# Traceability from the Business Value Model to the Enterprise Architecture: A Case Study

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**Abstract.** Information and communication technology (ICT) is a significant part of business value propositions. Netflix and Spotify would not have been possible without internet technology. Therefore, it is not sufficient to consider the ICT of a business as a cost center only. Rather it drives profit, and hence should be considered in concert with the business value model of a company. In previous research we have defined guidelines to transform a business value model into an enterprise architecture.
In this paper, we validate the set of guidelines in a real-world case study, in which we created the business value model of a ecosystem and used our guidelines to redesign its enterprise architecture (EA). We quantified the business value model with revenues and expenses for the company. We validated the resulting models and their traceability with management and the enterprise architect of the company. The result is a further improvement and simplification of our guidelines.
In this paper we present the case study, the models and the resulting guidelines. We end the paper with a discussion of further research needed to bring these research results to practice.

**Keywords:** $e^3value$ , ArchiMate, Traceability, Business Value Model, Enterprise Architecture.

## 1 Introduction

Commercial services and physical products rely heavily on ICT. For example, Netflix and Spotify would not have been possible without the large scale deployment of content servers and networks. Physical products often have digital twins, which complement the product with additional features, allowing for simulation, training, etc. Since ICT is an intrinsic part of the value proposition of an organization, it can not be considered as a cost-only factor. ICT should be part of value proposition design.

Additionally, many products and services are offered as bundles in complex *business ecosystems*, where each enterprise focuses on its core competence and jointly they satisfy a complex customer need. Following Moore [15], we define an

ecosystem as a "collection of companies that work cooperatively and competitively to satisfy customer needs."

In order to be financially sustainable, an ecosystem requires a *business value model* (henceforth called "business model"), which we define as a conceptual model that represents the creation, distribution, and consumption of economic valuable objects in a *network* of participants, namely the ecosystem [7]. Valuable objects are services and products that satisfy customer needs, as well as payment for these; also called the reciprocal value transfers.

With ICT-intensive services and products, the design of the provisioning *Enterprise Architecture* (EA) is part of business design. An EA is a high-level conceptual model of an enterprise designed to put the business strategy of an organization into operation [22]. Ideally, in case of ICT intensive products and services the EA puts the business model into operation and hence contributes directly to the profit of enterprise. For this, we need an approach to design the EA of ICT-intensive products and service *in concert* with the business model of the eco-system. Currently, there is no such approach.

As we take a network view of business models, we use *e*$^3$*value* as the business model notation [8, 7]. In accordance with our networked view, EAs too should be extended to an ecosystem of enterprises [20]. We use ArchiMate [18] as the EA language, where we focus on its capability to model business services and collaborations.

An *e*$^3$*value* model focuses on actors in a value network and the economic feasibility of the value adding activities in an organization. An ArchiMate model operationalizes this in terms of business services and collaborations, business processes and applications needed to realize this. The models contain different, but also partly overlapping information. A transformation from an *e*$^3$*value* model to an ArchiMate model can therefore not be automatic and the guidelines defined in this paper must be complemented with design choices. The contribution of this paper is that we provide a real-world validation of transformation guidelines we developed earlier, and present further improvements to the guidelines to make them more precise. We also elicit an evaluation from practitioners of how to use the conjunction of *e*$^3$*value* design and EA design for investment analysis.This paper is structured as follows. In section 2 we describe our research methodology and research questions. Section 3 lists our redesigned guidelines and section 4 describes our case study. Section 5 describes related work. We discuss our results in section 6 and conclude with an indication of future research in section 7.

## 2 Methodology and research questions

We have developed guidelines for business-model-driven EA design in three iterations of the design cycle [21].

- **Conceptual design:** We analyzed the metamodels of *e*$^3$*value* and ArchiMate to define an initial version of the guidelines (version 1). We tested it on a small real-world example: an EA for the Cirque du Soleil [4].

- **Lab validation and redesign:** We tested the guidelines in an experiment where we compared the EAs designed by practicing architects from a business model in a laboratory assignment, with the EA that results from our application of the guidelines [5]. Althouh the assignment took place in the lab, the cases for which the architects designed an $e^3value$ model and an EA were from the real world: the companies where they were employed. Analysis of the experiment led to a redesign of the guidelines (version 2).
- **Real-world validation and redesign:** We applied the guidelines to a real-world case to redesign the business layer of the enterprise architecture of an enterprise. This is the case study reported in this paper. This experience led to a further improvement of the guidelines (version 3).

Although version 3 of the guidelines are the result of applying version 2 on the case study, for readability we present version 3 in section 3 before presenting the case study in section 4.

The case study is technical action research, as it has two goals: to learn more about the guidelines and refine them, and if we can construct a correct business layer architecture from a $e^3value$ business model diagram. [21].We validated the resulting enterprise architecture, and the $e^3value$ model that we designed, with management and the enterprise architect of the company. This allowed us to answer the following research questions:

Q1 Do the guidelines produce a correct enterprise architecture of the business model?
Q2 Is the resulting traceability relation useful to make investment and divestment decisions?

To preserve confidentiality, we refer to this company as company X and we changed some details in the models that we will present.

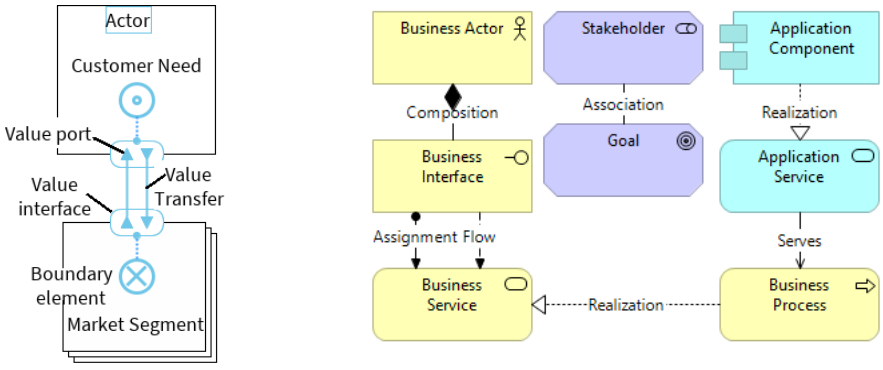
## 3 Redesigned guidelines

Figure 1 provides the legends of $e^3value$ and ArchiMate that we use in this paper [5]. Tables 1-3 present some of our revised guidelines. Table 1 gives one of the guidelines to transform an $e^3value$ model into an ArchiMate motivational model [6]. Basically, the idea is that:

- An $e^3value$ actor is mapped to an ArchiMate stakeholder. The reason is that an $e^3value$ actor is an actor who has something to gain or lose.
- A need of an $e^3value$ actor is mapped to an ArchiMate stakeholder goal. The reason is that a need in $e^3value$ is a lack of something valuable that the actors wants to acquire. In other words, it is a goal.

[5] See the $e^3value$ user guide at `https://e3value-user-manual.thevalueengineers.nl/` and the ArchiMate documentation at `https://pubs.opengroup.org/architecture/archimate3-doc/`.

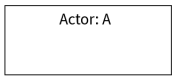
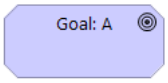
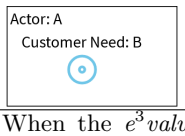
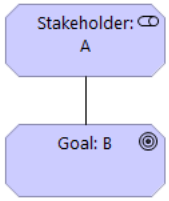
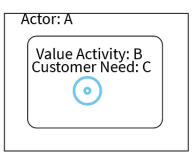
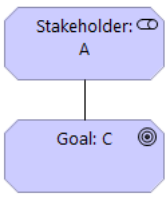
[6] A version of the paper with the complete table is available at `https://www.thevalueengineers.nl/pdf/EMMSAD-2021-long.pdf`.




(a) Legend for $e^3value$ . (b) Legend for ArchiMate.

Fig. 1: Legends for $e^3value$ and ArchiMate

Table 1: $e^3value$ mapping to the motivation layer of ArchiMate.

| No | Guideline | Additional advice |
|---|---|---|
| G1 | An $e^3value$ actor or a market segment can always be modeled as a stakeholder in the ArchiMate motivation layer with the same name. By definition an actor is always a stakeholder. This is not true for the other way around.   | Additional detail can be added to the stakeholder using the composition, aggregation or specialization relation in ArchiMate. It is not always necessary to model every actor as a stakeholder. This is a choice the enterprise architect has to make   |
| G2 | A customer need must be modeled as a goal from the ArchiMate motivation layer with the same name as from $e^3value$   | Construct a complete and correct goal model if needed.   |
| G3 | When the $e^3value$ actor contains a customer need, this combination must be modeled using stakeholder, goal and association relationship from the motivation layer of ArchiMate.   | This is a combination of G1 and G2.   |
| G4 | When the $e^3value$ actor contains a value activity and a customer need, this combination must be modeled using stakeholder, goal and association relationship from the motivation layer of ArchiMate.   | This is a combination of G1 and G2. The value activity is not translated into the motivation layer.   |

Tables 2 and 3 list the guidelines for designing an ArchiMate business layer model from an *e*$^3$*value* value model. Compared to version 2 [5], we improved the mapping of ports and collaborations, merged a few rules and added rules for and- and or-gates. The tables show the guidelines for designing an EA of a focal company, which is embedded in a network of companies. To design the EA of more than one company, the guidelines have to be applied to each company.

- An *e*$^3$*value* actor is mapped to an ArchiMate business actor.
  A *e*$^3$*value* actor is an entity that is responsible for its survival and well-being, e.g. a profit-and-loss responsible company or a consumer [7]. An ArchiMate business actor is a business entity that is capable of performing behavior [18]. This implies that all *e*$^3$*value* actors are ArchiMate actors but not the other way around. By definition an ArchiMate actor is always a stakeholder, as he has something to gain or lose. *e*$^3$*value* actors can therefore be depicted on both the stakeholder and business actor concepts.
- An *e*$^3$*value* value activity of an actor becomes an ArchiMate business service of that actor.
  An *e*$^3$*value* activity is a task performed by an actor that potentially results in a benefit for the actor [7]. An ArchiMate business service is explicitly defined behavior that a business role, business actor, or business collaboration exposes to its environment [18]. We view every *e*$^3$*value* activity as a potential business service exposed by the focal company. A value activity is connected to its environment through a value port, similarly as a business service is connected to its environment. This way, a value activity cannot be mapped to a business process, since a business process is internal to the organization.
- An *e*$^3$*value* value port of an actor becomes an ArchiMate business interface of a that actor. This is a change of version 2.
  An *e*$^3$*value* value port is a willingness to provide or request something of value (a value object) [7]. ArchiMate business interfaces are channels through which a business service is made available. An value port has no direct counterpart in ArchiMate. However a value port can be composed into an ArchiMate business interface. This adds a channel. Value ports from multiple value interfaces from an OR dependency graph can be mapped to a single business interface. One or more value ports of a single business interface or an AND dependency graph can also be represented as a single business interface. When there are different channels to a value port, multiple business interfaces are mapped to value ports from a single value interface.
- An *e*$^3$*value* value interface is a collection of two or more ports that defines a commercial transaction. This is not translated into an ArchiMate model component because transactionality of commercial transactions is not represented in ArchiMate.
- An *e*$^3$*value* value transfer can be mapped to an ArchiMate flow relation and to an ArchiMate serving relation with a direction that depends on the direction of the *e*$^3$*value* dependency path.

Table 2: $e^3value$ mapping to the Business layer.

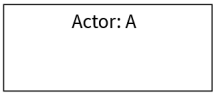
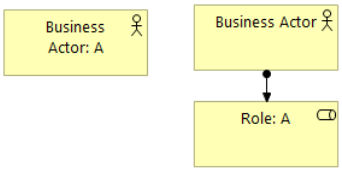
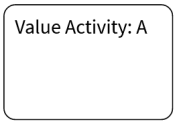
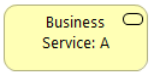
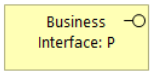
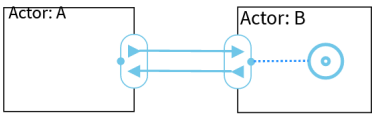
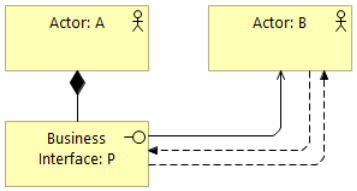
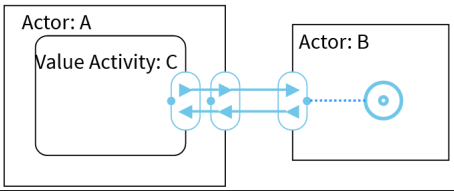
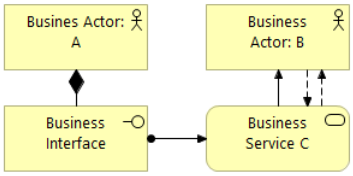
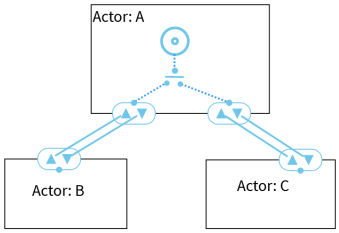
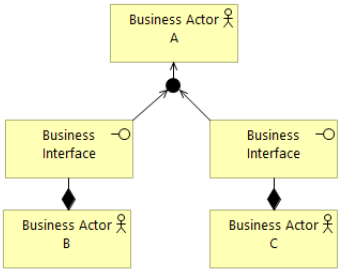
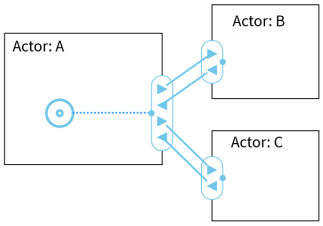
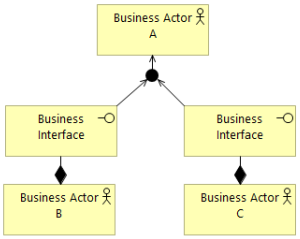
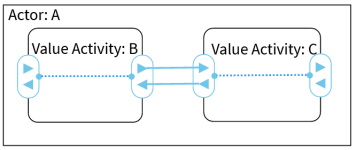
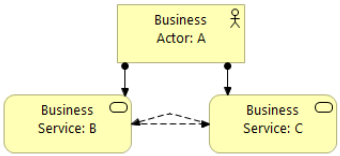
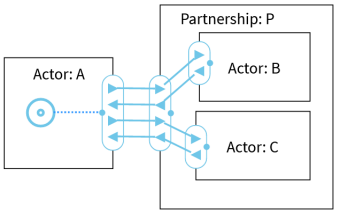
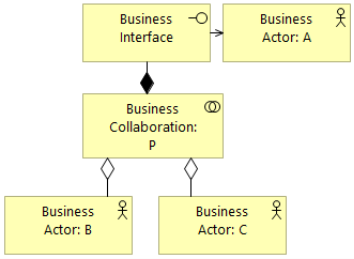
| No | Guideline | Additional advice |
|---|---|---|
| G5 | An $e^3value$ actor or market segment is mapped to an ArchiMate business actor with the same name, or to an ArchiMate actor that assumes a role with that name.   | In ArchiMate we can identify additional business actors. For example, we may identify actors internal to an organization and we may decompose an actor.   |
| G6 | An $e^3value$ value activity is mapped to an ArchiMate business service with the same name.   | Services can be internal or external to the organization itself. Additional detail and service composition might be required.   |
| G7 | $e^3value$ value ports are mapped to ArchiMate business interfaces   | one or more value ports from one or more value interfaces of a same value activity can be mapped to the same ArchiMate business interface.   |
| G8 | An $e^3value$ value exchange is mapped to ArchiMate flows. In addition, the exchange can be mapped to an ArchiMate serving relation in the direction of supplier to customer. Ports of the focal company will be mapped to one or more ArchiMate business interfaces.   | If B contains a boundary element instead of a need, the direction of the serving relation would be reversed.   |
| G9 | An $e^3value$ activity connected through a value exchange to a need of an actor is mapped to an ArchiMate business service serving the actor.   | If B contains a boundary element instead of a need, the direction of the serving relation would be reversed.   |

Table 3: $e^3$*value* mapping to the Business layer

| No | Guideline | Additional advice |
|---|---|---|
| G10 | An AND/OR gate in $e^3$*value* maps to an and/or junction in ArchiMate.   | For the or junction the connector in ArchiMate is a hollow circle. Flows can be added as needed as in G8.   |
| G11 | Two $e^3$*value* actors connect to a single value interface to address a customer need are mapped to an and-junction in ArchiMate in the same way as in G11.   |   |
| G12 | An $e^3$*value* value exchange between two value activities inside an actor maps to mutual flows between two ArchiMate business services of that actor.   | The flow relation denotes the transfer of money, information or goods. If the direction of the dependency path is known, this can be represented by a serving relation in ArchiMate.   |
| G13 | A composite actor in $e^3$*value* is mapped to a business collaboration in ArchiMate.   | The business collaboration will offer services from both actors as a bundle. Use a composition or aggregation relation between the parent and child services.   |

An $e^3value$ transfer is a willingness to transfer a value object from provider to requester [7]. A flow relationship is a transfer of information, goods or money between elements [18]. In addition, value transfers are part of a dependency path that starts from one or more needs. This determines which elements delivers a servive to which other element (the serving relation) [18].

– A value transfer is associated with a *value object* in $e^3value$ .
A value object is a money- or non-money object that is of economic value for at least one other actor in the value network. There are multiple ways to depict a value object in ArchiMate. A value object can be tangible or intangible. A tangible value object may be represented as a *business object* in ArchiMate. The *value* concept can be used for intangible value objects. But money is neither a business object nor value concept. Because of this, a value object will not be translated into ArchiMate for now.

## 4 Case study

### 4.1 The company

Company X is responsible for building startups based on an acquisition of intellectual property. The main goal of organization is to increase the share value of the startup and finally sell the startup to other investors. Company X has three major value-adding activities: Scouting new technology, supporting startups during their growth, and selling matured startups. Support provided by X ranges from HRM, legal, financial administration, providing management, etc. We cannot provide exact details and the business model below differs somewhat from the actual business model. The company had an existing EA in place.

### 4.2 Application of the guidelines

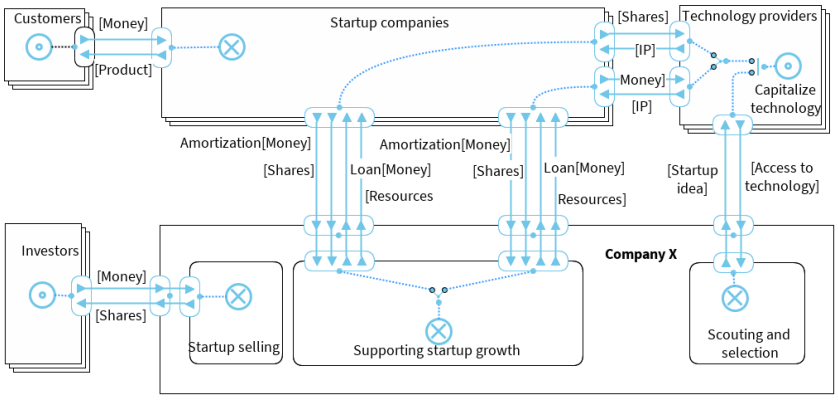



Fig. 2: $e^3value$ model of company X.

Figure 2 shows the business model of X. An $e^3value$ model represents commercial transactions in a time period called the *contract period*.

In the model of figure 2, company X performs three value-adding activities, Scouting and selection, Supporting startup growth, and Startup selling. Technology providers have the need to capitalize technology. To satisfy this need, they exchange access to technology for a startup idea with company X and they transfer IP in the technology to a startup. IP can be transferred in exchange for shares or in exchange for money. In both cases, X lends money to the startup, makes resources available, receives startup shares and receives the amortization of the loan. However, only a fraction of the shares will be transferred if the technology provider receives part of the shares. This will be represented in the quantified model, discussed later.

Since this model contains no time ordering, it provides no information about when the loan is given, when the amortization takes place, or when the startup is sold. The model in figure 2 shows *all* of the commercial transactions and value activities that X is involved in during the contract period. These are the activities to be supported by an EA.

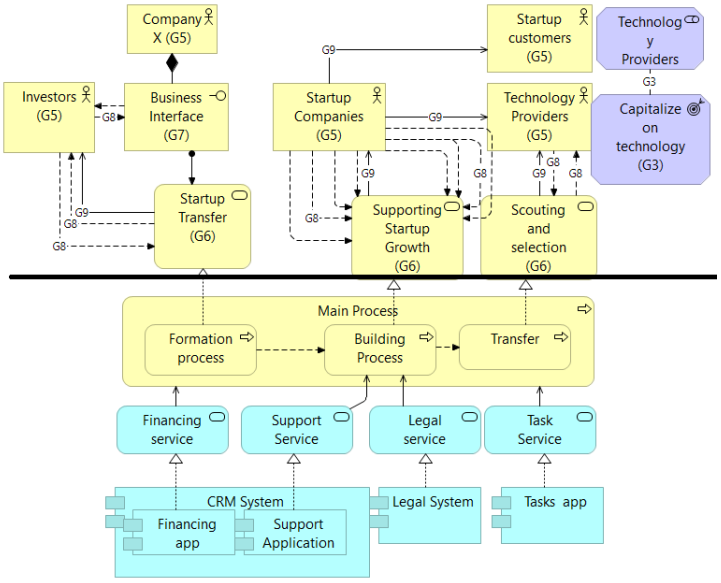



Fig. 3: Layered EA model of X.

Figure 3 shows a high level layered EA model of X. The top part is constructed by our guidelines. We have also included a simple goal model. The diagrams have been annotated with the names of the guidelines applied. The part of the EA below the line had already been designed by the enterprise architect of X. Our guidelines produced the part of the enterprise achitecture above

the line. This part differs from the enterprise architect's model; most of it was absent. In particular, the business services were not complete and the external actors were absent.

### 4.3 Quantification

A quantification of an $e^3$*value* model is called a *market scenario* [7]. For example, figure 4 shows a quantified version of the model in figure 2. It quantifies the size of market segments, the average number of needs per actor in a market segment, expenses of value activities, the value of money flows, the distribution of choices, and the value of any other variable that we introduced. Here, we introduce the initial share value of a startup as a variable. We use "f" as a generic currency symbol (read: "Florin"). The numbers in figure 4 are arbitrary and do not reflect company X.

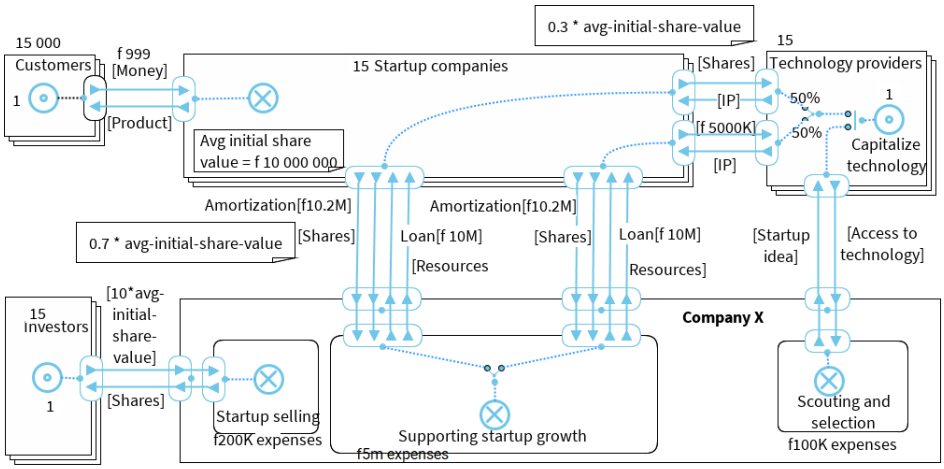
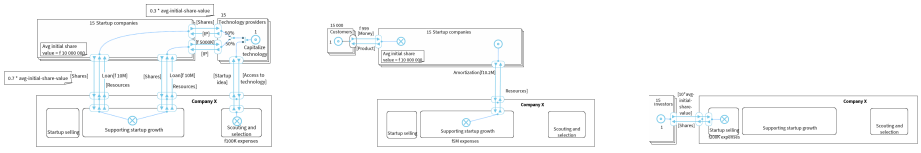



Fig. 4: A market scenario for company X. "f"is a generic currency symbol.



(a) Period 0: investment (b) Period 1: growth (c) Period 2: sale

Fig. 5: Sketch of a time series for company X. The three models are extracted from the market scenario in figure 4.

Each actor has revenues and expenses, and adding these up, the $e^3value$ tool computes that the company has a net revenue of f 747 M in this scenario. By making many different scenarios, we can assess how sensitive the business model is to differences in market assumptions.

A *time series* is a sequence of scenarios with an interest rate used for net present value (NPV) computations. Figure 5 shows what a time series looks like.[7] In the first period, X makes an investment in startups. In the second period, these startups do business and in the third period, they are all sold to investors. Using the quantifications of figure 4 and a fictional interest rate of 2%, our tool computes an NPV in period 0 of f 571 M. By varying the quantifications, an investment risk analysis can be done.

### 4.4 Expert evaluations

In order to validate and elaborate on the correctness and utility of the realized traceability we organized a validation and requirements elicitation session with management and the enterprise architect of X.

To answer Q1, we made some mistakes in our initial business model, which we corrected. The mistakes were not in the value activities or the actors in the value network, but how actual value was created. For example in our initial business model it is possible that not all shares are sold to X. In reality all shares are owned by X from startup creation. Also,the actual costs structure is completely different from our quantification. However, these mistakes have no impact on the resulting EA model.

The EA of figure 3 correctly represents the IT environment and business services of X and the upper part, designed by us, maps properly to the lower part, designed by the enterprise architect. This was also validated with the enterprise architect.

Our upper-part extension of the EA embodies an improved traceability from the EA to the $e^3value$ business model, and the discussion revolved around answering Q2: Is this traceability useful for investment and divestment decisions?

This discussion turned into a requirements engineering session for tool support. Management of X wish to determine what the effect of changes in the business model on the EA is. Their strategic goal is to scale up to more startups than they have now (a quantitative goal) and they need to decide on the best investment in IT to support this goal. The value activities of X will not change but the number of technology providers and startups they interact with will change. Traceability between an $e^3value$ model and an EA is a nice-to-have; the traceability will be considerably more useful to X if different quantified time series can be related to IT investments. X was particularly interested in being able to use NPV to evaluate different IT architectures from the business model in a top down manner and to be able to perform scenario generation and evaluation.

[7] Included to give a rough impression only. A version of the paper with a readable time series is available at `https://www.thevalueengineers.nl/pdf/EMMSAD-2021-long.pdf`.

## 5 Related Work

In previous work we have created transformation guidelines between *e*$^3$*value* and ArchiMate [4, 5]. This work extends on our previous work by applying the guidelines in a real-world scenario, an initial evaluation of utility by practitioners and a redesign of the guidelines based on this exercise.

Derzi et al. [3] propose traceability between UML deployment diagrams and *e*$^3$*value* . They annotate UML deployment diagrams with costs and benefits and create traceability between deployment diagrams and *e*$^3$*value* to be able analyze the profitability of an organization with the proposed IT. We have a similar goal but at a higher holistic level, because we use ArchiMate instead of the UML. Cost estimation usually takes place at the enterprise architecture level and not at the detailed UML level.

Meertens et al. [13, 10] propose a mapping from the Business Model Canvas (BMC) [16] to ArchiMate. This means that they miss the business model network view that we think is essential, and they do not have the capability to quantify the business model and simulate market scenarios, as *e*$^3$*value* has.

Related to this is the work of Iacob et al. [9] who propose a method for IT portfolio evaluation using ArchiMate. Aldea et al. also propose a way to link EA to the business strategy of the organization [1]. This work focusses on tracing business goals to an enterprise architecture. In our guidelines we relate a business model to the motivational extension of ArchiMate, which includes business goals. Also relevant is the work of Fritscher and Pigneur [6]. They link EA with the BMC on a very coarse-grained level. They do not realize actual traceability to different concepts of different languages nor do they provide guidelines or building blocks.

Petrikina et al. [17] describe a preliminary investigation about linking business models with EA at the meta-model level. The authors propose to link the business model to the products and services and create a new meta-model. However, this work is preliminary and they have not identified any transformation guidelines.

Aldea et al. propose adaptations of ArchiMate to incorporate value modeling [2]. Recently the Open Group also proposed to incorporate business modeling concepts in ArchiMate [19]. The result is a version of ArchiMate that has even more symbols and concepts than it has now. And it does not solve the problem of traceability between business models and enterprise architectures, because guidelines are absent.

Our approach differs from others because we use a networked approach to business models, allow quantification of business models, and define and test traceability guidelines to transform business models into an enterprise architecture. As argued elsewhere, business models as well as enterprise architectures should be networked [20, 12]. And we do not want to integrate business modeling and enterprise architecture design in one language.

De Kinderen, Gaaloul and Proper propose to link ArchiMate to *e*$^3$*value* using an intermediary language. They do not propose a direct mapping [11] and they do not provide guidelines.

Our work is different, because we focus on realizing traceabilty to the value network with guidelines. Using these guidelines we will create traceabilty to the value network from ArchiMate. We will not use intermediary languages to realize this. We see this work as an improvement of existing work.

## 6 Discussion

### 6.1 Traceability

Our application of the guidelines showed that we can produce the upper part of an ArchiMate EA that is a sound basis for designing a complete EA aligned to an $e^3value$ model. Such an alignment is needed in order to relate IT expenses to value-adding business activities. All value-adding business services are included in the EA model, and they are related to interfaces with other companies. However, expert feedback told us that to be of use in investment decisions, this traceability relation should allow quantification.

### 6.2 A business model-driven method for EA design

Designing a business model and an EA requires many decisions and we found it expedient to use the following steps:

1. Construct an $e^3value$ model for the value network of the focal organization.
2. Construct an ArchiMate motivation model.
   - Create a goal model for the organization using the guidelines of table 1.
   - Elaborate this goal model using ArchiMate guidelines and relations (composition, aggregation, specialization).
3. Construct an initial ArchiMate business layer model.
   - Construct a high level business service architecture (Tables 2 and 3).
   - Identify sub-services where needed using standard ArchiMate modeling guidelines and operations (composition and aggregation).
4. Design the business processes and application architecture and link them to the service architecture.

We consider this as a lesson learned from this project and we will use this method for our next case study and to teach to students.

### 6.3 Validity

*Internal validity* is the extent to which the outcome of an experiment has been produced by the treatment. In this action experiment, the outcome is an EA and the treatment is our set of guidelines. Our description in this paper shows that the outcome is indeed produced by this treatment.

The *utility* of this outcome is still an open question. The traceability that we established is a nice-to-have, but to be useful in investment and divestment

decisions, we need to provide tool support to relate IT expenses to revenue in different investment scenarios.

Another open issue is the *external validity* of this treatment. Can other people use these guidelines and come up with similar results? Are these guidelines sufficient for all companies? Are the resulting EAs useful for other companies too? To answer these questions we need to do more case studies and experiments, in which we ask other people to use these guidelines for other companies.

A higher-level external validity question is whether guidelines like these can be used with other business modeling and EA languages. Achieving that level of generality is not our goal. Since our guidelines are derived from an analysis of the metamodels of *e*$^3$*value* and ArchiMate and refined in experiments and case studies using these languages, we do not expect generalizability beyond these languages.

## 7 Conclusion and future Work

We conclude that establishing traceability between an EA and an *e*$^3$*value* business model is possible in practice and is potentially useful if we can quantify this traceability relationship. In future research, we will define a relationship between IT investments and company revenue and test this in a new case study. There is some previous research that we can build on [3, 14].

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