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ASSESSING AND MITIGATING RISKS OF ENGINEERING PROGRAMS WITH LEAN MANAGEMENT TECHNIQUES

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1. Introduction

1.1 Engineering Program Management

This paper investigates the use of lean management techniques as a risk mitigation approach for large-scale engineering programs. The key research questions are how lean best practices with the highest risk mitigation potential are identified, how the most relevant lean best practices for a specific program are identified and how the effort for implementation of these lean best practices is estimated.

Large-scale engineering programs have as results usually complex technical products or systems such as airplanes, satellites (GPS) or software programs, immense infrastructure efforts like the construction of a new airport, highway or bridge, or combine elements of both technology and infrastructure. The benefits they deliver are therefore immense and sometimes even groundbreaking, defining new levels of capabilities. But their sheer size and the built-in complexity also manifest themselves in higher risks, which can lead to significant cost-overruns and large delays in schedule [Oehmen et al. 2012], [Cantarelli et al. 2010], [Flyvbjerg et al. 2003], [GAO 2006].

Program success depends on four dimensions: delivery capability, organizational capability, marketing capability and innovative capability [Shao and Müller 2011], [Shao et al. 2012]. To incorporate these capabilities and to manage the obviously difficult entity of a program, a variety of standards and guidance books have been published. The two most prominent ones are Managing Successful Programs (MSP) and The Standard for Program Management by the Project Management Institute (PMI), that both include Risk Management as a focal activity [MSP 2011], [PMI 2013].

1.2 Lean Program Management

The description of “lean” production was first used by Krafcik to discern it from buffered production [Krafcik 1988]. The Toyota Production System (TPS), which served as the basis for Krafcik’s description, was invented by Toyota Motor Company’s Vice-President Taiichi Ohno [Sugimori et al. 1977]. Since then, the lean philosophy has not only conquered the world of production and manufacturing, but has also swept into product development and management. Womack and Jones played a decisive role in advertising the benefits of lean. In one of their books, the so called lean principles are introduced [Womack and Jones 2003]. The authors also openly dream of applying lean to other systems. Later, Lean Thinking was also applied to Systems Engineering [Oppenheim et al. 2011]. To fuse the topics of program management and Lean Systems Engineering, a research project in cooperation with the International Council on Systems Engineering (INCOSE) and the Project Management Institute (PMI) set out to study the overlaps between these fields and to identify best practices. As a result of the 15-month duration research project on lean program management, the

Guide to Lean Enablers for Managing Engineering Programs was published [Oehmen et al. 2012]. It has at its core the description of 43 best practices, the Lean Enablers, which are grouped by the so called six lean principles. Each Lean Enabler contains a sub-set of sub-enablers that offer more detailed information. The content of this book, mainly the 43 Lean Enablers, provide the basis for the present study. In a study on the relationship between success of a program and the use of Lean Enablers in it, it was found that successful programs show a significantly higher use of them than not successful programs [Steuber 2012]. In this paper, we investigate if these proposed "best practices" can also serve as risk mitigation actions.

1.3 Risk Management and Risk Mitigation in Program Management

Risk Management, according to ISO standard 31000, is understood to be "coordinated activities to direct and control an organization with regard to risk". In order to perform risk management, it is important to gain some understanding about the risks under investigation. To help a structured approach, different categories or taxonomies have been developed [Kaplan and Mikes 2012], [Oehmen and Ben Daya 2012], [de Weck and Eckert 2007]. Other experts do not agree with the idea of categorization, because, according to their argumentation, the interdependencies of different risk events are often ignored or not studied carefully enough in the presence of categories. Especially these interactions form the basis of the most serious risk events, which is why the careful study of the potentially disastrous effects of risk cascades and cumulative risks is highly important [Helbing 2013], [Marle 2010]. To conclude, risk management largely depends on the type of risk at hand and on the industry it is practiced in. The key question to risk management is if the methods work [Hubbard 2009]. Some industries apply rigorous quantitative analyses; others rely on qualitative assessments of probabilities. The ISO 31000 standard is assumed to be the - as of yet - most influential attempt so far to develop a comprehensive and integral risk management framework [ISO 31000 2009]. It has at its core a well-structured risk management process, which is composed of five main parts. Of special interest in the context of this study is the risk assessment phase, which again has three parts: Risk identification, risk analysis and risk evaluation. In *Management of Risk* (MoR), the same three steps are to be found [MoR 2004]. Interestingly, these three phases overlap with the first three steps of the program risk management process outlined in the *Standard for Program Management* [PMI 2013] and with the programme risk management cycle described in *Managing Successful Programmes* [MSP 2011]. As the focus of this study lies on program risks, this coincidence is helpful and the ISO risk assessment step will be used in the rest of this paper.

1.3.1 Risk Management Process: Risk Assessment

Risk identification is the first step of the risk assessment part of the risk management process. It is recommended to explore the context of the program before the actual risk identification, which stakeholders are involved, what assumptions have been made and how the program fits into its environment [MSP 2011]. At the same time, the consequences and their potential cascading or cumulating effects should be considered and examined [ISO 31000 2009]. A number of identification tools exist in order to facilitate this process [Thamhain 2009], [Klein 2007]. The most important requirement for the use of all these tools is that all information available is used and processed, and that people with relevant expertise and appropriate knowledge are involved. Especially in complex programs, collective stakeholder intelligence and its potential for risk identification should not be underestimated, e.g. in Delphi processes, review meetings, brainstorming and focus groups [Thamhain 2013]. Risk identification is supposed to be iterative, as new risks may become apparent or evolve over time. Another quite simple way to come up with a set of program risks is to use a fixed and already established checklist, as mentioned in [IEC/ISO 31010 2009]. Specifically for lean program management, a collection of ten so called "challenges" is presented in [Oehmen et al. 2012], which can be used as a starting point for a more thorough risk identification.

Risk analysis and risk evaluation represent the last two parts of the risk assessment. Risk analysis is the "process to comprehend the nature of risk and to determine the level of risk" [ISO 31000 2009, p. 5] and as such can be both qualitative and quantitative. Moreover, risk analysis provides information for risk evaluation and helps decision-making with respect to the way, if at all, and the priority the risks are treated. It comprises identification of sources and causes of risk and a subsequent assessment of the negative or positive consequences and the likelihood of these consequences occurring. These are the two main measures that constitute the level of risk, the magnitude of a risk.

Likelihood can be assessed in multiple ways, "defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically" [ISO 31000 2009, p. 5]. A consequence can be expressed qualitatively or quantitatively [ISO 31000 2009, p. 5]. These two measures can then be aggregated and visualized, for example in the popular risk matrix, which represents the level of risk and even an organizations risk profile [Engert and Lansdowne 1999], [Garvey and Lansdowne 1998], although this representation is not without criticism [Cox 2008]. A different angle towards risk analysis is to actually simulate the risk and its effect on a model, for example by using Monte Carlo analysis/simulations [Hubbard 2010], [Smith and Merritt 2002], [Thamhain 2013].

However, there are several psychological factors that, when not accounted for, can render risk assessment and management almost futile. Examples are effects such as anchoring and affect heuristic [Greenberg et al. 2012], [Slovic et al. 2004], the human tendency for wishful thinking and arrogance [Hall 2011], [Tversky and Kahneman 1985].

Risk evaluation is the "process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable" [ISO 31000 2009, p. 6] and therefore contributes to the consideration and decision on how to treat risks and in which order. This evaluation takes into account the results of the risk analysis and the context of the organization and program.

Risk treatment covers the fourth part of risk management process, but is beyond the scope of the risk assessment phase. The aim of risk treatment is to modify risks through targeted actions. Modification can range from avoiding a risk completely, to taking or removing the risk, changing the likelihood or the consequence, sharing the risk with others and retaining the risk [ISO 31000 2009]. The relevant task here is the selection of appropriate risk treatment options and their relative prioritization. This is usually done by balancing the derived benefits against the costs and efforts of implementation. As changes may introduce new risks, the most critical being the failure of the treatment action, the risk assessment process needs to be iteratively and continuously repeated. In [Oehmen et al. 2012], a mapping of the Lean Enablers to the collection of top ten challenges they address and help mitigate is presented.

1.4 Problem Statement

We hypothesize that the Lean Enablers contribute directly and indirectly to the mitigation of program risks by improving processes and performance. However, there is no method to be found that directly combines the analysis of risks with the identification of mitigation actions. Furthermore, the number of Lean Enablers and their corresponding sub-enablers prohibits overview over the full collection and impedes efficient and effective selection of program relevant best practices, especially those relevant for a specific program under investigation. Lastly, in order for an implementation of a certain Lean Enabler to be beneficial beyond the pure mitigation of risks, an understanding of the business case associated with the implementation is necessary, i.e. the costs incurred through implementation or the number of additional people required in accomplishing it. These considerations lead to the following questions, which are to be answered in the present paper:

1. How can lean best practices with the highest risk mitigation potential be identified?
2. How can lean best practices be tailored and customized to a specific program?
3. What is the effort associated with implementation of the lean best practices?

2. Methods

2.1 Literature Review

The sources for the literature review were found using the following resources: MIT libraries; BartonPlus, an online research tool that searches all MIT libraries and every database MIT has access to; WorldCat, an online search engine that provides access to libraries other than MIT's; Google

Scholar, an online search engine based on Google with focus on academic and scholarly literature; Recommendations from other researchers.

As the goal is to obtain an integrative review, the search was done by using simple keywords to increase the size of the results collection as well as by searching for specialized phrases and expressions. Literature cited in articles was also screened for suitable material. The search for literature was not solely centered on academic publications, as some knowledge domains for this study have not yet received rigorous and significant academic attention, but are based on collective industry expertise. In total, twenty-one papers, books and publications in the area of risk and risk management were reviewed, as well as ten documents in the domain of program management and performance measurement.

2.2 Interviews

A total of eight interviews were conducted, if possible with carefully planned interview guidelines. The first three interviews were of exploratory nature and only followed a rough outline of high-level questions. The remaining interviews were used to validate and get feedback on developed content. For these, only very few specific questions were detailed and asked. In most of them, important input was collected during subsequent discussions about the same topic. In addition to these interviews, regular feedback in form of responses to specific questions was obtained during regular bi-weekly conference calls with a group of industry subject matter experts. These findings were incorporated into the final solution, but were not documented thoroughly enough as a result of technical and organizational complexities of these calls.

3. Results

3.1 Overview of the proposed model

In order to answer the three research questions and thereby solve the practical problem underlying it, a three dimensional process model was developed and later implemented in Microsoft Excel to be used as a tool. Based on the aforementioned ten engineering challenges, a program risk profile is established and the most relevant mitigating Lean Enablers identified. Based on an assessment of level of implementation of the Lean Enablers, the most crucial gaps to be closed in a specific program are found, especially for the risk relevant Lean Enablers. These two measures already enable a prioritized top ten selection of Lean Enablers. With an idea of the benefits of implementation, the costs or effort of implementing Lean Enablers determine the last selection and prioritization step. The three dimensions are explained more thoroughly in the following:

3.2 Risk Mitigation Potential of Lean Enablers

To determine the level of risk (risk criticality) a program is exposed to, due to its simplicity, an approach similar to the Risk Matrix is chosen, where five level scales are employed [Engert and Lansdowne 1999]. Accordingly, the risk level of a specific challenge is calculated as the product of the likelihood of its occurrence and impact in case of its occurrence.

To identify the appropriate mitigation or treatment actions for the most relevant risks, an individual assessment of the user would not serve the purpose of having a fast and efficient process with minimal user input, even though higher accuracy and program specificity could be expected. Therefore, to find the correlated Lean Enablers, a matrix also developed in a previous study [Oehmen et al. 2012] is used and a quantified measure for Lean Enabler relevance is deduced. Said matrix denotes which Lean Enabler addresses which program risk using binary values. More precisely, the respondent using the algorithm is asked to judge risks inherent in a program of his choice according to the scales in Table 1. For the purpose of proofing the concept and in order to bypass any in-depth program risk identification, a collection of program challenges is used as the basis for this assessment. The resulting two values for likelihood of occurrence and impact in case of occurrence, corresponding with the number of the level, are then multiplied to obtain a measure for the level of risk. Based on a mapping of Lean Enablers to the challenges they help address, a score for each Lean Enabler is established, taking into account that one Lean Enabler can influence multiple challenges at the same time.

Table 1. Scales for Assessment of Risk Level

Level	Likelihood of occurrence	Impact in case of occurrence
1	0-10% / very unlikely to occur	Negligible: No effect on program
2	11-40% / unlikely to occur	Minor: Encounters small cost/schedule increases
3	41-60% / even likelihood to occur	Moderate: Encounters moderate cost/schedule increases
4	61-90% / likely to occur	Serious: Encounters major cost/schedule increases
5	91-100% / very likely to occur	Critical: Program will fail

3.3 Self-Assessment of Level of Implementation of Lean Enablers

To ensure program specificity, the current level of implementation of Lean Enabler or maturity of Lean Enablers in a program, or more likely an organization or enterprise under investigation is used as an additional selection criterion, besides the program risk profile. The current degree of implementation is proposed to be determined through a self-assessment. However, in this case, a method with no complicated model behind the self-assessment is preferred, such that this step rather requires only the judgment of Lean Enablers according to their maturity. This reasoning serves the purpose of overall efficiency and effectiveness, but might lack a comprehensive approach. The main reason for doing it in a simple and easily understandable way is to develop a sense of how much additional potential lies in the (remaining) implementation of Lean Enablers. When the task at hand is to prioritize and customize all the Lean Enablers for implementation, it does not make much sense to consider a specific Lean Enabler as extremely relevant and important, if it is implemented already fully or at least to a higher degree. To accomplish this, a simple scale is needed.

In general, a number of tools and models could be used for a self-assessment. However, only very few could be used in this context since only a small number of them incorporate simple scales. For this study, instead of developing a new and more specific scale, a CMMI-like scale is proposed, as the CMMI-model [CMMI 2010] is widely known and the corresponding maturity levels are of relative simplicity. The adopted scale, depicted in Table 2, distinguishes between five levels of maturity.

However, other than the scale, the model behind CMMI (Capability Model Maturity Integration), which is developed by the Software Engineering Institute of Carnegie Mellon University, is not used and no knowledge thereof is required for the assessment. The descriptions of the levels are expected to be sufficient for the user to obtain a measure for the maturity of each Lean Enabler in the program under investigation.

Table 2. Scale for Assessment of Lean Enabler Implementation Level

Level	Level of Implementation of Lean Enablers
1	Initial: Processes unpredictable, poorly controlled and reactive
2	Managed: Processes characterized for projects and is often reactive
3	Defined: Processes characterized for the organization and is often proactive
4	Quantitatively Managed: Processes measured and controlled
5	Optimizing: Focus on process improvement

Using these two important measures as coordinates, the Lean Enabler relevance and the current degree of implementation, the Lean Enablers can be plotted in a matrix which visualizes the priority attributed to each Lean Enabler (see Figure 2). Furthermore, using the coordinates to calculate the “utility” value the implementation of the respective Lean Enabler would bring, here called aggregated priority, a first prioritization is possible. This, for example, could result in the top ten Lean Enablers, not taking into account the effort for implementation.

3.4 Effort for Implementation of Lean Enablers

The third dimension in the overall process model, the implementation effort, was planned to be based on data obtained from a survey of engineering managers. Two values were assessed: the duration of initial implementation and the number of people required during the initial implementation (see Table 3). However, mostly due to time constraints, a sufficiently high number of responses could not be collected in order to derive significant information from the data. However, the design of the survey and the assessment method for implementation effort of Lean Enablers were thereby validated. Given more time, more promising results can be expected. The preliminary data is shown in Table 4 (see [Oehmen et al. 2012] to match numbers ro Lean Enablers).

Table 3. Survey Scale for Assessment of Implementation Effort for Lean Enablers

Duration of initial implementation		No. of people required during the duration of the implementation in full-time equivalents	
1	1 - 6 days	1	0.1 - 1
2	1 - 4 weeks	2	1 - 2
3	1 - 3 months	3	3 - 5
4	3 months - 1 year	4	6 - 10
5	1 - 3 years	5	11 - 15
6	More than 3 years	6	More than 15

Table 4. Survey Results for Assessment of Implementation Effort for Lean Enablers

Lean Enabler	Duration			No. of People		
	AVG	MED	SD	AVG	MED	SD
1.1	4.3	4.5	1.2	5	6	1.6
1.2	3.5	4	1.2	4.3	4	1.5
1.3	4.3	4	1.1	4.2	4	1.5
1.4	4.4	4	1.1	4.6	6	1.7
1.5	4.4	4	1.1	4.5	5	1.6
1.6	4	4	0.9	4.3	4	1.3
2.1	3.6	4	1.1	4.1	4	1.2
2.2	4.1	4	1.3	4.5	4	1.3
2.3	3.9	4	1	4.5	4	1.3
2.4	4.4	4	0.8	4.7	5	1.2
2.5	4.2	4	1.1	4.9	5.5	1.3
2.6	4.2	4	1.1	4.4	5	1.5
3.1	3.8	4	1.1	3.9	4	1
3.2	3.8	4	1.3	4.1	4	1.5
3.3	4	4	1	4.5	4	1.4
3.4	3.8	4	1.1	4.3	4	1.1
3.5	3.8	4	1.2	4.6	5	1.5
3.6	3.3	3	0.6	3.7	3	1.4
3.7	4	4	1	4.4	5	1.2
3.8	3.6	4	0.6	3.8	4	1
3.9	3.5	3.5	0.8	3.8	4	1.2
3.10	4.2	4	0.8	4.1	4	1.4
3.11	3.2	3	1.1	3.2	3	1.3
4.1	4.1	4	0.9	4.4	4	1.6
4.2	3.9	3	1.3	4	4	1.7
4.3	3.9	4	1.1	3.1	3	1.2
4.4	3.8	4	1.2	3.6	3.5	1.3
4.5	3.7	4	0.7	4.3	4	1
4.6	3.7	4	0.7	3.9	4	1.4
4.7	3.7	4	0.9	4.4	5	1.5
4.8	4.1	4	1	4.5	4.5	1.3
4.9	4.1	4	0.8	4.3	4	0.8
4.10	3.9	4	1	4.3	4	1.2
5.1	3.8	4	0.7	4	4	0.9
5.2	4.4	4	0.5	4.5	4	1
6.1	3.9	4	0.8	4.3	4	0.9
6.2	4.5	4	0.9	4.7	4	1.1
6.3	4.5	5	1	4.8	5	1
6.4	4.3	4	1.4	4.5	4	1
6.5	4.2	4	1.2	4.2	4	1.3
6.6	3.8	3.5	1.2	4.5	4	1.1
6.7	4	4	1.2	4.4	4	1.5
6.8	4.1	4	0.9	4.4	4	1

Alternatively and currently implemented, the user can choose the unit of measurement and assess each of the aforementioned top ten Lean Enablers based on this unit with respect to the effort for implementation in his specific program. Using this measure as an indicator for the “costs” of implementation, the final prioritization can be obtained by combining all three dimensions similar to a cost-utility analysis.

3.5 Overall Process Model for Prioritization and Customization

To summarize, the final process model or algorithm seen in Figure 1 therefore requires a three dimensional assessment from the user to generate a customized and prioritized list of Lean Enablers, which are expected to make the biggest contribution to a specific program's most critical risks. Only minor prior knowledge from the user is required, other than program related, to generate the results with the presented semi-automated process model. Using an approach similar to a cost-utility analysis (semi-quantitative) further ensures a balanced representation of the results.

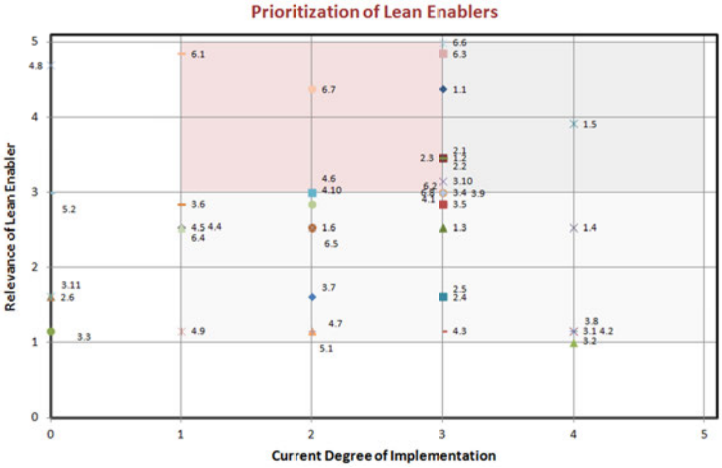

Figure 1. Process Model for Prioritization and Customization of Lean Enablers

4. Discussion

4.1 Validation and Feedback from Pilot Trials

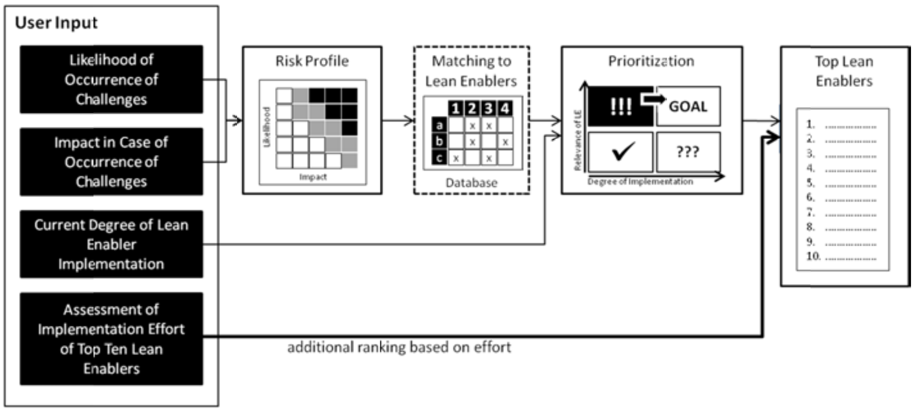

Figure 2. Screenshot of Result Visualization of Tool

The development of the first version of the tool was discussed on multiple occasions during conference calls with subject matter experts and the first (alpha) version was presented and pilot-tested during the INCOSE International Symposium 2013 in Philadelphia, PA; USA. The setting consisted of a short presentation of the functioning of the tool with a subsequent trial run of the tool by 12 out of 16 workshop participants. The purpose of this pilot run was to collect feedback on the individual components and their perception, but also to validate the underlying process/algorithm.

After implementation of the process in a Microsoft Excel spreadsheet, it was presented and discussed during conference calls with subject matter experts. The feedback was again implemented, and the Excel tool then validated in three companies. Two companies preferred a workshop setting with team assessment, whereas the third company found three employees that responded to the questions individually and independently. The three companies were a large car-manufacturing company, an aerospace manufacturer and an energy corporation.

The feedback in general was consistent across all participants. The overall process apparently makes sense and also the results are considered to be valid and applicable to the respective program. More specifically, one responder wrote that he "liked the tool, and thought that the top 10 made sense". Another feedback was: "It was absolutely great to have a tool that could help management understand Lean a little bit more. If I were to go to a new company, this tool would be very beneficial in helping the company leaders learn what Lean is about."

4.2 Limitations and future developments

When it comes to the assessment of risk mitigation potential, the collection of ten challenges used in this study represents a high level description of potential pitfalls which in turn might impede the identification and assessment of "real" risks. Furthermore, owed to their generality, they are hard to quantify and assess with the measures proposed here, even though a qualitative judgment can certainly be delivered. In general, there are always so called "unknown unknowns" to be expected in risk management. This also applies to these challenges, as they most likely do not cover all potential risks a program could face. Another limitation applies to the qualitative assessment of risks, which is, according to literature, prone to serious misjudgments due to psychological biases and subjectivity, which leads to low consistency of assessments [Kahneman and Tversky 1985]. This also applies to the scales, which with a different number of levels or different formulations of the levels could result in an altogether different outcome.

Even though the results of the mapping of challenges to Lean Enablers seem very promising, no guarantee exists that there is not a more comprehensive and accurate mapping, also with respect to the mathematics leading to the Lean Enabler relevance. As such a mapping could differ from program to program this fortunately also provides an opportunity for program specific adaptation of the process.

With regard to the topic of self-assessing the maturity of Lean Enablers, a CMMI-like scale was chosen based on its reputation and publicity. A more specialized scale might be harder to understand and grasp while providing easier judgment. This is even more the case with the Lean Enablers that do not classify as processes and are therefore hard to assess with the classic CMMI scale. Additionally, the calculation of the aggregated priority and the representation of it in a matrix can be discussed and criticized as being too simple. At the moment, the two dimensions are weighted equally and simple multiplication generates the aggregated priority. There might be room for fine-tuning this algorithm to increase accuracy and to avoid values of equal rank. It was decided to implement a qualitative assessment by the user based on a unit of his choosing, which is expected to be less credible compared to a quantitative measure, but is likely to facilitate judgment. For consistency reasons, it is important that the same unit be applied to all top ten Lean Enablers. Finally, as mentioned before, there are serious limitations to the human ability to judge accurately and objectively.

Most of these limitations are expected to be dealt with through more specific program risks and their qualitative analysis, a more detailed mapping of these risks to the Lean Enablers and their sub-enablers, and qualitative assessment of implementation efforts, either based on generic data or taken from data of a specific company.

4.3 Contribution to Lean Implementation Landscape and Practical Impact

Firstly, the process presented in this thesis contributes to a significant reduction of time needed in order to identify the most relevant best practices for a given program. Normally, the full collection of Lean Enablers with its sub-enablers is difficult to manage and quite some time would be required to go through them all. By shortening this identification task, the process model is expected to satisfy a need by program managers whose time is valuable and limited. Along with this, the operability of best practice implementation is greatly improved and facilitated.

Secondly, by linking risk identification and assessment to the Lean Enablers in two ways, this contribution to risk mitigation and lean implementation is expected to further induce substantial improvement in program performance. Through implementation of the Lean Enablers not only are the most critical risks reduced, but the program and its organization is also brought on track towards a sustainable, bright and most of all lean future.

Thirdly, as a by-product of risk mitigation and Lean Enabler prioritization, the process requires the user to reflect on the current status of the program and to quantify it on a maturity scale, thereby ensuring that progress is constantly monitored and continuous improvement incentivized. In addition to that and as mentioned before, the method is also aimed at aiding program management in establishing priorities for the realization of quick wins and interim measures by allocating resources accordingly. By allowing categorization of Lean Enablers along the two dimensions degree of implementation and relevance of Lean Enablers, the biggest gaps can be uncovered and the most promising and sensible strategies with respect to Lean Enabler implementation can be deducted. Moreover, the process gives the user an idea of a rough and non-monetary cost-benefit balance with respect to the use of Lean Enablers. The opportunity is provided to judge subjectively and qualitatively, but still independently on both the costs and the benefits that an implementation of certain Lean Enablers would entail. The associated thought process further is assumed to help in creating an idea of priority in the mind of the user.

Finally, the process is simple to use and can be applied in a variety of ways, by individuals or in a team, during the definition phase of a program or during program execution. It can further be applied across organizational units or hierarchies to facilitate understanding of different perspectives inside a program. Furthermore, no extensive data collection needs to precede application, only the experience and knowledge of the user/users is required.

Pilot trials have shown that the process and the respective tool are easily comprehensible, that the results are esteemed to be valuable and that the use of this tool contributes to a better understanding of Lean Thinking and its importance for organizations and programs not only as a compulsory exercise, but an essential mindset.

5. Conclusion

In the present study, a process model for the risk-based customization and prioritization of lean program management best practices is presented. The task of tailoring and prioritizing is achieved along three different dimensions: risk mitigation potential, current degree of implementation and effort for implementation of these best practices. Pilot trials of the process model with several industry experts resulted in overall positive and satisfactory feedback. The output was deemed useful and interesting. A first validation was conducted at a conference and in a company with multiple individual respondents. A second round of trials was done in two companies with a whole team acting as respondent. The two different approaches also uncovered two types of application which were both regarded as compelling and beneficial in certain situations.

The process model presented in this paper is expected to save valuable time of program managers, to greatly facilitate program risk management and to help improve program performance through faster and highly specific implementation of the most relevant and beneficial Lean best practices.

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