Business to System Requirements Agile Mapping

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Abstract: Business and Information Technology (IT) alignment methods and models have been developed for the last few years. Mainly, they focus on strategic alignment, however, the misunderstanding and lack of alignment are hidden in requirement mapping methods, tools, and approaches. Therefore, the paper aim is to present a model of business to system requirements mapping, based on the application of SysML and ArchiMate diagrams. The proposed approach is assumed to be considered as agile, because of its features. Finally, the approach is supported by online store case study. Beyond that, systematic literature review was done on SysML requirements engineering.

1 INTRODUCTION

Business requirements and IT requirements are accepted as aligned, if the IT functions are implemented to achieve business objectives. According to Mekawy et al. (2009), business – IT alignment is an ongoing process. However, this process is not only to be considered on strategic level, because each business change requires alignment considerations on the operational level. The purpose of this paper is not to evaluate the strategic alignment models, but to focus on the operationalization of the business – IT alignment (BITA). Therefore, the structure of the paper covers at first the discussion on System Modeling Language (SysML) requirement engineering. Next, systematic literature review (SLR) results are presented to reveal what requirement modeling languages, challenges, paradigms, and domain applications are included in literature. Finally, author presents an approach of mapping of business to system requirements and justifies the need to apply the agile principles and techniques in the proposed approach.

2 BITA OPERATIONALIZATION

IT alignment with business goals is considered as a critical success factor for private companies as well as for administrative sector units. As organizations cope with rapid changes in their business and IT environments, they need models and measures of BITA, e.g., Strategic Alignment Model (SAM), Integrated Architecture Framework (IAF), Luftman's Alignment Model (LAM), Reich and Benbasat Model (RBM), Sabherwal and Chan Alignment Model (SCAM), Hu Huang Alignment Model (HHAM) (Mekawy et al.,2009). The main problem is that models present high level discussions on BITA. Similarly, de Haes and van Grembergen (2009) have considered the impact of Enterprise Governance of IT on BITA on a strategic level, but BITA modeling requires further operationalization for business success. The operationalization covers the development and application of specific methods, languages and tools. According to Delligatti (2014) there are many useful languages and notations, i.e., Service oriented architecture Modeling Language (SoaML), Business Process Modeling Notation (BPMN), or visual modeling standards, e.g., Unified Profile for DoDAF/MODAF (UPDM) to support the development of system architecture, Semantics of Business Vocabulary and Business Rules (SBUR) specification, or Business Motivation Model (BMM).

In this paper, SysML is considered as a profile of the UML language to integrate many views of systems engineering, not only hardware and software, but also requirements, mathematical parametrization, facilities management, and designing for

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maintenance. The purpose of this paper is to present that SysML is a graphical modeling language to communicate the design of socio-technical systems of different scales and applications. According to the ISO/IEC 19514:2017 standard, SysML is a general purpose modeling language for systems engineering, i.e., for the specification, analysis, design, verification, and validation of complex systems. For applying SysML, the Model Based System Engineering (MBSE) approach was developed as a formalized application of modeling to support system requirements elicitation and management. Alternative to MBSE is the document-based approach, in which system architects generate artefacts, e.g., documents of requirements specifications and their traceability and verification matrices (RTVMs) manually (Delligatti, 2014). Concurrently, according to Patton (2014), the document-based approach offers certain advantages. Particularly, the usage of user story is to ensure the whole picture of business requirements. The stories are expected to ensure sharing the understanding, and they are supplemented by video and audio materials. The MBSE system models cover diagrams that present requirements, test cases, design rationale, and their interrelationships (Friedenthal et al., 2015). Modeling methods, tools, and SysML are the three MBSE pillars. The SysML diagrams include packages for requirements, behavior, structure, and parameters. The SysML requirement diagram is used to display text-based requirements, the relationships among requirements, and relationships to other SysML diagrams, i.e., use case, activity, sequence, or parameter diagrams.

Requirement engineering and mapping techniques for business information system design have been developed for years, however, just SysML is the most suitable language for requirement analysis, because of the requirement diagram development opportunity. The Visual Paradigm tool is proposed to combine system requirements with business requirements.

In the system development lifecycle, a lack of understanding may occur during the system conceptualization, as well as in the development phase. There is still an open question of “why”. The business stakeholders focus on business requirements, which drive the business rather than the information system. They may drive particular aspects of IT projects or set up some constraints on information system functionalities. The business requirements are to be considered in the business organization context, covering comparable systems, user groups, formal studies, or prototypes provided to stakeholders. They eventually need to be transformed into system requirements. The system engineering with SysML application concentrates on the definition and documentation of system requirements in the early development phase, the preparation of a system design, and the verification of the system as to comply with the business requirements. In this paper, aligning business and technology is not considered as an ongoing strategic executive responsibility, but as a process to learn and adopt business requirements to the SysML requirements. Therefore, the fundamental questions, which system analysts are requested to formulate are as follows:

- Why do people need the information system and software functionalities?
- Which information do you owe to the people with whom you work and on whom you depend? In what form? In what time period? What information is needed and from whom?
- Why is information important to compete in the business?
- What priorities for information use and management are important?
- When and why can information user be satisfied?

Table 1: Findings on Agile Requirement Engineering.

No	Representative Research	Findings
1	Abdullah et al., 2011	Using a combination of qualitative data collection and cognitive analysis techniques, authors termed “shared conceptualization” for engineering activities
2	Asghar et al., 2017	Prioritizing requirements helps software team to understand the importance of a particular requirement
3	Meligy et al., 2018	The ethnographic analyst remains in the organization and observes the actual ways in which people work, rather than only the formal requirements documented by the organization
4	Lorca et al., 2018	Motivational modeling is an efficient technique to support discussions between developers and non-technical clients.
5	Villamizar et al., 2018	Agile approaches typically involve modifying agile methods, introducing guidelines to handle security issues. More efforts are needed for empirical evaluations

The answers trigger business activities and explain the motivations and constraints that determine how the information system is designed. Managers usually need information for achieving the following goals: risk management, cost reduction, value adding, better

market position, eliminating the competitors, or creating new reality (Marchand, 2000).

The above questions are also valid in agile approach to the mobile business application development. Agile methods are expected to focus on the justification of business application development, not only on providing the functionalities in a short product design cycle. Therefore, the agile requirement engineering is a process of analysis of stakeholders, recognition of the system context, requirement elicitation, documenting, evaluation, and management, and business to system requirements mapping in an incremental and iterative manner (Cuesta, 2019). Table 1 includes illustrious papers on agile requirement engineering, wherein authors emphasize the benefits of agile method application. However, they focus on requirements conceptualization, traceability analysis, transformation into software components, and implementation. So, they do not accentuate any particular tools nor languages for that requirement engineering process.

Agile methods are nowadays developed and applied in different business management domains. Among others, they are very popular in information technology (IT) project management domain, in which they are oriented towards successful fulfilment of users' requirements in short time. The issue of combining of requirement engineering and project management methods is considered by Lampa et al. (2017). They focus strictly on linking project scope engineering and requirements engineering.

In this paper, the system context, stakeholders, principles, constraints, and regulation politics are assumed to be modelled in ArchiMate language and further the business requirements are mapped into SysML requirement diagram. The document-based approach and MBSE are proposed as the most suitable for e-business system analysis and design.

3 LITERATURE REVIEW

Systematic literature review (SLR) is accepted as a research method and a means for evaluating and interpreting all the available studies that are relevant to a particular research questions and topic areas. The SLR, which was conducted this year revealed the constraining and enabling factors of requirement mapping. The SLR research was realized in 2 phases, depending on the questions, formulated as follows:
RQ1: Requirement Mapping
RQ2: SysML Requirement

In the repositories, i.e., Association for Information Systems electronic Library (AISeLib), IEEE Xplore, SAGE Journals, Science Direct, and Scopus, overall 246 945 publications were found on Requirement AND Mapping (Table 2).

Table 2: Requirement Mapping Publications in 2009-2020 (absolute values).

	AISeLib	IEEE Xplore	SAGE journals	Science Direct	Scopus
2009	654	461	5517	7450	906
2010	589	516	5829	7355	980
2011	545	549	6200	8387	1073
2012	535	512	6425	9222	1138
2013	557	517	6983	10422	1138
2014	543	560	7041	11305	1148
2015	647	475	7250	12482	1159
2016	645	600	7485	13028	1201
2017	868	593	7933	14411	1252
2018	848	677	8603	16068	1378
2019	666	684	13335	18783	1333
2020	26	2	2257	7086	113

Unfortunately, they are not strictly on business to system requirements mapping (BSRM), because in literature, mapping is understood as reviewing. However, some of the found publications are important for BSRM activities. Kalbach (2016) argues that experiences mapping for BITA should respect the principles of holistic approach, multiplicity aspects, visualization, validity, and relevance. These principles, although proposed for experience mapping, are applicable for business requirement understanding and mapping into system requirements. Kop and Mayer (2012) proposed an approach that provided mechanisms for an automatic transformation of natural language requirements' specifications into UML or other conceptual languages specifications. Motta and Pignatelli (2010) discussed a proposed method that mapped strategic enterprise information into system conceptual information. Paper written by Wolny et al. (2020) seems to be important to answer question on SysML requirements (RQ2). Authors analyzed SysML publications in 2005-2017. They have noticed that language was used for design and validation, but not for implementation. They found requirement diagram, parametric and block diagrams, and activity and state machine diagrams as frequently used. Their research question was similar to the research question formulated in this paper, i.e., on SysML requirement. In the second SLR, the focus was on solutions that are either novel or a significant extension of existing techniques.

Table 3 includes the numbers of searching results in repositories, i.e., AIS eLib, IEEE Xplore, SAGE journals, Science Direct, Scopus, and Web of Science (WoS). In general, 2133 publications were found.

Table 3: SysML Requirement Publications in 2009-2020 (absolute values).

	AIS eLib	IEEE Xplore	SAGE journals	Science Direct	Scopus	WoS
2009	1	7	4	11	25	19
2010	2	17	1	14	51	25
2011	2	13	1	29	55	22
2012	1	15	5	66	64	23
2013	1	18	5	76	62	33
2014	1	21	6	111	70	46
2015	1	26	6	117	56	44
2016	1	20	5	93	61	51
2017	5	24	5	85	64	41
2018	4	27	10	89	73	42
2019	5	25	11	94	62	35
2020	1	1	1	19	5	1

Table 2 data is before deduplication and standardization. In Figures 1 and 3, linear graphs present the standardized number of publications.

The standardization was done in the following way (1): assuming that i=1…6, i=repository number, t=1…12, t=year

$$x^{s}_{it} = x_{it}/AVG\ (x_i) \quad (1)$$

The SLR was done at the beginning of 2020, so publications of 2020 are not included in Figure 1 nor in Figure 2. The searching results are usually poor at beginning of a year, because of their infinitesimal quantities.

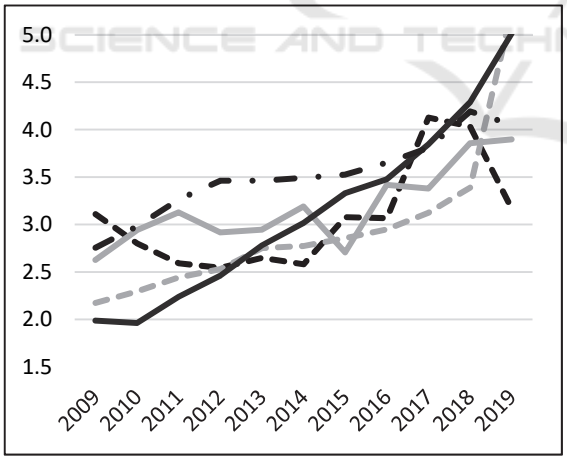

Figure 1: Requirement Mapping publications in 2009-2019 (standardized values).

Taking to account values in Figure 1, the exponential increase of publication numbers has been noticed, particularly for publications of Science Direct, SAGE journals, and IEEE Xplore repositories. The AIS eLibrary (AIS eLib) has registered less publications in 2019 than in 2017-2018.

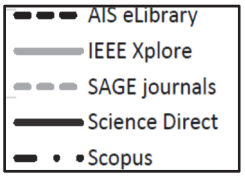

Figure 2: Requirement Mapping publications in 2009-2019 –legend.

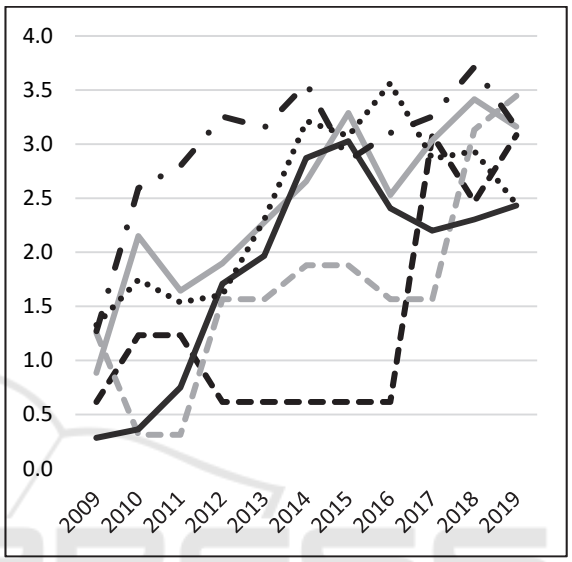

Figure 3: SysML Requirement publications in 2009-2019.

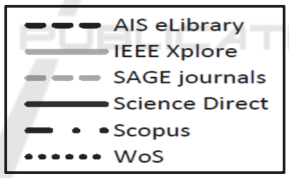

Figure 4: SysML Requirement publications in 2009-2019 - legend.

Considering values in Figure 3, in 2009-2013 an increase of publication numbers has been noticed, later however, no exponential increase of data was observed. Numbers of papers from AIS eLib and from SAGE journals repositories increase in 2016-2017.

After deduplication, papers have been grouped in six sets and the most representative papers are discussed below.

3.1 SysML vs. Other Languages

The first group of papers concerns the transformation of SysML requirements and SysML diagrams elements into elements of diagrams in other data modeling languages.

Table 4: Publications on SysML and other languages.

No	Representative Research	Findings
1	Ahmad et al., 2012	Applying of RELAX for adaptive systems
2	Ali et al., 2015	Internal block diagram of SysML is translated to PRISM language
3	Amyot et al., 2016	Combining SysML with the User Requirements Notation (URN)
4	Anda, 2018	Proposal of goal modeling with the Goal oriented Requirement Language and SysML
5	Berbedienne et al., 2015	SysML extension named TheReSe is proposed
6	Carrillo et al., 2014	Association of SysML requirement diagram with atomic requirements, represented as Linear Temporal Logic properties
7	Chabibi et al. 2019	Integration of SysML with Simulation Modeling Language (SimuML)
8	Chang et al., 2014	Transformation of requirement diagrams into other diagrams according to rules defined by ATLAS Transformation Language
9	Chourey & Sharma, 2019	Development of Enhanced Functional Flow Block Diagram (EFFBD)
10	Clegg et al, 2019	SysML Safety Profile development to model fault trees
11	Dori, 2016	Combining Object-Process Methodology (OPM) with SysML
12	Gaydamaka, 2019	Applicability of the ArchiMate to support requirement engineering
13	Helming et al., 2010	Proposal of the Unified Requirements Modeling Language (URML) to ensure integrity and interdisciplinary traceability
14	Hernandez et al., 2016	Combining SysML with process simulation language ASPEN
15	Kanthabhabhajeya, 2012	Comparison of SysML and Sequence Planner Language
16	Kapos et al., 2014	DEVS and SysML application in system structure description
17	Rahim et al., 2015	Transformation of SysML activity diagrams into modular Petri nets
18	Rebeiro et al., 2017	UML and SysML are used together for modeling non-functional requirements, as well as software functionalities.
19	Roudier & Apvrille, 2015	SysML-Sec for safety-related and security-related functions exploration with regard to attacks
20	Sena Marques et al., 2014	Integration of UML, MARTE and SysML standard notations
21	Sneps-Sneppe et al., 2017	Proposal of Lifecycle Modeling Language for digital economy information modeling
22	Vidal & Villota, 2018	SysML is coupled with Matlab and Modelica, enabling requirements verification
23	Zhe et al., 2018	Joint use of SysML, Architecture Analysis and Design Language (AADL) and Future Airborne Capability Environment (FACE) Technical Standard
24	Yamagishi et al., 2014	Applying the Design Structure Matrix clustering analysis and use of SysML diagrams

Although SysML is applied for modeling artefacts for designing software and hardware, researchers combine views in SysML with other languages views. Figure 5 presents the SysML linkages with other languages. Explanations of the links are in Table 4.

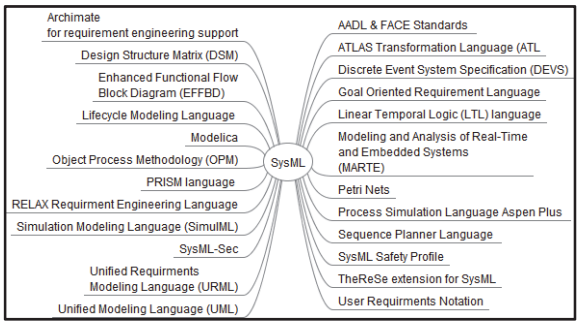

Figure 5: SysML and other modeling languages.

3.2 SysML Research and Development

SysML application encourages many practitioners towards research, development, and implementation of paradigms which control and impact the use of SysML (Table 5, Figure 6).

Table 5: Publications on SysML development paradigms.

No	Representative Research	Findings
1	Abid et al., 2015	Combining SysML and holonic control paradigm for system design
2	Al-Fedaghi, 2014	Offering the Flowthing Model to capture the requirement dynamics
3	Brace & Ekman, 2014	Checklist-oriented requirement analysis approach presentation CORAMOD methodology
4	Cui & Page, 2012	Combining SysML with Business Motivation Model (BMM)
5	Hinckel et al. 2016	Applying SysML for Product Development Process in multidisciplinary aspect. Adoption of the DSR principles.
6	Soares & Do Nascimento, 2014	Application of Technology Acceptance Model (TAM) for SysML diagrams evaluations
7	Zingel at al., 2012	Use of Contact & Channel Approach (C&C2-A), MBSE and SysML for system architecture planning

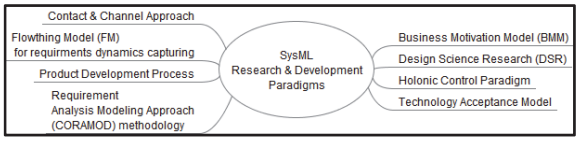

Figure 6: SysML development paradigms.

3.3 SysML Challenges

The IT involves practitioners of SysML application to formulate new challenges. They are presented as prototypes or as a proofs of concept in scientific publications (Table 6, Figure 7).

Table 6: Publications on SysML challenges.

No	Representative Research	Findings
1	Alenazi et al., 2018	Authors leverage goal-oriented obstacle analysis to identify the impediments to the fulfilment of SysML requirements
2	Gardan & Matta, 2017	Inclusion of Knowledge Management and SysML diagrams in MBSE
3	Jakjoud et al., 2012	Proposal of a meta-model to combine Software Process Engineering Meta-model (SPEM) and SysML concepts
4	Kinoshita et al., 2014	Translation of SysML diagrams to the abstract machine notations of the B method
5	Kotronis et al., 2020	A proof of concept of Level of Service (LoS) supported by SysML
6	Lopata et al., 2015	Enterprise Model generation process from SysML models and Knowledge Based Model Driven Architecture
7	Mir et al., 2011	Introduction of the Ontology for Requirements Engineering (ORE) compatible with SysML
8	Mori et al., 2016	Proposal of SysML profile for System-of-Systems (SoS) design and its applicability in a Smart Grid scenario
9	Nikolaidou & Michalakelis, 2017	Focus on the financial assessment of SysML models, estimating Total Cost of Ownership (TCO) and Return on Investment (ROI)
10	Tueno Fotso et al. 2018	Authors focused on mapping SysML/KAOS models into B System specifications
11	Zahoor et al., 2019	Use of Analytic Hierarchy Process (AHP) to rank the software requirements and to extend SysML Requirement diagram
12	Zhang et al., 2018	Method to combine SysML requirement diagrams and Event-B to model distributed system is proposed.

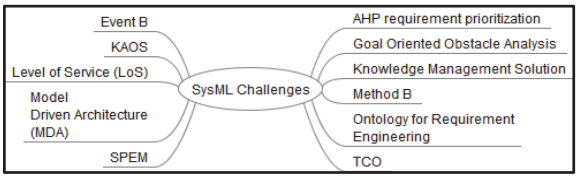

Figure 7: SysML Challenges.

3.4 SysML Application Domains

SysML is applied for modeling and designing hardware as well as software. The domains of applications are different, as it was presented in Table 7 and in Figure 8.

Table 7: Selected Papers on SysML Applications.

No	Representative Research	Findings
1	Artery & Spain, 2011	Development of SysML model of an integrated Product Lifecycle Management environment
2	Durugbo, 2013	SysML requirement diagram for product service system analysis and verification in the automotive industry
3	Hammad et al., 2013	By taking into account static, dynamic and requirement diagrams in SysML, realization of virtual verification of Wireless Sensor Network energy consumption
4	Hetherinton, 2014	Implementation of the SysML requirements model and the Blender industrial game sample
5	Jamro, 2015	SysML is applied for modeling communication between devices in Distributed Control Systems and Human Machine Interfaces
6	Lahboube et al., 2014	SysML for complex system modeling, e.g. Hospital Information Systems (HIS)
7	Leserf et al., 2015	Methodology for Embedded Cognitive Safety System design, using extension of SysML
8	Mahboob et al., 2017	SysML applied for virtual product modelling. Presentation of proof of concept
9	Maschotta et al., 2019	SysML graphical edition of model of automotive and E/E systems
10	Mhenni et al., 2014	SysML-based methodology is proposed, including black box and white box analysis
11	Qiao et al., 2013	SysML for analysing the complexity of the production management system for complex product
12	Tsadimas, 2015	For Enterprise Information System architecture design, SysML is applied as a modeling language
13	Wrycza & Marcinkowski 2011	Presentation of the authors' experiences in system specification relating to the SysML requirement diagrams

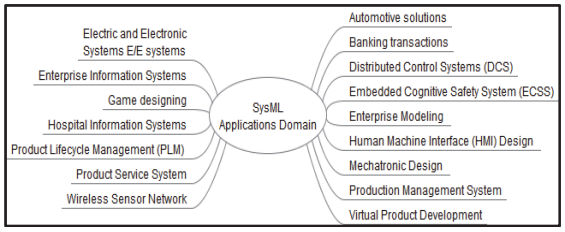

Figure 8: SysML application domains.

3.5 SysML Tools

Considering the SLR results on SysML Requirement it should be noted that authors do not emphasize value of particular modeling tools. The searching results are included in Table 8 and in Figure 9.

Table 8: Findings on SysML Software Tools.

No	Representative Research	Applied Software Tools
1	Casse, 2017	No Magic Cameo Systems Modeler
2	Chabibi et al. 2016	MATLAB/Simulink
3	Berrani et al., 2013	Topcased-toolkit in open source for critical applications & systems development
4	Cuesta, 2019	Papyrus graphical editing tool
5	Gross & Mukherjee, 2016	MagicDraw

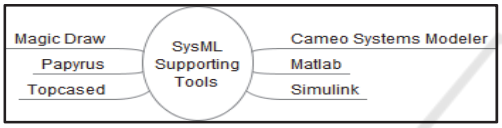

Figure 9: Tools for SysML use support.

3.6 SysML Specific Goals

The final group of papers includes publications, which illustrate the most characteristic goal of SysML application, i.e., requirement specification, traceability, verification, validation, and modeling contingency (Table 9, Figure 10). The system modeling language (SysML) is preferred more for analysis and modeling technical system than for business information systems.

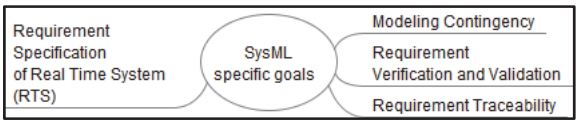

Figure 10: SysML application goals.

Table 9: SysML Application Goals.

No	Representative Research	Findings
1	Haidrar et al., 2018	Requirement traceability throughout system development process
2	Ribeiro et al., 2018	Real-time systems specification, analysis and design
3	Gauthier et al. 2015	Model Driven Engineering with requirements validation and verification using SysML
4	Nottage et al., 2015	Using SysML to enhance the collaboration with experts in the design domain

3.7 Case Study

The SLR research results encourage to focus on the agile requirement engineering. As it was presented in this SLR, there are still many opportunities to use SysML for business information system modeling. The requirement engineering with agile methods gives importance to the requirements as well as to stakeholders to ensure a correct and traceable process. By making users immerse into design process, system analysts can acquire business needs directly from their knowledge, behaviours, and reflections to software products. The paper focuses on the research gap to detect business-IT operational misalignment. Therefore, Requirement Map is proposed to transform ArchiMate business requirements into SysML system requirements (Table 10).

Table 10: Requirement Map.

No	ArchiMate Business Requirement	System Requirements		
		Functional	Non Functional	Interface
1	Sales Maximization	Sales Registration	Access Constraints	Order Registration
				Customer Interface
		Product Registration		Product Interface
				Product Data Registration
		Statistics of Orders		
		Data Mining		
2	Cash Flow Sustaining	Order Realization		Order Interface
		Customer Invoice Creation		
		Freight Bill Posting		
		Transport Company Connection		

Mapping user requirements into product system requirements is a crucial step for product design. The agile requirements engineering is particularly comfortable for Internet business or mobile business application design and development, because of the opportunity to work in a small team of stakeholders. Face-to-face communication with end user is absolutely necessary to collect answers on what, why

and for whom information is needed, what decisions are made in the business process. This answers are fundamental for business requirements specification by analysts. They should be responsible for the transformation of business requirements into the system requirements. ArchiMate is a language and tool strictly for business analyses and business requirements specification. SysML requirement diagram is to present the structure of system requirements. Successfully, Visual Paradigm modeling platform enables the usage of ArchiMate as well as SysML.

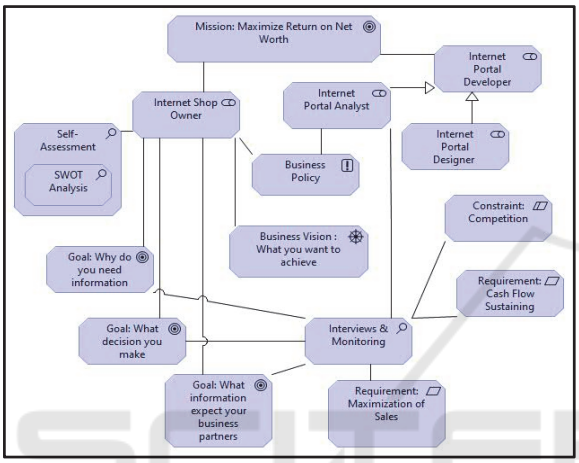

Figure 11: ArchiMate Business Requirement.

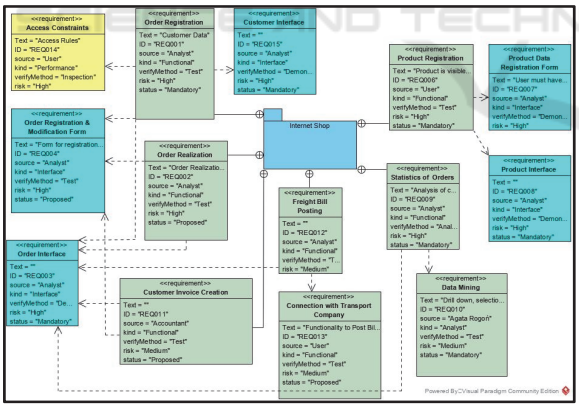

Figure 12: SysML Requirements for Online Store.

Therefore, the business requirements specified in ArchiMate diagram (Figure 11) are mapped into system requirements in the SysML requirement diagram (Figure 12). The Requirement Map in Table 10 is a static solution. Therefore, for agile approach to requirement engineering and management agile modeling tool is needed. The Visual Paradigm analysis and modeling software enables detailed specification and description of each requirements (Figure 13).

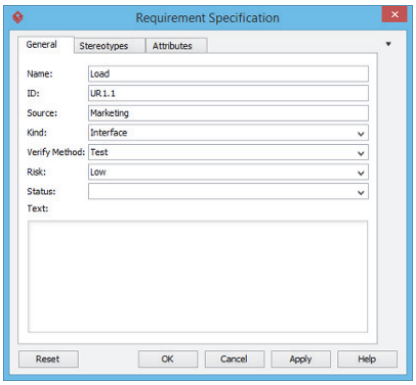

Figure 13: SysML Requirement Specification – General view in Visual Paradigm https://www.visual-paradigm.com/.

In Visual Paradigm, SysML requirement diagram, each requirement has an extendable list of characteristics, i.e., General, Attributes, Stereotypes (Figure 13). Beyond that, developers can add additional artefacts, i.e., Diagrams, References, Project Management, and Relations.

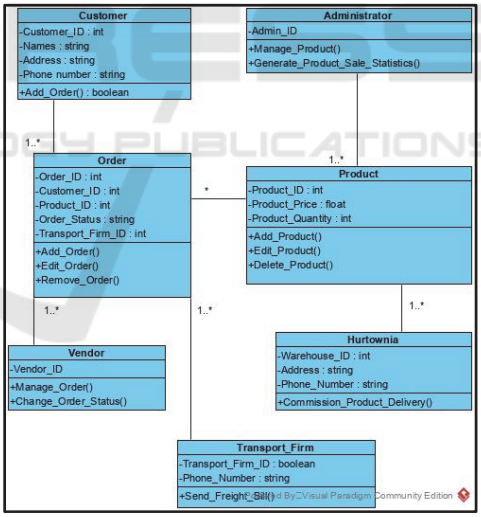

Figure 14: Class Diagram for Online Store.

Business information systems are mostly database system, therefore additional diagrams are developed. As it was mentioned in the SLR, the SysML language system model can be combined with the UML diagrams, i.e., class diagram (Figure 14) or use case diagram (Figure 15). In SysML requirement diagram, the use case diagram can be linked directly to a specific requirement.

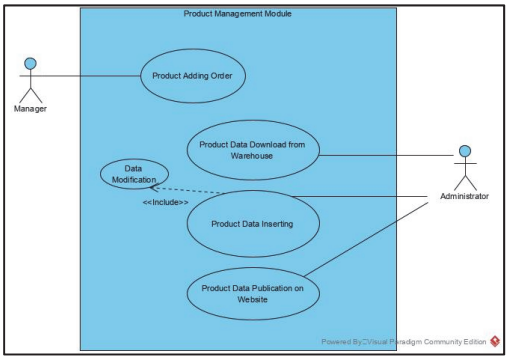

Figure 15: UML Use Case Diagram included in Product Registration requirement.

As it was presented in the SLR, researchers combine different modeling techniques and transfer models written in one language into another. The example of combination of modeling techniques in included in work done by Aparecido Nogueira and Carvalho de Oliveira (2017). In general, the combination of modeling techniques improves agility of requirement engineering and management. However, there is still a question about software tools enabling such flexible integration.

4 CONCLUSIONS

In this study, conducting a systematic literature review was done to investigate the practices, tools, patterns, and goals of SysML usage and requirement elicitation in agile context. Based on the SLR guidelines, eventually 64 papers have been selected for a detailed analysis. As BITA models are valid for strategic decisions, agile requirement engineering can be supported by languages and tools enabling the operationalization of the business – IT alignment. In this paper an online store ArchiMate and SysML diagrams were discussed as useful for that operationalization

For future work, the Decision Model Notation (DMN) and Case Management Model and Notation (CMMN) notations should be considered in business requirement modeling.

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