Using Metamodeling to represent Lean Six Sigma for IT Service Improvement

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***Abstract*— In today's competitive market, the need to continuously improve quality and lead time of IT services becomes more important. Over the last decades, too much complexity has been added to IT organizations after they had introduced IT frameworks like COBIT for IT Governance or ITIL for IT service management. As a result, many organizations face process inefficiencies and an increase in IT operational costs. Even though COBIT and ITIL, that we use as a reference in our research, contain continuous improvement (CI) processes and guidelines, their approach and effectiveness has been criticized. In this paper, we propose to apply Lean and Six Sigma, CI-approaches that gained popularity in other areas in industry, to CI of IT services. We use metamodeling to integrate Lean and Six Sigma to develop an integrated approach of Lean Six Sigma for CI of IT Services. Our Metamodels provide a visual representation to capture and integrate the main elements of Lean, Six Sigma, and Lean Six Sigma and model their interface with the IT Services framework. We apply metamodeling as part of a Design Science Research Methodology (DSRM) and use the Framework for Evaluation in Design Research (FEDS) to evaluate our results using practitioners in the evaluation. The objective of our research is to present a standard method for IT-Services CI. The resulting framework should support the design and implementation, in a standard way, of CI organizations to improve IT Service delivery.**

Keywords: IT Process framework, Lean, Six Six Sigma, IT Continuous Improvement, IT Service Management

I. Introduction

In this paper we present a metamodel for Lean Six Sigma (LSS) that can support standardization efforts of continuous improvement (CI) of IT Service delivery. Over the past decades, IT frameworks like COBIT for IT Governance or ITIL for IT service management have frequently been implemented in organizations. Despite their merits, ITIL and COBIT have also led to too much complexity [9,10,16,18,28]. As a result, organizations face process inefficiencies and an increase in IT operational costs. Even though both frameworks, that we use as a reference in our research, contain CI processes and guidelines, there is criticism about their approach and effectiveness. ITIL adopt the PDCA (Plan-Do-Check-Action) cycle to improve service management operations continuously. The PDCA cycle starts from the planning phase. However, it is difficult to develop a plan for improving service operations without clear understanding of the current service operations [43]. In ITIL's Continuous Service Improvement, the effort is limited to the end of each phase. COBIT 5 leverages the balanced scorecard insights, it provides a reference to build conceptual measurement frameworks for IT as a whole or for specific processes of IT, but still research is needed to understand if the measurement instruments are in use and optimized based on empirical findings and in what extend organizations are organizing the performance management process [9]. Outside IT services, Lean and Six Sigma approaches have gained popularity to improve manufacturing and service processes. Lean thinking and management is a continuous activity involving the different actors in the process [6]. While various practitioners propose the adoption of this methodology [5,12,27], little academic research has been done. Moreover, while several authors elaborate on the potential advantages of applying Lean and or Six Sigma to IT Services [8,12,20], there is no systematic overview available of applications and experiences. Furthermore, it has not been examined why adoption of LSS in IT services lags behind adoption of LSS in manufacturing and services. Applying LSS to IT services invites us to consider best practices from industries. For example, in car manufacturing and healthcare where significant improvements have been reported after adopting methodologies like Lean and/or Six Sigma for process improvement [32,34]. While some research [39] question if the benefits can be attributed exclusively to the application of these methodologies, we postulate that instead of using the improvement methods built into each individual IT services and/or governance framework, Lean Six Sigma (LSS) can be used as a standard for IT process improvement and may lead to superior results. Thus, it is our objective to design a CI approach for IT services based on Lean and Six Sigma.

II. Research Methodology

A. *Design Science Research Methodology*

We apply Design Science Research Methodology (DSRM). DSRM aims to design artefacts to solve observed problems, to make research contributions, to evaluate the designs, and to communicate the results to appropriate audiences. The methodology can be applied to solve organizational problems. DSRM differentiates from other research paradigms, because it tries to develop artefacts that can be proven effective in real world scenarios [29]. These artefacts can be categorized in: Constructs, Models, Methods and Instantiations.

There are six steps in the DSRM process that guide our research as follows: (1) problem identification and motivation; (2) definition of the objectives for a solution; (3)

978-1-7281-0650-2/19/$31.00 ©2019 IEEE
DOI 10.1109/CBI.2019.00034

design and development; (4) demonstration; (5) evaluation; (6) communication (presentation of the results in this conference paper). For the evaluation of the artifact we use the Framework for Evaluation in Design Research (FEDS).

B. Semi-structured interviews

To evaluate our design in practice, we conduct semi-structured interviews, flexible and open-ended in style. The focus of the interview relies on the actual experiences of participants instead of discussing general beliefs and opinions. Here, the relationship between interviewer and interviewee is crucial [19]. The semi-structured interview is generally preferred by researchers because it gives the freedom to ask both the pre-prepared questions, but also to go into more depth on topics that are relevant to the interviewee [24].

C. Metamodeling

In IS research, models are seen as design artefacts to abstract from reality and real-world objects [15]. Metamodeling gained popularity already in the 1990s to define core concepts and processes in systems development methods [21,37]. The rationale for the use of a process metamodel rather than just a process model rests on the obvious observation that the requirements for an industry process for software development vary greatly between industries [14] single process for all situations is not possible. If the object of research are models, and not the real world or the universe of discourse (UoD), we create models of models. This 'model of models', which is a higher level of abstraction, is called a metamodel.

D. ArchiMate a Metamodeling Languaage

We use ArchiMate 3.0 for modelling purposes. [22] positions ArchiMate above other modelling languages (IDEF, BPMN, ARIS, UML) for Enterprise Architecture infrastructure that describes and visualizes the different architecture domains and their underlying relations and dependencies. Its semantic rigor and ability to capture both static and dynamic elements make it suitable for metamodeling as well.

III. Related Work

A. Lean

The foundation of Lean, that is inspired in The Toyota Production System (TPS), is Toyota's unique approach to manufacturing and was born in the 1950s. The focus is on the individual product and its value stream (value added and non-value-added activities) and elimination of waste in all areas and functions within the system. Lean Thinking is one of the first books written in the US where the term ´Lean´ is used. Here, Womack and Jones [41] describe 5 principles of Lean (Understanding of Value, Understanding the value chain, Flow creation, Pull production, Seek for perfection) and make some suggestions for implementing these principles. According the authors: "To be a lean manufacturer requires a way of thinking that focuses on making the product flow through value-adding processes without interruption (one-piece flow), a pull system that cascades back from customer demand by replenishing only what the next operation takes away at short intervals, and a culture in which everyone is striving continuously to improve". To create a learning enterprise, Liker [23], in The Toyota Way, and building upon work from Womack and Jones, describes 14 management principles an organization should embrace. These 14 principles are divided and discussed using the 4P model: Philosophy, Process, People & Partners and Problem Solving. In addition, ISO 18404 describes the different Lean roles and training requirements needed in organizations applying Lean.

B. Six Sigma

The purpose of Six Sigma is to bring about improved business and quality performance and to deliver improved profit by addressing serious business issues that may have existed for a long time. The driving force behind this approach is for organizations to be competitive and to eliminate errors and waste [17]. Six Sigma was developed at Motorola in the 1980s. In 1995, Jack Welch, at that time CEO of General Electric (GE), adopted the methodology that became recognized in the market. Harry and Schroeder [13] were the first authors to document the Six Sigma model, directly following Six Sigma application at GE. Six Sigma refers to a statistical measure to indicate the defect within a process. A process performing at six sigma means that for every million opportunities there is a defect rate of 3.4. The added value of Six Sigma compared to other Quality Management methodologies is its organizational implementation [13,44] and the significant role for management seeking continuous improvement [42]. Key elements are: leadership of top management, role structure, structured improvement procedure (Define, Measure, Analyse, Improve, Control), focus on metrics, focus on the customer and the process. Since the first adoption of Six Sigma many companies worldwide have implemented the methodology adapting it to their own needs [7]. In order to standardize all these different approaches to Six Sigma, the International Organization for Standardization (ISO) issued two specific standards in 2011; ISO 13053 part 1 and part 2 and published a third one in 2015; ISO 18404. The scope of ISO 13053 is limited to the improvement of existing processes within organizations. It is applicable to organizations using manufacturing processes as well as service and transactional processes.

C. Lean Six Sigma

The term ´Lean Six Sigma´ (LSS) was introduced at the beginning of the new millennium [35]. This to overcome the limitations of each program when implemented in isolation. In [26,30], the evolution of Lean and Six Sigma into LSS is explained. LSS can be described as a methodology that focuses on the elimination of waste and variation, following the DMAIC structure, to achieve customer satisfaction with regards to quality, delivery and cost. It focuses on improving processes, satisfying customers and achieving better financial results for the business [33]. Various authors, illustrate the advantages of the integration [2,2,4,5,11,30,33]. Aligning the cultural aspects of Lean with the data driven investigations of Six Sigma holds huge potential in a bid for a genuine and sustainable approach to organizational change and process improvement. Individually, Lean manufacturing and Six Sigma are unable to reach the improvement rates that LSS is achieving [3,36].

IV. Research Problem

The research problem is defined as defining a modeling solution that aims to standardize the design and implementation of Lean Six Sigma Continuous Improvement methodology within IT Service delivery organizations that use COBIT 5 and ITIL v3 as reference frameworks.

V. DESIGN AND PROPOSAL

In this section, we design a metamodel for Lean, Six Sigma, and LSS. We use Lean Thinking and The Toyota Way to define the Lean metamodel elements. Next, we define a metamodel for Six Sigma. Here, we use the ISO 18404, ISO 13053-1 and ISO 13053-2 to present the important elements from Six Sigma. The resulting LSS metamodel is the combination of both models and evaluated by practitioners that have published books in this area and act in the role of Master Black Belt and Lean Sensei. In table I, we present an example of the mapping exercise. The complete table is available on request. Here we list the different elements from each methodology with its respective source and ArchiMate 3.0 modelling concept. There are elements, like organizational performance, maturity level, and critical to quality (CTQ) that relate only to Six Sigma, while elements like customer value and measure are mentioned in both Lean and Six Sigma. The mapping exercise is a combination of experience on the field, validated with practitioners, and literature. For the modelling effort, we adopt the ArchiMate 3.0 notation. The resulting metamodels are presented in figure 1,2, and 3.

A. Metamodel of Lean

The starting point in the Lean metamodel (Fig. 1) is the IT Process. The resulting process performance is measured using a metric. The customer value is reflected in a KPI and when the metric is below customer expectation it generates an action (trigger) for improvement. Trained personnel in the organization are responsible for working on the process improvements that are based on the 5 Lean Thinking principles. In addition, The Toyota Way emphasizes the importance of a Lean Culture or Philosophy that starts with established leadership. Both recommend best practices, tools and techniques. Furthermore, there are different roles in Lean organizations that people in the organization embrace to work on process improvements.

B. Metamodel of Six Sigma

Similar to the Lean metamodel, the starting point in the Six Sigma metamodel (Fig. 2) is the IT process. The resulting process performance is measured using a metric. Meanwhile, the process performance contributes to the organizational performance. To evaluate different levels of performance of an organization and to give a road map for continual improvement projects, the levels of maturity are used. The Six Sigma approach is project based and focuses on strategic business aims. The body of knowledge recommends the best practices, tools and techniques and the importance of a culture of continuous improvement and leadership. The DMAIC project phases (Define, Measure, Analyze, Improve, Control) are used during the execution of an improvement project. Furthermore, it describes the roles, competences and required training of the personnel involved in such projects. It is important that every Six Sigma project starts with the customers' needs and expectations (Voice of the Customer (VOC)) and that it is translated into a Critical to Quality (CTQ) and quantified as a KPI.

C. Lean Six Sigma Metamodel

The combined Metamodel (Fig. 3) integrates both metamodels of Lean and Six Sigma. In the combined metamodel, still the IT process and its process performance are of importance and trigger the start of a continuous improvement activity. The VOC, CTQ and its related measurement (KPI) determines required process performance. The Lean and Six Sigma body of knowledge contain tools, techniques, training requirement, and role descriptions that are needed when personnel work on a process improvement project. The goal remains to support organizations to reach a higher level of performance and is of support to define a CI. Key for a successful adoption of LSS is the ability to establish a culture of CI. From literature, but also from a practitioner's point of view, it is acknowledged that leadership is an important success factor.

VI. DEMONSTRATION

In this section, we elaborate on how the metamodels can be used. Further research and publication will lead the opportunity for an ad hoc test in a real case situation of an IT organization in the financial sector distributed in two different geographical locations. Our objective is to use the LSS metamodel, but one can also decide to use either Lean or Six Sigma as defined in previous paragraphs. The LSS metamodel can be used as a standard to define the main elements of a CI organization when working on IT service delivery improvement. In general, IT organizations design their processes based on one or more reference frameworks. In our example we use the COBIT and ITIL metamodel [1]. This representation presents the IT Framework landscape in a more understandable language. Allowing the researcher or practitioner to understand the main elements, the similarities, and the integration between the different frameworks. We visually (dark arrows in fig. 3 and illustrated in table II) present how to integrate each one using the LSS metamodel.

As an example, to further illustrate this concept, we take the incident management process that is present in both IT Reference Frameworks, ITIL v1.3 (Incident Management) and COBIT v5 (DSS02 Manage Service Requests and Incidents). An IT organization measures the output of the incident management process. If the average performance, in this case the average resolution time, of an incident is 3 days and the KPI is set to 2 days (table II), this underperformance is a trigger to start looking at process improvements. The proposed LSS metamodel supports the understanding of the principal components (Fig. 3) and their interaction and interfaces to the various IT Processes. It presents the different aspects to select as part of the implementation of a CI organization. When having the corresponding CI organization in place, as presented in the metamodel, including trained professionals on LSS, KPI´s aligned to the IT and business strategy and according to customer expectation, one can speak of a chosen standard to improve IT Service delivery.

TABLE II. METAMODEL ELEMENTS INTERFACING BETWEEN IT FRAMEWORKS – KPI

INTERFACE			EXAMPLE	
Lean Six Sigma	**COBIT**	**ITIL**	**Incident Management**	
Metric	Process Metric		Target	Actual Performance
KPI		KPI	2 days	**3 days**

Other IT Service delivery related processes present in ITIL and COBIT5 [40] are: Event Management (DSS01), Operation Management (DSS02), Request Fulfilment (DSS02), Problem Management (DSS03), and IT Service Continuity Management (DSS04).

VII. EVALUATION

In this research we use the Framework for Evaluation in Design Research (FEDS) [38]. FEDS was designed to help DSR researchers decide on an appropriate strategy for evaluating the outcomes of the build activity in DSR. It supports evaluation research design principles by creating a bridge between the evaluation goals and evaluation strategies. Two important aspects or dimensions determined by the analysis above are (1) the functional purpose of the evaluation (formative or summative) and (2) the paradigm of the evaluation (artificial or naturalistic). The first one focuses on the Why to evaluate and the second, on the How to evaluate. These dimensions lead to the following evaluation strategies: (1) Quick & Simple, (2) Human Risk & Effectiveness, (3) Technical Risk & Efficacy, and (4) Purely Technical Artefact strategy. We refer to [38] for further explanation. For the evaluation, we follow the DSR's evaluation strategy choice process. We initially select the Quick & Simple strategy. The evaluation of the construct is initially small and simple and risk or thread of not being able to use it in practice. This thread is mitigated by performing the interviews and the resulting positive evaluation outcome (Y=Yes) by practitioners (table III). We asked practitioners (P1 to P5 in table III) to evaluate our proposed metamodels for Lean, Six Sigma and LSS separately. The practitioners are two Master Black Belts and three Lean Sensei. Four of them have published books that are being used in university and business training programs and have more than 10 years of experience in the implementation of the LSS methodology. Our evaluation reviewed the following evaluands [25]: Correctness, Usability, Generalization, Flexibility, Comprehensible/ understandable, Reusable, Portable, Applicability. By following a protocol for the interviews (table IV), we collected additional information that helped us in the evaluation and to improve the metamodels. The three most remarkable additions are: (1) the inclusion of The Toyota Way next to Lean Thinking, emphasizing culture or philosophy; (2) emphasize the importance of leadership for a successful implementation; (3) include, in addition to the DMAIC project structure, a daily improvement activity that support the fifth principle of seeking for perfection/ continuous improvement. The practitioners concur that the metamodels can be also used outside IT and see a high degree of portability to other areas. The metamodel was also seen as support for other frameworks, like Scrum: ¨*Is answer to the unasked question in practice about how Lean can be used in Scrum/Agile*¨. According to one practitioner that actively works for a consultancy company, the challenge remains in: ¨*how to turn it into implementation*¨. The same person commented on the fact that IT frameworks in general are based on old organization structures, where specialization was dominant and today´s context is different: ¨*Autonomous teams are responsible for the delivery or performance and they are more generalists within a specialisation*¨. The latter applies also to CI implementation where multidisciplinary teams work on improvements. In table III, we present the evaluation results of the metamodels by practitioners. The result is positive as all confirm that the metamodel describes at a metamodel level the most important components of Lean, Six Sigma, and LSS. In further research we intend to further test the model in the field and have the opportunity to further improve the design work.

TABLE III. INTERVIEW SUMMARY: EVALUATION OF METAMODELS (Y=YES; P=PRACTITIONER)

	Lean					Six Sigma					Lean Six Sigma				
Correctness	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Usability	-	Y	Y	Y	Y	-	Y	Y	Y	Y	-	Y	Y	Y	Y
Generalization	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Flexibility	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Understandable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reusable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Portable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Applicability	-	Y	Y	Y	Y	-	Y	Y	Y	Y	-	Y	Y	Y	Y
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5

TABLE IV. INTERVIEW QUESTIONS FOR METAMODEL EVALUATION WITH PRACTITIONERS

Interview preparation:
We sent the metamodels to each practitioner and planned a 60 minutes interview.
Interview execution:
A. Elaboration on:
A1. Explanation of the concept Metamodel?
A2. Explanation of the sources we used for the design of the metamodel.
A3. Brief explanation of ArchiMate.
A4. Goal of the model as indicated in the Introduction section in this paper.
A5. Explanation of each metamodel.
B. Collecting feedback:
B1. Do you see improvements for the metamodel? B2. Where do you see opportunities to apply the metamodel?
C. Validation questions for each metamodel: Is the Metamodel [Lean], [Six Sigma], [Lean Six Sigma]…
C1. …correct? The logic and the used sources
C2. …usable by supporting the goal as explained in A4?
C3. …reliable to generalize?
C4. …flexible to add other insights?
C5. …understandable?
C6. …reusable?
C7. …portable?
C8. …applicability?
D. Closing

VIII. CONCLUSIONS

In this paper we propose a standard for CI for IT Services based on LSS, a best practice in the industry. We used DSRM to structure our research. We used metamodels to represent the different Lean, Six Sigma and LSS elements modelled with the ArchiMate 3.0 language. The LSS metamodel can be used for the design of a CI organization in a given IT Service delivery context where different IT frameworks are being used. The advantage here is the use of a market standard that can be customized to a given organization.

After de design work we were able to work on the definition of the interface between the different IT Frameworks and LSS, being in this case the metrics and KPI. We elaborated on the usability of the model by presenting it in the context of the Incident management. Here the goal is to design and implement the right CI organization, including for example trained professionals on LSS, KPI´s aligned to the IT and business strategy and according to customer expectation. For the validation of the metamodels we used FEDS and opted for a Quick & Simple strategy. The completeness of the model was validated by practitioners having a broad experience in the role of Master Black Belt and Lean Sensei. The risk of error or thread that characterizes this strategy was mitigated by the positive answer on the metamodel during the interview sessions with practitioners. Furthermore, in future research, we plan to test the metamodel in the field by designing and implementing a CI organization in a real case situation of an IT organization in the financial sector distributed in two different geographical locations. This will be achieved by having summative evaluations and documented in case studies. We also plan to further extend our expert validation exercise to more than the current 5 experts. This will give us the opportunity to improve the presented metamodel and include additional evaluation loops in our design work.

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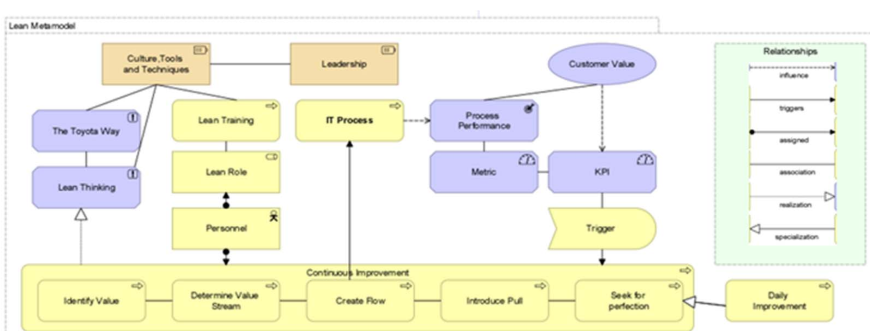


Fig 1. Lean Metamodel

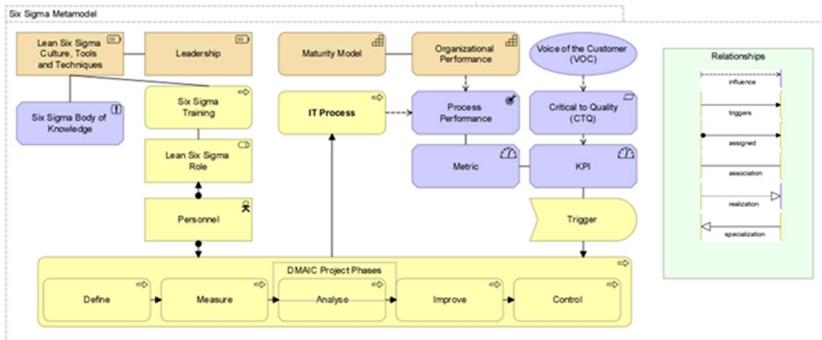


Fig 2. Six Sigma Metamodel

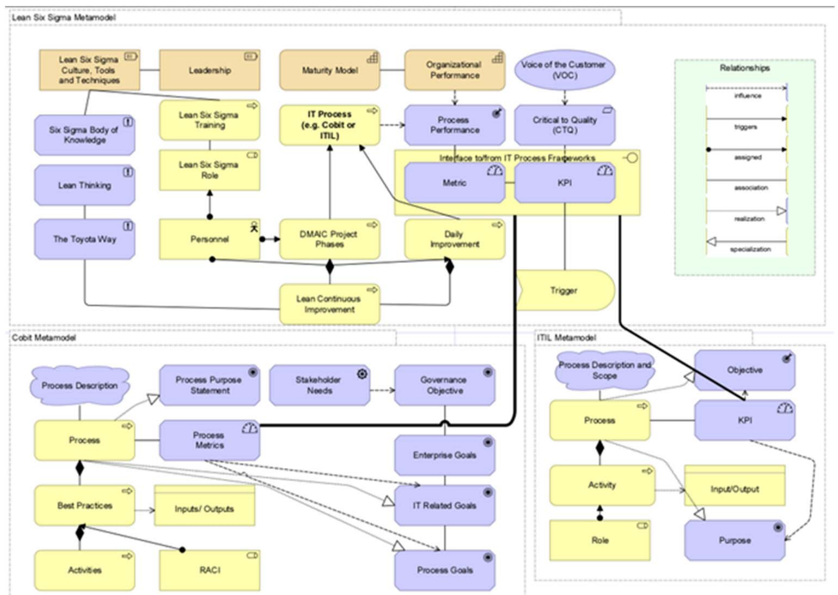
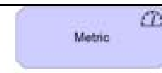
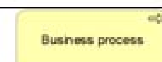
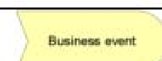
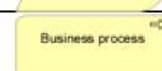
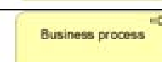
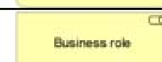


Fig 3. Lean Six Sigma Metamodel including interface to COBIT and ITIL Metamodel

Table I. Mapping Lean, Six Sigma, and Lean Six Sigma using ArchiMate modelling language

Lean	Lean Description	Six Sigma	Six Sigma Description	Lean Six Sigma	ArchiMate Notation	ArchiMate Representation
-	-	Organizational Performance	End result of a set of actions aiming for continuous improvement assessed by maturity levels.	Organizational Performance	Outcome	
-	-	Maturity Level	Supports the evaluation of different levels of performance of an organization and gives a road map for continual improvement projects. Five levels are used: Initial (Level 1), Managed (Level 2), Defined (Level 3), Quantitatively Managed (Level 4), Optimized (Level 5	Maturity Level	Metric	
Customer Value	Time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes.	Voice of the Customer (VOC)	Information from the customer that expresses his expectations.	Voice of the Customer (VOC)	Value	
-	-	Critical to Quality (CTQ)	Critical characteristics, the quality performance requirements which must be met to satisfy the customer.	Critical to Quality (CTQ)	Requirement	
Measure	The purpose of KPI (measures) is to be able to qualify the performance of a process.	KPI (measure)	The purpose of KPI (measures) in a Six Sigma project is to be able to qualify the performance of a process.	KPI (measure)	Metric	
Process	Lean looks at process outputs and ways to improve delivery time of services or goods to customer	Process	Set of interrelated or interacting activities that transforms inputs into outputs. Six Sigma looks at process outputs and ways to improve according VOC.	Process	Business Process	
Trigger to act	-	-	-	-	Business Event	
-	-	DMAIC project methodology	A Six Sigma project is executed by the DMAIC process.	DMAIC project methodology	Business Process	
Daily Improveme nt	As part of principle of continuous improvement	-	-	Daily Improvement	Business Process	
Lean Role	A set of responsibilities, activities, and authorities assigned to a person and acquired by training (Practitioner, Leader, Expert)	Six Sigma Role	A set of responsibilities, activities, and authorities assigned to a person and acquired by training (Yellow, Green, Black, and Master Black Belt).	Lean Six Sigma Role	Business Role	
Lean Principles	(1) Lean Thinking 5 principles; (2) Toyota Way	Six Sigma Body of Knowledge		Lean Principles and Six Sigma Body of Knowledge	Principle	
Lean Culture, Tools & Techniques	Required knowledge for driving Lean	Six Sigma Culture, Tools & Techniques	Tools & techniques used during each phase of the DMAIC approach.	Lean Six Sigma Culture, Tools & Techniques	Resource	
Lean Training	Methodology training	Six Sigma Training	Methodology training	Lean Six Sigma Training	Resource