Modeling ISO 31000 using Archimate

Abstract*— Organizations are subject to a set of internal and external factors that may have a negative effect on the achievement of their objectives. These uncertain effects are called risks. To deal with these risks and to improve risk management, ISO 31000 proposes the development, implementation, and continuous improvement of a framework that integrates the process of managing risk with an organization overall governance, strategy and planning, management, reporting processes, policies, values, and culture. Although many organizations have already adopted this standard and feel an improvement in how they manage and deal with risks, there are still many organizations that do not adopt ISO 31000. Thus, the main objective of this research is to reduce the complexity of the ISO 31000, thus facilitating the understanding of this standard. To achieve this objective, an ArchiMate representation of the ISO 31000 metamodel is proposed, as well as the use of an Enterprise Architecture tool that will allow us to promote Governance, Risk and Compliance initiatives aligned with the unique enterprise structure and behaviour.

Keywords—Archimate; Enterprise Architecture; ISO 31000; Modelling;

I. INTRODUCTION

Organizations are subject to a set of internal and external factors that may have a negative effect on the achievement of the organization's objectives. These uncertainty effects are called risks [1]. In everyday language, the word"risk" is used to describe the danger and uncertainty related to the possibility of an adverse event [2]. Organizations should take measures to control uncertainty in order to achieve their objectives [2]. These measures are known as "risk management" [3]. To deal with these uncertainties and also to improve the risk management of organizations, an International Standard was created.

ISO 31000 proposes the development, implementation and continuous improvement of a framework that integrates the process of managing risk with an organization overall governance, strategy and planning, management, reporting processes, policies, values and culture [1]. For all types of organizations, the implementation of this type of standard has become increasingly important over the years [5]. Organizations realized that risks cannot be seen in isolation, and should be integrated with other areas of the organization [1]. The problem is there are still many organizations that do not use this type of standards because they do not know exactly how to use them and how to integrate these practices with other frameworks and standards [6]. For example, according to a recent study, just 13 of the 42 organizations surveyed use ISO 31000. Moreover, nearly half of them have no plans to implement ISO 31000 at all [3]. According to [7] organizations struggle even more with the complexity and difficulty of understanding and interpreting several frameworks and standards, because each framework/standard defines its own scope, definitions, terminologies that make difficult to work in multimodel environments. In that way, organizations avoid learning and adopting different standards and frameworks.

Thus, this paper aims to reduce the perceived complexity of ISO 31000 in order to help organizations understand and apply more effectively its main concepts. In order to do so, we propose to model ISO 31000 using ArchiMate as a complement to the current textual representation of this standard [8][9]. Visual models depict a more comprehensible representation, making information more explicit [10].

ArchiMate is the "de facto" standard for modeling Enterprise Architecture (EA) and was the modeling language chosen for this paper since EA brings several advantages such as: communication, standardization, reusability and process improvement [8].

The term "Enterprise Architecture" has recently gained remarkable attention [11]. EA modeling is more than analyzing and designing information systems, and it is more than drawing "bubbles and arrows". EA is about conceptualizing an important part of the world, as it actually is and as it might be [12]. On a high level of abstraction, an enterprise model serves three interrelated purposes: to promote communication and collaboration, control, and change [12].

However, EA models size, level of detail and complexity can make its analysis a hard task [11]. In fact, ArchiMate models can be compared to standards, in which a set of documents written in natural language is also a large and complex set of guidance [10].

Therefore, we also propose to reduce the perceived complexity of multiple standards, not only by designing visual models but also by managing these models in an EA tool that will allow us to monitor all these models, instances and concepts over time.

The paper is organized as follows: In section II we present the state of the art including the ISO 31000 and modeling theories that will be used in this paper; Section III we present the proposal; Section IV presents the theoretical evaluation of the proposal; Section V we present the conclusion of the paper.

II. STATE OF ART

In This section we will discuss the most relevant topics that help to sustain our proposal.

A. ISO 31000

ISO 31000 is the title of the international standard on the best practices of risk management [13]. This International

Standard establishes a number of principles that need to be satisfied to make risk management effective. This International Standard recommends that organizations develop, implement and continuously improve a framework whose purpose is to integrate risk management into its overall management system [1][14].

ISO 31000 provides a structured framework which intends to align with the organization goals and needs, this link strengthen both the relevance and the importance of risk management [13][14]. In order to be applied to different risks and activities, the approach proposed in the standard is fundamentally intended to be generic and rational [14][15].

In summary, the ISO 31000 standard provides a vehicle to make risk management central to the success of an organization, and integrated with key processes such as planning, management and governance [13].

B. *Modelling Metamodel*

According to Lehman "any program is a model of a model within a theory of an abstraction of some portion of the world or of some universe of discourse" [16]. An Enterprise model comprises conceptual models of software systems that are integrated with conceptual models of action systems [12][17]. These models serve three basic interrelated purposes: to promote communication and collaboration, control and change [12]. Metamodel can be seen as "a model of a model" which has a higher level of abstraction [16]. It is important to note that when we talk about metamodels, the instances of our model are models and the real world or the universe of discourse [16]. This means that for a given real-world instance, it is associated with a model and further to a metamodel, which means we have three different levels of abstraction and the application of abstraction mechanisms takes a systematic look at how these hierarchies are constructed, in other words it is an operation that can be applied repeatedly [16]. The term "metaization principle" arises from this idea [16].

When modeling a metamodel, to achieve the previously mentioned purposes, it is very important to follow a set of principles and guidelines. Schutte and Rotthowe(1998) proposed a set of principles in order to evaluate information models [18]. We will apply the principles to the metamodel proposed in this paper. These principles are:

1) *Principle of Construction Adequacy:* The first principle, "Principle of Construction Adequacy" represents criteria for the evaluation of the problem representation in the model. This means that the construction of the model should be adequate to the problem and purpose and requires consensus regarding the represented problem and the type of construction [16] [18].

2) *Principle of Language Adequacy:* This principle is focused on the interrelation between the model and the language used. The modeling language should fit the purpose of the model [16][18].

3) *Principle of the economic efficiency:* The principle of the economic efficiency refers to economic restrictions formulated within the information modeling processes [16][18].

4) *Principle of Clarity:* This principle means that a model should be understandable and explicit [18]. All concepts and relationships of the model must make sense and be explicitly identified.

5) *Principle of Systemic Design:* The principle of Systemic Design refers to a well accepted differentiation between diverse model views [18]. The different model views should be consistent.

6) *Principle of Comparability:* The last principle is the Principle of Comparability. This principle aims to compare two or more models based on their semantic similarity [18]. Goeken and Alter (2009) argue that "comparability is one of the major principles in a metamodel environment", because metamodels have high abstraction levels and are often used to be compared [16].

These principles are suitable for any model and therefore suitable for the metamodels, however Goeken and Alter(2009) propose an extension of these principles when dealing with metamodels, since these principles focus more on the comparison of models with reality, while metamodels have a higher level of abstraction [16]. These guidelines are presented below:

- *Guideline 1- A metamodel reveals its principles of "metaization":* The principle of "metaization" defines the primary abstraction for structuring the objects of the lower level [16]. This means that for a given real-world instance, it is associated with a model and further to a metamodel, which means we have three different level of abstraction and the application of abstraction mechanisms takes a systematic look at how these hierarchies are constructed, in other words it is an operation that can be applied repeatedly [16].

- *Guideline 2 - A metamodel has an unambiguous mapping between the universe of discourse and the words and symbols which name and describe it:* The metamodel should have a clear map between a concept and it's meaning [16]. In the scope of this paper for example, we are modeling the ISO 31000 standard, and this standard has many concepts that can have the same name as other standards or frameworks but their meaning may change, it is important that every concept meaning is clearly identified.

- *Guideline 3 - A metamodel has semantically rich connections:* Due to the level of abstraction existing in the metamodels, it is very important that the connections that exist between two concepts are as strong and descriptive as possible [16].

C. Enterprise Architecture

Lankhorst (2009) defines EA as "a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure" [11]. EA captures the essentials of the business, IT and its evolution. Also, EA offers a holistic perspective of the current and future operations, and on the actions that should be taken to achieve the enterprise goals, thus facilitating the translation from corporate strategy to daily operations.

Authors recognize the relevance of models for the representation of the essence of an EA in an unambiguous form [11]. A model is an abstract and unambiguous conception of a domain, built to fulfil a purpose and meant to answer questions [11] It is rarely the case in which a stakeholder has interest in the full scope and detail of models representing EA. As such views over such models are required to address specific stake-holder's concerns. A view is specified by means of a viewpoint, which in turn prescribes the conventions for constructing and using a view. A viewpoint must contain the necessary concepts and relations to address the specific concerns [11].

D. Archimate

The purpose of ArchiMate is to provide a descriptive language for EA. This language consists of a metamodel describing the various concepts and relationships, as well as a standard notation for them [19].

ArchiMate is a language in which the service concept plays a central role. The objective of the ArchiMate language is to provide well-defined relationships between concepts in different architectures, the detailed modeling of which may be done using other, standard or proprietary modeling languages. Concepts in the ArchiMate language cover the business, application, and technology layers of an enterprise and provide an extended layer that represents the motivation. Services offered by one layer to another play an important role in relating the layers [20].

Moreover, ArchiMate is a formal visual design language, supports different viewpoints for selected stakeholders, and is flexible enough to be easily extended [21].

Lankhorst enumerates several languages for modeling IT and business such as IDEF, BPMN, ARIS and UML. However, Lankhorst also identifies common issues among them all, like poorly defined relations between domains, models not integrated, weak formal basis and lack of clearly defined semantics, and most of them miss the overall architecture vision being confined to either business or application and technology domains [22].

In turn, ArchiMate provides a uniform representation for diagrams that describe EAs and offers an architectural approach that describes and visualizes the different architecture domains and their underlying relations and dependencies [21].

III. Proposal

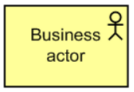
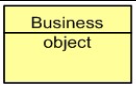
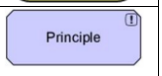
ISO 31000 is a recognized worldwide reference in the area of risk management. Organizations realized that risks cannot be seen in isolation, and should be integrated with other areas of the organization [1]. The problem is there are still many organizations that do not use this type of standards because they do not know exactly how to use them and how to integrate these practices with other frameworks and standards [6]. We think that the best way to solve these problems and facilitate the use of this standard, in order to align it with the objectives of an organization, is to develop a metamodel that allows a more effective use and understanding of all the concepts of the standard and their relations in an organization.

In this section we begin by proposing a metamodel in Archimate of ISO 31000, in which all concepts are taken from "ISO31000:2009 Risk Management – Principles and Guidelines" [1]. We then validate our metamodel with the principles and guidelines proposed by Goeken and Alter (2009) [16]. Finally, we present simple examples of how we can use the enterprise architecture and EA tools to incorporate metamodels and model views into a real organization.

A. Metamodel

Before setting up a metamodel for ISO 31000 using Archimate, we first mapped ISO31000 concepts to Archimate concepts, as shown at table 1.

TABLE I. MAPPING ISO 31000 CONCEPTS INTO ARCHIMATE CONCEPTS

ISO 31000 Concept	ISO 31000 Concept Description	Archimate Concept	Archimate concept Description	Archimate Representation
Framework	Set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization	**Business Process**	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 of business services	
Framework Components	Designing, implementing, monitoring, reviewing and continually improving risk management components			
Risk Management Process	Systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing risk			
Risk Management Stage	Communicating, consulting, establishing the context, and indentifying, analysing, evaluating, treating, monitoring and review risk phases			
Activities for the Framework Components	Set of activities which are related to framework components			
Activities for the Risk Management Stage	Set of activities which are related to risk management stage			
Organization	Person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives	**Business Actor**	A business actor is defined as an entity that performs behaviour in an organization such as business processes or functions	
Top Management	Person or group of people who directs and controls an organization at the highest level. Has the power to delegate authority and provide resources within the organization			
Risk Source	Element which alone or in combination has the intrinsic potential to give rise to risk			
Risk Owner	Person or entity with the accountability and authority to manage a risk	**Business Role**	A business role is defined as a named specific behaviour of a business actor participating in a given context. The actor performs the behaviour of the role	
Outcomes	Set of information produced during the framework component processes and risk management stage processes	**Business Object**	A business object is defined as a passive element that has relevance from a business perspective.	
Event	Occurrence or change of a particular set of circumstances	**Business Event**	A business event is defined as something that happens (internally or externally) and influences behavior.	
Principle	ISO 31000 Principles	**Principle**	A principle is defined as a normative property of all systems in a given context, or the way in which they are realized.	
Goal	Organizational goals and objectives	**Goal**	A goal is defined as an end state that a stakeholder intends to achieve	
Control Objective	Adequacy and objective of the control			
Control Measure	Measure that is modifying risk	**Requirement**	A requirement is defined as a statement of need that must be realized by a system.	
Risk	Effect of uncertainty on objectives	**Assessment**	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	
KPIs	Risk Management Performance Measures			
Attributes	Represents a high level of performance in managing risk			
Key Driver	Leading factors affecting performance and goals for an organization	**Driver**	Something that creates, motivates, and fuels the change in an organization.	
Stakeholder Needs	Organization internal and external needs			
Stakeholder	Organizational internal and external stakeholders	**Stakeholder**	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.	

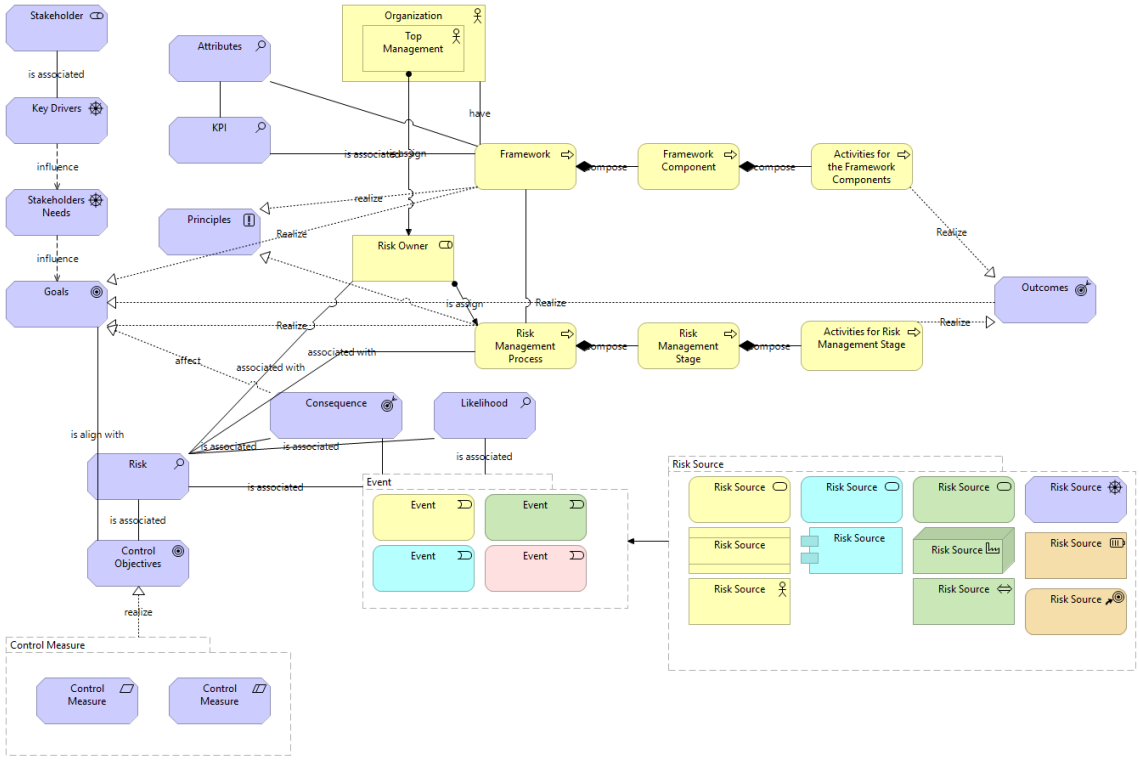


Figure 1 – ISO 31000 Metamodel in Archimate

The metamodel presents in figure 1 contain all the relevant concepts present in ISO31000:2009- Guidelines and Principles [1]. The main concepts of this standard and that are the basis of this metamodel are: Principles, Framework and Risk Management Process[1]. The framework realizes a set of specific principles inherent to the standard and implements the Risk Management Process, which is the process that deals with the risk. The organization can choose when it reaches the risk management stage -"Treatment", whether or not to use some control measure for risk treatment. The metamodel supports this option. The framework has a set of KPIs and attributes to evaluate the entire risk management performance, and thus make improvements in the risk management process. It is crucial that both the framework and the Risk Management Process are aligned with the scope and objectives of the organization in question [1].

B. *Principles and Guidelines*

1) Principle of Construction Adequacy

To fullfill this principle we have to ensure that our metamodel is adequate to the problem and purpose, to achieve consensus regarding the represented problem and the type of construction [16]. Our metamodel is based on “ISO 31000: 2009, Risk management - Principles and guidelines” [1]. We use our metamodel to represent and clarify all the components present in ISO31000.We find consensus in the sense that all the concepts represented in the metamodel are concepts of this standard and can be clearly indentified. The concepts of this standard are for the most part concepts that have a high level of abstraction to be applied to any type of organization. For that reason we use conceptual metamodels as the type of construction.

2) Principle of Language Adequacy

This principle is based on choosing a modeling language that fits the purpose of the model [16]. Archimate was the chosen language for modeling the metamodel. The purpose of ArchiMate is to provide a descriptive language for EA [11]. Lankhorst (2013) enumerates several languages for modeling IT and business such as IDEF, BPMN, ARIS and UML [22]. However, Lankhorst (2013) also identifies common issues among them all, like poorly defined relations between domains, models not integrated, weak formal basis and lack of clearly defined semantics, and most of them miss the overall architecture vision being confined to either business or

application and technology domains [22]. In turn, ArchiMate provides a uniform representation for diagrams that describe EAs and offers an architectural approach that describes and visualizes the different architecture domains and their underlying relations and dependencies [21].

3) Principle of the economic efficiency

This principle "formulates the economic restrictions every activity is exposed to" [16]. Goeken and Alter (2009) argue that "there is no need for changes or extensions in a metamodelling approach" [16].

4) and 5) Principles of Clarity and Systemic Design

To fulfill these principles it is important that our model is clear and contains all the components of the standard we are representing, in this case ISO 31000 [16]. In order to achieve these principles the metamodel represented in fig X contains all the relevant components of ISO 31000. The definition of these components as well as their mapping to the archimate language is represented in table 1.

6) Principle of comparability

Goeken and Alter (2009) argues that "comparability is one of the major principles in a metamodel environment". That's because metamodels are conceptual models with high abstraction levels and are often used to be compared with other models [16]. A good example of how we can use the comparison in our metamodel will be for example to analyze the differences between this version of the standard ("ISO 31000: 2009") and the version of the same standard that is planned to be published at the end of 2017 or early 2018.

- Guideline 1- *A metamodel reveals its principles of "metaization"*: The principle of "metaization" defines the primary abstraction for structuring the objects of the lower level [16]. This means that for a given real-world instance, it is associated with a model and further to a metamodel, which means we have three different level of abstraction and the application of abstraction mechanisms takes a systematic look at how these hierarchies are constructed, in other words it is an operation that can be applied repeatedly [16]. Our metamodel is highly abstract and where concrete concepts of the universe of discourse can be repeatedly instantiated for the metamodel, verifying the use of this principle.

- Guideline 2 - *A metamodel has an unambiguous mapping between the universe of discourse and the words and symbols which name and describe it*: We use ISO 31000 notion in our metamodel. The user of ISO31000 can identify and understand the concepts used in the metamodel.

- Guideline 3 - *A metamodel has semantically rich connections*: The relations used in the metamodel are not limited to simple relations and try as clearly as possible to represent the relations of the universe of discourse

C. How can we use EA tools to implement ISO 31000 metamodel in a real organization?

In addition to the metamodel in Archimate, this paper proposes the use of EA tools that can align models and organizations. For this purpose we propose the use of a tool that aligns all the concepts of ISO31000 and that makes all the alignment with the objectives of the organization. Any goal that is implemented in the EA tool of a certain organization can be directly linked to this whole metamodel and this will allow us to see if the organizations whether or not study and monitor the risks of failure to fulfill the goals it proposes. The tool chosen was Enterprise Architecture Management System (EAMS). This tool supports the Archimate language and even supports the import of Archimate models in the tool. We will now give some simple examples of how this tool can be used in order to implement ISO31000 in an organization. First it is necessary to have a metamodel that functions as a conceptual basis. For this we implement the same Archimate metamodel proposed with all the concepts and relations. Figure 2 represents a blueprint of the metamodel, generated automatically by EAMS.

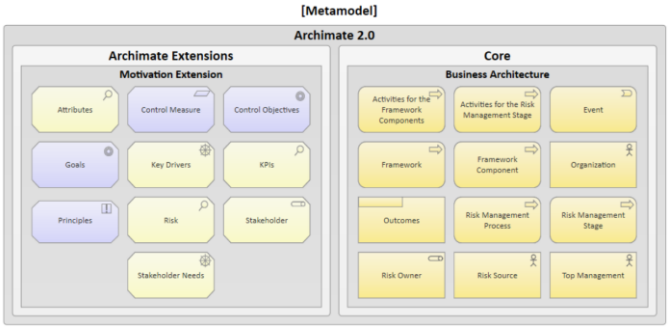


Figure 2- ISO31000 Metamodel in EAMS

EAMS is a highly configurable tool, it is possible to create instances of all concepts that have been stored in the EAMS database and can be edited when justified. With these instances we can create model views, these model views are highly configurable, and it is possible to represent the most diverse views, and even it is possible to verify changes over time of instances and models. These views can have a generic or hierarchical aspect and it is also possible to configure these model views in order to be able to navigate between views.

We can represent simple views, such as listing all the activities of a given instance of "Risk Management Stage" or list all the components and sub components of the framework in generic form as represented in figure 3 or hierarchical as shown in figure 4.

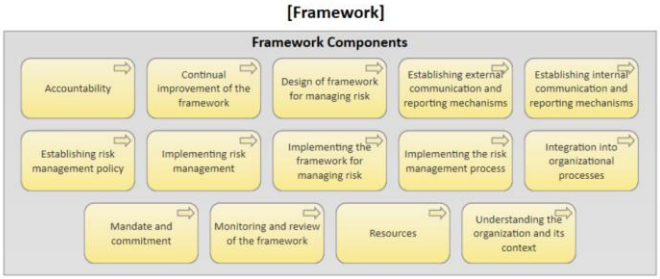


Figure 3 - Generic view of Framework Components

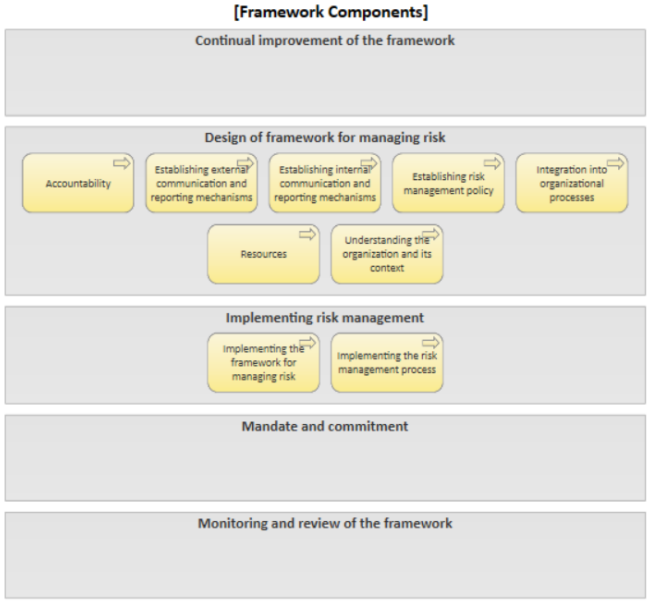


Figure 4- Hierarchical view of Framework Components

It is also possible to create more complex configurations such as creating a risk view, in which after selecting the risk instance, we can list all the instances of the concepts that have a connection with that risk. Another example can be the creation of views to list the outcomes of a certain framework component, in figure 5 we represent some of the possible outcomes that could be listed that correspond to the component of Design of framework for managing risk.

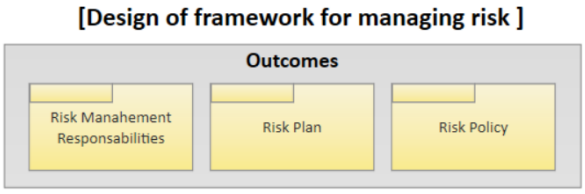


Figure 5 – Example of Design of Framework for Managing Risk Component Outcomes

We conclude this section with the idea that the use of EA tools can have a great impact and be an effective enabler of the use of the most diverse standards and in particular for this paper of ISO 31000.

IV. Evaluation

A. *Österle Principles*

Scientific research in general needs to be characterized by abstraction, originality, justification, and publication in order to distinguish itself from the way solutions are developed in the practitioners' community (e.g. in user organizations) or by commercial providers (e.g software vendors, consulting companies) [23].

- Abstraction: Each artifact must be applicable to a class of problems;
- Originality: Each artifact must substantially contribute to the advancement of the body of knowledge;
- Justification: Each artifact must be justified in a comprehensible manner and must allow for its validation;
- Benefit: Each artifact must yield benefit, either immediately or in the future, for the respective stakeholder groups.

Thus, we fulfilled the four principles of Österle et al. (2011) in the following manner, if:

- Abstraction: This artifact proposes the metamodel of the international standard ISO 31000.
- Originality: The proposal is not present in the Book of Knowledge of the domain, the fare as the authors are aware.
- Justification: The ArchiMate language and the [Goeken and Alem] Principles and Guidelines of Modeling justify the metamodel proposal
- Benefit: We believe that the use of Archimate metamodels and the use of EA tools to represent ISO 31000 reduce the complexity of the standard, thus facilitating the understanding and implementation of risk management practices.

V. Conclusion

In this paper we discuss and propose a metamodel using Archimate to represent the concepts and relationships that exist in ISO 31000 [1]. The main objective of this research is to reduce the complexity of ISO 31000, thus facilitating the understanding of this standard. In order to evaluate this meta-model and achieve the objectives of this paper, the principles and guidelines proposed by [16] were followed. Although there are some limitations, the metamodel drawn in Archimate was designed based on the knowledge and experience of the authors, and it would be important to validate with experts in the area this metamodel.

We also propose in this paper the use of EA tools that allow alignment between the objectives of the organization and the ISO 31000 standard [1]. To demonstrate the benefits of these tools, we used EAMS and we did some simple model views to demonstrate the benefits of using these EA tools.

It would be interesting as future work, to deepen the use of these tools based on the metamodel created, to instantiate and to put into practice in a real organization, creating several model views that were interesting from the point of view of the organization, with the aim of improving the control and practices of risk management.

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