5.1 FROM THE KNOWLEDGE BASE CAN HELP TO FORMULATE INITIAL APPLICATION SCENARIOS.
- ✓ SOMETIMES, DEFINING ADJUSTMENT MECHANISMS IS HARDLY FEASIBLE AT THE EARLY STAGE OF REA DEVELOPMENT. HOWEVER, IT IS IMPORTANT TO DISCUSS POTENTIAL MECHANISMS FOR SPECIFIC APPLICATION SCENARIOS AS THEY MIGHT INFLUENCE THE REA CONSTRUCTION PHASE SIGNIFICANTLY. A SPECIAL CASE OF ADJUSTMENT MECHANISMS IS CONFIGURATION BECAUSE IT HAS TO BE ANTICIPATED BEFORE NECESSARY KNOWLEDGE FOR REA CONSTRUCTION IS ELICITED. OTHER MECHANISMS SUCH AS AGGREGATION, INSTANTIATION, SPECIALIZATION, OR USER-INDUCED ADJUSTMENTS CAN BE IMPLEMENTED INTO THE REA DESIGN ITERATIVELY. IN CONTRAST, WHEN EMBEDDING CONFIGURATION MEANS INTO THE REA DESIGN, CONFIGURATION PARAMETERS NEED TO BE DEFINED BEFORE ELICITING PRACTICAL KNOWLEDGE. HENCE, IF THERE IS NO CLARITY ON WHAT ADJUSTMENT MECHANISMS TO USE FOR THE APPLICATION SCENARIOS, REAM RECOMMENDS TO DISCUSS, WHETHER CONFIGURATION NEEDS TO BE EMBEDDED OR NOT.
- ✓ AFTER IDENTIFYING THE APPLICATION SCENARIOS, EVALUATE THEM WITH DIFFERENT DOMAIN STAKEHOLDERS.

STEP 2C

- ✓ STEP 2C SHALL BE CONDUCTED BY MULTIPLE REA TEAM MEMBERS SEPARATELY TO GUARANTEE ITS OBJECTIVITY. AFTERWARD, RESULTS CAN BE COMPARED, AND DISAGREEMENTS NEED TO BE SOLVED. THAT ESPECIALLY APPLIES TO CONDUCTING SLRS. IN ANY CASE, IDENTIFIED REUSABLE KNOWLEDGE AND THE REA TEAM SHALL DISCUSS THEIR IMPACT ON REA CONSTRUCTION.
- ✓ TRY TO DOCUMENT EACH ELICITATION NEED CONCERNING THE REASON WHY THIS KNOWLEDGE IS NECESSARY FOR REA CONSTRUCTION AND WHAT TECHNIQUES MIGHT BE FEASIBLE TO GATHER IT (DEDUCTIVE OR INDUCTIVE REA CONSTRUCTION NECESSARY?).

STEP 2D

- ✓ BE VERY CONCISE AND AS CLEAR AS POSSIBLE WHEN DEFINING THE REA PORTFOLIO.
- ✓ EVALUATE THE REA PORTFOLIO WITH SEVERAL DOMAIN STAKEHOLDERS.
- ✓ REVISIT THE REA PORTFOLIO AT REGULAR INTERVALS. THAT ENSURES TO KEEP FOCUS WHEN CONSTRUCTING THE REA AND TO UPDATE ITS SCOPE.

6.4.3 A REFERENCE COMPLIANCE ORGANIZATION: PREPARATION PHASE

After the previous chapters described the two method components of REAM Phase (A), this section illustrates them put into practice. Therefore, it explains how each step was conducted and presents resulting artifacts in the context of the running example (see section 6.4.1).

6.4.3.1 COMPONENT 1: CLARIFYING THE SCOPE FOR THE RCO

STEP 1A + 1B: PROBLEM AND DOMAIN OF RCO. As the problem investigation identified earlier (see section 4.1.2), the project to develop a Reference Compliance Organization (RCO) emerged within a working group of nine ISVs for regulatory compliance management (RCM) in the financial sector. The working group functioned as a focus group as many, and regular meetings for dedicated discussion points took place up in the period of two and a half years. In an initial meeting, the participating domain experts highlighted the lack of integration between different IT solutions in the compliance field. Furthermore, they pointed out that financial institutes simultaneously face an increasing amount of regulatory requirements. In order to investigate these observations more precisely, the RCO team used different sources to gather a complete picture of the PROBLEM DOMAIN. First, a literature study was performed analyzing the existing body of knowledge in the field of RCM in financial industries. Second, expert interviews with the members of the focus group meetings helped to identify root causes for the initially identified needs. Third, telephone interviews with four banking federations were conducted that provided the perspective of financial institutes. While these activities primarily focused on the problem analysis, discussions with experts and practitioners also shed light on the problem domain that is addressed by the RCO. Thus, the conduction of STEP 1B followed seamlessly.

As a result, a SPECIFIED PROBLEM addressed by the RCO and its underlying root causes evolved. Furthermore, the PROBLEM DOMAIN was clarified. While section 4.1.2 discusses the results in more detail, the following paragraphs summarize the results:

SPECIFIED PROBLEM OF RCO: FINANCIAL INSTITUTES NEED SUPPORT IN IMPLEMENTING A HOLISTIC RCM THAT IS CHARACTERIZED BY INTEGRATING PRIOR ISOLATED COMPLIANCE PROGRAMS AND CAPTURING EFFECTS OF REGULATION FROM AN IT PERSPECTIVE ALIGNED WITH ORGANIZATIONAL IMPLEMENTATION.
THE PROBLEM ORIGINATES FROM SEVERAL ASPECTS:

- A PLETHORA OF DYNAMICALLY CHANGING REGULATORY REQUIREMENTS
- AN ABSENCE OF CONCRETE MEANS TO REALIZE THESE REQUIREMENTS AND RELEVANT PRACTICAL KNOWLEDGE
- A DEADLINE-DRIVEN APPROACH BY REGULATORY BODIES CAUSE ISOLATED COMPLIANCE PROGRAMS AT THE INSTITUTEAL LEVEL

The SPECIFIED PROBLEM relates to the following REA drivers from Table 27:

- Complexity Drivers: lack of business and IT alignment; the need for cost reduction
- Dynamics and Integration Drivers: lack of interoperability; need for standardization; increasing compliance requirements; inconsistent data models

PROBLEM DOMAIN ADDRESSED BY RCO:

(A) DOMAIN PERSPECTIVE: THE RCO AIMS TO PROVIDE A HOLISTIC PICTURE OF RCM IN THE FINANCIAL DOMAIN. THUS, THE RCO IS AN INDUSTRY-SPECIFIC REA. MORE PRECISELY, IT ADDRESSES THE GERMAN LEGAL SPHERE AND PROVIDES HOLISTIC RCM FROM THE PERSPECTIVE OF FINANCIAL INSTITUTES. REFERRING TO §1 OF THE GERMAN BANKING ACT (GERMAN FEDERAL REPUBLIC 24TH APRIL 2018), THE RCO SPECIFICALLY ADDRESSES CREDIT INSTITUTES (E.G., CREDIT BANKS, SAVINGS BANKS) AND FINANCIAL SERVICES INSTITUTES. THE RCO TEAM DELIBERATELY EXCLUDED THE REMAINING INSTITUTE GROUPS FINANCIAL HOLDINGS, PAYMENT SERVICE PROVIDERS, AND INSURANCES.

(B) FUNCTIONAL PERSPECTIVE: THE RCO WILL FOCUS ON RCM RELATED ASPECTS AND, THUS, WILL NOT COVER ALL FUNCTIONAL AREAS OF FINANCIAL INSTITUTES. ITS CONTENT CONCENTRATES ON THE COMPLIANCE PROCESS AND ITS INTERFACES TO OTHER FUNCTIONS OF A FINANCIAL INSTITUTE. FURTHERMORE, THE RCO TEAM DECIDED TO CONCENTRATE ON THREE SPECIFIC RCM FUNCTIONS, I.E., ANTI-MONEY LAUNDERING, KNOW YOUR CUSTOMER, AND FRAUD PREVENTION. AFTER INTERVIEWING BANKING FEDERATIONS REGARDING INSTITUTES' MOST SIGNIFICANT NEED, THESE THREE RCM DOMAINS EMERGED. THE REMAINDER OF THIS THESIS USES THE FOLLOWING ABBREVIATIONS FOR THESE THREE FUNCTIONS:

- ANTI-MONEY LAUNDERING (AML)
- KNOW YOUR CUSTOMER (KYC)
- FRAUD PREVENTION (FRAUD)

STEP 1C: STAKEHOLDERS OF THE RCO AND THEIR NEEDS. Based on the results from the previous two steps, the RCO Team identified the stakeholder groups addressed by the RCO and analyzed their interests. Therefore, the team utilized different methods and investigated several information sources. First, one focus group meeting was dedicated to collect a list of potential RCO users that share the SPECIFIED PROBLEM and are represented in the identified PROBLEM DOMAIN. Second, since the focus group participants were representatives of RCO addressees themselves, the RCO Team elicited their needs towards a holistic RCO as well. Third, interviews with the banking federations gave improved insights from the perspective of financial institutes. Fourth, during the construction process of the RCO (see Phase (B) in section 6.5.6), the RCO TEAM conducted more than 60 in-depth interviews with compliance officers of German financial institutes. While their primary purpose was to elicit practical knowledge of the domain, it further sharpened the understanding of their needs. Fifth, analyzing the relevant knowledge basis enhanced the results with additional empirical insights, e.g., by revealing insights from longitudinal studies that investigate the challenges of RCM from an instituteal perspective (Gozman and Currie 2015). Table 40 summarizes the resulting PROBLEM STAKEHOLDERS and their respective STAKEHOLDER NEEDS. While the needs of the first four PROBLEM STAKEHOLDER groups were validated with representatives of them, the RCO Team could only anticipate the needs of the last group identified as they were not able to elicit their needs. However, the STAKEHOLDER NEEDS of the Financial Supervisory Authorities were stated by several participants of the focus group and interviewees.

TABLE 40. STAKEHOLDERS AND THEIR RESPECTIVE STAKEHOLDER NEEDS TOWARDS RCO

PROBLEM STAKEHOLDER	**STAKEHOLDER NEEDS**
Financial Institutes	➢ integration of isolated compliance programs using an integrated data model for a holistic RCM program ➢ use a reference that builds from best practices to implement obscure legal texts into organizational structures ➢ be more resilient regarding regulatory dynamics ➢ mitigate risks (e.g., fraud, regulatory penalties)
Independent Software Vendors (ISVs)	➢ improve understanding of practical knowledge from financial institutes (which are most ISVs' primary customers) ➢ identify new business opportunities ➢ understand customer needs induced by regulatory requirements ➢ use a reference data model for IT product development ➢ improve interfaces of IT products

PROBLEM STAKEHOLDER	STAKEHOLDER NEEDS
Business/IT Consultancies	➢ consult institutes based on empirical research ➢ use a structured approach to assess an institute's current state in RCM and derive migration paths ➢ to systematically understand the consequences of regulatory dynamics ➢ to make expert knowledge explicit and transfer it among the personnel
Accountancy Firms	➢ to use a standardized approach for auditing compliance programs of financial institutes ➢ to systematically understand the consequences of regulatory dynamics
Financial Supervisory Authorities (anticipated)	➢ *define a standard that represents the necessary knowledge to implement regulatory requirements in an integrated model*

STEP 1D: OBJECTIVES OF THE RCO. Informed by the results of the previous steps, the RCO Team derived the overall REA OBJECTIVE that guided the RCO development.

REA OBJECTIVE OF RCO: DEVELOPMENT OF A RM FOR IT-BASED COMPLIANCE IN FINANCIAL INDUSTRIES THAT SUPPORTS ORGANIZATIONAL AND TECHNOLOGICAL IMPLEMENTATION OF REGULATORY COMPLIANCE AND BUILDS ON PRACTICAL KNOWLEDGE.

The RCO OBJECTIVE was translated into a list of REA REQUIREMENTS. Therefore, the RCO TEAM used three instruments: several focus group meetings, interview studies with banking federations as well as financial institutes, and a literature analysis. Each of these activities resulted in a list of RCO REQUIREMENTS. The RCO TEAM consolidated them to an initial requirements list, which was validated by further focus group meetings. That resulted in a final list of five requirements. Table 41 illustrates each requirement's source and defines its type. Therefore, the RCO TEAM used the types of requirements defined by Johannesson and Perjons (2014), who distinguish between functional, environmental, and structural requirements.

TABLE 41. CONSOLIDATED LIST OF RCO REQUIREMENTS

#	REQ DESCRIPTION	SOURCE	REQUIREMENT TYPE
REQ1	RCO must reveal interrelations among RCM processes, data structures, and IT systems.	Focus Group, Interview Studies, Literature Analysis	Functional
REQ2	RCO needs to combine regulatory requirements with knowledge from their actual practical implementations.	Focus Group, Interview Studies, Literature Analysis	Functional
REQ3	RCO has to be representative of the German legal sphere regarding financial regulations.	Focus Group	environmental (generality)
REQ4	The application contexts of the RCO needs to be investigated.	Focus Group, Interview Studies	environmental (usability, customizability)
REQ5	The RCO model has to provide a logical and consistent structure. Its content has to correspond with regulatory requirements.	Focus Group	Structural (consistence), environmental (correctness)

STEP 1E: SET UP THE RCO DEVELOPMENT TEAM. As described in section 4.1.2, the RCO project was initiated by the working group "financial compliance services" of the German IT-association *bitkom*. After identifying the need for an RCO, the working group convened the RCO TEAM. This team consisted of members with both a scientific and domain-related background. Table 42 enumerates the different members according to their roles and links them to their responsibilities and necessary skills stated above in section 6.4.2.2.

TABLE 42. RCO TEAM AND RELATED SKILLS

<table>
<tr><th colspan="2">RCO TEAM MEMBERS</th><th>RESPONSIBILITIES</th><th>RELATED SKILLS</th></tr>
<tr><td colspan="2">Organizational Project Leader</td><td>Project Organization</td><td>● project management skills
● professional network to financial institutes, banking federations, regulatory bodies, and other PROBLEM STAKEHOLDERS</td></tr>
<tr><td colspan="2">Technical Project Leader</td><td>Project Success</td><td>● expert knowledge of the PROBLEM DOMAIN
● experience in financial compliance projects
● professional network to financial institutes, banking federations, regulatory bodies, and other PROBLEM STAKEHOLDERS</td></tr>
<tr><td rowspan="4">Project Staff</td><td>Project Employee #1</td><td>Technical Lead of Work Packages,
Quality Management</td><td>● expert knowledge of the PROBLEM DOMAIN
● experience in financial compliance projects
● domain-specific background</td></tr>
<tr><td>Project Employee #2</td><td>Scientific Rigor</td><td>● long-term experience and expertise in conducting enterprise modeling projects
● expertise and experience in EAM domain
● scientific background</td></tr>
<tr><td>Project Employee #3</td><td>RCO Development</td><td>● expertise and experience in EAM domain
● experience in conducting enterprise modeling and elicitation techniques for enterprise modeling
● scientific background</td></tr>
<tr><td>Project Employee #4</td><td>Empirical Studies,
Project Communication</td><td>● expertise and experience in conducting qualitative research
● expertise in research communications</td></tr>
<tr><td colspan="2">Focus Group (ISVs for Compliance Software and Consulting)</td><td>Feedback</td><td>● expert knowledge of the PROBLEM DOMAIN
● expertise and professional networks to clients from financial domain</td></tr>
</table>

6.4.3.2 COMPONENT 2: SETTING RCO CONSTRUCTION STRATEGY

STEP 2A: APPLICATION SCENARIOS OF THE RCO. Once the RCO TEAM was set up, and RCO's scope had been determined, potential APPLICATION SCENARIOS were defined. These scenarios were defined in a multi-stage process. First, the RCO TEAM identified possible usage scenarios during meetings with the focus group during the first phase of REAM application. Second, while conducting the construction phase of REAM, direct contact with PROBLEM STAKEHOLDERS enabled the RCO TEAM to validate and extend the list of anticipated APPLICATION SCENARIOS. In concrete, the following activities contributed to this:

- At the end of conducting telephone interviews for eliciting practical knowledge, the interviewed compliance officers were asked regarding their expectations towards a RM for RCM
- During the validation of the different RCO versions, the RCO TEAM conducted validation workshops with seven ISVs, who are PROBLEM STAKEHOLDERS of the RCO themselves. Thus, the ideas and expectations were verified and extended after they got to know the RCO in more detail.
- After finishing the RCO construction, the RCO TEAM applied the RCO in two independent application pilots. This activity validated utilized application scenarios as well as identified new ones.

Table 43 summarized the list of RCO APPLICATION SCENARIOS and relates them to addressed PROBLEM STAKEHOLDERS as well as RCO VALUES they aim to realize.

In line with Vom Brocke (2006), the RCO TEAM discussed which ADJUSTMENT MECHANISMS to use for its application. The team decided to use the principles of aggregation and specialization. The different regulatory domains (e.g., AML) can be applied as modules or be aggregated in order to utilize synergy effects when expanding the model scope (aggregation). Moreover, the RCO does not intend to cover the plethora of enterprise specifics for a single RCO user. Thus, the model documents, where users have to specialize in certain aspects, such as specific processes or application landscapes (specialization). Next to these design principles, the RCO user most likely will require adjustments. The RCO TEAM did not consider during the construction (compositional adjustments).

TABLE 43. APPLICATION SCENARIOS OF THE RCO

RCO APPLICATION SCENARIOS	PROBLEM STAKEHOLDERS	RCO VALUE
GAP Analysis with Individual Models	Financial institute	• risk mitigation • RCM quality improvement
Building/ Extending a coherent RCM	Financial institute	• cost and time reduction • risk mitigation • RCM quality improvement
Improvement/ Development of Compliance Software	ISVs	• decrease of development time • product quality improvement
Analysis of new regulations	Financial institute, ISV, consultancy, auditing	• decrease time of implementation • improve integration quality
Personnel Training	institutes, ISV, consultancies, auditing	• knowledge transfer • risk mitigation

STEP 2B: FOCUS POINTS OF THE RCO. At this stage of the RCO project, the RCO Team defined following FOCUS POINTS of the RCO in consultation with members of the focus group:

- ❖ **RCO FOCUS POINT 1: DEVELOP A DATA-CENTRIC RCO.** While there was a consensus to develop an EA model to enable holistic RCM, the project team identified that an integrated data model of compliance processes is at the core of a successful integration of isolated compliance solutions. Thus, a specific focus lied on the data layer of the envision RCO.
- ❖ **RCO FOCUS POINT 2: USE VIEWPOINTS THAT MAKE USE OF PATTERNS KNOWN IN RCM.** Regarding the representation of the RCO model, the RCO TEAM agreed to make use of a twofold approach. While using standard viewpoints aimed to ensure model completeness from a technical EAM stance, a final RCO model shall comprise viewpoints, whose visualization reuses patterns known to potential RCO user. As an example, domain experts hinted at the Three Lines of Defense Model (Davies and Zhivitskaya 2018), which distinguishes between mitigating risk activities at the front office, the back office, and processes for internal auditing.
- ❖ **RCO FOCUS POINT 3: PROVIDE INTEGRATED AND MODULAR PERSPECTIVES.** In order to make the integrated RCM approach transparent while guaranteeing RCO's extendibility, the RCO Team decided to structure the model using modules. While each module shall represent a specific RCM topic (e.g., AML or KYC), the RCO shall further provide an overall perspective that represents an integrated view on the components of a holistic RCM.

STEP 2C: RELATED WORK FOR THE RCO. At the beginning of the project, the RCO TEAM conducted two activities to identify available knowledge that can be reused for developing an RCO:

(i) literature analysis: the approach and results of the literature analysis are documented in section 4.1.2.3
(ii) Interviews with domain experts

While (i) aimed to identify peer-reviewed research in the PROBLEM DOMAIN (which may include reference models or empirical knowledge), activity (ii) intended to identify known industry standards or taxonomies. Neither of both activities revealed knowledge that would contribute to the RCO development significantly. That was to no surprise to the RCO TEAM as experts stressed the absence of such an endeavor beforehand. However, the literature analysis supported the following conclusions, which further confirmed the project's raison d'être:

- the need to include practical knowledge from financial institutes in RCM solutions (Abdullah et al. 2010; Akhigbe et al. 2015);
- a more holistic approach for RCM realization (Cleven and Winter 2009);

- the need for RMs that support the implementation of such a solution (Akhigbe et al. 2015; Cleven and Winter 2009); and
- more transparency on sufficient IT support in RCM scenarios (Abdullah et al. 2010).

Furthermore, the team identified a reference architecture in the financial domain that is relevant to mention at this point—BIAN. The Banking Industry Network (BIAN) service landscape provides a semantic landscape for IT services in the financial domain (BIAN 2019). Although it identifies RCM as a vital business capability, it lacks guiding how to realize it. The domain experts agreed that there exists no standardization effort for RCM neither on the national nor international level.

As a result, the RCO TEAM identified following ELICITATION NEEDS and REUSABLE KNOWLEDGE for the RCO:

❖ REUSABLE KNOWLEDGE: BIAN Standard
❖ ELICITATION NEEDS: practical knowledge for RCM solutions, holistic RM for IT support in RCM

Since **STEP 2D** summarizes the results of COMPONENT 1 and COMPONENT 2 in the REA PORTFOLIO, this paragraph does not reiterate the results presented above.

6.5 PHASE (B): REA CONSTRUCTION

The primary purpose of Phase (B) is to construct the REA based on the REA PORTFOLIO provided by the components from PHASE (A). Therefore, it pursues the following objectives:

(i) to set up a framework and technical environment for REA development
(ii) to define an overall structure of the REA
(iii) to deductively or inductively elicit relevant knowledge for the REA
(iv) to construct the REA model and document it

Due to these objectives, PHASE (B) consists of time-consuming activities represented by five method components. The sequence flow of conducting PHASE (B) depends on each REA project' scope. COMPONENT 3, COMPONENT 4, and COMPONENT 7 are mandatory. For eliciting relevant knowledge, REAM defines COMPONENT 5 for deductive reasoning and COMPONENT 6 for inductive reasoning. While REAM recommends to use both in order to benefit from both approaches advantages (cf. chapter III), it might be appropriate to use only either deduction or induction in some cases. This methodological choice depends on several aspects:

- the REA OBJECTIVE and related REA REQUIREMENTS elaborated in PHASE (A)
- the ELICITATION NEEDS and REUSABLE KNOWLEDGE identified in PHASE (A)
- the APPLICATION SCENARIOS identified in PHASE (A)
- access and availability to commonly accepted domain-specific knowledge
- access and availability to practical knowledge of PROBLEM STAKEHOLDERS
- time and cost considerations

While deductive RM is beneficial to identify commonly accepted knowledge and to provide a more comprehensive REA MODEL from a high-level perspective, inductive RM enables the user to provide more detail as it uses practical knowledge. If a PHASE (A) identified the need to provide detailed knowledge from the PROBLEM DOMAIN that is not already available in the community, the inductive approach of COMPONENT 6 is necessary. If there is no need to construct an REA with a high level of granularity, it might be sensible to deploy COMPONENT 5 as it is much less time-consuming and cost-intensive. In the case there already exists such an appropriate RM or standard but detailed knowledge is required, COMPONENT 6 should be applied. Otherwise, both COMPONENT 5 and COMPONENT 6 are mandatory. In general, the REA TEAM has to define the appropriate construction strategy in advance as the right choice is essential for a successful execution of PHASE (B). Therefore, it is vital to assess the project's access to relevant knowledge carriers, such as domain experts, organizations that are PROBLEM STAKEHOLDERS, or REUSABLE KNOWLEDGE.

Moreover, it might be sensible to deploy several iterations of COMPONENT 6 during PHASE (B). Inductive RM is a complicated and time-consuming task that requires much effort. Depending on the REA STRUCTURE defined in COMPONENT 4, the REA TEAM can split REA construction into parts. Each part may conduct either COMPONENT 5 or COMPONENT 6 separately. For instance, if the REA spans over multiple business functions, COMPONENT 6 may be applied for each of them iteratively or in parallel. Figure 55 illustrates these considerations in a process model where each task represents the respective method components of PHASE (B).

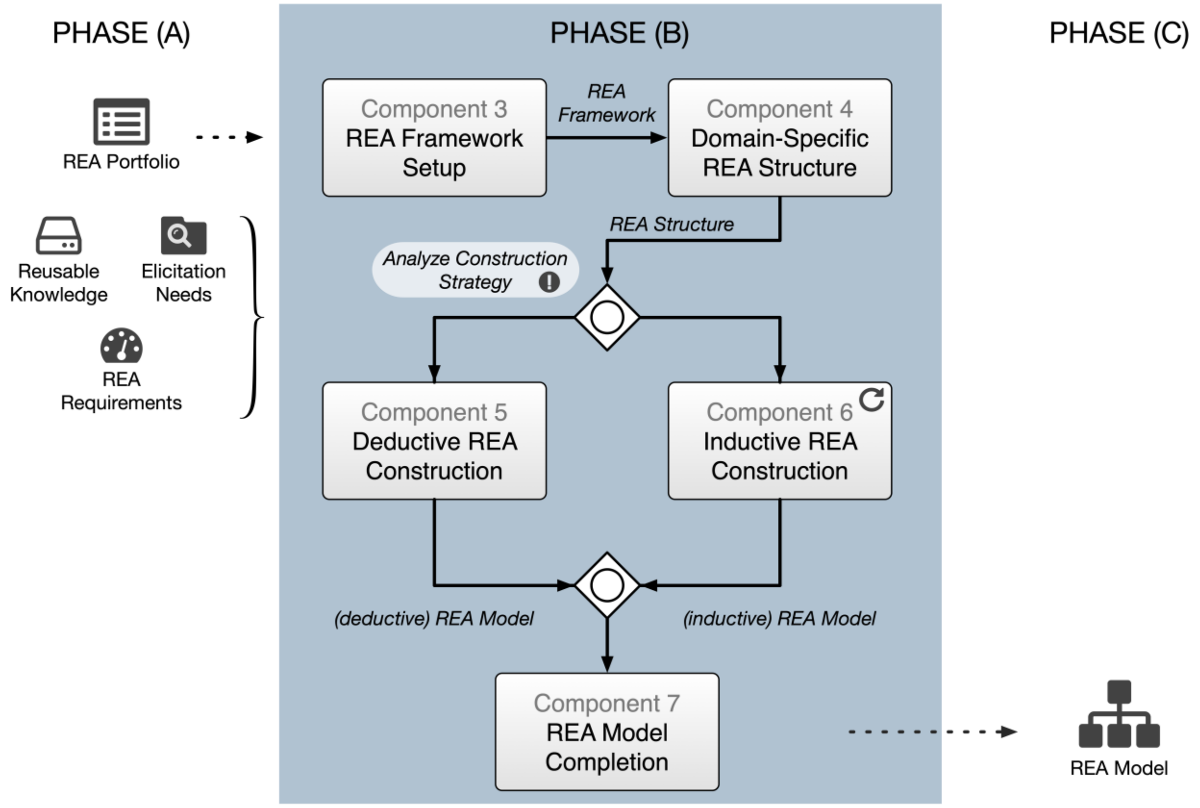


FIGURE 55. OVERVIEW ON PHASE (B) REA CONSTRUCTION

6.5.1 COMPONENT 3: REA FRAMEWORK SETUP

This component aims to agree on overall REA model design decisions. These are necessary in order to construct a model that uses a coherent set of EA techniques, such as modeling language, EA framework, or utilized tool support.

6.5.1.1 COMPONENT 3: USED CONCEPTS

Table 44 explains all concepts REAM COMPONENT 3 uses. The central input for this component is the result of the PHASE (A) PREPARATION stored in the final REA PORTFOLIO. On this basis and by consulting available EA frameworks and modeling languages, COMPONENT 3 defines the REA FRAMEWORK, which guides the remainder of PHASE (B).

TABLE 44. CONCEPTS USED IN COMPONENT 3: REA FRAMEWORK SETUP

INPUT	OUTPUT
REA PORTFOLIO	REA FRAMEWORK

6.5.1.2 COMPONENT 3: PROCEDURE AND NOTATION

Component 3 REA FRAMEWORK SETUP consists of four steps. While one can execute STEP 3A-3C in parallel, STEP 3D represents the last step of the component that finalizes the REA FRAMEWORK. Figure 56 visualizes this process.

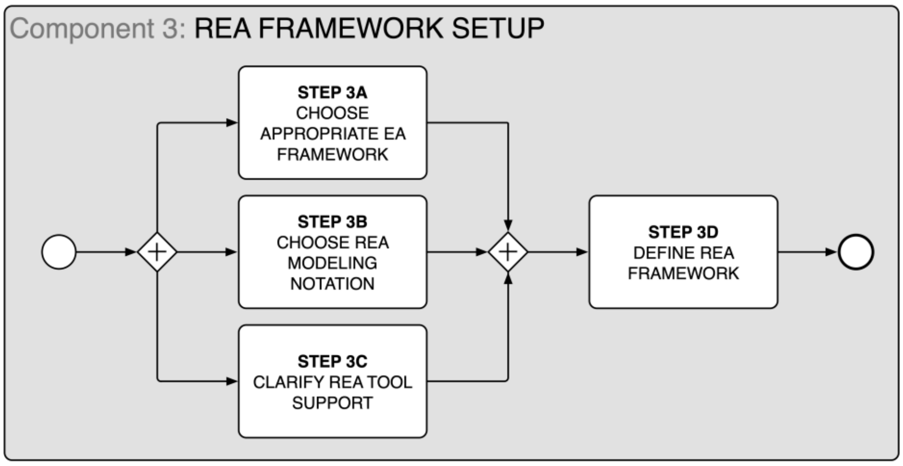


FIGURE 56. THE PROCEDURE OF METHOD COMPONENT 3: REA FRAMEWORK SETUP

STEP 3A: CHOOSE APPROPRIATE EA FRAMEWORK

INPUT: REA PORTFOLIO (from STEP 2D)

STEP DESCRIPTION: EA Frameworks provide structural guidance for describing an architectural model and identifying relevant model elements and architectural viewpoints (Lankhorst et al. 2017, p. 22). There are many different EA Frameworks available. As each of them addresses a specific purpose, STEP 3A chooses an appropriate EA framework that meets the requirements of and is appropriate for the REA endeavor. Some frameworks are industry-independent with a management purpose (e.g., TOGAF[1]), others address to governmental purposes (FEAF[2]), and others focus on technical aspects (RM-ODP[3]).

OUTPUT: REA FRAMEWORK (i.e., chosen EA Framework)

RECOMMENDED METHODS: Literature Reviews

TOOLS AND NOTATION: STEP 3A does not use any specific tools or notations.

STEP 3B: DEFINE REA MODELING NOTATION

INPUT: REA PORTFOLIO (from STEP 2D)

STEP DESCRIPTION: STEP 3B chooses the modeling language(s) used for modeling the REA. While EA Frameworks consider the structure of the REA, an appropriate modeling language is important to represent the information contained within the REA consistently.

[1] The Open Group Framework, https://www.opengroup.org/togaf
[2] Federal Enterprise Architecture Framework
[3] RM for Open Distributed Processing

OUTPUT: REA FRAMEWORK (i.e., chosen EA modeling language)

RECOMMENDED METHODS: STEP 3B does not use any specific methods.

TOOLS AND NOTATION: STEP 3B does not use any specific tools or notations.

STEP 3C: CLARIFY REA TOOL SUPPORT

INPUT: REA PORTFOLIO (from STEP 2D)

STEP DESCRIPTION: STEP 3C chooses the tool support used for modeling the REA. Since there exists a considerably high amount of possible tools on the market, this should be an informed choice. Next to commercial applications, some open-source tools exist as well, i.e., Archi[1]. While the tool selection is a project-specific tasks, some general aspects can guide that decision. The work by Schekkerman (2011) provides central aspects to consider when choosing an appropriate modeling tool. The following list summarizes further aspects the author identified during REAM development:

- Does the tool support chosen EA Frameworks and modeling language?
- How will the REA be modeling in terms of collaboration? Is it necessary to use a central repository?
- Does the tool support interoperability with solutions often used by REA STAKEHOLDERS?
- What reports of the REA MODEL will be necessary from both a construction process and an application perspective?

OUTPUT: REA FRAMEWORK (i.e., chosen modeling tool)

RECOMMENDED METHODS: STEP 3C does not use any specific methods.

TOOLS AND NOTATION: STEP 3C does not use any specific tools or notations.

STEP 3D: DEFINE REA FRAMEWORK

INPUT: REA PORTFOLIO (from STEP 2D), REA FRAMEWORK (from STEPS 3A-3B)

STEP DESCRIPTION: Based on the results of three prior STEP 3A – 3C, STEP 3D defines the REA FRAMEWORK. Using the result of PHASE (A), the following aspects need to be considered and documented:

- ➢ On what EA layers shall the REA focus? (REA FOCUS POINTS, REA REQUIREMENTS)
- ➢ Are all aspects represented by the chosen EA Framework and modeling language, or is it necessary to adjust them? (REA FOCUS POINTS, REA REQUIREMENTS)
- ➢ What model elements are central for a complete REA? (REA FOCUS POINTS, REA REQUIREMENTS)
- ➢ Is it necessary to train REA TEAM members for using the modeling language?

As a result, the REA TEAM shall define a project-specific meta-model based on the chosen modeling language, if the respective language allows it. For instance, ArchiMate does not restrict users to utilize all of the model elements. Often, elements such as application interface or business collaboration may not be used (Wierda 2017). Consequently, the decisions regarding the questions mentioned above can result in an adjusted meta-model of the modeling language. If so, this shall be clarified and documented.

[1] https://www.archimatetool.com/, supports ArchiMate Modeling Language

OUTPUT: REA FRAMEWORK

RECOMMENDED METHODS: STEP 3D does not use any specific methods.

TOOLS AND NOTATION: STEP 3D does not use any specific tools or notations. However, if the meta-model of the chosen EA modeling language is adjusted, this shall be documented.

GUIDELINES FOR COMPONENT 3 REA FRAMEWORK SETUP

STEP 3A

- ✓ FOR EVALUATING AVAILABLE EA FRAMEWORKS, BUI (2017) DEFINES EIGHT ESSENTIAL ELEMENTS AND IDENTIFIES THREE IDEAL TYPES OF FRAMEWORKS—TECHNICAL, OPERATIONAL, AND STRATEGIC EA FRAMEWORKS. REAM RECOMMENDS TO USE THIS DISTINCTION AS A STARTING POINT, IF THERE IS NO CLARITY REGARDING WHAT FRAMEWORK TO USE AT THIS STAGE OF REAM APPLICATION.
- ✓ THERE EXIST LITERATURE THAT GIVES A COMPREHENSIVE OVERVIEW OF AVAILABLE EA FRAMEWORKS AND COMPARES THEM:
  - “EVALUATING ENTERPRISE ARCHITECTURE FRAMEWORKS USING ESSENTIAL ELEMENTS” (BUI 2017)
  - “EA FRAMEWORK KOMPENDIUM” (MATTHES 2011)
  - “HOW TO SURVIVE IN THE JUNGLE OF ENTERPRISE ARCHITECTURE FRAMEWORKS” (SCHEKKERMAN 2006)
- ✓ IN THE CASE THAT THERE IS NO EA FRAMEWORK COMPLETELY MATCHING WITH THE PURPOSE OF THE REA, CONSIDER THE ONE CLOSEST TO ITS CHARACTERISTICS BEFORE DEVELOPING A NEW ONE. NOT ONLY WOULD THE LATTER BE A TIME-CONSUMING TASK, BUT ALSO WOULD THIS RISK THE REA’S ACCEPTANCE IN THE POTENTIAL USER BASE. ONE APPROACH MIGHT BE TO USE A GENERIC EA FRAMEWORK (E.G., TOGAF), FROM MOST ESSENTIAL ELEMENTS THAT CAN BE UTILIZED FOR PROJECT-SPECIFIC PURPOSES.
- ✓ IF THERE EXISTS MORE THAN ONE CANDIDATE, CONSULT THE RESULTS OF STEP 3B AND STEP 3C FOR A DECISION.
- ✓ CHECK, WHETHER THE EA FRAMEWORK PROVIDES CERTAIN ARCHITECTURE VIEWPOINTS THAT MAY REALIZE THE FOCUS POINTS DEFINED IN STEP 2B.

STEP 3B

- ✓ IN SOME CASES, IT MIGHT BE SENSIBLE TO USE MULTIPLE MODELING LANGUAGES. AS AN EXAMPLE, A BUSINESS PROCESS MODEL COULD ACCOMPANY EA MODELING LANGUAGE AS IT CAN PROVIDE MORE DETAIL ON THE PROCESS FLOW OF AN ESSENTIAL PROCESS OF THE REA (CZARNECKI AND DIETZE 2017C).
- ✓ THE REA TEAM MEMBERS SHALL BE FAMILIAR WITH THE CHOSEN MODELING LANGUAGE.
- ✓ IF A SPECIFIC MODELING LANGUAGE ACCOMPANIES THE CHOSEN EA FRAMEWORK, IT SHALL BE CONSIDERED FIRST AS IT MOST PROBABLY TRANSLATES THE FRAMEWORK’S CONCEPTS INTO VISUALIZATION (E.G., TOGAF IS ACCOMPANIED BY ARCHIMATE).

STEP 3C

- ✓ ENSURE THAT THE CHOSEN EA MODELING TOOL SUPPORTS THE CHOSEN EA FRAMEWORK AND, MORE IMPORTANTLY, THE CHOSEN MODELING LANGUAGE.
- ✓ CHECK ONLINE ARTICLES THAT COMPARE AVAILABLE EA MODELING TOOLS. THE FOLLOWING LIST MAY HELP AS A STARTING POINT:
  - HTTPS://WWW.GARTNER.COM/REVIEWS/MARKET/ENTERPRISE-ARCHITECTURE-TOOLS[1]
  - HTTPS://WWW.CAPSTERA.COM/ENTERPRISE-ARCHITECTURE-TOOLS/[2]
- ✓ CONSIDER THE LICENSING MODELS OF THE CHOSEN TOOL.

STEP 3D

- ✓ DOCUMENT THE DECISIONS.

6.5.2 COMPONENT 4: DOMAIN-SPECIFIC REA STRUCTURE

This component's objective is to define an overall structure that guides the REA construction. Based on the prior developed and rather technical REA FRAMEWORK, a domain-specific perspective on the REA is at the core of this component. As a result, it produces an REA STRUCTURE that captures domain-specific aspects in it. That could be domain-specific business functions or roles, a high-level value-added network of considered market roles, or domain-specific standards (for data exchange, or reference models).

[1] accessed 09/01/20
[2] accessed 09/01/20

6.5.2.1 COMPONENT 4: USED CONCEPTS

Table 45 explains all concepts REAM COMPONENT 4 uses. The central inputs are the PROBLEM DOMAIN, REA FOCUS POINTS from PHASE (A) PREPARATION, and the REA FRAMEWORK developed during Component 3 of this phase. While the former two serve to identify relevant domain-specific structural requirements towards the REA model, the latter is then deployed together with the previously gathered knowledge to produce the REA STRUCTURE. Likewise, an initial REA MODEL emerges from these activities. Beforehand, the component uses domain-specific knowledge furthermore to define a DOMAIN GLOSSARY that encompasses all naming conventions necessary.

TABLE 45. CONCEPTS USED IN COMPONENT 4: DOMAIN-SPECIFIC REA STRUCTURE

INPUT	OUTPUT
PROBLEM DOMAIN	DOMAIN GLOSSARY
REA FRAMEWORK	REA STRUCTURE
REA FOCUS POINTS	(initial) REA MODEL

6.5.2.2 COMPONENT 4: PROCEDURE AND NOTATION

COMPONENT 4 consists of three steps. Figure 57 visualizes their sequential execution. Each of the three steps is mandatory when applying REAM. STEP 4C might trigger another iteration of STEP 4B if the evaluation identified the flaws of the REA STRUCTURE.

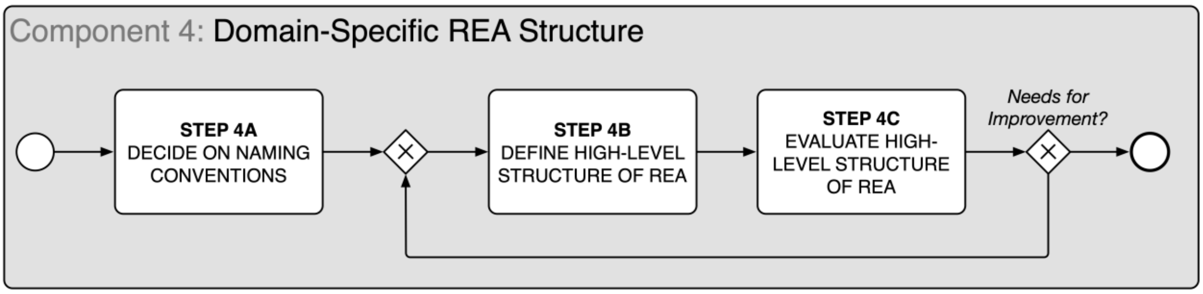


FIGURE 57. PROCEDURE OF METHOD COMPONENT 4: DOMAIN-SPECIFIC REA STRUCTURE

STEP 4A: DECIDE ON NAMING CONVENTIONS

INPUT: PROBLEM DOMAIN (from STEP 1B)

STEP DESCRIPTION: STEP 4A aims to establish domain-specific naming conventions. To do so, REAM recommends method users to develop a DOMAIN GLOSSARY, which stores domain-specific knowledge in a central document. It shall consist of domain-specific concepts and their explanation. It provides a basis for all members of the REA TEAM to use the same terms of concepts during REA construction in order to ensure a coherent content of the REA. Further, REAM intends to use the glossary as a reference that helps to understand these concepts. Often, there already exists relevant knowledge for developing the DOMAIN GLOSSARY (e.g., other glossaries, taxonomies, or systemizations). The following actions help to develop the glossary:

- search for taxonomies or systemizations in the PROBLEM DOMAIN
- consult domain experts
- identify essential concepts in the PROBLEM DOMAIN
- develop a DOMAIN GLOSSARY (if necessary)

Although developed in advance of the REA construction, it is important to continuously maintain the DOMAIN GLOSSARY as new knowledge emerges throughout the complete REAM execution. As an example, during the E-Energy project, a domain-specific glossary was developed. It is accessible online[1] and defines each concept using a predefined set of data item, e.g., description and regulative reference.

OUTPUT: DOMAIN GLOSSARY

RECOMMENDED METHODS: Literature Review, Expert Interview, Focus Group, Document Analysis

TOOLS AND NOTATION: STEP 4A does not mandate to use any specific tools or notations. However, it is advisable to store the respective information in a central document or system. Further, stakeholders shall be able to access it, and a particular group may need to be able to maintain it collaboratively. Thus, during the REA project, the glossary may evolve from a single tabular representation to a more sophisticated internet directory.

STEP 4B: DEFINE HIGH-LEVEL STRUCTURE OF REA

INPUT: REA FOCUS POINTS (from STEP 2B), REA FRAMEWORK (from STEP 3C)

STEP DESCRIPTION: STEP 4B aims to define an REA STRUCTURE based on the previously developed REA FRAMEWORK and the domain-specific aspects captured by the REA FOCUS POINTS. The REA STRUCTURE guides the remainder of PHASE (B) when the knowledge is elicited by COMPONENT 5 and COMPONENT 6 and when the REA model is completed by COMPONENT 7. Consequently, the initial REA STRUCTURE might be under constant review during the construction process. Looking at the reasoning process behind STEP 4B, COMPONENT 4 relates to deductive reasoning. Thus, it represents the first activity of deductive RM.

In order to define the REA STRUCTURE, REAM suggests to define a REA STRUCTURE based on the viewpoint concept (see chapter III). Therefore, the REA TEAM shall conduct the following activities:

1. Define concerns the REA shall address (→ REA FOCUS POINTS)

The REA FOCUS POINTS defined in PHASE (A) represent domain-specific requirements that shall be addressed by the REA MODEL. Taking an EA domain standpoint, they represent particular concerns towards the REA derived from the PROBLEM DOMAIN. While EA models tend to be too complex to be comprehensible using a single visualization, most EA frameworks define viewpoints. A viewpoint is the projection of certain aspects from the REA model that help fulfilling a (set of) concerns. Since REAs are reuse-driven, REAM defines the definition of these concerns as a starting point for defining the REA STRUCTURE. As a result, this activity produces a list of concerns towards the REA.

2. Define a Viewpoint Structure based on these concerns

Based on the identified concerns, STEP 4B defines architecture viewpoints that address for each of them. Therefore, REAM suggests to use two different perspectives when defining them:

a. EA based structure (vertical REA STRUCTURE): The vertical REA STRUCTURE systematizes the EA layers and elements addressed by the REA. Most EA modeling languages and frameworks provide predefined standard viewpoints that relate to different EA layers, EA elements, and their interrelations (The Open Group 2017). These help to structure the REA based on the EA layers

[1] https://teamwork.dke.de/specials/7/Wiki-Seiten/Homepage.aspx, accessed 14/01/20

provided by the chosen EA framework while ensuring to cover relevant aspects defined in the REA FRAMEWORK (e.g., what EA layers/elements to focus on or exclude).

b. Domain-Based structure (horizontal REA STRUCTURE): Next to the viewpoints that structure the REA based on EA layers/elements covered, REAM recommends to structure the REA from a domain-specific perspective. For instance, the REA may span over different topic. That could be different business domains, regulatory topics, or business processes.

Figure 58 illustrates the integration of these two perspectives and uses the three EA layers as defined by ArchiMate[1]. As this is an important step that intends to filter the essential knowledge represented by the REA, the REA STRUCTURE shall rely on different sources. Thus, STEP 4B may use different qualitative research methods.

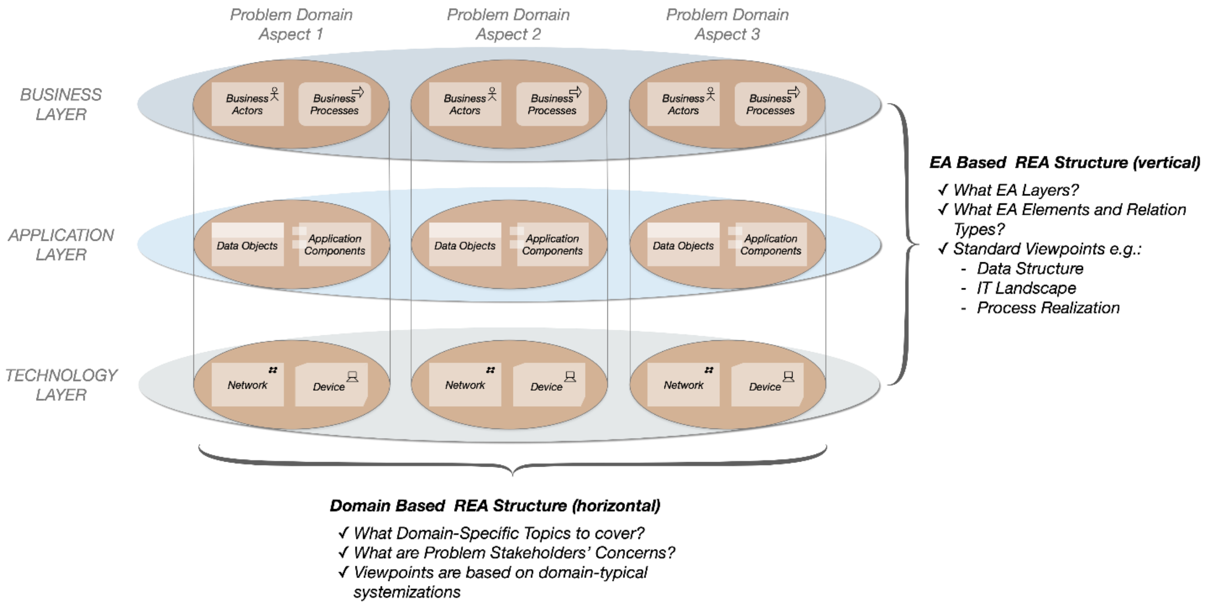


FIGURE 58. DEFINE AN REA STRUCTURE USING A HORIZONTAL AND VERTICAL PERSPECTIVE

3. Document Viewpoints and their purpose

Once the concerns and viewpoints are defined, they shall be documented. Since the REA STRUCTURE may evolve during the remainder of the REA project, it is vital to keep track of the changes regarding the REA STRUCTURE. Each viewpoint shall be labeled, provide a clear description of its purpose, and relate to the (set of) concerns it addresses.

4. Set up an (initial) REA MODEL

Instantiate the REA Structure in an REA Model employing it in the chosen modeling language in the EA tool. Each viewpoint shall be instantiated in the REA MODEL. REAM recommends providing an overview viewpoint that puts all viewpoints into the context of the PROBLEM DOMAIN.

OUTPUT: REA STRUCTURE, (initial) REA MODEL

RECOMMENDED METHODS: Focus Group, Survey, Participative Enterprise Modeling with PROBLEM STAKEHOLDERS (Stirna et al. 2007)

TOOLS AND NOTATION: REA MODEL in chosen modeling language, Documentation of Viewpoints

[1] https://pubs.opengroup.org/architecture/archimate3-doc/chap03.html#_Toc10045293, accessed 06/02/20

STEP 4C: EVALUATE HIGH-LEVEL STRUCTURE OF REA

INPUT: REA STRUCTURE (from STEP 4B)

STEP DESCRIPTION: STEP 4C intends to ensure that the REA STRUCTURE covers all aspects of the PROBLEM DOMAIN, that is correct and complete. Therefore, it is essential to evaluate it together with domain experts and DOMAIN STAKEHOLDER (preferably with people not involved during STEP 4B). Therefore, REAM suggests to investigate the following questions regarding the REA STRUCTURE and the (initial) REA MODEL:

- ✓ Does the (vertical) REA Structure cover all necessary EA layers?
- ✓ Does the REA STRUCTURE cover all concerns?
- ✓ Does the (horizontal) REA STRUCTURE cover all aspects relevant in the PROBLEM DOMAIN?
- ✓ Does the REA STRUCTURE represent the REA FOCUS POINTS?

OUTPUT: (evaluated) REA STRUCTURE

RECOMMENDED METHODS: Expert Interviews, Survey

TOOLS AND NOTATION: Document the flaws and needs for change of the REA STRUCTURE.

GUIDELINES FOR COMPONENT 4 DOMAIN-SPECIFIC REA STRUCTURE

STEP 4A

- ✓ DEPENDING ON THE REA TEAM SIZE, REAM RECOMMENDS TO MAINTAIN THE DOMAIN GLOSSARY COLLABORATIVELY.
- ✓ FOR COLLECTING DOMAIN-SPECIFIC KNOWLEDGE THAT CONTAINS DOMAIN CONCEPTS FOR THE GLOSSARY USE:
  - EXPERT KNOWLEDGE FROM DIFFERENT PROBLEM STAKEHOLDERS
  - RESEARCH LITERATURE
  - DOMAIN-SPECIFIC WHITE PAPERS (E.G., STUDIES CONDUCTED BY CONSULTANCIES)
- ✓ UPDATE THE DOMAIN GLOSSARY THROUGHOUT THE REA PROJECT

STEP 4B

- ✓ AVOID TO LET STANDARD EA VIEWPOINTS DICTATING THE REA STRUCTURE, AS IT SHALL BE DOMAIN-FOCUSED. INSTEAD, DOMAIN-SPECIFIC KNOWLEDGE (SYSTEMATIZATIONS, TAXONOMIES) SHALL BE AT THE CORE OF THE REA STRUCTURE. HOWEVER, STANDARD VIEWPOINTS, SUCH AS THE ONES FROM ARCHIMATE, MAY HELP TO FIND A STARTING POINT.

STEP 4C

- ✓ CLARIFY THE REA'S SCOPE AND EXPLAIN THE REA STRUCTURE TO PARTICIPANTS BEFORE THE EVALUATION.

6.5.3 COMPONENT 5: DEDUCTIVE REA CONSTRUCTION

The objective of this component is to elicit commonly accepted knowledge that is relevant to the scope of the REA. Based on the prior developed REA STRUCTURE, COMPONENT 5 fills the REA with knowledge using deductive RM techniques. The main challenge here is to identify the right knowledge sources, such as research literature, domain experts, and practitioners.

6.5.3.1 COMPONENT 5: USED CONCEPTS

Table 46 explains all concepts REAM COMPONENT 5 uses. The central inputs are the PROBLEM DOMAIN, REUSABLE KNOWLEDGE and ELICITATION NEEDS from PHASE (A) PREPARATION, the REA FRAMEWORK from Component 3, and the REA STRUCTURE from Component 4. On this basis, COMPONENT 5 produces several outputs. First, especially the REUSABLE KNOWLEDGE and ELICITATION NEEDS, determine the DEDUCTIVE KNOWLEDGE BASE and what further knowledge needs to be gathered for the REA. Second, elicited knowledge is then integrated into a (deductive) REA MODEL using the predefined REA STRUCTURE.

TABLE 46. CONCEPTS USED IN COMPONENT 5: DEDUCTIVE REA CONSTRUCTION

INPUT	OUTPUT
PROBLEM DOMAIN	DEDUCTIVE KNOWLEDGE BASE
REUSABLE KNOWLEDGE	
ELICITATION NEEDS	
REA FRAMEWORK	
REA STRUCTURE	(deductive) REA MODEL
(initial) REA MODEL	
DOMAIN GLOSSARY	
REA REQUIREMENTS	

6.5.3.2 COMPONENT 5: PROCEDURE AND NOTATION

Component 5 consists of four steps. Either one or both of Step 5a and Step 5b are executed in parallel as they identify and elicit Domain Knowledge. This decision depends on the input from Phase (A). If Step 2c identified Reusable Knowledge, Step 5a is mandatory. Further, Step 5b is mandatory, if (some of) the Elicitation Needs can be satisfied by the knowledge available in terms of domain experts' and Problem Stakeholders' expertise. Then, Step 5c and Step 5d are mandatory as represented in Figure 59. Step 5d might trigger another iteration of Step 5c if the evaluation identified flaws of the REA MODEL.

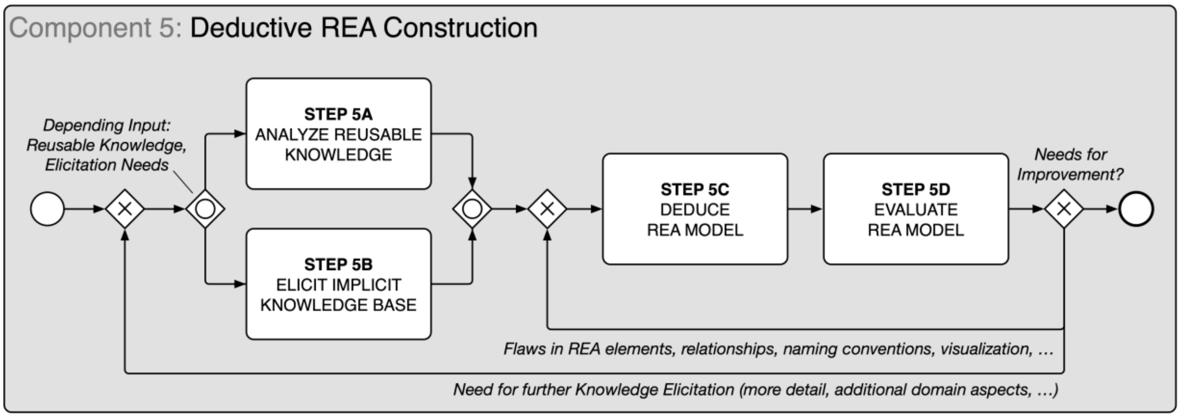


FIGURE 59. THE PROCEDURE OF METHOD COMPONENT 5: DEDUCTIVE REA CONSTRUCTION

STEP 5A: ANALYZE REUSABLE KNOWLEDGE

INPUT: PROBLEM DOMAIN (from STEP 1B), REUSABLE KNOWLEDGE (from STEP 2C), REA STRUCTURE (from STEP 4C)

STEP DESCRIPTION: STEP 5A analyzes the previously identified REUSABLE KNOWLEDGE regarding the value it provides for the REA. It filters that knowledge by identifying its contribution to the viewpoints of the REA STRUCTURE. Furthermore, the REA Team may repeat the activities of STEP 2C. That may be the case if the team recognizes that the meanwhile improved understanding of the REA's content requires a new investigation for related work. For instance, search queries domain-specific content is understood better. Again, there are different forms of REUSABLE KNOWLEDGE:

- Academic Research that is related to the REA Scope
- Regulatory Texts
- Industrial Standards
- Existing Reference Models
- Documentation of "Top of the Bread" IT solutions
- Industry White Papers

OUTPUT: DEDUCTIVE KNOWLEDGE BASE

RECOMMENDED METHODS: Document Analysis (Online), Literature Review, Expert Interviews, Focus Group

TOOLS AND NOTATION: STEP 5A does not use any specific tools or notations. However, gathered information shall be stored systematically (e.g., using templates in word processing or spreadsheet files).

STEP 5B: ELICIT IMPLICIT KNOWLEDGE BASE

INPUT: PROBLEM DOMAIN (from STEP 1B), ELICITATION NEEDS (from STEP 2C), REA STRUCTURE (from STEP 4C)

STEP DESCRIPTION: While the STEP 5A focused on generally accepted knowledge that is explicit and already available, STEP 5B aims to identify knowledge, which may only exist implicitly in domain experts or PROBLEM STAKEHOLDERS. Based on the ELICITATION NEEDS and the insights from STEP 5A, the REA Team identifies what gaps to close and uses qualitative elicitation methods. While there exist different possible sources for such knowledge, the focus shall lie on domain experts, such as (IT) consultants, and PROBLEM STAKEHOLDERS, which STEP 1C identified earlier.

OUTPUT: DEDUCTIVE KNOWLEDGE BASE
RECOMMENDED METHODS: Participative Enterprise Modeling Workshops (Stirna et al. 2007), Focus Group, Expert Interviews

TOOLS AND NOTATION: STEP 5B does not use any specific tools or notations. However, gathered information shall be stored systematically (e.g., using templates in word processing or spreadsheet files).

STEP 5C: DEDUCE REA MODEL

INPUT: REA FRAMEWORK (from STEP 3D), REA STRUCTURE + (initial) REA MODEL (from STEP 4C), DEDUCTIVE KNOWLEDGE BASE (from STEP 5A/B), DOMAIN GLOSSARY (from STEP 4A)

STEP DESCRIPTION: STEP 5C extends the (initial) REA MODEL with the prior identified DEDUCTIVE KNOWLEDGE BASE. Therefore, it aggregates the knowledge identified in STEP 5A and STEP 5B using the REA STRUCTURE and integrates it into the (initial) REA MODEL. REAM defines the following activities while doing so:

1. Aggregate the documents that store the DEDUCTIVE KNOWLEDGE BASE from both STEP 5A and STEP 5B.
2. Identify distinct knowledge items using the terminology from the DOMAIN GLOSSARY (e.g., specific business processes, business actors, or information system components)
3. Match each item to an appropriate REA element from the REA FRAMEWORK
4. Identify interrelations among the items and relate them to relationship types from the REA FRAMEWORK
5. Relate each item to the viewpoints of the REA STRUCTURE
6. Integrate these REA model elements and relations into the existing REA STRUCTURE

OUTPUT: (deductive) REA MODEL

RECOMMENDED METHODS: STEP 5C does not require any research methods.

TOOLS AND NOTATION: REA MODEL based on the REA FRAMEWORK and REA STRUCTURE

STEP 5D: EVALUATE REA MODEL

INPUT: REA REQUIREMENTS (from STEP 1D), (deductive) REA MODEL (from STEP 5C)

STEP DESCRIPTION: STEP 5D conducts an initial evaluation of the REA MODEL that was deductively constructed. There are many ways of conducting such an evaluation. However, the REA TEAM shall focus on a limited set of aspects since the profound REA model validation is part of REAM COMPONENT 10. The driving questions for this evaluation shall be:

- ✓ Does the (deductive) REA Model represent the identified DEDUCTIVE KNOWLEDGE BASE?
- ✓ Are all (deductive) REA MODEL elements matched to the corresponding viewpoints of the REA STRUCTURE
- ✓ Does the (deductive) REA MODEL cover all relevant domain-specific topics (compare to REA OBJECTIVE, REA REQUIREMENTS)?

The results of STEP 5D might trigger the iteration of any other steps from this COMPONENT 5.

OUTPUT: (evaluated deductive) REA MODEL

RECOMMENDED METHODS: Expert Interview, Participative Enterprise Modeling (Stirna et al. 2007)

TOOLS AND NOTATION: STEP 5D does not use any specific tools or notations. However, its results may alter the (deductive) REA MODEL. Further, documenting the evaluation results is recommended.

GUIDELINES FOR COMPONENT 5 DEDUCTIVE REA CONSTRUCTION

STEP 5A
- ✓ SORT THE DEDUCTIVE KNOWLEDGE BASE USING THE REA STRUCTURE VIEWPOINTS.
- ✓ ASSESS THE REUSABLE KNOWLEDGE TOGETHER WITH DOMAIN EXPERTS AND PROBLEM STAKEHOLDERS.

STEP 5B
- ✓ BEFORE ELICITING THE KNOWLEDGE FROM THE PARTICIPANTS (I.E., THE KNOWLEDGE CARRIERS), INTRODUCE THE REA SCOPE USING THE REA PORTFOLIO AND ITS DEFINED REA STRUCTURE IN DETAIL.
- ✓ IF POSSIBLE, CONDUCT PARTICIPATIVE MODELING WORKSHOPS SINCE INTERVIEWS MAY HINDER THE PARTICIPANTS FROM GRASPING THE INTENTIONS OF THE REA ENDEAVOR COMPLETELY.
- ✓ TRY TO IDENTIFY BUILDING BLOCKS FOR EACH EA LAYER, FOR EXAMPLE:
  - o BUSINESS LAYER: BUSINESS FUNCTIONS, BUSINESS ACTORS)
  - o APPLICATION LAYER: ELICIT LANDSCAPE OF IMPORTANT IT COMPONENTS
  - o DATA LAYER: HIGH-LEVEL DATA OBJECTS (E.G., "CUSTOMER RISK PROFILE" OR “CONTRACT DETAILS”)
- ✓ STORE GATHERED KNOWLEDGE BY
  - o IDENTIFYING ITS RELATION TO THE VIEWPOINTS OF THE REA STRUCTURE AND
  - o ANTICIPATING POTENTIAL MODELING NOTATION ELEMENTS THAT REPRESENT IT

STEP 5D
- ✓ CONDUCT EVALUATION WITH SEVERAL DIFFERENT PROBLEM STAKEHOLDERS AND DOMAIN EXPERTS
- ✓ USE VARIOUS EVALUATION ROUNDS.

6.5.4 COMPONENT 6: INDUCTIVE REA CONSTRUCTION

The objective of COMPONENT 6: INDUCTIVE REA CONSTRUCTION is to elicit practical knowledge from the PROBLEM DOMAIN and analyze it regarding its contribution to the REA. The practical knowledge relates to individual EA models that represent a current state of affairs at PROBLEM STAKEHOLDERS. That results in a set of INDIVIDUAL MODELS that comply with the aspects defined by the REA STRUCTURE. Using inductive strategies, an (inductive) REA MODEL is abstracted based on the INDIVIDUAL MODEL SET.

6.5.4.1 COMPONENT 6: USED CONCEPTS

Table 47 explains all concepts REAM COMPONENT 6 uses. The central inputs are the PROBLEM STAKEHOLDERS, and ELICITATION NEEDS from PHASE (A) PREPARATION, the REA FRAMEWORK from COMPONENT 3, and the REA STRUCTURE from COMPONENT 4. On this basis, COMPONENT 6 produces several outputs. It uses the input to prepare the elicitation of practical knowledge. For this purpose, the component defines an ORGANIZATION SAMPLE to elicit from and an INDUCTIVE ELICITATION PLAN that determines the concrete mode of elicitation. Then, carrying out the elicitation produces several INDIVIDUAL MODELS—represented by the INDIVIDUAL MODEL SET. Last, an ABSTRACTION TECHNIQUE is chosen that derives an (inductive) REA MODEL from that set.

TABLE 47. CONCEPTS USED IN COMPONENT 6: INDUCTIVE REA CONSTRUCTION

INPUT	OUTPUT
PROBLEM STAKEHOLDERS	ORGANIZATION SAMPLE
REA PORTFOLIO	INDUCTIVE ELICITATION PLAN
ADJUSTMENT MECHANISMS	INDIVIDUAL MODEL
ELICITATION NEEDS	INDIVIDUAL MODEL SET
REA STRUCTURE	ABSTRACTION TECHNIQUE
REA REQUIREMENTS	(inductive) REA MODEL

6.5.4.2 COMPONENT 6: PROCEDURE AND NOTATION

Figure 60 illustrates all nine steps COMPONENT 6 consists of and their execution path. Except for STEP 6H, every step is mandatory when executing COMPONENT 6. In general, their execution is sequential. However, some steps can be applied in parallel, Figure 60 indicates. Further, the results of the evaluation in STEP 6I may trigger another iteration of previous steps. Depending on the identified needs for improvement, the evaluation could lead to an entirely new iteration of COMPONENT 6, require another collection of individual models (STEP 6D), or prompt using a different approach for abstraction the collected INDIVIDUAL MODEL SET to an REA MODEL (STEP 6G). The approach for this COMPONENT 6 primarily builds from the method for inductive RM by Fettke (2014).

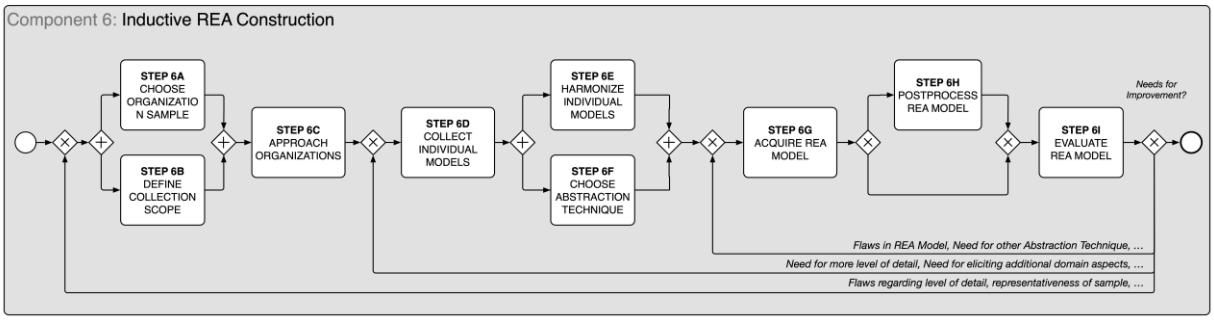


FIGURE 60. THE PROCEDURE OF METHOD COMPONENT 6: INDUCTIVE REA CONSTRUCTION

STEP 6A: CHOOSE ORGANIZATION SAMPLE

INPUT: PROBLEM STAKEHOLDERS (from STEP 1C), REA PORTFOLIO (from STEP 2D)

STEP DESCRIPTION: STEP 6A sets up the elicitation of individual models. Before STEP 6B clarifies what data to elicit from the organizations, STEP 6A determines the ORGANIZATION SAMPLE. The sample might consist of organizations that represent any of the in STEP 1C defined PROBLEM STAKEHOLDERS. However, it shall probably focus on organizations directly affected by the SPECIFIED PROBLEM in the PROBLEM DOMAIN as the REA MODEL aims to represent their structures. When defining the ORGANIZATION SAMPLE, consider the following aspects:

- ✓ What criteria exist that determine a representative ORGANIZATION SAMPLE in the PROBLEM DOMAIN? (global vs. national sample, the total number of participants for certain PROBLEM STAKEHOLDER groups)
- ✓ For each PROBLEM STAKEHOLDER group, identify potential candidates.
- ✓ Define an ORGANIZATION SAMPLE that consists of a representative group of candidates and meets the identified criteria.

The REA TEAM shall be aware of the fact that a lot of potential PROBLEM STAKEHOLDERS might refuse to participate in the study. The ORGANIZATION SAMPLE should be determined accordingly.

OUTPUT: ORGANIZATION SAMPLE

RECOMMENDED METHODS: STEP 6A does not use any specific research methods.

TOOLS AND NOTATION: STEP 6A does not use any specific tools or notations. However, REAM recommends to use a central document that represents the ORGANIZATION SAMPLE. It shall store additional information for each candidate, such as contact data.

STEP 6B: DEFINE COLLECTION SCOPE

INPUT: ADJUSTMENT MECHANISMS (from STEP 2A), ELICITATION NEEDS (from STEP 2C), REA STRUCTURE (from STEP 4C)

STEP DESCRIPTION: STEP 6B defines the INDUCTIVE ELICITATION PLAN for the elicitation process based on the above-stated inputs. The plan provides a structured approach to guide the knowledge elicitation at the respective organizations. It ensures that the gathered data is comparable and correct. Therefore, when developing the INDUCTIVE ELICITATION PLAN, consider the following aspects:

- ✓ Identify **what knowledge** to gather. What ELICITATION NEEDS are missing in the current version of the REA MODEL? Use the REA STRUCTURE in order to identify further knowledge gaps.
- ✓ Identify the necessary **level of detail** to gather. That may depend on previously defined ADJUSTMENT MECHANISMS in COMPONENT 2. As an example, if the REA MODEL shall use the configuration principle, it is necessary to agree on configuration rules and characterizations that demarcate different groups of PROBLEM STAKEHOLDERS in order to integrate them later on in the REA construction process. That is, the different organizational characteristics and rules identified. Further, similar considerations apply to the principle of instantiation since it requires different variants of generic REA Model elements.

- ✓ What are **participants from the organizations** necessary for the envisioned elicitation? Depending on the elicited knowledge, this could include IT experts, management, business consultants, process owners, or caseworkers.
- ✓ What **organizational material** might exist the organization may place at the disposal of the REA Team? For instance, the participants may provide process documentation, documentation of their IT landscapes, or structured forms that represent data objects used.
- ✓ What **elicitation method** is preferable but still feasible? Depending on the organizations' willingness, this is not easy to predict. Therefore, define a *best-case and worst-case scenario* and define means of elicitation for each. That ensures flexibility in case the organization change their minds regarding the resource they release for the elicitation. While there exist several different methods to elicit the necessary knowledge, REAM recommends the following approaches regarding both scenarios:
    a. *Best-case scenario:* REAM recommends to conduct interactive elicitation workshops that may span several days. Based on the experience of the author, most knowledge carriers are inexperienced in the terms and concepts of EAM. Thus, REAM recommends putting domain-specific business processes and functions at the center of the elicitation workshop. When elaborating on the business process, participants from the REA Team can ask the questions related to the concepts of the REA FRAMEWORK. Timm et al. (2015a) describes that approach in more detail.
    b. *Worst-case scenario:* If such time-intense elicitation workshops are not feasible, REAM recommends to conduct structured interviews with the respective participants. Therefore, STEP 6B shall develop a detailed questionnaire.
- ✓ What is the anticipated **agenda** for the elicitation? Shall all necessary knowledge be elicited in a single appointment, or is it sensible to split it into several ones? If split, REAM recommends to dedicate each appointment to a specific domain-specific topic (e.g., dominant business processes).
- ✓ What **value** does such an elicitation workshop provide for the participating organization? REAM recommends clarifying this in order to persuade potential organizations to participate. The results from COMPONENT 1 (i.e., STAKEHOLDER NEEDS) provide a basis for this.
- ✓ REAM recommends to structure the INDUCTIVE ELICITATION PLAN using the following approach:

- ✓ Define a **detailed agenda** that includes the purpose of elicitation, the topics under investigation, a list of preferred participants, and an anticipated timeline.
- ✓ Develop a **standardized questionnaire** that forms the basis for every elicitation (independent of the final elicitation method).

At the end of STEP 6B, REAM recommends evaluating the INDUCTIVE ELICITATION PLAN with several domain experts regarding its completeness and correctness.

<u>*OUTPUT:*</u> INDUCTIVE ELICITATION PLAN

<u>*RECOMMENDED METHODS:*</u> STEP 6B recommends to use methods for designing questionnaires.

<u>*TOOLS AND NOTATION:*</u> STEP 6B does not use any specific tools or notations. However, it recommends to store them in a structured document using either word processing or spreadsheet tools.

STEP 6C: APPROACH ORGANIZATIONS

INPUT: ORGANIZATION SAMPLE (from STEP 6A), INDUCTIVE ELICITATION PLAN (from STEP 6B)

STEP DESCRIPTION: STEP 6C aims to make contact with the organizations from the ORGANIZATION SAMPLE and to win organizations for the elicitation study. In order to establish correct expectations, provide the following material:

- Detailed Agenda
- Elicitation Method
- Preferred Participants
- Value for Organization and Participants

After conducting STEP 6C, it is necessary to compare the list of participating organizations against the criteria for representativity. It may be necessary to approach an extended list of potential organizations.

OUTPUT: ORGANIZATION SAMPLE

RECOMMENDED METHODS: STEP 6C does not use any specific methods.

TOOLS AND NOTATION: STEP 6C does not use any specific tools or notations.

STEP 6D: COLLECT INDIVIDUAL MODELS

INPUT: ORGANIZATION SAMPLE (from STEP 6A), INDUCTIVE ELICITATION PLAN (from STEP 6B)

STEP DESCRIPTION: STEP 6D applies the INDUCTIVE ELICITATION PLAN for each organization that participates in the elicitation study. Each elicitation round results in an INDIVIDUAL MODEL. As stated above, REAM recommends to use a process-driven interactive elicitation workshop (cf. Timm et al. (2015a). Conduct the following activities for each elicitation round:

1. Set up an individual agenda for the organization, depending on the elicitation method.
2. Conduct the elicitation round.
3. Document elicited information.
4. Examine additional material from the organization (if accessible).
5. Review and aggregate all information. Define a template
6. Develop INDIVIDUAL MODEL that uses the REA FRAMEWORK and REA STRUCTURE for the REA MODEL.
7. Evaluate INDIVIDUAL MODEL and aggregated information with participants.

OUTPUT: INDIVIDUAL MODEL, INDIVIDUAL MODEL SET

RECOMMENDED METHODS: STEP 6D may use different qualitative methods, e.g., interview study or participative enterprise modeling (Stirna et al. 2007).

TOOLS AND NOTATION: Every INDIVIDUAL MODEL shall be documented in the globally defined REA STRUCTURE using the REA FRAMEWORK (i.e., modeling language with the chosen modeling tool).

STEP 6E: HARMONIZE INDIVIDUAL MODEL

INPUT: INDIVIDUAL MODEL SET (from STEP 6D)

STEP DESCRIPTION: STEP 6E aims to prepare the collected INDIVIDUAL MODEL SET for their abstraction to the REA MODEL. Therefore, the REA TEAM needs to harmonize the INDIVIDUAL MODELS regarding the following aspects:

- *Level of Detail*. While some elicitation workshop provide much detailed information regarding certain aspects of the REA MODEL, others may result in more general knowledge and, thus, might not be useful for representing practical knowledge. In some of the latter cases, it might be sensible to eliminate those from the INDIVIDUAL MODEL SET.
- *Naming Conventions*. Different organizations may use different terms while pointing at the identical concepts. In order to avoid confusion, harmonize such differences using the DOMAIN GLOSSARY.
- *Structural Conformance.* Assess whether each INDIVIDUAL MODEL complies with the REA STRUCTURE from COMPONENT 2.

OUTPUT: (harmonized) INDIVIDUAL MODEL SET

RECOMMENDED METHODS: STEP 6E does not use any specific methods.

TOOLS AND NOTATION: STEP 6E uses the REA FRAMEWORK and REA STRUCTURE to develop the (harmonized) INDIVIDUAL MODEL SET.

STEP 6F: CHOOSE ABSTRACTION TECHNIQUE

INPUT: (harmonized) INDIVIDUAL MODEL SET (from STEP 6E)

STEP DESCRIPTION: Before generating an (inductive) REA MODEL from the INDIVIDUAL MODEL SET, STEP 6F chooses an appropriate ABSTRACTION TECHNIQUES. It defines the approach and ruleset on how to proceed when deriving an (inductive) REA MODEL from the INDIVIDUAL MODEL SET (cf. chapter III). Thus, STEP 6F analyzes the ABSTRACTION TECHNIQUES available in the body of knowledge and chooses the approach that meets the REA project's purpose. Therefore, different criteria exist. The following list provides general criteria that helps to identify appropriate ABSTRACTION TECHNIQUES (list does not claim to be complete):

- **Shall the ABSTRACTION TECHNIQUE identify *best practice or common practice*?** While the majority of available approaches aims to identify common practice, some provide means to identify best practice as well (Scholta 2016).
- **Is the ABSTRACTION TECHNIQUE restricted to *specific model structures*?** The majority of approaches are developed for business process models (e.g., event-driven process chains) or based on graph structures. Thus, STEP 6F needs to identify an approach that either applies to the REA modeling language chosen in COMPONENT 3 or is adjustable to it.
- **Does the ABSTRACTION TECHNIQUE provide a running implementation that is available?** Some approaches are only documented in pseudo-code, while others provide an implementation in open-source software (Ardalani et al. 2013).
- **Is the ABSTRACTION TECHNIQUE adequately documented?** That assesses an approach's quality in documentation. As an example, we understand a documentation to be of high quality, if authors provide appropriate pseudo-code, define precise value ranges, and describe specific calculations in detail. Especially when adapting the technique to other model structures, this criterion is essential.

Table 48 enlists articles that provide ABSTRACTION TECHNIQUES, which the author identifies applicable to EA structures. To provide a first overview of the approaches, it further analyzes them regarding the above stated general criteria. The list emerged during research published in Timm et al. (2018b). There, one can find a more detailed analysis of even more abstraction approaches. Further, it provides detailed examples for applying them to EA models.

TABLE 48. OVERVIEW ON ABSTRACTION TECHNIQUES FOR INDUCTIVE RM

APPROACH	TITLE	PRACTICE	MODEL STRUCTURE	IMPLEMENTATION	DOCUMENTATION
(Ardalani et al. 2013)	Towards A Minimal Cost Of Change Approach For Inductive RM Development	Common Practice	Event-Driven Process Chains (EPCs)	Prototype in *RefMod Miner*, uses graph edit distance and cost functions	Definitions, Pseudo-Code
(Fettke 2015)	Integration of process models on a large scale: Concept, method and experimental applications (translated)	Common Practice	Business Process Models, Case Study, uses Petri Nets	Prototype in *RefMod Miner*, needs EPML input, uses agglomerative clustering	Case Study, abstract explanation of steps
(La Rosa et al. 2013)	Business process model merging. An approach to business process consolidation.	Common Practice	Business Process Models abstracted to graph structures	unknown, provides merge and intersect algorithms	Definitions, Pseudo Code
(Li et al. 2009)	Discovering reference models by mining process variants using a heuristic approach	Common Practice	Business Process Models defined as activity nets	unknown, uses process mining approaches	Definitions, Pseudo Code
(Ling and Zhang 2016)	Generating hierarchical reference process model using fragments clustering	Common Practice	Business Process Models abstracted to graph structures	unknown, uses clustering algorithms	Definitions, Pseudo Code
(Martens et al. 2014)	A genetic algorithm for the inductive derivation of reference models using minimal graph-edit distance applied to real-world business process data	Common Practice	Business Process Models abstracted to graph structures	Prototype in *RefMod Miner*, uses graph edit distance and cost functions	Definitions, Pseudo Code
(Martens et al. 2015)	Inductive Development of Reference Process Models Based on Factor Analysis	Common Practice	Business Process Models abstracted to graph structures	Prototype in *RefMod Miner,* uses Clustering and Factor Analysis	Definitions, Description of Algorithm
(Scholta 2016)	Semi-automatic inductive derivation of reference process models that represent best practices in public administrations	Best Practice	not specified, example uses EPCs, uses graph structures	only Prototype, uses merging and grouping mechanisms	Description of Approach, Example Case
(Sonntag et al. 2017)	Inductive Reference Modelling Based on Simulated Social Collaboration	Common Practice	EPCs	Prototype in *RefMod Miner,* uses genetic mutation algorithm	Pseudo Code, Proof of Concept

The list is neither complete, nor have all approaches been applied to EA model structures. However, in the course of the Ph.D. project, the author used three different approaches to develop REA models inductively:

(i) In Timm and Sauer (2017), we applied the Minimal Cost of Change approach by Ardalani et al. (2013) to EA structures in order to identify a common practice REA model.
(ii) In Timm et al. (2018b), we applied the RefPa approach by Scholta (2016) to EA structures in order to identify an REA model that also provided best practice insights.
(iii) Furthermore, we used a manual approach to elicit the common practice of an INDIVIDUAL MODEL SET: First, for each REA STRUCTURE viewpoint count the frequency of identical model elements across all INDIVIDUAL MODELS. Second, define a threshold for each viewpoint that determines the minimal frequency of a model element in order to select it for the REA MODEL. Third, identify all REA model elements and their corresponding relationships to other model elements. Fourth, integrate all REA model elements and their relationships into a final REA MODEL.

OUTPUT: ABSTRACTION TECHNIQUE

RECOMMENDED METHODS: Literature Review, Software Development

TOOLS AND NOTATION: STEP 6F does not use any specific tools or notations.

STEP 6G: ACQUIRE REA MODEL

INPUT: (harmonized) INDIVIDUAL MODEL SET (from STEP 6E), ABSTRACTION TECHNIQUE (from STEP 6F)

STEP DESCRIPTION: STEP 6F applies the chosen ABSTRACTION TECHNIQUE(S) to the INDIVIDUAL MODEL SET. Thus, what concrete actions to take depends on the technique chosen. REAM identifies two modes that can be distinguished when conducting STEP 6F:

(a) acquire the REA MODEL by applying the ABSTRACTION TECHNIQUE for the complete REA STRUCTURE
(b) acquire the REA MODEL for each viewpoint of the REA STRUCTURE separately. That may be necessary if the purposes of different viewpoints require the application of different ABSTRACTION TECHNIQUES. This mode further requires to integrate the loose REA MODEL viewpoints, which in STEP 6H.

OUTPUT: (inductive) REA MODEL

RECOMMENDED METHODS: STEP 6G does not use any specific method.

TOOLS AND NOTATION: REA MODEL based on the REA FRAMEWORK and REA STRUCTURE

STEP 6H: POST-PROCESS REA MODEL

INPUT: (inductive) REA MODEL (from STEP 6G)

STEP DESCRIPTION: STEP 6H aims to harmonize the (inductive) REA MODEL. In the case STEP 6G applied an automated approach, the resulting REA MODEL may need to be revised and adjusted. That can have many different reasons, for instance:

- The INDIVIDUAL MODELS have been transformed into other structures (i.e., graphs), and their re-transformation needs to be revised to check whether they still comply with the REA FRAMEWORK and REA STRUCTURE.
- In case different ABSTRACTION TECHNIQUES have been used for different viewpoints, the resulting REA viewpoints have to be integrated (see modes when acquiring REA MODELS in STEP 6G)
- The internal behavior of an applied ABSTRACTION TECHNIQUES is not entirely known to the REA Team. Thus, results may need to be adjusted.

The following aspects have to considered when post-processing the (inductive) REA MODEL:

- Are all viewpoints and EA layers integrated?
- Do there exist model elements without any interrelation to other elements?
- Do there exist still multiple model elements that relate to the same real-world concept?
- Are important interrelations missing?

OUTPUT: (harmonized inductive) REA MODEL

RECOMMENDED METHODS: STEP 6H does not use any specific method.

TOOLS AND NOTATION: REA MODEL based on the REA FRAMEWORK and REA STRUCTURE

STEP 6I: EVALUATE REA MODEL

INPUT: REA REQUIREMENTS (from STEP 1D), (harmonized inductive) REA MODEL (from STEP 6H)

STEP DESCRIPTION: STEP 6I intends to conduct an initial evaluation of the (inductive) REA MODEL. There are many ways of conducting such an evaluation. However, the main focus of STEP 6I is to verify the correctness (inductive) REA MODEL and its appropriate level of detail since the profound REA model evaluation is part of REAM COMPONENT 9. Furthermore, it is necessary to understand whether the chosen ABSTRACTION TECHNIQUE(S) have served the overall REA REQUIREMENTS (e.g., whether it identified best practice vs. common practice). The results of STEP 6I might initiate another iteration of steps from this component, as indicated in Figure 60. The driving questions for this evaluation shall be:

- ✓ Does the resulting level of detail of the meet the REA REQUIREMENTS? Does the (inductive) REA MODEL provide enough detail in order to realized chosen ABSTRACTION TECHNIQUES (e.g., frequency thresholds)?
- ✓ If the REA MODEL intends to identify best practices, is this proven by domain experts?
- ✓ Is the identified practical knowledge correctly structured or shall be certain parts of the REA STRUCTURE be adjusted/refined?
- ✓ Does the resulting (inductive) REA MODEL comply with the standard of the chosen EA modeling language?
- ✓ Does the used ORGANIZATION SAMPLE represent relevant organizations of the PROBLEM DOMAIN?

The results of STEP 6I might trigger the iteration of any of the steps from this COMPONENT 6. In contrast to the evaluation of the (deductive) REA MODEL in COMPONENT 5 (STEP 5D), REAM recommends to consult at least one representative from a PROBLEM STAKEHOLDER into the evaluation process, since they carry the practical knowledge necessary.

OUTPUT: (evaluated inductive) REA MODEL

RECOMMENDED METHODS: Focus Group, Expert Interview, Survey

TOOLS AND NOTATION: STEP 6I does not use any specific tools or notations. However, its results may alter the (inductive) REA MODEL. Further, the REA TEAM shall document the findings of the evaluation.

GUIDELINES FOR COMPONENT 6 INDUCTIVE REA CONSTRUCTION	
STEP 6A	
✓	NOT ALL PROBLEM STAKEHOLDERS MIGHT QUALIFY FOR CANDIDATES FOR ELICITING PRACTICAL KNOWLEDGE. WHILE SOME PROBLEM STAKEHOLDERS MIGHT HAVE AN INTEREST IN USING THE REA (E.G., IT CONSULTANCIES), THE REA MODEL ITSELF REPRESENTS STRUCTURES OF A CERTAIN PROBLEM STAKEHOLDERS (E.G., DIRECTLY AFFECTED STAKEHOLDERS).
STEP 6B	
✓	THE AVAILABLE RESOURCES OF PROBLEM STAKEHOLDERS PARTICIPATING IN THE STUDY MIGHT VARY. THUS, THE REA TEAM SHALL PREPARE FOR DIFFERENT SCENARIOS OF ELICITATION. WHILE PRIORITY SHALL LIE ON MORE INTERACTIVE AND DIRECT APPROACHES (I.E., MODELING WORKSHOPS), THE REA TEAM SHALL BE ABLE TO ELICIT A SIMILAR QUALITY OF DATA USING MORE TRADITIONAL METHODS SUCH AS TELEPHONE INTERVIEWS OR SURVEYS.
✓	REAM SUGGESTS TO DESIGN A MODELING WORKSHOP THAT SPANS FOR ONE OR TWO DAYS AND ELICITS NECESSARY KNOWLEDGE USING A PROCESS-CENTERED APPROACH (TIMM ET AL. 2015A).
✓	AFTER DEFINING THE STANDARDIZED QUESTIONNAIRE, IDENTIFY WHAT KNOWLEDGE EACH QUESTION ADDRESSES AND RELATE IT TO THE VIEWPOINTS OF THE REA STRUCTURE. THAT UNCOVERS MISSING ASPECTS.
STEP 6C	
✓	FROM EXPERIENCE, THE APPROACHED ORGANIZATIONS MORE PROBABLY TAKE PART IF THEY ARE CLIENTS OF RELATED ISVS, WHO ARE PART OF THE REA PROJECT.
STEP 6D	
✓	IN ORDER TO KEEP ELICITED KNOWLEDGE FROM DIFFERENT PROBLEM STAKEHOLDERS COMPARABLE, USE AN AGENDA TEMPLATE. THE AGENDA USED IN TIMM ET AL. (2015A) PROVIDES A REUSABLE BLUEPRINT.
✓	ASK PROBLEM STAKEHOLDERS FOR AVAILABLE DOCUMENTATION (PROCESS MODELS, EA MODELS, PROCESS DOCUMENTATION), WHICH CAN SERVE AS ADDITIONAL MATERIAL. FURTHER, THIS AVOIDS ELICITING KNOWLEDGE THAT IS ALREADY EXPLICIT.
STEP 6E	
✓	IF STEP 6F CHOOSES AN ABSTRACTION TECHNIQUE THAT ANALYZES THE SEMANTICAL DISTANCE OF LABELS FROM THE INDIVIDUAL MODEL SET, LABELS DO NOT HAVE TO BE HARMONIZED (C.F. *NAMING CONVENTIONS* ASPECT).
STEP 6F	
✓	IN SOME CASES, IT MAY BE POSSIBLE TO CHOOSE SEVERAL ABSTRACTION TECHNIQUES, IF DIFFERENT PARTS OF THE REA MODEL FULFILL DIFFERENT PURPOSES. FOR INSTANCE, AN REA MODEL MAY AIM TO REPRESENT BEST PRACTICES ON A BUSINESS ARCHITECTURE LEVEL (BEST PRACTICE PROCESSES), WHILE ITS DATA ARCHITECTURE MAY INTEND TO REPRESENT ALL DATA OBJECTS PREVALENT IN THE PROBLEM DOMAIN.
STEP 6I	
✓	EVALUATE WITH SEVERAL DIFFERENT PROBLEM STAKEHOLDERS OR DOMAIN EXPERTS.

6.5.5 COMPONENT 7: REA MODEL COMPLETION

The objective of COMPONENT 7 is to integrate all previously developed knowledge—the REA PORTFOLIO, the REA STRUCTURE, the REA MODEL parts (both deductively and inductively developed)—into a coherent and complete REA MODEL. Since the different REA MODEL parts have been collected in different ways, COMPONENT 7 provides means how to structure them in order to produce an integrated REA MODEL before initiating PHASE (C) of REAM.

6.5.5.1 COMPONENT 7: USED CONCEPTS

Table 49 explains all concepts REAM COMPONENT 7 uses. The central inputs are outputs produced by previous REAM components in PHASE (B)—the REA STRUCTURE, the deductively and inductively developed REA MODELS, and DOMAIN GLOSSARY. On this basis, COMPONENT 7 produces two outputs. First, integrates and harmonizes all previously developed REA MODELS from COMPONENT 5 and COMPONENT 6 into an integrated REA MODEL. Second, it produces an REA DOCUMENTATION that adds important auxiliary information from a reuse oriented perspective to it.

TABLE 49. CONCEPTS USED IN COMPONENT 7: REA MODEL COMPLETION

INPUT	OUTPUT
REA STRUCTURE	(integrated) REA MODEL
DOMAIN GLOSSARY	REA DOCUMENTATION
(initial) REA MODEL	
(deductive) REA MODEL	
(inductive) REA MODEL	
REA PORTFOLIO	
ADJUSTMENT MECHANISMS	

6.5.5.2 COMPONENT 7: PROCEDURE AND NOTATION

Figure 61 illustrates all five steps COMPONENT 7 consists of and their execution path. All steps of this method component are mandatory. After finishing STEP 7A, one can conduct STEP 7B-D in parallel. After their completion, apply STEP 7E.

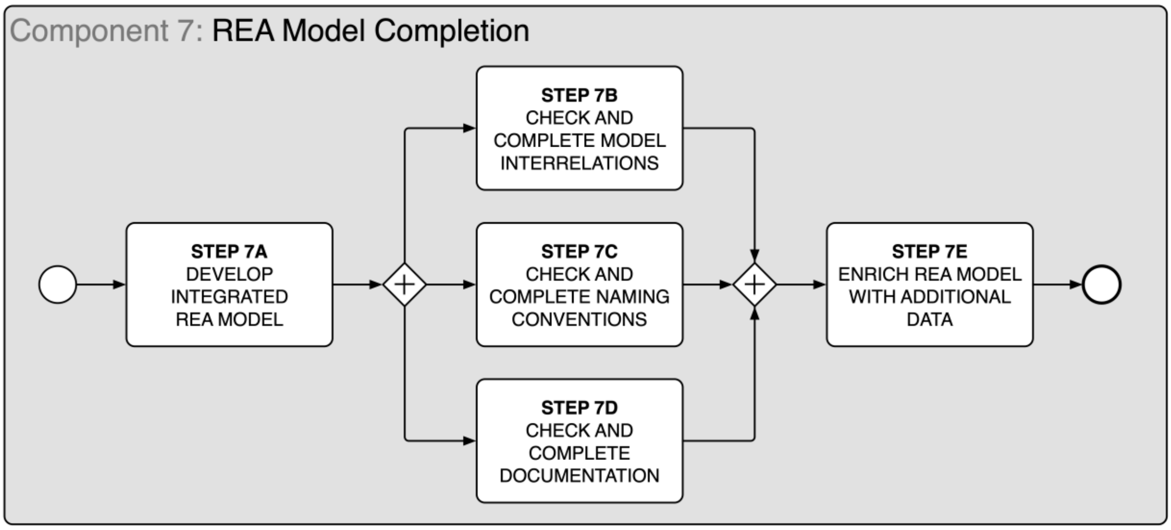


FIGURE 61. THE PROCEDURE OF METHOD COMPONENT 7: REA MODEL COMPLETION

STEP 7A: DEVELOP INTEGRATED REA MODEL

INPUT: REA STRUCTURE (from STEP 4C), DOMAIN GLOSSARY (from STEP 4A), initial REA MODEL (from STEP 4C), deductive REA MODEL (from STEP 5D), inductive REA MODEL (from STEP 6I)

STEP DESCRIPTION: STEP 7A organizes all REA MODEL parts produced in the course of the REA construction. Therefore, the following sources are relevant:

- the REA STRUCTURE
- the deductively developed REA MODEL
- all inductively developed REA MODELS
- the DOMAIN GLOSSARY
- developed documentation of the modeling parts
- further material that produced in the course of REAM

On this basis, STEP 7A further integrates all prior collected REA MODEL parts and puts them into an integrated REA MODEL. That represents the first step towards a completed REA MODEL and organizes all previously constructed models parts in one architecture file.

OUTPUT: (integrated) REA MODEL

RECOMMENDED METHODS: STEP 7A does not use any specific methods.

TOOLS AND NOTATION: STEP 7A does not use any specific tools or notations.

STEP 7B: CHECK AND COMPLETE MODEL INTERRELATIONS

INPUT: (integrated) REA MODEL (from STEP 7A)

STEP DESCRIPTION: STEP 7B analyzes the integrated REA MODEL regarding its coherence. Therefore, it focuses on interrelations among elements of the REA MODEL parts from STEP 7A. Thus, the REA Team shall analyze whether existing interrelations are correct and complete. In this context, STEP 7B analyzed the REA MODEL from different perspectives:

(i) relations among REA MODEL elements of a specific REA viewpoint
(ii) relations among REA MODEL elements of a specific REA viewpoint from different layers of the REA STRUCTURE
(iii) relations among REA MODEL elements from different domains of the REA STRUCTURE (cf. horizontal REA STRUCTURE in STEP 4B), as they may have been developed independently by COMPONENT 5 or COMPONENT 6.

Further, STEP 7B checks the correctness of chosen relation types. That includes revisiting modeling decisions made regarding what relation type to use in what circumstances. While the REA MODEL shall follow the specification of the chosen modeling language, some situations require a case-specific modeling decision. STEP 7B aims to make these decisions coherent across the REA MODEL.

OUTPUT: (integrated) REA MODEL

RECOMMENDED METHODS: STEP 7B does not use any specific methods.

TOOLS AND NOTATION: STEP 7B does not use any specific tools or notations.

STEP 7C: CHECK AND COMPLETE NAMING CONVENTIONS

INPUT: DOMAIN GLOSSARY (from STEP 4A), (integrated) REA MODEL (from STEP 7A)

STEP DESCRIPTION: STEP 7C analyzes the integrated REA MODEL regarding its coherence of labeling and naming conventions. Since the different REA MODEL parts may originate from different sources (COMPONENT 5 or COMPONENT 6), there may exist REA MODEL elements with different labels relating to the same real phenomenon. STEP 7C eliminates such inconsistencies with the use (and extension) of the DOMAIN GLOSSARY.

OUTPUT: DOMAIN GLOSSARY, (integrated) REA MODEL

RECOMMENDED METHODS: STEP 7C does not use any specific methods.

TOOLS AND NOTATION: STEP 7C does not use any specific tools or notations.

STEP 7D: CHECK AND COMPLETE DOCUMENTATION

INPUT: REA PORTFOLIO (from STEP 2D), REA STRUCTURE (from STEP 4C), REA MODEL (from STEP 7A)

STEP DESCRIPTION: STEP 7D focuses on the documentation of the REA MODEL. Therefore, each REA MODEL element needs proper documentation. REAM recommends to document the following aspects of the REA MODEL:

- Documentation of the REA Scope (based on the REA PORTFOLIO)
- Documentation of the REA FRAMEWORK including the explanation of the chosen modeling language and used meta-model (i.e., the results of COMPONENT 3)
- Documentation of the REA STRUCTURE and the explanation of the defined viewpoints of the REA MODEL as well as their purpose (i.e., the results of COMPONENT 4)
- Documentation of the elements of the REA Model. That may be:
    - the explanation of a specific business process,
    - the definition of a particular business role,
    - a reference to the DOMAIN GLOSSARY regarding a specific domain-specific term
    - the link to an online document that explain certain aggregated elements of the REA MODEL in more detail
    - example instantiations of data objects or generalized application components
- Documentation of the process behind the REA construction (i.e., a summary of data basis used in COMPONENT 5 and COMPONENT 6)
- Documentation of modeling conventions defined throughout the REA MODEL construction. That could be:
    - practices when to use what model elements
    - practices when to use what relation type
    - conventions how to visualize specific patterns (e.g., using nesting for visualizing decompositions)

While the majority of REA Documentation aspects are essential for potential REA users in terms of comprehensibility, the latter two have a project-internal purpose. Since the resulting REA Model will be under constant evolution, modeling conventions need to be documented. Also, the REA Team needs to keep track of already used knowledge sources.

OUTPUT: REA DOCUMENTATION, (integrated) REA MODEL

RECOMMENDED METHODS: STEP 7D does not use any specific methods.

TOOLS AND NOTATION: REA MODEL based on the REA FRAMEWORK and REA STRUCTURE

STEP 7E: ENRICH REA MODEL WITH ADDITIONAL DATA

INPUT: (integrated) REA MODEL (from STEP 7D), ADJUSTMENT MECHANISMS (from STEP 2A)

STEP DESCRIPTION: During PHASE (A), preferred ADJUSTMENT MECHANISMS may have been identified, which demand the REA MODEL to provide certain principles for its application (e.g., configuration or specification). STEP 7E analyzes the (integrated) REA MODEL regarding missing information that is required to make these ADJUSTMENT MECHANISMS feasible. While in some cases, this step requires much effort (e.g., to enable REA configuration using different configuration rules and metrics), others do not need extra annotation (e.g., analogy). That may include enriching the REA Model with quantitative metrics, as described in Schütte (1998, pp. 300–308). The following list provides recommendations on how to embed the five design principles by Vom Brocke (2006) in order to implement chosen ADJUSTMENT MECHANISMS into the REA MODEL:

- CONFIGURATION:
  - REA MODEL ANNOTATIONS (IF PROVIDED BY CHOSEN MODELING TOOL)
  - PROPERTIES OF ARCHITECTURE ELEMENTS WITH PREDEFINED MANIFESTATIONS OF PROPERTIES REGARDING
  - IN CASE THERE EXIST ONLY FEW CONFIGURATION RULES, DIFFERENT ARCHITECTURE VIEWPOINTS CAN BE USED TO REPRESENT THE DIFFERENT CONFIGURATION VARIANTS
- INSTANTIATION:
  - REA MODEL ANNOTATIONS (IF PROVIDED BY CHOSEN MODELING TOOL)
  - PROPERTIES OF ARCHITECTURE ELEMENTS
  - LINK TO ARCHITECTURE VIEWPOINTS THAT REPRESENT ALTERNATIVE INSTANTIATIONS OF A GENERIC MODEL ELEMENT
- AGGREGATION:
  - ARCHITECTURE VIEWPOINTS
  - DISTINCT REA MODEL PACKAGES
  - DOCUMENT AND STORE INTERRELATIONS AMONG IDENTIFIED AGGREGATES
- SPECIALIZATION:
  - REA MODEL ANNOTATIONS (IF PROVIDED BY CHOSEN MODELING TOOL)
  - PROPERTIES OF ARCHITECTURE ELEMENTS
  - SPECIALIZATION RELATIONSHIP (E.G., ARCHIMATE DEFINES SUCH A RELATION TYPE)
- ANALOGY:
  - HARDLY FEASIBLE TO EMBED SUCH INFORMATION WITHIN THE REA ITSELF
  - USE SEPARATE DOCUMENTATION FOR THIS

OUTPUT: (integrated) REA MODEL

RECOMMENDED METHODS: STEP 7E does not use any specific methods.

TOOLS AND NOTATION: REA MODEL based on the REA FRAMEWORK and REA STRUCTURE

GUIDELINES FOR COMPONENT 7 REA MODEL COMPLETION

STEP 7A
- ✓ USE A TOP-DOWN APPROACH BY STARTING FROM THE HIGH-LEVEL REA STRUCTURE, INTEGRATING IT WITH DEDUCTIVELY DEVELOPED REA MODELS, AND INTEGRATING IT THEN WITH INDUCTIVELY DEVELOPED REA MODELS, WHICH OFTEN POSSESS A HIGHER LEVEL OF DETAIL.
- ✓

STEP 7B
- ✓ HAVE A FIRST LOOK AT THE REA MODEL WITHIN REA TEAM REGARDING THE INTERRELATIONS.
- ✓ DECIDE WHETHER IT IS NECESSARY TO CONDUCT STEP 7B WITH DOMAIN EXPERTS.
- ✓ IN SOME CASES, IT MAY BE NECESSARY TO CONDUCT FURTHER ITERATIONS OF COMPONENT 6 IF ALL REA MODEL PARTS ARE TOO LOOSELY-COUPLED.

STEP 7C
- ✓ CONSULT DOMAIN EXPERTS AND PROBLEM STAKEHOLDERS IN CASE THERE IS UNCERTAINTY REGARDING CERTAIN NAMING CONVENTIONS.

STEP 7D
- ✓ IF SUPPORTED BY THE MODELING TOOL, USE ITS DOCUMENTATION FUNCTIONALITY.
- ✓ IF SUPPORTED BY THE MODELING TOOL, CREATE MODEL REPORTS THAT CAN BE MODIFIED AND DISTRIBUTED ACROSS RELEVANT TEAM MEMBERS AND WITH DOMAIN EXPERTS OR PROBLEM STAKEHOLDERS.
- ✓ FOR BEST PRACTICES IN MODELING CONVENTIONS, CONSULT LANKHORST ET AL. (2017).

6.5.6 A REFERENCE COMPLIANCE ORGANIZATION: CONSTRUCTION PHASE

The following subsection demonstrates the application of the five method component of REAM PHASE (B) in using the running example from the financial industry.

6.5.6.1 COMPONENT 3: SETTING UP THE RCO CONSTRUCTION FRAMEWORK

As described in PHASE (B) of REAM, the REA FRAMEWORK builds from the earlier developed REA PORTFOLIO (cf. section 6.4.3.2). In summary, this included selecting an appropriate EA framework, an EA modeling language, and the decision of what modeling tool to use. Revisiting the results produced in PHASE (A), the following findings were central for defining the RCO Framework:

- **REQ1 from the RCO REQUIREMENTS:** RCO must reveal interrelations among RCM processes, data structures, and IT systems (cf. Table 41).
- **RCO FOCUS POINT 1:** Develop a data-centric RCO.

Hence, the RCO framework focuses on business, data, and application layer as well as their interrelations among each other. Also, the data played an essential part in the RCO. Further, the PROBLEM DOMAIN of Financial Service Compliance required a business-driven approach, which usually starts defining the business layer that subsequently determines the remaining layers. In the context of the RCO, this was necessary because required practical knowledge (cf. REQ2 in Table 41) and the regulatory requirements did primarily address aspects of the business layer (e.g., business processes, requirements, business actors). According to the comparison framework by Bui (2017), these observations hinted at using an "operational EA framework." Since there exist no EA frameworks tailored to the specifics of the financial industry (Harmsen van der Beek, Wijke ten et al. 2012), the RCO Team decided to use The Open Group Architecture Framework (TOGAF) as an operational framework developed for the private sector (The Open Group 2011). Further, two project employees were familiar with the framework from previous EA projects. Another reason to use TOGAF was that it comes along with the notation standard ArchiMate. ArchiMate is a modeling language aligned with TOGAF and its defined concepts (The Open Group 2017). At the time the project started, the current version ArchiMate 2.1, was chosen. As the project proceeded, the REA TEAM converted all results to the new version ArchiMate 3.1. At the project start, the RCO Team decided to use an open-source modeling tool for modeling with the ArchiMate notation—the Archi® modeling toolkit[1]. The rationale behind this decision was to develop a digital REA MODEL that is accessible to every member of both the REA Team and the ISVs from the focus group. As the project advanced, requirements regarding the tool support increased. One critical requirement was that the tool should provide more reporting functionalities. Consequently, the REA Team switched to a commercial EA tool. As a result, the following RCO Framework evolved:

RCO FRAMEWORK:
- *EA FRAMEWORK:* TOGAF 9.1
- *EA MODELING LANGUAGE:* ARCHIMATE 3.1
- *TOOL SUPPORT:* ARCHI® MODELING TOOLKIT, COMMERCIAL ARCHIMATE MODELING SOFTWARE

BASED ON THE SPECIFICS OF THE PROBLEM DOMAIN, THE RCO FRAMEWORK FOCUSES ON THE FOLLOWING ASPECTS:
- *FOCUS ON EA LAYER:* BUSINESS LAYER, INFORMATION LAYER, APPLICATION LAYER
- *IMPORTANT EA MODEL ELEMENTS (ARCHIMATE SPECIFICATION[2]):*
  - BUSINESS LAYER: BUSINESS ACTORS, BUSINESS PROCESSES, BUSINESS EVENTS
  - APPLICATION LAYER: DATA OBJECT, APPLICATION COMPONENT

Since hardware landscapes and network infrastructures are very heterogeneous across the financial institutes and are often outsourced to IT service organizations, domain experts agreed that there is no need for the RCO to focus on the technological layer. Hence, the RCO TEAM excluded the technological

[1] https://www.archimatetool.com/, accessed 23/01/20.
[2] https://pubs.opengroup.org/architecture/archimate3-doc/, accessed 23/01/20.

layer when constructing the RCO. ArchiMate integrates the data and application layer defined by TOGAF into a single application layer. Figure 62 presents the utilized meta-model elements of the ArchiMate language and the interrelations among them. On the business layer, the RCO Framework uses business roles, actors, business processes—which represent the realization of specific business services—triggering business events as well as generic business data objects (e.g., certain forms or customer data). On the application layer, central elements are the application component—which represents certain IT functionality—and data objects that concretize business objects. Application services encapsulate the behavior of the application layers that serve specific processes on the business layer. Further, the several element types may be aggregated. For reasons of clarity, Figure 62 does not illustrate that relationship.

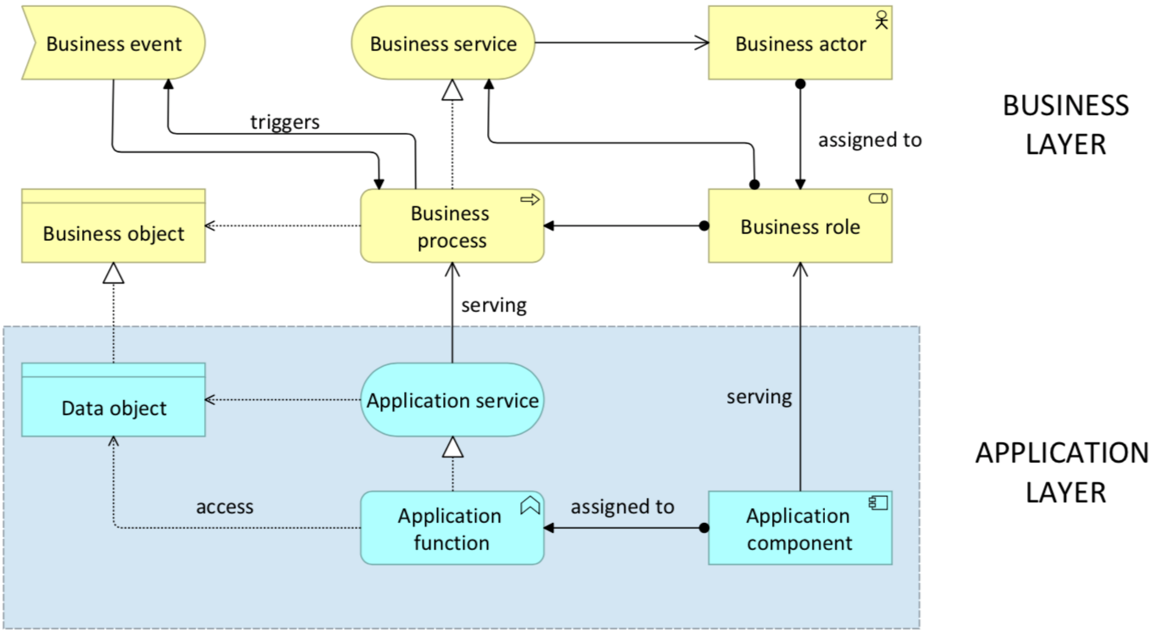


FIGURE 62. ADJUSTED ARCHIMATE META-MODEL FOR RCO FRAMEWORK

6.5.6.2 COMPONENT 4: SETTING UP THE RCO STRUCTURE

STEP 4A: NAMING CONVENTIONS FOR THE RCO. Since regulatory compliance management in the financial service domain is characterized by many domain-specific terms stated in regulatory texts, the RCO Team decided to collect such terms in a DOMAIN GLOSSARY. The glossary intended to cover the following aspects:

(i) general RCM related terms
(ii) terms relating to the specific RCM function the RCO aims to cover, i.e., AML, KYC, and Fraud as defined in COMPONENT 1 (cf. section 6.4.3)

Therefore, the RCO TEAM used different sources. First, the RCO TEAM search existing taxonomies and systematizations. While there existed no widely-accepted domain-specific glossary or taxonomy for RCM, the current version of the BIAN standard (BIAN 2019)[1] and the compliance taxonomy by the community-based platform *compliance next* (Compliance Next 2019) qualified. While the former provides documentation of relevant capabilities in the BIAN business domain "regulations and compliance," the latter provides definitions on general RCM related terms such as "code of conduct." However, both lack enough detail for the scope of the RCO. Second, the RCO TEAM analyzed relevant regulatory

[1] https://bian.org/servicelandscape-8-0/index.html provides a HTML-based report of the BIAN landscape in v8.0, accessed 24/01/20

texts regarding terms for the RCO. Here, general RCM related laws were consulted, such as the German Banking Act (German Federal Republic 24th April 2018), as well as laws that correspond to either AML, KYC, or Fraud. In the case of AML, the RCO TEAM studies the European Directive 2018/843 (European Union 2018) and the corresponding German law (German Government 2017). Unfortunately, regulatory texts did lack concrete definitions as well. Third, the RCO Team consulted domain experts from the focus group. Therefore, the RCO Team developed a systematization for each of the three RCM functions based on the insights gathered during the prior activities. That was then evaluated and enhanced with the domain knowledge by the experts. To give an example, Figure 63 shows a high-level perspective on the KYC function. These systematizations were accompanied by a DOMAIN GLOSSARY that provided concrete definitions for the concepts used by the systematization.

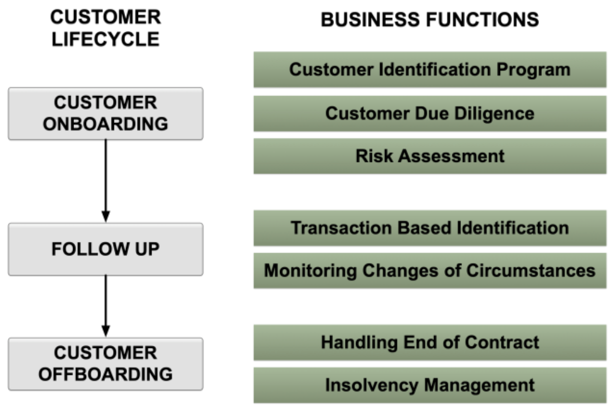


FIGURE 63. HIGH-LEVEL SYSTEMATIZATION OF KYC FUNCTION OF THE RCO

STEP 4B + 4C: THE HIGH-LEVEL STRUCTURE OF THE RCO. In order to define a high-level RCO STRUCTURE, the RCO Team followed the activities described in section 6.5.2.2. First, general concerns towards the RCO MODEL were identified based on the RCO FOCUS POINTS. Second, these concerns led to an initial RCO STRUCTURE, in which the RCO TEAM used EA viewpoints to address the particular concerns. These viewpoints relate to both the different RCO layers (i.e., business, data, or technical) and a particular RCM function (i.e., AML, KYC, or Fraud). Third, the RCO STRUCTURE documents each viewpoint's purpose. That included a list of ArchiMate elements that shall be used by each viewpoint. Fourth, the RCO TEAM developed an initial RCO MODEL that initialized the RCO STRUCTURE. Afterward, several domain experts from four ISVs evaluated the RCO STRUCTURE.

Figure 64 represents the resulting structure. Each rectangle represents a specific ArchiMate viewpoint, which addresses a concern of the RCO. For means of coherence, each RCM function uses a similar set of viewpoints. For instance, the RCO defines a data usage viewpoint for AML, KYC, and Fraud. It reveals the data processed for the completion of specific business functions and processes. Vertically read, Figure 64 illustrates the different TOGAF layers, i.e., the vertical RCO STRUCTURE. Horizontally read, it shows the several regulatory domains AML, KYC, and Fraud, i.e., the horizontal RCO STRUCTURE. Some RCO viewpoints address concerns related to a single TOGAF layer (e.g., *"AML Data Structure"*), while some reveal interrelations between two layers (e.g., *"AML Data Usage").* The right column summarizes general concerns addressed by the RCO. Next to these domain-specific viewpoints, the RCO provides integrated views (e.g., *"Compliance Organization"*). These aggregate the RCO elements across all RCM functions in order to generate the demanded holistic overview on RCM. One view may consist of up to three different layers of detail (indicated by *"LOD"* of each view). That emerged after the RCO Model was finalized, i.e., after completing PHASE (B) of REAM. While the RCO STRUCTURE origins in ArchiMate's core framework, other perspectives on the RCO after the evaluation with domain experts. For instance, the RCO TEAM structured RCO's business layer by dint of the Three-Lines-of-Defense model. It distinguishes between mitigating risk activities at the front office, the back office, and processes for internal auditing. Although its effectiveness for risk management is not yet proven, compliance organizations of financial institutes use it (Davies and Zhivitskaya 2018). In additional ArchiMate views, the RCO provides such an overview for each regulatory domain. Figure 64 presents the final version of the RCO STRUCTURE. Results of COMPONENT 5, COMPONENT 6, insights from PHASE (C) of REAM triggered changes in the RCO STRUCTURE.

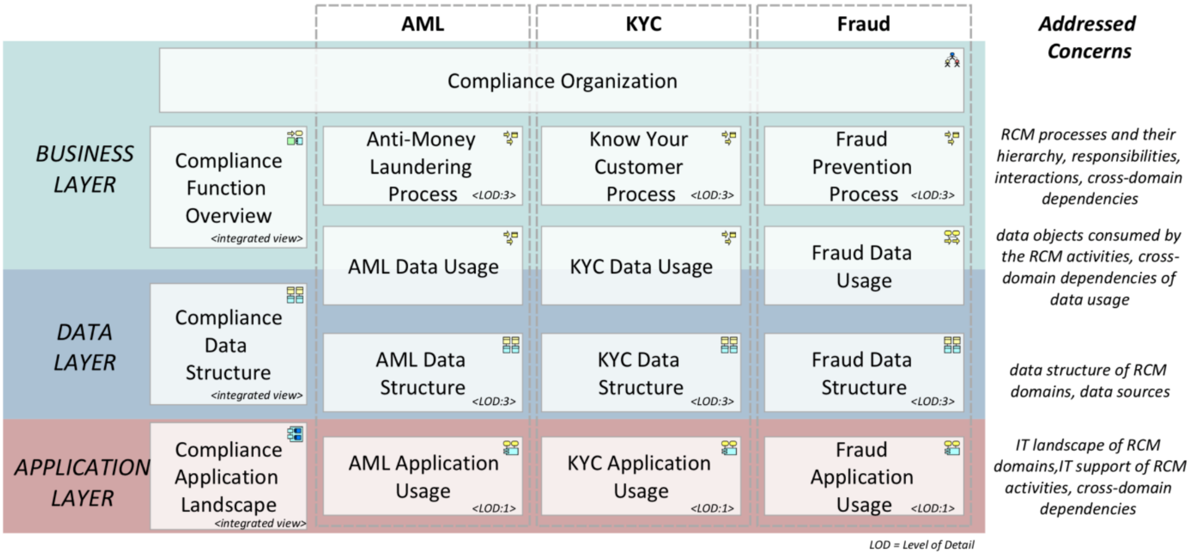


FIGURE 64. OVERVIEW OF THE RCO STRUCTURE

6.5.6.3 COMPONENT 5: DEDUCTIVE RCO CONSTRUCTION

REAM defines that the application of COMPONENT 5 and COMPONENT 6 depends on the respective REA scope. In the context of RCO, the RCO Team decided to apply both methods with the following purposes:

- **Conduct COMPONENT 5 in order to develop an initial RCO Model that covers central model elements**, e.g., high-level business processes or data groups. Although the results from PHASE (A) had shown that there merely exists commonly accepted knowledge in the RCM domain that is reusable for the RCO project, the RCO TEAM decided to conduct deductive REA construction because the RCO Team had access to many domain experts of ISVs in the PROBLEM DOMAIN. Furthermore, the RCO Team realized that the results of COMPONENT 5 positively influenced the elicitation process of COMPONENT 6 as the gained knowledge helped to formulate more detailed questions addressed to PROBLEM STAKEHOLDERS.
- **For each RCM domain, COMPONENT 6 was applied.** That resulted in three iterations of Component 6—once for AML, KYC, and Fraud. Section 6.5.6.4 presents these results.

STEP 5A: REUSABLE KNOWLEDGE FOR THE RCO. During STEP 2C, the BIAN standard was the only REUSABLE KNOWLEDGE for the RCO. However, the RCO TEAM repeated that activity during the beginning of COMPONENT 5 since advanced knowledge might have positive effects on the search process. In the end, the following DEDUCTIVE KNOWLEDGE BASE evolved:

- **Regulatory Texts:** German Banking Act (German Federal Republic 24th April 2018), EU Directive for AML (European Union 2018), German AML law (German Government 2017).
- **Industrial Standards:** BIAN Service Landscape (BIAN 2019)
- **Documentation of IT solutions:** Documentations of IT solutions by the IT provider members of the focus group (e.g., SIRON AML, Actico MLDS)

The regulatory texts lacked concrete means that were directly transferable into the RCO MODEL. Although the BIAN standard provides an architecture model based on ArchiMate, its content regarding "regulations and compliance" provides no means as to what concrete actions to take for AML or what data to use for it. For example, in the AML domain, it only provides three service groups, "AML origination," "AML invocation," and "AML reporting." However, the several documentations of IT solution provided useful information regarding central data object groups and general procedures, especially in the context of AML processes.

STEP 5B: ELICIT KNOWLEDGE FOR THE RCO. Because the RCO Team assessed the results of STEP 5A as insufficient, STEP 5B was conducted as well. Another reason for this decision was that the RCO Team had easy access to implicit domain expertise since the project was supervised by a consortium IT consultancies and ISVs. Thus, the RCO TEAM conducted expert interviews with the domain experts. For each of the three RCM functions, two domain experts were consulted. Therefore, the interview questions referred to the respective viewpoints shown in Figure 64, while the interviewers used open questions. Here, interviewers would ask for a general process that shall be implemented in an AML program, what kind of data they use for that purpose, or what critical IT systems are available in the industry.

STEP 5C + 5D: DEDUCTIVE RCO MODEL. Following the procedure for STEP 5C, as documented by REAM, the RCO Team aggregated the results from STEP 5A and STEP 5B. The RCO TEAM further identified domain-specific terms, and extended the DOMAIN GLOSSARY. Subsequently, the aggregated DEDUCTIVE KNOWLEDGE BASE was mapped to the RCO FRAMEWORK. Further, systematization that emerged during STEP 4A was extended by the additional knowledge. Among other things, these extended systematizations helped to relate certain aspects of the RCM functions to viewpoints from the RCO STRUCTURE. Afterward, the RCO Team identified high-level business processes, data objects, and application components. That resulted in a (deductive) RCO MODEL. In one meeting, participants of the focus group evaluated that model. The RCO Team presented the RCO MODEL and discussed the content regarding each of its different viewpoints. Figure 65 presents an extract of the model as it shows the high-level KYC process.

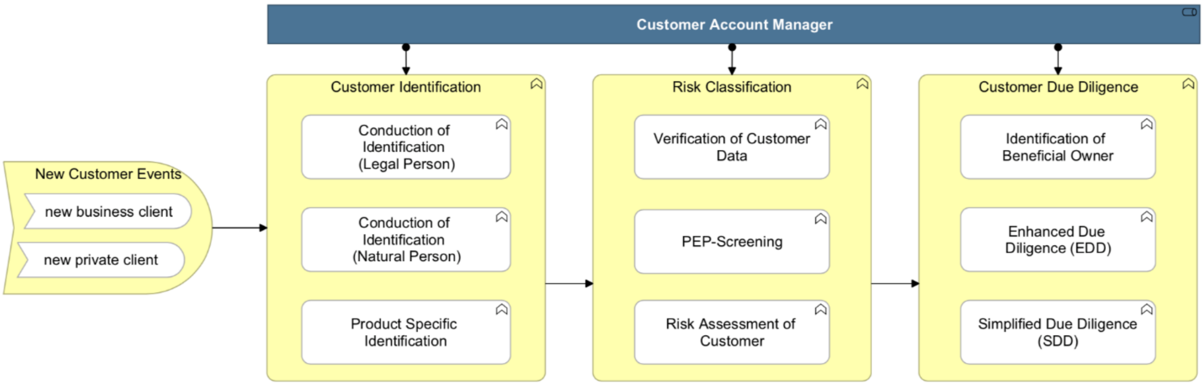


FIGURE 65. DEDUCTIVELY DEVELOPED RCO MODEL: KYC PROCESS VIEWPOINT

6.5.6.4 COMPONENT 6: INDUCTIVE RCO CONSTRUCTION

As explained at the beginning of section 6.5.6.3, the RCO project applied three iterations of COMPONENT 6—one for each RCM function. Each iteration followed the same procedure when applying STEP 6A-6I. Hence, this section will present the results of the iteration that focused on the KYC function.

STEP 6A – 6C: Preparation for Individual Model Elicitation for RCO. The objective of the RCO was to represent practical knowledge for a holistic RCM using EA structures. Different types of financial institutes face different densities of regulatory requirements (e.g., CRR institutes face more regulatory requirements than financial service institutes). Thus, the RCO TEAM intended to focus on credit institutes as potential candidates for eliciting individual models. For conducting STEP 6A, the RCO TEAM structured the financial institutes from the German legal sphere (cf. REQ 3 in Table 41). For this purpose, definitions from §1 of the German Banking Act (German Federal Republic 24th April 2018) were used. It divides credit institutes by their federations based on the directory of the German Central Bank (2018). The RCO TEAM deliberately excluded financial holding institutes, payment service providers, and insurances from the sample due to the elaborations above. The two left columns of Table 50 showcase the structure of the industry.

Meanwhile, the INDUCTIVE ELICITATION PLAN was developed (STEP 6B). The RCO Team identified the following aspects for the elicitation:

- **Knowledge:** The inductive REA Construction aims to elicit practical knowledge for KYC, AML, and Fraud from the perspective of financial institutes. Therefore, the elicitation shall focus on business processes, responsible business actors, used data structures, and utilized application components.
- **Level of Detail**: PHASE (A) identified the need for a data-centric RCO. Thus, inductive elicitation methods shall gather detailed information regarding the data used by interviewed financial institutes for the respective RCM functions. Grasping all relevant data required a thorough investigation of implemented business processes. Further, the RCO TEAM decided to identify whether IT systems supported stated business processes, which processes are automated, or whether the interviewees identify a need for IT support regarding certain aspects.
- **Participants**: (Chief) Compliance Officer, AML Officer
- **Material**: process documentation, related forms, IT systems documentation
- **Elicitation Method**: The RCO Team defined two alternative elicitation methods to elicit the above mentions aspects.
  - *Elicitation Workshop:* in a one-to-two-day interactive workshop that covers all RCM functions based on a predefined agenda that defines time slots and necessary participants, respectively.
  - *Telephone Interview* used a standardized questionnaire for each of the three RCM functions.
- **Value**: Each participating financial institute would get an aggregated report of the study.

In STEP 6C, the RCO Team approached credit institutes and financial services institutes using two channels:

(a) Using e-mail distribution lists via associated banking federations. The e-mail summarized the INDUCTIVE ELICITATION PLAN, as presented above.
(b) The RCO TEAM used direct contacts of the focus group's members' customer base. They provided the RCO TEAM with contact persons of several financial institutes.

STEP 6D – 6H: Inductive RCO Model acquisition. Unfortunately, the majority of contacted institutes refused to conduct an elicitation workshop. However, most agreed to conduct a detailed telephone interview for at least one of the RCM functions. The right columns of Table 50 show the number of participating institutes of the different institutes types for each RCM function. The RCO Team decided to only conduct telephone interviews in order to keep results comparable. In total, the RCO Team conducted 64 interviews with compliance officers and AML officers from 26 different institutes. As explained above, the RCO TEAM conducted three interview studies. For each study, a standardized questionnaire contained open, multiple, and single choice questions. For the development of questionnaires, the team consulted the domain knowledge of the focus group and conducted pre-tests with one domain expert. A single interview could take from two to three hours. Each interview used an online survey tool. The interviewer transcribed all answers. Based on these transcripts, two members of the RCO TEAM conducted the development of the individual models. Therefore, each INDIVIDUAL MODEL instantiated the viewpoints of the REA STRUCTURE. In the end, a distinct INDIVIDUAL MODEL SET emerged for each of the three RCM functions AML, KYC, and Fraud. Afterward, the INDIVIDUAL MODEL SETS were harmonized (STEP 6E). Doing so, the following aspects were considered during harmonization:

- ✓ Do all INDIVIDUAL MODELS the previously defined viewpoints of the RCO STRUCTURE?
- ✓ Do insights of the elicitation require an adjustment of the RCO STRUCTURE?
- ✓ Have there been modeling decisions taken that differ across the INDIVIDUAL MODEL SET?
- ✓ Did respondents use different labels for identical concepts?

TABLE 50. ORGANIZATION SAMPLE OF THE INDUCTIVE RCO CONSTRUCTION

Type by Regulation	Type by Federation	AML	KYC	Fraud
Credit Institutes	Credit Banks	6	10	3
	Savings Banks	5	8	3
	Mutual Banks	5	3	6
	Mortgage Banks	0	1	0
	Building Society	1	0	0
Financial Services Institute		4	4	5
	∑	**21**	**26**	**17**

One advantage of using standardized questionnaires was that they ensured a consistent level of detail across the INDIVIDUAL MODEL of the three elicitation studies. Further, there was no need to alter the RCO STRUCTURE. However, the RCO TEAM decided to define views with different levels of detail for certain viewpoints (e.g., process and data-centric viewpoints in Figure 64). Most adjustments concerned the labeling of the elements. Therefore, the DOMAIN GLOSSARY was consulted and, in some cases, extended.

In STEP 6F, the RCO Team identified two ABSTRACTION TECHNIQUES. On the one hand, the RCO TEAM applied the minimal cost of change approach (MCC) by Ardalani et al. (2013) to identify common practices among the individual models. On the other hand, the team applied the RefPa method proposed by Scholta (2016) for identifying best practices (Timm et al. 2018). Consequently, the RCO's recommendatory character provides both industry's common and best RCM practices. While RCO's common practices primarily become apparent in essential compliance tasks and vital data for risk calculation, it consists of additional data fields and software applications that embody identified best practices.

In order to apply the chosen ABSTRACTION TECHNIQUES during STEP 6G, several adjustments were necessary. Since both the MCC and RefPa approaches focused on event-driven process chains, new methods were necessary in order to adapt the approaches to ArchiMate models. Therefore, the RCO TEAM transformed the XML-based ArchiMate models to graph structures, which still provided all necessary information such as element type, label, or corresponding relations. After applying both approaches to these graphs, the resulting reference models for each AML, KYC, and Fraud were transformed back into ArchiMate models. Timm et al. (2018b) documents on this in more detail. Therefore, it was necessary to conduct STEP 6H as some behavior of the implementation, which was not anticipated, occurred. This related primarily to visualization aspects since the transformation back to ArchiMate models did not enable the correct position of RCO element in the respective viewpoints.

After the post-processing of the (inductive) RCO MODEL, the model was evaluated (STEP 6I). Therefore, the RCO Team proceeded for each iteration of COMPONENT 6 as follows. After finalizing STEP 6H, the RCO Team presented the respective (inductive) RCO MODEL in a focus group meeting scheduled for this purpose. During these meetings, the RCO Team would recapture the construction process, present the structure, and go through the viewpoints of the (inductive) RCO MODEL in detail. Afterward, members of the focus group openly discussed several aspects:

- ✓ Does the Organization Sample represent the financial institutes of the German legal sphere? (RCO Requirement REQ3 of Table 41)
- ✓ Is the model structure fitting for the respective business domain? (RCO STRUCTURE)
- ✓ Does the (inductive) RCO MODEL lack any general domain aspects? (completeness)
- ✓ Does the (inductive) RCO MODEL provide an appropriate level of detail to reveal interrelations among compliance processes, utilized data, and support IT systems? (level of detail, REQ1 of Table 41)

The RCO TEAM applied the remarks from the focus group to the RCO. As the several (inductive) RCO MODEL consisted of several hundreds of elements, the RCO TEAM distributed the new (inductive) RCO MODEL to each member. Each member then again evaluated the RCO—this time with the request to check whether it lacs any concrete compliance processes, data objects of application components. That resulted in an (evaluated inductive) RCO MODEL. Figure 66 presents the resulting inductively developed RCO MODEL by the KYC Process Viewpoint. Comparing it to the corresponding viewpoint of the (deductive) RCO MODEL (see Figure 65), one can see the improved level of detail. Further, the control flow of the viewpoint changed as the majority of financial institutes conduct due diligence activities before carrying out monitoring duties.

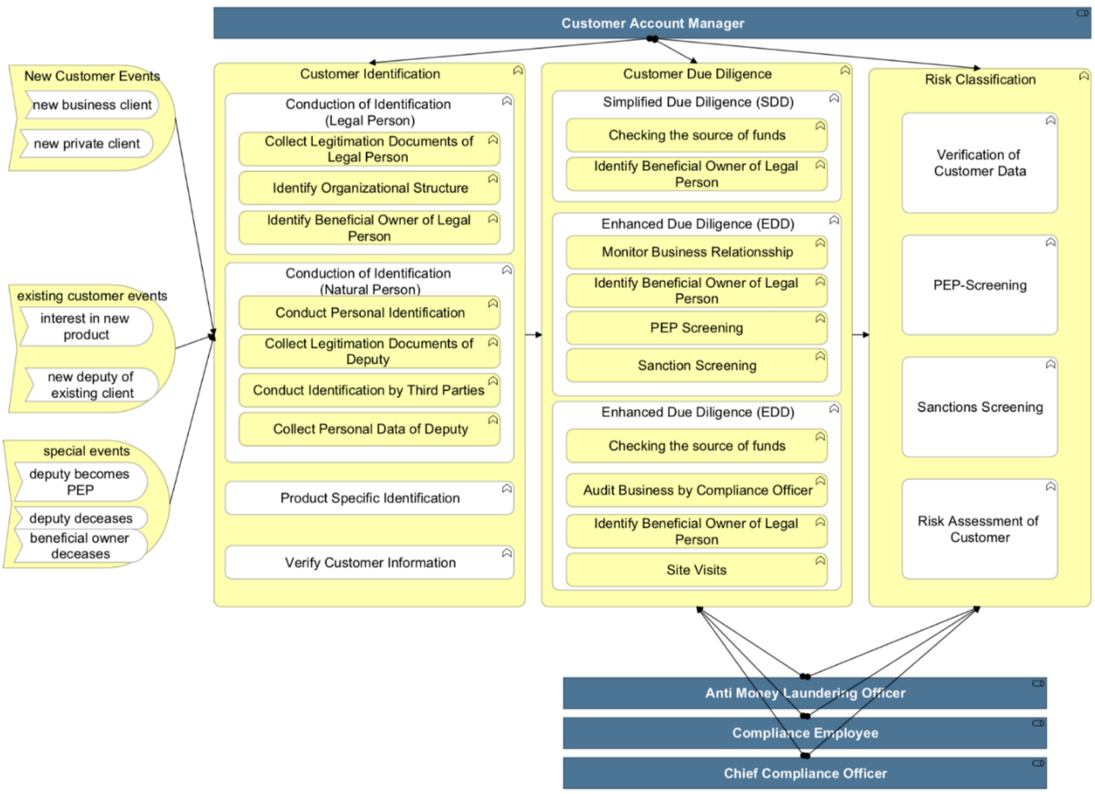


FIGURE 66. KYC PROCESS VIEW AS A RESULTS OF STEP 6G

6.5.6.5 COMPONENT 7: RCO MODEL COMPLETION

Based on all previous findings, an integrated RCO MODEL evolved. Since the deductively developed RCO MODEL already followed the previously developed RCO STRUCTURE, the primary task while conducting COMPONENT 7 was to integrate the deductive RCO MODEL with the three inductively constructed RCO MODELS for each AML, KYC, and Fraud. In practice, this meant that the RCO TEAM deployed a new model repository and added the several RCO parts to it. The most time-consuming task was to identify interrelations among elements from the three RCM functions. That was primarily the case regarding relations among elements from the business and data layers. During the model integration, the modeling tool identified duplicates and automatically added new relations when done so. For instance, the tool recognized if the AML and KYC business processes used the same data object. However, the RCO TEAM consulted domain experts to identify whether further inter-domain relations existed. Since the RCO TEAM maintained the DOMAIN GLOSSARY throughout the construction process, naming conventions were consistent (STEP 7C). Next to the documentation of the RCO MODEL elements, the RCO TEAM further reported on the concrete RCO construction process. That also included documenting decisions taken during the modeling process and detailed information of the RCO STRUCTURE (STEP 7D). Here, the main objective was to make the construction process, the model itself, and its structure more transparent for domain experts and PROBLEM STAKEHOLDERS. The members of the focus group proved all produced documentation.

Following aspects in STEP 7E further refined the (integrated) RCO MODEL:

- ❖ Integrated viewpoints were added to the RCO STRUCTURE (see left rectangles of Figure 64). These viewpoints reveal synergies among the different RCM functions. For instance, they reveal what data objects are used by what business process from either AML, KYC, or Fraud.
- ❖ As required by one RCO FOCUS POINT (see section 6.4.3.2), the RCO shall provide viewpoints that make use of known patterns of the RCM domain. Consequently, the RCO MODEL used specific viewpoints. For instance, a dedicated perspective structured all business processes of the RCO MODEL using the Three-Lines-of-Defense perspective. Doing so, potential RCO users would now be able to easily understand at what line of defense specific processes shall be implemented.
- ❖ During the evaluation workshops during STEP 6I, several domain experts proposed to augment the content of the RCO MODEL with their respective regulatory requirements. Thus, the RCO Team analyzed corresponding regulatory texts (e.g., the German Money Laundering Act for AML) regarding particular requirements. Together with domain experts, the RCO TEAM related them to business processes, data objects, or application systems from the RCO MODEL that realized them.

In the end, the (integrated) RCO MODEL, as displayed in Figure 64, evolved. One view may consist of up to three different layers of detail (indicated by *"LOD"* of each view). For example, the "AML information structure" view contains over 200 data objects with three levels of detail. Moreover, the "Fraud Prevention Process" view structures 243 business functions in three levels of detail.

6.6 PHASE (C): REA APPLICATION

The primary purpose of REAM's third phase is to prepare the REA for its actual application by taking an application-oriented perspective on the REA produced in PHASE (B). Therefore, PHASE (C) pursues the following objectives:

(i) to holistically evaluate the REA constructed in PHASE (B)
(ii) to prepare the REA for its application in practice based on the PROBLEM STAKEHOLDERS' needs as identified in PHASE (A)
(iii) to continuously maintain the REA over time

Addressing these objectives, PHASE (C) consists of three method components. Before an REA can be applied in practice, REAM considers two aspects beforehand. First, COMPONENT 8 defines an REA APPLICATION DESIGN, which communicates the different possible modes of applying the REA and produces communication material to the REA user. Second, COMPONENT 9 conducts a holistic validation of the REA. Doing so, it focuses on both a model-centric and a user-centric REA validation. Afterward, COMPONENT 10 addresses the maintenance of the REA MODEL.

Although PHASE (C) concentrates on the application of the REA, REAM does not cover the actual procedure for application from the perspective of the REA user. The author understands the process an REA user shall follow to apply an REA Model to be similar to generic steps of RM application stated in the literature. According to Fettke and Loos (2002a), a user applies a RM in the following four phases:

(1) **Reusability Design**: The RM is distributed so that a RM user can access or procure it.

(2) **RM Retrieval**: The RM user searches, selects, and purchases the reference model.

(3) **RM Adjustment**: The user adjusts the RM to its specific needs. That may include user-induced adjustments, which have not been foreseen by the RM constructor. However, a RM shall also provide means that describe how to adjust it concerning pre-defined application contexts. Usually, these adjustments use the design principles defined in Vom Brocke (2006).

(4) **Evaluation**: Each application might identify flaws in the reference model. Thus, there shall be a feedback loop between the RM application and construction.

From a user perspective, especially activity (2) and (3) are essential when applying a reference model. From the perspective of RM constructors, activities (1), (3), and (4) are essential since they aim to make the model easily accessible, guide the user during adjustments, and provide feedback from each application project to enhance the reference model. Translating these considerations into the scope of REAM, PHASE (C) provides means to enable these three steps of reusability design, RM adjustment, and evaluation in the following way:

- ❖ COMPONENT 8 consists of steps that define an REA DISSEMINATION STRATEGY and produce appropriate COMMUNICATION MATERIAL. Therefore, it supports realizing activity (1).
- ❖ The REA APPLICATION DESIGN, developed by COMPONENT 8, provides an approach to support activity (3). Therefore, several APPLICATION SCENARIOS exist that relate to different intentions of REA application and derive concrete actions for REA adjustment.

The evaluation concerned by activity (4) is addressed by COMPONENT 9 and COMPONENT 10. While the former provides an approach to what questions to ask when evaluating an REA application, the latter concretizes how to integrate evaluation insights into REA Model maintenance.

Overall, these observations lead to the following execution path when conducting PHASE (C). After PHASE (B) finishes, each of the COMPONENTS 8 – 10 are conducted in sequential order. Afterward, every application of an REA uses the APPLICATION DESIGN and COMMUNICATION MATERIAL of COMPONENT 8. Each REA application further leads to an iteration of COMPONENT 9, which evaluates the REA MODEL based on the observations during the application. That may also trigger a new iteration of COMPONENT 10, if room for improvement exists. Figure 67 illustrates this.

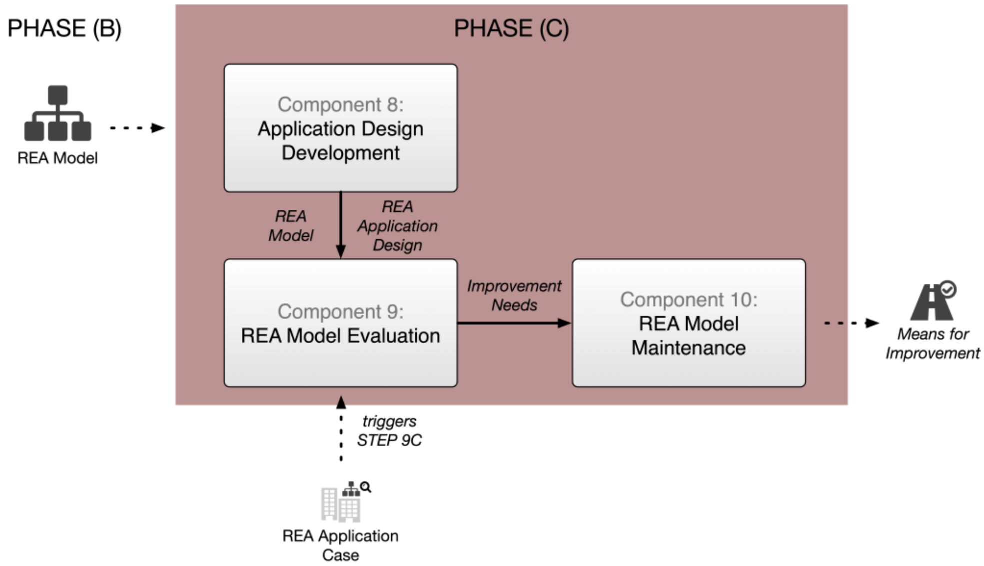


FIGURE 67. OVERVIEW ON PHASE (C) REA APPLICATION

6.6.1 COMPONENT 8: APPLICATION DESIGN DEVELOPMENT

The overall objective of COMPONENT 8 is to prepare the REA for its application in practice. Therefore, it consists of steps that define APPLICATION SCENARIOS. An APPLICATION SCENARIO streamlines the different ways how REA users can apply the REA. It includes defining the delivered REA VALUE and ADJUSTMENT MECHANISMS used during the application. Further, COMPONENT 8 produces COMMUNICATION MATERIAL as well as a DISSEMINATION STRATEGY in order to make the REA accessible to potential REA users. COMPONENT 8 builds from the RM application process delineated by Fettke and Loos (2002a). Timm (2018a) discusses the concept of APPLICATION SCENARIOS in the context of REAs further.

6.6.1.1 COMPONENT 8: USED CONCEPTS

Table 51 explains all concepts that COMPONENT 8 uses. The central inputs of COMPONENT 8 are the integrated REA MODEL from PHASE (B) and the REA CONSTRUCTION PORTFOLIO from PHASE (A), from which especially the REA OBJECTIVE, STAKEHOLDER NEEDS, and REA REQUIREMENTS are necessary input. On this basis, COMPONENT 8 produces the REA APPLICATION DESIGN, a DISSEMINATION STRATEGY, and COMMUNICATION MATERIAL. The REA APPLICATION DESIGN consists of APPLICATION SCENARIOS, REA VALUE, PROBLEM STAKEHOLDERS, and STAKEHOLDER NEEDS.

TABLE 51. CONCEPTS USED IN COMPONENT 8: APPLICATION DESIGN DEVELOPMENT

INPUT	OUTPUT
PROBLEM STAKEHOLDERS	REA VALUE
STAKEHOLDER NEEDS	APPLICATION SCENARIOS
REA OBJECTIVE	REA APPLICATION DESIGN
(integrated) REA MODEL	DISSEMINATION STRATEGY

INPUT	OUTPUT
APPLICATION SCENARIOS	COMMUNICATION MATERIAL
ADJUSTMENT MECHANISMS	
REA PORTFOLIO	

6.6.1.2 COMPONENT 8: PROCEDURE AND NOTATION

Figure 68 illustrates all five steps COMPONENT 8 consists of and their execution path. All steps of this method component are mandatory. STEP 8A, STEP 8B, and STEP 8C are executed sequentially. After finishing STEP 8C, one can conduct STEP 8D and STEP 8E in parallel. The remainder of this section explains them in detail.

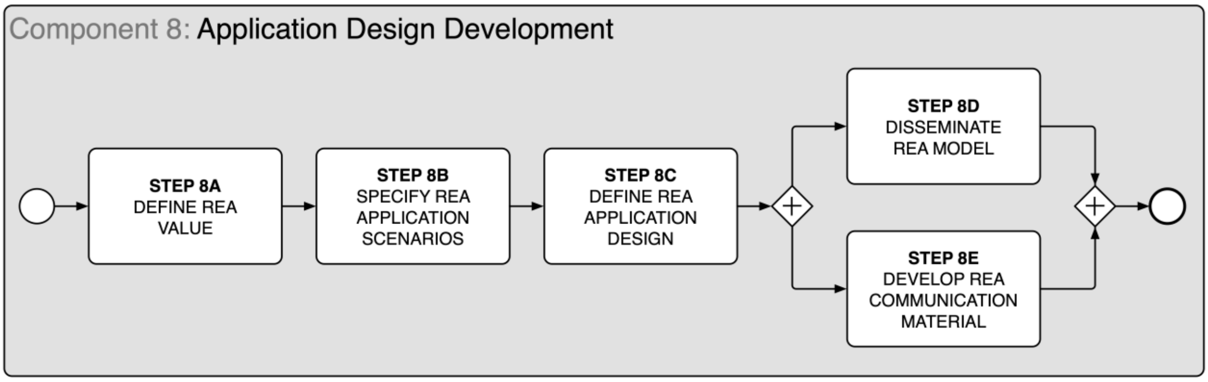


FIGURE 68. PROCEDURE OF METHOD COMPONENT 8: APPLICATION DESIGN DEVELOPMENT

STEP 8A: DEFINE REA VALUE

INPUT: PROBLEM STAKEHOLDER (from STEP 1C), STAKEHOLDER NEEDS (from STEP 1C), REA OBJECTIVE (from STEP 1D), (integrated) REA MODEL (from STEP 7E)

STEP DESCRIPTION: STEP 8A aims to clarify what value the developed REA does provide to the addressed PROBLEM STAKEHOLDERS. While the reference modeling domain identifies many generic types of value, each REA will further offer values that are specific to its addressed PROBLEM DOMAIN. Moreover, not all values are offered to all PROBLEM STAKEHOLDERS equally. For identifying the REA VALUES provided, the STAKEHOLDER NEEDS defined by COMPONENT 1 from PHASE (A) form the basis. However, these have to be augmented by the insights gained during the REA construction during PHASE (B) since the developed REA Model might reveal the potential value the REA preparation did not identify during PHASE (A).
As a starting point, REAM provides a list of generic REA Values. It consists of values from the KBA as documented in Table 24. Looking at the list, one recognizes that it concretizes the overall values research literature ascribes towards reference models, as documented in Schütte (1998), Fettke and Loos (2004b), Becker and Knackstedt (2003), and Fettke and Loos (2006).

Generic REA VALUES:

- shared understanding and communication improvement
- higher efficiency of EA initiatives (time, costs)
- quality improvement of EA initiatives
- supporting transformation process of EA
- interoperability improvement (e.g., within EA or to other organizations)
- enable more efficient decision-making processes
- risk mitigation

- facilitating regulatory compliance
- improving understanding of impacting external factors
- cost reduction of EA initiatives
- benchmarking with industry
- facilitating employee training

Based on these generic REA VALUES, the REA Team shall analyze STAKEHOLDER NEEDS and produce a list of REA VALUES.

OUTPUT: REA VALUE

RECOMMENDED METHODS: STEP 8A does not use any specific methods.

TOOLS AND NOTATION: STEP 8A does not use any specific tools or notations. However, the step shall result in a documented list of REA VALUES that are related to STAKEHOLDER NEEDS.

STEP 8B: SPECIFY REA APPLICATION SCENARIOS

INPUT: PROBLEM STAKEHOLDER (from STEP 1C), STAKEHOLDER NEEDS (from STEP 1C), REA OBJECTIVE (from STEP 1D), APPLICATION SCENARIOS (from STEP 2A), REA Value (STEP 8A)

STEP DESCRIPTION: Based on the defined REA VALUE and PROBLEM STAKEHOLDERS, STEP 8B aims to revise the APPLICATION SCENARIOS that developed in COMPONENT 2 during PHASE (A). In concrete, the REA Team shall make previously sketched APPLICATION SCENARIOS more concrete and applicable from an REA user's perspective. Therefore, a thorough description specifies each APPLICATION SCENARIO, a linkage to PROBLEM STAKEHOLDERS it addresses, the anticipated REA VALUE it offers, and the dimension of the application. The dimensions of REA application refer to specific characteristics that describe the way the REA MODEL is applied in a particular application case. Initially defined by Fettke (2008) for reference models in general, REAM adapts them to REA MODELS: breath, detail, depth, volume, and use of language the REA is applied by the REA user (see section 3.2.3).

OUTPUT: APPLICATION SCENARIOS

RECOMMENDED METHODS: STEP 8B does not use any specific methods.

TOOLS AND NOTATION: STEP 8B does not use any specific tools or notations. However, the step shall result in a documented list of APPLICATION SCENARIOS that are specified as described above.

STEP 8C: DEFINE REA APPLICATION DESIGN

INPUT: ADJUSTMENT MECHANISMS (from STEP 2A), (integrated) REA MODEL (from STEP 7E), APPLICATION SCENARIOS (from STEP 8B)

STEP DESCRIPTION: PHASE (B) embedded ADJUSTMENT MECHANISMS within the REA MODEL (see STEP 6B and STEP 7E). On this basis, STEP 8C defines what ADJUSTMENT MECHANISMS to use in a concrete APPLICATION SCENARIO and how this affects the respective application process from a user's perspective. While most APPLICATION SCENARIOS might utilize the same ADJUSTMENT MECHANISMS, in some cases, this might differ. These ADJUSTMENT MECHANISMS refer to REA adjustments that have been anticipated by the REA Team, as Schütte (1998) and Delfmann (2006) define. Additionally, they argue that REA users usually need to make case-specific adjustments the RCO TEAM did not anticipate. Hence, REAM recommends to capture such case-specific adjustments based on experience gained during concrete REA application cases over time. In the end, STEP 8C produces the REA APPLICATION DESIGN. It consists of the APPLICATION SCENARIOS and defines what ADJUSTMENT MECHANISMS to use in which APPLICATION SCENARIO.

OUTPUT: REA APPLICATION DESIGN

RECOMMENDED METHODS: STEP 8C does not use any specific methods.

TOOLS AND NOTATION: STEP 8C does not use any specific tools or notations. However, it is necessary to document the produced REA APPLICATION DESIGN using a systematic structure.

STEP 8D: DISSEMINATE REA MODEL

INPUT: REA PORTFOLIO (from STEP 2D), (integrated) REA MODEL (from STEP 7E), REA APPLICATION DESIGN (from STEP 8C)

STEP DESCRIPTION: In STEP 8D, the REA Team determines how to disseminate the constructed REA. DISSEMINATION STRATEGY captures this. Depending on the overall context of the REA project, there exist manifold possibilities on how to distribute the REA MODEL to potential REA users. When defining the DISSEMINATION STRATEGY, the REA Team shall consider the following aspects:

- ✓ Who is responsible for the REA dissemination and the REA's maintenance?
- ✓ What business model to associate with the distribution of the REA?
- ✓ How to distribute and market the REA?

While a community-driven REA construction will often lead to an open-source strategy, an REA MODEL initiated within an industrial committee (e.g., working groups of industry federations) will most probably serve as a product or consulting instrument. Furthermore, some REA can be administered by an independent organization (e.g., the SCOR Model for supply chain management). As an impulse, REAM exemplifies following business models:

- *Open Source Approach:* Community-based approach, in which the community maintains the REA and makes it available.
- *(IT-) Consulting Product:* The REA is used by IT consulting firms for acquisition or even business transformation tools
- *Certification Standard:* The REA Team intends to let the REA become a standard, for which users can get certified. That requires high maturity and close cooperation with standardization, regulatory, and industrial bodies.
- *Fee-Based Approach*: The REA can be purchase by REA users.

How to distribute and market the REA again brings manifold possibilities. REAM suggest the following:

- Develop a website that covers the REA's essentials.
- In case the REA addresses a particular industry, the REA can be marketed via existing industry federations.

- A central repository storing the REA in a systematic way using a RM catalog (Fettke and Loos 2002b; González Vázquez and Appelrath 2010).

OUTPUT: DISSEMINATION STRATEGY

RECOMMENDED METHODS: STEP 8D does not use any specific methods.

TOOLS AND NOTATION: STEP 8D does not use any specific tools or notations.

STEP 8E: DEVELOP REA COMMUNICATION MATERIAL

INPUT: REA PORTFOLIO (from STEP 2D), (integrated) REA MODEL (from STEP 7E), REA APPLICATION DESIGN (from STEP 8C)

STEP DESCRIPTION: STEP 8E summarizes all material necessary for a potential REA user to get to know the REA. Its purpose and value, its overall structure, and how it can be applied. The COMMUNICATION MATERIAL aggregates this. Based on the findings of the KBA in section 4.3.5.3, REAM recommends the COMMUNICATION MATERIAL to consist of the following aspects:

- Overview on REA: PROBLEM DOMAIN, REA OBJECTIVE
- Benefits of REA: PROBLEM STAKEHOLDERS, STAKEHOLDER NEEDS, REA VALUE
- Model Overview: REA STRUCTURE and what perspectives it covers
- REA Application: Summarize the possible APPLICATION SCENARIOS, whom they address. That might include providing example use cases that illustrate the application.

OUTPUT: COMMUNICATION MATERIAL

RECOMMENDED METHODS: STEP 8E does not use any specific methods.

TOOLS AND NOTATION: STEP 8E does not use any specific tools or notations.

GUIDELINES FOR COMPONENT 8 APPLICATION DESIGN DEVELOPMENT

STEP 8C
- ✓ WHEN DEFINING ADJUSTMENT MECHANISMS, DO NOT OVERCOMPLICATE THEIR INTEGRATION IN THE REA MODEL. THE PROCESS OF APPLYING AN REA IS CASE-SPECIFIC. APPLICATION MECHANISMS' PURPOSE IS TO GUIDE THE USER BUT NOT RESTRICT THEM.
- ✓ ANALYZE EACH APPLICATION PROJECT (I.E., USING INTERVIEWS OR STANDARDIZES SURVEYS) IN ORDER TO CAPTURE INSIGHTS REGARDING CASE-SPECIFIC USER ADJUSTMENTS BY THE USER.

STEP 8E
- ✓ IF POSSIBLE, TRY TO ILLUSTRATE THE APPLICATION PROCESS OF THE REA BY DINT OF LIGHTWEIGHT APPLICATION EXAMPLE USE CASES, IDEALLY FOR EACH APPLICATION SCENARIO.
- ✓ TRY TO COLLECT REAL-WORLD USE CASES THAT CAN BE SIMPLIFIED AND USED AS A REFERENCE FOR POTENTIAL REA USERS.

6.6.2 COMPONENT 9: REA MODEL EVALUATION

The overall objective of COMPONENT 9 is to evaluate the REA. While some steps during PHASE (B) already evaluated certain aspects of the REA (e.g., STEP 4C evaluates the REA STRUCTURE), COMPONENT 9 takes a holistic perspective on REA evaluation. While there exist many ways of validating reference models in general and REA MODELS in concrete, COMPONENT 9 aims to guide the REA Team through this process. Therefore, REAM evaluates the REA MODEL regarding REA REQUIREMENTS defined in PHASE (A). REAM splits the evaluation process into two parts—each focusing on a different perspective. On the one hand, the model-centric evaluation investigates how well the REA MODEL itself meets the REA REQUIREMENTS and uses criteria such as completeness. On the other hand, the user-oriented evaluation assesses the applicability of the constructed REA in real-world scenarios. While the former perspective concerns the generalizability of the REA in the PROBLEM DOMAIN against its REA REQUIREMENTS, the latter refers to the claims of the reference modeling domain regarding a user-oriented definition of reference models (cf. section 3.1).

6.6.2.1 COMPONENT 9: USED CONCEPTS

Table 52 explains all concepts that COMPONENT 9 uses. The central inputs of COMPONENT 9 are the REA OBJECTIVE and the REA REQUIREMENTS defined in PHASE (A), the integrated REA MODEL from PHASE (B), and the REA APPLICATION DESIGN from PHASE (C). On this basis, COMPONENT 9 defines an EVALUATION STRATEGY, which determines a plan for the evaluation process and defines EVALUATION CRITERIA. The evaluation further produces IMPROVEMENT NEEDS.

TABLE 52. CONCEPTS USED IN COMPONENT 9: REA MODEL EVALUATION

INPUT	OUTPUT
REA OBJECTIVE	EVALUATION STRATEGY
REA REQUIREMENTS	EVALUATION CRITERIA
(integrated) REA MODEL	IMPROVEMENT NEEDS
REA APPLICATION DESIGN	

6.6.2.2 COMPONENT 9: PROCEDURE AND NOTATION

Figure 69 visualizes the three steps of COMPONENT 9 and their execution path. Their execution depends on several variables. First, if alterations of the EVALUATION STRATEGY are required, execute STEP 9A. That is, the first execution of COMPONENT 9 requires to conduct STEP 9A as an EVALUATION STRATEGY does not exist yet. Second, REAM requires to execute STEP 9B every time a new version of the REA MODEL evolves. Likewise to STEP 9A, it is conducted in the initial iteration of COMPONENT 9. Third and last, the REA Team shall execute STEP 9C each time the REA is applied in practice. However, this might not be possible in all cases since the REA might be applied without the guidance of REA TEAM members.

STEP 9A: DEFINE EVALUATION STRATEGY

INPUT: REA OBJECTIVE (from STEP 1D), REA REQUIREMENTS (from STEP 1D), (integrated) REA MODEL (from STEP 7E)

STEP DESCRIPTION: STEP 9A defines an EVALUATION STRATEGY based on the REA OBJECTIVE and its derived REA REQUIREMENTS. The EVALUATION STRATEGY defines how to evaluate what aspects of the REA MODEL. Thus, it consists of the following aspects:

- **EVALUATION METHOD**: What methods to use for the evaluation? What methods are feasible for the REA project context?
- **EVALUATION CRITERIA:** Define the criteria to evaluate the REA MODEL. These need to address both the model- and user-centric evaluation of the last two steps.
- **PARTICIPANTS:** Who to consult for evaluation? That especially applies to the model-centric evaluation (see STEP 9C) since, in the case of user-centric evaluation, the PROBLEM STAKEHOLDERS involved in the application process will evaluate the REA.

As the literature analysis in section 4.3.6 revealed, research lacks an approach that defines how to evaluate REAs. However, REAM suggest to use the multi-perspective framework for evaluating reference models provided by Fettke and Loos (2003) when defining an EVALUATION STRATEGY. While analytical ad-hoc or theory-driven evaluation methods apply for the model-centric evaluation in STEP

9B, empirical methods are appropriate when conducting user-centric evaluation in STEP 9C. In order to clarify the scope of an REA evaluation, one can consult the work by Frank (2006a). He proposes to investigate reference models from economic, deployment, engineering, and epistemological perspectives.

Based on the results of the KBA (see section 4.3.5.2), the most utilized criteria used for evaluating REAs are completeness, ease of use, and customizability. While analytical evaluation methods assess the former, the latter two require an empirical method. Additionally, the KBA identified further criteria. As an overview, Table 53 enumerates a selection of EVALUATION CRITERIA, defines them, and relates them to either model-centric or user-centric REA evaluation. Since the evaluation of an REA is a context-dependent task, REAM refers to related literature from the enterprise modeling domain (Timm et al. 2017a; Niemi and Pekkola 2013; Becker et al. 2012; Krogstie 2012) as well as the RM domain (Fettke and Loos 2003; Frank 2006a; van Belle 2006; Misic and Zhao 2000).

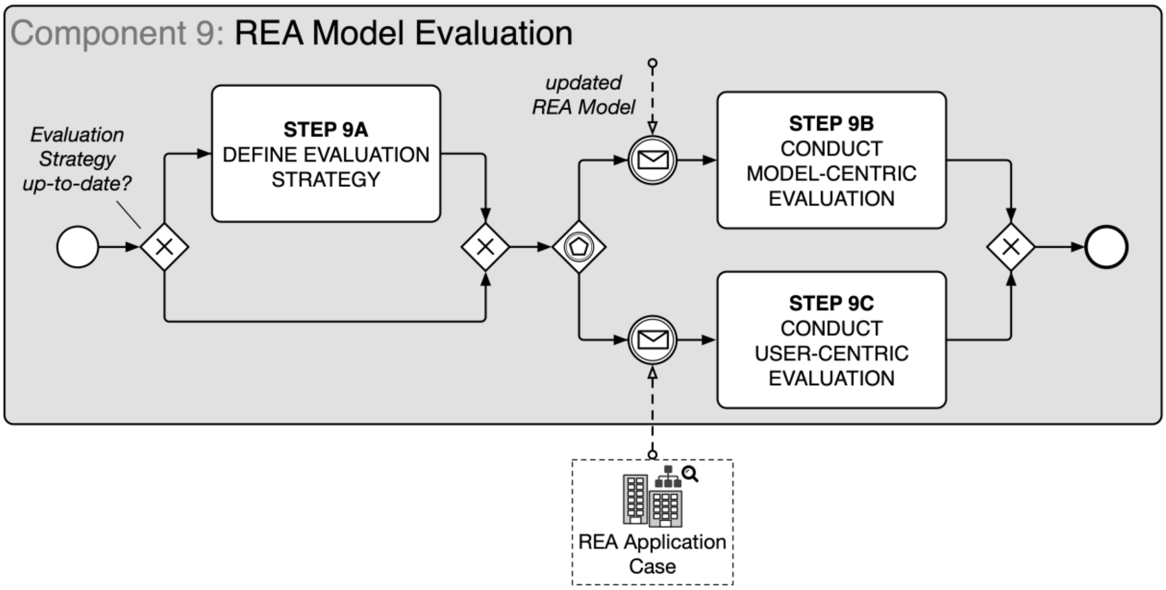


FIGURE 69. THE PROCEDURE OF METHOD COMPONENT 9: REA MODEL EVALUATION

<u>*OUTPUT:*</u> Evaluation Strategy, Evaluation Criteria

<u>*RECOMMENDED METHODS:*</u> STEP 9A does not use any specific methods.

<u>*TOOLS AND NOTATION:*</u> STEP 9A does not use any specific tools or notations.

TABLE 53. EVALUATION CRITERIA FOR CONDUCTING REA MODEL EVALUATION

PERSPECTIVE	CRITERIA	EXPLANATION	RELATED WORK
Model-Centric Evaluation (STEP 9B)	completeness	The degree to which an REA Model includes all aspects relevant to capture the Problem Domain. Sometimes also defined as semantical properness.	Johannesson and Perjons (2014, p. 111) Krogstie (2012) Lakhrouit et al. (2014) Becker et al. (2012) Spence and Michell (2016)
	correctness	The degree to which the content of an REA Model corresponds to the specifics of the Problem Domain it represents. Further, the degree to which the used REA Models complies with the chosen modeling language's specification.	Johannesson and Perjons (2014, p. 111) Krogstie (2012) Lakhrouit et al. (2014) Becker et al. (2012) Spence and Michell (2016)
	up-to-dateness	Does the REA MODEL and REA STRUCTURE represent the current situation of the PROBLEM DOMAIN?	Niemi and Pekkola (2013) Kotzampasaki (2015)
	coherence	The degree to which the parts of the REA MODEL are logical, orderly, and consistently related; coherence is low if an REA Model includes parts or viewpoints that do not fit in with the rest of the model.	Johannesson and Perjons (2014, p. 109)
	consistence	The degree to which an REA Model is free from conflicts. That may be labeling or structural conflicts.	Johannesson and Perjons (2014, p. 109)

PERSPECTIVE	CRITERIA	EXPLANATION	RELATED WORK
User-Centric Evaluation (STEP 9C)	customizability	Does the REA MODEL provide appropriate means for tailoring its context to specific STAKEHOLDER NEEDS? Do anticipated APPLICATION SCENARIOS address actual STAKEHOLDER NEEDS in practice?	Angelov et al. (2008) Czarnecki and Dietze (2017c) Kotzampasaki (2015) Nakagawa et al. (2014)
	comprehensibility	The ease with which PROBLEM STAKEHOLDERS understand the REA MODEL. Investigating this criterion relates to REA STRUCTURE, appropriate complexity, appropriate REA COMMUNICATION MATERIAL, or sufficient REA DOCUMENTATION.	Johannesson and Perjons (2014, p. 110) Kotzampasaki (2015) Niemi and Pekkola (2013) Khayami (2011) Krogstie (2012) Becker et al. (2012) Lim et al. (2009)
	availability	The degree to which the REA is accessible to the Problem Stakeholders when applying it. That further includes interoperability from both a technical and domain-specific perspective. Investigating this criterion relates to the REA DISSEMINATION STRATEGY or the REA FRAMEWORK.	Kotzampasaki (2015) Krogstie (2012) Lim et al. (2009) Lakhrouit et al. (2014)

STEP 9B: CONDUCT MODEL-CENTRIC EVALUATION

INPUT: (integrated) REA MODEL (from STEP 7E), EVALUATION STRATEGY (from STEP 9A), EVALUATION CRITERIA (from STEP 9A)

STEP DESCRIPTION: STEP 9B conducts the model-centric evaluation based. Therefore, it executes the previously defined EVALUATION STRATEGY that focuses on model-centric aspects. REAM understands the model-centric evaluation to investigate the REA's fidelity to the real world, i.e., the PROBLEM DOMAIN. Following questions shall guide the REA Team when conducting STEP 9B:

- Is the REA MODEL complete? Does it miss essential elements? (completeness)
- Does the REA MODEL reflect an appropriate level of detail? (minimality)
- Does the REA MODEL conform to the chosen modeling language standard? (syntactical validity)
- Does the REA MODEL reuse relevant standards or reference models? (minimality)
- Does the REA MODEL namespace correspond to domain-specific naming conventions? (correctness)

While it might be feasible to let REA Team members evaluate some model-centric aspects (e.g., modeling language conformance), most of the above-enlisted aspects need consultation of domain experts from the PROBLEM DOMAIN. Consequently, REAM recommends to consult following participants:

- concrete PROBLEM STAKEHOLDERS that possess a fitting role in an organization that is directly affected by the SPECIFIED PROBLEM (cf. section 6.4.1)
- domain experts from stakeholders of the Problem Domain (e.g., IT consultants, correspondents of industrial federations, independent system providers)

Depending on the participants of the model-centric evaluation, the evaluation shall use appropriate methods. After the evaluation, collect IMPROVEMENT NEEDS and document the parts of the REA MODEL they address accordingly. Depending on the implications of the IMPROVEMENT NEEDS cause in the REA MODEL, the findings of this step might trigger COMPONENT 4, COMPONENT 5, or COMPONENT 6. For instance, a missing process step in a specific viewpoint should be directly added to the REA MODEL. In contrast, in case the evaluation reveals an absence of entire business domains in the REA MODEL, it would trigger the first adjustments of the REA STRUCTURE (COMPONENT 4) and a new iteration of either or both of COMPONENTS 5 and 6.

OUTPUT: (validated) REA MODEL, IMPROVEMENT NEEDS

RECOMMENDED METHODS: Surveys, Expert Interviews, Focus Group, and similar methods.

TOOLS AND NOTATION: STEP 9B does not use any specific tools or notations. However, the REA Team shall agree on a standardized way to document IMPROVEMENT NEEDS.

STEP 9C: CONDUCT USER-CENTRIC EVALUATION

INPUT: (integrated) REA MODEL (from STEP 7E), REA APPLICATION DESIGN (from STEP 8C), EVALUATION STRATEGY (from STEP 9A), EVALUATION CRITERIA (from STEP 9A)

STEP DESCRIPTION: STEP 9C focuses on evaluating the applicability of the REA MODEL. Thus, its insights build from use cases that applied the REA in a real-world setting. According to Angelov et al. (2008, pp. 237–238), in such user-centric evaluations, PROBLEM STAKEHOLDERS apply the REA in a particular APPLICATION SCENARIO. In this context, REAM suggests to conduct STEP 9C in two ways:

a. After constructing the REA MODEL, the REA TEAM shall test it in a practical context, in which a representative PROBLEM STAKEHOLDER applies the REA (probably using a concrete APPLICATION SCENARIO)—optionally under the supervision of members from the REA TEAM.
b. The REA TEAM shall manifest a process based on STEP 9C initiated when applying the REA MODEL in practice.

While there are many ways of conducting STEP 9C, REAM suggests to use evaluation methods such as observation or action research in order to guide or supervise the REA application. In advance, the REA team needs to clarify what EVALUATION CRITERIA are evaluated in each application case (see Table 53). Guiding questions may be:

- Is the REA MODEL and the REA APPLICATION DESIGN comprehensible?
- Are ADJUSTMENTS MECHANISMS appropriate?
- Is the REA DOCUMENTATION proper and comprehensible?
- How does the REA user assess the REA VALUE?
- Does the REA agree with the APPLICATION SCENARIOS, or do involved participants identify further ones?

Furthermore, a user-centric evaluation might assess model-centric criteria as well.

OUTPUT: IMPROVEMENT NEEDS

RECOMMENDED METHODS:, Action Research, Case Study, Interview Studies, Observation

TOOLS AND NOTATION: STEP 9C does not use any specific tools or notations. However, the REA Team shall agree on a standardized way to document IMPROVEMENT NEEDS.

GUIDELINES FOR COMPONENT 9 REA MODEL EVALUATION

STEP 9A

- ✓ WHEN PLANNING THE EVALUATION, ALIGN THE EVALUATION STRATEGY TO THREE CHARACTERISTICS OF REFERENCE MODELS: GENERALIZABILITY, RECOMMENDATION, AND REUSABILITY. WHILE IT IS CRUCIAL TO CONDUCT A MODEL-CENTRIC EVALUATION, REAM SUGGESTS TO FOCUS ON REAL-WORLD SETTINGS.
- ✓ EVALUATING REAS IS A COMPLICATED TASK. ALTHOUGH IT MAY BE APPROPRIATE TO USE THEORY-DRIVEN REA EVALUATION (CF. (FETTKE AND LOOS 2003)), REAM RECOMMENDS TO PRIORITIZE EMPIRICAL EVALUATION METHODS THAT FOCUS ON THE USER'S PERCEPTION OF THE REA.

STEP 9B

- ✓ IN ORDER TO THE EVALUATION'S INFORMATION VALUE, INTRODUCE THE REA MODEL TO PARTICIPANTS IN DETAIL BEFORE CONDUCTING THE EVALUATION.
- ✓ IN SOME CASES, IT IS REASONABLE TO EVALUATE DIFFERENT PARTS OF THE REA MODEL SEPARATELY. THEREFORE, THE GROUP IDENTIFIED PARTICIPANTS TO THEIR CONCERNS/EXPERTISE REGARDING THE PROBLEM DOMAIN/ REA MODEL.
- ✓ WHEN CONDUCTING THE EVALUATION, REAM RECOMMENDS GOING THROUGH THE REA MODEL VIEWPOINT BY VIEWPOINT.
- ✓ USE A STANDARDIZED QUESTIONNAIRE TO MAKE EVALUATION ROUNDS COMPARABLE.

6.6.3 COMPONENT 10: REA MODEL MAINTENANCE

The overall objective of COMPONENT 10 is to maintain the REA MODEL over time. On the one hand, it defines a MAINTENANCE PLAN dictating when to assess the current REA MODEL against what aspects. That may include regular investigation of the PROBLEM DOMAIN and its context. On the other hand, COMPONENT 10 uses the feedback produced by COMPONENT 9 to improve the REA MODEL. Based on this feedback, the component analyzes prior identified IMPROVEMENT NEEDS and translates them into appropriate actions that trigger components and steps from PHASE (B).

6.6.3.1 COMPONENT 10: USED CONCEPTS

Table 54 explains all concepts that COMPONENT 10 uses. The central inputs are the PROBLEM DOMAIN from PHASE (A) and the IMPROVEMENT NEEDS from COMPONENT 9. On this basis, COMPONENT 10 defines a MAINTENANCE PLAN that plans regular maintenance cycles of the REA MODEL. It includes revisiting the PROBLEM DOMAIN and may produce adjusted REA REQUIREMENTS. Based on the IMPROVEMENT NEEDS, COMPONENT 10 also derives MEANS OF IMPROVEMENT that put these needs into action, i.e., triggering steps of PHASE (B).

TABLE 54. CONCEPTS USED IN COMPONENT 10: REA MODEL MAINTENANCE

INPUT	OUTPUT
PROBLEM DOMAIN	MAINTENANCE PLAN
REA REQUIREMENTS	REA REQUIREMENTS
IMPROVEMENT NEEDS	MEANS FOR IMPROVEMENT

6.6.3.2 COMPONENT 10: PROCEDURE AND NOTATION

Figure 70 visualizes the execution path of COMPONENT 10. It consists of four steps. While COMPONENT 10 executes them in sequential order, two events affect the way of executing STEPS 10B and STEP 10C. When executing the component, one starts with STEP 10A, which defines a MAINTENANCE PLAN. Afterward, there are two possible execution paths. First, according to the MAINTENANCE PLAN, STEP 10B may be executed. That may result in new insights that cause changes in the REA MODEL. Thus, STEP 10D is executed. Second, COMPONENT 9 may identify IMPROVEMENT NEEDS. These cause the execution of STEP 10D as well.

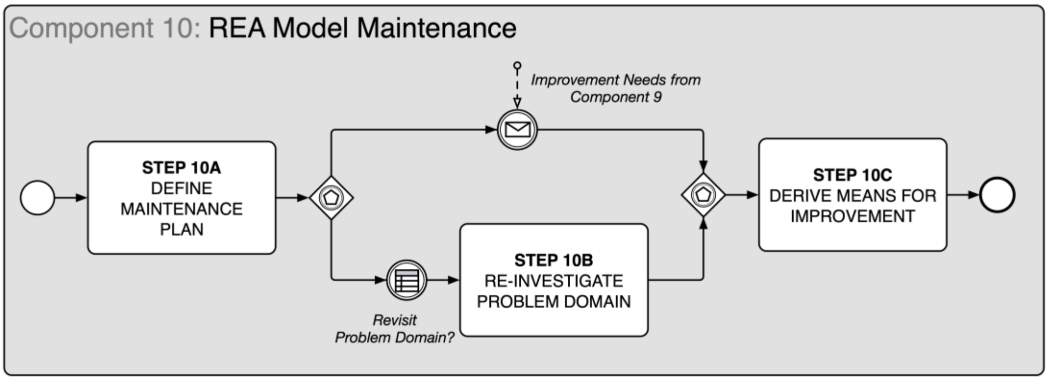


FIGURE 70. THE PROCEDURE OF METHOD COMPONENT 10: REA MODEL MAINTENANCE

STEP 10A: DEFINE MAINTENANCE PLAN

INPUT: PROBLEM DOMAIN (from STEP 1B)

STEP DESCRIPTION: STEP 10A develops a MAINTENANCE PLAN under what circumstances to re-evaluate the REA. That includes determining regular periods in time when the REA needs to be evaluated and identifying certain events that may cause a change in the context of the PROBLEM DOMAIN. The REA Team shall consider the following aspects when determining the MAINTENANCE PLAN:

- *Up-to-dateness of the REA Model*: What context variables exist in the PROBLEM DOMAIN (e.g., laws, technological change)?
- *Completeness of the REA*: Are there areas in the PROBLEM DOMAIN that shall be additionally covered by the REA?
- *Applicability of the REA:* Did the market change in a way that new potential REA users exist? Did STAKEHOLDER NEEDS change? Do new APPLICATION SCENARIOS of the REA exists?
- *Generalizability of the REA:* Do other industries face similar challenges?

OUTPUT: MAINTENANCE PLAN

RECOMMENDED METHODS: STEP 10A does not use any specific methods.

TOOLS AND NOTATION: STEP 10A does not use any specific tools or notations.

STEP 10B: RE-INVESTIGATE PROBLEM DOMAIN

INPUT: PROBLEM DOMAIN (from STEP 1B), REA REQUIREMENTS (from STEP 1D)

STEP DESCRIPTION: STEP 10B revisits the PROBLEM DOMAIN intending to monitor changes regarding REA REQUIREMENTS. Thus, STEP 10B triggers a new iteration of COMPONENT 1 from PHASE (A) in order to change requirements towards the REA.

OUTPUT: (updated) REA REQUIREMENTS

RECOMMENDED METHODS: see COMPONENT 1

TOOLS AND NOTATION: see COMPONENT 1

STEP 10C: DERIVE MEANS FOR IMPROVEMENT

INPUT: IMPROVEMENT NEEDS (from STEP 9B OR 9C), (updated) REA REQUIREMENTS (from STEP 10B)

STEP DESCRIPTION: STEP 10C analyzes the previously collected IMPROVEMENT NEEDS and derives MEANS FOR IMPROVEMENT that update the REA MODEL accordingly. Based on the respective IMPROVEMENT NEEDS, STEP 10C identifies what method component to initiate in order to implement the means. While there exist a plethora of consequences, the following list provides some examples:

- change/update/delete of specific elements or viewpoints of the REA MODEL (this does not necessarily trigger another component)
- insights from successful application cases might identify new APPLICATION SCENARIOS and REA VALUES (→ conduct COMPONENT 8)
- the evaluation identified the need to cover an additional business domain of the Problem Domain (→ conduct COMPONENT 5 or COMPONENT 6)
- a new law has been passed, which relates to the Problem Domain (→ conduct COMPONENT 9 in order to identify IMPROVEMENT NEEDS the REA MODEL accordingly)

OUTPUT: MEANS FOR IMPROVEMENT

RECOMMENDED METHODS: STEP 10C does not use any specific methods.

TOOLS AND NOTATION: STEP 10C does not use any specific tools or notations. However, the REA Team shall document IMPROVEMENT NEEDS and MEANS FOR IMPROVEMENT in a transparent manner.

GUIDELINES FOR COMPONENT 10 REA MODEL MAINTENANCE

STEP 10A
- ✓ DEFINE MEMBERS OF THE REA TEAM THAT ARE RESPONSIBLE FOR THIS TASK. DEPENDING ON CHOICES MADE DURING STEP 8D, THIS MAY BE AN ACTOR FROM WITHIN THE ORGANIZATION THAT MANAGES THE REA MODEL.

6.6.4 A REFERENCE COMPLIANCE ORGANIZATION: APPLICATION PHASE

6.6.4.1 COMPONENT 8: RCO APPLICATION DESIGN

As described in section 6.6.1, the RCO Team defined an RCO APPLICATION DESIGN using the five steps defined by REAM's COMPONENT 8. Based on the findings of PHASE (A) and in consultation with the domain experts of the focus group, the following RCO VALUES were identified (STEP 8A):

- ❖ **Cost reduction:** Applying the RCO helps institutes to avoid penalty charges as well as a reduction of development costs for regulation-specific software development.
- ❖ **Quality improvement:** Transforming isolated RCM solutions into an integrated and IS supported state by applying best practice approaches enhances the RCM's quality.
- ❖ **Risk mitigation:** The application of the RCO mitigates the risk of the institute's reputational and financial damage in case of an unidentified case of money laundering or fraud.
- ❖ **Time and effort reduction:** Applying the RCO saves the time and effort to build a holistic RCM from scratch or to implement regulatory changes manually.

After the RCO VALUES had been identified, the RCO TEAM further identified RCO APPLICATION SCENARIOS (Step 8b). Since comprehensive APPLICATION SCENARIOS need to related to addressed PROBLEM STAKEHOLDERS and offered RCO VALUES, the RCO formulated several scenarios. These were first derived by prior identified STAKEHOLDER NEEDS and then discussed with the domain experts from the focus group. Table 55 provides the list of the resulting five RCO APPLICATION SCENARIOS.

TABLE 55. APPLICATION SCENARIOS OF THE RCO

#	APPLICATION SCENARIO	PROBLEM STAKEHOLDER	RELATED RCO VALUE
(I)	GAP Analysis with Individual Models	Financial institute	• risk mitigation • RCM quality improvement
(II)	Building/ Extending a coherent RCM	Financial institute	• cost and time reduction • risk mitigation • RCM quality improvement
(III)	Improvement or Development of Compliance Software	ISV	• decrease of development time • product quality improvement
(IV)	Analysis of new regulations	Financial institute, ISV, consultancies, accountancy firms	• decrease time of implementation • improve integration quality
(V)	Personnel Training	Financial institutes, ISV, consultancies, accountancy firms	• knowledge transfer • risk mitigation

Next, the RCO Team conducted Step 8c. Thus, the RCO TEAM documented what ADJUSTMENT MECHANISMS to embed within the RCO MODEL'S design. As described in section 6.6.1, this includes anticipated ADJUSTMENT MECHANISMS and case-specific adjustments. The RCO TEAM decided to define the principles of aggregation and specialization as ADJUSTMENT MECHANISMS. The different regulatory domains (e.g., AML) can be applied as modules or also be aggregated in order to utilize synergy effects when expanding the model scope. Moreover, the RCO does not intend to cover the plethora of enterprise specifics for a single RCO user. Thus, the RCO MODEL indicates where RCO users have to specialize in certain aspects (e.g., specific processes or application landscapes). Although it might be desirable to use configuration when applying the RCO, the RCO TEAM concluded that this was not feasible since the RCO addresses different PROBLEM STAKEHOLDERS that use different APPLICATION SCENARIOS when applying the RCO. The RCO TEAM further discussed to use instantiation, but similarly to the configuration mechanisms, the RCO would lose its flexibility as this would imply to restrict the RCO user to choose from predefined placeholders. Lastly, analogy would give RCO users too much freedom. Since the RCO contents compliance processes, this was disqualified as well. Next to these ADJUSTMENT MECHANISMS, the RCO user most likely will require adjustments, which the RCO Team did not anticipate during the RCO construction. Based on experiences in applying the model, the RCO Team identified the need to mark compulsory RCO Model elements (e.g., aspects that are required by regulations) and optional elements, which may include best practices that improve the RCM but may not be necessary to comply with the law.

Subsequently, the RCO Team analyzed all material that had been developed until then, i.e., during PHASE (A), PHASE (B), and previous steps of COMPONENT 8, in order to summarize relevant aspects to the RCO COMMUNICATION MATERIAL (STEP 8E). It resulted in a document package containing:

- A document that summarized the TOGAF framework and introduced chooses modeling language ArchiMate. Further, the document explained the layers and elements of the modeling language, on which the RCO focuses.
- A PDF and HTML Report on the RCO STRUCTURE and high-level perspectives. That included the explanation of the several viewpoints utilized by the RCO STRUCTURE.
- A document that summarized the RCO APPLICATION DESIGN and exemplified how to apply the RCO using an example. The example built from a concrete real-world application case that was supervised by RCO Team members. The use case related to Application Scenario (I) Gap Analysis from Table 55.

Simultaneously, the RCO Team discussed how the RCO should be disseminated (STEP 8D). The resulting DISSEMINATION STRATEGY identified two separate dissemination paths. The first path was a logical conclusion from the RCO project constellation. ISV and consultancy members of the federation's working group for financial service compliance intended to use the final RCO MODEL as an IT and consultancy product. While the former group aimed to use the RCO as a reference to enhance their IT products and during the acquisition process of the clients, the latter used it as a tool for consulting projects, in which clients from the financial industry were involved. The second path, in contrast, aimed to manage the RCO beyond the project's scope. That included the maintenance and extension of the RCO MODEL as well as its dissemination to other potential PROBLEM STAKEHOLDERS. Therefore, the independent institute for regulatory management involved in the RCO project, was chosen to be responsible for these tasks. Future activities included extending the RCO to other RCM topics and involving regulatory bodies in future construction endeavors.

6.6.4.2 COMPONENT 9: EVALUATING THE RCO MODEL

In order to assess the RCO's generalizability, character of recommendation, and reusability, the RCO Team conducted COMPONENT 9. First, the EVALUATION STRATEGY was determined (STEP 9A). The RCO TEAM proposed it to the focus group. That resulted in the following evaluation design:

Model-Centric RCO Evaluation (STEP 9B):

- Evaluation Method: The team decided to use a feature-based evaluation (cf. Fettke and Loos (2003)) because of the lack of metrics for identified evaluation criteria. The RCO REQUIREMENTS represented the features. In concrete, the RCO Team conducted eight expert interviews, while several domain experts participated during each interview.
- Evaluation Criteria: completeness, correctness, consistency, coherence, comprehensibility
- Participants: 19 domain experts from eight ISVs and IT consultancies from the financial service domain:
  - IT consultants
  - software developers
  - key account manager
  - chief executives
  - software product managers
  - compliance managers

User-Centric RCO Evaluation (STEP 9C):

- Evaluation Method: User-centric evaluation relates to empirical evaluation methods (cf. Fettke and Loos (2003)). Since after completing the RCO MODEL, two real-world application use cases were already determined, the RCO TEAM decided to conduct a test for user-centric evaluation. Following evaluation methods were utilized for the two use cases:
  - Case 1: Action Research
  - Case 2: Case Study
- Evaluation Criteria: ease of use, comprehensibility, correctness
- Participants:
  - Case 1: Compliance Officer, Anti-Money Laundering Officer of a German savings bank
  - Case 2: software product manager, compliance officer of an ISV

Accordingly, the RCO Team conducted STEP 9B and 9C. As summarized above, the RCO TEAM conducted eight validation workshops with 18 experts from seven ISVs and IT consultancies for model-centric evaluation. The participants ranged from compliance software product managers to IT developers and IT consultants as well as chief executives. Based on a standardized questionnaire, the RCO TEAM discussed each element of the RCO and their meaning, relevance, and relation to other elements. One workshop lasted one day, whereby each module of AML, KYC, and Fraud was evaluated at least four times in total. Each workshop started with an assessment of the RCO's overall objective, structure. In the end, the participants discussed the RCO APPLICATION DESIGN. As a result, the evaluation assessed RCO's level of detail sufficient. Further, the participants estimated the model to be coherent across the different modules. The core result of this episode was an improved RCO MODEL since the experts' knowledge was used to answer open modeling questions (e.g., the relations among elements) and corrected mistakes, which emerged during the modeling process (e.g., misunderstood answers during the interview study). Further, the evaluation identified the application layer to be too generic. The expertise of the participants provided additional material in this regard. In terms of comprehensibility, the participants advised to develop additional viewpoint for each RCM domain, which represent familiar systemizations like the lines-of-defense model. Further, it was required to include control statements in the RCO representing regulatory requirements and relate them to the respective elements of the RCO MODEL. Moreover, participants assessed the APPLICATION SCENARIOS as valid.

For user-centric RCO evaluation, the two use cases assessed the RCO MODEL regarding ease of use, correctness, and comprehensibility. In Case 1, the RCO TEAM conducted action research at a German savings bank. On a two-day workshop with a focus on AML and KYC related processes and IT solutions, the RCO TEAM conducted a gap analysis between the RCO and the current situation of the savings bank (APPLICATION SCENARIO (I) from Table 55). After the workshop, the team interviewed the participants about the RCO's ease of use and correctness (REQ 4 and REQ5 from Table 41). They stated that the gap analysis helped them to identify room for improvement in their RCM approach, which validated the associated RCO VALUE. Even though their compliance processes—namely customer identification and AML case management—were thoroughly implemented, the detailed data layer and its relations with the different domains of the business layer helped them to structure their RCM from a more holistic perspective (REQ1 and REQ3). The compliance officer especially named the RCO's expressive power and the visualized gap analysis as a reason to apply it.

Further, the results of Case 1 validated the overall correctness of the RCO MODEL and extended the AML domain with enhanced details regarding AML case reporting. In Case 2, the RCO TEAM conducted a case study. An ISV applied the RCO to develop a new compliance software product for AML case documentation. In the application case, the RCO was used to identify potential new markets in the field of RCM (APPLICATION SCENARIO (III) from Table 55). The RCO revealed that a prior developed IT solution of the ISV might cover a specific need for IS support in the process of AML case management. The ISV's customer base validated the identified need. Afterward, the ISV emphasized the advantage of the RCO to discover synergies using the integrated perspective of different RCM domains that expands the legal demands by practical experience (REQ2).

To summarize, the following list gives some examples of IMPROVEMENT NEEDS the evaluation of the RCO MODEL identified after conducting COMPONENT 9:

- ❖ **IMPROVEMENT NEED 1:** extend RCO STRUCTURE by modeling regulatory requirements (model-centric evaluation)
- ❖ **IMPROVEMENT NEED 2:** extend RCO STRUCTURE by viewpoint that relates the compliance process to lines-of-defense systemization (model-centric evaluation)
- ❖ **IMPROVEMENT NEED 3:** update the AML viewpoints adding more level of detail regarding AML case reporting

6.6.4.3 COMPONENT 10: MAINTAINING THE RCO MODEL

As described in section 6.6.4.1, the RCO Team decided that an independent academic institute is responsible for maintaining the RCO MODEL. As part of STEP 10A, the RCO Team defined a MAINTENANCE PLAN for the RCO. At the time of writing this Ph.D. thesis, maintaining the RCO primarily considered its up-to-dateness. Since the RCO addresses the PROBLEM DOMAIN of RCM in the financial industry, the main task is monitoring the regulatory landscape in terms of new or updated laws.

After completing the RCO MODEL, there have been several updates in the PROBLEM DOMAIN, that causes the execution of STEP 10B. Two examples of that are the General Data Protection Regulation (GDPR) by the European Union, implemented in May 2018, and an amendment of the European Directive regarding AML (European Union 2018). After analyzing these regulations, this resulted in two further IMPROVEMENT NEEDS:

- ❖ **IMPROVEMENT NEED 4:** develop a viewpoint that puts a GDPR lens on the data layer of the RCO MODEL (STEP 10B)
- ❖ **IMPROVEMENT NEED 5:** update the AML domain of the RCO MODEL (STEP 10B)

As both COMPONENT 9 and STEP 10B identified IMPROVEMENT NEEDS, the RCO TEAM executed STEP 10C several times. Depending on the particular needs, following MEANS FOR IMPROVEMENT were implemented:

- ✓ **MEANS FOR IMPROVEMENT 1:** Conduct COMPONENT 5 as deductive reasoning can be used to derive requirements from regulatory texts (IMPROVEMENT NEED 1).
- ✓ **MEANS FOR IMPROVEMENT 2:** Conduct COMPONENT 4 as IMPROVEMENT NEED 2 requires a new viewpoint on existing RCO MODEL elements (IMPROVEMENT NEED 2).
- ✓ **MEANS FOR IMPROVEMENT 3:** Conduct COMPONENT 7 as the insights from Case 1 provided useful insights for AML case reporting (IMPROVEMENT NEED 3).
- ✓ **MEANS FOR IMPROVEMENT 4:** Conduct both COMPONENT 4 and COMPONENT 5 in order to realize IMPROVEMENT NEED 4. First, the RCO STRUCTURE was extended by a GDPR viewpoint. Nevertheless, it was also necessary to analyze general knowledge regarding GDPR in order to define high-risk data in that concern.
- ✓ **MEANS FOR IMPROVEMENT 5:** Conduct COMPONENT 5 as new regulatory requirements may require re-designing the AML domain of the RCO. If essential changes need to be made, COMPONENT 6 may need to be conducted as well (IMPROVEMENT NEED 5).

To illustrate the results, Figure 71 visualizes the results implementing MEANS FOR IMPROVEMENT 2. It structures the KYC Process Viewpoint (see Figure 66) by dint of the three lines of defense model. While customer identification processes refer to the first line (i.e., the front office), diligence and risk management processes are conducted on the second line (i.e., the back office). Additionally, the third line of defense monitors and governs all these processes (i.e., internal revision).

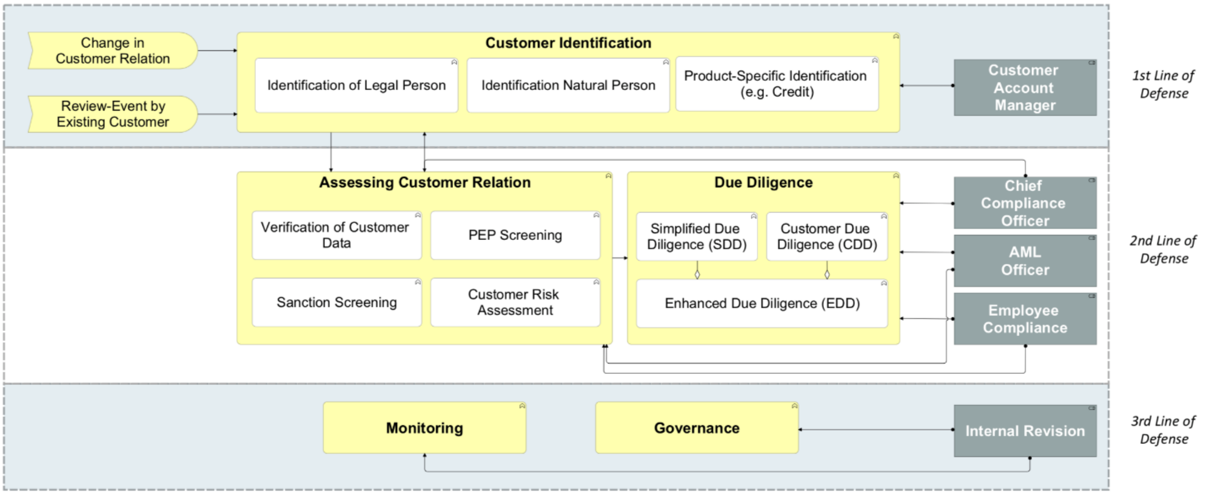


FIGURE 71. DOMAIN-SPECIFIC STRUCTURE OF RCO VIEWPOINTS

6.7 REFLECTING ON REAM DESIGN

After the previous sections presented REAM from different angles and demonstrated its application in a real-world use case, this section revisits the design of REAM from different angles. Therefore, section 6.7.1 discusses design decisions taken during REAM development. Then, section 6.7.2 provides transparency regarding knowledge reuse of REAM as it highlights what parts of REAM reuse existing methods from the RM and EAM research domains.

6.7.1 DESIGN RATIONALES BEHIND REAM

According to Johannesson and Perjons (2014, p. 124) a thorough artifact documentation includes reflecting and justifying design decisions designers took during the development. Design rationales capture such decisions. *Design rationales* represent design decisions and the arguments that led to them. Table 56 presents all major design decisions made during the development of REAM. The table explains the design rationales behind each decision. Further, the explanation refers to one of the three phases of

REAM development as introduced in chapter IV, i.e., early phase, development phase, or late phase. Moreover, Table 56 indicates the related REAM Components and Steps.

TABLE 56. DESIGN RATIONALES OF REAM

#	DESIGN DECISION	DESIGN RATIONALE	COMPONENT/STEP
1	Phase Concept of REAM	One major design decision of REAM was to adjust its underlying method conceptualization and to divide the execution REAM into three phases. This decision evolved in the late phase of the DSR project. Its central reason was that the author realized that REA construction might be conducted iteratively and in several iterations. While most RM methods do simply integrate RM application as a last activity of a cycle, REAM uses the phase-based approach instead. To keep REAM design consistent, REAM further adds a preparation step that separates planning activities from the ones that construct the REA.	PHASE (A) PHASE (B) PHASE (C)
2	REAM combines Induction and Deduction	During the early phase, the author decided to integrate both inductive and deductive reasoning within REAM design. The rationale behind this decision was to profit from the advantages of both approaches (see chapter III). Combining inductive and deductive reasoning in a method is also demanded by recent RM literature (Rehse et al. 2016; Scholta et al. 2019).	COMPONENT 5 COMPONENT 6
3	Split Deductive Reasoning Activities into COMPONENT 4 and COMPONENT 5	PHASE (B) highlights that inductive and deductive construction strategies are optional, and their execution depends on the project context. However, the author decided to define another REAM method component that uses deductive reasoning for REA construction during the development phase. Therefore, COMPONENT 4 was defined. It uses deduction to create a REA STRUCTURE. In contrast to COMPONENT 5, here, deductive reasoning informs structural design decisions and does not focus on the actual content of the REA (e.g., concrete business processes or data structures). The results of several evaluation episodes backed that decision (see chapter VII). Defining REA STRUCTURE was the starting point of each REA development and helped to form the scope of subsequent knowledge elicitation steps of either COMPONENT 5 or COMPONENT 6 (or both). In the course of the DSR iterations, the author recognized that available knowledge in the form of related (academic or industry) documents and expertise (stakeholders or experts) played an essential part in forming the REA STRUCTURE and high-level elements. Consequently, the author decided to define the execution of COMPONENT 4 as mandatory. It helps to translate	COMPONENT 4
4	REA Evaluation throughout REAM execution.	During the first application of REAM's first version, the author observed the necessity to evaluate certain aspects of the REA throughout the development process. As the REA construction is a complex and iterative process, the author decided to evaluate activities from two different perspectives. First, REAM integrates evaluation activities within components that contribute directly to the REA model construction (e.g. COMPONENT 4 produces the REA STRUCTURE). This is especially important as the validity of these components' outputs strongly influence the quality of remaining REAM outputs (i.e. an invalid REA STRUCTURE may lead to a misinformed elicitation of INDIVIDUAL MODELS for inductive reasoning). Second, COMPONENT 9 "REA MODEL EVALUATION" in PHASE (C) provides means how to evaluate the produced REA from a holistic angle.	STEP 4C (COMPONENT 4) STEP 5D (COMPONENT 5) STEP 6I (COMPONENT 6) STEP 7B-D (COMPONENT 7) COMPONENT 9
5	Model-Centric and User-Centric REA Evaluation	In the late phase of the DSR projects, the author recognized that REAM should evaluate the finalized REA from two distinct perspectives: one perspective that evaluates the REA's fidelity to the PROBLEM DOMAIN and one perspective that investigates how PROBLEM STAKEHOLDERS assess the REA while applying it. Consequently, COMPONENT 6 distinguishes between model-centric and user-centric evaluation activities. Related research agrees with this. Regarding the evaluation framework defined by Fettke and Loos (2003), the former relates to analytical evaluation, while the latter addresses empirical evaluation.	STEPS 9B AND STEP 9C (COMPONENT 9)
6	ADJUSTMENT MECHANISMS represent Design Principles	During the development phase, the author decided to include the concept of design principles as proposed by Vom Brocke (2006) in REAM. While vom Brocke states that they are used both "for reuse" (i.e., during construction) and "with reuse" (i.e., during application), REAM primarily relates to the latter and provides means how to embed them into the REA MODEL. REAM refers to this concept as "ADJUSTMENT MECHANISMS." Their definition and usage spans through all phases of REAM. When developing the REA APPLICATION DESING in COMPONENT 8 of PHASE (C), this helps to define mechanics for applying the REA in practice. To do so, the REA TEAM needs to be aware of ADJUSTMENT MECHANISMS during PHASE (A) in order to acquire the necessary knowledge accordingly later on. That is in line with recent research on RM (Rehse and Fettke 2019). However, the using ADJUSTMENT MECHANISMS is optional as it also increases the effort for REA construction.	STEP 2A (COMPONENT 2) STEP 6B (COMPONENT 6) STEP 7E (COMPONENT 7) STEP 8C (COMPONENT 8)
8	Including a Component for REA MAINTENANCE	At the late phase of REAM development, the author decided to define a last method component that focuses on maintaining the REA. While applying REAM in the COFIN project, the RCO TEAM realized that regulatory requirements changed during the RCO construction (see section 6.6.4.3). This required revisiting developed REA MODEL parts. Consequently, the author decided to embed such a revision process in PHASE (C) of REAM. Thus, COMPONENT 10	COMPONENT 10

#	DESIGN DECISION	DESIGN RATIONALE	COMPONENT/STEP
		was defined. Besides monitoring the REA's context for such changes, COMPONENT 10 further analyzes IMPROVEMENT NEEDS identified during REA evaluation and translates them into MEANS FOR IMPROVEMENT. As a result, Component 10 encapsulates the process that decides what REAM parts to execute again in order to fulfill identified IMPROVEMENT NEEDS.	
9	Exclude actual application of REA from REAM method	Although PHASE (C) of REAM addresses the application aspect of the REA, it does not explicitly provide an application process from the perspective of REA MODEL users. In contrast, COMPONENT 8 focuses on preparing the developed REA for its application. While considered throughout REAM development process, the author finally dismissed such a process. The rationale behind this had several reasons. First, the author intends to keep the focus of the already complex REAM clear. Second, developing a generally valid process for REA application would have implied further DSR iterations that analyze real-world applications of different REAs. The author understood this aspect out of this PhD's scope. Third, there already exist some approaches that provide a procedure on how to apply reference models or REA in specific. REAM refers to these in this regard: (Czarnecki and Dietze 2017c; Kotzampasaki 2015; Rodriguez 2018; Delfmann 2006; Schütte 1998; Becker and Knackstedt 2003)	PHASE (C)
10	Including the Concept of APPLICATION SCENARIOS	In the late phase of REAM development, the author discovered the various reasons that can lead to applying an REA. As shown by Table 40, a diversity of stakeholders may have an interest in applying an REA. Further, their interest may differ as their STAKEHOLDER NEEDS differ, too. In order to tailor an REA towards this diversity of needs, the author introduced the concept of APPLICATION SCENARIOS. They encapsulate homogenous groups of STAKEHOLDER NEEDS and provide means on how to apply the REA accordingly.	STEP 2A (COMPONENT 2) COMPONENT 8
11	Defining the REA PORTFOLIO	In the late phase of REAM development, the author learned that the scope definition and domain analysis during PHASE (A) produced many results that have a significant combined influence on REAM development. As an REA development project may last over a more extended period, the author, therefore, decided to define the REA PORTFOLIO as a central concept that summarizes relevant REAM results affecting the construction of the REA and is under constant review throughout REAM execution.	STEP 2D (COMPONENT 2)

6.7.2 KNOWLEDGE REUSED BY REAM

In order to ensure scientific rigor, REAM reuses existing knowledge from the domains of RM and EAM (cf. chapter III). In concrete, certain parts of REAM refer to existing methods or adjust them to the specifics of REAM context. For instance, PHASE (C) refers to existing procedures for applying reference models from a user perspective (cf. #10 of Table 56). Likewise, the inductive REA construction during COMPONENT 6 borrows from existing inductive RM methods (see section 6.5.6.4).

REAM method documentation of this chapter makes this transparent in two ways. First, in the case a REAM component or specific component step reuses such knowledge, this is documented in the respective section. Second, Table 57 provides an overview that enumerates this knowledge reuse. It relates all method components to a corresponding work from which it borrows. Further, Table 57 shortly identifies the knowledge that REAM reused. As the table shows, REAM covers the general activities established by the methods for RM, but dives deeper in certain activities in order to cover REA specifics.

TABLE 57. OVERVIEW ON HOW REAM REUSES EXISTING KNOWLEDGE

REAM PART	REUSED WORK	REUSED ASPECT
COMPONENT 1	Schütte (1998) Becker and Knackstedt (2002)	Problem Definition Phase of Reference Modeling Methods
STEP 1A	see Table 27 in section 4.3.5.1	Driver for an REA
STEP 1B	Fattah (2009) Wiermeier and Haberfellner (2007)	taxonomies to demarcate REA PROBLEM DOMAIN
STEP 1C	see Table 25 in section 4.3.5.1	list of potential PROBLEM STAKEHOLDERS of the REA
STEP 1D	Sommerville (1997) Robertson and Robertson (1999) Pohl (2010)	refers to requirements engineering methods
STEP 2A	Thomas (2005)	reuse-oriented understanding of REA
	Vom Brocke (2006)	Design Principles as the basis for ADJUSTMENT MECHANISMS
STEP 2C	Kitchenham (2004) Vom Brocke et al. (2009) Webster and Watson (2002)	Methods for Conducting Systematic Literature Reviews
COMPONENT 3	Schütte (1998)	Define the Structure of the Reference Model
STEP 3A	Bui (2017) Matthes (2011) Schekkerman (2006)	Overview of available EA Frameworks
STEP 3C	Schekkerman (2011)	Criteria for EA Tool Selection
COMPONENT 4	Schütte (1998)	Model Structure Construction Phase of Schütte's Method
COMPONENT 5	Schütte (1998) Becker and Knackstedt (2002)	Reference Modeling Methods often refer to this as "reference modeling."
COMPONENT 6	Fettke (2014) Rehse and Fettke (2019)	Component 6 adjusts the procedure of inductive reference modeling approaches to REA specifics. Further, it adds STEP 6A, STEP 6B, STEP 6C, AND STEP 6H.
STEP 6B and STEP 6D	Timm et al. (2015a)	Reuses the Template and Guidelines for Conducting Elicitation Workshops
STEP 7E	Vom Brocke (2006) Rehse and Fettke (2019)	enriches REA MODEL regarding chosen ADJUSTMENT MECHANISMS
COMPONENT 8	Schütte (1998) Becker and Knackstedt (2002) Delfmann (2006) Vom Brocke (2006)	COMPONENT 8 generally relates to the application of the REA MODEL. However, it focuses more on the preparation to apply it rather than the application process itself.
STEP 8A	Becker and Knackstedt (2002) Schütte (1998) Fettke and Loos (2006)	reuses general RM values
STEP 8B	Fettke (2008)	Application Scenarios reuses dimensions concept of RM application
STEP 8C	Schütte (1998) Delfmann (2006)	REAM reuses the two perspectives regarding adjustments during RM application
COMPONENT 9	Schütte (1998) Becker and Knackstedt (2002) Delfmann (2006) Fettke and Loos (2002a)	As addressed by known reference modeling methods, COMPONENT 9 addresses REA MODEL evaluation
STEP 9A	see Table 29	reuses list of EVALUATION CRITERIA for REA Model evaluation found in knowledge base

VII. REAM EVALUATION

The purpose of an evaluation is to investigate an artifact's utility, which is to address the question of how well it solves the explicated problem and fulfills formulated requirements (Johannesson and Perjons 2014, p. 137). Consequently, evaluating REAM examines whether it provides methodological guidance to construct a Reference Enterprise Architecture (REA), which represents adequate knowledge regarding a specified problem in a particular problem domain, and applies to its practice. Moreover, the evaluation shall assess REAM's performance regarding the five functional and three non-functional requirements defined earlier in chapter IV. The following sections present the evaluation of REAM, its results, and general conclusions the author draws from them. After section 7.1 presents the evaluation design and the rationale behind it, section 7.2 then discusses the seven evaluation episodes conducted as well as its results. Finally, section 7.3 gives conclusions by providing an aggregated perspective on REAM evaluation.

7.1 DESIGNING THE EVALUATION

For designing the evaluation, the author applied the Framework for Evaluation in Design Science (FEDS) proposed by Venable et al. (2016). This section focuses on how the author adapted the four-step procedure suggested by FEDS. That procedure starts defining overall evaluation goals (section 7.1.1), then to choose an adequate evaluation strategy that is likely to fulfill these goals (section 7.1.2), to identify relevant evaluation properties to be investigated during the evaluation (section 7.1.3), and finally, to design a trajectory of evaluation episodes that put previous aspects into practice (section 7.1.4).

7.1.1 REAM EVALUATION GOALS

According to Johannesson and Perjons (2014, p. 141), each DSR evaluation strategy is determined by the context in which it is conducted. Consequently, this section describes the evaluation context of REAM by discussing resources such as time, people, and access to users that have been available for the author. Afterward, the section defines evaluation goals.

The author evaluated REAM in the context of two research projects—the ECLORA project for developing a *UTILITY REA* and the COFIN project for developing a *REFERENCE COMPLIANCE ORGANIZATION (RCO)*. The author participated in both projects with the responsibility of developing a domain-specific REA and providing methodological guidance for these endeavors (see chapter IV for details of each local practice). The projects were carried out one after the other with a total duration of four years. Throughout this period, the author had access to several domain experts from both project domains. In concrete, the author had frequent contact with practitioners (business and IT consultants, executives, software developers, enterprise architects, accounts managers) from different problem stakeholders in both domains during the duration of the respective research projects. The author not only developed the methodological baseline for both research projects, but also conducted the REA development in both cases. However, the risk of evaluation bias was mitigated as was part of project teams with the size of five (in the case of ECLORA) and six members (COFIN), respectively. That ensured that other people than the author applied different parts of REAM in naturalistic settings, too.

Next to the evaluation context, two other determinants inform REAM evaluation design, i.e., the list of requirements defined towards REAM and the nature of REAM itself. First, the requirements elicitation (see chapter IV) defined five functional (FREQ) and three non-functional requirements (NFREQ) towards REAM. For each of them, the author defined fit criteria and authorities. Since one primary purpose of an evaluation is to investigate to what extend requirements are met (Hevner et al. 2004, p. 85), the author derives evaluation goals from these fit criteria. Second, different DSR artifacts require different evaluation designs. March and Smith (1995, p. 261) argue that IS methods can require evaluating criteria such as effectiveness, efficiency, or ease of use. Moody (2003) says that an IS method is useful, if applied in practice and fulfilling the objective it ought to fulfill. The evaluation design of REAM puts the focus on evaluating effectiveness. The overall objective of REAM is to guide the development of an REA. Since this work agrees with the reuse-oriented notion of reference models, the author defines an REA by the fact that stakeholders from the domain it addresses apply it. **Based on these considerations, the author argues that REAM can be considered effective under the prerequisite that it meets its requirements and produces an REA addressed stakeholder apply in their practice.**

In their FEDS approach, Venable et al. (2016) define four competing goals to consider when designing a DSR evaluation—(i) rigor, (ii) design uncertainties, (iii) ethics, and (iv) efficiency. Besides, Johannesson and Perjons (2014, p. 141) suggest to investigate (v) side effects of the artifact and (vi) comparing its performance against similar existing approaches if appropriate. The following paragraphs shortly discuss them in the context of REAM.

RIGOR. According to Venable et al. (2016), rigor in DSR evaluation relates to *efficacy* and *effectiveness*. While the former ensures that it is the DSR artifact that causes a desired outcome when applied in ideal circumstances, the latter investigates whether it also works in practice. The author defines *effectiveness* as a central determinant for evaluating REAM. Not only does REAM need to provide methodological guidance for developing REAs, but its output also needs to offer value for addressed stakeholders. That is supported by Hevner et al. (2004, p. 91), who say that an evaluation shall provide evidence that an artifact provides utility. One can investigate an artifact's utility by answering the two questions *"What utility does the new artifact provide?"* and *"What demonstrates that utility?"*. REAM's utility is to produce an REA that is relevant for its practical domain. Applying REAM in a naturalistic setting and assessing the resulting REA's validity demonstrates this. Further, that REA needs to be applied by a problem stakeholder from the addressed problem domain. Consequently, evaluating REAM needs to focus on naturalistic evaluation that focuses on investigating its effectiveness. March and Smith (1995, p. 260) agree with this, saying that instantiations of IS methods provide real proof that they work in practice, i.e., are effective.

UNCERTAINTY AND RISK REDUCTION. One central uncertainty regarding REAM's design is to ensure its generalizability. Derived from this work's research objective, REAM is required to apply to any endeavor that qualifies for REA development—regardless of the domain the REA does address. Consequently, designing REAM requires to identify all activities necessary for such endeavors. To mitigate the risk that REAM is tailored to a specific problem domain, evaluating REAM requires several formative evaluation episodes in different problem domains. That further avoids another design risk that REAM might lack specific activities or dictates method users to perform unnecessary tasks.

ETHICS. Since REAM is an IS method that guides its users to perform specific tasks associated with knowledge elicitation and its analysis to design an IS model, there exists no risk for animals, people, or organizations. Hence, the author did not formulate any ethical evaluation goals.

EFFICIENCY. Former considerations highlight the importance of evaluating REAM's performance in practice. Unfortunately, thoroughly applying REAM is a cost-intense and time-consuming task. However, due to the contextual circumstances, the author was able to evaluate REAM in several naturalistic evaluation episodes. Nevertheless, it was not feasible to evaluate every single aspect of REAM in each episode. Thus, the author decided that the majority of evaluation episodes focus on particular method components of REAM.

COMPARISON. The author argues that comparing REAM with other similar methods is not necessary as the KBA showed that there are no methods that claim to develop an REA (see section 4.3). General methods for RM such as the ones by Schütte (1998) and Becker et al. (2002) as well as methods for developing reference architectures (Nakagawa et al. 2014) have a different objective than REAM. Further, section 6.7.2) already illustrated how REAM adapts from them for developing REAs.

SIDE EFFECTS. The author decided to exclude the investigation of REAM's side effects from this evaluation design. The rationale behind that decision is that it would require a significant increase in time and effort to conduct such evaluation. It would require a more significant sample of use cases that apply REAM. That is especially unfeasible since a REAM application realistically spans over several months or even years (depending on the respective REA scope). As a result, evaluating the side effects of REAM is out of this dissertation's scope. However, this may be an aspect of subsequent research. Further, the discussion (see chapter VI) of this thesis will shortly summarize the author's observations in this regard.

Based on these considerations, REAM evaluation design has the following objectives:

- **EVALUATION GOAL 1**: *To evaluate REAM in several naturalistic evaluation episodes that apply all its method components.*
- **EVALUATION GOAL 2**: *To evaluate REAM in several formative evaluation episodes.*
- **EVALUATION GOAL 3**: *To evaluate REAM's effectiveness. Consequently, REAM's output needs to be assessed by real-world problem stakeholders that apply it.*
- **EVALUATION GOAL 4**: *To evaluate REAM in different problem domains that apply it in different problem contexts.*

7.1.2 STRATEGY FOR EVALUATING REAM

Venable et al. (2016) define the second step of FEDS to choose an appropriate strategy based on prioritization of the artifact's design risks, the costs, and need to evaluate it with real users in real-world settings, and the complexity of the artifact itself. The authors propose four different evaluation strategies. The proposed evaluation strategies differ in their trajectories of evaluation episodes within their proposed framework. The framework defines a matrix of an evaluation's purpose (formative or summative) and an evaluation's paradigm (artificial or naturalistic). According to Venable et al. (2016, p. 81), an evaluation strategy is a planned trajectory of evaluations that is appropriate for the circumstances of a particular DSR project. While each trajectory highly depends on the DSR project's context, the authors suggest that an evaluation strategy shall define a trajectory from a state of no evaluation to—if possible—a more summative and naturalistic evaluation.

The author used the evaluation goals depicted in section 7.1.1 to develop an evaluation strategy. The most significant design risks for REAM are its generalizability and effectiveness in naturalistic settings. Moreover, the evaluation context provides access to real-world users and problems. Since REAM envisions to be applied by these users in their practical contexts, REAM's design risks are preferably user-oriented than technologically oriented. Comparing this to the four strategies proposed by FEDS, the author argues that evaluating REAM requires a strategy similar to the *"Human Risk & Effectiveness"* strategy. That strategy requires an evaluation design to focus on formative evaluation and naturalistic settings as soon as possible. Although REAM's design risks and design context strongly hinted to deploy that strategy, the actual timing of the evaluation episodes still highly depended on REAM's project context. Thus, the author points out that REAM's evaluation episode has similarities with the *"Human Risk & Effectiveness"* trajectory suggested by FEDS, while various episode designs differ.

7.1.3 REAM EVALUATION PROPERTIES

In its third step, FEDS determines what properties to evaluate. These depend on the specifics of the DSR project. The author defined them based on evaluation goals and requirements towards REAM. For this purpose, the author used evaluation goals to prioritize the evaluation of defined FREQs and NFREQ (see chapter IV) and define appropriate evaluation properties. For evaluating IS methods, Moody (2003) proposes the Method Evaluation Model (MEM). MEM divides the "success" of an IS method into the dimensions actual efficacy (*Does the method improve the task?*) and adoption in practice (*Is the method used in practice?).* Moody understand a method successful if both actual efficacy and adoption in practice of the method is proven. Next to actual efficacy, MEM introduces the concept of "perceived efficacy" adapted from the technology acceptance model (Davis 1989). While the former is defined by "actual effectiveness" and "actual efficiency," the latter uses the constructs "perceived ease of use," "perceived usefulness," and "intention to use." They are determined by a user's subjective assessment of the method. On that basis, Moody argues that an IS method's likelihood of adoption in practice is not only determined by a method's actual efficacy but also by the degree of how useful and easy to use a potential user perceives that IS method. Although the method's actual efficiency and effectiveness determine a user's perceptions of that method, there exist other factors, such as a user's prior knowledge, that influence the user's perception.

To demonstrate MEM, Moody evaluates an IS method not in a naturalistic setting but in a controlled environment. He operationalizes his model by defining items for the properties "perceived ease of use," "perceived usefulness," and "intention to use." After applying the method with an example case designed for the evaluation, users assess the method regarding these items. On that basis, Moody derives the likelihood of whether the method will be adopted in practice. Further, these items facilitate the comparability of an IS method to similar solutions.

As discussed above, the context of this evaluation design enabled that REAM is applied in several naturalistic settings. Further, previous elaborations showed that the primary evaluation objective is to investigate REAM's effectiveness. Consequently, the author decided to focus on REAM's actual efficacy rather than its perceived efficacy. However, the author agrees with Moody that any IS method would benefit from a high degree of usability, but argues that they are out of this work's scope due to the following reasons:

(i) Even with an artificial and straightforward example use case, the application of REAM takes too long to investigate its perceived ease of use and perceived usefulness in a controlled environment, e.g., with computer science students. As the first evaluation episode later revealed, applying REAM may last at least several weeks if not months (and in real-word projects even years). In order to gather enough data for generating accurate insights, this would imply a very long period, while these do not directly relate to the primary objective of this evaluation. As Moody's (2003) findings further revealed, the results of experiments involving students may not be generalizable due to their limited knowledge in the field. His suggestion to involve experienced practitioners instead would make such an experiment even less feasible in the context of this Ph.D. project.

(ii) Further, the author argues that the investigation of whether REAM produces desirable outputs is a complex and demanding task itself. Since the author follows a reuse-oriented understanding of the REA notion, an appropriate evaluation of REAM requires to prove that REAM's output, an REA, is applied by a real-word problem stakeholder.

In conclusion, the primary property for evaluating REAM is ACTUAL EFFECTIVENESS. Since the author applied REAM in several real-world scenarios, the evaluation investigates insights regarding its ACTUAL EFFICIENCY as well. Due to the above arguments, a complete evaluation of REAM's perceived efficacy—i.e., perceived usefulness and perceived ease of use—is out of this evaluation's scope. Nevertheless, the project context allowed for examining the first aspects of actual efficacy. In the COFIN project, the author had regular contact with domain experts from the problem domain in terms of a focus group. Throughout REAM design process, focus group meetings took place, in which the experts gave regular feedback towards the COFIN project progress, i.e., the RCO model. Although these experts primarily acted as problem stakeholders of the RCO, they accompanied the several REAM application cycles that finally produced that RCO as well. While none of these experts applied REAM themselves, they gave feedback regarding specific method components of new REAM versions. Further, the author used feedback from the other project members as well as they applied REAM. Therefore, some evaluation episodes investigated the properties COHERENCE, MODULARITY, and COMPREHENSIBILITY in order to make initial conclusions for REAM perceived efficacy, from which future work may build.

That resulted in the below list of evaluation properties. Each property is defined and related to requirements it concerns, if applicable. Moreover, each paragraph shortly states what aspects the evaluation assessed while investigating the respective evaluation property. Afterward, the author was able to plan necessary evaluation episodes as the subsequent section documents.

- **ACTUAL EFFECTIVENESS:** the degree to which a method achieves its objectives (Moody 2003).
  - Related Requirements: FREQ1 – FREQ5, NFREQ2
  - Thomas (2005) understands a reference models only as one, if it is applied in practice (see chapter III). The author derives the following two requirements REAM's output shall meet for its effectiveness:
    - (i) Domain experts shall evaluate the REA produced by REAM application as correct and complete. The author defines this as construction-oriented effectiveness of REAM.
    - (ii) That produced REA shall be applied in practice by real problem stakeholders addressed by the REA. The author defines this as reuse-oriented effectiveness of REAM.

- **ACTUAL EFFICIENCY:** the effort required to apply the method (Moody 2003). To examine efficiency, the author used the following metrics that aim to make REAM's efficiency more transparent:
  - Related Requirement: NFREQ3
  - the *period* the application of REAM took for the particular evaluation episode.
  - the *most complex and effortful activities* and method components of REAM application
  - the project team members and their *work input* regarding REAM application during the respective evaluation episode.
  - While one can analyze general metrics such as time and effort for several episodes, the author points out that there exist several aspects that may bias the results:
    - Conducting REAM relies on the availability of domain experts. That resulted in delays in project progress, e.g., feedback of REA objectives, REA structure, REA content, which could not be tracked by the author and, thus, may blur results.
    - Conducting inductive REA construction further relies on the availability and response of representatives of organizations to collect individual models. That resulted in delays in project progress as well, especially during the collection of individual models.
    - Since evaluation goals focus on effectiveness rather than efficiency, the author is aware of an evaluation bias. However, some evaluation episodes still discuss actual efficiency to derive some general conclusions in this regard.

- **COHERENCE:** the degree to which the parts of an artifact are logical, orderly, and consistently related (Johannesson and Perjons 2014, p. 109).
  - Related Requirement: NFREQ1

- **MODULARITY** (NFREQ1)**:** the degree to which an artifact consists of components that may be separated and recombined and are characterized by low coupling, high cohesion, and composability (Johannesson and Perjons 2014, p. 109).
  - Related Requirement: NFREQ1

- **COMPREHENSIBILITY:** the ease with which an artifact can be understood or comprehended by a user (Johannesson and Perjons 2014, p. 110).
  - Related Requirement: NFREQ1

The author derived the following conclusions regarding these evaluation properties:

- ACTUAL EFFECTIVENESS: Results were either drawn from the feedback of the involved domain experts (construction-oriented effectiveness) or the results of a concrete application case of a produced REA (reuse-oriented effectiveness).
- ACTUAL EFFICIENCY: The author draw results from the metrics stated above, depending on REAM parts applied in the respective evaluation episode.
- COHERENCE + MODULARITY + COMPREHENSIBILITY: Conclusions were made based on several data sets:
  - focus group meeting notes,
  - the author's observations during REAM applications, which based on discussions and decisions made by the involved project team during the respective REAM application, and
  - expert interviews conducted throughout REAM design process, as depicted in the respective evaluation episode.

7.1.4 EPISODE DESIGN FOR REAM EVALUATION

In the fourth and last step of FEDS, evaluation episodes, as well as their anticipated chronological order, are planned (Venable et al. 2016). Each episode is designed based on previous evaluation design decisions. Since a Ph.D. project spans over a more extended period and, thus, the evaluation context may change, the actual chronology of evaluation episode may change, too. Consequently, the episode design below considers a retrospective perspective REAM evaluation, i.e., presenting the evaluation as it was performed rather than how the author anticipated it. For instance, the author did not foresee the naturalistic episodes applied in the context of the COFIN project at the beginning of his Ph.D. project as the first version of REAM existed before the COFIN research project existed.

The design of each evaluation episode defines the following aspects:

(i) a RUNNING IDENTIFICATION NUMBER (#) with the prefixed abbreviation "EE," which stands for evaluation episode,
(ii) a short DESCRIPTION of the episode,
(iii) its FUNCTIONAL PURPOSE, i.e., summative or formative,
(iv) its evaluation PARADIGM, i.e., artificial or naturalistic,
(v) the PARTICIPANTS involved in the episode,
(vi) the research METHOD(S) used for conducting the episode,
(vii) the evaluation PROPERTY addressed by the episode,
(viii) the aspects of REAM the episode puts its FOCUS on,
(ix) REAM REQUIREMENTS for which the episode provides insights.

Regarding aspect (vi), the evaluation of REAM applied the following research methods:

- **ACTION RESEARCH**: Action research is useful for formative design if real users are easily accessible, and both researchers and practitioners are involved in REAM application. Further, conducting action research is reasonable if it is feasible, i.e., it comes with a considerable amount of costs and effort (Johannesson and Perjons 2014; Venable et al. 2012). The specifics of the evaluation context allowed the author to conduct five episodes using action research.

- **CASE STUDY:** Case studies are useful for summative evaluation if real users are accessible and were involved in the application of REAM for a real-world problem. It allows the researcher to make a sincere evaluation of REAM regarding the reasons behind its success or failure. One episode applied case study research. A problem stakeholder applied the results of a REAM application to develop a new software product.

- **CRITERIA-BASED EVALUATION:** The author used criteria-based evaluation for evaluating the general structure and high-level procedure of REAM before applying it, i.e., in a formative ex-ante evaluation. According to Venable et al. (2012), this method usually is used with unreal users.

- **FOCUS GROUP**: Using focus groups can be an appropriate tool for both formative and summative evaluation (Hevner and Chatterjee 2010, pp. 121–143). In this context, Tremblay et al. (2010) two types of focus group deployment for DSR evaluation:

  - ***Exploratory Focus Groups*** study the design to propose improvements to it. The author deployed several focus group meetings with an exploratory setting for the formative evaluation of REAM.

  - ***Confirmatory Focus Groups*** provide insights regarding the artifact's utility (i.e., useful for summative evaluation). The author deployed the last focus group meeting with a confirmatory setting for the summative evaluation of REAM.

  - All results of focus group meetings presented in section 7.2 refer to meeting notes that were taken during these meetings and were validated by the respective participants.

- **INTERVIEWS:** The author conducted several expert interviews in a separate formative evaluation episode to collect feedback from domain experts regarding REAM's output.

In total, the author conducted seven evaluation episodes. Most of them resulted in a new REAM version as the results of each formative episode provided input to for design changes in the form of improvement needs. The context of REAM evaluation forced the author to conduct two episodes subsequently without designing a new REAM version in between. Since the evaluation goals require a focus on formative and naturalistic evaluation, the author prioritized more evaluation episodes over an alternating sequence of episodes and REAM versions. For instance, the project schedule did not allow the researcher to develop a new REAM version after EE5. Thus, both EE5 and EE6 applied REAM v5 and resulted in REAM v6. As both focused on separate parts of REAM and its output, this did not lead to a missing evaluation opportunity to mitigate design risks. In total, six different REAM version evolved throughout this DSR project. Figure 72 visualizes this. For each episode, it indicates the purpose (formative or summative), evaluation paradigm (artificial or naturalistic), and the time when it was conducted. The next section presents each evaluation episode in detail and discusses its results.

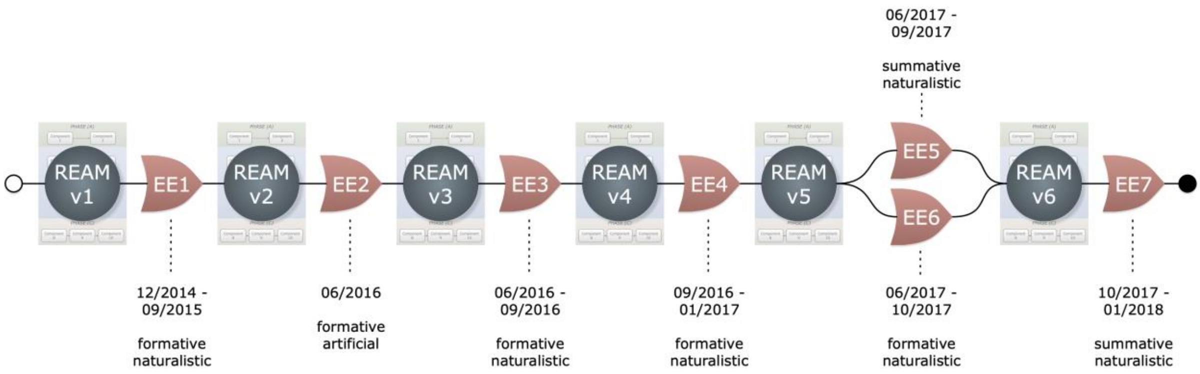


FIGURE 72. TRAJECTORY OF EVALUATION EPISODES AND EVOLUTION OF REAM

7.2 EVALUATION EPISODES

This section discusses each evaluation episode using the list of evaluation aspects provided in the previous section. Each section discusses how the author conducted the particular episode, describes the involved participants, and presents the results. Further, each section shortly presents the corresponding REAM versions.

7.2.1 EVALUATION EPISODE 1: DEVELOPING THE UTILITY REA USING REAM

Evaluation Episode 1 (EE1) applied the first version of REAM in the context of the ECLORA project in order to develop a Utility REA for the energy sector. Table 58 summarizes the evaluation design of EE1.

TABLE 58. EVALUATION DESIGN OF EVALUATION EPISODE 1

#	PURPOSE	PARADIGM	PARTICIPANTS	METHOD	PROPERTY	REQs
EE1	FORMATIVE	NATURALISTIC	PROBLEM STAKEHOLDERS OF UTILITY REA	ACTION RESEARCH	ACTUAL EFFECTIVENESS ACTUAL EFFICIENCY	FREQ1 FREQ2 FREQ3 NFREQ1 NFREQ2

TIME ASPECT. EE1 was conducted in the period between December 2014 until September 2015.

CONTEXT OF EE1. The conduction of EE1 represents the actual demonstration of this DSR project's artifact REAM. After designing a first solution (REAM V1) of this work's underlying problem, it was applied in the naturalistic setting of the ECLORA project (see section 4.1.1) in order to demonstrate that the method produces a desirable output. EE1's PURPOSE was formative, with a FOCUS on the complete REAM V1. Therefore, EE1 aimed to assess the extent to which REAM v1's fulfills its objective and how much effort it takes to be deployed, i.e., investigating its (construction-oriented) ACTUAL EFFECTIVENESS and ACTUAL EFFICIENCY. The author was part of a research team that applied REAM v1. The research team consisted of two other researchers from the field of business information systems and four domain experts from an ISVs from the utility industry, SIV.AG[1]. The three domain experts were one enterprise architect, a business consultant, a software engineer, and one IT manager. The project objective was to develop a Utility REA that helps organizations from the utility industry to transform their legacy organizational structures to overcome the challenges following the market liberalization and the trend of renewable energy sources. Next to public utilities, ISVs like SIV.AG were problem stakeholders, too. Since next to the author, other researchers, and practitioners for SIV.AG were involved in the process of applying REAM v1, EE1 deployed action research. The results of EE1 aimed primarily to

[1] see https://www.siv.de/de/ for more information (accessed 11/03/2020)

contribute towards FREQ1 (REAM output conforms to EA structures), FREQ2 (REAM covers RM lifecycle), FREQ3 (REAM shall use practical domain knowledge), NFREQ1 (coherent and modular REAM structure), and NFREQ2 (REAM shall produce desirable outputs).

REAM v1. The first version of REAM primarily applied the configurative reference modeling method (*cRMM*) introduced by Becker et al. (2002). *cRMM* defines five phases (1) project objective, (2) modeling approach, (3) reference modeling, (4) model evaluation, and (5) market reference model. Except for the last, REAM v1 adjusted them to the specifics of enterprise architecture structures. Figure 73 illustrates the adjusted procedure model of REAM v1. Exemplary adjustments are the definition of an REA framework based on a chosen EA framework and a detailed approach on how to collect what data during phase (3).

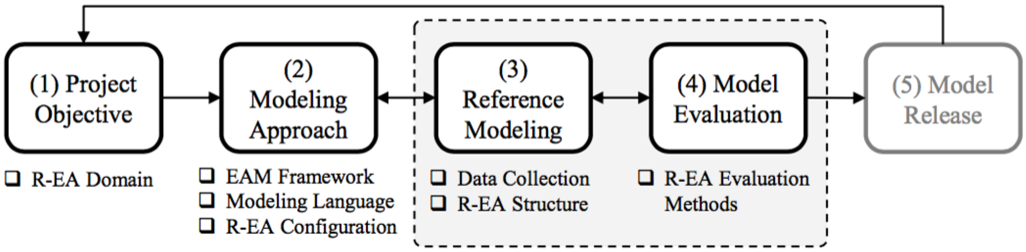


FIGURE 73. HIGH-LEVEL PROCEDURE MODEL OF REAM V1 BASED ON BECKER ET AL. (2002)

RESULTS OF EE1. At the beginning of ECLORA, the concrete objective was to develop an REA that provides detailed insights on the overall value generation of roles in the utility industry, necessary organizational structures of a typical public utility, and the business functions necessary to overcome current market challenges. Concerning the latter, the REA needed to reveal interrelation between business (processes, responsibilities, value generation) and IS (processed data and utilized software components) perspectives. Therefore, the SIV.AG decided to put particular focus on four domain-specific business processes, e.g., closing of new electricity contracts as it involves multiple market roles. Every project team member was involved in each of REAM v1's four phases. The application resulted in the Utility REA. Figure 74 shows one part of the Utility REA that addresses the contract closing process. Overall, the domain experts from SIV.AG agreed that applying REAM v1 provided desirable results. In the end, the Utility REA met all its requirements stated above. However, its ACTUAL EFFECTIVENESS could only be partly verified as REAM v1 provided no concrete means how the resulting Utility REA can be applied (construction-oriented effectiveness). Further, the focus on configurative adjustment mechanisms proofed not to be sufficient as REAM v1 also lacked giving detailed guidance in this respect. Still, the development of the Utility REA was deemed successful by SIV.AG, as they used it to enhance their understanding of the utility market, augment their consultancy portfolio, and to maintain their core product—the ERP system kVASy. Concerning REAM v1's ACTUAL EFFICIENCY, EE1 provided insights regarding time and effort when conducting REAM. Applying REAM is a task that demands an extended period. Applying REAM v1 in EE1 took ten months in total. Next to the seven members of the project team, it involved one additional student of business information systems. Further, the elicitation of data from practice required conducting multiple (in the case of EE1 four) workshop at public utilities, which spanned over two days each. The author concluded that the time and effort necessary to apply REAM v1 successfully is directly related to the scope of the REA development endeavor and the manning level of project member and their experience in the EAM domain. Besides, REAM v1 seemed to lack concrete guidance in certain areas of the development process. For instance, REAM v1 did lack advising on how to collect practical knowledge and how to evaluate its influence on the REA construction. That resulted in increasing preparation time and effort when conducting phase (3).

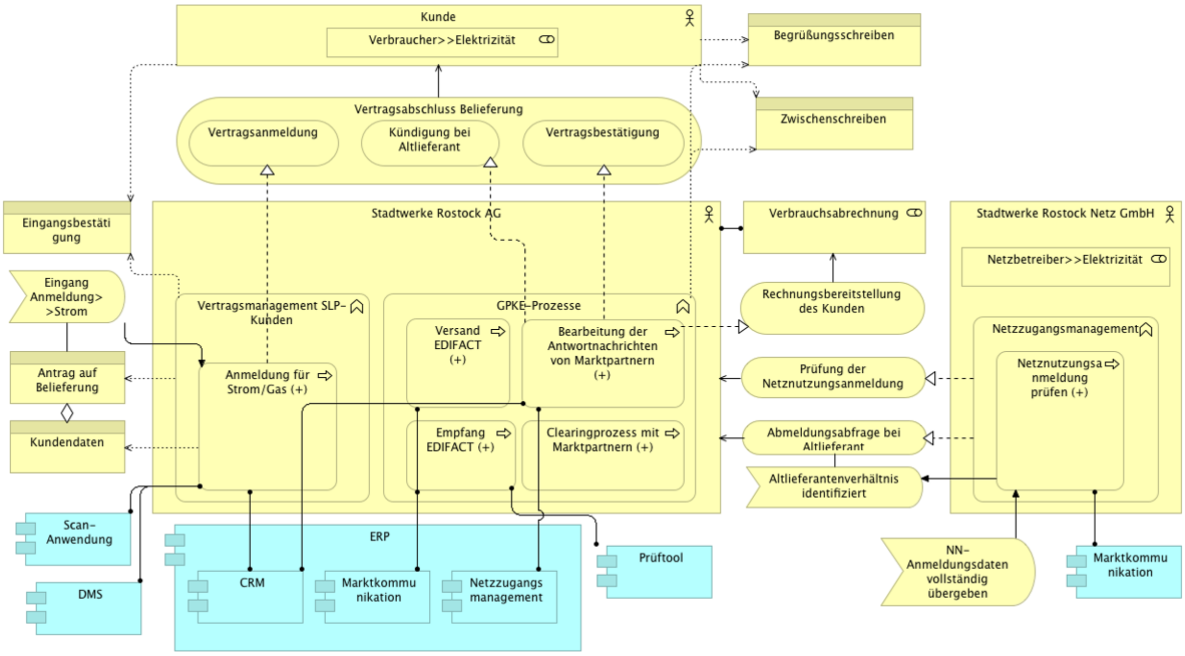


FIGURE 74. SOFTWARE USAGE FOR CLOSING ELECTRICITY CONTRACTS

Reflecting on the evaluation properties is closely related to EE1's evaluation of REAM's requirements. Hence, the following list provides insights structured by the individual requirements they contribute to:

- ✓ **FREQ1:** One project member of the REA Team was the enterprise architect of SIV.AG. Together with him, the author assessed REAM output regarding FREQ1. The enterprise architect agreed that the resulting Utility REA conforms with EA principles as it covered business, data, and application layer related viewpoints. However, his feedback also hinted that some steps prescribed by REAM v1's need to be more dedicated towards EA structures since structuring and developing the REA required many iterations and could have been more straight forward.
- ✓ **FREQ2:** EE1 identified that REAM v1's primarily focuses on REA construction. No REAM component addresses REA application or REA maintenance. As a result, EE1 identified improvement needs in that regard.
- ✓ **FREQ3:** The participating domain experts of SIV.AG evaluated the correctness of REAM's output. They stated that the resulting Utility REA represents detailed knowledge of the problem domain as defined by the project objective. All elements were verified to relate to real-world phenomena in the utility industry. Further, the experts deemed the Utility REA to contain practical knowledge on an appropriate level of detail.
- ✓ **NFREQ1:** Although the application of REAM v1 resulted in a useful REA, the usage of the adjusted cRMM (Becker et al. 2002) was assessed as too opaque in certain parts of the method description (see above). Further, there was no guidance on how to inductively derive an REA based on the practical knowledge gathered during the elicitation workshops. Thus, EE1 revealed the need to develop a standalone method for REA development that builds from the experience of the ECLORA project.
- ✓ **NFREQ2:** As described above, the author assessed REAM v1' effectiveness. However, the domain experts hinted that there might be hidden potential of the developed Utility REA regarding the value it provides to the industry. This was caused by the fact that REAM v1 did not provide any means for REA application.

IMPROVEMENT NEEDS DERIVED FROM EE1. Based on the prior elaborations, the author derived the following improvement needs towards REAM v1, which resulted in REAM v2:

- To design REAM as a standalone IS method that builds from existing RM methods and tailors them to the specifics of EAM based on lessons learned from ECLORA and subsequent formative episodes.
- To provide a more sophisticated methodological guidance for designing an appropriate REA Framework.
- To design a method component dedicated to the construction of an REA Structure appropriate to the REA objective and the specifics of the problem domain it is addressing.
- To enrich REAM with a method component that supports method users to prepare the REA for its application and provides best practices in this regard.
- To investigate means for inductive REA development in order to enable building REAs based on practical knowledge.

7.2.2 EVALUATION EPISODE 2: FOCUS GROUP ASSESSMENT OF REAM

Evaluation Episode 2 (EE2) applied the second version of REAM in the context of the COFIN project. Table 59 summarizes the evaluation design of EE2.

TABLE 59. EVALUATION DESIGN OF EVALUATION EPISODE 2

#	PURPOSE	PARADIGM	PARTICIPANTS	METHOD	PROPERTY	REQS
EE2	FORMATIVE	ARTIFICIAL	DOMAIN EXPERTS	CRITERIA-BASED EVALUATION, EXPLORATORY FOCUS GROUP	COHERENCE COMPREHENSIBILITY MODULARITY	NFREQ1

TIME ASPECT. The focus group meeting for EE2 was held in June 2016.

CONTEXT OF EE2. The author conducted episode EE2 in the context of the COFIN research project. The overall objective of that project was to develop (RCO)—an REA that represents compliance organization for the financial industry with the focus on business and IS perspectives as well as their interrelations. The RCO intends to guide its implementation in practice and to reveal synergies among different financial compliance domains (such as anti-money laundering or fraud prevention). EE2 was based on REAM v2 and had a FORMATIVE purpose. It took place in an ARTIFICIAL setting. The author intended to evaluate REAM v2 ex-ante before he applied it within the context of COFIN. The rationale behind the ex-ante evaluation design was to identify flaws in REAM v2 beforehand, in order to avoid potentially unnecessary costs and efforts—at least these flaws that could be detected by domain experts. Therefore, EE2 combined a criteria-based approach in combination with a focus group. The focus group, which had regular meetings throughout the COFIN project, consisted of nine domain experts from ISVs and IT, respectively, business consultancies. Each member had several years of experience in the financial services compliance domain with an IT focus. Due to the objective of EE2, the focus group had an exploratory purpose. Although the domain experts did lack experience in RM, the author assessed that their knowledge regarding relevant stakeholders, domain-specific processes, and organizational structures of the problem domain informed REAM v2's procedures—in terms of approaching practical knowledge holders and structuring the RCO. In this context, the author used EE2 to evaluate REAM v2 regarding its COHERENCE, COMPREHENSIBILITY, and MODULARITY (NFREQ1).

REAM V2. The second version of REAM was developed based on REAM v1 with the improvement needs identified during EE1. First and foremost, REAM v2 was as a standalone method, which reused certain aspects of the cRMM by Becker et al. (2002), as the previous section depicted. Figure 75 illustrates the overall structure of REAM v2, consisting of four method components. First, component 1 analyzes the addressed problem domain, its problem stakeholders, and derives a particular purpose of the REA under development. Second, component 2 then uses that knowledge to define an appropriate REA design framework—choosing a guiding EA framework and EA modeling language as well as its meta-models elements relevant to the problem domain—before it designs a baseline REA structure. On this basis, component 3 develops the REA using a combination of deductive and inductive approaches before abstracting an REA model. Component 3's general idea was to use deductive reasoning for developing an initial high-level REA model that utilizes the previous REA structure (step A). Then, modeling workshops gather more detailed knowledge from practice (step B). In the end, the REA model is abstracted (step C). Component 3 further defines several validation steps. First, domain experts evaluate the initial REA. Second, workshop participants validated the corresponding results. Third, another consultation of domain experts validates the final REA model. Finally, component 4 analyzes the REA model from the perspective of different problem stakeholders and their needs and adjusts it for its application accordingly.

RESULTS OF EE2. After presenting REAM v2 and its anticipated instantiation in the context of the COFIN project, the (exploratory) focus group discussed about aspects that addressed the evaluation properties under investigation. Following questions were asked:

(i) Is the REA development approach comprehensible and reasonable? (COMPREHENSIBILITY)
(ii) Is REAM v2 logically structured? (COHERENCE)
(iii) Are components of REAM v2 separated from each other, and is the distinction between them reasonable? (MODULARITY)

Regarding (i), the participants agreed that the approach of REAM v2 is comprehensible as there were only minor questions regarding the method. However, in subsequent bilateral telephone calls with some focus group members, the author recognized that some participants missed more additional information regarding specifics of some steps of REAM v2 (e.g., the actual procedure of abstracting the RCO during the last step of component 3). In terms of (ii), participants validated the logical order of REAM v2 and that it provides clear guidance through the RCO development process. However, the focus group members pointed out that conducting modeling workshops for eliciting individual models during Step (B) of component 3 will not be feasible. According to them, this was due to two reasons. First, because the high effort conducting such workshops would imply. Second, and most of all, they questioned financial institutes' willingness to participate in workshops due to the political sensibility of the topic. Thus, they asked the author to alter plans for eliciting practical knowledge from the institutes and suggested to use telephone interviews as they estimated that they would generate more study participants and provide an improved comparability. Concerning (iii), however, participants found the integration of RCO evaluation within the development component (component 3) misleading. Apart from this, they stated that REAM v2 defines a clear distinction between remaining method components' foci.

IMPROVEMENT NEEDS DERIVED FROM EE2. Based on the prior elaborations, the author identified the following improvement needs towards REAM v2, which resulted in REAM v3:

- To enhance inductive REA construction by using different elicitation means (telephone interviews for eliciting practical knowledge)
- To improve the clarity of evaluation and defining a new method component dedicated for REA evaluation
- To enhance documentation of REAM

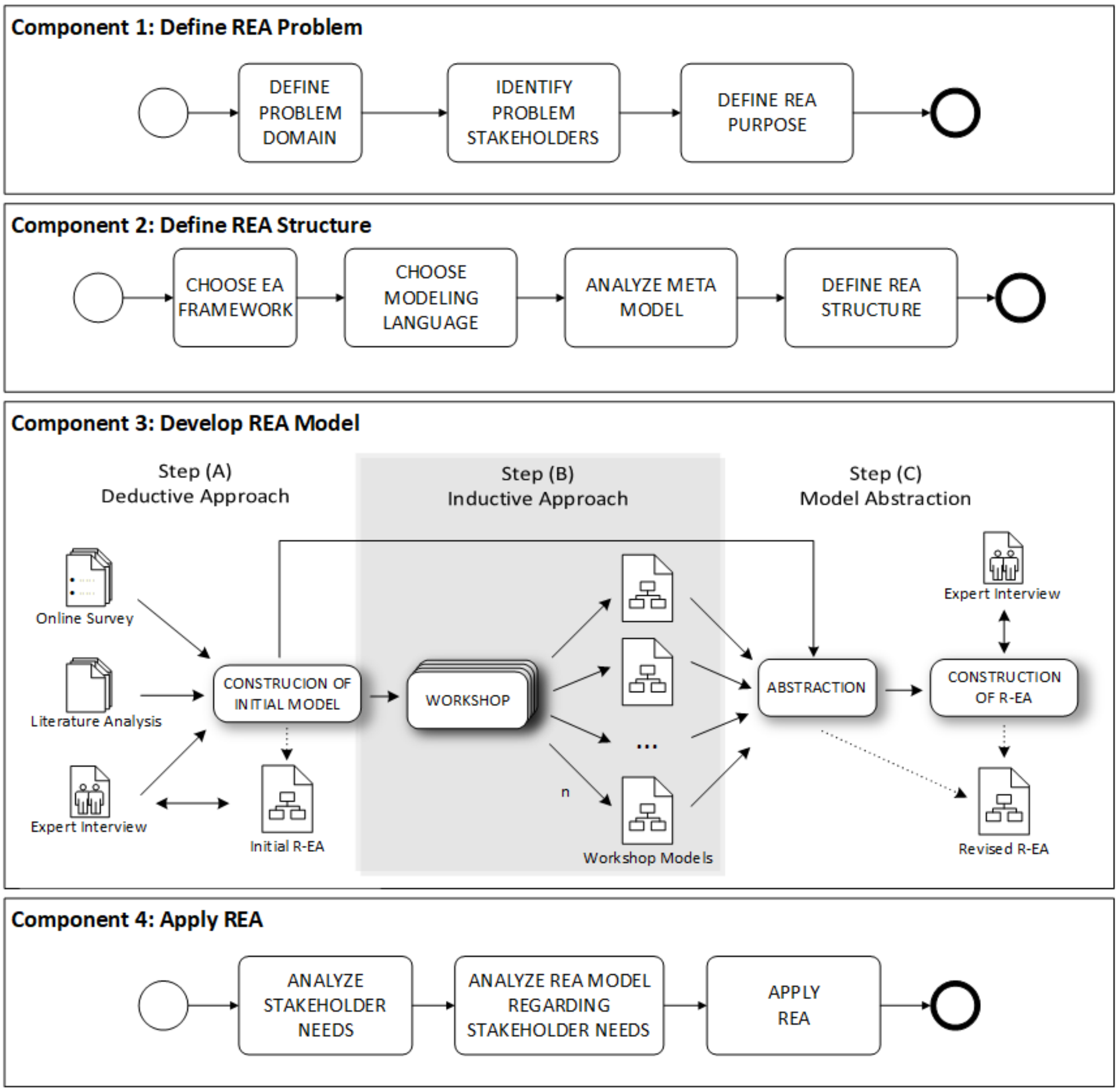


FIGURE 75. OVERVIEW OF REAM V2

7.2.3 EVALUATION EPISODE 3: DEVELOPING AN REA FOR ANTI-MONEY LAUNDERING

Evaluation Episode 3 (EE3) applied the third version of REAM in the context of the COFIN project. Table 60 summarizes the evaluation design of EE3.

TABLE 60. EVALUATION DESIGN OF EVALUATION EPISODE 3

#	PURPOSE	PARADIGM	PARTICIPANTS	METHOD	PROPERTY	REQS
EE3	FORMATIVE	NATURALISTIC	DOMAIN EXPERTS, PROBLEM STAKEHOLDER OF RCO	ACTION RESEARCH, EXPLORATORY FOCUS GROUP	ACTUAL EFFECTIVENESS MODULARITY COMPREHENSIBILITY	FREQ3 NFREQ1 NFREQ3

TIME ASPECT. EE3 was conducted in the period between the end of June until early September 2016.

CONTEXT OF EE3. During episode EE3, the author applied the third version of REAM in the first cycle of the COFIN project. REAM v3 (see Figure 76) was applied to develop an REA that focuses on anti-money laundering (AML). That AML REA represented one of the business domains later covered by the final RCO model (see Figure 64). Thus, EE3 deployed a NATURALISTIC setting. From an evaluation perspective, its purpose was FORMATIVE as it aimed to identify the flaws of REAM v3. Likewise to the first episode, EE3 utilized ACTION RESEARCH since the author was a member of the project team that applied REAM v3 in the AML context. Due to the project context, EXPLORATORY FOCUS GROUP meetings took place. In this context, the main focus of EE3 related to the first four components of REAM v3, i.e., everything except REA application. Next to several bilateral interactions between the author and members of the focus group, a focus group meeting took place in September 2016. After summarizing EE3's results (the AML REA) to the focus group members, the participants discussed REAM v3's (construction-oriented) ACTUAL EFFECTIVENESS, MODULARITY, and COMPREHENSIBILITY while the author and the remaining project team members acted as moderators. Thus, the results of EE3 contributed towards FREQ3 (practical knowledge represented in AML REA), NFREQ1 (modular REAM structure), and NFREQ3 (operationality of REAM's output that is shared among the participating project team and focus group members).

REAM V3. Figure 76 represents REAM v3. Its design implements the improvement needs identified during EE2. In contrast to REAM v2, component 3 was not restricted to modeling workshops for eliciting individual models. REAM v3 also suggested in-depth interviews or document analysis of process and IT documentation, for instance. As described in EE2's results, the main change from REAM v2 was a new method component dedicated to model evaluation (component 4). As shown in the respective component of Figure 76, chosen elicitation methods for defining the individual models can also be used to validate and refine the initial REA. After conducting the model abstraction step, the resulting REA needs to be further validated. REAM v3 addressed this by conducting expert interviews with specialists for evaluating the REA in detail. REAM v3 suggests to interview managers or business consultants should in order to assess the REA's overall validity. On the one hand, the interviewees should be familiar with EA models. On the other hand, they should not have been playing a part in the REA construction, if possible.

RESULTS OF EE3. The following results are derived from two sources. On the one hand, the focus group meeting in September 2016 discussed the aspects under this episode's investigation. On the other, it derives from observations that the author made while he and the remaining project team applied REAM v3. The overall goal of REAM v3's application was to develop the AML REA that provides guidance derived from practice how to perform compliant AML on business, data, and application level from the perspective of financial institutes. After its application, the domain experts (with professional experience in compliance software product development and consultancy) assessed the resulting AML REA to be correct, complete, and of adequate detail in the final focus group meeting. Figure 77 presents one example view of the AML REA. That only partly validated the ACTUAL EFFECTIVENESS of REAM v3 in this application context as it was not applied in practice then. However, since EE3's objective was to construct and evaluate the AML REA, REAM v3's application was deemed successful. Further, the author learned that focus group members only had limited access to the AML REA model as they were not able to install the utilized EA modeling tool. Moreover, EE3 aimed to investigate REAM v3's COMPREHENSIBILITY. Since the COFIN project team applied it, members of that team primarily determined this evaluation criteria. However, the author further considered focus group meetings as its members monitored the construction process in regular feedback loops by dint of regular project updates, project calls, and focus group meetings. In doing so, the two central aspects under investigation were whether REAM produced relevant results that trace the project's progress and whether these outputs were quickly accessible to all participants. During the process, the author learned that these aspects have to be made more explicit by the method. Thus, REAM shall define interim results as well as how to document and distribute them. From a methodological perspective, the method users, i.e., the COFIN project team, the majority of them assessed REAM v3's steps were precise. The next step was always clear to the team. However, the application of component 3 proved to be more challenging than anticipated as REAM v3 lacked clear guidance on how to derive an REA model from the different individual models. Finally, EE3 also investigated REAM v3's MODULARITY. During the construction of AML REA, the project team sometimes confused between inductive and deductive reasoning throughout the process. For instance, the modeling processes of the initial AML REA (deductive) was iteratively conducting and sometimes interfered with the models that evolved during REA abstraction (inductive). Thus, the author identified the need to define deductive and inductive reasoning in separate method components.

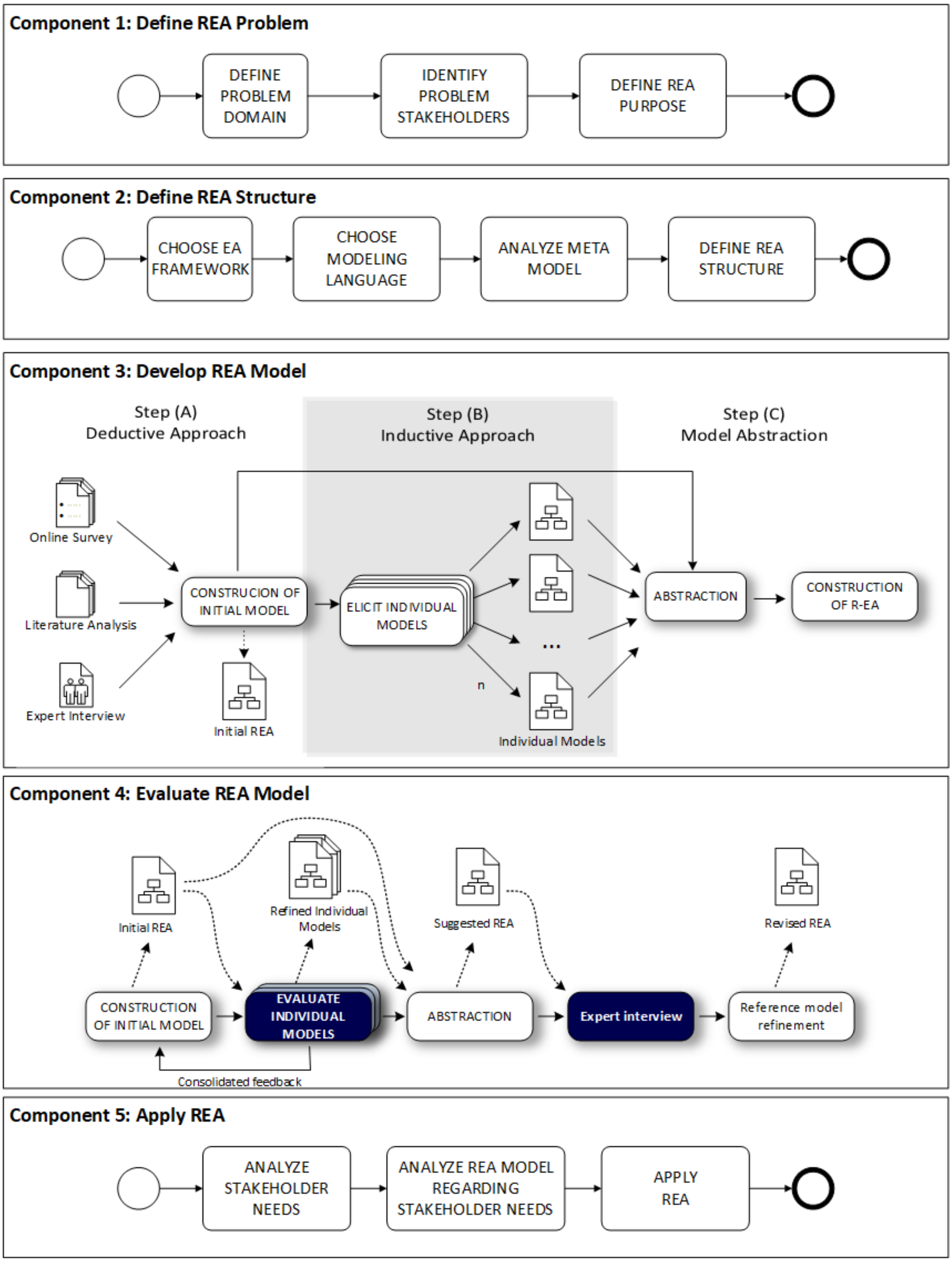


FIGURE 76. OVERVIEW OF REAM V3

The following list provides insights structured by the particular requirements they contribute to:

- ✓ **FREQ3:** Due to the focus group meeting, the domain experts verified that the overall knowledge represented by the AML REA appropriately reflects practical knowledge of the domain. However, the author noted that a more profound investigation of the REA content would be necessary in order to make a more informed assessment regarding FREQ3. In conclusion, the author altered the evaluation design and integrated EE5 (see section 7.2.6). There, the author used expert interviews to evaluate FREQ3 in more detail.
- ✓ **NFREQ1:** Regarding inductive REA construction during component 3, the elicitation techniques provided by REAM were assessed feasible. Further, during the structure development, the harmonization between the general REA structure and the numerous individual models was identified to be crucial. Further, existing abstraction techniques for deriving an REA from several individual models were assessed to be immature in the context of REA, as they mostly focus structures like BPMN or EPCs. In conclusion, REAM v3 lacked detailed guidance to elicit, compare, and reason about individual models in order to derive a REA inductively.
- ✓ **NFREQ3:** The communication of the results was more challenging than anticipated. The need for appropriate means for result distribution was identified, e.g., by HTML reports. Further, the need for REAM to provide an activity dedicated to REA documentation was identified.

IMPROVEMENT NEEDS DERIVED FROM EE3. Based on the prior elaborations, the author derived the following improvement needs towards REAM v3, which resulted in REAM v4:

- ❖ To separate inductive and deductive reasoning into different method components of REAM
- ❖ To improve the methodological guidance for conducting inductive REA construction
- ❖ To define means in REAM that guide its user in how to document the (interim) results of the method application
- ❖ REAM shall provide best practices on how to share interim results among project team members and relevant stakeholders.

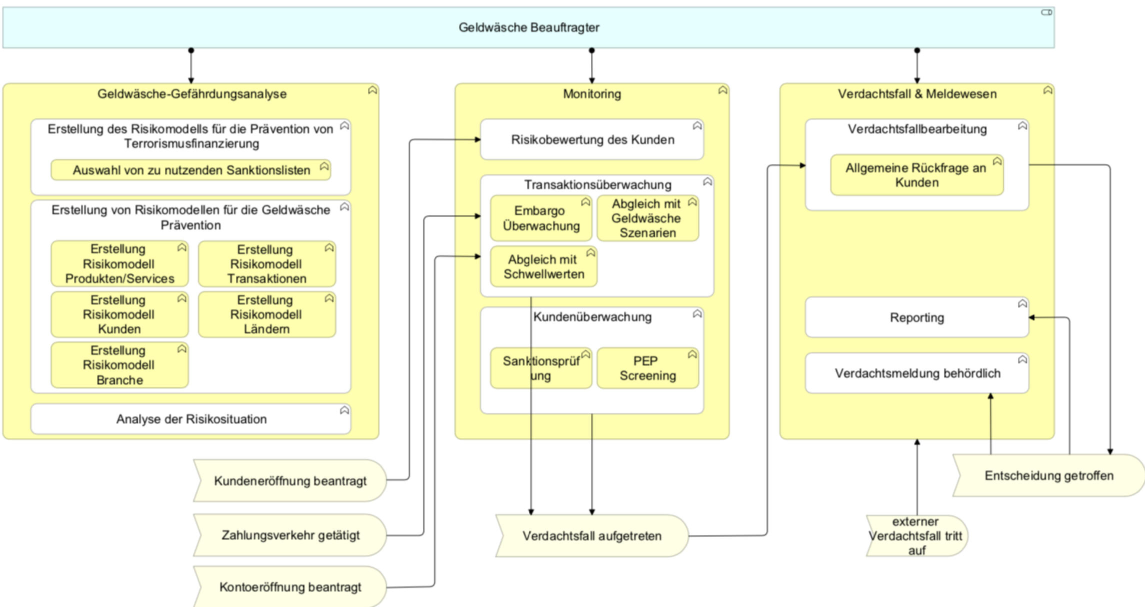


FIGURE 77. BUSINESS FUNCTION OVERVIEW OF HIGH-LEVEL AML FUNCTIONS

7.2.4 EVALUATION EPISODE 4: RCO MODEL FOR "KNOW YOUR CUSTOMER"

Evaluation Episode 4 (EE4) applied the fourth version of REAM in the context of the COFIN project. Table 61 summarizes the evaluation design of EE4.

TABLE 61. EVALUATION DESIGN OF EVALUATION EPISODE 4

#	PURPOSE	PARADIGM	PARTICIPANTS	METHOD	PROPERTY	REQS
EE4	FORMATIVE	NATURALISTIC	DOMAIN EXPERTS, PROBLEM STAKEHOLDERS OF RCO	ACTION RESEARCH, EXPLORATORY FOCUS GROUP	ACTUAL EFFECTIVENESS ACTUAL EFFICIENCY COMPREHENSIBILITY COHERENCE	NFREQ1 NFREQ3

TIME ASPECT. EE4 was conducted in the period between the end of September 2016 until end of January 2017.

CONTEXT OF EE4. During episode EE4, the author applied the fourth version of REAM in a new cycle of the COFIN project. The episode applied REAM in the context of developing an REA model for the "know your customer" (KYC) domain. That domain focuses on processes, data objects, and IT components that facilitate the identification and management of financial institutes' customer base and related due diligence requirements from authorities in this regard. The resulting KYC REA represented another business domain later covered by the final RCO model. (see Figure 64). EE4 deployed a NATURALISTIC setting with a FORMATIVE purpose. Similar to EE3, it used ACTION RESEARCH and EXPLORATORY FOCUS GROUP. Again, the focus of EE4 was to apply REAM v4 for REA construction and excluded REA application.

Moreover, the author mainly focused on evaluating the inductive construction guidelines REAM v4 provided. In the period of EE4, two focus group meetings took place—one in early September that kicked off the episode and one that discussed the resulting KYC REA. The latter was dedicated to discuss (construction-oriented) ACTUAL EFFECTIVENESS, ACTUAL EFFICIENCY, and COHERENCE of REAM v4. Thus, the results of EE4 contributed towards NFREQ1 (coherent REAM structure) and NFREQ3 (operationality of REAM's output shared among the participating project team and focus group members).

REAM V4. Figure 78 gives an overview of REAM v4. In comparison to prior versions, REAM v4 provided three main changes. First, component 3 and component 4 separately provided means for deductive and inductive REA construction, respectively. While the former reused previous REAM versions, the latter borrowed general steps, as proposed by Fettke (2014). Second, component 5 aimed to support better documentation and reporting guidance throughout the REA development process. Third, component 5 and component 6 did not follow a prescribed sequence of activities. The time of conduct of the components' steps depended on the current project progress. For instance, method users should document the REA structure during the conduct of component 2.

RESULTS OF EE4. The overall goal of applying REAM v4 was to develop the KYC REA, which was required to reveal interrelations between process, utilized data, and supporting IT components for conducting compliant and risk-aware of customer identification process in the financial services domain. Results of EE4 originated from two focus group meetings that discussed the progress of the endeavor, current results, and observations from the project team during the application of REAM v4. Appendix A (see p. XIV) provides anonymized meeting notes of the first focus group meeting, which took place on the 13th of September in Munich. It intended to validate the results of components 1 and 2—i.e., the overall KYC REA structure—and to discuss the anticipated way of model construction for components 3 and 4 as well as general next steps. The focus group meeting that took place at the end of January 2017 was dedicated to discuss the results of the KYC REA development. While the overall consensus of the focus group members was that the resulting REA met its requirements, ongoing discussions led to the agreement that the means of a focus group meeting do not provide the ideal context to evaluate the complex KYC REA's correctness and completeness. Thus, the author integrated EE6 into the evaluation design (see section 7.2.6). However, in an initial assessment, the experts deemed the results successful. Likewise to previous episodes, the author derived a (construction-oriented) ACTUAL EFFECTIVENESS of REAM v4 on this basis. Additionally, the author investigated the ACTUAL EFFICIENCY by reflecting on the time and effort for applying REAM v4 in the KYC context. Overall, EE4 validated the insights from EE1 that conducting REAM requires much effort and needs several months for a finished REA model. In concrete, the application of REAM v4 during EE4 involved the project team of six project team members (from which two worked full-time for developing KYC REA), the nine members of the focus group, a bachelor's student (her bachelor's thesis focused on applying REAM v4's component 4), and the respondents of 26 financial institutes (primarily compliance officers). From start to finish, conducting REAM v4 took nineteen workweeks without applying component 7. The most significant effort of applying REAM v4 was to conduct inductive REA construction (component 4). The 26 telephone interviews for collecting individual models lasted two hours on average. That was accompanied by harmonizing and validating transcripts as well as the actual modeling of the individual models. Moreover, the last step of component 4—abstracting an REA model from these individuals—lacked guidance on what techniques to use for deriving an REA model. Thus, a time-consuming effort to identify existing abstraction techniques was necessary. That slowed down the overall progress, not least because existing techniques related to the specifics of business process model structures and, thus, the RCO Team had to adapt them towards the used ArchiMate language for EA. In retrospect, the author identified the potential for increasing the ACTUAL EFFICIENCY regarding component 4. In order to minimize the effort of inductive REA construction without ignoring its importance, REAM shall provide guidelines on how when to apply deductive or inductive methods.

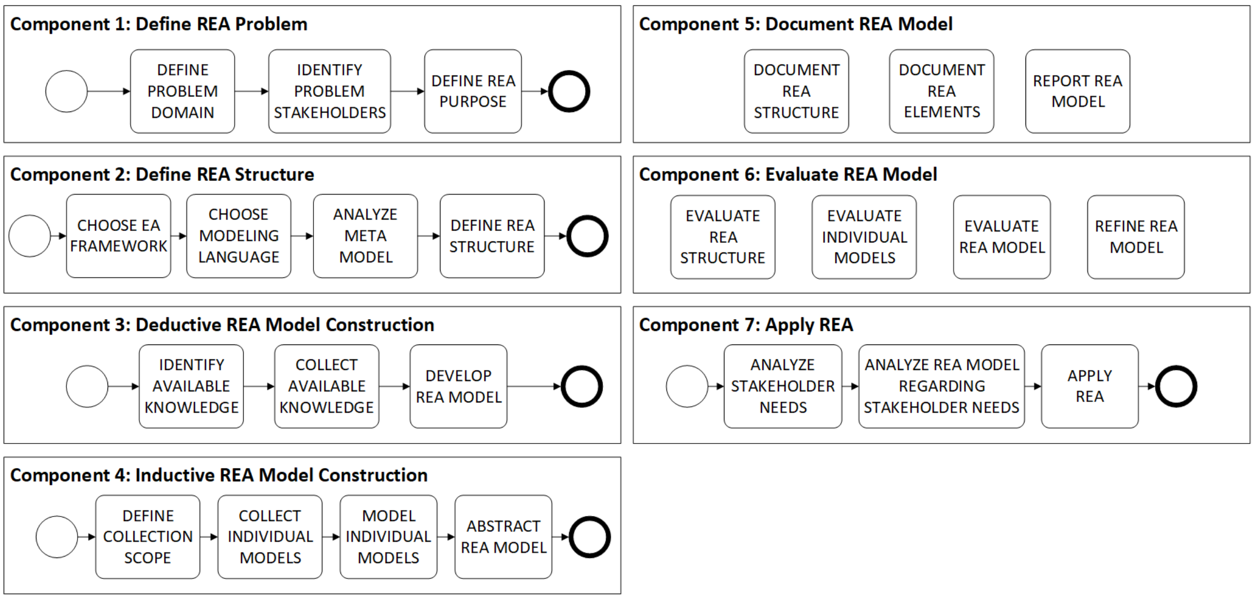


FIGURE 78. OVERVIEW OF REAM V4

During the method application, the author and other team members made the following observations regarding REAM v4's COMPREHENSIBILITY a. While the team members assessed the majority of components as easy to understand, the team mentioned three aspects of REAM v4 as hard to grasp. First, the decision regarding what reasoning strategy (i.e., deduction or induction) to use was unclear at some points. Second, conducting inductive REA construction not only required much effort, but also the project team was unsure how to proceed during the abstraction step of component 5. Third, the author learned that REAM v4 lacked a clear trace of results throughout the method application, which led to obscurity whether specific steps were finished or not. The latter aspect was further stressed as focus group members asked for more transparency of the KYC REA's development progress.

Finally, the application of REAM v4 provided insights regarding the method's COHERENCE. While the project team assessed the order of the method as logical and reasonable, discussions during the application regarding some ambiguities revealed further needs for improvement in this regard. First, the actual points in time when to apply component 5 and component 6 were unclear. For instance, team members agreed that steps and components that contribute to REA construction should also produce appropriate documentation. Thus, component 5 shall not be a separate method component.

Further, there may exist a method step that retrospectively assesses the appropriateness of the REA documentation. Further, the combination of deductive and inductive REA construction led to confusion in terms of which REA part to use deductive and when to use inductive reasoning. Further, integrating the results of the two components 3 and 4 into the final REA model was not captured by REAM v4 either. Since the results of EE3 and EE4 contributed to the same overall objective of the COFIN project (the RCO model), the question arose how to integrate AML and KYC REAs into one global REA. The team members agreed that REAM should provide guidelines in this respect as well.

The following list provides insights structured by the particular requirements they contribute to:

- ✓ **NFREQ1:** EE4 identified the following aspects regarding REAM v4's logical order:
  - Although EE4 represents an episode distinct from EE3, both resulting REAs contributed to the same overall REA—the RCO. The problem stakeholders identified the need to integrate the results from the AML case with the ones from the KYC case. In order to identify synergies and interrelations, REAM lacked insights on how to identify these.
  - REAM v4 lacked guidance for concrete techniques for inductive reasoning. The author concluded a demand for REAM to provide more profound techniques for this. Furthermore, Problem stakeholders claimed that it would be necessary to distinguish between common and best practice approaches. While some approaches of inductive RM are adaptable to EA models, the majority considers common practice as the desired reference output when abstracting references. While there exists no approach that meets all possible requirements in this regard, REAM shall provide some guidelines for choosing an appropriate technique.
- ✓ **NFREQ3**: While all participants involved in the development process of the KYC REA stated to be satisfied with the communication of interim and final results, some mentioned an ambiguity regarding at what point of time which result will be provided. The author concluded, to define in- and outputs of the different REAM components in more transparent within the method design.

IMPROVEMENT NEEDS DERIVED FROM EE4. Based on the prior elaborations, the author identified the following improvement needs towards REAM v4, which resulted in REAM v5:

- ❖ To define a new method component that clearly defines a strategy for constructing the REA and, thus, analyzes whether inductive REA construction is necessary
- ❖ To guide how to integrate different REA sub-models into one coherent one
- ❖ To identify feasible abstraction techniques for inductive REA derivation
- ❖ To enhance the method design regarding interrelations among the method components
- ❖ To improve the transparency of inputs used and outputs produced by the different REAM components.

7.2.5 EVALUATION EPISODE 5: DEVELOPING THE RCO MODEL FOR "FRAUD PREVENTION"

Evaluation Episode 5 (EE5) applied the fifth version of REAM to develop an REA for Fraud Prevention in the context of the COFIN project. Table 62 summarizes the evaluation design of EE5.

TABLE 62. EVALUATION DESIGN OF EVALUATION EPISODE 5

#	PURPOSE	PARADIGM	PARTICIPANTS	METHOD	PROPERTY	REQS
EE5	SUMMATIVE	NATURALISTIC	DOMAIN EXPERTS, PROBLEM STAKEHOLDERS OF RCO	ACTION RESEARCH, CONFIRMATIVE FOCUS GROUP	ACTUAL EFFECTIVENESS ACTUAL EFFICIENCY COHERENCE MODULARITY	FREQ2 FREQ3 NFREQ1

TIME ASPECT. EE5 was conducted in the period between early June 2017 until the end of September 2017.

CONTEXT OF EE5. The author designed EE5 to evaluate the fifth version of REAM. Similar to EE4 and EE5, REAM v5 deployed a NATURALISTIC setting of the COFIN project by developing an REA for Fraud Prevention. In contrast to prior evaluation episodes, the purpose of EE5 was SUMMATIVE, i.e., the author aimed to make empirically-based interpretations about REAM v5. Thereby, EE5 focused on REAM components that are dedicated to the construction of REAs since these already went through several formative evaluation episodes (EE1-EE4).

Regarding FREQ2, this episode aimed to assess REAM v5 from a construction-oriented perspective as the RM community understands it (see section 3.2.1). In order to evaluate REAM v5, whether it provides methodological guidance to construct desirable REAs, EE5 conducted a complete iteration of REAM v5 except for component 8. The objective of applying REAM v5 in the context of EE5 was to develop a Fraud Prevention REA (Fraud REA), which represents practices of preventing internal and external fraud from a business, data, and IT perspective. In this context, EE5 focused on REAM v5's (construction-oriented) ACTUAL EFFECTIVENESS, ACTUAL EFFICIENCY, and COHERENCE. Next to contributing to FREQ2 and NFREQ1, EE5 further intended to understand what part of REAM v5 is essential in order to develop an REA with correct knowledge of the problem domain (FREQ3).

REAM V5. Figure 79 gives an overview of REAM v5. Based on the improvement needs identified in EE4, REAM v5 consisted of two new components. While component 2 used the REA objective from component 1 to investigate central needs for the envisioned REA in order to derive a construction strategy based on existing available knowledge (represented in by the REA Portfolio in the last step), the new component 6 integrated REA parts, which were developed separately (such as AML and KYC REAs from EE3 and EE4), into a coherent REA model. Furthermore, component 5 (inductive REA construction) provided a more detailed procedure and provide guidelines on what abstraction techniques to use for acquiring an REA based on individual models. Moreover, REAM v5 addressed the need to make interrelations among method components more explicit, which resulted in a control (solid line) and feedback flow (dotted line) as well as an OR-connector. Finally, the detailed description of steps made explicit what input they use and what output they produce. Therefore, REAM documentation template was established, which was further used by the final version of REAM (see chapter VI).

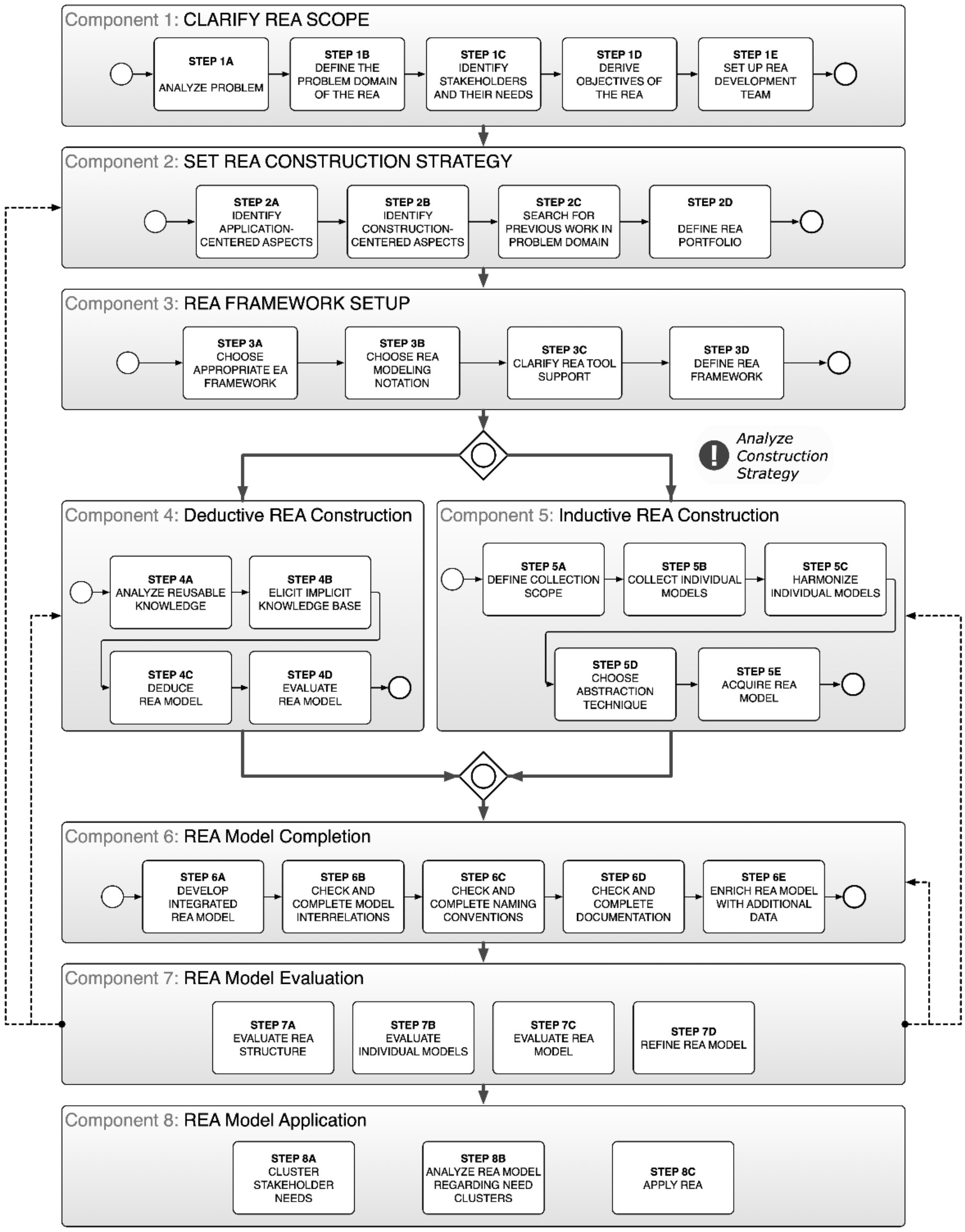


FIGURE 79. OVERVIEW OF REAM V5

RESULTS OF EE5. Results of EE5 originated from insights and observations from the project team when applying REAM v5 and a confirmatory focus group meeting in early September 2017. The author investigated whether observations made by himself or other project members, meeting notes from the focus group, and the results of applying REAM v5 allowed for general interpretations regarding evaluation properties addressed by EE5. The objective for applying REAM v5 in EE5 was twofold. First, it aimed to construct an REA for Fraud Detection, which required similar specifics as the REAs developed in EE3 and EE4. Figure 80 gives an overview of the overall data structure for Fraud, which represents one of thirteen viewpoints of the Frau REA. Second, that Fraud REA had to be integrated with the prior developed AML REA and KYC REA (see Figure 81). After applying REAM v5, problem stakeholders of the focus group assessed both objectives as successful. The results of EE5 support the findings of earlier evaluation episodes regarding REAM's (construction-oriented) ACTUAL EFFECTIVENESS. For instance, domain experts agreed that REAM v5 produced a Fraud REA, which met their requirements (FREQ2), and assessed Fraud REA's content as representative for practical knowledge in the domain

(FREQ3). Further, the discussion among focus group and project team members revealed that all participants agreed that they would use REAM v5 again for similar tasks, such as extending the RCO by another financial service compliance domain. There was a consensus that REAM v5 provides an effective approach to develop an REA.

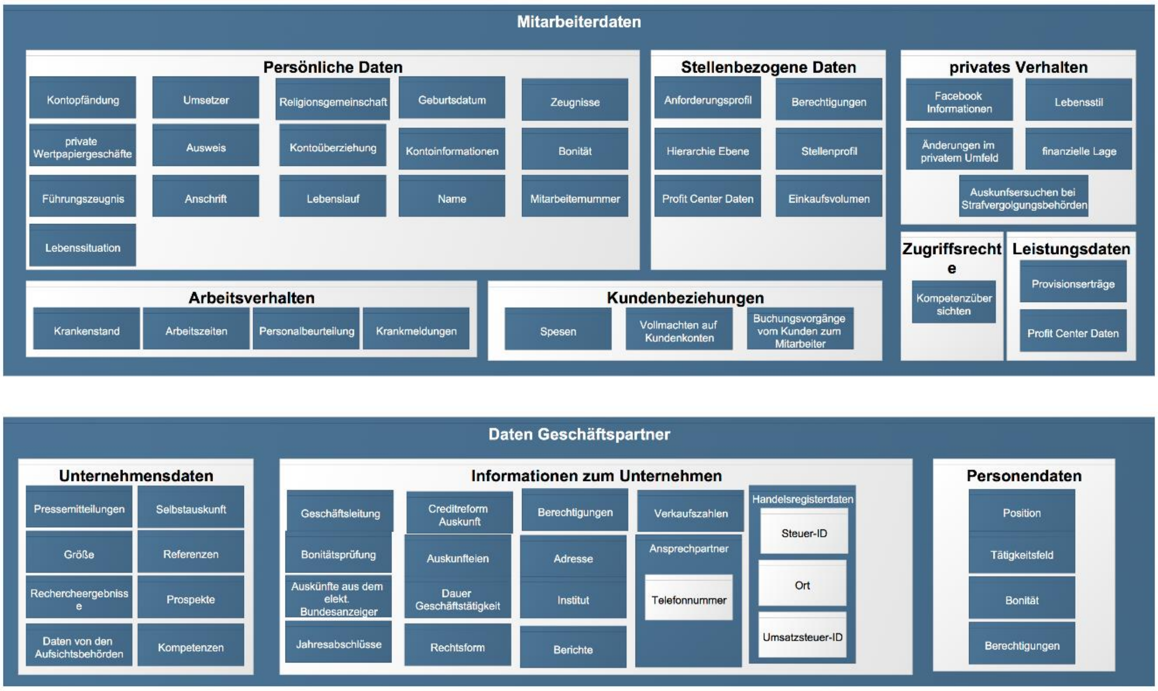


FIGURE 80. VIEWPOINT OF THE FRAUD REA'S DATA LAYER

EE5 revealed the following insights regarding REAM v5's ACTUAL EFFICIENCY. As in EE4, applying REAM v5 involved the project team of six project team members (from which two worked full-time for developing Fraud REA), the nine members of the focus group, a master's student (her master's thesis focused on applying REAM v5's component 5), and the respondents of 17 financial institutes (primarily compliance officers). Applying REAM v5 to develop Fraud REA and an integrated RCO took seventeen workweeks. Similar to EE4, EE5 did not conduct REAM v5'component 8 "REA Model Application," which makes their results comparable. Overall, these results and discussions within the project team led to the conclusion that REAM v5 slightly improved the duration and effort, which is primarily due to the enhanced guidance for inductive abstraction techniques (component 6) and clarity of what aspects to elicit from practice (component 3). Otherwise, results did not reveal any insights efficiency-wise. However, the author made the following observations regarding the conduction of component 5. While the actual elicitation of individual models (step 5b) was faster than in EE4, conducting step 5c-5e still took almost as long as in EE4. That was due to a fewer amount of participating financial institutes in the study (17 in EE5 comparing to 26 in EE4) and the fact that each interview collected more data than in EE4. That especially applied for elements of the data layer covered by the Fraud REA. In conclusion, the actual efficiency of inductive REA construction seems to relate to (a) the amount of individual models collected and (b) the amount of data collected for the individual models. Within the focus group, the question arose at what point of time method users know that they collected enough individual models. During discussions, the focus group reached a consensus that two factors may influence this decision:

- if the sample of organization, from which individual models are collected, are a representative extract from reality and/or
- if the collection of an individual model of another organization does not add to the knowledge base for inductive REA construction

In conclusion, the author assumes that the following factors determine the ACTUAL EFFICIENCY of conducting REAM (i.e., time and effort consumed):

(i) the problem scope of the envisioned REA (i.e., business domains to cover),

(ii) the width and depth in which the several EA layers need to be covered by the REA,

(iii) the requirements towards the REA's representativity as well as the heterogeneity of organizations of the problem domain,

(iv) the diversity of problem stakeholders and their needs,

(v) the amount and availability of explicit knowledge in that domain, and

(vi) the dynamics of the problem domain (i.e., frequently changing laws in the case of the RCO). While these factor and their influence on REAM's efficiency are to be investigated by future work, the author argues that REAM users shall be aware of them.

Generally, focus group and project team members agreed upon REAM v5's COHERENCE and MODULARITY (NFREQ1). After the application of all related REAM components, project team members agreed that REAM v5 provides coherent guidance to construct an REA, and REAM logically structures activities in the several method components. Interestingly, the author learned that project members found REAM v5 easier to use than REAM v4, although the overall actual efficiency did not change significantly. In consultation with team members who performed REAM v5, this was due to an improved clarity of the documentation of component 5. Further, the definition of in- and outputs of the components steps helped to understand when a project activity terminated. However, the author wants to point out that these conclusions are very prone to bias. All project members did conduct REAM a third time (even if the versions changed throughout the project). Consequently, one can argue that a learning effect of how to use REAM caused the mentioned improvement of REAM v5's coherence. Further, the above statements are based on observations and meeting notes rather than scientifically rigor inquiry.

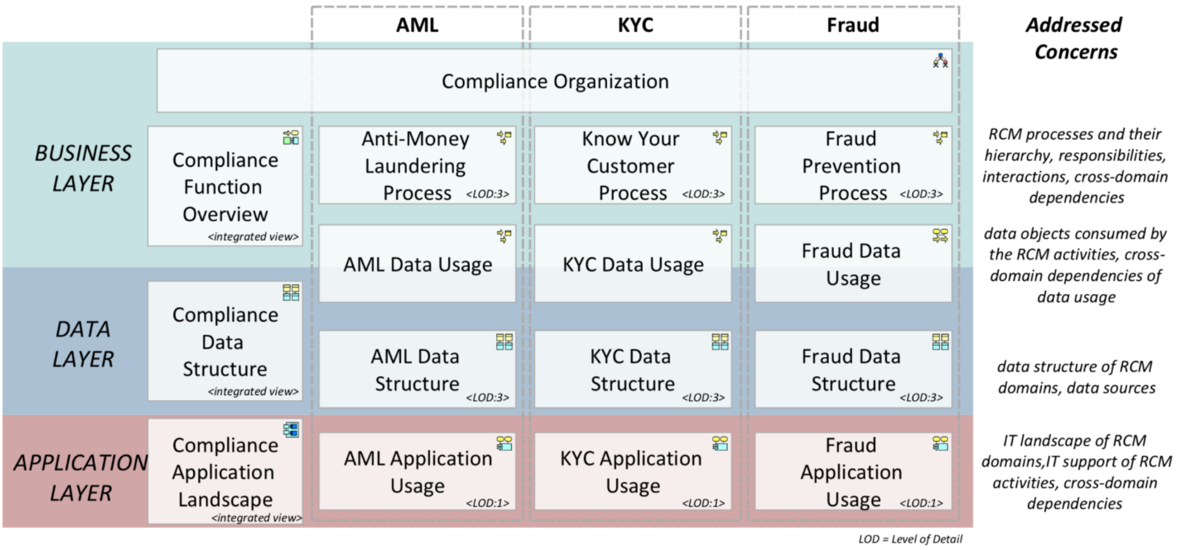


FIGURE 81. THE INTEGRATED RCO PRODUCED BY EE5

IMPROVEMENT NEEDS DERIVED FROM EE5. Although EE5 had a summative purpose, the EE5 revealed some flaws in REAM v5 design that the author interprets as improvement needs for future REAM versions:

- During the application of components 3, 4, and 7, the project team did not follow the exact order of steps as prescribed by REAM v5. As these alterations still resulted in a desirable output, future REAM version may consider to conduct these steps in parallel.
- Focus group members were wondering whether the produced RCO represents best practices of the problem domain. The author observed that REAM still lacks clear guidance on how to identify best practices when inductively developing an REA in Component 6. Although REAM provides an overview of existing abstraction techniques, this evaluation episode revealed that future versions of REAM should provide more precise criteria for identifying best practices.

7.2.6 EVALUATION EPISODE 6: ASSESSMENT OF AN REA'S FIT TO PRACTICE

Evaluation Episode 6 (EE6) also applied the fifth version of REAM in the context of the COFIN project. Table 63 summarizes the evaluation design of EE6. Due to the context of the evaluation, some activities of EE5 and EE6 had overlaps in time.

TABLE 63. EVALUATION DESIGN OF EVALUATION EPISODE 6

#	PURPOSE	PARADIGM	PARTICIPANTS	METHOD	PROPERTY	REQS
EE6	FORMATIVE	NATURALISTIC	PROBLEM STAKEHOLDERS OF RCO	EXPERT INTERVIEWS	ACTUAL EFFECTIVENESS COMPREHENSIBILITY COHERENCE MODULARITY	FREQ1 FREQ2 FREQ3 FREQ4 NFREQ1

TIME ASPECT. EE6 was conducted in the period between the end of June 2017 until end of October 2017.

CONTEXT OF EE6. As depicted earlier in the results of EE6 (see section 7.2.3), the author decided to conduct EE6 as he had learned that evaluating whether REAM produces output that represents correct knowledge of the problem domain (FREQ3) was not feasible in the context of a focus group meeting. For a feasible evaluation of FREQ3, the author conducted EXPERT INTERVIEWS with PROBLEM STAKEHOLDERS of the RCO based results developed during EE3, EE4, and (partly) EE5. While the main focus of these interviews was to evaluate the correctness and completeness of the RCO's content, the interviews applied component 7 "REA Model Evaluation." Thus, EE6's primary objective was to evaluate the ACTUAL EFFECTIVENESS of REAM v5's component 7 "REA Model Evaluation." In this context, EE6 intended to provide first insights regarding the reuse-oriented understanding of REAM's effectiveness since the author aimed to discuss application-related aspects with participating domain experts as well (FREQ2). In order to do so, the first results of component 8 "REA Model Application" have been discussed. In this regard, EE6 investigated the COHERENCE and MODULARITY of components 7 and 8.

Moreover, EE6 put focus on these components' COMPREHENSIBILITY. Since participants were both experts in the problem domain and familiar with EA concepts, EE6 investigated whether REAM v5 produces an REA that conforms to EA models (FREQ1) and whether it complies with domain-specific systematizations (FREQ4). Consequently, EE6 used a NATURALISTIC setting with a FORMATIVE purpose. In total, the author conducted seven expert interviews with 18 experts from seven ISVs and IT consultancies. As Table 64 presents, the participants ranged from compliance software product managers to IT developers and IT consultants as well as chief executives. Further, the table reveals on what part of the RCO the respective expert focused (AML, KYC, or Fraud).

TABLE 64. PARTICIPANTS OF EXPERTS INTERVIEWS DURING EE6

#	DATE	STAKEHOLDER	FOCUS	PARTICIPANTS	EXPERTISE	CONTRIBUTION
1	30th June 2017	IT consultancy	AML	IT Consultant Financial Services	(Mobile) Payments, Trading	RCO structure, integration to financial institute, correctness
				IT Consultant Financial Services	IT Security, IT Governance, IT Risk Compliance	RCO structure, integration to financial institute, correctness
				IT Consultant Financial Services	Governance-Risk-Compliance Program	fit with practice, RCO structure
				Software Developer	Cryptography, IT Security	RCO data and application layer
2	14th July 2017	IT consultancy	AML KYC	IT Consultant Financial Services	Financial Service Compliance	processes KYC + AML, IT landscapes
				IT Consultant Financial Services	Financial Service Compliance	processes KYC + AML, IT landscapes
3	17th July 2017	Information Logistics Provider	RCO	Sales Representative and former banker	Financial Industry and Instituteal Practices	feasibility of RCO application
4	19th July 2017	Compliance Software Provider	AML KYC	Product Consultant	AML Processes and IT Support	completeness and correctness of AML, KYC
				2x Product Managers	Compliance Program, AML Data Structures and IT Support	completeness and correctness of AML, KYC data + application layer
				Department Head Compliance Suite	Compliance Software and Integration	integration to financial institute
				2x Chief Executive	Compliance Products in Financial Industry	feasibility of RCO application, stakeholder needs
5	19th October 2017	IT Service Provider	Fraud	Executive Consultant	Regulatory Landscape, Compliance Programs	RCO structure, correctness and completeness Fraud
6	24th October 2017	Payment Service Provider	Overall RCO Fraud	Department Head Compliance & Data Privacy	Financial Payments, Fraud Detection	completeness and correctness Fraud
				Chief Executive	Regulatory Landscape, Financial Payments, Fraud Detection	RCO structure, feasibility of RCO application, stakeholder needs
				Software Developer	IT Support Fraud Detection	completeness and correctness Fraud
7	October 2017[1]	Compliance Software Provider	AML KYC	Senior Consultant	AML+ KYC Processes and IT Support	RCO structure, AML + KYC correctness

EXPERT INTERVIEW DESIGN. The author designed the expert interviews as follows. Each of the seven interviews followed a workshop-like setting. They took one workday each and followed the same structure. In the beginning, the author gave a detailed introduction of the RCO and its structure after a summary of the used ArchiMate modeling language. The central part of the workshop focused on the validation of the RCO. Using a prior developed structured questionnaire (see Appendix B on p. XV), the participants evaluated each of the RCOs viewpoints represented in Figure 81. Evaluating an RCO viewpoint proceeded as follows. First, the author gave an overview of the concerns addressed by it and explained the structure. Second, the author went through all elements. The participants evaluated the elements regarding their correctness and the completeness of elements displayed. Third, the author used the structured questionnaire to ask questions that came up within the project team during the development process. Fourth, the author asked whether participants had further questions. After doing this for all viewpoints, the third and final part of the workshop was dedicated to conduct REAM v5's component 8, i.e., steps to prepare REA application. In an open discussion, the participants discussed the needs of problem stakeholders and how the RCO could be applied to address them.

Further, the author asked participants whether they think that problem stakeholders would understand the systematizations and labeling used by the RCO. The author documented the results of the workshops by two means. While validating the single RCO viewpoints, the author directly changed the models and highlighted them. Thus, each expert interview resulted in an adjusted version of the RCO. Furthermore, the author documented answers regarding questions of the structured questionnaire and any other type

[1] #7 was the only exception to how the expert interviews were conducted. The scheduled workshop was cancelled. Instead, a two-level correspondence between the author and the expert was implemented. First, the author presented the RCO focusing on AML and KYC and provided access the material. Second, after examining the RCO, the expert gave feedback regarding the model via a telephone interview. While insights were somehow limited due to the nature of interaction, the expert validated overall findings from previous exert interviews.

of feedback (e.g., during the open discussions at the end of the workshops) in a separate text document. After each workshop, the author sent these notes to the participants for review. After conducting all seven expert interviews, the author consolidated the results. As a result, a list of improvement needs evolved. That list then resulted in an adjusted version of the RCO.

RESULTS OF EE6. The overall objective of applying REAM v5 in EE6 was to evaluate the RCO and prepare it for its application. The application of REAM v5 component 7 for evaluation resulted in a list of 66 change requests that directly affected the RCO. Appendix C (see p. XVI)provides a consolidated list of these change requests. Further, applying the first steps of component 8 produced five distinct scenarios for applying the RCO (see Table 55). These results allow the conclusion of both components' ACTUAL EFFECTIVENESS. This conclusion may be biased because EE6 only allowed to apply certain parts of REAM v5. In concrete, EE6 only applied step 7c and step 7d of component 7 and step 8a and step 8b of component 8. However, the workshop agenda allowed the author to discuss REAM's actual procedure for REA evaluation and application. Hence, following conclusions regarding the COMPREHENSIBILITY of both components were drawn (FREQ2):

- **REA Evaluation (Component 7):** While the experts deemed the overall approach for REA evaluation as feasible and agreed that the several expert interviews are necessary to guarantee RCO's validity, they stated the procedure of component 7 is not specific enough and should provide more guidance. Although the participants found the procedure of respective method components easy to understand, most stated they did not seem intuitive. In concrete, they proposed that one should perform the evaluation of the REA structure and the individual models at design time. While this remark addresses REAM v5's coherence, experts seemed to lack an understanding of what REAM v5's evaluation component would require them to do as they found step 7a and step 7b to be confusing. Furthermore, the experts agreed that any application of an REA in practice might also evaluate the REA. Moreover, the majority of participants lamented that REAM did not tackle the aspect of model maintenance. They stressed that, especially in the domain of financial services compliance, regulatory requirements frequently change. One should consider that when evaluating an REA.
- **REA Application (Component 8):** Overall, participants stated that component 8 would prepare RCO for its application. However, the discussions revealed that there exist many diverse scenarios of applications that may pursue different goals of RCO application as well. Further, some participants stated that the steps of component 8 were too separated from the construction of the RCO. They state that they would be irritated if they should now conduct the REA application. While subsequent discussions eliminated some uncertainties in this regard, the author concluded that considering these remarks will improve a future REAM design.

With the above findings, the author learned further aspects regarding REAM v5's COHERENCE. The participants' remarks regarding component 8 revealed the flaw of REAM that it did not address possible application scenarios when analyzing the problem domain and deriving an appropriate construction strategy during components 1 and 2. Further, REAM lacked a comprehensive and logical order between construction, evaluating, applying, and refining the REA. Lessons learned from REA application did not result in concrete feedback of the REA. Moreover, the expert hinted that REAM should consider application aspects before constructing an REA.

Finally, the author learned that REAM provides room for improvement regarding its MODULARITY as well. One central finding of EE6 was that the RCO did not reuse domain-specific systematizations, which were widely used by RCO's problem stakeholders. One example was the line-of-defense model, which is a known concept for compliance programs. All participants agreed that this would be an essential aspect concerning user acceptance of REAs. The author concluded to define a separate method component for this. The same applied to the maintenance of REAs as participants argued that there might exist more triggers for REA maintenance than the results of REA evaluation.

The following list summarizes how EE6 and its findings contributed to REAM's requirements:

- ✓ **FREQ1:** Conducting the expert interviews with experts possessing different expertise of all EA layers (see Table 64), the author assessed FREQ1. Participants verified that the RCO represented detailed knowledge of addressed EA layers and made interrelations among these layers transparent.
- ✓ **FREQ3:** Since the workshops intensively evaluated the content of the RCO, the participants acknowledged that the RCO represented practical domain knowledge. They stated that the depth of knowledge would go beyond the information detailed offered by other documents, such as official legal text interpretations. Especially the fact that the RCO relates the compliance aspects into the context of instituteal practice was stressed.
- ✓ **FREQ4:** The diversity of participants made it possible to intensively evaluate REAM output's domain-specific knowledge and its conformance with domain-known systematizations. Participants primarily assessed the domain vocabulary as appropriate. However, some participants lamented that the REA lacked known systematizations.
- ✓ **NFREQ1:** As the above paragraphs discussed in detail, EE6 identified the need for REAM to define two more method components (maintenance and domain-specific REA structure) and an improved logical structure among REAM's components.

IMPROVEMENT NEEDS DERIVED FROM EE6. Based on the prior elaborations, the author identified the following improvement needs towards REAM v5, which resulted in the final REAM v6:

- ❖ In order to address the specific needs of the diverse range of problem stakeholders, the concept of application scenarios shall be introduced, which relates concrete stakeholders needs with certain aspects of REAM output
- ❖ To provide a more detailed approach to REA evaluation
- ❖ To define a new method component dedicated to developing a domain-specific REA structure, which reuses systematizations and terms widely accepted in the problem domain
- ❖ REAM shall guide on how to implement adjustment mechanisms in an REA's design, which supports REA users to apply a REA correctly.
- ❖ to define a new method component that considers how to maintain an REA model once developed
- ❖ to improve the logical order of REAM

7.2.7 EVALUATION EPISODE 7: APPLYING AN REA IN TWO DISTINCT PRACTICES

Evaluation Episode 7 (EE7) also applied the final version of REAM in the context of the COFIN project. Table 65 summarizes the evaluation design of EE7. Due to the context of the evaluation, some activities of EE6 had overlaps in time.

TABLE 65. EVALUATION DESIGN OF EVALUATION EPISODE 7

#	PURPOSE	PARADIGM	PARTICIPANTS	METHOD	PROPERTY	REQs
EE7	SUMMATIVE	NATURALISTIC	PROBLEM STAKEHOLDERS OF RCO: ISV	CASE STUDY	ACTUAL EFFECTIVENESS	FREQ2 FREQ3 FREQ4 FREQ5 NFREQ2
			PROBLEM STAKEHOLDERS OF RCO: GERMAN THRIFT INSTITUTE	ACTION RESEARCH		

TIME ASPECT. EE7 was conducted at two points time. First, the RCO was applied in October 2017 by an ISV that also participated in the focus group. Second, the RCO was applied at a German thrift institute in January 2018.

CONTEXT OF EE7. In the last evaluation episode, EE7 applied the final version REAM v6 (see chapter VI) in a NATURALISTIC setting with a SUMMATIVE purpose. Its central evaluation focus was to evaluate REAM (reuse-oriented) ACTUAL EFFECTIVENESS. As elaboration from section 7.1.3 depicted earlier, this required to apply the with REAM constructed REA by real-world users. Thus, EE7 focused on REAM's method components 8-10 "Application Design Development," "REA Model Evaluation," and "REA Model Maintenance." That assessed, whether REAM covers the complete RM development cycle (FREQ2), produces an REA that represents correct practical knowledge of the addressed problem domain (FREQ3) using recognizable domain-specific systematizations of that knowledge (FREQ4), and whether REAM provides appropriate means for problem stakeholders to apply the REA in a way that addresses their specific needs (FREQ5). According to evaluation goals 3 and 4 (see section 7.1.3), EE7 investigated two distinct application scenarios (see Table 55) of the RCO model that was developed by earlier evaluation episodes. Each of them applied the RCO for different reasons and used different application scenarios defined using REAM. The two cases had the following specifics:

Case (A): Application of RCO at Payment Service Provider (ISV)

- Used Research Method for Evaluation: CASE STUDY
- Application Scenario applied in case: Improvement or Development of Compliance Software

In case (A), an ISV used the stated application scenario in order to develop a new compliance software product. The ISV provides IT solutions for payment transactions to financial institutes from the German financial sector. The initial idea to use the RCO was to identify potential new markets by analyzing the common practice of AML. Therefore, the ISV primarily consulted the business and data layer of the RCO's AML module with the help of the author. A workshop day generated various ideas, from which participants concretized one specific product idea. This idea was based on a lack of IT support in a specific part of the AML reporting process (one task of the AML program). Participants further consulted RCO for data necessary for this activity. In the end, the ISV applied the RCO to develop a new product for AML case management. The tool supports banks to document AML case investigation thoroughly, which, hitherto, was mainly conducted manually.

Case (B): Application of RCO at a German Financial Thrift Institute

- Used Research Method for Evaluation: ACTION RESEARCH
- Application Scenario applied in case: Gap Analysis of RCO and Compliance Program of Institute

In case (B), a German thrift institute applied the RCO using the stated application scenario. The overall objective was to identify gaps between the bank's as-is situation and the RCO regarding two specific segments of the model: the identification of business clients from the KYC module and the processing of suspected cases from the AML module. For the actual application, the author and a second member of the COFIN project team conducted a two-day workshop at the bank. The bank's long-standing compliance officer and AML manager, as well as his deputy, acted as the RCO user. In essence, the first day captured the bank's current practice of the two processes, while the second day's purpose was to conduct the gap analysis with the RCO. The project members recorded the bank's situation using participative modeling sessions with the help of a bulletin board and facilitator's toolbox (Stirna et al. 2007). Afterward, these materials were translated into an ArchiMate model following the RCO structure. Then, the team used a professional modeling tool to conduct a gap analysis between the bank's as-is model with the RCO's corresponding views. The tool helped to visualize the similarities and differences of the models and proofed to be a very conducive approach to trigger reasoning about them.

REAM V6. REAM v6 represents the final version of REAM. Chapter VI thoroughly describes the method. It further demonstrates all ten final method components using the exemplary results from the COFIN project. The main adjustments in comparison to earlier method versions are the introduction of REAM's phase concepts—Phase (A): Preparation, Phase (B): Construction, Phase (C): Application. Further, REAM v6 defined two new method components for defining a domain-specific REA structure (Component 4, see section 6.5.2) and REA maintenance (Component 10, see section 6.6.3). Finally, the author enhanced the method components for REA evaluation and application based on EE5's and EE6's insights.

RESULTS OF EE7. Before this section discusses the general findings of EE7, the next paragraphs present the results of both application cases.

CASE (A). The objective of this RCO usage was to apply it in a second real-world scenario. The ISV consulted the existing RCO and developed a new IT artifact for their product portfolio by the guidance of the RCO and its documentation. The RCO revealed that a prior developed IT solution of the ISV might cover a specific need for IS support in the process of AML case management. The ISV's customer base validated the identified need. Afterward, the ISV reported their RCO application to the author and presented in a one day workshop how they did so. During discussions with the ISV, the author learned that this combination of structured information made the application possible. The ISV emphasized the advantage of the R-CO to discover synergies using the integrated perspective of different RCM domains that expands the legal demands by practical experience.

CASE (B). The gap analysis by dint of a professional modeling tool helped to visualize the similarities and differences of the models and proofed to be a very conducive approach to trigger reasoning about them. Different reasons for such differences emerged:

(a) parts were missing in the institute EA model because they were not discussed during the modeling sessions;

(b) there was a misunderstanding between the participants and the workshop team;

(c) aspects captured in the RCO did not apply to the institute;

(d) the institute applied processes that were not captured by the RCO yet, since they were just implemented after the RCO construction; and,

(e) the RCO unveiled room for improvement of the institute's compliance approaches.

While case (a) and (b) are often observed in modeling sessions (Stirna et al. 2007), cases (c) and (d) confirmed claims by REAM to use application cases for improving REAs as well. Nevertheless, the most interesting discussions emerged in case (e). Without any further input, both participants directly started thinking whether missing elements should be implemented in their compliance division and why. Figure 82 illustrates the gap analysis of a simplified model view for the IS support of the AML case handling process.

While the institute by the time of the workshop already used a new system for the official reporting instead of a fax system (case d), discussion arose whether the institute's process should implement the support of a risk analysis system and sanction screening (case e). Consequently, this validated REAM's approach and structure of "Phase (C) REA Application" that recommends method users to distinguish between user-driven and model-driven evaluation (see Figure 69). These findings were fruitful for applying REAM in order to develop a new version of the AML and KYC domains of RCO. After the workshop, both project members interviewed the participants about the RCO's reusability (FREQ5) and correctness (FREQ3). They stated that the gap analysis helped them to identify room for improvement in their RCM approach. Even though their compliance processes—namely customer identification and AML case management— were thoroughly implemented, the detailed data layer and its relations with the different domains of the business layer helped them to structure their RCM from a more holistic perspective. The compliance officer especially named the RCO's expressive power and the visualized gap analysis as a reason to apply it. Further, the participants verified the remaining application scenarios' value and added that the RCO and the further development of it would be a useful tool at the federation level of the German banking industry.

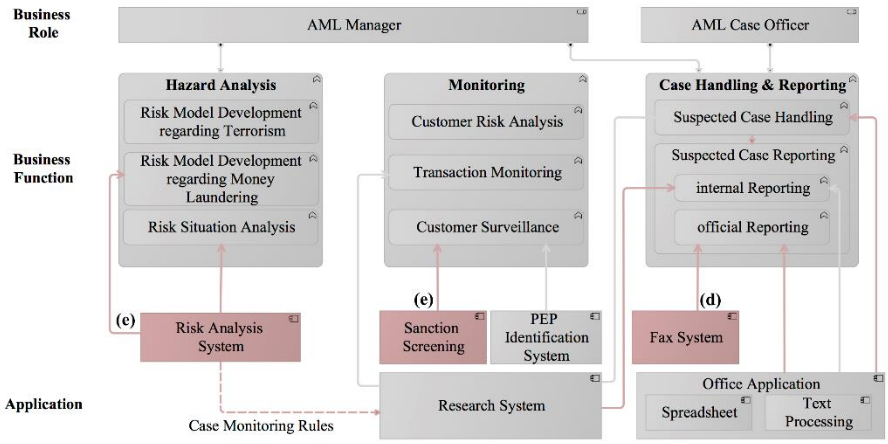


FIGURE 82. GAP ANALYSIS OF THE AML CASE HANDLING IS SUPPORT[1]

All in all, both the ISVs involved in the focus group and the financial institutes consulted during and after the RCO construction stated that the developed REA produced by REAM provides a solution for holistic and robust RCM, which incorporates and interrelates organizational and IS concepts. Based on the evaluation's insights presented above, the author argues that the output of REAM not only seems to be a universally valid REA with recommendatory character, but was also reused by to different real-world problem stakeholders. Thus, according to Thomas (2005) and Vom Brocke (2006), REAM produced a valid REA. From this, the author derives that EE7 validated REAM's reuse-oriented ACTUAL EFFECTIVENESS (NFREQ2).

The following list summarizes how EE7 and its findings contributed to REAM's remaining requirements:

- ✓ **FREQ2:** EE7 focused on applying Phase (C) of REAM. That included applying REAM's output in practice and evaluating it. While applying the RCO at the financial institute, the RCO Team identified some flaws of the RCO regarding its completeness and actuality. In a concluding discussion, the participants stated that the RCO lacks some detail in the reporting processes of the AML module. Further, they hinted that the RCO soon would be outdated in some parts because the EU shortly publishes an amendment of the money laundering directive. That triggered an iteration of Component 10, in which the project team eliminated these flaws. In conclusion, the author argues these observations verify REAM's approach to interpret an application of an REA as an evaluation, which may trigger the maintenance process of REAM.
- ✓ **FREQ3:** In case (B), both participants assessed RCO's content as representative of its practical domain. Although they had no prior experience with EA models and the RCO in particular, they found both RCO structure and elements as relevant to their practice and assessed it as much more useful than other available knowledge of the domain, e.g., regulatory interpretations. In this regard,

[1] red elements indicate elements the institute did not implement

they validated REAM's approach to abstract from practical knowledge and found it essential for an REA's success, i.e., its actual application by problem stakeholders.

- ✓ **FREQ4:** One aspect of this episode was to evaluate whether the domain-specific terms, produced models, and their systematizations are familiar to problem stakeholders that were not involved in the development process of the RCO. That was important to understand whether REAM meets FREQ4. During the detailed presentation of the RCO, participants of the Thrift Institute directly understood the RCO models and agreed with domain-specific terms. The author and another RCO Team member observed that both participants directly engaged with the RCO and started discussing its content in the context of their practice. On this basis, the author understands that REAM meets FREQ4.
- ✓ **FREQ5:** As required by FREQ5, the REA produced by REAM shall be at least applied in two distinct real-world cases to validate its reusability. During discussions with the problem stakeholders, the author learned, especially the thorough documentation of the resulting RCO, which is driven by REAM, helped to identify concrete means for application. However, both application cases did not correctly apply recommended adjustment mechanisms as the application of REAM defined for the RCO application design. The author recognizes that future versions of REAM shall either improve the integration of adjustment mechanisms for applying REAs or exclude it from its design in order to avoid confusion. Notwithstanding, the author identifies this open issue as a potential future research topic.

7.3 SUMMARY OF REAM EVALUATION

The author applied the FEDS approach by Venable et al. (2016) to evaluate REAM. FEDS defines a four-step approach to evaluate DSR. After setting up overall evaluation goals, the author chose an evaluation strategy. After identifying relevant evaluation properties, the author designed seven evaluation episodes that realize that evaluation strategy. To summarize the evaluation of REAM, this section will conclude to what extend the evaluation episodes achieved the evaluation goals from section 7.1.1, which helps to judge the insights from the evaluation design. Afterward, this section will briefly revisit central findings regarding the requirements formulated for a successful REAM. Finally, it summarizes future improvement needs of REAM and enlists open questions the author deems essential for evaluations of future REAM versions.

Table 66 provides an overview of all evaluation episodes conducted in the course of this Ph.D. project in order to assess REAM regarding its requirements and the four evaluation goals defined at the start of the evaluation design. Table 67 further maps each episode with the evaluation goals from section 7.1.1, the requirements formulated in chapter IV, and the evaluation properties defined in section 7.1.3.

In short, the evaluation design required REAM evolved by dint of many naturalistic and formative episodes that primarily address its effectiveness. To ensure its generalizability, REAM needed to be applied in different problem domains. That implied applying an REA, which was produced by REAM in distinct contexts. In retrospect, the evaluation design met all of these goals. The author applied REAM in two distinct problem domains, i.e., the utility industry and the financial service domain. In the latter domain, REAM produced a thoroughly evaluated Reference Compliance Organization (RCO), which two different problem stakeholders applied (see section 7.2.7). Six episodes evaluated REAM in naturalistic settings while focusing on its effectiveness, i.e., whether it provides appropriate means to develop a desired REA. The author wants to point out that he was involved in REAM applications of these episodes, which may lead to a biased result of this evaluation. However, the episodes implemented two means that addressed mitigating that bias: (i) the author acted as one project team member in a team of five (ECLORA) respectively six (COFIN) members that applied REAM accordingly; (ii) in all cases the project team was in frequent contact with several domain experts. All results, including the resulting Utility REA and

RCO, were validated by them. Furthermore, five episodes had a formative purpose. Consequently, REAM evolved over six design versions (see Figure 72). Hence, the author concludes that the evaluation design met its goals.

TABLE 66. OVERVIEW OF EVALUATION EPISODES

#	PURPOSE	PARADIGM	DESCRIPTION	PARTICIPANTS	METHOD
EE1	FORMATIVE	NATURALISTIC	DEVELOPING THE UTILITY REA USING REAM	PROBLEM STAKEHOLDERS OF UTILITY REA	ACTION RESEARCH
EE2	FORMATIVE	ARTIFICIAL	FOCUS GROUP ASSESSMENT OF REAM	DOMAIN EXPERTS	CRITERIA-BASED EVALUATION, EXPLORATORY FOCUS GROUP
EE3	FORMATIVE	NATURALISTIC	DEVELOPING AN REA FOR ANTI-MONEY LAUNDERING	DOMAIN EXPERTS, PROBLEM STAKEHOLDER OF RCO	ACTION RESEARCH, EXPLORATORY FOCUS GROUP
EE4	FORMATIVE	NATURALISTIC	DEVELOPING AN REA FOR KNOW YOUR CUSTOMER	DOMAIN EXPERTS, PROBLEM STAKEHOLDERS OF RCO	ACTION RESEARCH, EXPLORATORY FOCUS GROUP
EE5	SUMMATIVE	NATURALISTIC	DEVELOPING AN REA FOR FRAUD PREVENTION	DOMAIN EXPERTS, PROBLEM STAKEHOLDERS OF RCO	ACTION RESEARCH, CONFIRMATIVE FOCUS GROUP
EE6	FORMATIVE	NATURALISTIC	ASSESSMENT OF AN REA'S FIT TO PRACTICE	PROBLEM STAKEHOLDERS OF RCO	EXPERT INTERVIEWS
EE7	SUMMATIVE	NATURALISTIC	APPLYING AN REA IN TWO DISTINCT PRACTICES	CASE (A): APPLICATION OF RCO AT PAYMENT SERVICE PROVIDER	CASE STUDY
				CASE (B): APPLICATION OF RCO AT A GERMAN FINANCIAL THRIFT INSTITUTE	ACTION RESEARCH

FREQ1: REAM SHALL PRODUCE A RM USING EA STRUCTURES. As formulated in chapter IV, FREQ1 is met if the REA produced by REAM conforms to EA standards. That is to be evaluated by enterprise architects. One participant of EE1 was an enterprise architecture. While the results of that episode also revealed some flaws regarding the structural definition REAs in the beginning, the EA expert evaluated the resulting Utility REA to conform with EA standards as it provided detailed insights regarding a public utility's business, data, and application landscapes as well as their interrelations. The Utility REA applied the well-accepted TOGAF framework and utilized the EA modeling standard ArchiMate for representation. Furthermore, the final REAM version integrated more detailed guidance for both defining the overall REA Framework (see Component 3) and developing a domain-specific REA structure (see Component 4). While REAM reuses available knowledge from the EA community for the former (see section 6.5.1), the latter then tailors these frameworks and modeling languages to the specifics of the addressed problem domain. IT and consulting experts validated this during EE6.

FREQ2: REAM SHALL COVER THE COMPLETE RM LIFECYCLE. FREQ2 is met if REAM users and potential users of an REA assess the method to provide methodological guidance for REA construction, application, and maintenance. In contrast to FREQ1, REAM only addressed this requirement late in the design process. According to the results of EE1, early versions of REAM put the main focus on REA construction. Although interim versions of REAM put increased focus on applying and maintaining REAs, episodes EE2-EE4 still focused on the construction-oriented evaluation of REAM. Thus, FREQ2 was not a primary focus since EE1 already evaluated this aspect of FREQ2. However, throughout the iterative design process of REAM and increased stakeholders involvement during REAM application in the context of the COFIN project (EE2-EE7), REAM's final design defines three method components that are dedicated for REA application and maintenance, i.e., Component 8-10 aggregated in Phase (C) of REAM. The final episodes EE6 and EE7 then applied the components of Phase (C). EE7 validated REAM's approach to use REA application cases as a means for both evaluating and maintaining an REA. However, the author points out that future research further should investigate the maintenance of REAs. While REAM provides first guidance in that regard, only one evaluation episode evaluated the respective method component 10.

TABLE 67. MAPPING EES WITH GOALS, REAM REQS, AND EVALUATION PROPERTIES

# EVALUATION EPISODE	EVALUATION GOAL				REAM REQUIREMENTS								EVALUATION PROPERTY				
	1: NATURALISTIC	2: FORMATIVE	3: EFFECTIVENESS	4: CONTEXTS	FREQ1	FREQ2	FREQ3	FREQ4	FREQ5	NFREQ1	NFREQ2	NFREQ3	ACTUAL EFFECTIVENESS	ACTUAL EFFICIENCY	COHERENCE	MODULARITY	COMPREHENSIBILITY
1	☑	☑	☑	☑	☑	☑	☑			☑	☑		☑	☑			
2		☑								☑					☑	☑	☑
3	☑	☑	☑				☑			☑		☑	☑			☑	☑
4	☑	☑	☑							☑		☑	☑	☑	☑		☑
5	☑		☑			☑	☑			☑			☑	☑	☑	☑	
6	☑	☑	☑	☑	☑	☑	☑	☑		☑			☑		☑	☑	☑
7	☑		☑	☑		☑	☑	☑	☑		☑		☑				

FREQ3: ANALYZE PRACTICAL KNOWLEDGE IN COMBINATION WITH GENERALLY ACCEPTED KNOWLEDGE. According to FREQ3, knowledge represented by the resulting REAs shall conform to existing knowledge and phenomena in the respective problem domains' practices. Earlier elaborations stated that this has to be evaluated in collaboration with practitioners from the problem domain REAM was applied in. Generally, all episodes (EE1, EE3, EE5, EE6, EE7) that addressed FREQ3 assessed the respective REA to represent practical knowledge. The domain experts involved in ECLORA and COFIN, as well as project team members, agreed that the application of method component 6 “Inductive REA Construction” is essential if the envisioned REA requires the inclusion of detailed practical knowledge. While one of the most challenging activities of REAM, the elicitation of individual models play a central role in this respect, the results of EE6 verified this. Eighteen domain experts and potential RCO users stated that the depth of information represented in the RCO model would not have been achieved if the development process would only have relied on analyzing existing explicit knowledge such as laws or industry standards. In EE7, two practitioners from a German bank, who were not involved in the development process found the model to be relevant to their practice.

Consequently, the author argues that the evaluation rigorously showed that REAM fulfills FREQ3. It further verified the need to include inductive methods for developing REAs. Further, several evaluation episodes found it essential to reuse existing domain knowledge and, hence, to combine inductive and deductive approaches when developing an REA. That underlines REAM’s approach to recommend a combination of deduction and induction, as components 5 and 6 of Phase (B) suggests.

FREQ4: REAM SHALL PROVIDE METHODOLOGICAL GUIDANCE TO INTEGRATE DOMAIN-SPECIFICS IN AN REA DESIGN. While FREQ3 addressed the interplay of deduction and induction, FREQ4 focuses more on how to present the REA content. It requires REAM to define methods to structure REAs in a way that shall conform to systematizations and concepts known within the respective problem domain. Hence, it was essential to evaluate FREQ4 by dint of interviewing experts and problem stakeholders from the domain, in which REAM is conducted. Since this requirement was defined after EE1 applied REAM in the utility industry, the author only evaluated in the context of the COFIN project, i.e., after developing the RCO using REAM. Throughout REAM design process, the author learned that one essential aspect for REA user acceptance is to implement systematizations and visualizations in an REA design recognizable for potential users. Thus, the final version of REAM defined component 4 "Domain-Specific REA Structure," in which the development team shall investigate such reusable systematizations but also glossaries in order to provide domain-specific vocabulary within a produced REA as well. Later in EE6 and EE7, the author observed that the participants without prior knowledge of RCO, directly engaged with it and its content. At the end of the COFIN project, the focus group members stated this as an essential factor and verified the need for REAM to define method component 4.

FREQ5: REAM SHALL GIVE CLEAR GUIDANCE ON HOW TO DESIGN AN APPLICABLE REA. This requirement refers to the reuse-oriented effectiveness of REAM. It investigated by evaluating how well REAM application produces an REA that documents how to apply it in practice. Thus, the dedicated evaluation episodes had to include problem stakeholders and experts of the respective domain. Since FREQ5 was formulated during the late phase of this DSR project (see chapter IV), only the two cases of EE7 evaluated this requirement. Domain stakeholders identified the application scenario of REAM's component 7 "REA Application Design" to be an essential concept. All participants agreed that an application scenario encapsulates essential information for potential REA users to understand why and how to use an REA. Especially Case (A) of EE7 demonstrated this, as the payment service provider applied the RCO on their own without the author's involvement. During the application process, they consulted the author for further feedback.

To conclude, the author argues that the definition of application scenarios based on stakeholder needs and related REA values is vital for REAM reuse-oriented effectiveness. Nevertheless, the evaluation also revealed that adjustment mechanisms (defined for each application scenario) had not been used as defined. That may be because REAM did not correctly define how to apply them in an REA design or because REA application cases are conducted in a too specific context to restrict themselves to predefined REA adjustment mechanisms.

NFREQ1: REAM SHALL PROVIDE A COHERENT AND MODULAR STRUCTURE. This non-functional requirement referred to REAM's overall structure and was evaluated by many different REAM users in all evaluation episodes but EE7. While the author was involved in REAM application in all these episodes, he applied REAM together with two different project teams in the ECLORA and COFIN context. Further, in EE2-EE6, domain experts of the focus group acted as consultants throughout REAM application. During regular focus group meetings, the author requested feedback regarding different REAM parts regarding their coherence and modularity. As REAM evaluation design included five formative episodes, each resulted in an enhanced coherence and modularity of the method. Starting from adjustment of Becker et al. (2002)'s method, REAM finally arrived at defining ten distinct method components, which themselves are related to one of three REA development phases and span over the whole REA lifecycle (FREQ2).

Further, several iterations of designing and evaluating REAM helped to define clear demarcations among the method components and improving methodological guidance on how and in which order to deploy REAM. The summative evaluation episode EE5 further verified this. However, the author does hint that there may exist further possible paths through the components when applying REAM. It is not yet clear whether long-term maintenance of a specific REA can easily apply REAM for this purpose. Nevertheless, the findings from this evaluation allows the conclusion that REAM is of a coherent and modular design.

NFREQ2: REAM SHALL PRODUCE AN REA THAT IS ACTUALLY APPLICABLE TO PRACTICE. This requirement also referred to the reuse-oriented effectiveness of REAM. Only real REA users can assess REAM in this regard. At this point, the author wants to stress the effort behind both developing and then applying an REA using REAM. Thanks to the evaluation context, it was possible not only to verify the construction-oriented effectiveness of REAM, but also to apply its output in practice. Although EE1 states that the produced Utility REA was not applied at a specific problem stakeholder, the ISV involved in the development process later used the Utility REA to improve their software product. EE7 made similar observations.

Nonetheless, it is essential to point out that there exist additional factors that determine an REA's application than the effectiveness of the method used for its construction. First, the involvement of experienced domain experts from the problem domain was beneficial in both ECLORA and COFIN contexts. Further, the cooperation of stakeholders during the inductive REA construction was essential in both cases for the REAs' success. Finally, this involvement seemed to raise those stakeholder's interest in the REAs as well.

NFREQ3: REAM SHALL UTILIZE ADEQUATE TOOL SUPPORT AND PROVIDE TRACEABLE INTERIM RESULTS. This requirement addressed the fact that applying REAM may involve many different stakeholders who intend to have frequent access to the results of the method application. Further, REAM shall define precise interim results as it can span over a long period. Six evaluation episodes applied REAM in a naturalistic setting and involved a total of twelve experts. Especially during EE3 and EE4, the author recognized improvement needs regarding NFREQ3. As a result, the final REAM defines the inputs and outputs of the method components.

Moreover, each step of its method components recommends appropriate software support for the corresponding results. Thereby, the author designed REAM to use as many software products, from which one can assume that all involved REAM stakeholders have access to, e.g., office suites. Also, one essential decision for developing REAs is to use an appropriate modeling tool. While there exist open-source tools that provide essential functionalities, both COFIN and ECLORA switched to professional commercial modeling tools in order to make use of more sophisticated functionalities such as automated view generation based on specific concerns or a visual gap analysis. Especially for REA application, these can be of high value. Thus, REAM's component 3 "REA Framework Setup" was adjusted in order to support this decision.

Overall, the author concludes that REAM meets all its functional and non-functional requirements. While the previous summaries for each of them revealed some room for improvement, REAM fulfills the general fit criteria, as defined in chapter IV. In retrospect, the author understands the complexity of the final REAM design as one significant design risk as the evaluation of all ten method components resulted in much effort and lasted almost four years. The several formative and naturalistic evaluation activities enabled REAM design to mature. In summary, the author argues that the evaluation design at hand validated REAM's actual effectiveness thoroughly, which was the primary goal in the scope of this thesis. However, the author also wants to emphasize the current limitations of REAM evaluation. As section 7.1.3 discussed in detail, future research shall evaluate REAM's perceived efficacy, as Moody (2003) proposes. While this chapter revealed that REAM produces desirable results, it lacks insights regarding how method users perceive its ease of use and usefulness. These will help understand REAM's adoption in practice. Further, the author actively participated in all REAM applications. Thus, the author cannot wholly dismiss the fact that evaluation results are somehow blurred. Finally, future investigations may also improve the metrics for measuring REAM's efficiency. While the evaluation showed that REAM's efficiency generally improved throughout the different method versions, more exact metrics may help to derive an improved understand of REAM in this regard.

VIII. DISCUSSION AND CONCLUSION

Increasingly flexible business environments force organizations to continually revisit and improve their organizational structures, business processes, IT landscapes, and their alignment to stay competitive. While the causes of such industrial changes can be manifold, they often affect a group of diverse enterprises who lack a systematic approach to react to these adequately. This Ph.D. thesis investigates this phenomenon from the perspective of enterprise architecture management (EAM) and reference modeling (RM, see chapter III) and argues that Reference Enterprise Archictectures (REAs) help organizations to overcome this challenge. The author shows that practice laments the absence of a systematic approach that holistically captures industrial changes and helps affected organizations to align their business and IT landscapes in this context (see chapter IV). Although research agrees that REAs are meaningful to achieve this, the author reveals that the knowledge base of IS research lacks methodological support for developing them (see section 4.3).

Applying the research paradigm of design science research (DSR, see chaper II), the thesis at hand identifies requirements towards a potential solution (see chapter VI) and proposes the IS method *REAM* that supports the systematic construction and application of REAs (see chapter VI). The author shows REAM's utility by demonstrating and testing its fit to the defined requirements over seven evaluation cycles (see chapter VII). In the end, the thesis successfully applies REAM in two different real-world problem domains, i.e., the utility industry and financial services. The author claims that REAM solves the practical problem and further argues for its generalizability to other domains that share the same problem characteristics.

The remainder of this section structures as follows. Section 8.1 summarizes the results and discusses them in the context of DSR. Afterward, section 8.2 discusses the threats that exist towards REAM's validity and further elaborates on additional limitations. On that basis, section 8.3 revisits the different contributions of this thesis and discusses their practical and theoretical implications. In section 8.4, the author retrospectively reflects on lessons he learned during the Ph.D. project—concerning his experiences with the DSR methodology and the observations he made while applying REAM in practice. Finally, section 8.4 intends to encourage future research as it points to research directions in the context of REA development.

8.1 SUMMARIZING THE RESULTS IN THE CONTEXT OF DESIGN SCIENCE RESEARCH

Based on the investigation of two distinct local practices in the utility and financial domain, the author identifies the practical problem that industrial change forces organizations to adjust both their business and IT landscapes holistically. Not only do these organizations often lack practical knowledge to overcome this challenge, they do not possess capabilities to acquire it, either. The research domains RM and EAM in general (Proper et al. 2017) and REA in specific (Czarnecki and Dietze 2017c) address this problem. REAs provide a reusable solution to a group of organizations sharing the same problems of a particular problem domain (e.g., the liberalization of the utility industry). However, this thesis identifies a lack of methodological support for constructing and applying REAs. On that basis, the central research question (RQ) of the Ph.D. thesis is as follows:

> **RQ: HOW TO PROVIDE METHODOLOGICAL SUPPORT FOR SYSTEMATICALLY CONSTRUCTING AND APPLYING DOMAIN-SPECIFIC REAS?**

In order to answer this RQ, the author applies the construction-oriented research paradigm of design science research (DSR) and proposes REAM—a method for developing REAs. REAM's overall objective is to guide method users for developing REAs. Based on certain REA drivers (e.g., new regulations or technological disruptions force enterprises of a particular industry to revise and realign their business and IT structures), REAM defines a specific set of actions and produces a reusable REA for the problem domain it addresses. Therefore, REAM uses the following principles for its design:

- **STRUCTURING REAM**: For a transparent documentation, REAM applies and slightly adjusts the conceptualization framework for information system (IS) methods by Goldkuhl et al. (1998). For instance, REAM defines method components that encapsulate particular tasks when developing REAs, provides a framework that defines the order of conducting these tasks, and discusses the necessary skills to perform them.
- **PHASE CONCEPT OF REAM**: From a lifecycle perspective, research distinguishes between two interrelated phases of REA development: constructing and applying REAs. Furthermore, REAM's design emphasizes the importance of preparing REA development. Thus, REAM defines three phases for developing REAs: *REA Preparation*, *REA Construction*, and *REA Application*. REAM defines method components for each phase and reveals how the phases interrelate with each other.
- **INTEGRATION OF DEDUCTIVE AND INDUCTIVE REASONING**: IS research discusses the benefits and drawbacks of deductively and inductively developing RMs (Schütte 1998; Rehse and Fettke 2019; Scholta et al. 2019). REAM argues that both approaches are necessary to produce a successful REA that is relevant to practice. Thus, REAM's design integrates both deductive and inductive means to construct an REA.
- **REUSE-ORIENTED APPROACH FOR REA:** Research emphasizes the importance of reference models' (RMs) reusability (Thomas 2005; Vom Brocke 2006). REAM follows that stance since EA models provide manifold benefits (Niemi and Pekkola 2019). Therefore and in line with recent approaches such as Rehse and Fettke (2019), REAM investigates REA's stakeholders and their needs in order to anticipate potential usage contexts that influence the REA construction. REAM introduces the concept of *Application Scenarios* that encapsulate different modes of applying REAs and related benefits for its users.

The design of REAM evolved through six DSR cycles of design and evaluation (see chapter VII). While chapter II thoroughly reflects on how the author applied DSR in the context of the thesis, the seven guidelines for conducting DSR proposed by Hevner et al. (2004) help to illustrate how the design process of REAM complied with the DSR paradigm:

GUIDELINE 1: DESIGN AS AN ARTIFACT. As summarized above, this thesis applied DSR in order to develop an IS method that provides the systematic development of REAs, called REAM. All research activities conducted focused on ensuring its practical relevance and improving its design following existing knowledge. Chapter VI presents REAM and illustrates it by dint of a simplified real-world application.

GUIDELINE 2: PROBLEM RELEVANCE. DSR aims to develop IT-related solutions to important and relevant business problems. This thesis provides profound evidence from two distinct local practices and derives a business need of global relevance. Section 4.2 further investigates the problem's characteristics and identifies two central root causes a potential solution shall tackle to solve the problem.

GUIDELINE 3: DESIGN EVALUATION. In order to prove REAM's utility, the thesis applied the framework for evaluation in DSR (FEDS) by Venable et al. (2016). Being an IS method that is primarily applied in a socio-technical context, the evaluation focused on naturalistic and formative evaluation design. As chapter VII shows, the author demonstrated and evaluated REAM in two distinct practical domains using seven evaluation episodes. In the end, REAM matured over six different method versions.

GUIDELINE 4: RESEARCH CONTRIBUTIONS. The central contribution of this DSR project is REAM, which addresses the research gap of how to develop reusable REAs systematically. In this context, the thesis further contributes to both research and practice, as explained in section 1.5. From an academic perspective, this thesis gives a systematic overview of the REA research domain, elaborates an enhanced notion of the REA concept, and contributes to application-oriented RM research. From a practical perspective, the thesis produces two domain-specific REAs for two real-world local practices, i.e., the *Utility REA* (Timm et al. 2015a) and the *Reference Compliance Organization* (Timm and Sandkuhl 2018a). Section 8.3 further elaborates on the theoretical and practical implications of these contributions.

GUIDELINE 5: RESEARCH RIGOR. The central build and evaluation cycle of DSR requires the utilization of rigorous methods for the construction and evaluation of the design artifact. As chapter III shows, the design of REAM builds from widely accepted methods, concepts, and theories of the EAM and RM research domains. On that basis, the knowledge base analysis in section 4.3 conducts a systematic literature analysis to identify and evaluate available solutions to the global problem. Furthermore, the thesis utilizes a variety of research methods for the remaining phases of the DSR project, e.g., focus group research, expert interviews, action research, or case study research. Chapter II discusses them in detail.

GUIDELINE 6: DESIGN AS A SEARCH PROCESS. REAM evolved through an inherently iterative search process over a long period, in which the author constantly searched for optimal and alternative designs that improve REAM's utility regarding the identified problem space, demonstrated its feasibility in real-world environments, and assessed its performance regarding formulated requirements. Discussions in chapter II and chapter VII (see Figure 72) illustrate this. Consequently, this search process led to changes in REAM's design. For instance, while the initial version of REAM was an adapted design of Becker et al.'s (2002) method for configurative RM, later insights revealed a need to define REAM as a standalone IS method.

GUIDELINES 7: COMMUNICATION OF RESEARCH. DSR needs to communicate its results to both scholars and practitioners. As section 1.5.3 enumerates, the author published interim and final results of this Ph.D. project in both academic (Timm and Sandkuhl 2018a) and practice-oriented outlets (Timm et al. 2019). Discussions that arose during these publications helped to improve REAM design as experienced scholars and domain experts provided fruitful feedback from different angles in the context of constructing and using REA.

8.2 THREATS TO VALIDITY AND LIMITATIONS

This section reflects on REAM by discussing threats that exist towards its validity and what means the author implemented to mitigate them. Furthermore, it discusses further limitations of REAM design that the author wants to point out to potential method users. In general, validity refers to the trustworthiness of the results and to what extent they are true and not biased by the researcher's subjective point of view (Runeson and Höst 2009, p. 153). DSR projects establish validity by using a rigorous evaluation of the design artifact. In this context, Wieringa (2009) distinguishes between internal and external validity of a design artifact. As this thesis utilized qualitative research methods for evaluating REAM, this section also reflects on threats regarding construct validity (Runeson and Höst 2009). *Construct validity* reflects "to what extent the operational measures that are studied represent what the researcher has in mind and what is investigated according to the research questions" (Runeson and Höst 2009, p. 153). *Internal validity* reflects on the question of whether the design artifact would satisfy the criteria identified for a potential solution when applied in the problem context (Wieringa 2009). *External validity* further investigates whether the design artifacts would still satisfy these criteria, when applied in a slightly different problem context (Wieringa 2009).

THREATS TO CONSTRUCT VALIDITY. As mentioned above, the author conducted qualitative research methods, such as expert interviews, focus group research, and case study research in order to evaluate REAM's actual efficiency, actual effectiveness, coherence, modularity, and comprehensibility (see section 7.1.3). The primary threat to construct validity was that participants of the evaluation episodes had a different comprehension of these constructs as they were primary practitioners. In order to establish a common understanding of these evaluation constructs, the author discussed them with the participants. While they quickly arrived at a common understanding of the constructs actual efficiency and effectiveness, a clear delineation of coherence, modularity, and comprehensibility was reached by providing participants an appropriate definition (see section 7.1.3). On that basis, the author ensured that evaluation participants interpreted the construct in the same way the author intended. Furthermore, the author used the same questions for measuring them during the evaluation episodes one (see section 7.2.1) and six (see section 7.2.6). However, the author argues that this threat cannot be entirely eliminated. As discussed in section 7.1.3, the primary focus of evaluating REAM was to investigate its actual efficacy. Thus, a more standardized approach using a more profound questionnaire would, even more, mitigate that threat.

THREATS TO INTERNAL VALIDITY. In general, the internal validity for evaluating REAM was ensured by six design and evaluation iterations that evaluated the utility of REAM against the defined requirements. The majority of these cycles ended by evaluating the various REAM design versions in naturalistic settings. Based on the results presented in chapter VII, the author argues that REAM is internally valid. However, there exist several threats to the internal validity:

- *SELECTION OF SUBJECTS IN THE CONTEXT OF THE COFIN PROJECT:* Throughout the COFIN project, REAM traversed five design and evaluation cycles (the first cycle was iterated in the context of the ECLORA project). While evaluation participants changed, most participants were part of the focus group and evaluated REAM several times. According to Wieringa and Moralı (2012), these participants may have answered questions in a socially desirable way. However, the author argues that this threat is minor since the vast majority of participants were either sponsors of the COFIN project that were primarily skeptical towards using EA structures at project start, external problem stakeholders (e.g., independent financial institutes that were unaware of the REA notion), or executive manager questioning the overall benefits of REAs.
- *LEARNING CURVE OF PARTICIPATING PROBLEM STAKEHOLDERS:* An application of REAM spans over a significant amount of time. For instance, the COFIN project needed one and a half years for developing and completing the RCO. Throughout this period, the problem stakeholders participating in the several evaluation episodes may have improved their understanding of EA and architectural thinking. Thus, their evaluation of REAM may have been biased. In order to mitigate this, the author implemented a final evaluation episode with unbiased problem stakeholders. Not involved in previous evaluations or design activities, they evaluated REAM and its output. As documented in section 7.2.7 (see case B), they arrived at findings similar to previous evaluation episodes of REAM.

THREATS TO EXTERNAL VALIDITY. According to Wieringa and Moralı (2012), one major threat to external validity is the fact that the artifact designer, i.e., in the case of REAM, the author of this thesis, can apply the artifact in a way no one else is capable of. Indeed, the author was responsible for methodological guidance in both local practices that applied REAM. However, being responsible did not necessarily imply that the author conducted all activities REAM required for developing REAs on his own. As the running example from the COFIN project in chapter VI showcases thoroughly, applying REAM was a team effort that involved several researchers and practitioners. That fact mitigated the risk that REAM's utility is restricted to its designer. Instead, the author argues that other method users benefit from REAM's effectiveness as well.

The author further claims that REAM applies to other practices that share the characteristics of the global problem defined in section 4.2. The successful application of REAM to the distinct local practices of the utility and financial domains allows the conclusion that REAM is generalizable to other domains as well (see section 8.3 for a further elaboration on this aspect). However, one threat to REAM's external validity is that the author applied REAM in those practices, from which he derived the practical problem. Consequently, the authors conjecture regarding REAM's generalizability may be restricted. Hence, the application of REAM in an independent practical domain is necessary to eliminate this risk.

FURTHER LIMITATIONS TOWARDS REAM. The remainder of this section discusses further limitations of REAM's design that do not directly refer to the validity of the results. The following list intends to help potential REAM users assessing the method's value for their specific application context by minimizing false expectations towards REAM:

- *USABILITY OF REAM:* One major limitation of this work is that it lacks insights regarding REAM's usability due to pragmatic reasons for conducting a Ph.D. project. Based on Davis (1989), Moody (2003) emphasizes the importance of evaluating ease of use and usefulness perceived by a potential IS method user (defined by Moody as "perceived efficacy"). As section 7.1.3 discusses in detail, the author acknowledges the importance of investigating an IS method's perceived efficacy as it determines whether potential REAM users intend to apply it. Unfortunately, such an investigation was not feasible in the context of this thesis. The rationale behind this decision was that such an investigation would require to teach a group of potential REAM users the method and provide a simplified artificial use case on that these users would apply REAM before answering a standardized questionnaire that operationalizes the constructs of perceived efficacy and intention to use. Not only would the effort behind such an evaluation be very high, but the author also doubts the meaningfulness of its possible results. Making such an investigation feasible would demand to provide a REAM version that can be easily taught in a short period. Further, a simplified use case would have to be realistic enough to deliver an adequate set of data, and small enough to apply REAM is a short period at the same time. While one may argue that both restrictions are feasible, it remains unclear whether method users could still make meaningful statements regarding REAM's usability. Furthermore, the application of REAM in two distinct local practices revealed first insights regarding REAM's comprehensibility and showed that problem stakeholders verify its effectiveness. Thus, the author decided to exclude investigating potential users' perceived efficacy and intention to use REAM. However, since team members of the ECLORA and COFIN research teams stated that they found REAM useful and easy to use (once acquainted with REAM), the author argues that initial evidence gives reason to suppose REAM's perceived efficacy is acceptable. Nevertheless, these observations may be biased (see threats to internal validity). Thus, future research is required. It might use longitudinal studies that investigate Moody's constructs in real-world REAM applications.
- *RESULTS DEPEND ON REAM USER:* From a general perspective, REAM is a method for enterprise modeling in particular, i.e., developing REAs. Thus, it defines activities to develop domain-specific EA models that abstract the reality from different perspectives. Since several users perform these activities, they may arrive at slightly different results depending on their EAM knowledge, experience in the particular domain, or perceptions of the reality. Although REAM defines a set of skills required from method users (see section 6.2.3) and provides modeling guidelines for each REAM method component, this limitation still exists and users need to be aware of it.
- *THE VALUE OF REAS:* The author argues that the reuse-oriented notion of reference models (see section 3.2.1) also applies to REAs. As the evaluation in chapter VII revealed, REAM produces REAs that stakeholders of the particular problem domain apply in their practices. The values these stakeholders ascribe to the REA highly depend on the application context and the problem domain addressed by it. While REAM provides a list of values and benefits related to REAs (see section

6.6.1), it is neither exhaustive nor based on empirical evidence. The author argues that knowing the REA's value at the time of constructing it (i.e., during Phase (A) and (B) of REAM) will improve its design. However, research still lacks empirical evidence regarding the value of REAs (Timm 2018a) in specific and RMs in general (Fettke 2008). To minimize this limitation, REAM investigates the perspective of REA stakeholders, their needs, and additional application-centered aspects before constructing the REA (see preparation phase in section 6.4).

- *LIMITATIONS OF SYSTEMATIC LITERATURE REVIEW.* The results of the SLR in section 4.3.6 provided essential insights for REAM's design process. In this regard, the author points out some limitations. The primary limitation is that the author conducted the SLR on his own. That implies several risks for the validity of the SLR's results regarding the different stages of conducting SLRs (see Figure 27 in section 4.3.1). First, the author may have missed other relevant synonyms in the context of REA development while formulating a search string. Second, the selection of relevant studies may have been biased as other researchers may have made different decisions for in- or excluding found articles. Third, the data extraction of the selected studies may have been blurred for the same reasons. As the author was aware of these limitations when conducting the SLR, he implemented some means to mitigate these risks. As documented in section 4.3.1, the SLR evolved over a long period and included two independent searches at the early and late phases of this Ph.D. project. Further, the final search query build not only from the author's experience gathered during the ECLORA and COFIN projects but also used results from the related SLR conducted by Sanchez-Puchol and Pastor-Collado (2017). Moreover, the author defined inclusion and exclusion criteria. This list iteratively evolved during the study selection and was applied to all search results. Finally, the conceptual framework used for data extraction intended to mitigate the risk of inaccurate data extraction as it provided a structured approach the author used for each study under review.

8.3 DISCUSSING THE CONTRIBUTIONS

As section 1.5 discussed at the beginning of this work, the thesis at hand provided both theoretical and practical contributions. From a theoretical stance, REAM—the core contribution of this thesis—closes the absence of methodological guidance and conceptual obscurity for REA development in ISR. Furthermore, it contributes to the knowledge base of inductive and application-oriented RM. From a practical stance, the thesis develops two REAs that have been accepted by practitioners in the context of the research projects ECOLRA and COFIN (see section 4.1). Both REAs were the output of applying REAM in the utility and financial industry with real-world users. The remainder of this section discusses the theoretical and practical implications of the core contribution REAM, elaborates on its generalizability, and classifies it in the context of contribution frameworks established in DSR.

CONTRIBUTION TYPE IN THE CONTEXT OF DSR. DSR outputs can provide different types of contributions to the knowledge base, depending on the current problem and solution maturity of the problem space. As section 2.1.1 discussed, DSR Gregor and Hevner (2013) propose a DSR contribution framework that identifies four contribution types in DSR: invention, improvement, exaptation, and routine design. In the context of this framework, REAM represents an *improvement*. An improvement addresses a known problem and offers a new solution or enhancement to an existing one. A vast amount of research acknowledges the overall problem that organizations often fail to react to environmental change from an IS perspective adequately (Henderson and Venkatraman 1993; Proper et al. 2017). The problem investigation (see chapter IV) of this work provides a more concrete perspective on this problem from the stance of business and IT alignment. Nevertheless, the author argues that REAM addresses a mature problem space. Although this work investigates approaches from the RM and EAM research domains, including some related work concerning software reference architectures. However, they do not meet the requirements for an adequate solution. As the KBA in section 4.3 reveals, research lacks methodological support for developing REAs.

Consequently, the author understands the design artifact of this thesis as an improvement of available approaches from the EAM and RM research domains. While EAM provides frameworks and modeling notations such as TOGAF and ArchiMate to develop, structure, and manage organization-specific enterprise architectures, they are too specific to be reusable for a group of organizations. Reference models (RMs) provided by TOGAF, such as the technical reference model, do not address specific practical problems. Further, EA frameworks lack methodological guidance on how to develop REAs. The research domain of RM provides widely-accepted methods for RM construction (see section 3.2). However, these are either too generic to be feasible for the development of REAs (Schütte 1998; Becker et al. 2002), or focus on other model structures such as reference process models (Rehse and Fettke 2019; Scholta et al. 2019) or software reference architectures (Nakagawa et al. 2014). From the perspective of this thesis' RQ, REAM improves these approaches as it specifically guides REA development. Its output provides a holistic perspective on organizations that face organizational change.

IMPLICATIONS TO PRACTICE AND THEORY. REAM design evolved in close interactions with real-world settings. Thus, the author derived several practical implications of REAM. The thesis provides empirical evidence that REAM and its output is relevant to practice. Practitioners from different practices have successfully applied REAs produced by REAM. In the context of the COFIN project, independent software vendors (ISV) used the developed RCO to enhance their IT product portfolios, consult their clients, or train their employees. Further, financial institutes applied the RCO to improve their compliance programs regarding anti-money laundering regulations or customer onboarding due diligence. Further, these successful REAM applications in the utility and financial industry verify the author's conjecture that REAs help organizations to cope with the challenges induced by industrial change in terms of business and IT alignment. The naturalistic evaluation episodes show that organizations acknowledge the benefits research associates with applying REA. Moreover, the results of the COFIN project revealed that a variety of organizations from the problem domain perceive the same REA as valuable. The author derives that the involvement of all problem stakeholders during the REA development is vital for its acceptance. In addition to that, the author identifies a need that industries implement means to manage, maintain, and distribute REAs.

The above elaborations give reason to argue for REAM's theoretical significance. This thesis proposes descriptive and prescriptive knowledge that enhances the body of knowledge EAM and RM. Analyzing and structuring related research, the KBA reveals current research gaps and describes the current state of REA research. On that basis, REAM proposes how to abstract domain-specific and REAs from practical knowledge that is accepted by practitioners. It further demonstrates how to apply REAs in practice and shares experiences from practice.

GENERALIZABILITY OF REAM. The findings of this thesis provide evidence that the prescriptive knowledge residing in REAM design is generalizable to a certain extent. This Ph.D. thesis shows that the practical problem addressed by REAM builds from two local practices. The results of chapter VII allow to conclude that REAM is not restricted to a specific domain or local problem. The author argues that REAM can be applied to business domains characterized by industrial change, where different drivers (see section 4.3) force organizations to holistically restructure their business and IT landscapes and lack the capability to do so. While this work successfully applies REAM in the utility and financial industries, the author asserts that other domains such as the telecommunications (Czarnecki and Dietze 2017c), e-commerce (Aulkemeier et al. 2016b), health (Rodriguez 2018), manufacturing (DIN 2016), and education (Sánchez-Puchol and Pastor-Collado 2018a) industries would benefit from applying

REAM, too. This conjecture builds from related research identified during the KBA in section 4.3. Although this related research proposes REAs in particular domains, they do not reflect on a systematic approach to develop or apply the proposed REAs. Based on the above-mentioned practical implications of this work, their acceptance in practice might benefit from applying REAM.

ASSESSING REAM CONTRIBUTION MATURITY, ACCORDING TO GREGOR AND HEVNER (2013). In addition to their DSR contribution framework, Gregor and Hevner argue that the contributions of a design artifact can be of different maturity. In this context, they distinguish between three maturity levels of knowledge produced by the DSR project. As Table 2 in section 2.1.2 illustrates, contributions that relate to level 1 provide more specific, but limited and less mature knowledge. Level 1 refers to instantiations, such as software products, that refer to a situated implementation of an artifact. In contrast, knowledge that is more abstract, complete and mature relates to level 3. Level 3 refers to well-developed design theories about embedded phenomena. In between, the majority of DSR artifact types (i.e., constructs, methods, or models) refer to maturity level 2. They often provide nascent design theory. The authors emphasize that a particular DSR project may produce artifacts that relate to more than one of these levels (Gregor and Hevner 2013, p. 341).

The author of this thesis positions REAM as the central contribution on maturity level 2. As an IS method, it provides prescriptive knowledge that generally valid it defined problem domains of global relevance. It further builds from theories established in the domains of EAM and RM research, improves the understanding of the REA phenomena (see Figure 48), and defines its underlying concepts (see Table 36). However, further research is necessary to gather more explanatory knowledge about REAM as an artifact, which would qualify for a design theory and, thus, maturity level 3.

In addition to REAM itself, this Ph.D. project provides further contributions. During its evaluation, REAM produced two REAs in the context of the ECLORA and COFIN projects. In case of the former—the Utility REA (see section 7.2.1)—the author relates it to maturity level 1. Although it can be understood as a model and applies to different stakeholders of the German utility industry, this thesis does not provide enough evidence to relate its knowledge to maturity level 2. Thus, the author understands it as an instantiation of REAM accepted in a local practice. In the case of the latter, i.e., the Reference Compliance Organization (RCO) produced by REAM application during the COFIN project, the author argues that its contribution maturity relates to level 2. Although the six evaluation episodes (see Table 66) focused on evaluating REAM's utility, the knowledge residing in the RCO matured as well. As Timm and Sandkuhl (2018a) discuss in more detail, the RCO itself is a design artifact relevant to various stakeholders of a practical problem. Thus, the author argues that it is not only an instantiation of REAM but also a design artifact that provides complete and mature knowledge as well.

8.4 LESSONS LEARNED

The results of this Ph.D. thesis emerged during research activities performed over a long period. Next to the contribution in the context of DSR, the author gathered new experiences not only in terms of REA development and REAM application in specific, but also regarding conducting DSR research in general. Furthermore, the regular interaction with practitioners from the utility and financial industry and their perceptions while applying REAM provided fruitful input, the author intends to share in the following.

LESSONS LEARNED REGARDING THE DSR PARADIGM. DSR provides a practical framework for designing IS methods—especially in terms of planning research activities and structuring results during this Ph.D. project. However, planning concrete research activities following the ideal DSR process by Peffers et al. (see section 2.1) sometimes proved to be challenging. While trying to strictly follow the process at the beginning of the Ph.D. project, the author recognized that conducting DSR shall primarily focus on the object under investigation, i.e., designing REAM. Therefore, thinking in build and evaluate cycles (March and Smith 1995; Hevner et al. 2004) instead of meticulously conducting the several DSR steps defined by Peffers et al. (2007) in an ideal order helped to emphasize answering the research question addressed by this work. For instance, the requirements towards REAM evolved throughout the DSR project. As section 5.2 documents, the author retrospectively identified different phases of REAM's design progress, in which he identified additional requirements. Furthermore, the author investigated the two local practices at different points of time during the Ph.D. project. Consequently, the author's understanding of the problem improved after developing an initial version of REAM. Likewise, DSR requires research to address a practical problem of global relevance. Hence, the author contends that an iteratively enhanced DSR artifact is accompanied by an iteratively improved understanding of the problem space. Nevertheless, Peffers et al.'s (2007) DSR process helped to revisit and structure the overall research activities regularly. The work of Johannesson and Perjons (2014) further enhanced the author's comprehension of conducting DSR as they provided additional information and guidelines in a DSR framework similar to the process by Peffers et al. (2007).

CONDUCTING SLRS FOR KBA. Analyzing the knowledge base is an essential activity at the beginning of a DSR project (Hevner et al. 2004). An SLR is a reliable tool for conducting knowledge base analyses as it aims to investigate related research transparently. However, some methods for conducting SLRs require researchers to already possess sufficient knowledge of related research domains in order to identify adequate search strings and research outlets before conducting the actual KBA (Kitchenham 2004). That is especially challenging when analyzing relatively immature research domains, such as REA development. During this Ph.D. project, the author conducted several literature reviews and one explicit SLR for the KBA (see 4.3). That enabled both an initial understanding of existing solutions for the tackled research problem and a transparent and structured analysis of related work at a later stage of the Ph.D. project. It ensured capturing related work published after the initial literature review and enabled the author to follow a strict SLR method with an improved understanding of the research domain of REA development. Furthermore, it proved helpful to combine the existing SLR method by Kitchenham (2004) and Vom Brocke et al. (2009) with using back- and forward searches during population and conceptual framework for data extraction (Webster and Watson 2002).

USING FEDS FOR EVALUATING DSR ARTIFACTS. The author applied the framework for evaluation in DSR (FEDS) by Venable (2006) for evaluating REAM. As the research environment of the two research projects ECLORA and COFIN, enabled the author to improve REAM's design through six design and evaluate cycles, FEDS helped to plan and structure the research activities systematically. Likewise to the DSR process, the author learned that planning evaluation episodes in advance might be counterproductive. That mainly applied to episodes with a naturalistic setting as the author highly depended on the availability and accessibility of evaluation participants from practice. For instance, the author initially planned to conduct EE6 (see section 7.2.6) in a shorter period. However, in order to interview as many experts as possible, he decided to span the episode over four months. Meanwhile, the same version of REAM was applied in the context of EE5. That led to parallel evaluation activities the author did not anticipate before. Furthermore, FEDS recommends to choose an appropriate evaluation strategy when planning the evaluation. That includes defining the functional purpose and paradigm of each evaluation episode. Doing so is challenging at the beginning of a DSR project due to the reasons above. Thus, while evaluation strategies proposed by Venable et al. (2012) may help to give initial hints or blueprints for evaluating DSR artifacts, the author asserts that each evaluation plan is individual and may be adjusted throughout the research project.

AWARENESS OF EAM BENEFITS REQUIRES ITS APPLICATION TO A RELEVANT PROBLEM. Throughout the Ph.D. project, the author spoke with various stakeholders of the practical problem from both the utility and financial domain. In general, these were primarily ISVs and consultancies from both industries, small and medium-sized public utilities, and financial institutes. Although their precognition of EAM slightly differed, the author observed that their acceptance of EAM concepts increased as they learned how EAM could help them to react to industrial change. For instance, REAM was applied in the utility domain to develop a Utility REA based on modeling workshops conducted at PUs. While participants seemed skeptical during the EAM introduction at the beginning of each workshop, the author recognized an increased interest in REAs once he presented the resulting Utility REA and the possibilities to use it. Similar observations were made with financial institutes.

USING DOMAIN-SPECIFIC BUSINESS PROCESSES FOR ELICITING EA RELATED KNOWLEDGE. As discussed thoroughly in Timm et al. (2015a), one major obstacle for eliciting practical knowledge for REA construction was to gather adequate data from practitioners that are not yet aware of the EAM concepts. In the context of the research projects, the author learned that one feasible approach to do so is to use domain-specific business processes for data collection. As the majority of practitioners are aware of business process modeling, this helped to get workshop participants from the different departments engaged. On that basis, the project team iteratively extended the knowledge base from the remaining perspectives of EA. While this effect is widely known in the domain of enterprise modeling (Stirna et al. 2007), the author learned that this is a useful way of collecting individual models for inductive REA construction as well.

8.5 FUTURE RESEARCH

The previous section of this chapter summarized the results of this thesis, discussed its contributions, its limitations, and summarized additional lessons learned. On that basis, this section aims to encourage future research in the context of REA development by explicating potential future research directions.

FUTURE RESEARCH DIRECTIONS TO IMPROVE REAM AS A DESIGN ARTIFACT. As previous elaborations have shown, REAM possesses several limitations future research initiatives can address. First, it might be worth studying the side-effects of REAM as the evaluation of this work did not investigate this aspect. For instance, the effort related to apply REAM may influence users' and problem stakeholders' awareness of EAM benefits or develop a more profound understanding of the problem space. In the context of ECLORA and COFIN, the author observed that developing REAs enabled the diverse problem stakeholders to improve their understanding of each other's problems and agendas. Further, it seemed that collectively working with REAM facilitated a consensus among them.

Second, research still lacks explanatory knowledge regarding why RMs in general and REAs in specific are perceived valuable by its users. That may further include the investigation of REAM's usability following the method evaluation framework by Moody (2003). As section 8.2 discussed, a better understanding of REAM's perceived usefulness and ease of use may reveal the potential to improve its design.

Third, REAM does not clarify the question of what criteria to apply to assess whether the data basis for inductively developing REAs is exhaustive. Further, discussions within the focus group meeting arose at what point of time one knows he or she has collected enough individual models. During discussions, the focus group reached a consensus that two factors that may inspire future research:

(i) if the organization sample, from which individual models are collected, is a representative extract from reality

(ii) if the collection of an individual model of another organization does not add to the knowledge base for inductive REA construction

Fourth, the author deems adjustment mechanisms useful in order to simplify REA application for problem stakeholders. However, there is still some unclarity regarding their integration during REA construction. Results of evaluation episode 7 (see section 7.2.7) revealed that they have not always been used as prescribed by the method.

Fifth, while REAM defines a fixed number of method components and prescribes a sequence of executing them to develop REAs, the author encourages future research to investigate variants of REAM depending on its application context. Referring to the concept of "trade-offs," Wieringa (2009) asks whether slightly different artifact designs would still satisfy criteria that define REAM's utility. In this regard, future REAM version might benefit from identifying mandatory and optional method components when applying the method to increase its efficiency. For instance, developing the Utility REA in the ECLORA project did not require such a diverse portfolio of application scenarios as the RCO in the COFIN project (see REAM component 8 in section 6.6.1). Further, the means to collect data for inductive REA development seems to depend on the resources available and the necessary level of detail. While the context of ECLORA allowed to conduct multi-day workshops with problem stakeholders to collect individual models (see section 6.5.4), financial institutes were not open for such workshops and preferred in-depth telephone interviews. However, a thorough trade-off analysis of REAM is yet to be investigated rigorously.

RESEARCH REGARDING INDUCTIVE REA DEVELOPMENT. REAM provides a first investigation of abstraction techniques available for inductive reasoning for REA construction. While the majority of available techniques focus on business process models, REAM adjusts two of them to EA structures (Timm et al. 2018b; Timm and Sauer 2017). However, the author emphasizes the need to investigate the inductive abstraction of REA models further. While it may be fruitful to adjust more available approaches, developing approaches dedicated to EA structures may be valuable as well. Although inductive RM builds on a vast set of data, approaches that analyze this data for best practices are scarce (Scholta et al. 2019). Thus, future research might focus on defining common and best practices in more detail and provide solutions that identify best practices. In the context of REA development, the author sees potential in a hybrid approach. Such an approach would define an REA model with a common practice baseline and identify areas of the REA that require best practice approaches based on REA stakeholders' needs.

MATURITY OF REA MODELS. At many stages of this Ph.D. project, the author observed that the project teams of ECLORA and COFIN did question when a "final" REA would be reached. In concrete, the question arose at what point to decide that sufficient data is collected to construct the REA and after results were evaluated with practitioners. The author argues that, although an RM is defined as one as soon as it is acknowledged and applied in practice, it is still an essential aspect of RM construction to understand if an RM may be complete (i.e., sufficient data is collected) or not (i.e., more data needs to be collected).

EMPIRICAL STUDIES REGARDING REA VALUE. As the limitations of this thesis discussed earlier, research of RM in general and REA in specific lacks empirical evidence of the value of REAs. While this work provides initial empirical evidence based on the results of the ECLORA and COFIN project (see chapter VII) as well as a generic list of REA values identified during the knowledge base analysis (see section 4.3), the author identifies the potential for future research in this regard. As a starting point, longitudinal studies that accompany the application process of existing REAs (Czarnecki and Dietze 2017c) and investigate their effects could provide meaningful results.

DISSEMINATION OF REAS. After finishing the ECLORA and COFIN projects, it was not clear how the developed REAs will be maintained and disseminated. In the case of the former, the Utility REA was further used by the project partner SIV group for internal purposes. While the same applied to the latter case of the RCO, the project team also discussed additional opportunities. For instance, the RCO may be disseminated using an open-source approach. In order to cover costs of maintaining, extending, and providing application support for RCO users, establishing an independent organization may be possible as well. The RM domain lacks approaches or guidelines on how to disseminate RMs. While there exists an approach to define RM catalogs that systematize existing RMs (González Vázquez and Appelrath 2010; Becker and Knackstedt 2002), their effectiveness is not verified.

APPENDICES

APPENDIX A: FOCUS GROUP MEETING NOTES FOR EVALUATION EPISODE 4

Protokoll: Treffen 13.09.2016 (München)

AKTIVITÄTEN BIS ENDE DES JAHRES

TOP 1: KYC Entwicklung:
- Fokus: Onboarding Prozess
  - Front Office Aufgaben (wirtschaftlich Berechtigter und andere im Back Office genannte Bereiche auch)
  - Fokus auf Geschäftskunden
  - auch Interessant: Dritte, die die Identifizierung durchführen
- Vorgehen:
  - Version des Fragebogens (KW 38)
  - Feedback des Fragebogens
  - Finale Version des Fragebogens (Ende September)
- OFFEN:
  - Kontakte rekrutieren für Identifizierung
  - Jedes Konsortiumsmitglied noch einmal direkt ansprechen

TOP 2: Validierung des RCO:
- Einladung der Partner zu einem web-basierten Walkthrough durch das Modell
- **Ziel:** RCO Modell erklären und aktuellen Stand validieren

TOP 3: Übersicht Compliance Organisation von Finanzinstituten als RCO Top Level Ansicht:
- High Level Übersicht mithilfe von ArchiMate Sichten
- Version ist fertig —> Überarbeitung
- Welche Themen werden 2017 bearbeitet?
- potentielle Themen:
  - Finanzsaktionen
  - sonstige strafbare Handlungen (hierzu zählt auch Fraud)
  - Kapitalmarkt-Compliance
  - Interessenkonflikte (bei Wertpapierhandel)
  - (Compliance in Tax) [optional]
    - FATCA, CRS
- Validierung durch Konsortium

TOP 4: Durchführung eines Workshop-Days
- Konkretisierung bei einem nächsten Treffen im Konsortium
- jede Firma präsentiert ihr Angebotsspektrum und potentiale für Integration in RCO Modell wird geprüft
- Methodik/Vorgehen für so einen Workshop-Tag planen

TOP 5: Übersicht der Compliance Software Lösungen
- Verortung der Lösungen der einzelnen Konsortialteilnehmer
- Prüfen und Integration in bestehendes RCO

TOP 6: Ideen von Themen in 2017;
- Vorschlag Teilnehmer A
  - End-To-End Prozess durchleben, der einen Querschnitt der Interessen des Konsortiums
  - Angebote des Konsortiums gegenüberstellen
  - Bsp: Banken haben Medienbrüche
- Vorschlag Teilnehmer B:
  - Produktvertrieb:
  - erstmal Modul der Compliance Software
  - danach aber immer Beratungsgeschäft wichtig
  - Identifizierung

APPENDIX B: QUESTIONNAIRE FOR EXPERT INTERVIEWS IN EE6 (EXCERPT)

REA PART: ANTI-MONEY LAUNDERING

View	Aspekt	Frage
VP2 Ablauf GWP 1. Ebene	Grundlegender Ablauf	Fehlen hier Aspekte oder ist die Aufteilung in GA->Monitoring->Bearbeitung/Meldung komplett?
		Fehlt hier eine Management-Perspektive?
		Ist die Interne und externe Meldung richtig?
	Verantwortlichkeiten	Sind die Verantwortlichkeiten plausibel?
		Fehlen Rollen?
	Ereignisse	Sind die Events richtig dargestellt?
		Fehlen Ereignisse?
	Sonstige Bemerkungen	
VP4 Ablauf GWP 3. Ebene	Generell	Sind alle Teilaufgaben der GA plausibel?
		Fehlen Aufgaben?
		Bei welchen Aufgaben macht es Sinn eine Detailstufe tiefer zu gehen? (Z.B. als Prozess oder Teilaktivitäten?)
	Gefährdungsanalyse	Gehört für Sie die Kundenidentifikation dazu?
	Monitoring	Gehört für Sie die "Prävention von Terrorismusfinanierung" als Teilbereich zum Monitoring?
	Verdachtsfall & Meldewesen	Würden Sie diese Bereiche inhaltlich voneinander trennen oder finden Sie die Integration sinnvoll?
		Sind die Aufgaben plausibel?
	Sonstige Bemerkungen	
VP5 Risikostufen	Risikostufen	Welche Risikoeinstufung sehen Sie als sinnvoll, um in diesem Referenzmodell verwendet zu werden?
		Denken Sie, dass sich die Risikostufen für die einzelnen Risiko-Kategorien unterscheiden?
	Sonstige Bemerkungen	
VP6 IT-Support	SW Gefährdungsanalyse	Sind die genannten Systeme plausibel an der Stelle?
		Welche Systeme denken Sie fehlen?
		Sind Beziehungen in dem Modell fehlerhaft? Bzw. Fehlen welche?
	Sonstige Bemerkungen	
VP7 Daten Nutzung	Daten Gefährdungsanalyse	Sind die gezeigten Daten plausibel an dieser Stelle?
		Werden an dieser Stelle noch andere Informationen genutzt?
		Sind die Beziehungen hier fehlerhaft?
	Sonstige Bemerkungen	
VP8-10 Datenstruktur	Datenstruktur Gefährdungs.	Gibt es hier Daten, die Ihnen nicht plausibel erscheinen? (unnötig bzw. unverständlich)
		Fehlen Daten, die Sie hier wichtig finden?
	Datenstruktur Monitoring	Gibt es hier Daten, die Ihnen nicht plausibel erscheinen? (unnötig bzw. unverständlich)
		Fehlen Daten, die Sie hier wichtig finden?
	Datenstruktur Bearb./Meldung	Gibt es hier Daten, die Ihnen nicht plausibel erscheinen? (unnötig bzw. unverständlich)
		Fehlen Daten, die Sie hier wichtig finden?
	Sonstige Bemerkungen	

OPEN ROUND

View	Frage
Repräsentativität	An welchen Stellen denken Sie, dass das Modelle für verschiedene Institute (Sparkasse, Bürgschaftsbank, Großbank, etc.) grundsätzlich verschiedene Ausprägungen haben sollte?
	Wenn Sie das Modell betrachten und die Stichprobenbefragung: Wo sehen Sie noch Handlungsbedarf bei der Erhebung?
	Sonstige Bemerkungen
Inhaltliche Fragen	Bis zu welcher Detailstufe sollten in dem Modellen sein? (Geschäftsebene)
	Bis zu welcher Detailstufe sollten in dem Modellen sein? (Datenebene)
	Bis zu welcher Detailstufe sollten in dem Modellen sein? (Anwendungsebene)
	Welche Aspekte fehlen bislang in dem Modell und sollten in nächsten Befragungen noch erhoben werden?
	Sonstige Bemerkungen
Nutzung des Modells	Welche Möglichkeiten sehen Sie, um das Modell für sich zu nutzen?
	Kann sich Ihr Unternehmen in dem Modell wiederfinden (z.B. wo Sie Expertise haben, wo sie Produkte für Ihre Kunden anbieten)
	Wo sehen Sie für die Finanzinstitute die größten Bedarfe im Modell?
	Welche Anforderungen haben Sie an die Dokumentation der Modelle? Was würde Ihnen zur Verwertung helfen?
	Sonstige Bemerkungen

APPENDIX C: CHANGE REQUEST FROM EXPERT INTERVIEWS REGARDING AML IN EE 6

AML Concern	ACTION	WS
Viewpoints AML Process Structure	Event "externer Verdachtsfall tritt auf"	#1 #7
	Aufgabe „KYC“ gehört nicht hier rein	#1 #2 #4
	Aufgabe „Prävention Terrorismusfinanzierung“ eher Ziel oder Control Statement	#1 #7
	„Gefährdungsanalyse“ findet auf 2nd Line of Defense statt	#1
	Welche Verbindungen zu anderen Bereichen der Compliance?	#1
	Welche Verbindungen zu anderen Bereichen des Finanzinstituts?	#1
	Abbildung des Three Lines of Defense Ansatzen im Modell	#1
	Monitoring: Was wird hier genau beobachtet? Woher kommen die Daten?	#2 #7
	Die Phases sollten als Kreislauf dargestellt werden GA-M-VB-GA	#2
	"Kontoeröffnung beantragt" triggert nicht "Verdachtsfall aufgetreten" an	#4
	"Kundeneröffnung beantragt" triggert "Verdachtsfalls aufgetreten" an	#4
	"Risikobewertung/Risikoanalyse" ändern in " Risikomodell GWP	#4
	"Prävention Terror" ändern in "Risikomodell Terrorismusfinanzierung"	#4
	neues Element unter "Risikomodell Terror": "Auswahl der Sanktionslisten"	#4
	"Gefährdungsanalyse" ist abstrakt --> "Risikobewertung" ändert sich zu "Risikomodell" (alle relevanten Elemente einbezogen)	#4 #7
	Kundeneröffnung beantragt triggert "Risikobewertung des Kunden" an, aber nicht auf abstrakter Ebene	#4
	"Erstellung Risikokategorien" sollte wegfallen, weil zu abstrakt	#4
	es gibt noch weitere Risikokategorien , z.B. "Risikomodell der Branche"	#4
	Welche Risikokategorien gibt es noch?	#4 #7
	"Analyse der Risikosituation" des Unternehmens muss hinzugefügt werden	#4
	Gefährdungsanalyse ist auf abstrakter bzw. Mgmt Ebene, Monitoring und Bearbeitung eher operativ. Das muss besser im Modell abgebildet werden.	#4
	"Prävention Terror" hier löschen	#4
	"Risikobewertung Kunde" muss hier passieren	#4 #7
	"Kundenüberwachung" mit "Sancionscreening" und "PEP Screening" hinzufügen	#4
	"Transaktionsüberwachung" verfeinert durch "Embargo Überwachung" und "Überwachung nach GW Szenarien"	#4
	Verdachtsfall wird von "Transaktionsüberwachung" und "Kundenüberwachung" getriggert	#4
	externe Revision fehlt --> in Mgmt Ebene einbauen	#4
	GW-Szenarien basierend auf Risikomodellen könnten eingebaut werden	#4 #7
Viewpoint Risk Categories	Welche Seiten/Quellen haben das „Blessing“ der Aufsicht?	#1
	Konkretere Benennung der Datenquellen	#1
	es fehlen Daten, die das Risiko nach Kategorien speichern. Diese müssen pro Risikokategorie hinzugefügt werden.	#4
	Welche weiteren Risiko-bezogenen Daten gibt es?	#4
	Die Quellen der Daten sollten überarbeitet werden	#4
	Man könnte Regeln auf der Ebene der Risikomodelle definieren	#4
Viewpoint IT Support	Welche Unterstützung kommt aus Standard-Bank-IT?	#1 #2
	Welche hierfür spezialisierte IT brauche ich und wofür?	#2
	MS Office Produkte: Textverarbeitung + Tabellenkalkulation	#2
	evtl. "End-User Computing" hinzufügen	#4
Viewpoints Data Structure	MUST HAVEs und NICE TO HAVES unterscheiden	#1
	Welche Daten werden vom Gesetzgeber gefordert?	#1
	neues Datenfeld "Geschäftsbeziehung" mit Unter-Elementen	#2
	manche Felder gehören zu "Geschäftsbeziehung"	#4
	fehlende Datenfelder hinzufügen zu Kundendaten	#4
	"Schwellenwerte" hier nicht, sondern in VP5	#7
	fehlende Datenfeld "Zahlungsrichtung"	#7

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Studium

2015 – 2020	**Promotionsvorhaben**: “A Method for Developing Reference Enterprise Architectures” (working title).
03/2014 – 10/2014	**Masterarbeit**: „Development of a Context Modeling Method for the Capability-as-a-Service Project“ (Prof. Dr. K. Sandkuhl), Note: 1,2 Die Masterarbeit wurde in Kooperation mit der Universitat Politécnica de Valéncia (UPV) und dem IT-Consultant Everis im Rahmen des CaaS Projektes[1] erarbeitet.
10/2012 – 09/2014	**Masterstudium Wirtschaftsinformatik**, Universität Rostock. (Note 1,5)
10/2011 – 01/2012	**Bachelorarbeit**: „Mobile Enterprise Modeling Applications“ (Prof. Dr. K. Sandkuhl), Note: 1,4
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Praktika/ Berufserfahrung

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10/2015 – 09/2016	**Wissenschaftlicher Mitarbeiter** am Lehrstuhl für Wirtschaftsinformatik der Universität Rostock. Angestellt in dem Projekt COFIN – Die Erarbeitung einer Referenz-Compliance Organisation von Finanzinstituten.
11/2014 – 09/2015	**Wissenschaftlicher Mitarbeiter** am Lehrstuhl für Wirtschafts-informatik der Universität Rostock. Angestellt in dem Projekt ECLORA – Entwicklung einer Cloud-Referenzarchitektur für die Versorgerindustrie.
04/2014 – 10/2014	**Mitarbeit an dem EU FP7 „Capability as a Service“ Projekt**[1] im Rahmen der Masterarbeit in Valencia, Spanien. Kooperation mit der UPV und Everis, um eine validierte Methode für Kontextmodellierung von Unternehmensmodellen zu entwickeln.
01/2012 – 03/2014	**Betriebspraktikum bei Mr. Net**[2] in Lissabon, Portugal. Entwicklung einer Suchmaschine für betriebsintern entwickelte Online-Plattformen unter Nutzung des Paradigmas der Defensiven Programmierung.
04/2011 – 08/2011	**Studentische Hilfskraft** am Lehrstuhl für Wirtschaftsinformatik an der Universität Rostock mit der Aufgabe der Entwicklung einer E-Learning Plattform für das Modul Betriebsinformatik.

Rostock, d. 20.01.2021
Felix Timm

[1] Siehe http://caas.blogs.dsv.su.se/ für weitere Informationen über das Projekt
[2] Heute Full IT. Siehe http://www.fullit.pt/Default/en/Homepage