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Using Enterprise Architecture for COBIT 5 Process Assessment and Process Improvement

Gonçalo Rodrigues Cadete

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Supervisors: Prof. Miguel Leitão Bignolas Mira da Silva / Prof. Steven De Haes

Examination Committee

Chairperson: Prof. Nuno João Neves Mamede

Supervisor: Prof. Miguel Leitão Bignolas Mira da Silva

Member of the Committee: Prof. José Manuel Nunes Salvador Tribolet

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Resumo

O quadro de referência COBIT 5 promove a Arquitectura Empresarial como área processual relevante para a criação e manutenção dos facilitadores da governação e da gestão dos Sistemas de Informação. Estes facilitadores são, por sua vez, instrumentais para garantir o alinhamento entre as necessidades das partes interessadas e as soluções sistémicas que endereçam essas mesmas necessidades.

A eficácia e a eficiência das iniciativas de avaliação e melhoria dos processos de governação e gestão poderão ser negativamente afectadas por uma capacitação deficiente da área de Arquitectura Empresarial. De facto, a falta de auto-conhecimento organizacional obriga as partes interessadas a empregarem uma quantidade desproporcionada de recursos na sincronização activa de informação e de conhecimento, requerida para suportar as actividades típicas de recolha e de validação de evidências – entre outras. Como consequência deste desperdício, ficarão assim disponíveis menos recursos para as actividades de optimização dos facilitadores da governação e da gestão.

Este trabalho propõe, como forma de melhorar os resultados das iniciativas de avaliação e melhoria de processos, a utilização de descrições arquitecturais que integram a lógica dos processos COBIT 5, recorrendo para tal às extensões standard do ArchiMate - de forma a facilitar a adopção da solução.

A solução arquitectural aqui proposta foi desenvolvida ao longo de quarto iterações, usando o modelo processual da metodologia *Design Science Research Methodology* (DSRM). Esta abordagem iterativa permitiu que se obtivessem melhorias incrementais em cada um dos ciclos ciclo de desenho, no que concerne à definição dos objectivos, ao desenho dos artefactos e às técnicas de avaliação utilizadas.

A solução proposta foi demonstrada usando três casos reais, no contexto de duas organizações do sector público, usando cenários do tipo *ex-ante* e *ex-post*. Para as fases de avaliação deste trabalho, foram utilizadas as demonstrações, formulários de avaliação, bem como entrevistas e sessões de grupo, de forma a avaliar a eficácia, a consistência contextual e a qualidade estrutural da solução de Arquitectura Empresarial proposta.

Palavras-Chave: COBIT, Enterprise Architecture, governance of enterprise IT, TOGAF, ArchiMate, business and IT alignment, design science, design science research methodology.

Abstract

The COBIT 5 best practice framework promotes Enterprise Architecture (EA) as a key process for helping to guide the creation and maintenance of governance and management enablers. These governance and management enablers are sought as instrumental for providing assurance regarding the alignment between the business stakeholders' needs and the information system solutions.

Deficiencies in the required EA capabilities may hinder the effectiveness and efficiency of process assessment and process improvement initiatives. Indeed, the lack of organizational self-awareness forces the assessment stakeholders to engage a disproportionate amount of resources in wasteful evidence collection, evidence validation, and other interactive synchronization activities, thus leaving less resources for performing the actual optimization of the organizational enablers.

In order to improve the outcomes of COBIT 5 process assessment and process improvement initiatives, we propose to integrate the COBIT 5 process rationale in the EA representations, using the standard ArchiMate extensions in order to promote easy adoption.

We designed the EA solution using four iterations of the Design Science Research Methodology (DSRM) process model. This iterative learning approach enabled incremental improvements on each design cycle, regarding the definition of the solution's objectives, the artifacts' design, and the evaluation techniques.

We demonstrate the proposal by applying in three field studies, in the context of two public sector organizations, using both *ex-ante* and *ex-post* scenarios. For the evaluation of this work we used the demonstrations, evaluation forms, as well as interviews and group sessions, in order to evaluate the goal efficacy, the environment consistency, and the structural quality of the proposed EA solution.

Keywords: COBIT, Enterprise Architecture, governance of enterprise IT, TOGAF, ArchiMate, business and IT alignment, design science, design science research methodology.

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List of Acronyms

Acronym	Term	Sources
ACF	Architecture Content Framework (TOGAF context)	[1]
ADM	Architecture Development Method (TOGAF context)	[1]
COBIT	Control Objectives for Information and related Technology	[2]
DS	Design Science	[3]
DSRM	Design Science Research Methodology	[3] [4] [5]
EA	Enterprise Architecture	[6]
GEIT	Governance of Enterprise IT	[7]
IS	Information system(s)	[8]
IT	Information technology(ies)	[8]
ITIL	IT Infrastructure Library	[9]
TIPA	Tudor's ITSM Process Assessment	[10]
TOGAF	The Open Group Architecture Framework	[1]

Glossary

Term	Definition	Sources
Architecture	A formal description of a system, or a detailed plan of the system at component level, to guide its implementation (source: ISO/IEC/IEEE 42010:2011 [11]). The structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time.	[1] [11]
Architecture framework	A conceptual structure used to develop, implement, and sustain an architecture.	[1]
Artifact **(in the context of: design science)**	Artifacts may include: - Constructs, models, methods, and instantiations. - They may also include social innovations or new properties of technical, social, or informational resources. Note: In short, this definition includes any designed object with an embedded solution to an understood research problem. [4]	[4]
Artifact **(in the context of: TOGAF)**	An artifact is an architectural work product that describes an aspect of the architecture. Artifacts are generally classified as: - Catalogs (lists of things); - Matrices (showing relationships between things), and; - Diagrams (pictures of things). Note: Artifacts will form the content of the Architecture Repository. [1]	[1]

COBIT 5	Formerly known as Control Objectives for Information and related Technology (COBIT); now used only as the acronym in its fifth iteration. A complete, internationally accepted framework for governing and managing enterprise information and technology (IT) that supports enterprise executives and management in their definition and achievement of business goals and related IT goals. Scope Note: Earlier versions of COBIT focused on control objectives related to IT processes, management and control of IT processes and IT governance aspects.	[2]
Capability	An ability that an organization, person, or system possesses. Capabilities are typically expressed in general and high-level terms and typically require a combination of organization, people, processes, and technology to achieve. For example, marketing, customer contact, or outbound telemarketing.	[1]
Concern(s)	The key interests that are crucially important to the stakeholders in a system, and determine the acceptability of the system. Concerns may pertain to any aspect of the system's functioning, development, or operation, including considerations such as performance, reliability, security, distribution, and evolvability.	[1]
Constructs	The conceptual vocabulary of a domain. [12] Note: Constructs provide the vocabulary and symbols used to define problems and solutions. [5]	[12] [5]
Design Science	Design science creates and evaluates IT artifacts intended to solve identified organizational problems. Note: Such artifacts may include constructs, models, methods, and instantiations. They may also include social innovations or new properties of technical, social, or informational resources; in short, this definition includes any designed object with an embedded solution to an understood research problem.	[4]

Design Science Research Methodology (DSRM)	A methodological guideline for effective Design Science research. Note: In this work we will use the process model developed by Peffers et al [4]. Other process models may be found in [12].	[4] [12]
Enterprise	The highest level (typically) of description of an organization and typically covers all missions and functions. An enterprise will often span multiple organizations.	[1]
Enterprise Architecture **(in the context of: organization of the enterprise; or formal description of such organization)**	The architecture of an enterprise, see the definitions for the terms “architecture” [1] [11] and “enterprise” [1].	[1] [11]
Enterprise Architecture **(in the context of: discipline; or process area)**	Discipline or process area that aims to establish and maintain a common architecture consisting of business process, information, data, application and technology architecture layers for effectively and efficiently realizing enterprise and IT strategies by creating key models and practices that describe the baseline and target architectures. It achieves this objectives by representing the different building blocks that make up the enterprise and their inter-relationships as well as the principles guiding their design and evolution over time, enabling a standard, responsive and efficient delivery of operational and strategic objectives.	[13]
Framework	A structure for content or process that can be used as a tool to structure thinking, ensuring consistency and completeness.	[1]
Governance	Governance ensures that stakeholder needs, conditions and options are evaluated to determine balanced, agreed-on enterprise objectives to be achieved; setting direction through prioritization and decision making; and monitoring performance and compliance against agreed-on direction and objectives.	[2]

Governance of enterprise IT	A governance view that ensures that information and related technology support and enable the enterprise strategy and the achievement of enterprise objectives. It also includes the functional governance of IT, i.e., ensuring that IT capabilities are provided efficiently and effectively.	[2]
Information	An asset that, like other important business assets, is essential to an enterprise's business. It can exist in many forms: printed or written on paper, stored electronically, transmitted by post or electronically, shown on films, or spoken in conversation.	[2]
Information system	Interrelated components working together to collect, process, store, and disseminate information to support decision making, coordination, control, analysis, and visualization in an organization.	[8]
Instantiations	The operationalization of constructs, models, and methods.	[12]
Information technology	All the hardware and software technologies a firm needs to achieve its business objectives.	[8]
Management	Management plans, builds, runs and monitors activities in alignment with the direction set by the governance body to achieve the enterprise objectives.	[2]
Methods	A set of steps used to perform a task – how-to knowledge.	[12]
Models	A set of propositions or statements expressing relationships between constructs.	[12]
Risk	The combination of the probability of an event and its consequence (ISO/IEC 73).	[2]
Stakeholder **(in the context of: enterprise)**	Anyone who has a responsibility for, an expectation from or some other interest in the enterprise — e.g., shareholders, users, government, suppliers, customers and the public.	[2]

Stakeholder **(in the context of: enterprise architecture)**	An individual, team, or organization (or classes thereof) with interests in, or concerns relative to, the outcome of the architecture. Different stakeholders with different roles will have different concerns.	[1]
View	The representation of a related set of concerns. A view is what is seen from a viewpoint. An architecture view may be represented by a model to demonstrate to stakeholders their areas of interest in the architecture. A view does not have to be visual or graphical in nature.	[1]
Viewpoint	A definition of the perspective from which a view is taken. It is a specification of the conventions for constructing and using a view (often by means of an appropriate schema or template). A view is what you see; a viewpoint is where you are looking from — the vantage point or perspective that determines what you see.	[1]

1 Introduction

Information systems (IS) and related information technologies (IT) are implemented and managed for the purpose of improving the effectiveness and efficiency of organizations [5]. The automation and intelligence capabilities provided by IS are becoming increasingly relevant for achieving strategic goals and supporting the operational excellence of enterprises [8].

Indeed, IT has become pervasive in enterprises, enabling business objectives in many areas, namely: supporting efficiency gains through automation of key business processes, facilitating remote collaboration, providing business innovation and competitive advantage through the production and delivery of digital goods, enabling greater customer intimacy by providing knowledge about the customer's habits, needs, and preferences, and supporting business decisions by providing timely and high quality information and knowledge [7] [8].

Therefore, enterprises increasingly recognize information and related technologies as critical business assets, that need to be governed and managed effectively [7] [2] [14]. Other key drivers for implementing and maintaining excellence in governance of enterprise IT (GEIT) are the need to comply with regulatory requirements [7] [2], as well as to address information-related and IT-related risks [15] [16] [17] [18] [19].

1.1 Motivation for Developing EA Capabilities

The COBIT 5 framework [2] can be instrumental in providing a good practice approach for implementing GEIT initiatives, in order to maximize the value from IT investments, manage IT-related risks and achieve compliance [7].

The framework itself provides specific guidance for implementing governance using COBIT 5 [7]. This means that each successful COBIT 5 initiative may facilitate its own future path, by enhancing the capabilities required for supporting governance and management.

In particular, COBIT 5 recommends a set of processes that are instrumental in guiding the creation and maintenance of GEIT enablers. Among these processes, the *APO03 Manage Enterprise Architecture* is proposed as one of the key GEIT initiative enablers [7]. This recommendation should come as no surprise; indeed, Enterprise Architecture (EA) is instrumental for providing holistic organizational self-awareness [20], including relevant entities and their relationships, cutting across business domains, as well as bridging business and technology divides [21] [6] [22] [11] [1] [23]. Therefore, EA provides shared inter-domain knowledge and shared viewpoints, which enable different stakeholder to conduct effective conversations for engaging in compliance assessments [24] [25], risk management [15] [16], and change initiatives [26] [27] [28] [14] [29] [30] [13].

As related guidance for the *APO03* process, the COBIT 5 frameworks recommends the TOGAF architecture framework, an Open Group standard [1]. The ArchiMate architecture modelling language [31], which is another Open Group standard, provides a good match for TOGAF [32], enabling the

analysis and visualization of inter-related architectures, by providing views and viewpoints for addressing stakeholders' concerns.

Therefore, the COBIT 5 framework and the TOGAF standard are synergistic sources for requirements, regarding the enhancement of EA capabilities for enabling governance initiatives.

1.2 Research Problem

During the years 2014 and 2015, the author was engaged in GEIT initiatives using COBIT 5, which required assessing the performance of governance and management processes and providing recommendations on improving organizational capabilities. The experience thus gained by COBIT 5 practice demonstrated, we argue, how EA capabilities can be valuable for GEIT initiatives. Indeed, the lack of adequate organizational self-awareness and interactive synchronization tools forces the assessment stakeholders to engage a disproportionate amount of resources in the auditing and consulting activities, especially during the evidence collection and evidence validation iterations. Besides the efficiency penalty, resource-constrained initiatives will also suffer from effectiveness hindrances because less resources will be made available for performing the actual assessment, documenting exceptions and gaps, communicating the assessment conclusions, and optimizing the improvement recommendations and roadmaps [18] [17].

However, the current TOGAF standard does not provide specific architectural building blocks for COBIT 5. Note that TOGAF version 9.1 - currently the latest TOGAF release - was published in 2011, i.e. before the initial 2012-2013 COBIT 5 framework specifications were published.

Generally, the research problem may thus be defined as a search for a solution with the purpose of providing adequate EA capabilities, in order to assist process assessment and process improvement initiatives using COBIT 5.

In this work, we propose an EA approach that integrates COBIT with EA principles, methods, and models, using the ArchiMate standard as the architecture modeling language to describe the EA. In order to maximize the solution effectiveness, we propose to embed the COBIT best practices (formerly control objectives [33]) rationale directly in the EA models.

Note that this work is not focused on finding optimal solutions for detailed analysis (such as dependency analysis) and specific engineering optimization efforts. Instead, it seeks to provide standards-based EA instruments which may serve as a basis for improving self-awareness and interactive synchronization efforts, for the benefit of GEIT stakeholders engaged in the typical auditing and consulting activities. Nevertheless, the high-level views and viewpoints which we propose may serve a basis for providing architectural representations on top of which such detailed work may be designed and performed.

1.3 Research Methodology

In this thesis work, we propose to use the Design Science Research Methodology (DSRM) [5] [4] [3] in order to guide the construction and evaluation of the architectural IS artifacts that will be developed. DSRM incorporates principles, practices and a process model which are adequate [3] to conduct design science (DS) research in applied research disciplines, such as engineering research and – more recently [5] [4] – information systems research, whose cultures value incrementally effective solutions. The design science paradigm seeks to create and evaluate "what is effective" [5] in the problem space.

Regarding the architectural IS artifacts that we propose in this work, we will use a definition of artifacts that includes instantiations (implemented and prototype systems), constructs, models, and methods [5] that enable Enterprise Architecture capabilities [1]. We will design and evaluate the artifacts not simply by their own intrinsic features, but by their effectiveness in a specific context and in order to achieve a defined goal: the capacitation of the COBIT 5 process APO03 [13] [30], in the context of governance of enterprise IT initiatives [7] [15] [16] [24] [29] [25], for the typical auditing and consulting activities for process assessment and process improvement.

In this work, we define constructs as artifacts that "provide the vocabulary and symbols used to define problems and solutions" [5], enabling the construction of models or representations of the problem domain.

The DSRM process model includes six activities (see Figure 1-1): problem identification and motivation, definition of the objectives for a solution, design and development, demonstration, evaluation, and communication.

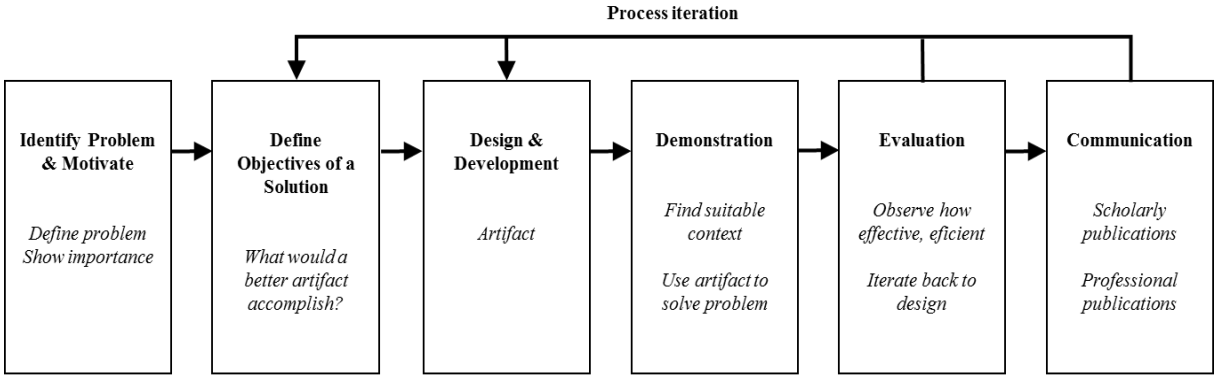


Figure 1-1: The DSRM Process Model. [4]

Note that the DSRM process model includes process iteration paths, that allow for cycling between generation-related activities (i.e. define objectives and design & development) and testing-related activities (i.e. demonstration, evaluation, and communication). Indeed, design science is an iterative

search process, where heuristic-based search iterations seek to produce feasible and effective solutions [1].

In order to obtain frequent and valuable feedback for the design process, we executed four iterations of the generation and testing cycle. With this approach we were able to collect frequent feedback, achieve better risk control for the design process and, ultimately, more valuable outcomes from this work.

For each generate/test cycle iteration, we used the COBIT and TOGAF guidelines and best practices for identifying, (re)defining, and managing the solution objectives and requirements, as well as for further developing the desired EA capabilities. Note that according to the DSRM, “a methodology to support research within a specific stream in IS might incorporate elements specific to the context of that research” and that “with respect to specific activities in the research process, future researchers may enhance the DSRM, for example, by developing subsidiary processes” [25].

2 Related Work

We begin our analysis of related work in a systematic way, by first trying to establish the search space boundaries.

2.1 Research Scope

We will kick-start our search endeavour by recognizing and asserting that:

> **Statement 2-1: EA is a key enabler for GEIT using COBIT 5.**
>
> The COBIT 5 process *APO03 Manage enterprise architecture* is key for helping to guide the creation and maintenance of governance and management enablers. [3]

The previous assertion allows for the definition of the opportunities search space (see Figure 2-1): we will search for design opportunities regarding the improvement of EA capabilities, pondering the enabling value for governance of enterprise IT.

In the remainder of this section we will aim to identify the success factors, as well as the solution requirements, that may facilitate the achievement of an adequate capability level for the APO03 COBIT 5 process.

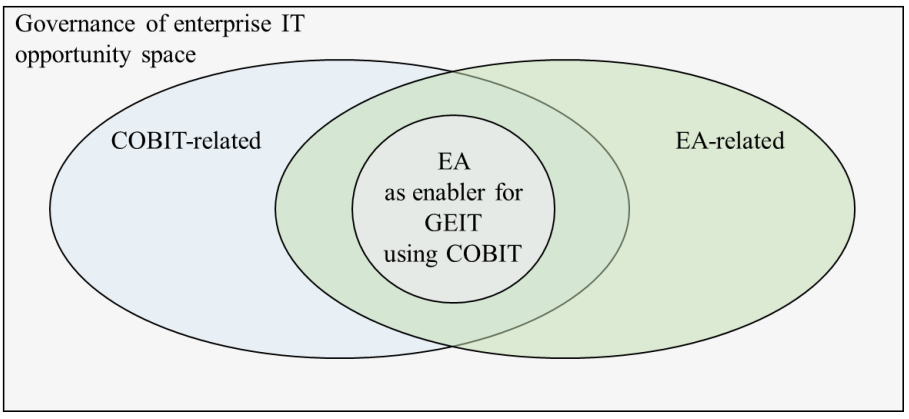


Figure 2-1: GEIT opportunity space.

Along the search process, we will identify and define relevant EA capability needs and gaps, regarding governance of enterprise IT. Then we will seek to bridge these gaps with the help of an effective solution.

2.2 Objectives and Requirements

Out related work search should provide relevant references and creative ideas for each activity of the DSRM process model. In practice, we want to elicit objectives, requirements, and generating/testing best practices in order to conduct and enrich the systematic design and development process.

For the initial stages of the first iteration of the DSRM process, namely the "Identify Problem & Motivate" activity and the first execution of "Define Objectives of a Solution" activity (see Figure 1-1), we used the following approach:

- Search for relevant stakeholders' needs and requirements, using globally recognized state-of-the-art standards and best practice frameworks. This search strategy aims to establish a solid foundation for future acceptance and adoption of the solution. We followed the steps:
    - Use the COBIT 5 framework, as the starting point for best practice.
    - Prioritize further search efforts in COBIT-related guidance, namely TOGAF.
    - Define the main design variables:
        - Define the design target: who are the relevant stakeholders?
        - Define the objectives and requirements: fundamentally, what do the stakeholders need, want, and require?
- Search for relevant state-of-the-art scientific and professional literature, which may provide (partial) solutions for similar/related problems.
    - Assess the scope and applicability.
    - Define the objectives and requirements: adopt, tailor or extend some of the proposals.
- Finally, identify and systematize the design opportunities. This search outcome will thus provide the foundational basis for the following DSRM activities:
    - Activity "Identify Problem & Motivate": we will identify the gaps and motivations.
    - Activity "Define Objectives of a Solution": we provided the design opportunity rationale, for the first generation/test iteration.

2.3 Stakeholders

We can define several classes of stakeholders, depending on the relevant scope and concerns:

- Enterprise stakeholders;
- Enterprise Architecture (EA) stakeholders;
- Governance of enterprise IT (GEIT) stakeholders;
- *APO03 Manage enterprise architecture* process stakeholders.

In this work we are directly concerned with enabling GEIT through capacitation of the APO03 process, in order to assist process assessment and process improvement activities. Therefore we will focus primarily on implementation of GEIT [7] and the enabling process APO03 [13], thus on the guidance provided by related COBIT 5 best practices.

We may now state our stakeholder focus requirement:

Requirement 2-1: Stakeholder focus.

Focus on GEIT and *APO03* related stakeholders.

2.4 COBIT 5

In the introductory section we have presented the COBIT 5 rationale for promoting EA, noting that the *APO03 Manage Enterprise Architecture* is proposed as a key process for helping to guide the creation and maintenance of governance and management enablers [3]. The purpose of the *APO03* process is to "represent the different building blocks that make up the enterprise and their inter-relationships as well as the principles guiding their design and evolution over time, enabling a standard, responsive and efficient delivery of operational and strategic objectives" [30]. Therefore, the COBIT 5 framework provides the business case for improving EA capabilities, for the purposes of improving GEIT and thus enable value creation.

2.4.1 APO03 Manage Enterprise Architecture Process

A general description of the EA stakeholders' needs can be found in the APO03 process description and process purpose statement [13]. From these statements we can identify and define the following capability needs, as well as the corresponding requirements:

Capability 2-1: Models and practices for architectural descriptions.

Enable the creation of key models and practices that describe the baseline and target architectures**.** [17]

Capability 2-2: Establish a common architecture.

Establish a common architecture consisting of business process, information, data, application and technology architecture layers, for effectively and efficiently realizing enterprise and IT strategies**.** [17]

These capabilities can be related to the following requirements:

Requirement 2-2: Shared vocabulary.

Define requirements for taxonomy**.** [17]

Requirement 2-3: Methods and standards.

Define requirements for standards, guidelines, and procedures. [17]

Requirement 2-4: Templates and tools.

Define requirements for templates and tools. [17]

Requirement 2-5: Architectural representations for all building blocks.

Represent the different building blocks that make up the enterprise and their inter-relationships, as well as the principles guiding their design and evolution over time, including those related to the COBIT 5 principles and practices.

Note that we have included, in the above definition, the COBIT 5-related motivational layer as a required building block, with the goal of "enabling a standard, responsive and efficient delivery of operational and strategic objectives" [13].

Capability 2-3: EA development method and architecture services.

The TOGAF standard is recommended by COBIT 5, as related guidance for EA. At the core of TOGAF is the Architecture Development Method (ADM), which maps to several COBIT 5 practices. Some TOGAF components map to the COBIT 5 practice of providing enterprise architecture services. [17]

2.5 TOGAF

The *APO03 Manage Enterprise Architecture* process promotes TOGAF [1] as related guidance for an EA framework. The TOGAF Architecture Development Method (ADM), as well as other TOGAF components, map to the *APO03* process key management practices [13].

The current TOGAF 9.1 specification recognizes the need for a tailored approach for COBIT, by stating that TOGAF tailoring “may include adopting elements from other architecture frameworks, or integrating TOGAF methods with other standard frameworks, such as ITIL, CMMI, COBIT, PRINCE2, PMBOK, and MSP” [1].

Therefore we can conclude that TOGAF is helpful in establishing capabilities that facilitate the implementation of GEIT initiatives and thus the achievement of the governance objectives and goals. However the standard TOGAF approach is generic, in the sense that it is not specifically tailored to the COBIT 5 rationale.

2.5.1 Mapping TOGAF ADM Components to COBIT 5 Practices

As part of the analysis phase, it is important to understand how the TOGAF ADM phases, guidelines, and techniques map to the COBIT 5 practices, in order to understand how TOGAF can be used to enable GEIT.

Table 2-1 - Mapping TOGAF ADM components to COBIT 5 practices

TOGAF ADM components	**COBIT 5 practices**
Phase A, Architecture Principles	APO03.01 Develop the enterprise architecture vision
Phases B, C, D	APO03.02 Define reference architecture
Phase E	APO03.03 Select opportunities and solutions
Phases F, G	APO03.04 Define architecture implementation
Requirements Management, Architecture Principles, Stakeholder Management, Business Transformation Readiness Assessment, Risk Management, Capability-Based Planning, Architecture Compliance, Architecture Contracts	APO03.05 Provide enterprise architecture services

From the mapping presented in Table 2-1, we conclude that the TOGAF standard can be instrumental for coverage of the relevant COBIT 5 practices, generally providing a good fit for the EA methodology needs. So now we have a sound basis for stating the following requirement:

Requirement 2-6: Use the TOGAF ADM for architecture development.

Use the TOGAF ADM as a methodology for developing the enterprise architecture. [17]

2.5.2 Using TOGAF for Enabling COBIT 5

The TOGAF 9.1 specification recognizes the need for a tailored approach for COBIT, by stating that TOGAF tailoring "may include adopting elements from other architecture frameworks, or integrating TOGAF methods with other standard frameworks, such as ITIL, CMMI, COBIT, PRINCE2, PMBOK, and MSP" [1].

We can conclude that TOGAF is helpful in establishing capabilities that facilitate the implementation of GEIT initiatives and thus the achievement of the governance objectives and goals. However the standard TOGAF approach is generic, in the sense that it is not specifically tailored to the COBIT 5 rationale.

Requirement 2-7: Tailor TOGAF for COBIT 5.

Tailor the TOGAF ADM for COBIT 5 stakeholders' specific needs. [17] [18]

Some of the TOGAF components which are relevant for COBIT 5 stakeholders are presented and analysed in the following section.

2.5.3 TOGAF Modelling and Content Framework

TOGAF provides guidelines for the type of artifacts that are relevant for architectural conversations, meaning facilitating understanding and cooperation between stakeholders at different levels [1]. The TOGAF recommendations concerning the need to represent the motivational rationale are especially important in the COBIT 5 context.

Requirement 2-8: Stakeholder concerns, views, and viewpoints.

Develop viewpoints and views of the architecture that show how the concerns and requirements are going to be addressed. [18]

In the TOGAF context, several types of artifacts should be pondered. These artifacts should be part of an architectural repository.

Requirement 2-10: Content concepts: catalogues, matrices, and diagrams.

A TOGAF architecture is based on defining a number of architectural building blocks within architecture catalogues, specifying the relationships between those building blocks in architecture matrices, and then presenting communication diagrams that show in a precise and concise way what the architecture is. [18]

Requirement 2-9: Artifacts and architectural repository.

An artifact is an architectural work product that describes an aspect of the architecture. Artifacts are generally classified as catalogues (lists of things), matrices (showing relationships between things), and diagrams (pictures of things). Artifacts will form the content of the Architecture Repository [18].

Furthermore, the artifacts should be tailored for GEIT using COBIT 5:

Requirement 2-11: Artifacts tailored for COBIT 5.

TOGAF deliverables may be replaced or extended by a more specific set, defined in any other framework that the architect considers relevant. [18]

The TOGAF specification states that the “benefits of using this (motivation) extension are as follows: highlights misalignment of priorities across the enterprise and how these intersect with shared services (e.g., some organizations may be attempting to reduce costs, while others are attempting to increase capability); shows competing demands for business services in a more structured fashion, allowing compromise service levels to be defined” [1].

Requirement 2-12: Represent the COBIT 5 motivational rationale.

The motivation extension is intended to allow additional structured modelling of the drivers, goals, and objectives that influence an organization to provide business services to its customers. The scope of this extension is as follows [18]:

- Driver: that shows factors generally motivating or constraining an organization;
- Goal: shows the strategic purpose and mission of an organization;
- Objective: shows near to mid-term achievements that an organization would like to attain.

The standards also recommend that templates or schemas be defined, for promoting re-use, sharing and adoption:

Requirement 2-13: Modelling viewpoints: templates and tools.

An architecture description be encoded in a standard language, to enable a standard approach to the description of architecture semantics and their re-use among different tools.

A viewpoint should be developed, visualized, communicated, and managed using a tool. Standard viewpoints (i.e., templates or schemas) should be developed, so that different tools that deal in the same views can interoperate, the fundamental elements of an architecture can be re-used, and the architecture description can be shared among tools. [18].

2.6 ArchiMate

The TOGAF and ArchiMate specifications are both developed by The Open Group, and their development efforts are becoming increasingly coordinated [34] [32] [35] [36] [37]. The ArchiMate standard is also widely supported by modelling tool providers [38] [39] [40] [41] [42] [43] [44] [45], which makes the language an attractive option for fast and easy adoption.

Requirement 2-14: Use ArchiMate as a visual modelling language for EA.

Use the ArchiMate standard for modelling the EA.

2.6.1 ArchiMate Extensions

The language provides extension mechanisms to extend the core language, through adding attributes to ArchiMate concepts and relationships, as well as specialization of concepts and relationships [31]. Extending the ArchiMate language can be useful for optimizing the ontological fit of the architectural representations. Business concepts like organizational competencies [46] and key performance indicators [47] can be modeled using such an approach. Also, ontology-related techniques can be used assist the modeling of enterprise architectures through the analysis and validation of models [48].

However, in this work we aim to maximize the value of the COBIT 5 window of opportunity. So we based our artifacts on constructs that are an integral part of the ArchiMate specification, for fast and widespread adoption, thus facilitating the use of popular ArchiMate-compatible modeling tools. Other proposals have used the standards-based modeling approach that we adopt in this work, namely for modeling ITIL [49] [9], ITIL process assessments [50] [10], as well as security and risk [51].

Therefore, in this work we based our artifacts on constructs that are part of globally-adopted specifications, thus lowering the implementation costs and easing fast and widespread adoption of the solution.

Requirement 2-15: Use standard ArchiMate constructs.

Use standard ArchiMate constructs for modelling the COBIT 5 rationale.

2.7 DSRM Iterations

Note that the DSRM process model is iterative. Therefore it is important that we keep track of all relevant feedback as work progresses along the different process model activities and cycle iterations. Namely, we will seek to elicit the lessons learned at any stage in order to incorporate this valuable knowledge as feedback for future latter stages. We may restate this statement by saying that the lessons learned in one stage become relevant related work for latter stages.

2.8 Solution Objectives and Requirements

The goal of the proposed thesis work is to provide a reference EA approach that effectively supports governance initiatives that use COBIT. From the related work analysis, we can identify the solution objectives for the proposed EA approach, as presented in Table 2-1. These solution objectives and requirements will be developed further in the "Theoretical Background" section.

Table 2-2: Solution objectives, before the theoretical background analysis.

Solution objectives (SO)	Objective's rationale	Related requirements
SO1: Provide a tailored EA approach for GEIT, based on the TOGAF framework.	Enable fast and easy adoption, standards-based.	Requirement 2-2, Requirement 2-3, Requirement 2-6
SO2: Integrate the COBIT 5 rationale in the EA principles, methods, and models.	Provide an effective EA approach for enabling GEIT using COBIT 5.	Requirement 2-5, Requirement 2-7, Requirement 2-10, Requirement 2-12, Requirement 2-1
SO3: Use standard ArchiMate constructs to describe the EA.	Enable fast and easy adoption, standards-based.	Requirement 2-13, Requirement 2-14, Requirement 2-15
SO4: Provide templates for relevant viewpoints.	Enable effective architectural conversations, addressing all the relevant stakeholder's concerns.	Requirement 2-4, Requirement 2-8, Requirement 2-9, Requirement 2-11, Requirement 2-13

3 Research Problem

In the previous section, we identified the stakeholder's needs and reviewed the state-of-the-art regarding the problem space. In this section we will define the specific research problem which we have addressed in this work.

In order to define the research problem, we will provide definitions for the problem context and the problem statement:

- The problem context:
  - Clearly stating the problem setting is important, in order to remove ambiguity regarding the problem space.
  - The problem statement assumes the problem context as its workspace. This enables a more compact formulation for the problem statement.
  - A clear and precise definition of the problem context will also help ensure that the correct conditions will be set for the demonstration scenarios (i.e. the field studies) and the evaluation activities.
- The problem statement:
  - The problem statement will be key in understanding the value of the proposed solution - and thus justify its development and later usage.
  - The problem statement, along with the solution's objectives, is the basis for the development and evaluation of the artifacts that will provide the proposed solution.

Note that the definition of the full set of solution objectives will be deferred to the DSRM iteration sections, after a review of the relevant theoretical background. This staged approach will enable us to carefully ponder – and take into account – globally recognized standards and best practice frameworks, which will be valuable in identifying, defining, and justifying the solution's objectives and requirements.

3.1 Problem Context

From the analysis of the related work, made in the previous section, we have concluded that some qualified EA approaches, especially those based on TOGAF and ArchiMate, may be helpful in establishing and maintaining capabilities that facilitate the implementation of GEIT initiatives and thus the achievement of governance objectives.

So now we can formulate the problem context statement, as:

Statement 3-1: The problem context.

COBIT 5 identifies the need - and recommends guidance – for qualified EA approaches like TOGAF, in order to enable GEIT.

3.2 Problem Statement

The notion that EA is instrumental as a communication tool between business and IT stakeholders is well established [21] [7] [13] [22]. EA practices help promote dialog, in order to foster shared meaning and promote alignment of enterprise's means and ends [6].

Furthermore, the COBIT 5 framework explicitly recommends [7] the *APO03 Manage Enterprise Architecture* process as an enabler for governance of enterprise IT. The framework also recommends the TOGAF standard as related guidance [13] for enterprise architecture.

However, the TOGAF and the ArchiMate standards are generic specifications, as far as COBIT 5 practice is concerned, in the sense that they are not specifically tailored to the COBIT 5 rationale.

In other words – borrowing from the engineering terminology – we need an enabling adapter to compensate for the likely impedance mismatch; otherwise, a significant amount of energy may be wasted. More precisely, the ontological mismatch between the COBIT and EA domains implies an enabler performance risk: the threat of missing the expected targets for benefits and costs for the governance of enterprise IT in general; and for governance initiatives in particular.

Therefore, we can formulate the problem statement, as:

Statement 3-2: The problem statement.

The COBIT 5 framework and the TOGAF 9.1 related guidance do not, by themselves, provide a specific EA approach that helps bridge the gap between the desired COBIT 5 EA enabler performance goals and the actual EA practice, namely for COBIT 5 process assessment and process improvement initiatives.

Specifically, the TOGAF 9.1 standard does not provide specific enabling support for COBIT 5 governance initiatives, namely a tailored EA methodology and COBIT-specific building blocks.

3.2.1 Value of the Solution

In simple terms we may argue that, without an adequate EA approach, we risk missing the desired alignment between governance motivations (i.e. governance goals and strategy) and actual EA outcomes (i.e. enabler performance and strategy execution).

On the upside, we may argue that by adopting and customizing an adequate EA approach, enterprises may optimize the value of implementing governance of enterprise IT initiatives using COBIT 5 [7], namely in the context of COBIT 5 process assessment and process improvement initiatives.

Risks related to higher governance costs

The lack of adequate EA tools for enabling governance implies the use of less efficient approaches; in such a scenario, a significant amount of additional effort may be spent, for each governance initiative, in wasteful collection and validation activities, as well as in burdensome and demotivating misunderstanding-related corrections. We can argue that these wasteful activities need not have occurred if EA had been adequately managed on an ongoing basis, with repeatable and well-understood methodologies that promoted shared knowledge, and used common and up-to-date architectural descriptions.

Note that we should not underestimate the complexity of the tasks involved; the COBIT 5 and TOGAF 9.1 frameworks are not, by any reasonable measure of effort, conceptual models which are easy to understand and implement. It should be expected that someone new to these subject matters will have to endure quite a steep learning curve, both in order to dominate the knowledge domains, as well as to be able to take full advantage of the application potential. Actually, it should come as no surprise that the high complexity of the frameworks may be invoked as a showstopper for their use in governance-related initiatives - especially in enterprises with low levels of governance maturity and capability.

Therefore, we can argue that there is value in designing and using a solution that helps to handle the conceptual and practical complexities, thus facilitating adoption of COBIT 5 for GEIT initiatives.

Risks related to loss of governance benefits

Generic EA approaches, i.e. which do not explicitly take into account the COBIT 5 rationale, risk being ineffective when used as governance enablers. Indeed, if the COBIT 5 control objectives are not embedded in the EA models and practices, further architecture change initiatives risk “forgetting” the COBIT 5 motivational rationale, namely when analysing opportunities and solutions, as well as making decisions regarding implementation changes; and as time goes by, it is reasonable to expect that such gaps between strategy and execution will become larger, thus seriously degrading the expected governance benefits.

4 Theoretical Background

In the ”Related Work” section we have identified and defined relevant EA capabilities and requirements for enabling governance of enterprise IT. Those EA capability needs and EA requirements represent statements of need, which the proposed solution should address. The related work review process also allowed us to define the design research problem that we want to solve.

Now that we have defined the problem with the help of state-of-the-art references, we further aim to understand the state-of-the-art regarding the solution space. So in this section we will review additional theoretical background that will help us design a solution for the stated problem.

4.1 Architecture Principles

Architecture principles are, arguably, the cornerstones of EA [23]. According to the TOGAF framework architecture principles “are a set of principles that relate to architecture work. They reflect a level of consensus across the enterprise, and embody the spirit and thinking of existing enterprise principles” [1]. Therefore we should identify and define the following solution requirement:

Requirement 4-1: Provide representations for enterprise principles and architecture principles.

The ArchiMate models and viewpoint templates should provide architectural representations for enterprise principles and architectural principles.

In particular, for the context of GEIT using COBIT 5, we should also identify and define the following solution requirement:

Requirement 4-2: Provide representations for COBIT 5 principles.

The ArchiMate models and viewpoint templates should provide architectural representations for the COBIT 5 framework principles.

Note that these solution requirements are relevant for achieving the solution objective “SO2: Integrate the COBIT 5 rationale in the EA principles, methods, and models” (see Table 2-2).

4.2 Architectural Method

We have already established TOGAF as the framework of choice for the proposed solution. The TOGAF specification provides guidance [1] on how to establish and maintain EA capabilities, stating that as “with any business capability, the establishment of an enterprise Architecture Capability can be supported by the TOGAF Architecture Development Method (ADM)” [18]. So we should define the solution requirement:

Requirement 4-3: Establish and maintain EA capabilities using the ADM.

The establishment and maintenance of an enterprise Architecture Capability should be supported by the TOGAF Architecture Development Method (ADM). [18]

4.2.1 Using COBIT 5 with ITIL and Other GEIT-related Initiatives

Note that any GEIT change initiative entails a potential for architectural change, to be addressed with the ADM. In order to ensure coordination of all governance and management initiatives with EA impact, we should define the requirement:

Requirement 4-4: GEIT change initiatives should use the ADM.

The implementation of GEIT change initiatives should be supported by the TOGAF Architecture Development Method (ADM) and described in the Architecture Landscape at the Strategic Architecture level. [18]

This requirement ensures that GEIT and EA activities are adequately synchronized and that the architectural descriptions regarding the GEIT initiative are represented at the adequate abstraction level, thus enabling integration (both of the rationale and the architectural descriptions) with other strategic, governance and management initiatives that use EA methodologies, such as ITIL-related [49] and TIPA-related [50].

4.3 Architectural Models and Artifacts

As a source of good practice for modelling in ArchiMate, we have pondered the practical guidance offered in the “Mastering ArchiMate” book by Gerben Wierda [51]. Examples of recommended practice range from the simple (and effective) inclusion of an element’s type name - e.g. “(Business Process)” – in the element’s label, to more elaborate guidelines for modelling risk, security, and capability.

5 First DSRM Iteration

In the first DSRM iteration, we designed and tested a proof-of-concept EA proposal, in order to demonstrate and evaluate the feasibility of the scientific project as a whole, as well as to collect early feedback for the following DSRM iterations.

The proof-of-concept proposal is composed of:

- The solution statement (of intent), which aims to address the problem statement;
- The initial set of solution objectives and requirements, which are work products of the first execution of the DSRM “Define Objectives of a Solution” research activity;
- Draft artifacts, corresponding to draft outcomes of the first execution of the DSRM “Design & Development” research activity.

5.1 Solution Proposal

We begin by discussing and defining the solution statement (of intent), which aims to address the problem statement (see Section 3.2).

5.1.1 Solution Statement

The solution statement is formulated in the same context as the problem statement: *COBIT 5 identifies the need - and recommends guidance – for qualified EA approaches like TOGAF, in order to enable governance of enterprise IT* (see Statement 3-1).

The solution statement is a counterpart for the problem statement (see Statement 3-2) and has the following definition:

Solution statement 5-1

Provide an Enterprise Architecture approach (EA) which:

- Is based on TOGAF and tailored for GEIT initiatives using COBIT 5, in order to assist in process assessment and process improvement activities;
- Integrates the COBIT 5 rationale in the EA principles, methods, and models; and
- Uses standard ArchiMate constructs for describing the EA.

5.1.2 Solution Objectives and Requirements

The full set of initial solution objectives and requirements is presented in Table 5-1.

Table 5-1: Solution objectives and requirements, for the first DSRM iteration.

Solution objectives **(first DSRM iteration)**	**Objective's rationale**	**Related requirements**
SO1: Provide a tailored EA approach for GEIT, based on the TOGAF framework.	Enable fast and easy adoption, standards-based.	Requirement 2-2, Requirement 2-3, Requirement 2-6, Requirement 4-3, Requirement 4-4
SO2: Integrate the COBIT 5 rationale in the EA principles, methods, and models.	Provide an effective EA approach for enabling GEIT using COBIT 5.	Requirement 2-5, Requirement 2-7, Requirement 2-11, Requirement 2-12, Requirement 2-1, Requirement 4-1, Requirement 4-2, Requirement 4-4
SO3: Use standard ArchiMate constructs to describe the EA.	Enable fast and easy adoption, standards-based.	Requirement 2-13, Requirement 2-14, Requirement 2-15
SO4: Provide templates for relevant viewpoints.	Enable effective architectural conversations, addressing all the relevant stakeholder's concerns.	Requirement 2-4, Requirement 2-8, Requirement 2-9, Requirement 2-10, Requirement 2-13, Requirement 4-4

Each solution objective is associated with a corresponding list of related requirements – derived from analysis of the related work (see Section 2.8) and the theoretical background (see Section 4). The objectives' effectiveness rationale is presented in the column "Objective's rationale".

5.1.3 Proposed Artifacts

The proof-of-concept ArchiMate served as modeling prototypes, in order to demonstrate and evaluate the feasibility of the project as a whole, as well as to collect early feedback.

The proof-of-concept artifacts are:

- A Constructs Mapping table set (see Appendix A: First DSRM Iteration - Constructs Mapping), which maps the relevant COBIT 5 concepts to the corresponding ArchiMate constructs, thus demonstrating the ontological fit of the proposed solution. The mapping is defined by the following tables:
    - The COBIT 5 framework end goals;
    - The COBIT 5 Goals Cascade;
    - Pain Points and Trigger Events.
- Viewpoints for addressing the relevant stakeholder's concerns:
    - The Goals Cascade viewpoint (see Appendix Figure 1: Goals Cascade viewpoint.): this templates shows how the COBIT 5 "Meeting stakeholders' needs" principles cascades down to the enablers – in particular to the enabling processes.
    - The Enabling Process Performance viewpoint (see Appendix Figure 2: Enabling Process Performance viewpoint.): this viewpoint shows the main concepts and relationship involved in a process performance assessment and uses – thereby proving links to – concepts from the Goals Cascade viewpoint.

5.2 Demonstration

For the purposes of demonstration, the proof-of-concept viewpoints were instantiated for the *APO 02 Manage Strategy* process. Note that, for the remaining COBIT 5 processes, the corresponding viewpoints would have - *mutatis mutandis* - a very similar structure [30] [13].

5.3 Evaluation

For this proof-of-concept stage, an interim dissertation report was produced, presented, discussed, and evaluated at Instituto Superior Técnico, in a public session, as part of the formal evaluation process for the "Master Project in Information and Software Engineering" course. The proof-of-concept proposal was thus validated.

5.3.1 Lessons learned

The evaluation discussion brought to light a major concern regarding the practical value of the work - as a whole -, namely how real world organizations should be approached, in order to maximize the value of the proposed solutions and foster adoption.

As a consequence, the following DSRM iterations used a more pragmatic approach to the evaluation process, targeting evaluation criteria which were more directly related to the solutions' usefulness. In particular, we replaced the proposed evaluation approach based on the Wand and Weber Method [52] [53] (ontological expressiveness) and on the Moody and Shanks Framework [54] (quality), with a new approach that explicitly included goal efficacy evaluation criteria.

Also, three more DSRM iterations were performed as field studies - thus in real world organizations – thus broadening the initial statement of work and making it more pragmatic (a theoretical case study proposal was dropped).

The field studies provided practical experience, both formal (i.e. evaluation forms) and informal (interviews, group sessions), on how to approach and motivate the organization stakeholders. In particular, the evaluation forms used in the field study included questions regarding the degree of confidence of the evaluators.

5.4 Communication

As stated in the previous section, an interim dissertation report was produced, presented, discussed, and evaluated at Instituto Superior Técnico, in a public session, as part of the formal evaluation process for the “Master Project in Information and Software Engineering” course.

5.5 Conclusion

The proof-of-concept DSRM iteration provided the foundational work necessary to demonstrate and validate the feasibility and scientific correctness of the thesis work, and provide feedback for the following DSRM iterations.

The main lessons learned concern conducting the following DSRM iterations with the goal of maximizing the value of the proposed solutions and ultimately fostering adoption in real world organizations.

6 Second DSRM Iteration

For the second DSRM iteration, the generating and testing work was based on the following guidelines:

- Field study:
  - The study was performed in a military organization setting, in order to demonstrate and evaluate a new solution design (see Section 5.3.1);
  - We have also used a secondary group for experimental control purposes.
- Design focus (agile approach):
  - Focus on artifacts for assisting process assessments activities;
  - Focus on the process capability level 1 rationale, i.e. process performance. Note that this capability level relates directly to the goals cascade methodology, therefore bringing the business-IT alignment perspective into play.
- Demonstration and evaluation:
  - Use an ex-ante demonstration and evaluation strategy, in order to get early field study feedback for this interim iteration.
- Evaluation criteria:
  - We have explicitly included goal efficacy evaluation criteria (see Section 5.3.1).

With these guidelines we have sought to incorporate the lessons learned from the previous DSRM iteration.

6.1 Solution Proposal

The proposed solution, designed in order to model the COBIT 5 process performance indicators and the related assessment context, consists of the following IS artifacts:

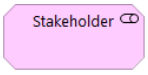
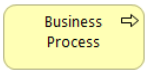
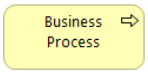
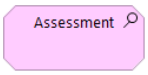
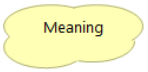
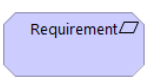
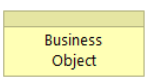
- Constructs mapping: we propose a mapping between the relevant COBIT 5 process performance assessment concepts and the standard ArchiMate constructs;
- Model: we propose an ArchiMate viewpoint template, that addresses the specific concerns of the stakeholders engaged in COBIT 5 process performance assessments;
- Method: we propose general guidelines for applying the proposed viewpoint template, in order to tailor the solution for the specific setting of each enterprise.

6.1.1 Constructs Mapping

The proposed ontological mapping between the COBIT 5 process performance assessment concepts and the ArchiMate constructs is presented in Table 6-1Table 6-1: COBIT 5 to ArchiMate Ontological Mapping. The column “COBIT 5 concept description” contains definitions and explanations taken from the relevant COBIT 5 publications [2] [25] [13] [30]. The column “ArchiMate concept description” contains definitions and explanations taken from the ArchiMate specification [31]. The semantic matching

between the contents of these two columns provides the justification for the proposed ontological mapping.

Table 6-1: COBIT 5 to ArchiMate Ontological Mapping

COBIT 5 concept	**COBIT 5 concept description** *[2] [25] [13] [30]*	**ArchiMate concept description** *[31]*	**ArchiMate notation**
IT-related goal	A statement describing a desired outcome of enterprise IT in support of enterprise goals. An outcome can be an artefact, a significant change of a state or a significant capability improvement.	A goal is defined as an end state that a stakeholder intends to achieve.	
Stakeholder	Anyone who has a responsibility for, an expectation from or some other interest in the enterprise— e.g., shareholders, users, government, suppliers, customers and the public.	A stakeholder is defined as the role of an individual, team or organization (or classes thereof) that represents their interests in, or concerns relative to, the outcome of the architecture.	
Process	Generally, a collection of practices influenced by the enterprise's policies and procedures that takes inputs from a number of sources (including other processes), manipulates the inputs and produces outputs (e.g., products, services).	A business process is defined as a behavior element that groups behavior based on an ordering of activities. It is intended to produce a defined set of products or business services.	
Activity	The main action taken to operate the process. Activities describe a set of necessary and sufficient action-oriented implementation steps to achieve a practice; consider the inputs and outputs of the process; are non-prescriptive and need to be adapted and developed into specific procedures.	A business process is defined as a behavior element that groups behavior based on an ordering of activities. It is intended to produce a defined set of products or business services.	
Process performance assessment result (assessment output, process attribute rating)	Assessment output: all of the tangible results from an assessment. Process attribute rating: a judgment of the degree of achievement of the characteristic for the assessed process. Note: The proposed model represents only the process attribute PA 1.1 Process Performance.	An assessment is defined as the outcome of some analysis of some driver. An assessment may reveal strengths, weaknesses, opportunities, or threats for some area of interest. These outcomes need to be addressed by adjusting existing goals or setting new ones, which may trigger changes to the enterprise architecture.	
Process purpose statement	A description of the overall purpose of the process. The high-level measurable objectives of performing the process and the likely outcomes of effective implementation of the process.	A goal is defined as an end state that a stakeholder intends to achieve.	
Process description	An overview of what the process does and a high-level overview of how the process accomplishes its purpose.	It is a description that expresses the intent of a representation; i.e., how it informs the external user. Meaning is defined as the knowledge or expertise present in a business object or its representation, given a particular context.	
Process outcomes	An observable result of a process.	A goal is defined as an end state that a stakeholder intends to achieve.	
Base practice	An activity that, when consistently performed, contributes to achieving a specific process purpose. Base practices are the activities or tasks required to achieve the required outcome for the process. They are specified in the COBIT PAM at a high level without specifying how they are carried out.	A requirement is defined as a statement of need that must be realized by a system. Requirements model the properties of these elements that are needed to achieve the "ends" that are modeled by the goals. In this respect, requirements represent the "means" to realize goals.	
Process metrics	At each level of the goals cascade, hence also for processes, metrics are defined to measure the extent to which goals are achieved. Metrics can be defined as 'a quantifiable entity that allows the measurement of the achievement of a process goal. Metrics should be SMART—specific, measurable, actionable, relevant and timely'.	A requirement is defined as a statement of need that must be realized by a system. Requirements model the properties of these elements that are needed to achieve the "ends" that are modeled by the goals. In this respect, requirements represent the "means" to realize goals.	
Inputs and Outputs	The process work products/artefacts considered necessary to support operation of the process.	A business object is defined as a passive element that has relevance from a business perspective. Sometimes, business objects represent actual instances of information produced and consumed by behavior elements such as business processes.	

6.1.2 Viewpoint Template

The proposed viewpoint template (see Figure 6-1) represents the main concept and relationships related to COBIT 5 process performance assessments, according to the COBIT 5 PAM [30] and COBIT 5 Enabling Processes [13] publications.

The template is generic (note the "[GENERIC]" notation in Figure 6-1), meaning that is may be used for any of the 37 COBIT 5 governance and management processes.

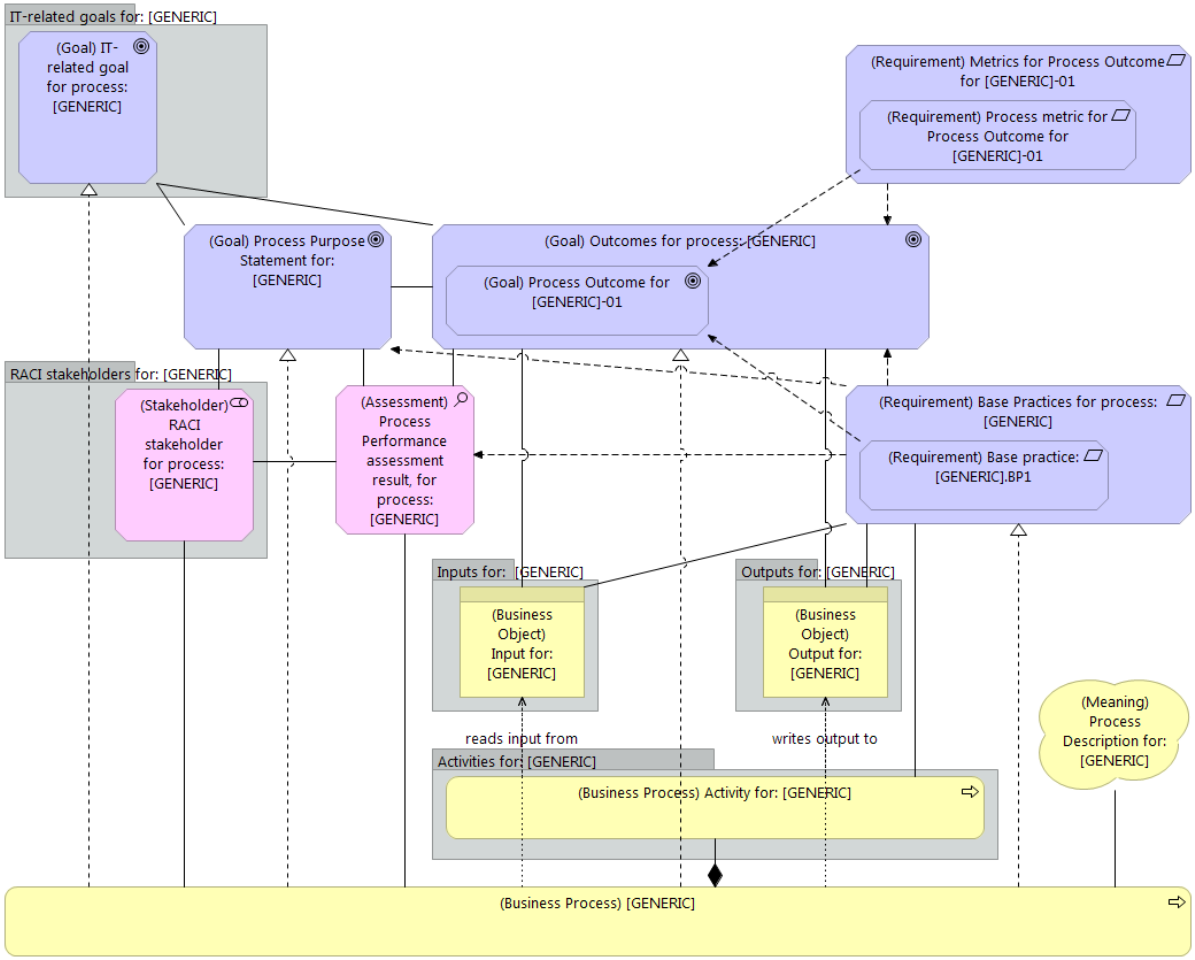


Figure 6-1: Generic ArchiMate template, for viewpoints used in COBIT 5 Process Performance Assessments.

6.1.3 Guidelines for using the Viewpoint Template

In order to use the template, it should first be instanced for all relevant COBIT 5 processes (i.e. all the processes under performance assessment), by replacing the "[GENERIC]" notation with the process name (e.g. "APO02 Manage Strategy").

The viewpoint for individual processes may then be tailored to the specific enterprise setting, using the following steps:

- Represent all instances for groups and aggregates: some of the ArchiMate template elements may represent more than one instance, according to the COBIT 5 PAM [30] and COBIT 5 Enabling Processes [13] specifications, such as: IT-related goals, stakeholders; process outcomes, process outcome metrics, base practices, activities, inputs, and outputs. Also note that the COBIT 5 guidelines allow for some flexibility in adding other instances (e.g. other IT-related goals) that the enterprise wishes to adopt, represent, and manage. The template only represents one such instance. In practice, the ArchiMate modeling tools should provide an easy way to duplicate these elements and tailor the copies according to the instance characteristics.
- Relate the COBIT 5 rationale with the IS/IT implementation: the tailored viewpoints should be integrated in the EA repository, using the functionalities provided by the ArchiMate modeling tool adopted by the enterprise. Once they are made available to the tool user, the assessment stakeholders may establish the relationship links between the viewpoint elements and the ArchiMate elements that represent the IS/IT implementation. We suggest that the ArchiMate association relationship (i.e. the semantically weakest relationship) is used for this purpose, although other relationship types may be used, in order to enforce more specific relationship semantics [31].

6.2 Demonstration

During the group sessions and interviews, for demonstration purposes, we presented and discussed an instantiation of the generic template, which consists of a viewpoint for the *APO02 Manage Strategy* process, as shown in Figure 6-2.

We have also presented and discussed the corresponding APO02 process performance indicator tables, as specified in the COBIT 5 PAM [30] and COBIT 5 Enabling Processes [13] publications, in order to justify the ontological rationale for the construct mappings.

The demonstration viewpoint was built and presented with the following demonstration criteria, in order to support the evaluation activities:

- All concepts from the generic template were represented in the viewpoint, in order to help demonstrate the model's completeness;
- All 3 IT-related goals, 5 process outcomes, and 6 management base practices, defined for the *APO02 Manage Strategy* process, were represented in the viewpoint;
- For simplicity and ease of graphical interpretation of the demonstration artifact, the viewpoint presents the following simplifications:

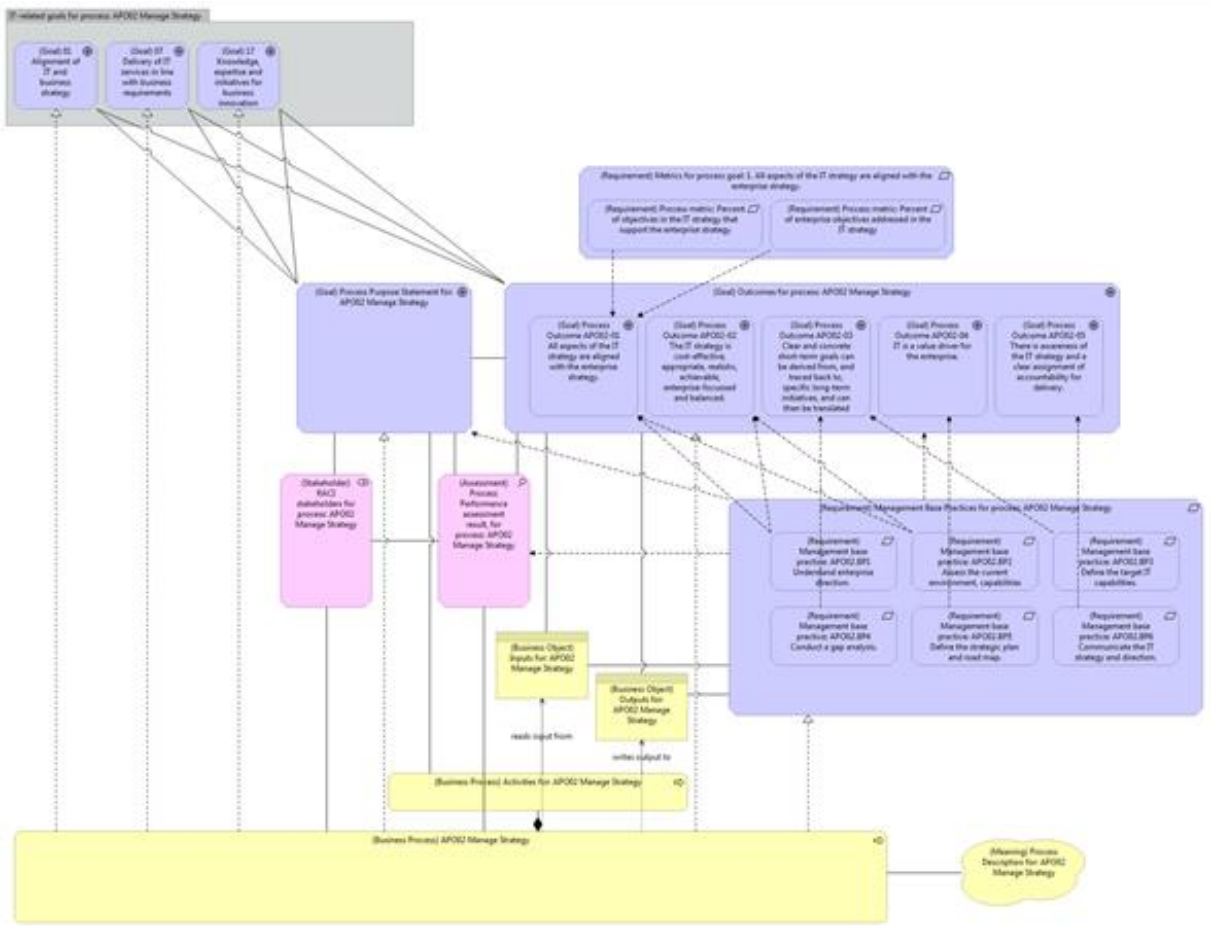


Figure 6-2: ArchiMate viewpoint, showing an instantiation of the viewpoint template for the APO02 process.

- Process outcome metrics are shown in the view, but only for the first process outcome (APO02-O1).
- The viewpoint shows only single instances for stakeholders, activities, inputs, and outputs. Note that in practice modelling tools [45] are used to manage the full model richness, providing adequate graphical interfaces for easing the usage complexities.

6.3 Evaluation

For the evaluation activities, we used the following approach:

- Selection of the evaluators:
  - Select a primary test group, as representatives of the solution's target stakeholders;
  - Select a secondary test group, for evaluation control purposes (as discussed below), with lower EA maturity than the primary group;
  - Selection pre-requisites: all of the evaluators were volunteers and had prior (practical or academic) knowledge of at least one of the key three evaluation subject matters: COBIT 5, ArchiMate, and managing IS/IT assessments;

    - Post-assessment validation: at the end of the assessment activities, each evaluator was asked to rate the overall quality of the demonstration and evaluation activities, as well as the evaluation form, in terms of clarity, understandability, and representability of personal opinion. The validation of the each evaluation form depended on the evaluator's agreement with the following statement: "I felt comfortable in proving the evaluation ratings. They represent my current opinion."
- Evaluation sessions: for the testing sessions, we conducted:
    - Group sessions: we conducted group sessions (focus groups) with the practitioners from the primary group, as well as a separate group session with the students from the secondary group. The agenda for these session included a formal presentation which covered the subject matters and the demonstration, an informal debate, detailed instructions for filling out the evaluation form, and performing the actual evaluation assessment using an evaluation form (questionnaire);
    - Interviews: we conducted individual interviews with two members of the primary group, who had relatively higher expertise levels in the relevant subject matters (i.e. COBIT 5, ArchiMate, and managing IS/IT assessments).
    - The evaluation forms are anonymous and were classified only on the basis of group type (primary or secondary) for the purposes of comparing the primary and secondary ratings.

6.3.1 Selecting the evaluators and validating the ratings

For the primary test group, we have selected a group of 10 enterprise IT practitioners composed of military officers, having a mix of both business and IS/IT experience and knowledge, namely:

- 70% (i.e. 7 officers) had both business and IS/IT working experience;
- 10% (i.e. 1 officer) had mainly business working experience; and
- 20% (i.e. 2 officers) had mainly IS/IT working experience.

The purpose of this primary test group is to represent a practitioner's group that is relatively mature, in terms of EA capabilities and managing IS/IT assessments, as well as motivated to improve existing EA capabilities. Note that military officers are practitioners who understand and value, we argue, the importance of adequate blueprints which provide shared knowledge and views on top of which situational awareness and cooperative action can be leveraged, for informing strategic, operational and tactical decisions. Military officers are surely no strangers to cartographical practice, skills and capabilities. Hence, in a military environment, the value of EA can be easily grasped using cartographical analogies for enterprise IS/IT blueprints, principles, and methodologies.

Given that the selected primary group is expected to be somewhat biased towards higher usefulness ratings (relative to the market average) we selected a secondary test group in order to obtain lower expected ratings, both in terms of rating the research problem approach and in rating the solution's usefulness. Together, we hope that the two sets of ratings (i.e. primary and secondary) will provide a broader representation of the market target and thus a more informed basis for discussing the

generalization potential, as well as the expected usefulness and fitness of the proposed solution in other organizational settings.

For the secondary test group we have selected a group of 15 IS/IT master students, working towards a major in Enterprise Information Systems. At the time of the evaluation sessions, these students were preparing their first IS/IT field assessment using COBIT 5, as an academic exercise in the context of the discipline of "Organization and IT Function Management". Only 1 of the 15 members had business-related experience. The informal group feedback, provided during the debate period of the demonstration and evaluation session, hinted at characterizing the secondary group as less enthusiastic than the primary group, regarding agreement with research problem approach and the solution's usefulness claims. The formal ratings, provided by the evaluation form results (see Section 6.3.3), are consistent with the informal feedback received during the evaluation session. It is also interesting to note that the initial pool of evaluation volunteers was composed of 19 candidates, of which only the selected 15 provided valid evaluation forms (see "Post-assessment validation" above). On the other hand, all 10 evaluation volunteers from the primary group provided valid evaluation forms, which may be indicative of a higher degree of confidence in evaluating the proposed solution.

In order to provide a basis for discussing and generalizing the evaluation results, we asked the evaluators to consider the following contextual requests:

- Generalization request: in order to test for usability, we chose two specific naturalistic settings (i.e. a military setting and an academic IS/IT assessment exercise), thus using real users with real systems and real problems (practitioner or academic). For generalization purposes, the evaluation form (questionnaire) included the following introductory request: "When rating the following evaluation statements, the Evaluator is required to generalize his/her evaluation by generalizing in two dimensions: for a generic enterprise setting for COBIT 5 assessments; and for a generic COBIT 5 process, i.e. any of the 37 processes of the COBIT 5 Process Reference Model."
- Settings assumptions: for the purposes of evaluation, we asked the evaluators to assume that the enterprise had put in place a reasonable level of enabling capabilities for performing IS/IT Assessments, namely adequate capabilities regarding the governance system, policies, and management of human resources [3] [18].

6.3.2 Evaluation ratings

We asked the evaluators to rate the usefulness of the proposed solution, which was designed to help integrate the COBIT 5 Assessment rationale in Enterprise Architecture models, using ArchiMate as the visual modeling language.

Following the DSRM methodology, each generating and testing iteration should (re)define the solution's objectives and requirements, as well as the design and development of the IS artifacts [25] [26]. Therefore, we have evaluated the levels of agreement regarding two dimensions: agreement with the solution's objectives rationale (related to the research problem approach) and agreement with the

solution's usefulness claims. These two separate sets of ratings may thus provide feedback for different DSRM activities, in the context of future research iterations:

- Agreement with the solution's objectives rationale: provides feedback for the DSRM activity "Define Objectives of a Solution";
- Agreement with the solution's usefulness claims: provides feedback for the DSRM activity "Design & Development".

We used the same rating scale for all statement evaluations, with the following four agreement levels: "Strongly Disagree", "Disagree", "Agree", and "Strongly Agree".

Regarding the research problem approach (related to the solution's objectives rationale), we asked the evaluators to rate their agreement level with the following statements (see Figure 6-3):

- "Enterprise Architecture facilitates Assessments";
- "The Assessment criteria should be included in the architectural diagrams";
- "ArchiMate is useful for providing architectural diagrams".

After providing ratings for the statements above, the evaluators then provided ratings for the solution's usefulness claims, classified along the system dimensions and evaluation criteria presented in Table 6-2 [27].

Table 6-2: Evaluating the Solution's Usefulness.

System Dimension	Evaluation criteria /sub criteria	Statement (claim) regarding objectives / requirements
Environment	Consistency with organization /Utility; Fit with organization	The Solution is useful for facilitating architectural conversations between the Assessment stakeholders, enabling a shared understanding of the assessment rationale ("why") and providing a link for system implementation representations ("what"). Therefore, the Solution is useful to speed up the initial assessment activities (planning, data collection, and data validation).
Goal	Efficacy	The Solution is useful for facilitating architectural conversations between the Assessment stakeholders, enabling a shared understanding of the assessment rationale ("why") and providing a link for system implementation representations ("what"). Thus, it may be used to improve the effectiveness of the assessment, by speeding up the initial assessment activities (planning, data collection, and data validation) and thus providing more resources for the value-added assessment activities (performing the actual assessment, documenting exceptions and gaps, and communicating the assessment results and conclusions) .
Environment	Consistency with people /Utility; Understandability; Ease of use	The Solution is useful for providing an architectural representation of the Assessment rationale and providing a link to the system implementation. The graphical notation is easy to understand and the template is easy to use in practice.
Structure	Completeness [54]	The Solution is complete, meaning that it provides a template for representing all the key concepts required for process performance assessments: stakeholders, assessment result, process purpose, process outcomes, base practices, inputs, and outputs.
Structure	Homomorphism / Correspondence with another model [52] [53]	The Solution provides a model which conforms to the modeled assessment framework, presenting an adequate ontological mapping between the assessment concepts and the ArchiMate constructs.

6.3.3 Evaluation rating results

Overall, the primary group provided ratings dominated by the “Strongly Agree” level, whereas the secondary group ratings were dominated by “Agree” rating levels. The results obtained (see Figure 6-3 and Figure 6-4) are aligned with the author’s expectations, due to the way the demonstration and evaluation activities were designed and conducted:

- The primary group evaluators gave higher (than the secondary group) ratings regarding the solution’s usefulness evaluation criteria (see Fig. 4).
    - This result is consistent with the informal feedback exchanged during the discussions and interviews;
    - This result was somehow expected, due to the relatively higher EA maturity levels of the primary group members (see section VI.A Selecting the evaluators and validating the ratings);
    - This result is also consistent with the higher ratings given to the agreement with the research problem approach (see Fig.3).
- The secondary group’s results are overall high, in absolute terms (i.e. adding the “Agree” and “Strongly Agree” ratings).
    - However, not all evaluators in the secondary group agreed with the solution’s usefulness claims, which may be indicative of adoption issues that need to be addressed, especially if we want to target market segments with lower EA maturity.
    - It is interesting to note that the ArchiMate usefulness ratings (see Fig.3) were not very reassuring, for the secondary group. In a future DSRM iteration it would be interesting to further investigate this issue, which may impact adoption.

Note that we have performed an *ex-ante* evaluation, meaning that the relatively high ratings that were obtained should be interpreted with moderation, given that we demonstrated and evaluated a preliminary version of the artefact [55].

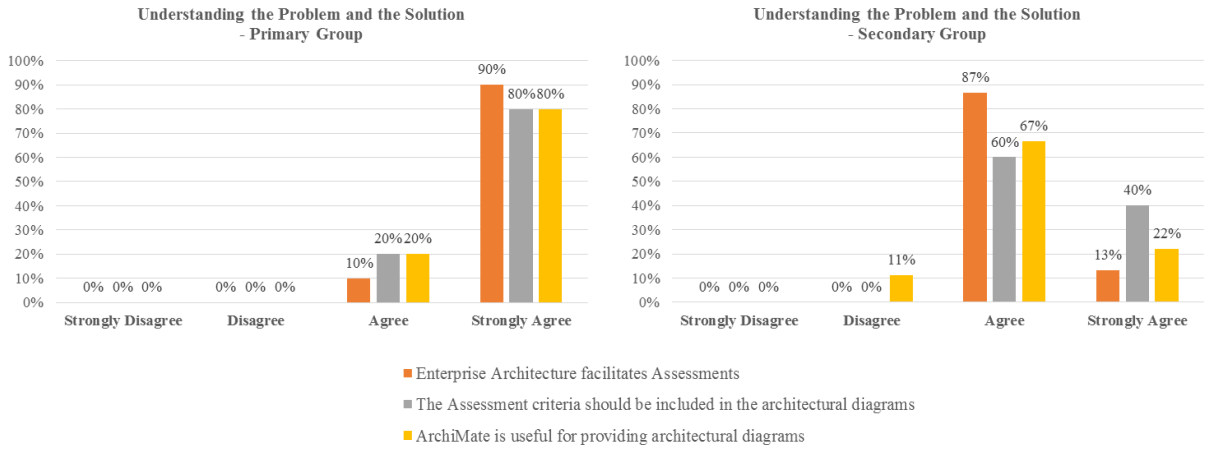


Figure 6-3: Ratings regarding the agreement level with the research problem approach.

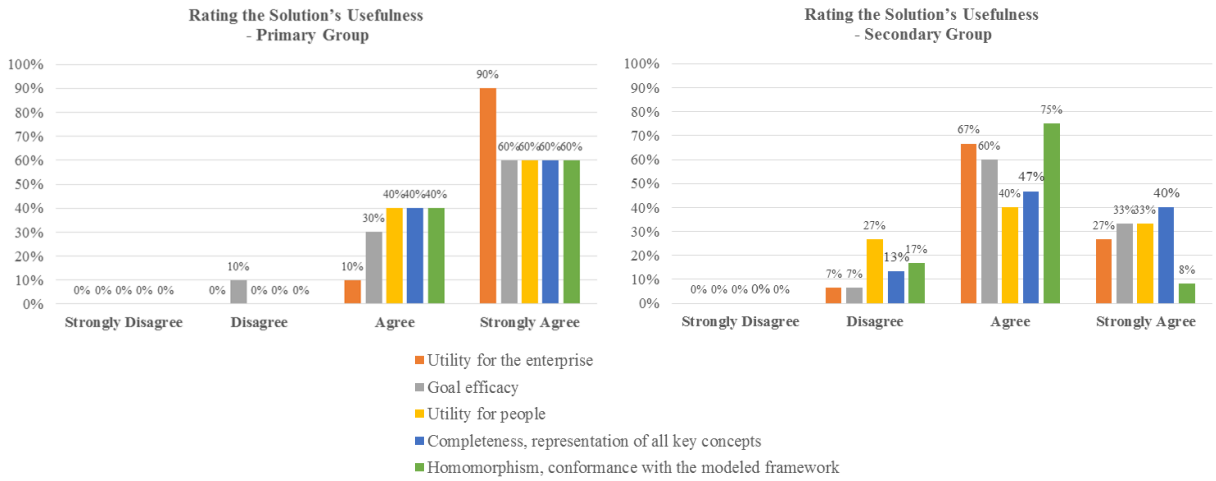


Figure 6-4: Ratings regarding the agreement level with solution's usefulness claims.

Finally, it is interesting to note that the set of ratings regarding the research problem approach (see Figure 6-3) are useful for providing valuable feedback for the next DSRM iteration (for discussing and redefining the solution's objectives), as well as to help explain the usefulness ratings differences that were observed between the primary group (higher EA maturity) and secondary group (lower EA maturity).

6.3.4 Lessons learned

We have identified potential adoption issues regarding the current ArchiMate version, which may be addressed in future work.

6.4 Communication

For the purposes of communication, a paper was submitted to the CBI 2015 conference, reporting on the second DSRM iteration. The paper was evaluated by three reviewers, one of which gave a low rating. The rationale of this reviewer – flawed, in our opinion - provided information regarding adoption barriers, thus providing feedback for the following DSRM iterations. The main objection of the negative review is analyzed in Table 6-3.

Table 6-3: CBI2015 conference review analysis.

Reviewer evaluation	**Analysis**	**Lessons learned**
«First, the idea of modelling COBIT using EA modelling languages is not a new one. This is according to the reviewer, who has sound experience with EA and IT Governance projects, usually done in enterprises that use COBIT and do EAM, especially when using dedicated EAM tools. To achieve this, tool vendors (e.g. BOC for ADOit) offer reference models that contain modelled COBIT content ready for use»	The reviewer recognizes that vendors offer COBIT related contents in their EA tools. However, the BOC tool is not based on a standards-based EA approach.	In future communications, stress the importance of standards-based solutions. In future communications, stress the importance of using a scientific approach like DSRM, for designing and validating solutions.
«The task of the architect is to create the integration between the COBIT and the EA models. The task of the auditor is to know COBIT and search for gaps. For this she/he does not need a model of COBIT content (especially the processes, roles/ responsibilities and indicators), but basically just the relations between goal indicators and customer processes»	The reviewer seems to assume that auditors are the main (or only) stakeholders in COBIT 5 process assessments, which contradicts the COBIT 5 framework. The reviewer seems to assume that a holistic view of the organization is not required for performing process assessments, which contradicts the COBIT 5 principles. The reviewer seems to assume that all the relevant assessment information is readily available for the auditors; and that EA artifacts are not useful for active synchronization between all the relevant stakeholders.	In future communications, stress the points: 1) Auditors are not the only stakeholders in COBIT 5 process assessments; 2) The importance of active synchronization tools, for fostering communication and reaching agreement regarding the organizational status; 3) Auditors are stakeholders of EA; 4) «The architecture vision describes how the new capability will meet enterprise goals and strategic objectives and address stakeholder concerns when implemented» [13].
«The assumption that without a completely modelled COBIT model an audit is harder, is not quite true according to my experience»	This assertion seems to contradict the previous assertions, where a case is made of commercial and operational value of EA artifacts which integrate the COBIT 5 rationale in the EA descriptions.	

6.5 Conclusion

In the second DSRM iteration we have evaluated both the research problem approach and the solution's usefulness claims, using a field study. For this purpose, we have used a naturalistic setting and an *ex-ante* demonstration and evaluation approach, thus complementing the theoretical validation provided by the first DSRM iteration.

Also, interesting feedback was collected from a reviewer who fundamentally opposed the problem and solution approaches that we have followed in the first two iterations. Indeed, one conference reviewer presented an interpretation of COBIT 5 process assessments that seems to contradict the COBIT 5 framework - especially the COBIT 5 holistic principle and the role of EA in assisting the implementation of this principle. This occurrence is indicative, we argue, of misunderstandings regarding the holistic approach of COBIT 5 – especially among scholars and practitioners who are used to working with earlier versions of COBIT. Therefore, in future communication efforts, we should stress the relevance and implications of the holistic rationale, as well as the importance of active synchronization tools, for fostering communication and reaching agreement regarding the organizational status. Also, we should stress the importance of standards-based solutions and of the use of a scientific approaches (like DSRM) to build them.

The evaluation ratings that were obtained in this iteration, regarding both the research problem approach and the solution's usefulness claims, were considered sufficiently reassuring to envisage broadening the scope for the following iterations.

7 Third DSRM Iteration

For the third DSRM iteration, the generating and testing scope was considerably changed:

- Field study: (diversified scope – a different public organization)
    - The field study was performed in the information systems department of a public organization with nationwide scope and reach.
- Design focus: (enlarged scope – all capability levels)
    - As for the previous iterations, focus on artifacts for assisting process assessments activities;
    - But now we will address all five process capability levels.
- Demonstration and evaluation: (ex-post and ex-ante setting, enlarged scope of four processes)
    - This organization had already performed a process assessment based on COBIT 5, so we were able to demonstrate and evaluate parts of the proposed solution using an ex-post setting.
    - We have prepared ex-post demonstration and evaluation artifacts up to the maximum capability level previously assessed in the organization – level 3. Therefore the artifacts related to the capability levels 4 and 5 were demonstrated and evaluated in an ex-ante setting. However, note that the capability levels 2 to 5 share, fundamentally, the same ontological structure, therefore allowing for ex-ante arguments to be made for the upper level (i.e. levels 4 and 5) based on the experimental outcomes for the lower levels (i.e. levels 2 and 3).
    - We have demonstrated the proposed solution using four COBIT 5 processes, selected by a goals cascade exercise.
- Evaluation criteria: (same as for the second iteration)
    - We have kept the same evaluation approach that was used in the second iteration, therefore allowing for a comparison between the second and third iterations' experimental outcomes.

7.1 Solution Proposal

For the third iteration, besides extending the scope to encompass all five capability levels, the capability level 1 viewpoints (i.e. for process performance assessments) were refined based on the feedback collected from the previous iterations:

- IT-related goals were removed from the process performance viewpoint (see Appendix Figure 2) and the IT goals and base practices cascade were detailed in a new viewpoint (see Appendix Figure 7);
- Work products and activities were modelled using ArchiMate concepts from the motivation extension, in order to allow for a more explicit representation of the entities and relations that

represent capability evidence, capability motivations, and their corresponding relations (see Appendix Figure 4, Appendix Figure 10, Appendix Figure 11, Appendix Figure 12, and Appendix Figure 13);

- A separate viewpoint was introduced, representing base practices, activities, and detailed activities (see Appendix Figure 11);
- The importance of stakeholder's need and responsibilities was stressed (see Section 6.5), by introducing a new viewpoint (see Appendix Figure 9) which relates stakeholder concepts and the associated goals and requirements cascade.

7.2 Demonstration

For demonstration purposes, we performed interactive modelling sessions with the process owners of four COBIT 5 processes. This approach enabled the process owners (who later performed the evaluations) to become acquainted with concrete ArchiMate modelling tools and techniques, as well as the activities and costs involved in creating and maintaining EA capabilities for managing COBIT 5 process assessments. In order to avoid presenting redundant information, only artifacts related to one of the processes are shown in the appendixes (see Appendix C: Third DSRM Iteration – Viewpoints).

This ex-post approach was also made possible by the fact the process owners had previously been engaged in COBIT 5 process assessments. These assessments had been assisted with the help of several architectural representations, both ArchiMate and non-ArchiMate based. This means that the evaluators were able to draw conclusions based on their previous assessment and modelling experiences.

7.3 Evaluation

For the third iteration, we have used the same approach and evaluation criteria as for the second iteration, which allows for comparison between the two sets of evaluation ratings:

- Overall, the two sets of results are not too dissimilar, even though the demonstration and evaluation scope was broadened for the third iteration;
- However, the following differences can be observed:
    - Research problem approach ratings (see Figure 7-1): the civil (third iteration) setting shows higher agreement levels concerning the assumptions "EA is useful" and "The assessment criteria should be included in the diagrams". However these evaluators provided lower agreement ratings concerning the usefulness of the modelling language (ArchiMate).
    - Solution usefulness ratings (see Figure 7-2): the civil (third iteration) setting shows higher agreement levels concerning the "goal efficacy" and the "utility for people". However the structural quality ratings (i.e. "completeness" and "homomorphism") were lower in his third iteration – which is consistent with the lower observed ArchiMate usefulness related ratings.

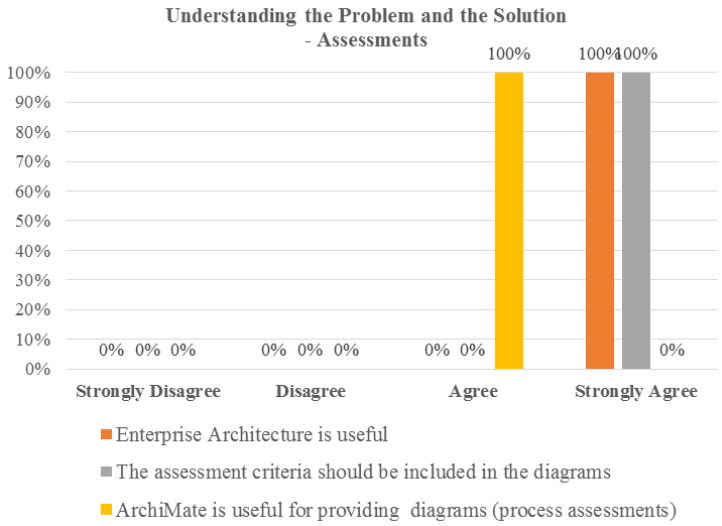


Figure 7-1: Ratings regarding the agreement level with the research problem approach.

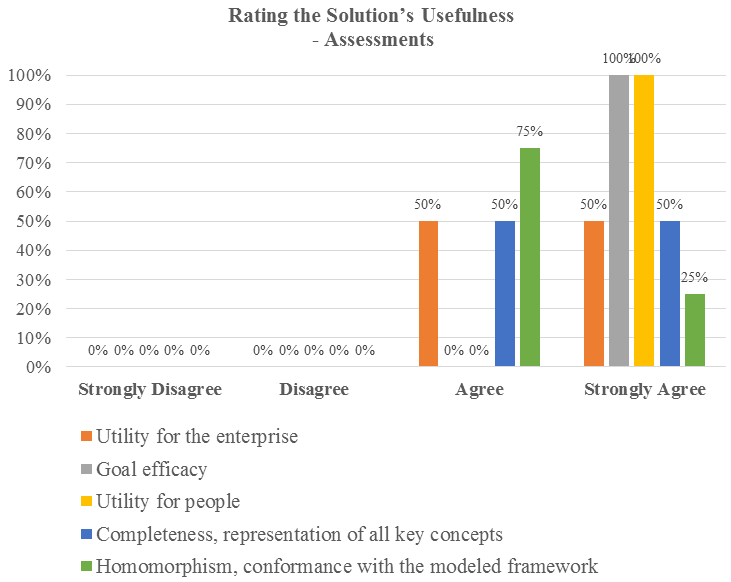


Figure 7-2: Ratings regarding the agreement level with solution's usefulness claims.

7.4 Communication

The outcomes from both the second and third iterations provide material for a scientific paper on using EA for assisting COBIT 5 process assessment activities. Therefore a paper on this subject is being

prepared for submission to the CAiSE conference (http://caise2016.si/, the paper submission deadline is the 30th November 2015).

7.5 Conclusion

In this DSRM iteration we observed maximum evaluation ratings regarding “goal efficacy” and “utility for the people” (i.e. providing architectural representations which are easy to understand and easy to use). Therefore we feel comfortable in broadening the work scope for the next DSRM iteration.

However, the ratings related to the usefulness of the ArchiMate language and the structural quality of the artifacts were not as high. This fact may be indicative that the ArchiMate modelling language may be improved. These results are consistent with known criticism regarding the current language expressiveness shortcomings - e.g. regarding modelling the capacity concept [51] [31].

8 Fourth DSRM Iteration

For the fourth DSRM iteration, the generating and testing work focused on addressing COBIT 5 process improvement activities:

- Field study:
  - The field study was performed in the same setting (i.e. organization and stakeholders) as the third iteration, allowing for direct comparison between the two sets of ratings.
- Design focus:
  - Complementing the process assessment solution proposal, we now addressed process improvement EA needs and requirements.
  - An additional solution requirement was defined for the design: links should be provided between the process assessment descriptions and the process improvement descriptions, in order to leverage synergies between all related activities.
  - As in the previous iteration, all five process capability levels were addressed.
- Demonstration and evaluation:
  - The demonstration for this iteration was performed after performing the third iteration demonstration. However, we used a single evaluation form for recording the ratings of both the third and fourth iterations, in order to allow a more meaningful comparison between the two sets of ratings.
- Evaluation criteria: (same as for the second iteration)
  - We have kept the same evaluation approach that was used in the second and third iterations, therefore allowing for a direct comparison between the second, third, and fourth iterations' experimental outcomes.

8.1 Solution Proposal

COBIT 5 provides guidance on how to implement GEIT initiatives [7], based on a continual improvement life cycle is tailored to suit the enterprise's specific needs.

According to COBIT 5 best practice, improvement initiatives should be driven using a programme and project approach, up to the point when the acquired capacity has become embedded in the ongoing business activity [7].

Therefore our solution proposal seeks to address the fundamental concepts which are involved in such an improvement approach.

In this work we will focus on process improvement initiatives. Note, however, that the focus on improving enabling processes does not contradict the COBIT 5 holistic principle; indeed, the COBIT 5 body of knowledge provides links between all enablers. Therefore, GEIT initiatives may use process improvement initiatives as a convenient entry point for enhancing all GEIT enablers.

8.1.1 ArchiMate Constructs

In order to model the programme and project concepts, we may use constructs from the ArchiMate Implementation and Migration Extension [31].

Note that we have not used these constructs in any of the previous three DSRM iterations, which were focused on EA solutions for performing process assessments. This does not mean that we could not have modelled the rationale of specific assessment projects with these constructs; it just means that the improvement rationale is intrinsically related to the concept of change (i.e. a dynamic perspective), whereas the assessment rationale concerns getting a snapshot of the status quo, in a specific point in time (i.e. a static perspective).

8.1.2 Integrating the Assessment and Improvement Perspectives

One of the objectives for the design of the solution is to enable the integration of the process assessment and process improvement perspectives. In order to address this objective, the solution that we have designed and developed in this iteration is based on the COBIT 5 implementation guidelines (see Figure 8-1).

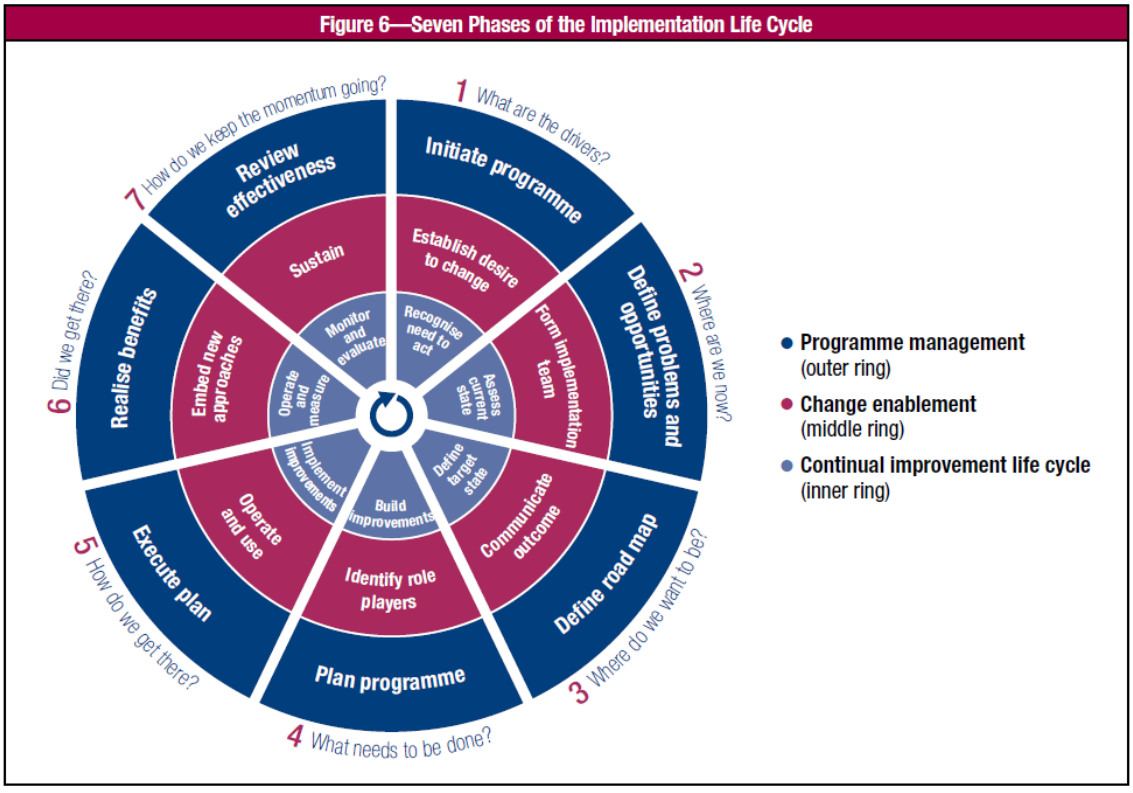


Figure 8-1: The Implementation Life Cycle, taken from “COBIT 5 Implementation” [7]

Indeed, in Phase 2 of the Implementation Life Cycle we are concerned with assessing the current state. This approach has inspired the idea of including an assessment construct in the improvement viewpoints, thereby providing a COBIT 5 perspective of the relation between assessments and improvements, which the EA descriptions may help enforce.

8.1.3 Modelling Capability and Capability Improvement

A severe hindrance had to be removed in order to proceed with the solution design: the current ArchiMate standard does not provide a construct - nor related recommendations – for modelling the "capability" concept, which is central to process assessment and process improvement according to COBIT 5.

Indeed, the ArchiMate standard explicitly recognizes this shortcoming, proposing this concept for inclusion in a future version of the language [31].

This problem is also discussed in the book "Mastering ArchiMate", by Gerben Wierda.

We have solved this modelling problem by first defining the following objectives and requirements:

1. Objective: Design a future proof solution. This objective relates to the following requirement:
    1.1. Do not map the capability concept directly to an ArchiMate construct (as a future version of the language may introduce this construct). Instead, represent relevant aspects related to the COBIT 5 capability concept, which may later be linked to a future capability-specific construct;
2. Objective: Represent concepts which may be associated with all relevant aspects of the COBIT 5 Implementation Life Cycle phases. This objective relates to the following requirements:
    2.1. Provide representations that may be mapped to the phase "What are the drivers?"
    2.2. Provide representations that may be mapped to the phase "Where are we now?"
    2.3. Provide representations that may be mapped to the phase "Where do we want to be?"
    2.4. Provide representations that may be mapped to the phase "What needs to be done?"
    2.5. Provide representations that may be mapped to the phase "How do we get there?"
    2.6. Provide representations that may be mapped to the phase "Did we get there?"
    2.7. Provide representations that may be mapped to the phase "How do we keep the momentum going?"
3. Objective: Promote the business-IT alignment rationale. This objective relates to the following requirement:
    3.1. Provide representations that relate the motivational aspects with the implementation aspects.

Note that the COBIT 5 PAM [30] defines five capability levels. However, note that from a COBIT 5 improvement perspective there is nothing that recommends against modelling the capability improvement initiatives from any one level to the next one using similar conceptual structures. This structural similarity enables us to split the problem into smaller problems that share a similar structure:

we therefore chose to model the improvement initiative from level N to level N+1 in a consistent manner, for N={1,2,3,4}.

The resulting process improvement structure is represented in Figure 8-2, instantiated for Level 0 to Level 1, and for process APO12 Manage Risk.

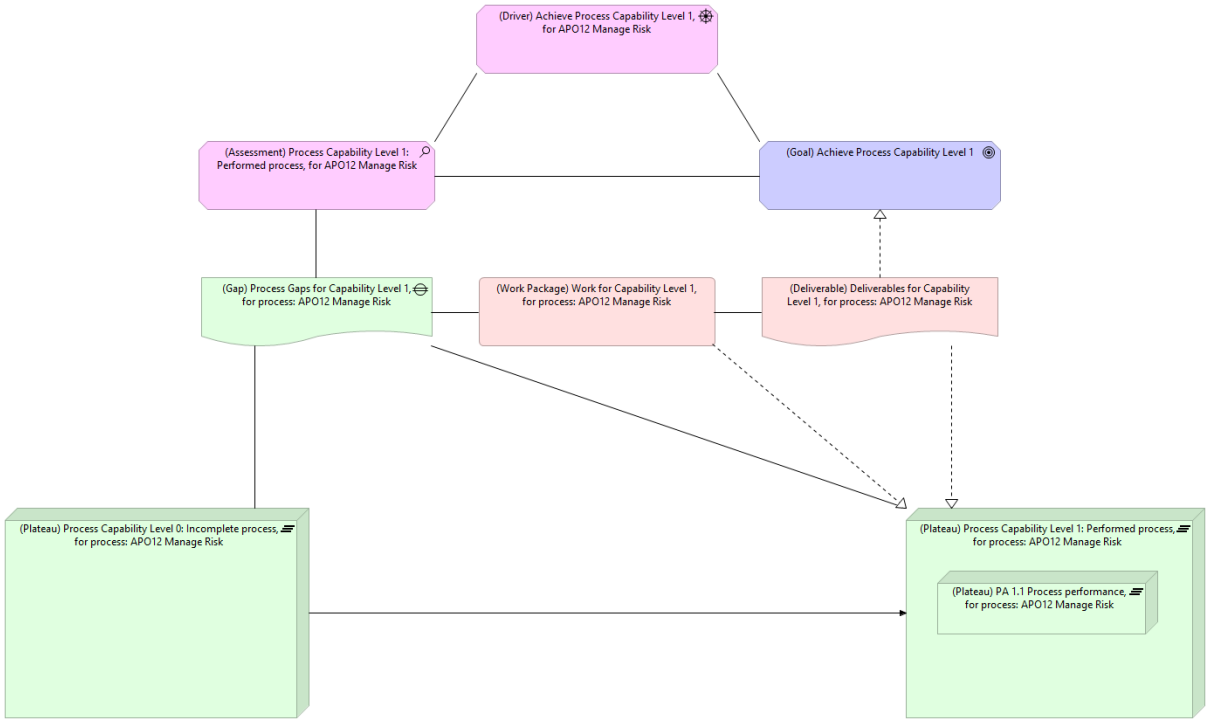


Figure 8-2: Process improvement structure, instantiated for Level 0 to Level 1, and for process APO12 Manage Risk.

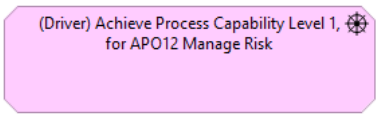
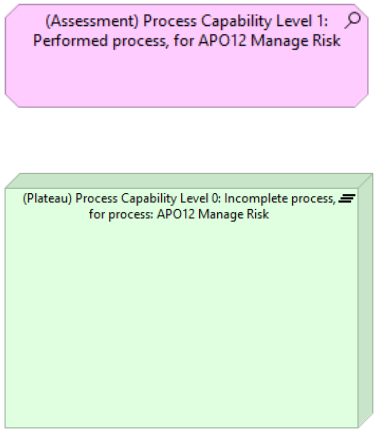
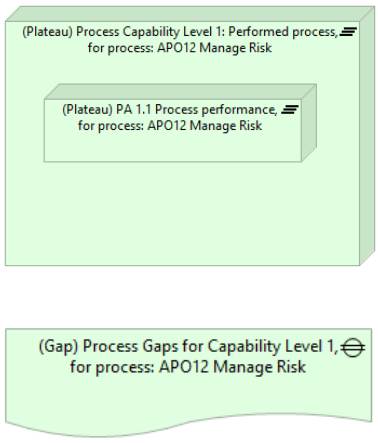
Note that this structure meets the first design objective, by providing representations for capability concept aspects, using all the available ArchiMate constructs from the Implementation and Migration Extension; by using all such constructs we intended on maximizing the expressiveness of the descriptions, thus allowing for more accurate conceptual mappings.

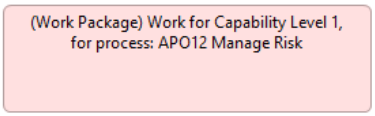
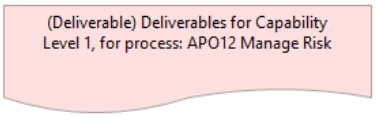
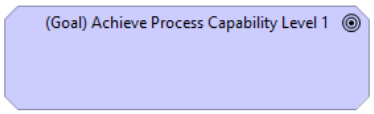
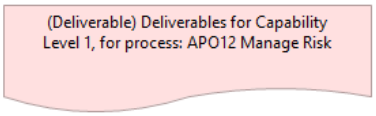
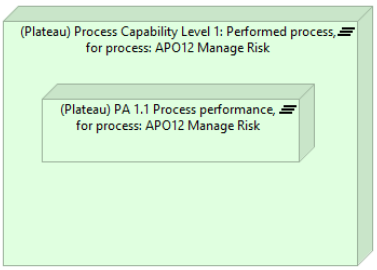
Note also that the third design objective was met: the motivational aspects are represented as:

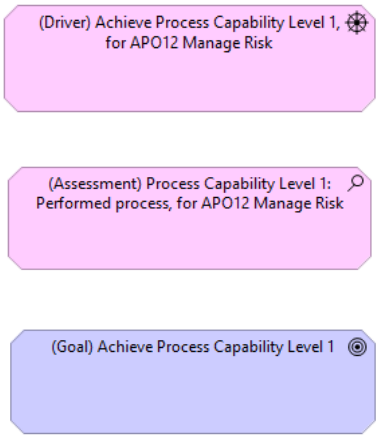
- The process improvement driver, i.e. achieving a certain process capability level;
- The process improvement goal, which is realized by the improvement initiative deliverables.
- The process assessment outcomes, which relate to the gap analysis, and to the previously described motivational aspects of the process improvement initiative (i.e. the improvement driver and the improvement goal); note that this element provides a bridge between the process assessment rationale and the process improvement rationale.

In order to meet the second objective, Table 8-1 provides a proposal for a conceptual mapping between the COBIT 5 Implementation Life Cycle phases and the EA artifacts.

Table 8-1: Conceptual mapping between the COBIT 5 Implementation Life Cycle phases and the EA artifacts.

COBIT 5 Implementation Life Cycle phases	**EA artifact** **(NOTE: instantiated for Level 0 to Level 1, and for process APO12 Manage Risk)**	**Notes and guidelines for practical usage**
What are the drivers?		• Continual improvement phase: recognize the need to act [7]. • This driver element may be linked to the concept of Stakeholder Drivers (see Appendix Figure). • A change driver is an internal or external event, condition or key issue that serves as a stimulus for change [7].
Where are we now?		• Continual improvement phase: assess current state [7]. • Management needs to know its current capability and where deficiencies may exist. This is achieved by a process capability assessment of the as-is status of the selected processes. [7] • Note that the assessment element provides a bridge between the process assessment rationale and the process improvement rationale.
Where do we want to be?		• Continual improvement phase: define target state. [7] • This phase sets a target for improvement followed by a gap analysis to identify potential solutions. [7]

What needs to be done?		• Continual improvement phase:: build improvements. [7] • This phase plans feasible and practical solutions by defining projects supported by justifiable business cases and developing a change plan for implementation.
How do we get there?		• Continual improvement phase: implement improvements. [7] • This phase provides for the implementation of the proposed solutions into day-to-day practices and the establishment of measures and monitoring systems to ensure that business alignment is achieved and performance can be measured. [7].
Did we get there?	  	• Continual improvement phase: operate and measure [7]. • This phase focuses on sustainable transition of the improved governance and management practices into normal business operations and monitoring achievement of the improvements using the performance metrics and expected benefits. [7]

How do we keep the momentum going?		• Continual improvement phase: monitor and evaluate [7]. • All motivational elements are relevant in order to describe and demonstrate the will to sustain the change. • This phase reviews the overall success of the initiative, identifies further governance or management requirements and reinforces the need for continual improvement. It also prioritizes further opportunities to improve GEIT. [7]

8.2 Demonstration

For demonstration and evaluation purposes, we used the artifacts presented in *Appendix D: Fourth DSRM Iteration – Viewpoints*. The artifacts were instantiated for one of the COBIT 5 processes that had been previously assessed, namely the *APO12 Manage Risk* process.

Note that the ArchiMate assessment constructs are shared by both the process assessment and the process improvement viewpoints, thereby linking the assessment rationale with the improvement rationale (confront e.g. Appendix Figure 10Appendix Figure with Appendix Figure 23).

8.3 Evaluation

For the fourth iteration, we have used the same approach and evaluation criteria as for the third iteration, which allows for direct comparison between the ratings regarding process assessment (third iteration) and those regarding process improvement (fourth iteration):

- Each and every rating obtained for the process improvement solution is either equal of higher that the corresponding rating obtained for the process assessment solution;
- Higher ratings were obtained for the following evaluation ratings, for the process improvement solution:
    - Research problem approach ratings (see Figure 7-1 and Figure 8-3):
        - “ArchiMate is useful for providing diagrams”;
    - Solution usefulness ratings (see Figure 7-2 and Figure 8-4):
        - “Utility for the enterprise”.

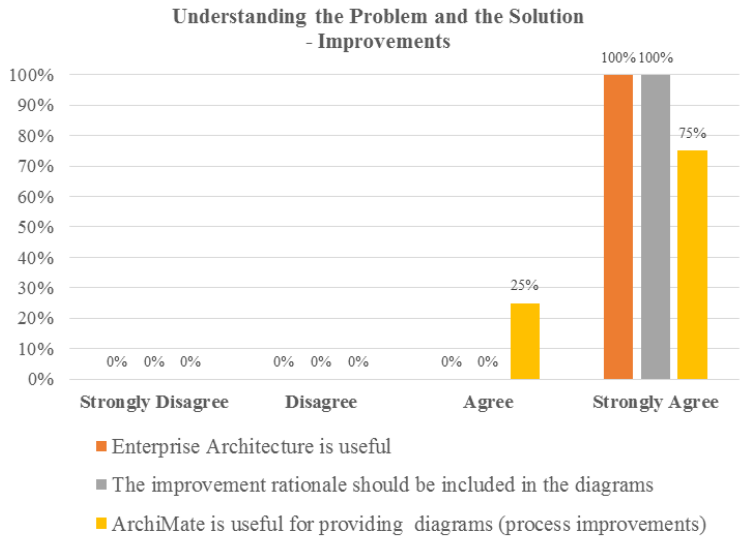


Figure 8-3: Ratings regarding the agreement level with the research problem approach.

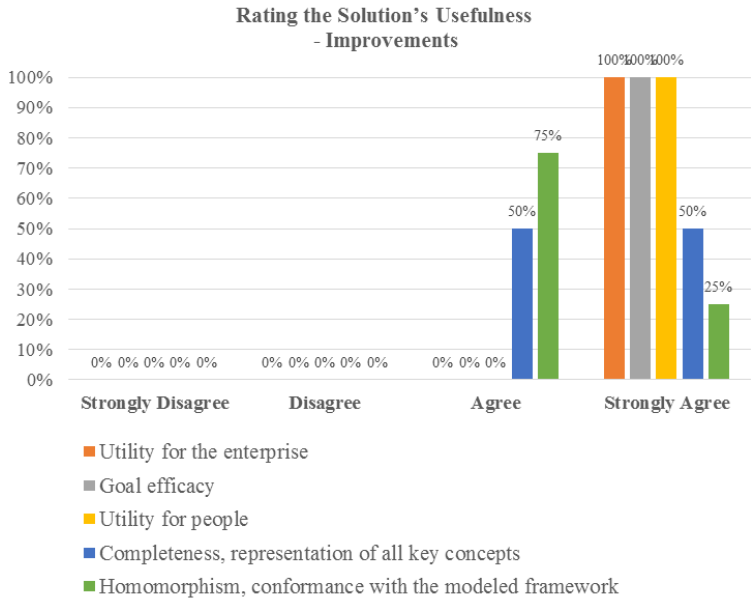


Figure 8-4: Ratings regarding the agreement level with solution's usefulness claims.

8.4 Communication

The outcomes from the fourth iteration provide material for a scientific paper on using EA for assisting COBIT 5 process improvement activities. Therefore a paper on this subject is being prepared for

submission to the ECIS conference (http://www.ecis2016.eu, the paper submission deadline is the 27th November 2015).

8.5 Conclusion

In the fourth (and last) DSRM iteration we observed high evaluation ratings regarding the solution's usefulness, regarding both efficacy (i.e. goal efficacy) and utility (i.e. people and enterprise) measures.

However, these ratings contrast with the relatively lower ratings regarding the expressiveness of the modelling artifacts based on the ArchiMate language. The same conclusion can be drawn when considering the field study ratings as a full set, i.e. when considering the second, third, and fourth iterations as a whole.

9 Conclusion

In this work we have designed and validated an integrated EA solution for assisting COBIT 5 process assessments and process improvement initiatives.

We have applied the DSRM methodology, which enables an agile approach to the generating and testing activities, thus allowing for the incorporation of frequent feedback during the design process. This feedback was instrumental for improving the solution design in an incremental and controlled manner, as well as for identifying and overcoming adoption barriers.

By providing a link between the process assessment and process improvement artifacts, the solution enables integration between several architectural aspects:

- The enterprise motivational aspects, modelled with constructs taken from the ArchiMate Motivation Extension;
- The assessment aspects, modelled with the use of constructs taken from the ArchiMate Motivation Extension, as well as core ArchiMate concepts;
- The improvement aspects, modelled with the use of constructs taken from both the ArchiMate Implementation and Migration Extension and the ArchiMate Motivation Extension, as well as core ArchiMate concepts;
- The ArchiMate framework core concepts, belonging to the business, application, and technology layers.

This means that the enterprise may adopt a single consolidated EA database that integrates the core layers with both the COBIT 5 PAM [30] rationale and the COBIT 5 GEIT process improvement [7] rationale.

This integration feature may be leveraged to enable synergies and to avoid duplication of work, regarding the creation and maintenance of EA capabilities for GEIT - which use process assessment and improvement activities - purposes.

9.1 Research Communication

This work enabled a total of five research communication opportunities, whose outcomes, feedback (i.e. internal) value, and communication (i.e. external) value are summarized in the following list of research communication contributions:

- First DSRM iteration:
    - Outcome: an interim dissertation report was produced, presented, discussed, and evaluated at Instituto Superior Técnico, in a public session, as part of the formal evaluation process for the “Master Project in Information and Software Engineering” course.

- Design feedback value: as a consequence of the feedback received, the work scope was more directed towards applied research, focused on real-world field studies. Also, the sought contributions - to the practice and to the knowledge base - were biased towards enabling adoption success and overcoming adoption barriers.
- Communication value: the report which was produced has since been requested for helping inform other master thesis works performed at Instituto Superior Técnico.

- Second DSRM iteration:
  - Outcome: a paper was submitted to the CBI 2015 conference, reporting on the second DSRM iteration.
  - Design feedback value: the paper was evaluated by three reviewers, one of which gave a low rating. The rationale of this reviewer – flawed, in our opinion – provided valuable information regarding adoption barriers, thus providing feedback for the following DSRM iterations.
  - Communication value: due to the low rating which was provided by one of the three reviewers, the communication efficacy of this second iteration was hindered.
- Third DSRM iteration:
  - Expected outcome: the second and third iterations provide material for a scientific paper on using EA for assisting COBIT 5 process assessment activities. Therefore a paper on this subject is being prepared for submission to the CAiSE conference (http://caise2016.si/, the paper submission deadline is the 30th November 2015).
  - Expected design feedback value and communication value: we expect that the reviewer comments and ratings will provide feedback for future work. We also expect to promote adoption of EA solutions for COBIT 5 process assessment initiatives - besides providing a concrete solution for the stated purpose.
- Fourth DSRM iteration:
  - Expected outcome: the fourth iteration provides material for a scientific paper on using EA for assisting COBIT 5 process improvement activities. Therefore a paper on this subject is being prepared for submission to the ECIS conference (http://www.ecis2016.eu , the paper submission deadline is the 27th November 2015).
  - Expected design feedback value and communication value: we expect that the reviewer comments and ratings will provide feedback for future work. We also expect to promote adoption of EA solutions for COBIT 5 process improvement initiatives - besides providing a concrete solution for the stated purpose.
- Final dissertation report:
  - Outcome: this dissertation report.
  - Expected design feedback value: we expect that the dissertation examination committee will provide valuable feedback for informing future work, namely the PhD thesis work which the author in currently engaged in – and which relates also to EA research problems and solutions.

- Expected communication value: as was the case for the interim report produced at the end of the first DSRM iteration, we hope that this dissertation report will help inform other thesis works, namely the PhD thesis work which the author in currently engaged in – and which relates also to EA research problems and solutions.

9.2 Contributions

In this section we summarize the dissertation contributions to the practice and to the knowledge base.

The final contributions are to be understood as the outcomes of the third and fourth DSRM iterations, respectively for the purposes of process assessment initiatives and process performance initiatives. All the other outcomes presented in this work are to be taken as interim contributions.

We will start by first defining the reasonable generalization scope, which stems from the reach and limitations of the field studies that were performed, as well as the evidence which was presented in the work:

- Field study scope:
  - We have performed three field studies in two large (Portuguese-scale) public sector organizations. However, note that these organizations are different in their nature: one is military and the other is non-military (civil).
  - Therefore we may make an argument regarding the likely applicability of the proposed solution for other large public sector organizations.
- Goal efficacy scope:
  - We have formally evaluated the goal efficacy using the assertions:
    - Process assessment initiatives: «the Solution is useful for improving the effectiveness of Process Assessment initiatives»;
    - Process Improvement initiatives: «the Solution is useful for improving the effectiveness of Process Improvement initiatives».
  - The context of these assertions is limited to COBIT 5 GEIT initiatives.
- Agreement with the solution approach:
  - The evaluators provided a high level of agreement regarding the assumptions:
    - EA is useful for process assessment initiatives;
    - EA is useful for process improvement initiatives.
  - Furthermore, in the second DSRM iteration we found a counter-example instance, where a reviewer fundamentally opposed the thesis assumptions.
  - Therefore, based on the evidence that was presented, we cannot recommend generalizing the solution for settings where key stakeholders fundamentally oppose the thesis claims, i.e. that using EA solutions may assist in performing process assessment or process improvement initiatives using COBIT 5.

It is important to clarify that this work is not focused on finding optimal solutions for detailed analysis (such as dependency analysis) and other specific lower-level engineering optimization efforts. Instead, it seeks to provide standards-based EA instruments, primarily for stakeholder-to-stakeholder (i.e. meaning human) communication, which may serve as a basis for improving self-awareness and interactive synchronization efforts, for the benefit of GEIT stakeholders engaged in the typical auditing and consulting activities. Nevertheless, the high-level views and viewpoints which we propose may serve a basis for providing architectural representations on top of which such detailed work may be designed and performed.

Minding the above caveats, we may now describe the main contributions presented in this dissertation.

9.2.1 Contributions to COBIT 5 and EA practice

This thesis work provided the following contributions to the COBIT 5 and EA practice:

- A set of EA viewpoints, for use in COBIT 5 process assessment and process improvement initiatives, with the following characteristics:
    - Their efficacy was validated in two large public sector organizations;
    - Their constructs are based on ArchiMate (version 2.1);
    - May be integrated with other ArchiMate architectural descriptions that use standard ArchiMate constructs;
    - Were developed using a DSRM process model, DSRM-related evaluation techniques, and taking into account objectives and requirements derived from COBIT 5 and TOGAF best practice.

These viewpoint are presented in the appendixes “Appendix C: Third DSRM Iteration – Viewpoints” and “Appendix D: Fourth DSRM Iteration – Viewpoints”.

9.2.2 Contributions to the COBIT 5 and EA knowledge base

This thesis work provided the following contributions to the COBIT 5 and EA knowledge base:

- New knowledge:
    - The formal evaluation ratings provide new sources of knowledge, which confirm that organizations indeed appreciate the value of EA in enabling GEIT using COBIT 5.
    - However, we found one occurrence of strong opposition, concerning the usefulness claims of EA for assisting COBIT 5 process assessments. Although we believe that the stated argument is flawed, this occurrence may be indicative that works needs to be done regarding promotion of the COBIT 5 holistic principle and engagement of auditors in EA activities.
    - The evaluation ratings regarding the usefulness of the ArchiMate (version 2.1) constructs were consistently lower than the usefulness ratings regarding the viewpoints which were based on these same constructs. This fact may be indicative

that there is room for improvement regarding the expressiveness of the ArchiMate language.

- Dissemination of knowledge:
    - The demonstrations and group sessions enabled the dissemination of COBIT 5 knowledge and EA knowledge in two large public sector organizations.
    - This dissemination of knowledge is relevant for the following reasons:
        - These organizations are currently building their initial capabilities, both in terms of COBIT 5 and of EA;
        - The high evaluation ratings obtained in this work may encourage other similar organization to adopt the COBIT 5 framework for GEIT, as well as improving EA capabilities and adopting EA solutions.

Finally, this thesis work also enabled five research communication opportunities, as described in Section 9.1.

9.3 Future Work

Based on the outcomes of this work, we may point to the following opportunities for related future work:

- Conduct further DSRM work, integrating more aspects of the COBIT 5 framework, as well as related guidance (e.g. ITIL and ISO 27000);
- Extend the scope and/or depth of the thesis work, e.g. by:
    - Demonstrating and evaluating the proposed (or an enhanced) EA solution in more public sector organizations;
    - Demonstrating and evaluating the proposed (or an enhanced) EA solution in private sector organizations, eventually comparing the results with those obtained in the public sector domain;
    - Demonstrating and evaluating the proposed (or an enhanced) EA solution in small or medium size organizations, eventually comparing the results with those obtained in larger organizations.
- Understand the shortcomings of the current ArchiMate version, regarding its expressiveness for use in GEIT use cases, and provide recommendations for a future version of the standard.

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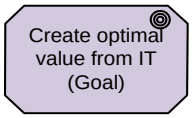
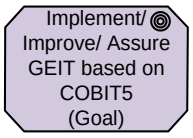
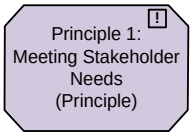
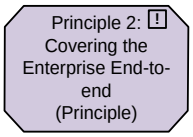
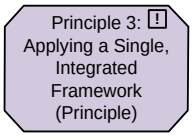
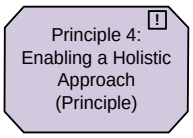
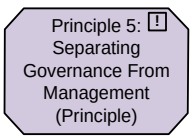
Appendixes

Appendix A: First DSRM Iteration - Constructs Mapping

Appendix Table 1: The COBIT 5 framework end goals.

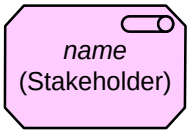
COBIT®5 concept	**COBIT®5 concept description**	**ArchiMate concept description**	**ArchiMate notation**
The Governance Objective: Value Creation Create optimal value from IT	Enterprises exist to create value for their stakeholders. Consequently, any enterprise—commercial or not—will have value creation as a governance objective.	A goal is defined as an end state that a stakeholder intends to achieve.	
Implement/ Improve/ Assure GEIT based on COBIT®5 adoption	COBIT®5 framework goal: to help create optimal value from IT. COBIT 5 provides a comprehensive framework that assists enterprises in achieving their objectives for the governance and management of enterprise IT. The goals cascade is important because it allows the definition of priorities for implementation, improvement and assurance of governance of enterprise IT based on (strategic) objectives of the enterprise and the related risk.	A goal is defined as an end state that a stakeholder intends to achieve.	
Principle 1: Meeting Stakeholder Needs	The COBIT 5 framework is built on five basic principles. Principle 1: Meeting Stakeholder Needs—Enterprises exist to create value for their stakeholders by maintaining a balance between the realisation of	A principle is defined as a normative property of all systems in a given context, or the way in	

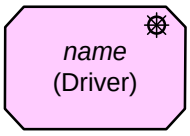
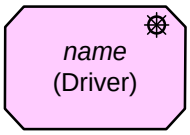
	benefits and the optimisation of risk and use of resources. COBIT 5 provides all of the required processes and other enablers to support business value creation through the use of IT. Because every enterprise has different objectives, an enterprise can customise COBIT 5 to suit its own context through the goals cascade, translating high-level enterprise goals into manageable, specific, IT-related goals and mapping these to specific processes and practices.	which they are realized.	
Principle 2: Covering the Enterprise End-to-end	The COBIT 5 framework is built on five basic principles. Principle 2: Covering the Enterprise End-to-end—COBIT 5 integrates governance of enterprise IT into enterprise governance: – It covers all functions and processes within the enterprise; COBIT 5 does not focus only on the 'IT function', but treats information and related technologies as assets that need to be dealt with just like any other asset by everyone in the enterprise. – It considers all IT-related governance and management enablers to be enterprisewide and end-to-end, i.e., inclusive of everything and everyone—internal and external—that is relevant to governance and management of enterprise information and related IT.	A principle is defined as a normative property of all systems in a given context, or the way in which they are realized.	
Principle 3: Applying a Single, Integrated	The COBIT 5 framework is built on five basic principles. Principle 3: Applying a Single, Integrated Framework—There are many IT-related	A principle is defined as a normative property of all systems in a	

Framework	standards and best practices, each providing guidance on a subset of IT activities. COBIT 5 aligns with other relevant standards and frameworks at a high level, and thus can serve as the overarching framework for governance and management of enterprise IT.	given context, or the way in which they are realized.	
Principle 4: Enabling a Holistic Approach	The COBIT 5 framework is built on five basic principles. Principle 4: Enabling a Holistic Approach—Efficient and effective governance and management of enterprise IT require a holistic approach, taking into account several interacting components. COBIT 5 defines a set of enablers to support the implementation of a comprehensive governance and management system for enterprise IT. Enablers are broadly defined as anything that can help to achieve the objectives of the enterprise. The COBIT 5 framework defines seven categories of enablers: – Principles, Policies and Frameworks – Processes – Organisational Structures – Culture, Ethics and Behaviour – Information – Services, Infrastructure and Applications – People, Skills and Competencies	A principle is defined as a normative property of all systems in a given context, or the way in which they are realized.	
Principle 5: Separating Governance From	The COBIT 5 framework is built on five basic principles. Principle 5: Separating Governance From Management—The COBIT 5 framework	A principle is defined as a normative property of all systems in a	

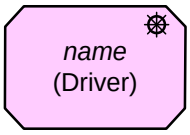
Management	makes a clear distinction between governance and management. These two disciplines encompass different types of activities, require different organisational structures and serve different purposes. COBIT 5's view on this key distinction between governance and management is: – Governance: ensures that stakeholder needs, conditions and options are evaluated to determine balanced, agreed-on enterprise objectives to be achieved; setting direction through prioritisation and decision making; and monitoring performance and compliance against agreed-on direction and objectives. In most enterprises, overall governance is the responsibility of the board of directors under the leadership of the chairperson. Specific governance responsibilities may be delegated to special organisational structures at an appropriate level, particularly in larger, complex enterprises. – Management: Management plans, builds, runs and monitors activities in alignment with the direction set by the governance body to achieve the enterprise objectives. In most enterprises, management is the responsibility of the executive management under the leadership of the chief executive officer (CEO).	given context, or the way in which they are realized.	

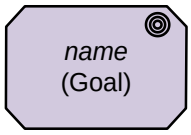
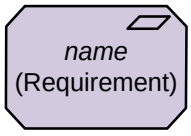
Appendix Table 2: The COBIT 5 Goals Cascade.

COBIT®5 concept	**COBIT®5 concept description**	**ArchiMate concept description**	**ArchiMate notation**
Stakeholder	Appendix H -Glossary Stakeholder: Anyone who has a responsibility for, an expectation from or some other interest in the enterprise — e.g., shareholders, users, government, suppliers, customers and the public. Internal Stakeholders: • Board • Chief executive officer (CEO) • Chief financial officer (CFO) • Chief information officer (CIO) • Chief risk officer (CRO) • Business executives • Business process owners • Business managers • Risk managers • Security managers • Service managers • Human resource (HR) managers • Internal audit • Privacy officers • IT users	A stakeholder is defined as the role of an individual, team or organization (or classes thereof) that represents their interests in, or concerns relative to, the outcome of the architecture.	

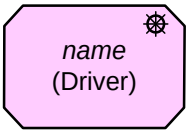
	• IT managers • Etc. External Stakeholders: • Business partners • Suppliers • Shareholders • Regulators/government • External users • Customers • Standardisation organisations • External auditors • Consultants • Etc.		
Stakeholder driver	Stakeholder needs are influenced by a number of drivers, e.g., strategy changes, a changing business and regulatory environment, and new technologies.	A driver is defined as something that creates, motivates, and fuels the change in an organization.	
Stakeholder needs	Stakeholder needs drive the governance objective of value creation: • Benefits Realization • Risk optimisation • Resource Optimisation Enterprises have many stakeholders, and 'creating value' means different—and sometimes conflicting—things to each of them. Governance is about negotiating and deciding amongst	A driver is defined as something that creates, motivates, and fuels the change in an organization.	

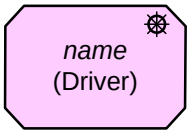
	different stakeholders' value interests. By consequence, the governance system should consider all stakeholders when making benefit, risk and resource assessment decisions. For each decision, the following questions can and should be asked: For whom are the benefits? Who bears the risk? What resources are required?		
Governance objective of value creation	Stakeholder needs drive the governance objective of value creation: • Benefits Realization • Risk optimisation • Resource Optimisation The goals cascade is important because it allows the definition of priorities for implementation, improvement and assurance of governance of enterprise IT based on (strategic) objectives of the enterprise and the related risk. COBIT 5 defines 17 generic (enterprise) goals, as shown in figure 5, which includes the following information: • The BSC dimension under which the enterprise goal fits • Enterprise goals • The relationship to the three main governance objectives—benefits realisation, risk optimisation and resource optimisation. ('P' stands for primary relationship and 'S' for secondary relationship, i.e., a less strong relationship.) Appendix H – Glossary Value creation: The main governance	A goal is defined as an end state that a stakeholder intends to achieve.	

	objective of an enterprise, achieved when the three underlying objectives (benefits realisation, risk optimisation and resource optimisation) are all balanced.		
Risk (NOTE: check also risk scenarios)	The goals cascade is important because it allows the definition of priorities for implementation, improvement and assurance of governance of enterprise IT based on (strategic) objectives of the enterprise and the related risk. Appendix H –Glossary Risk: The combination of the probability of an event and its consequence (ISO/IEC 73).	A driver is defined as something that creates, motivates, and fuels the change in an organization.	
Enterprise Goals	Stakeholder needs can be related to a set of generic enterprise goals. These enterprise goals have been developed using the balanced scorecard (BSC) dimensions, and they represent a list of commonly used goals that an enterprise may define for itself. Although this list is not exhaustive, most enterprise-specific goals can be mapped easily onto one or more of the generic enterprise goals. COBIT 5 defines 17 generic (enterprise) goals, as shown in figure 5, which includes the following information: • The BSC dimension under which the enterprise goal fits • Enterprise goals • The relationship to the three main governance objectives—benefits	A goal is defined as an end state that a stakeholder intends to achieve.	

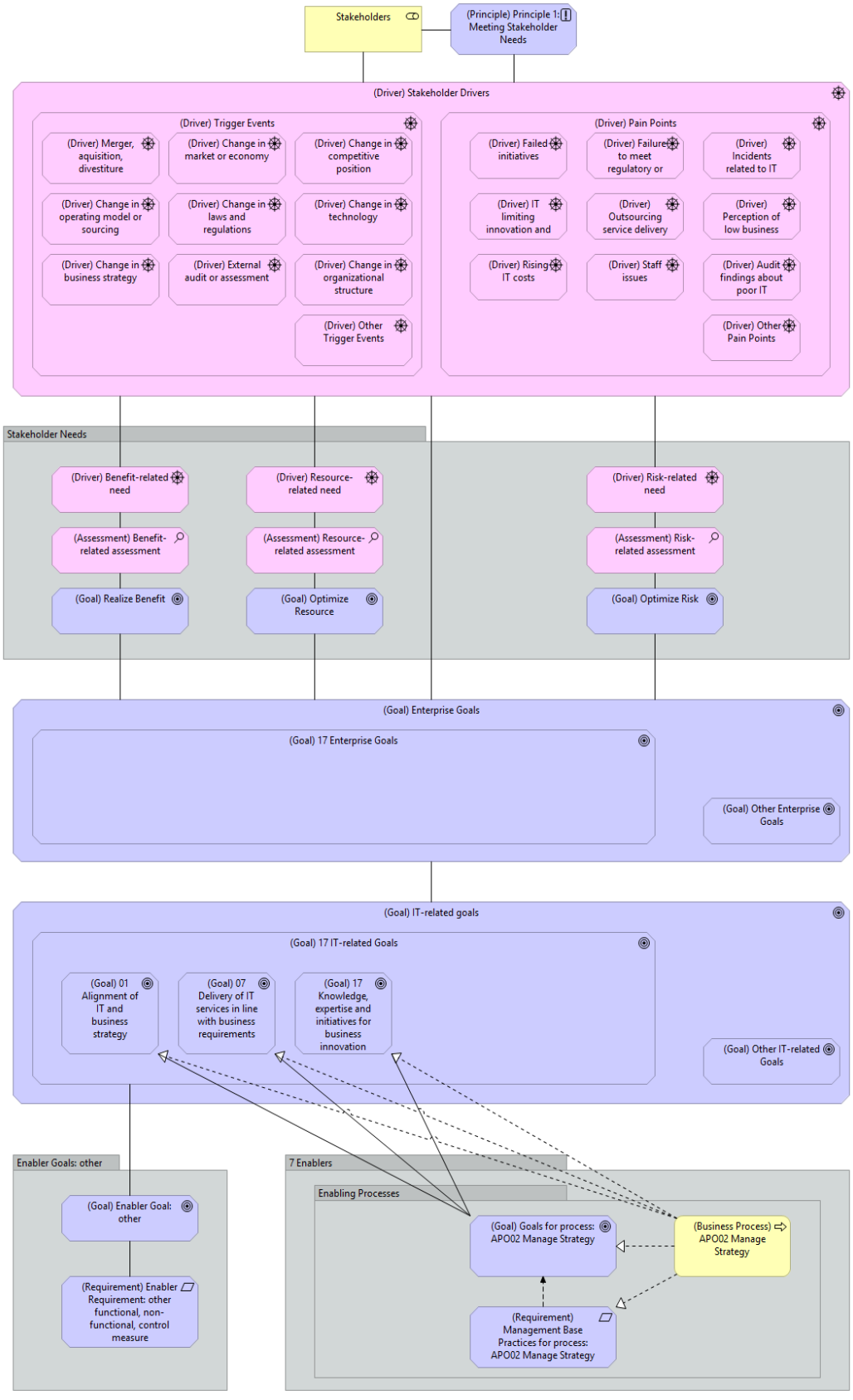
	realisation, risk optimisation and resource optimisation. (‘P’ stands for primary relationship and ‘S’ for secondary relationship, i.e., a less strong relationship.)		
IT-related Goals	Achievement of enterprise goals requires a number of IT-related outcomes, which are represented by the IT-related goals. IT-related stands for information and related technology, and the IT-related goals are structured along the dimensions of the IT balanced scorecard (IT BSC). COBIT 5 defines 17 IT-related goals.	A goal is defined as an end state that a stakeholder intends to achieve.	
Enabler Goals	Enablers include processes, organisational structures and information, and for each enabler a set of specific relevant goals can be defined in support of the IT-related goals.	A goal is defined as an end state that a stakeholder intends to achieve. A requirement is defined as a statement of need that must be realized by a system. (See paper “Where have all the CO gone?” CO-> control requirements, i.e. practices. See also COBIT 5: Enabling Processes, figure 13)	 

Appendix Table 3: Pain Points and Trigger Events.

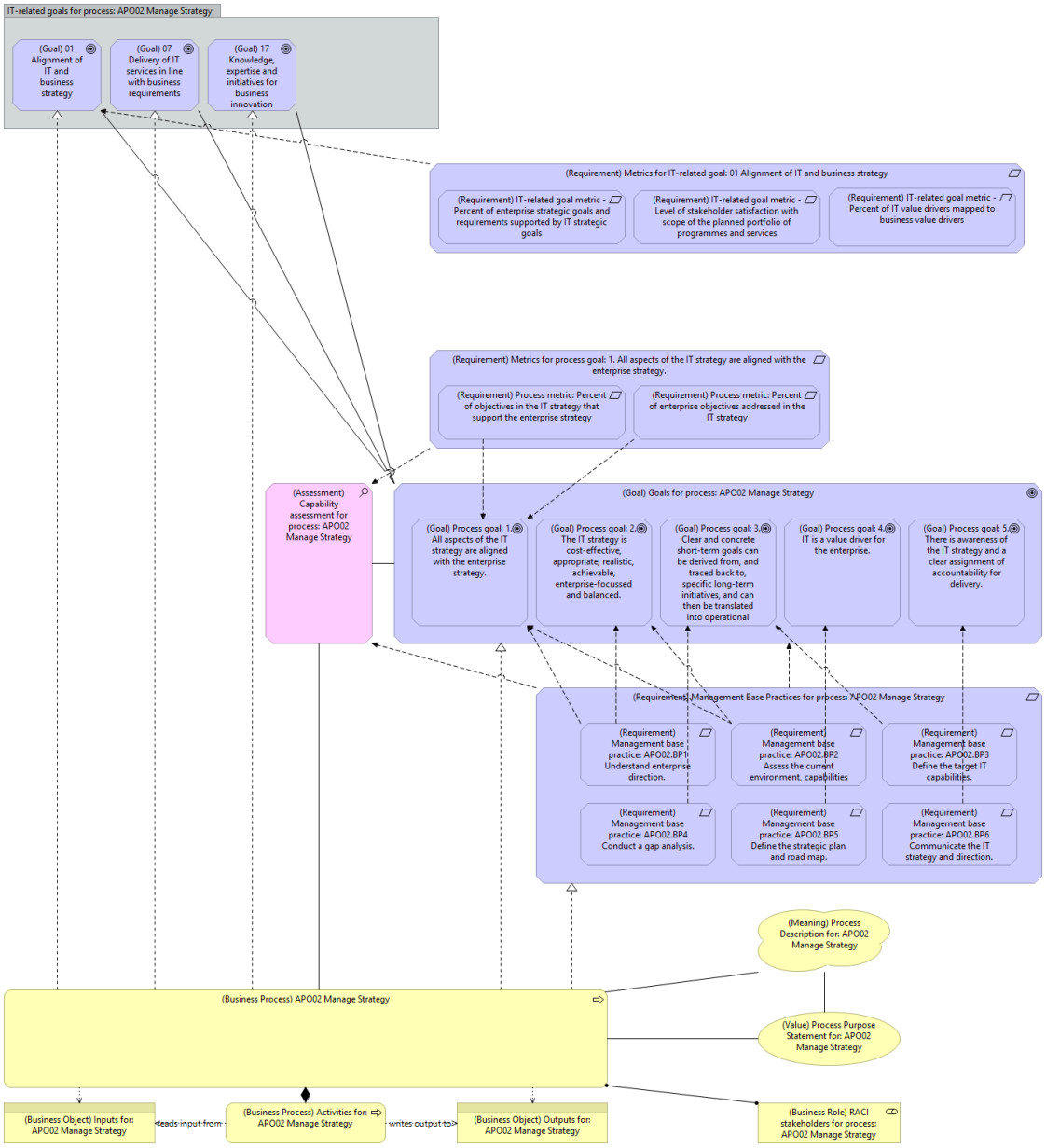
COBIT®5 concept	COBIT®5 concept description	ArchiMate concept description	ArchiMate notation
Pain point	Examples of some of the typical pain points for which new or revised governance or management of IT enablers can be a solution (or part of a solution), as identified in COBIT 5 Implementation, are: • Business frustration with failed initiatives, rising IT costs and a perception of low business value • Significant incidents related to IT risk, such as data loss or project failure • Outsourcing service delivery problems, such as consistent failure to meet agreed-on service levels • Failure to meet regulatory or contractual requirements • IT limiting the enterprise's innovation capabilities and business agility • Regular audit findings about poor IT performance or reported IT quality of service problems • Hidden and rogue IT spending • Duplication or overlap between initiatives or wasting resources, such as premature project termination • Insufficient IT resources, staff with inadequate skills or staff burnout/dissatisfaction • IT-enabled changes failing to meet business needs and delivered late or	A driver is defined as something that creates, motivates, and fuels the change in an organization.	

	over budget • Board members, executives or senior managers who are reluctant to engage with IT, or a lack of committed and satisfied business sponsors for IT • Complex IT operating models		
Trigger	Events in the enterprise's internal and external environment can signal or trigger a focus on the governance and management of IT. Examples from chapter 3 in the COBIT 5 Implementation publication are: • Merger, acquisition or divestiture • A shift in the market, economy or competitive position • A change in the business operating model or sourcing arrangements • New regulatory or compliance requirements • A significant technology change or paradigm shift • An enterprisewide governance focus or project • A new CEO, CFO, CIO, etc. • External audit or consultant assessments • A new business strategy or priority	A driver is defined as something that creates, motivates, and fuels the change in an organization.	

Appendix B: First DSRM Iteration - Viewpoints

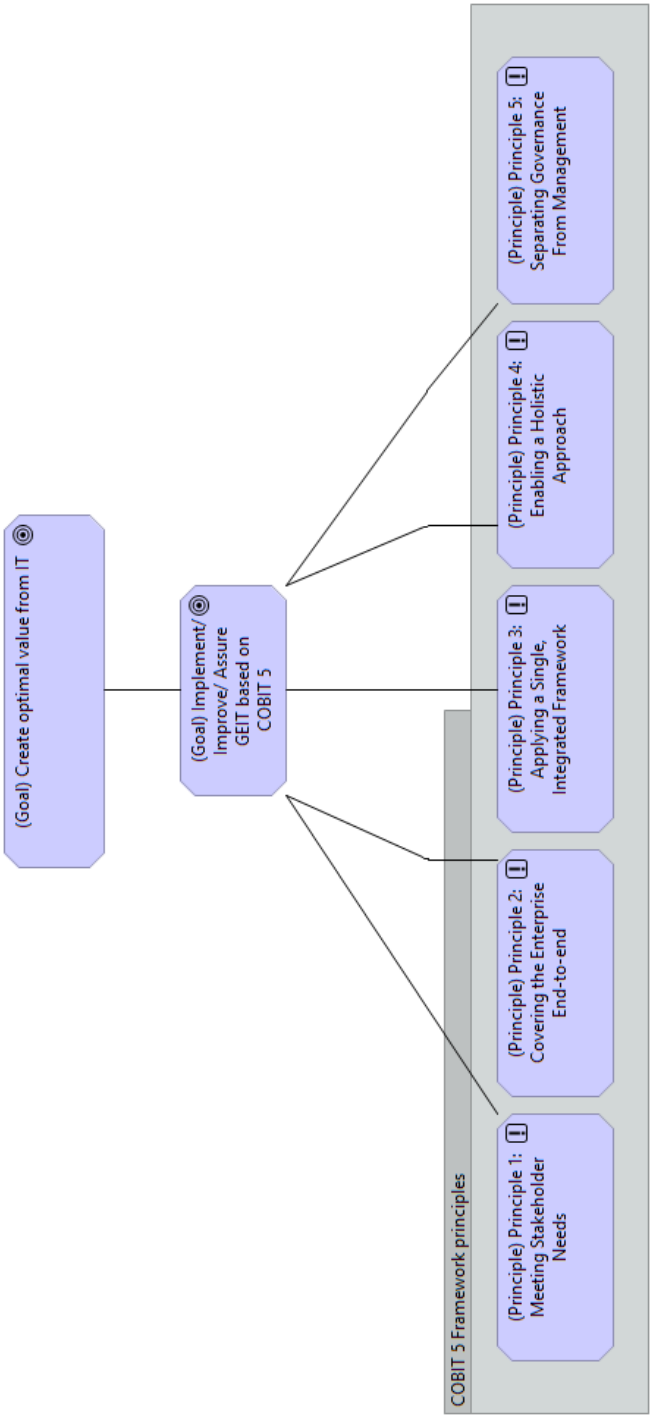


Appendix Figure 1: Goals Cascade viewpoint.

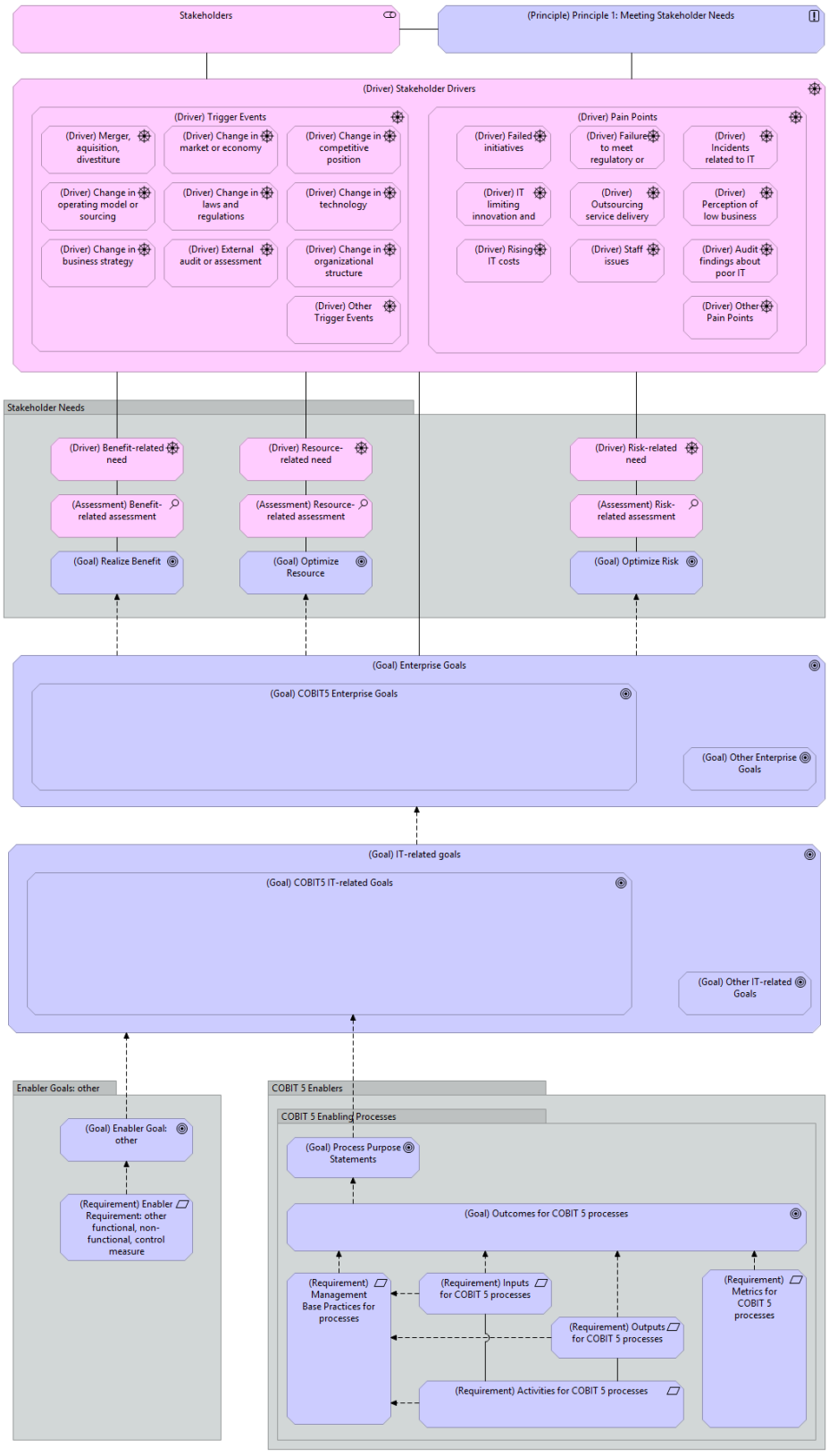


Appendix Figure 2: Enabling Process Performance viewpoint.

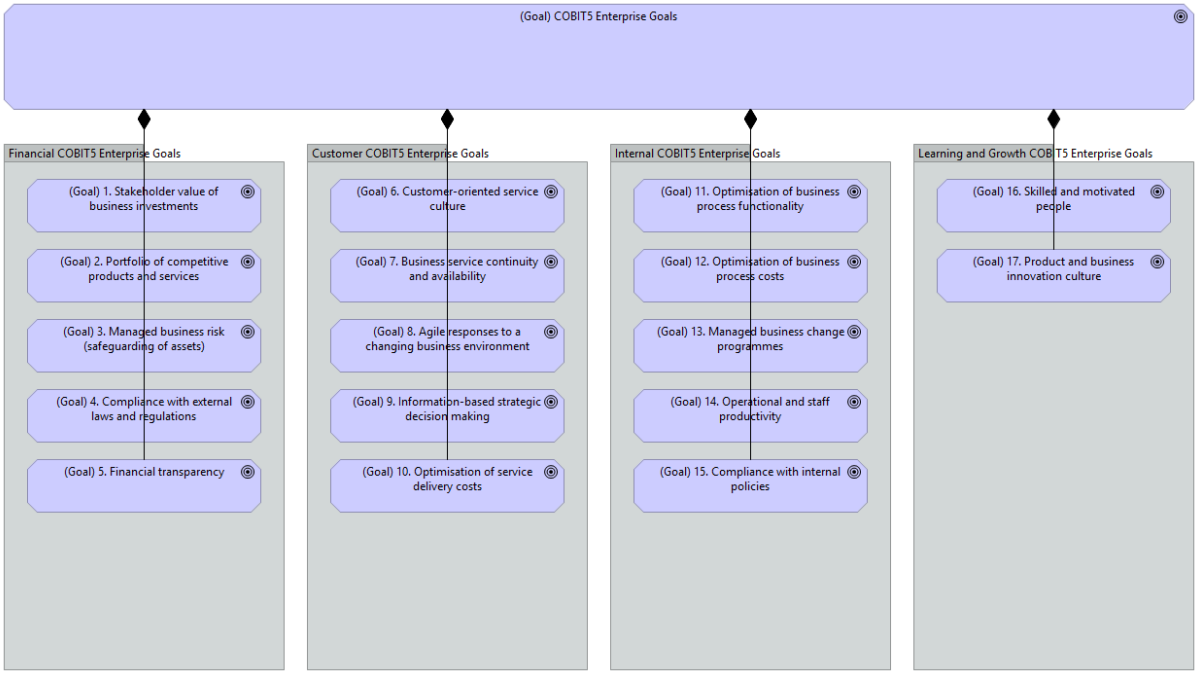
Appendix C: Third DSRM Iteration – Viewpoints



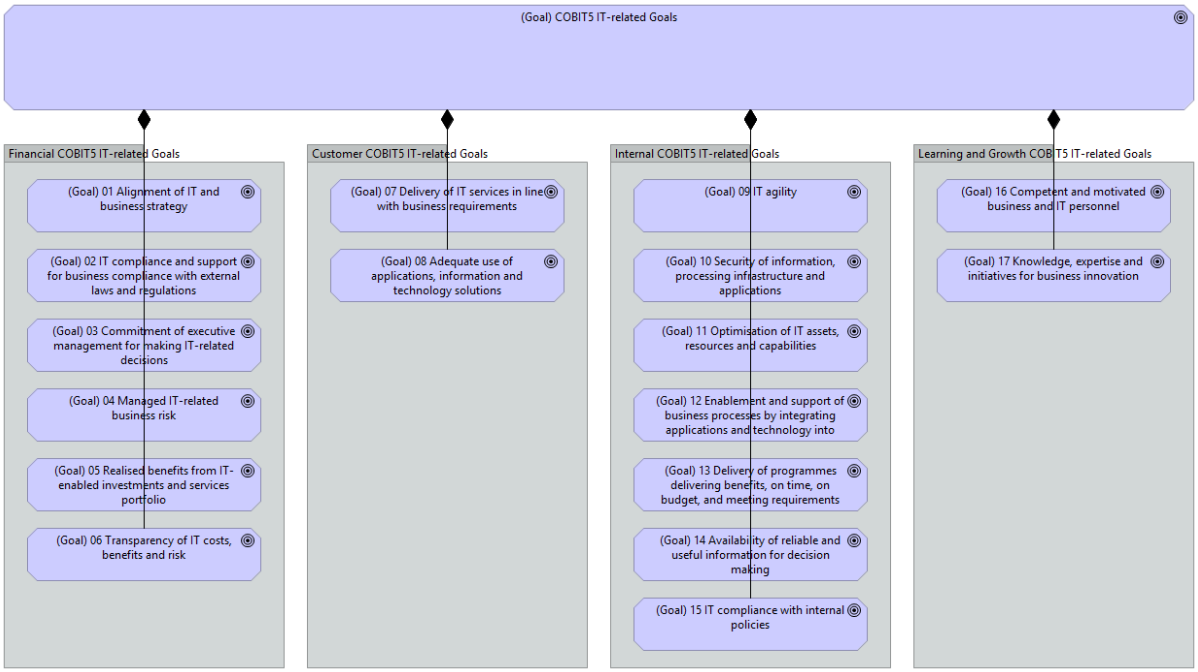
Appendix Figure 3: COBIT 5 Goals and Principles



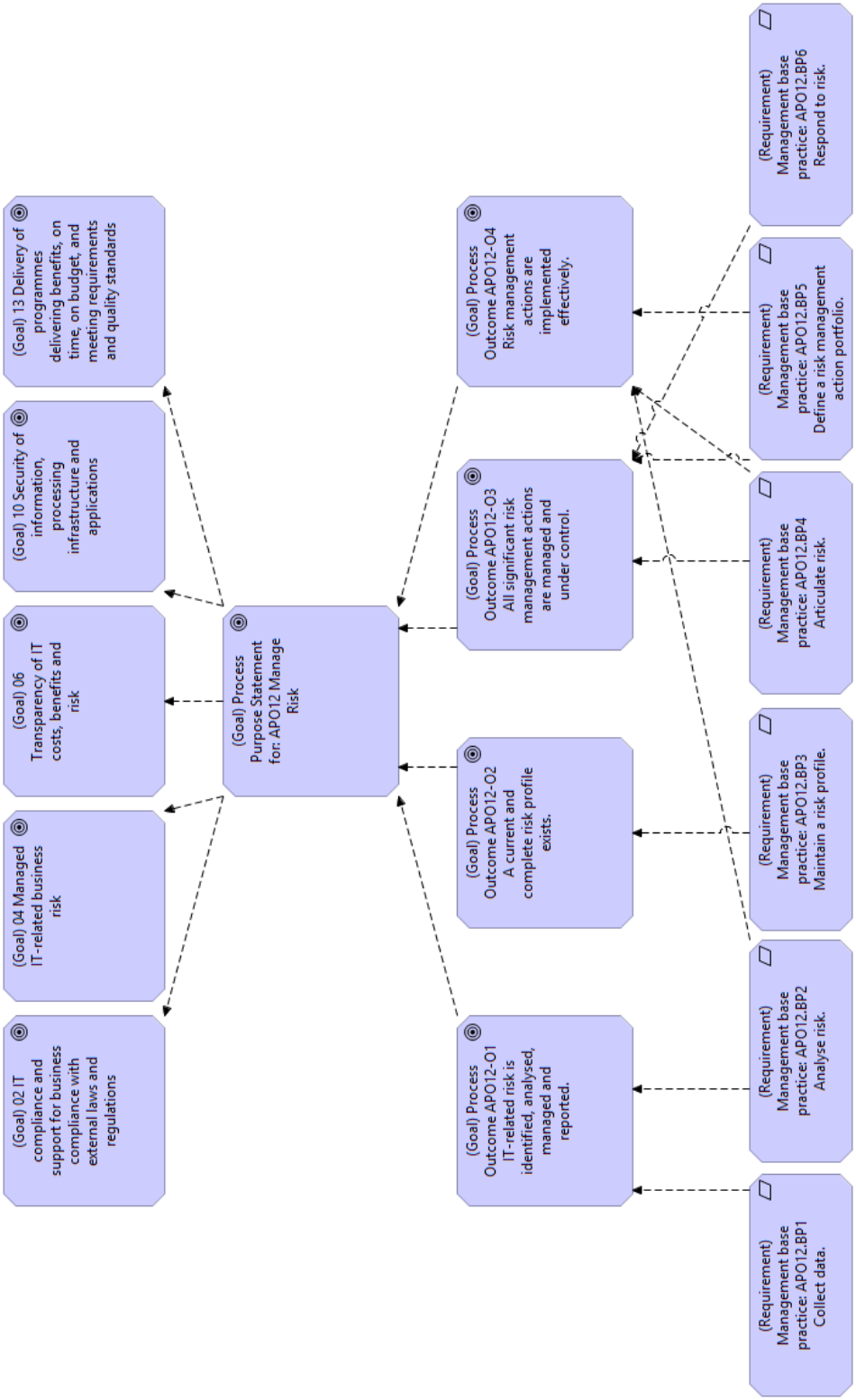
Appendix Figure 4: Principle 1 (Meeting Stakeholder Needs)



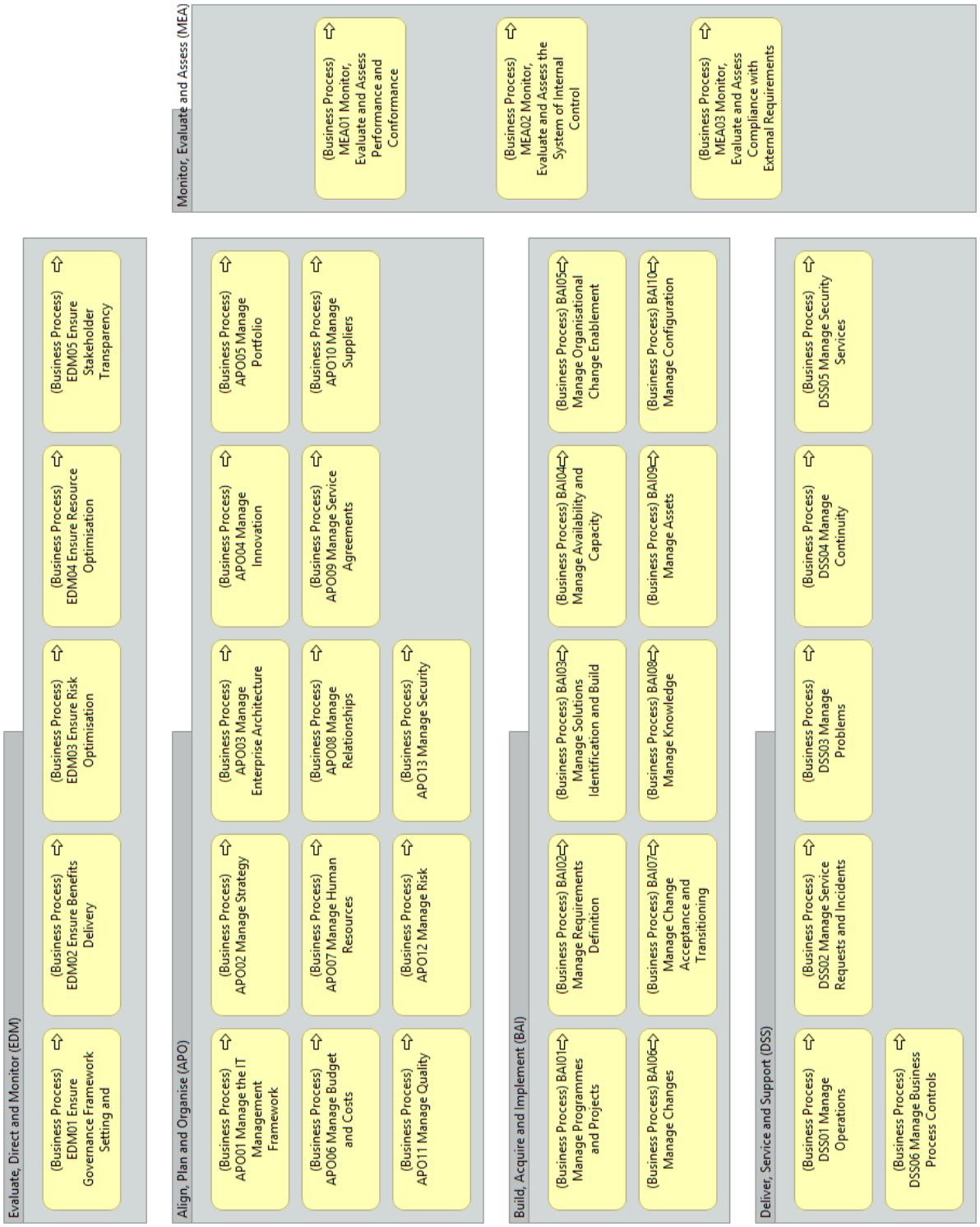
Appendix Figure 5: Enterprise Goals



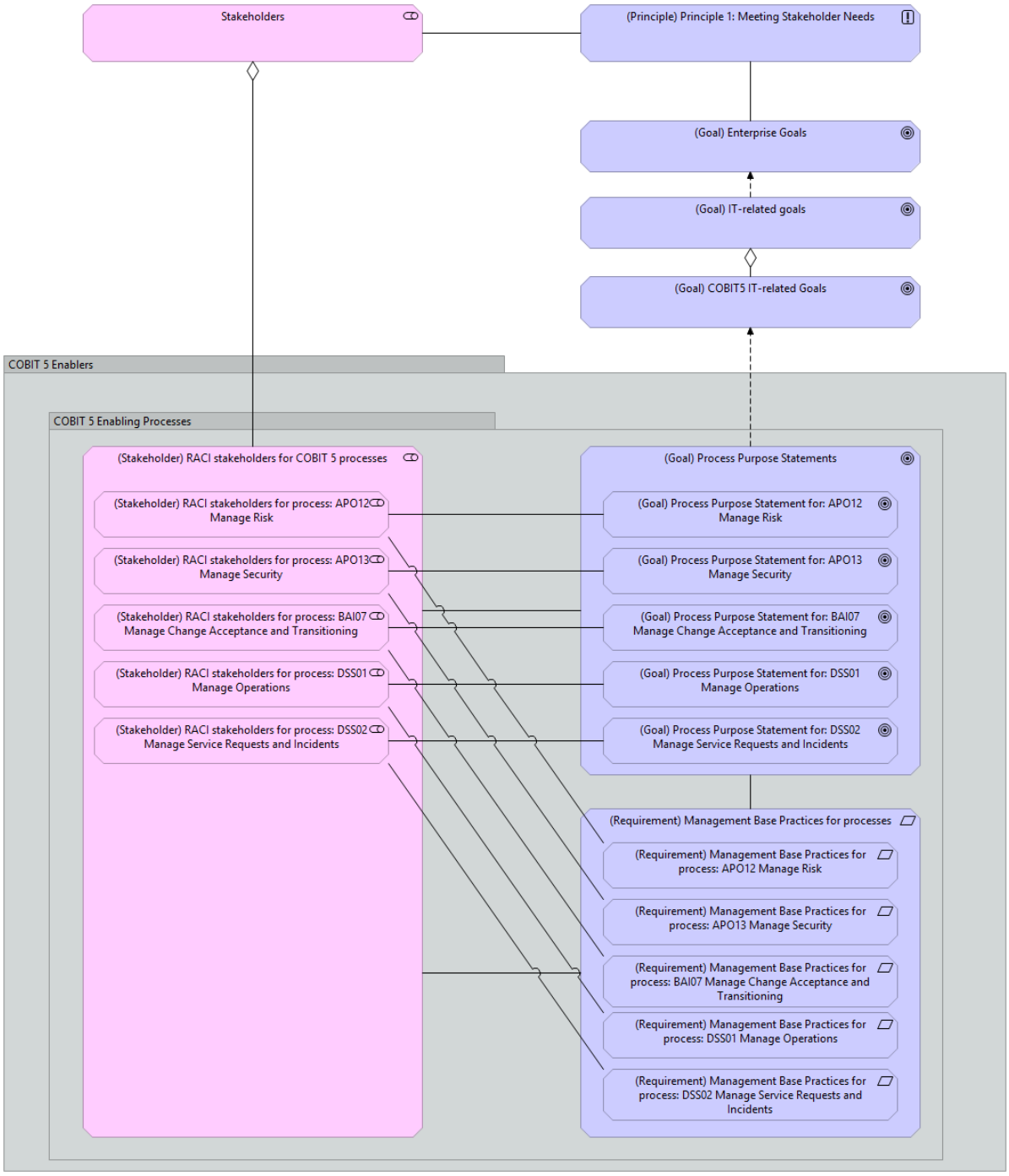
Appendix Figure 6: IT-related Goals



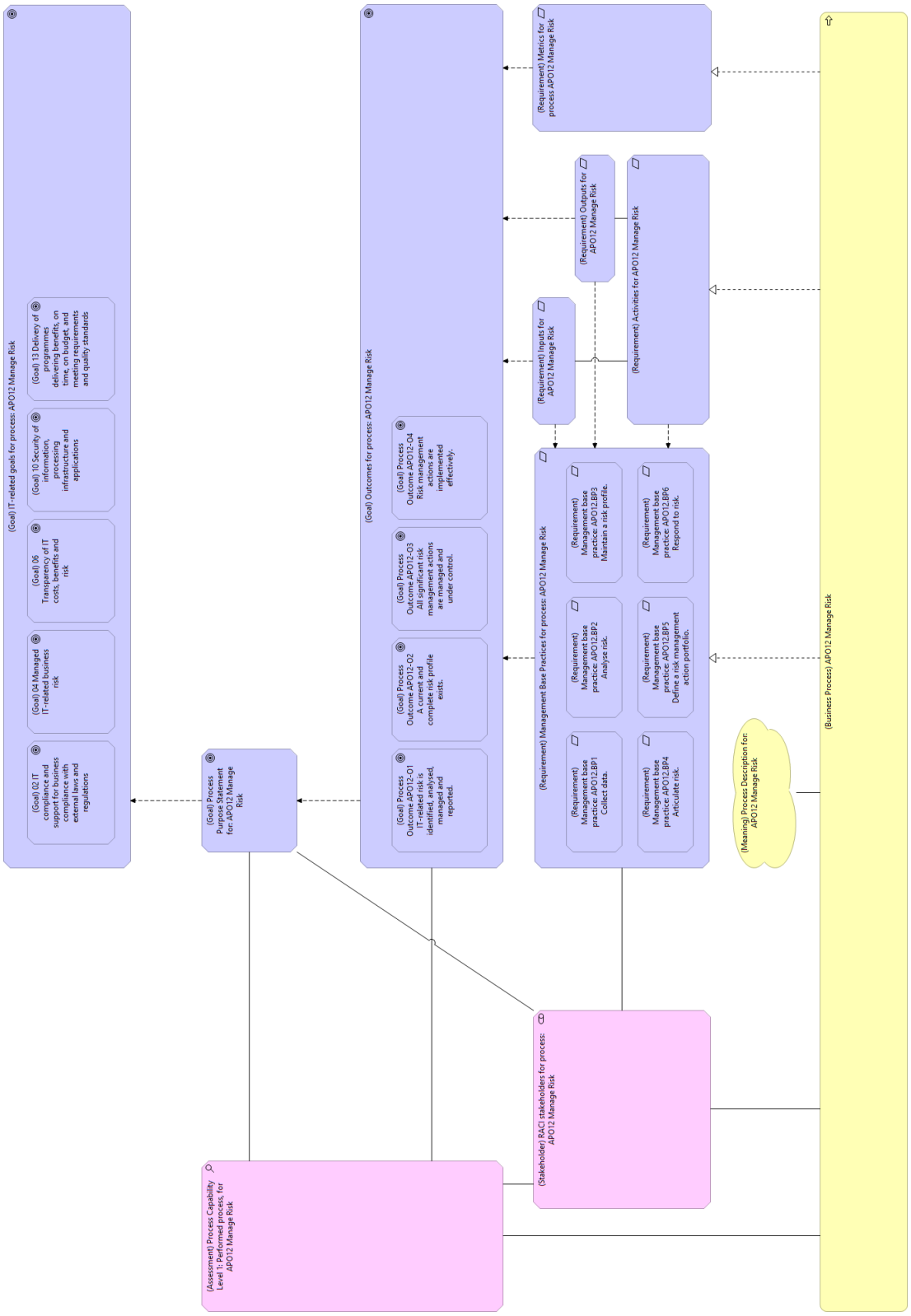
Appendix Figure 7: IT-related goals and base practices, for process APO12 Manage Risk



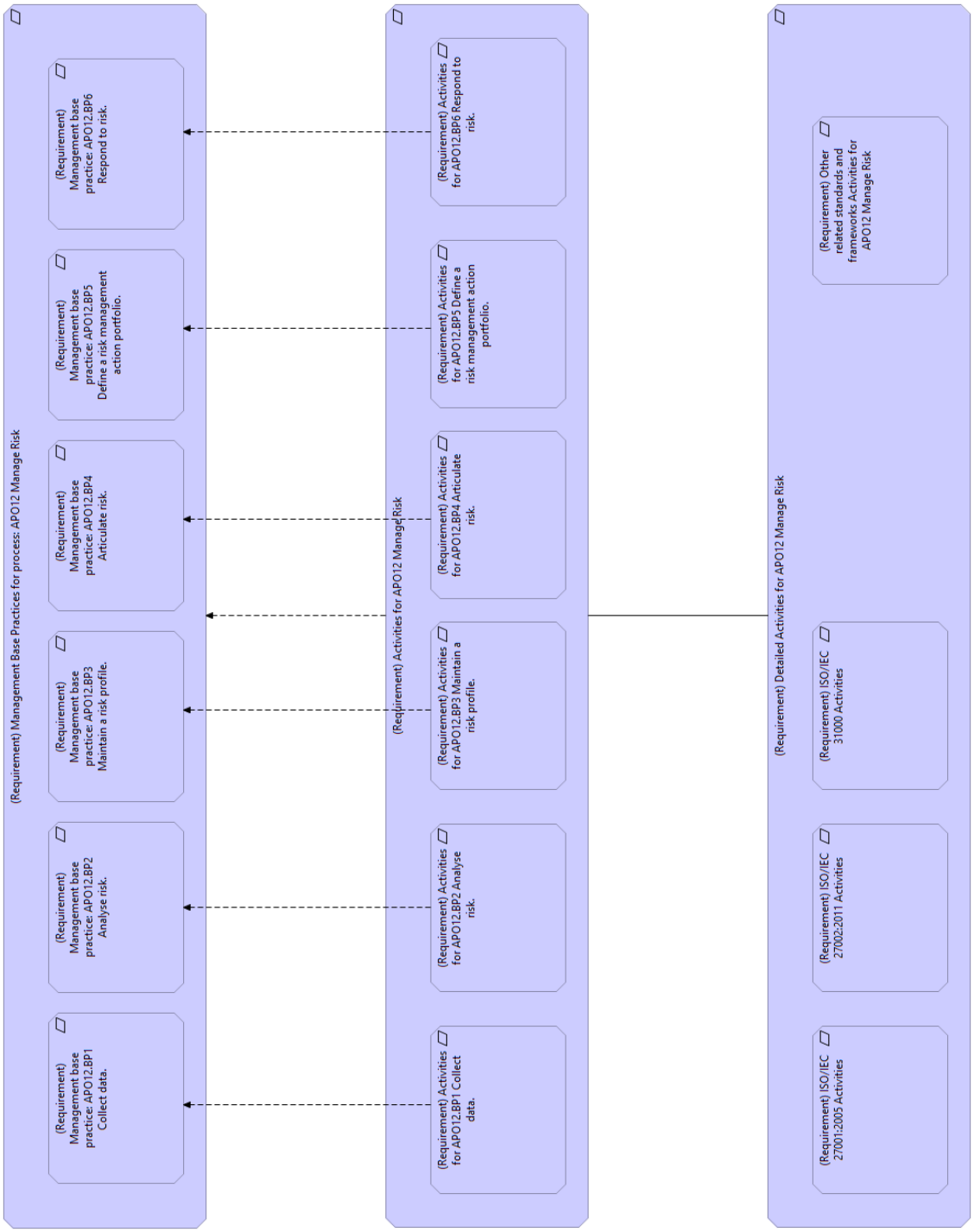
Appendix Figure 8: Enabling Processes



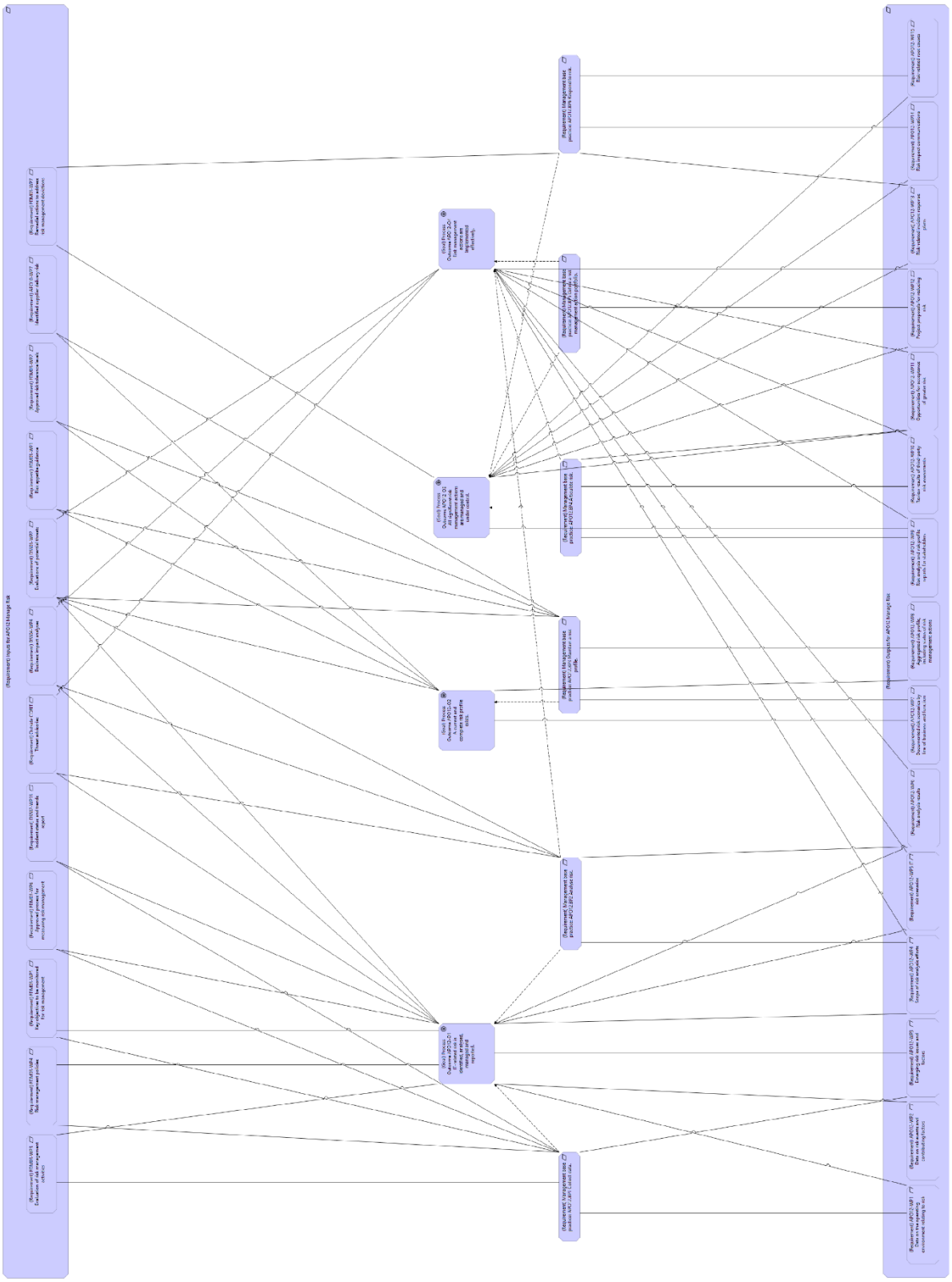
Appendix Figure 9: Enabling Processes Stakeholders, Goals and Requirements View, for process APO12 Manage Risk



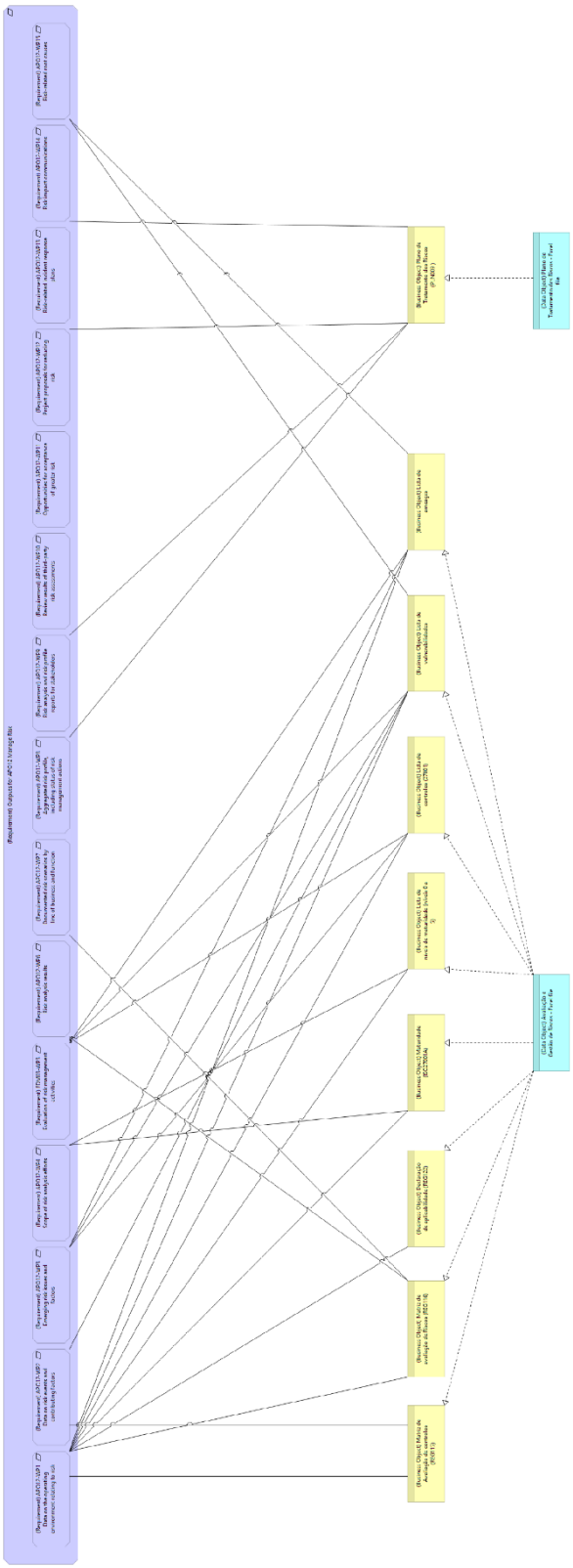
Appendix Figure 10: Process Capability Level 1 Performed process, for process APO12 Manage Risk



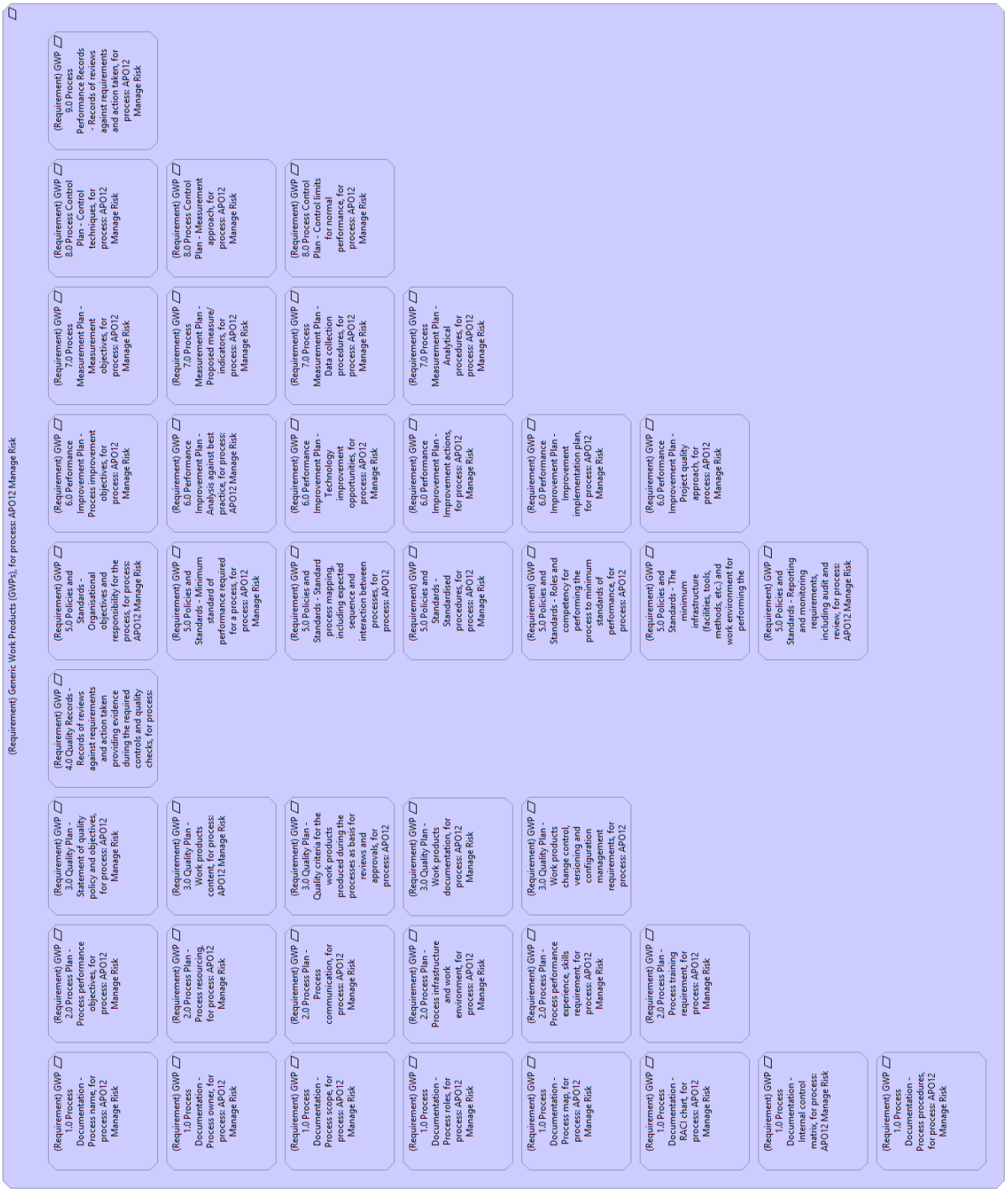
Appendix Figure 11: Activities View, for process APO12 Manage Risk



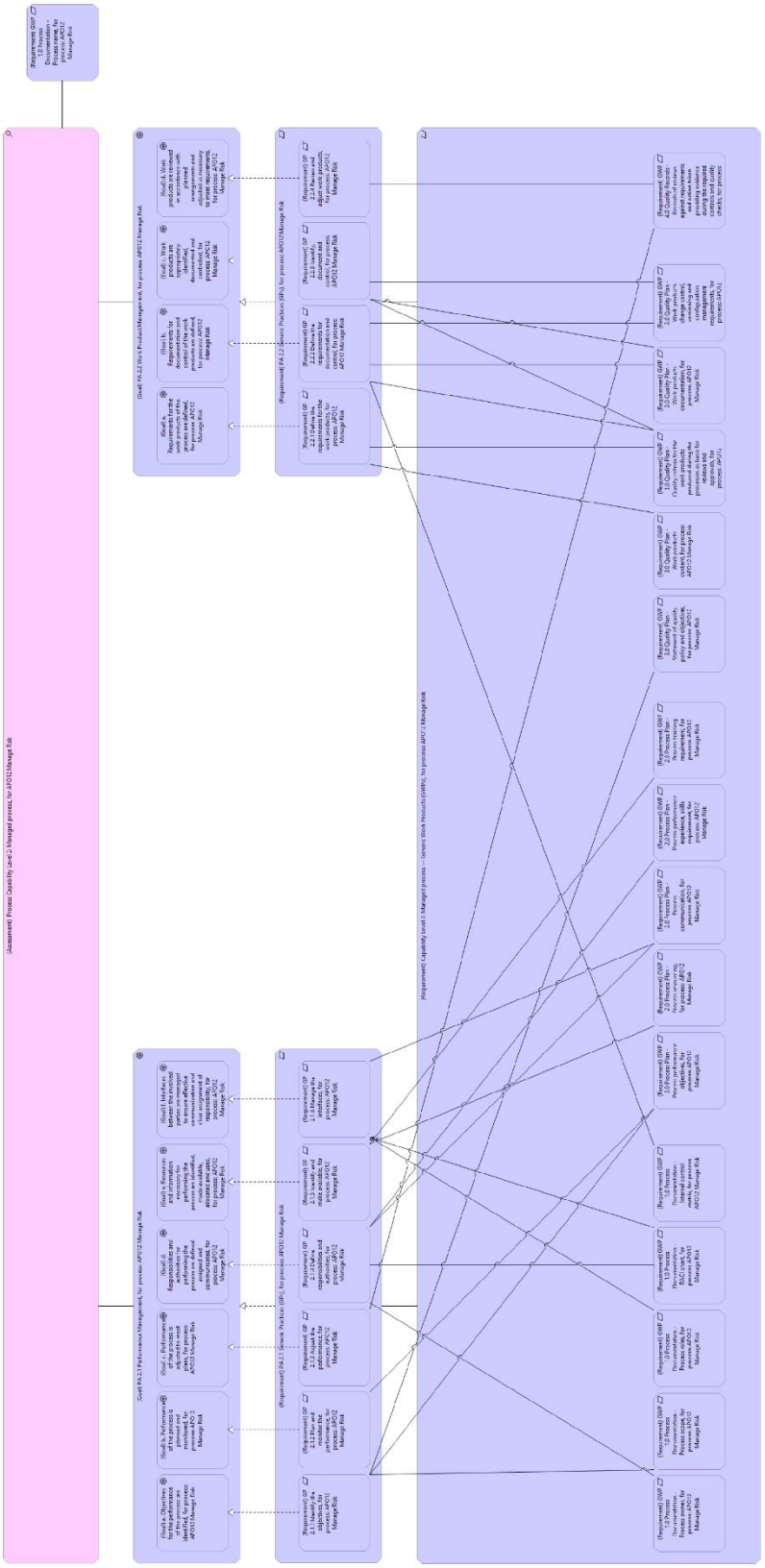
Appendix Figure 12: Work Products (Inputs and Outputs) View for APO12 Manage Risk



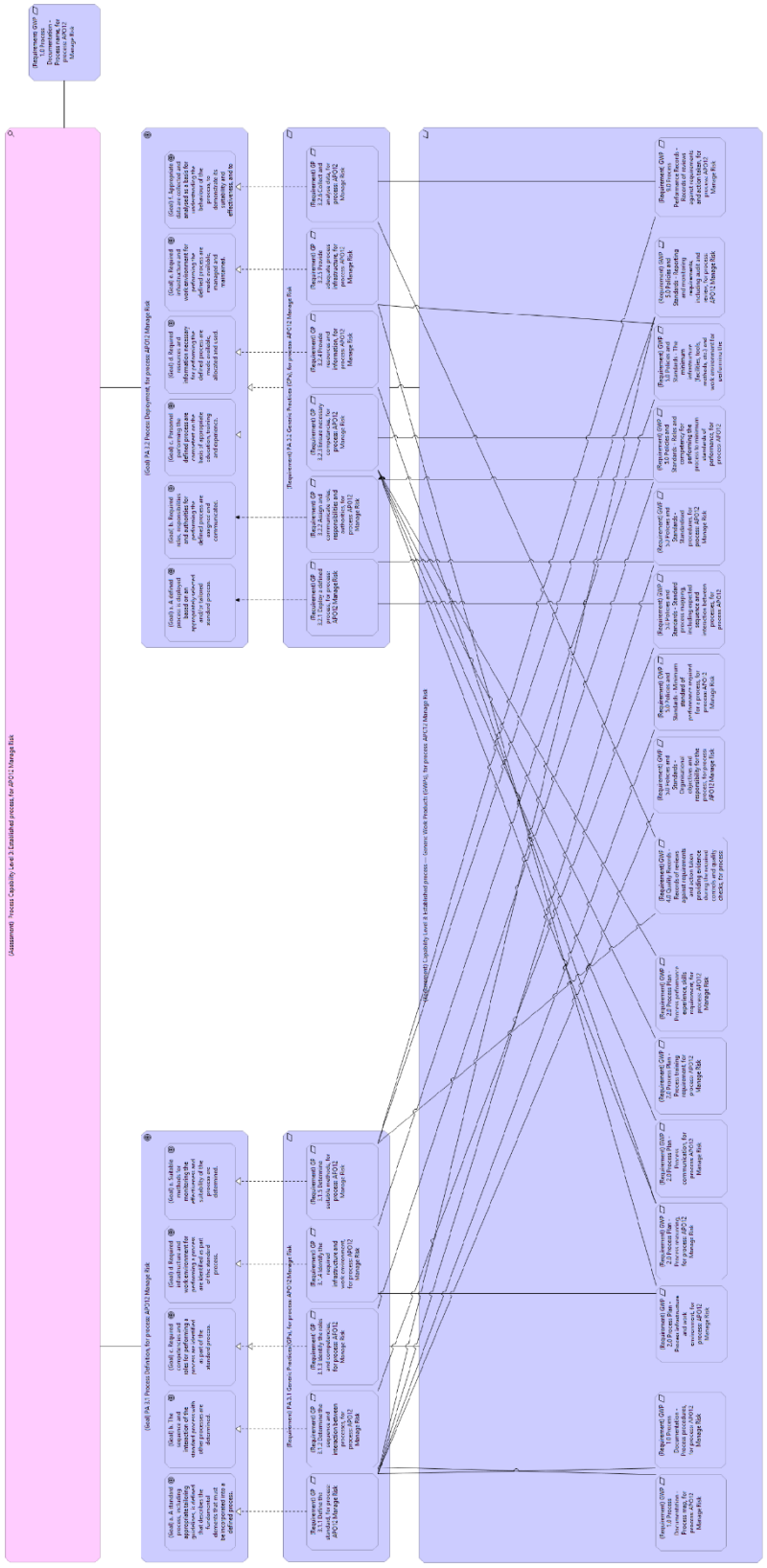
Appendix Figure 13: Work Products (Outputs) View for APO12 Manage Risk



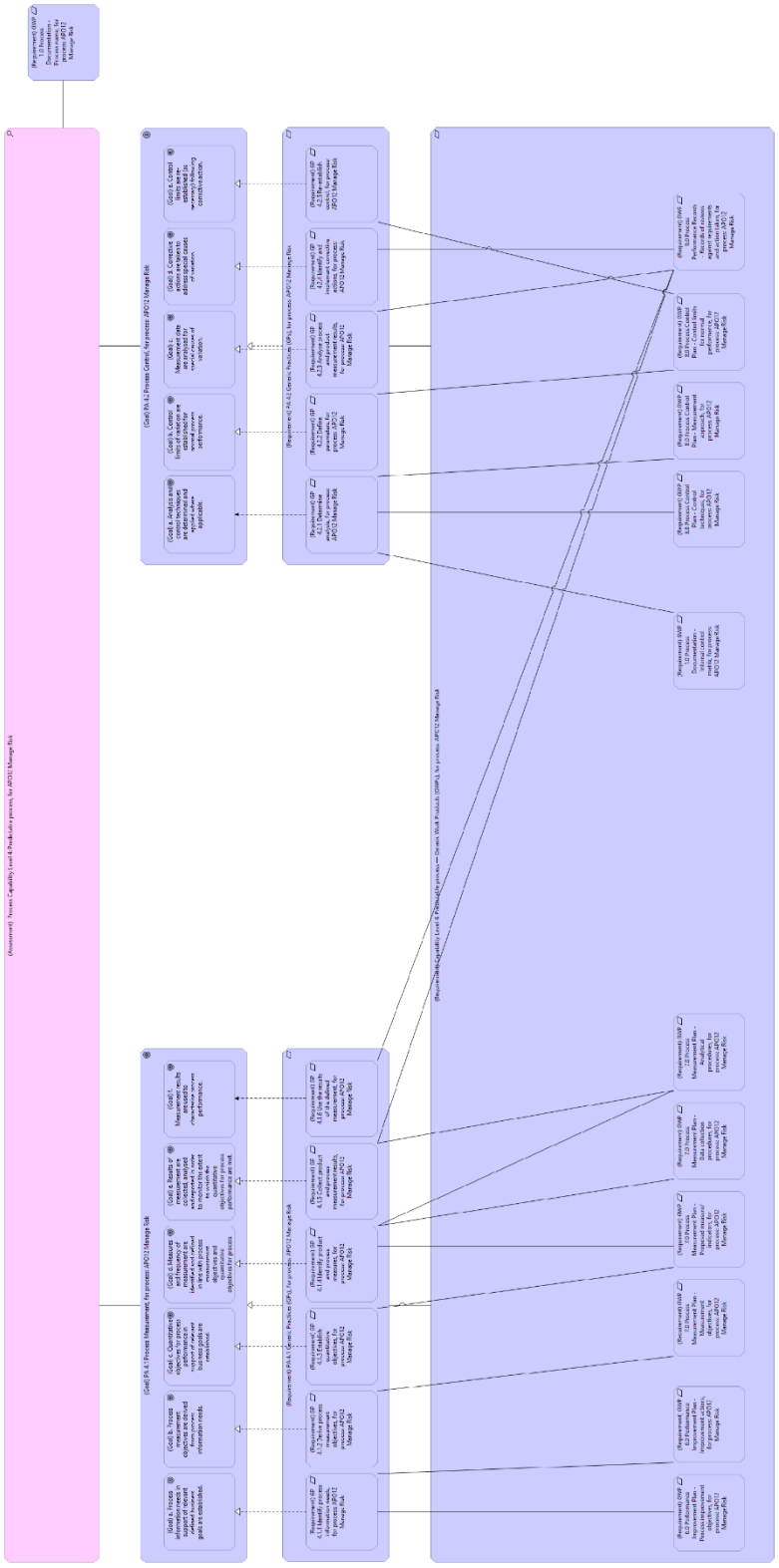
Appendix Figure 14: Generic Work Products (GWPs), for process APO12 Manage Risk



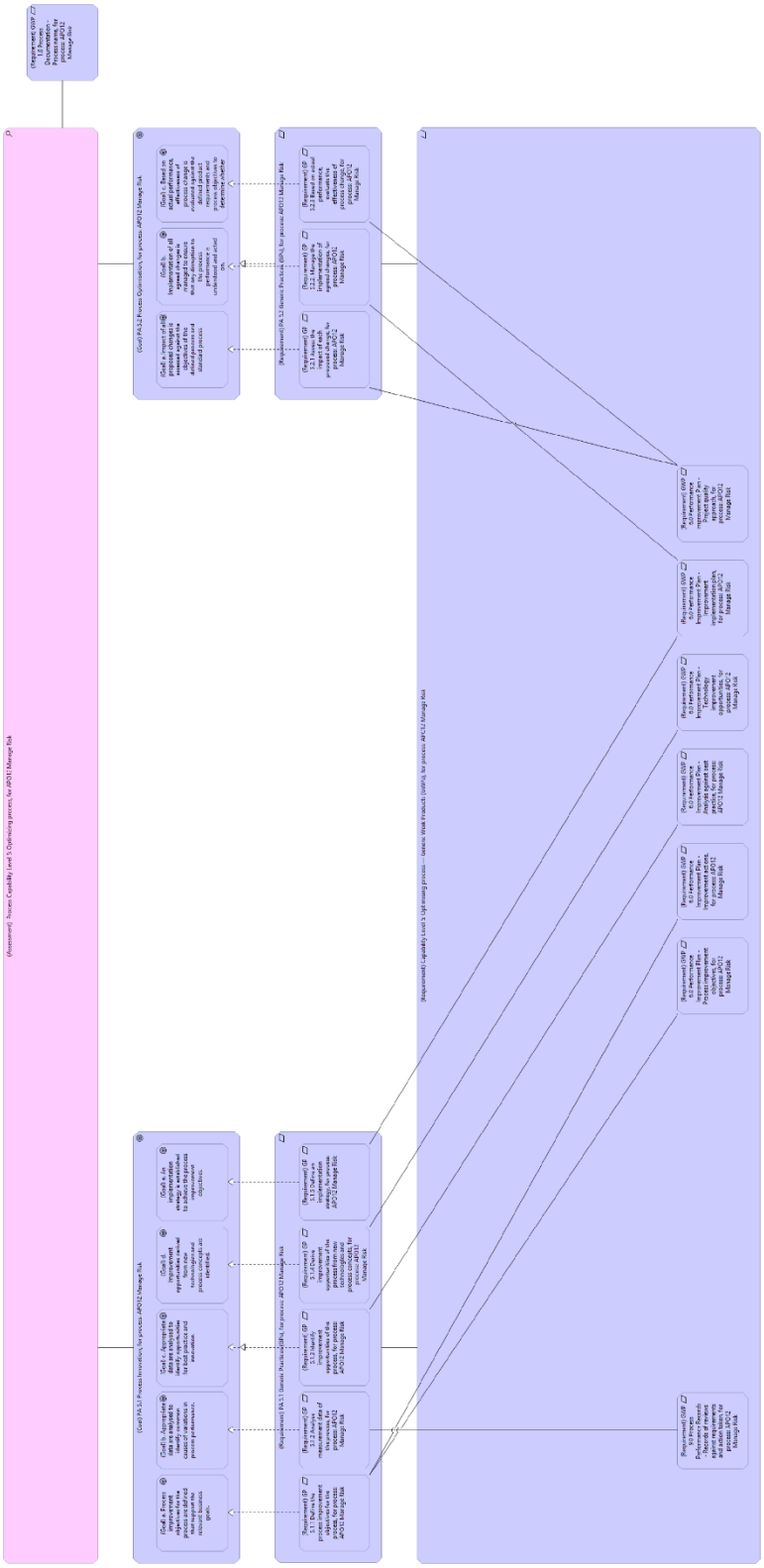
Appendix Figure 15: Process Capability Level 2 Managed Process, for process APO12 Manage Risk



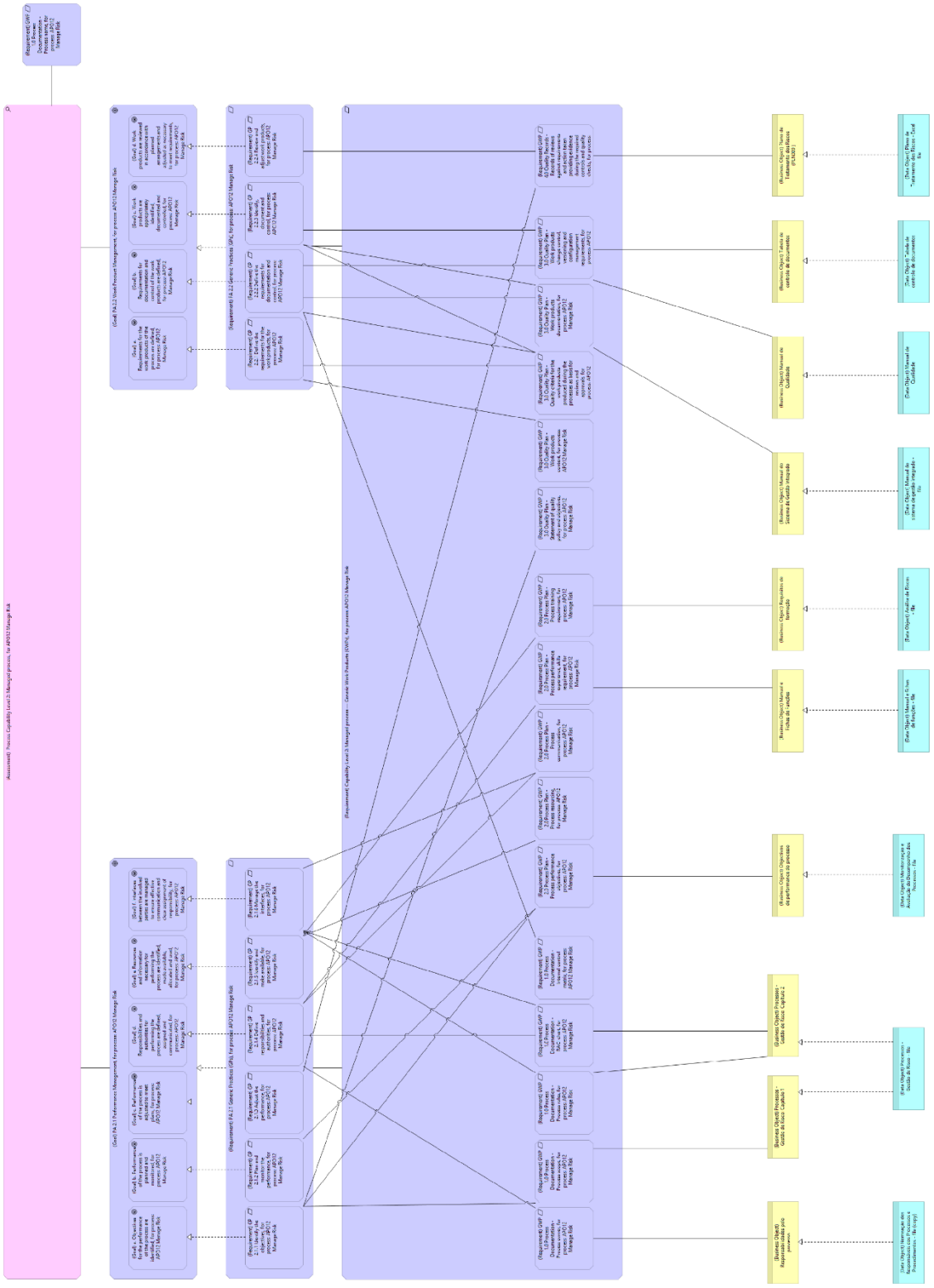
Appendix Figure 16: Process Capability Level 3 Established process, for process APO12 Manage Risk



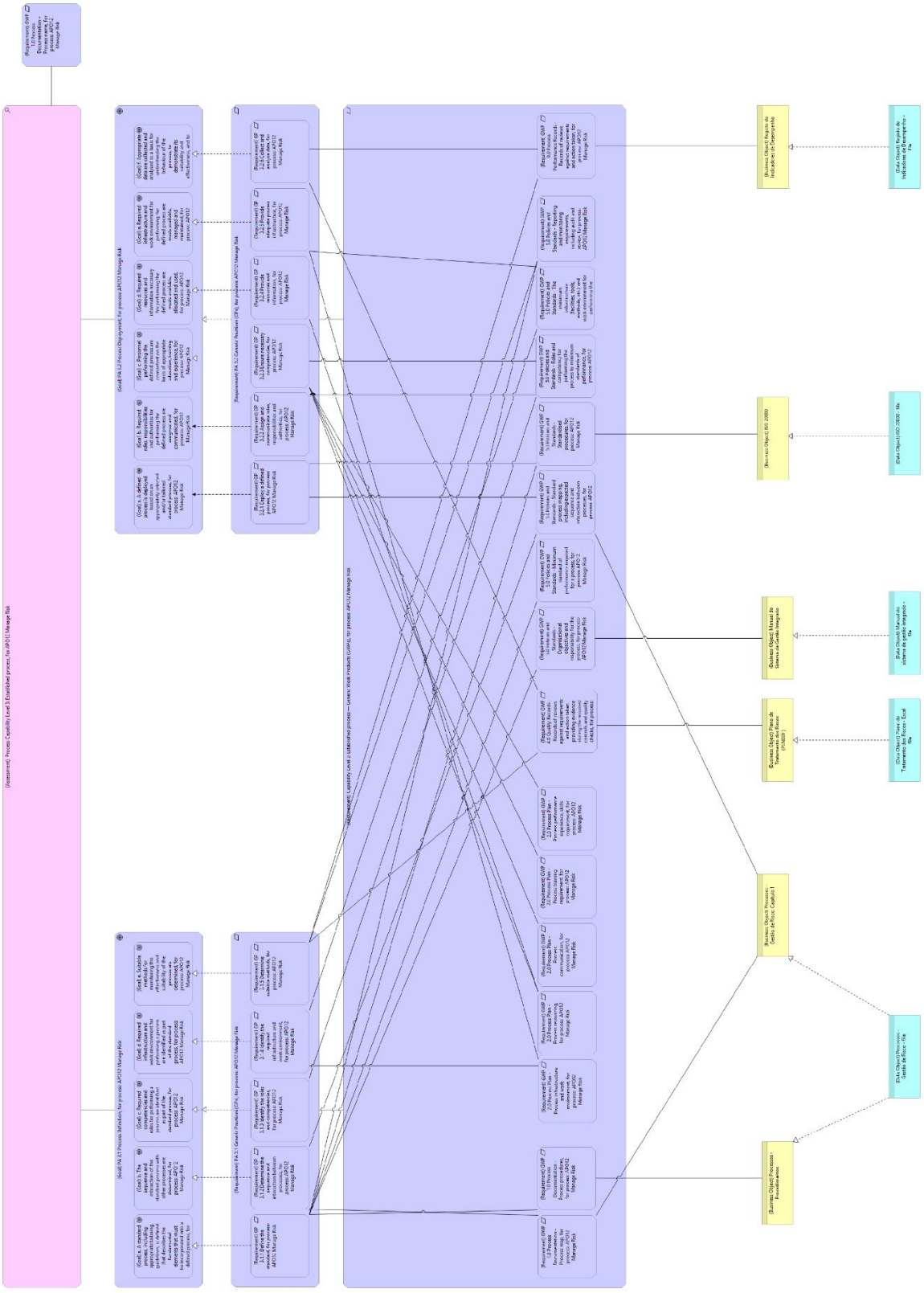
Appendix Figure 17: Process Capability Level 4 Predictable process, for process APO12 Manage Risk



Appendix Figure 18: Process Capability Level 5 Optimizing process, for process APO12 Manage Risk

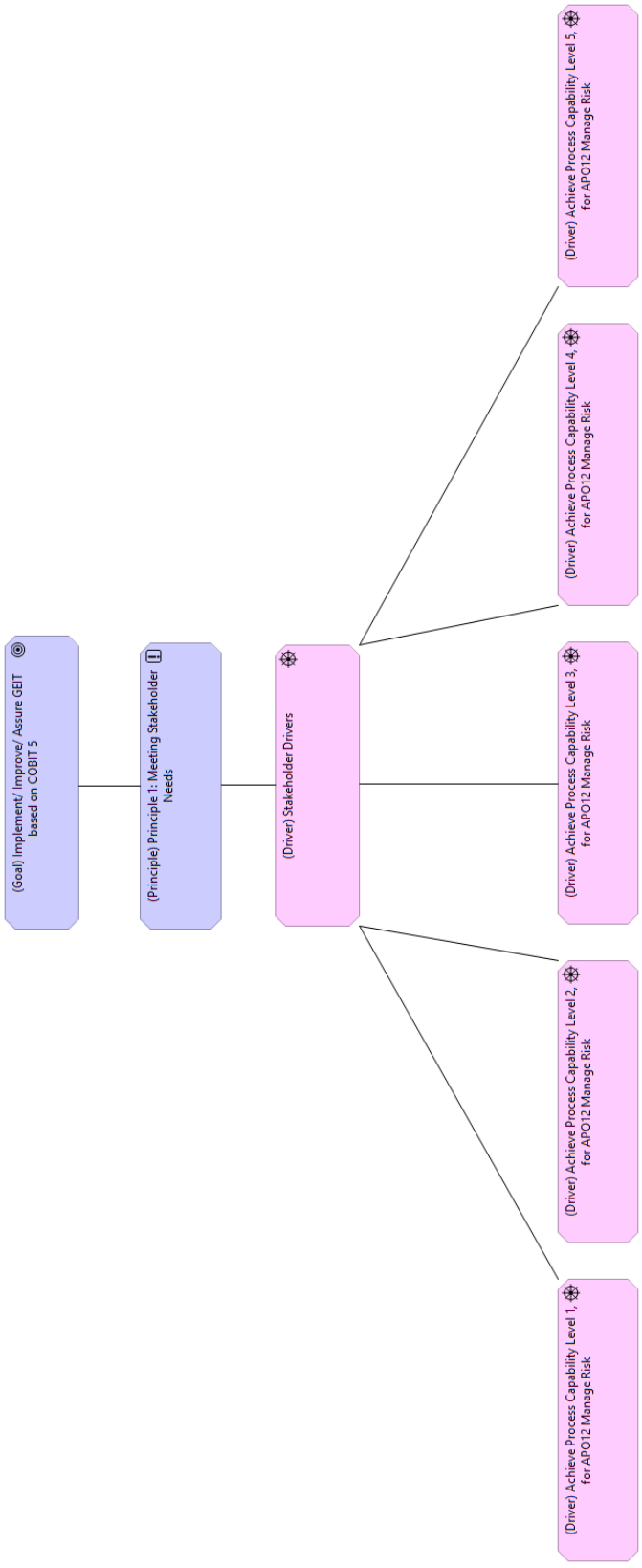


Appendix Figure 19: Generic Work Products for Process Capability Level 2: Managed Process, for process: APO12 Manage Risk

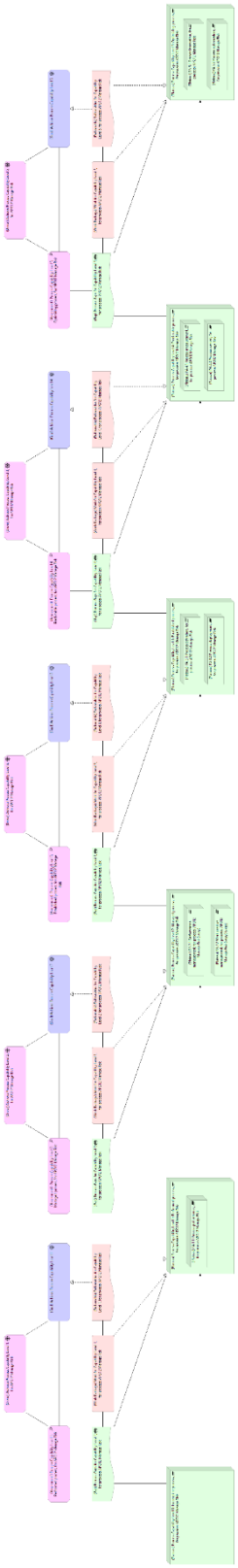


Appendix Figure 20: Generic Work Products for Process Capability Level 3: Established process, for process: APO12 Manage Risk

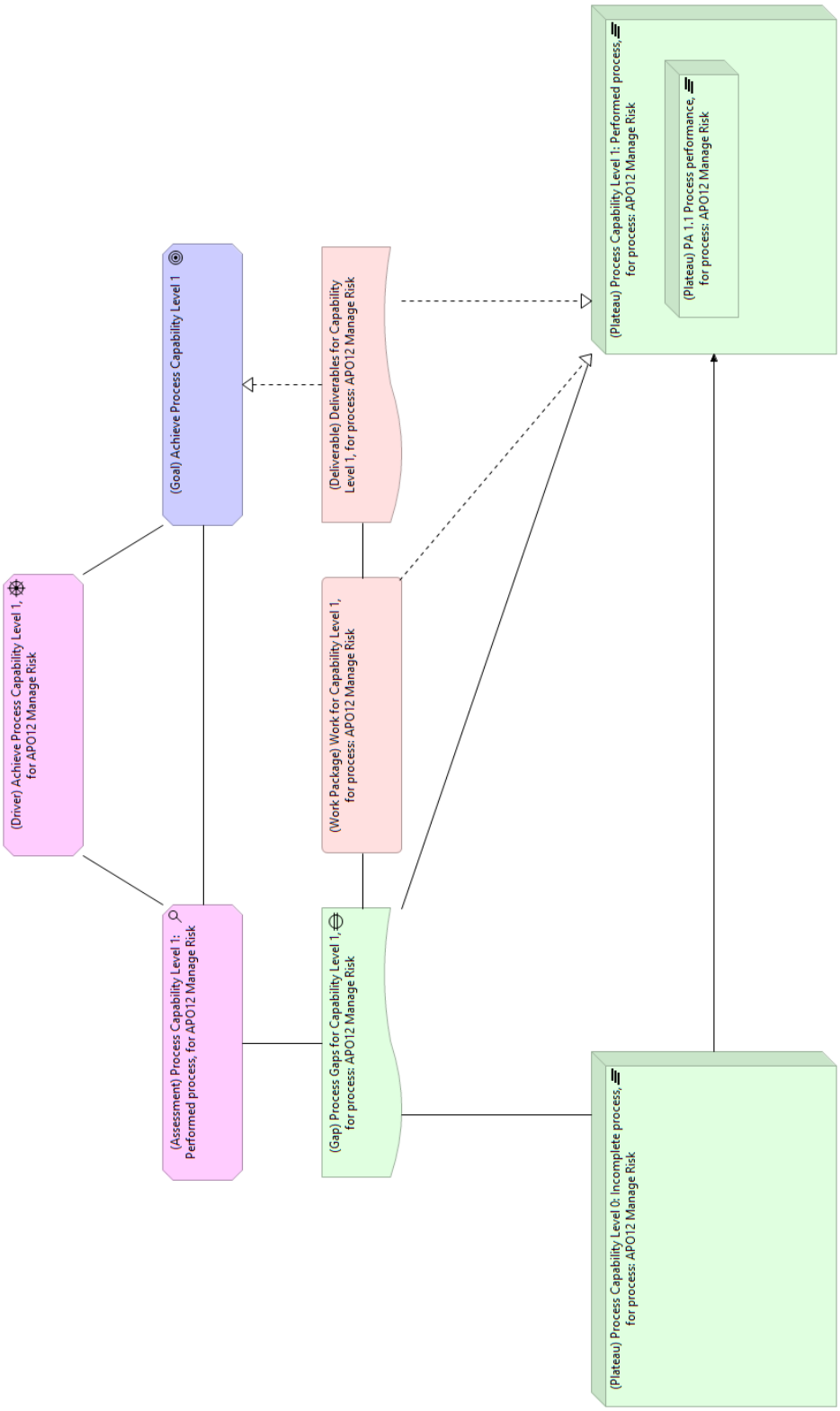
Appendix D: Fourth DSRM Iteration – Viewpoints



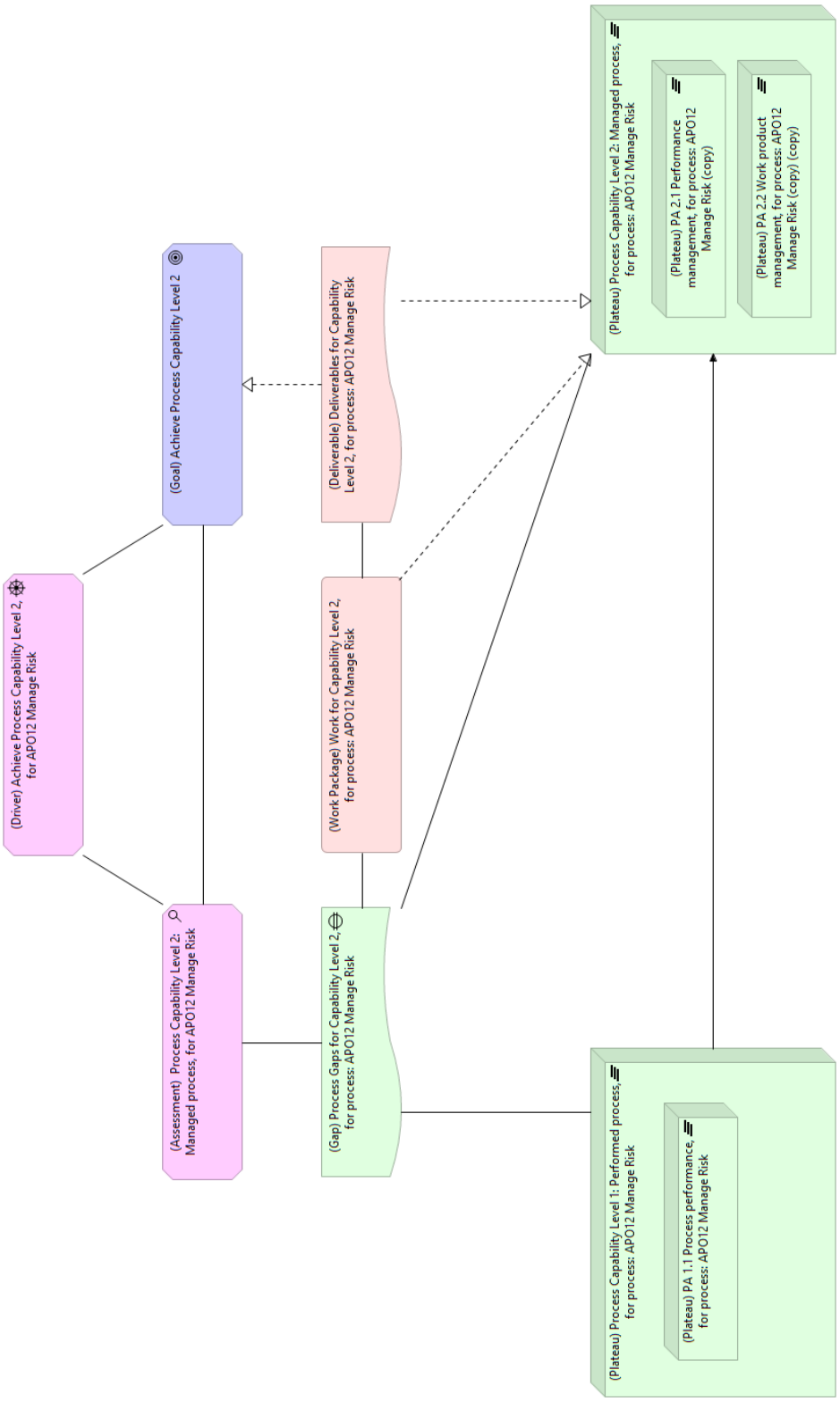
Appendix Figure 21: Process Capability Improvement and GEIT View, for APO12 Manage Risk



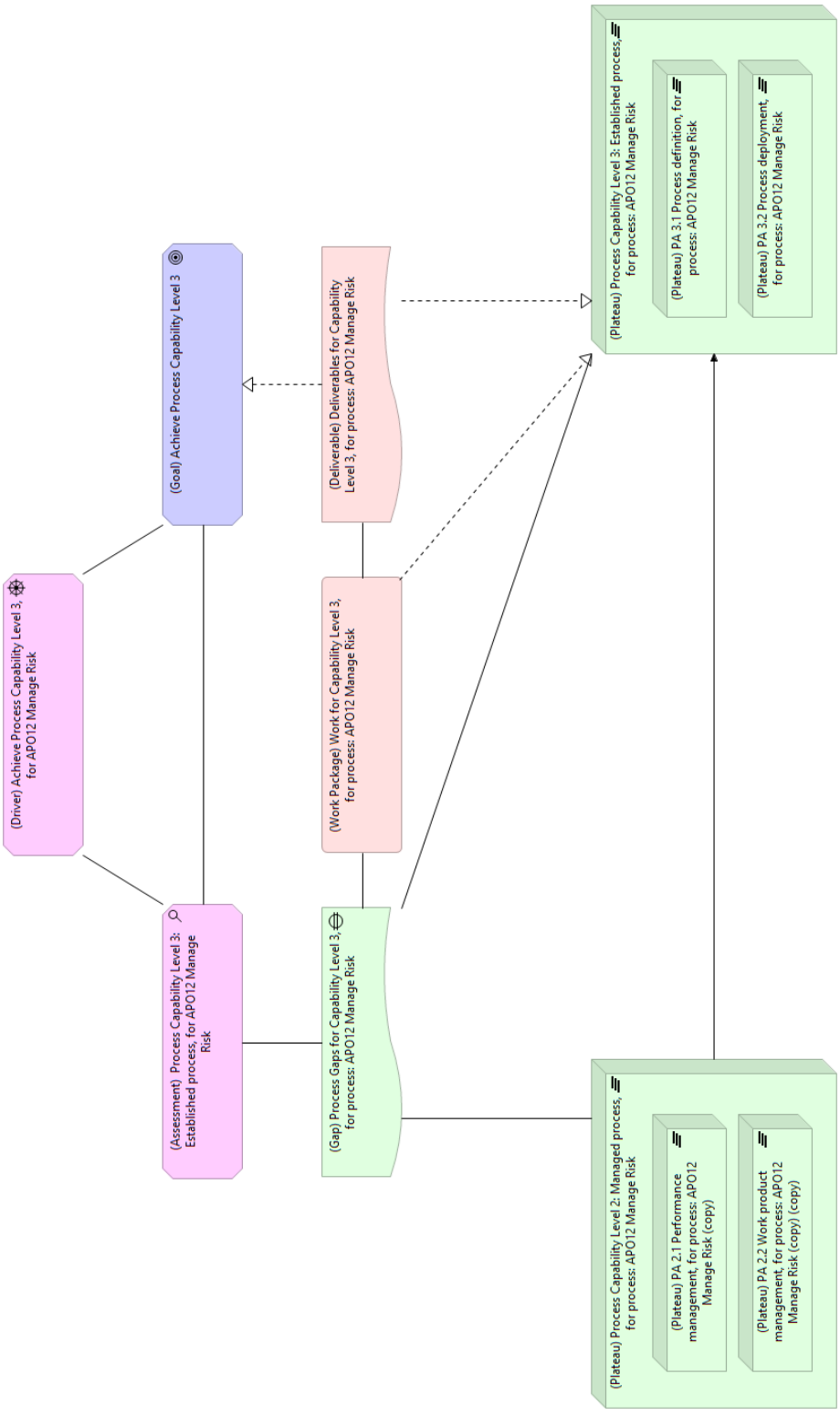
Appendix Figure 22: Process Capability Improvement View, for process APO12 Manage Risk



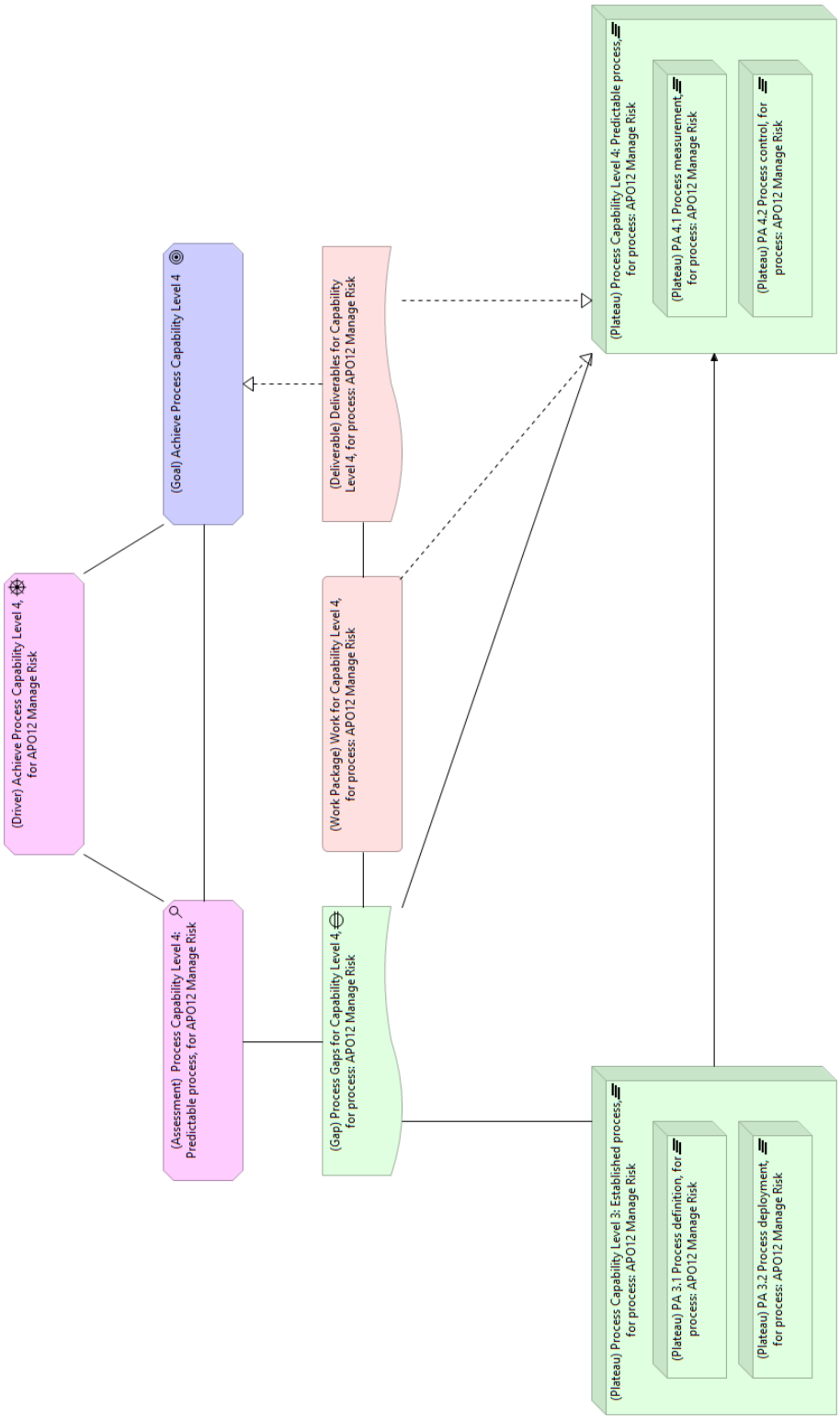
Appendix Figure 23: Process Capability Improvement View, Level 0 to Level 1, for process APO12 Manage Risk



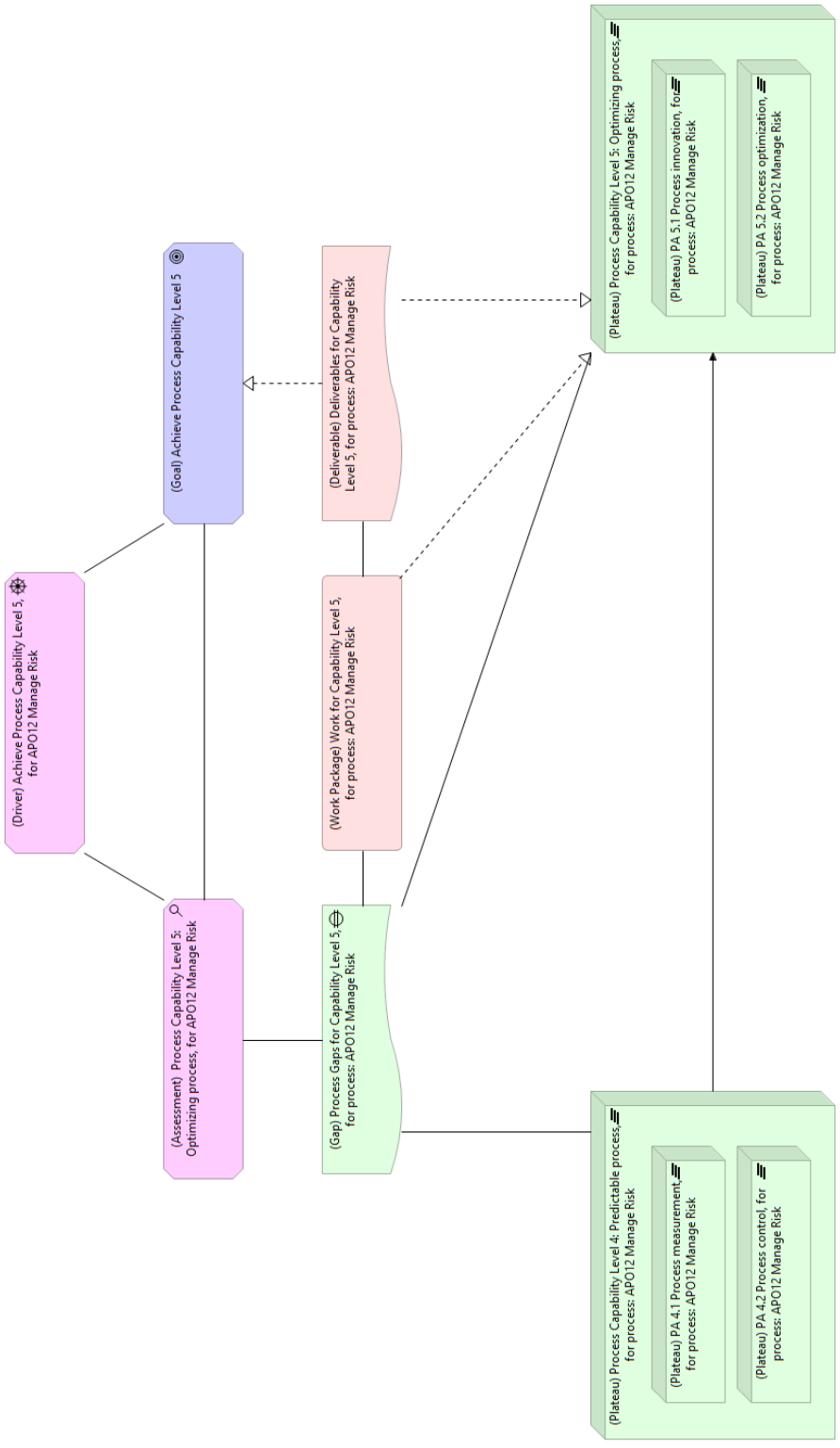
Appendix Figure 24: Process Capability Improvement View, Level 1 to Level 2, for process APO12 Manage Risk



Appendix Figure 25: Process Capability Improvement View, Level 2 to Level 3, for process APO12 Manage Risk



Appendix Figure 26: Process Capability Improvement View, Level 3 to Level 4, for process APO12 Manage Risk



Appendix Figure 27: Process Capability Improvement View, Level 4 to Level 5, for process APO12 Manage Risk