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Minimizing Supply Chain Risks in IoT Product Through Standardization of the Onboarding Process

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It is a great moment writing this final part of the thesis after this short and interesting journey. The whole study gave me a great opportunity to improve my skills, to learn how to properly manage time, to work under pressure and lastly it opened up so many new opportunities in my career that I have already started utilizing. At this moment I can already see the outcomes of taking this program, very positive ones. Looking back, the study process now seems to be easier than I thought in the beginning, partially because the content was very well planned, but mostly because there were people willing to support the studies I took.

Firstly, I would like to thank my business partner from the case company, for the opportunity to build this interesting (in my opinion) thesis together even though there were so many changes on the way. Thank you for spending time, for sharing your own knowledge, providing information and allowing an open book dialogue we had.

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Lastly, I would like to thank my family for helping me reach my goals.

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The objective of this thesis was to propose a solution to minimize supply chain risks in the case company by standardization of the onboarding process. With the current process, it was seen complicated to perform the onboarding of new suppliers in a systematic and standardized way. Additionally, it was seen difficult to evaluate the quality of the supplier's products as well as to distribute responsibilities evenly within the supply network.

In this study, the design research method was chosen to conduct the study and from the data collection perspective, this study is dependent on the in-depth insights of the supply chain topic, thus qualitative research method was chosen. To find the challenges existing in the case company's supply chain, a current state analysis was performed. After that, a literature review was made to find solutions for the identified challenges. Based on the findings, a proposal for the end-to-end onboarding process was co-created with the case company. Thereafter, the initial proposal was validated by receiving the feedback from the product owner.

The proposal for the end-to-end onboarding process includes three key areas of improvement by introducing a five-phase approach to the supplier onboarding. Firstly, the onboarding process enhancement was performed by combining such methods of supply chain management such as responsibility management, supplier selection, and performance measurements. Secondly, risk management process was introduced due to the existence of "empty activities" in the RACI matrix. Risk management introduced practices to identify risks, log them, and then transform into a problem that can be owned. Lastly, process standardization was presented by introducing a set of standardized documents and alignment with ISO standard was created to evaluate the quality of the supplier's product.

With a standardized onboarding process and built-in practices, the case company will be able to minimize the risks in the supply chain related to the supplier operation. Also, by implementing the end-to-end onboarding process case company will ensure that risks are identified in the early phases of the cooperation with a new supplier. Such risks include the performance of the supplier, product related risks, logistics risks, etc. Furthermore, it allows the company to automate the process, save time by keeping process standardized and in the end, it can improve the performance of the deliveries. Currently, the case company is planning to begin the implementation of the most critical parts of the proposed end-to-end onboarding process.

Keywords	Supply chain management, Process development, IoT

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1 Introduction

The supply chain process is a constantly changing environment that requires a set of components to be able to optimally deliver any sort of solution or product. The current market requires a high percentage of adaptability of the supply chain elements. Especially in the IoT (internet of things) market it is important to be able to build reliable partner/supplier networks, be able to cope with competition and also build trustful consolidated networks. It is equally important to share responsibilities for deliverables in a well-planned and systematic way.

The importance of supply chain is visible from any perspective, both from B2B segment and B2C. Simply put, the customer wants to get their products quickly and at a specified time. (Leon Teeboom 2018)

1.1 Business Context

The case company is a Nordics leading software and services company. It is a multinational company that has a history of over 50 years and is present in 52 countries. The company covers many business areas, including financial services, public, healthcare and welfare, industrial and consumer services. Additionally, since 2016 company is running a data-driven-business area consisting of products and services which intention is to digitalize customer's businesses using digital tools. The focus of this thesis study is limited to data-driven-business's Empathic Building product. The Empathic Building is a software solution using smart technologies in the office environment to boost employee well-being, happiness, productivity, and innovation.

1.2 Business Challenge, Objective and Outcome

One of the main business challenges for the companies running IoT products entering the digital market is too big risks in managing IoT hardware elements in its products. Management of hardware includes the technical evaluation of the hardware, purchase process, manufacturing, delivering, deploying at the field and later maintaining. In most cases the current market of IoT hardware solutions does not provide an end-to-end supply chain, nor any party is ready to take end-to-end responsibilities for deployed IoT hardware and its usage in connection with other products. In addition, both software and hardware IoT solutions lack evaluation standards, thus creating uncertainty in its usage.

When considering having hardware as part of the digital product every organization faces a problem with declaring the ownership of that hardware. It is very challenging to properly set the owner no matter whether it is a supplier, the case company or the customer. In B2B it is the customer who makes a decision on either to own hardware or not, and therefore supplier's supply chain should be well-planned to cope with any scenario. Also, ownership of any IoT component could potentially bind an owner to an unneeded responsibilities.

Another business challenge related to the topic is caused by the IoT supplier competition. The current market is full of manufacturers of IoT goods. The problem with most of them is that they only deliver a physical piece and that is where the customer journey ends missing integral components of the IoT supply chain. For the software company it means that value is the piece itself and not any other value generated by that piece. That leads to a problem where the manufacturer and value creator are two different companies who have no relationships between each other. In practice it means there is no existent supply network or eco-system which could be utilized as a bundle with needed suppliers for the case company to deliver its product. That is why the case company has to organize its own supply network with all these parties combined. Therefore, that leads to a need of setting up the onboarding process adopted to every potential supplier joining the supply network, which is a resource intensive task to accomplish.

The objective of this thesis is to develop an end-to-end onboarding process for Empathic Building managers with the intention to minimize risks and ensure a measurable responsibility ownership of the hardware, as well as setting up the methods to evaluate the suppliers and their products. Additionally, in order to define the viability of the process from importance perspective the recommendations for implementation will be developed.

The outcome of this thesis is an end-to-end onboarding process and recommendations for implementation.

1.3 Thesis Outline

The thesis report is written in total of seven sections. The first section introduces the context of this thesis and explains the business challenge, objective, and outcome. The second section elaborates the method and material used to conduct the study, covering

the research approach, design, and the data collection principle. The third section reveals the current state analysis findings presenting the process description of the current supply chain model. The fourth section explores the supplier onboarding process, risk management and technical product evaluation, establishing the conceptual framework based on the literature review. Section five proposes the end-to-end onboarding process as part of risk minimization challenge. In the sixth section, the proposal is finalized based on the feedback from the product owner. The conclusions and discussion of the results of this thesis are reporting in Section seven.

2 Method and Material

This section explains the approach for research work used in thesis study. Firstly, the research approach is explained. Secondly, the research design is described and data collection plan is presented.

2.1 Research Approach

Generally, there are 2 types of research approaches used to conduct some sort of study. The first one is a basic research method, the second is applied research method. Basic research method is aimed at expanding existing knowledge in science, thus it can be mainly considered having more of a theoretical nature. The result of basic research is knowledge itself. Meanwhile, applied research is more practical, focusing on solving specific problems or answering specific questions under consideration based on real cases from business organizations, society or industry. The result of applied research is a solution for the problem. (Surbhi, S. 2018)

In addition to that, there are two types of research strategies to categorize data utilization in the study: qualitative and quantitative research. Qualitative research is used to collect in-depth insights of the topics that are not well understood and formulate a theory as a result. Qualitative data is collected through interviews, focus groups or case studies.

Quantitative research is used to generalize results about the topic focusing more on theory while mainly analyzed through math and statistics. Data collection in qualitative research is mainly conducted through surveys, experiments and content analysis. It is important to mention that research can be purely based on either qualitative or quantitative results, but also it can be based on combination of these method called “mixed methodology” (Kananen 2015).

To perform a research in an organization various applied research methodologies can be used. These can be a case study, design research or action research. The first one - case study, is an in-depth analysis of a specific issue over a long period of time used to test and create a theory. In most cases researchers do not take part in research study. The second one is action research it is a learning by doing type of research study which assumes that solution to the problem can be found in multiple cycles generating both

theoretical and practical knowledge. In action research, researchers can also be part of the research study. Design research, according to (Distinctive Analysis of Case study, 2014), is intended to develop artifacts that allow satisfactory solutions to practical problems. The same as with case study, in design research researcher is not part of research study.

In this study, knowing the context of the business challenge with the objective of the study, the design research method was chosen to conduct the study. The design research is suited for the study because the purpose is to develop or improve components solving existing challenges in an IoT driven organization. Action research could also fit the study if only there were more time for the research. From the data collection perspective, this study is dependent on the in-depth insights of the supply chain topic therefore qualitative research method will be chosen. The study will additionally be based on interviews with the product owner of the Empathic Building product.

The next section describes the Research design for the study.

2.2 Research Design

As described in section 2.1 this thesis follows the design research method using qualitative data as a source. As seen in the research design of the study presented in Figure 1, this study consists of four gradually developing stages that use in total three data sets. The study began with defining the business challenge.

In the first stage, the current IoT supply chain process was analyzed to understand which processes can be improved or what type of components might be beneficial to solve listed challenges. The result of the first stage is a current state analysis, which is conducted by reviewing the documents provided by the case company and clarifying them with the product owner. Documentation review with the comments received from the product owner define strengths and weaknesses of the current IoT supply chain model and the supplier onboarding process.

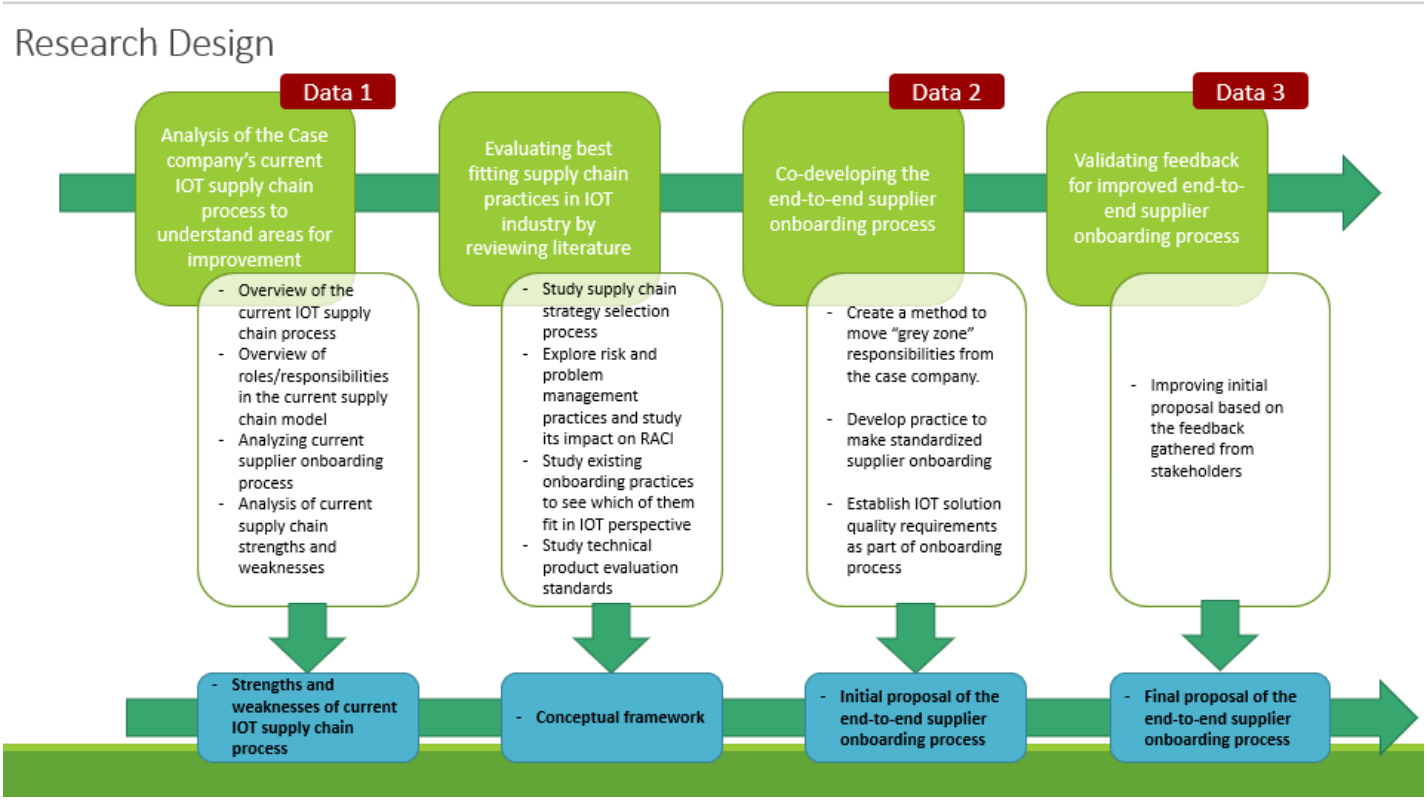

Figure 1. Research design of the study

As depicted in Figure 1, the second stage is about building the conceptual framework by learning best performing supply chain practices in the IoT industry. Since one of the challenges for the case company appeared to be the hardware product ownership within the IoT industry context, it was decided to pay attention to learning technical product evaluation method, corresponding responsibility management, and how exactly to consider risks in supply chain from the RACI matrix perspective. Another important criteria is the way how new suppliers/partners get onboarded in the case company's supply chain and how to follow best performing world practices. Lastly, as part of each pracitce literature will open up methods to create standardized documents for the supplier self-evaluation. Altogether, the literature review will result in the conceptual framework for the end-to-end supplier onboarding process.

The third stage aims at developing a practical end-to-end supplier onboarding process based on the literature review. One of the first steps is to utilize known practices and create a method to automate the potential supplier and product quality evaluation pro-

cesses. Next, the risk management process is revisited with the suggested way of assessing the risk, transforming risk states, and documenting the process. At that stage a method to move “empty activities” away from the case company is defined. Lastly, the supplier/partner onboarding process is revisited with the suggested new standardized process. Additionally, as part of the onboarding process continuous improvement process recommendations are being defined for all supply chain network partners. As a result, an initial proposal of the end-to-end supplier onboarding process is made.

In the fourth stage, the proposed end-to-end supplier onboarding process was presented to receive feedback and get ideas for improvement and changes. Additionally, a theoretical projection of the process on the existing suppliers was performed through the interview with the product owner.

2.3 Data Collection and Analysis

The data collection and analysis of the thesis is presented in Table 1. Table 1 shows three data collection stages revealing contents of the data, data sources, informants, timing for data collection and the outcome of data collection.

As mentioned in section 2.2 this study is divided in four stages, requiring three data sets to be collected. These four stages are: Current state Analysis; Literature review; Improving of Process; Feedback Validation of Proposed Process.

In the current state analysis stage, data was collected through various data sources. Firstly, internal documentation was reviewed to understand the current supply chain process. Documentation included the Supply chain architecture, products/services material and existing RACI matrices which are part of the same current state analysis stage. Secondly, to understand additional strengths and weaknesses of the existing supply chain process interview with the product owner was conducted. Also, together with the product owner the supply network roles and responsibilities were mapped. Interview consisted of a set of questions addressed to the respondent.

Data plan	CONTENT	SOURCE	INFORMANT	TIMING	OUTCOME
DATA 1 **CURRENT STATE ANALYSIS**	- Description of current IOT supply chain process - Description of roles/responsibilities in current supply chain - Description of the supplier onboarding process - Analysis of current supply chain strengths and weaknesses	- Supply chain architecture document - Products/Services materials - RACI matrices review - One on one interview	- Product owner	JANUARY	- Strengths and weaknesses of current IOT supply chain process - Management expectations
DATA 2 **IMPROVING OF PROCESS**	- Establish IOT supplier and product evaluation as part of the onboarding process - Create a method to move "empty activities" from the case company. - Develop practice to make standardized supplier onboarding	- Stakeholder 1to1 theme interviews - Literature reviews	- Product owner	MARCH	- Initial proposal of the end-to-end supplier onboarding process
DATA 3 **FEEDBACK VALIDATION OF PROPOSED PROCESS**	- Improvement ideas to initial proposal	- Stakeholder 1to1 theme interviews - Simulation	- Product Owner	MARCH-APRIL	- Final proposal of improved the end-to-end supplier onboarding process

Table 1. Data plan

As it is stated in Table 1, the result of the current state analysis is an IoT supply chain process strengths and weaknesses.

One of the biggest inputs for the current state analysis is the documentation. Therefore, the study additionally included the internal documents provided by the case company. Documents were the main source of information for the current state analysis, since they included all needed data for getting a deep understanding of the supply chain operation in the case company.

The internal documents that were used for the current state analysis are presented in Table 2.

ID	Name of the document	Description
1	Supply chain overview	The overview of the existing supply chain components in the Empathic Building organization.
2	RACI	Roles and Responsibilities matrix applicable to the existing supply network
3	Supplier onboarding process	The overview and a flowchart of the existing supplier onboarding process.

Table 2. Internal documents used in the current state analysis. Data 1.

The process improvement stage consists of a literature review where the best practices regarding IoT product's supply chain are studied to define the most suitable model for the case company. Further, an interview is conducted with the product owners to align the theoretical model with a practical implementation of it. As the outcome of the stage, an initial proposal of the improved end-to-end supplier onboarding process was developed.

The findings of the current state analysis are discussed in Section 3 below.

3 Current State Analysis

This section describes the current state analysis of the Empathic Building product's supply chain model. This section starts with an overview of the current state analysis, describing the supply chain process from the supply network perspective, revealing what are the corresponding roles and responsibilities in it. The section gets finalized with the outcomes from the current state analysis elaborating the management expectations from the supply chain process change as well as showing the strengths and weaknesses of the current supply chain model

3.1 Overview of the Current State Analysis Stage

The main purpose to conduct the current state analysis (CSA) is to describe the present process of the IoT product supply chain (SC) in a way it is currently handled within the case company. Additionally, the current state analysis is supposed to help identifying the challenges management has with the current operation of the supply chain, pointing out the strengths and weaknesses of the current approach. As a result of the CSA problems/issues in the supply chain should be identified and the results analyzed to then create a practical action plan or a new process framework.

CSA data was collected using two methods: product owner interview and documentation review. In the first stage, interview with the product owner was conducted to define the current IoT supply chain model and what is potentially missing in it creating the challenges. Also, interview helped to define the current supply chain's roles and responsibilities distribution and to define partner/supplier onboarding process. Additionally, the supply chain model was mapped during the same interview. As the conclusion, possible strengths and weaknesses of the current supply chain model are discussed. The interview is processed through questions, active discussion and model mapping.

In the second stage, documentation was studied to get a deeper knowledge on the existing practices used in the case company. Documentation review introduced the principles that are used to onboard the suppliers, ways how responsibilities are managed within the existing parties, and what type of supply chain strategy is in use.

3.2 Description of Current Supply Chain Process

Presently, there are three existing groups of suppliers/partners responsible for the delivery of hardware and services that are related to its deployment, as well as one group under development. They are hardware suppliers, technology delivery partners, Support/Reseller channels and Monitoring partners under development. All the groups are connected to each other in one way or another, sharing the responsibilities for solution delivery. Even though there are challenges with the current model, the supply chain is already running as an eco-system, being modular and making sure the customer receives value as the end product.

Additionally, from the architecture point of view, there is an extra component in the model called “outer layer” which ensures that the whole supply chain network achieves high performance.

Overall, the supply chain flow is presented in Figure 2, showing both how the supply chain works at the moment provision and data wise, as well as how it should operate ideally.

In the next section the operation of all four groups is briefly described to give a better view on how the supply chain process works from the IoT product perspective. Thereafter, the outer layer and its importance is presented.

3.2.1 Hardware Supplier Operation

As shown in Figure 2 the supply chain process for the case company’s IoT product is initiated at the hardware supplier level, where suppliers take the responsibility for hardware provision towards the Hardware as a service supplier, which practically means that the hardware supplier acts as a design house for electronic devices as well as a possible manufacturer or one taking responsibility for organizing the manufacturing process. Based on the feedback from the interview with the product owner the hardware suppliers take common responsibilities like supporting RFI, RFQ processes, handling warranties, tracking parts availability, validating products, ensuring correct lead times and running hardware certifications when needed.

3.2.2 Technology Delivery Partner

The second phase of the process consists of technology partners who are responsible for delivering the IoT product’s essential components, that are needed to support the

technical layer of the solution. These partners are: Connectivity partner, HW as a service supplier, Asset tracking partner and MiniPC supplier. The connectivity partner is ensuring that all needed services are in place to provide internet connectivity for the IoT sensor networks, including a sim card provision towards HW as a service supplier. The hardware as a service supplier is responsible for acquiring hardware, setting up technical requirements for the hardware directed to hardware suppliers, establishing deployment plans and forwarding hardware towards installation party via the service level agreement. The asset tracking partner has similar responsibilities to HW as a service supplier except that technology is different. And lastly, a MiniPC supplier ensures that Display technology used in the case company's IoT product is operating properly, taking care of selecting those displays, installing them and maintaining them during the lifecycle of the product.

3.2.3 Support / Resellers Group

The third phase of the process is the last one before the customer receives the goods. A group with support and reseller functions share the same process of providing support service for all the parties within the supply chain network. A group mainly consists of Reseller, who acts as an agent or sales channel, and an IoT product owner (case company) which in case of the supply chain should ideally be only taking tier 3 support function. One key difference is that Reseller has an exceptional responsibility of providing physical installation/maintenance of the case company's IoT product. That means, by the nature of the product there are various devices that have to be installed in the customer environment (i.e. building). Therefore, by default it is a Reseller who is managing/owning the responsibility of installation and maintenance of those devices. As mentioned, Reseller and product owner share the same responsibility of performing supply network support. That said, Reseller is taking all the tier 1 and 2 responsibilities and product owner takes only tier 3 support function.

3.2.4 Outer Layer

To ensure better supplier/partner performance within the supply chain process several common methodologies are already implemented into the process. They are RACI matrices, Onboarding process, Technical product evaluation. First listed are RACI matrices which are used as a method to distribute responsibilities between the parties. However, it is important to mention that RACI components among all the parties, even from the same type vary, missing generalization. Meaning there is significant time investment in

preparations of RACI matrix for every new supplier/partner. Second, the onboarding process - it is used to identify best performing practice to onboard new suppliers/partners. Currently, the onboarding process is done per partner, meaning no standardized approaches are taken to generalize the process. Lastly, a technical product evaluation process is presented in the form of a questionnaire poorly delivering requirements for the technology solution implementation additionally missing the quality criteria as one of the needs.

3.2.5 Monitoring Partners

Uncovered during the interview monitoring partners were also added to the model presented in Figure 2. Even though the group is still under development high level architecture has already been presented to understand a potential impact on other components of the supply chain process. Monitoring partners are intended to add missing software tooling between partners provisioning hardware and partners who are responsible for providing support. Monitoring in general is supposed to enable partial automation of failure detection, which has been done manually until now. Also, such an automation enables automatic reporting towards the Information Technology Service Management (ITSM) platform, which already assists with delivering IT services to the case company's customers by providing functions such as support, problem and incident management, asset management and knowledge management.

Figure 2 depicts the supply chain process mapping.

Supply chain process mapping

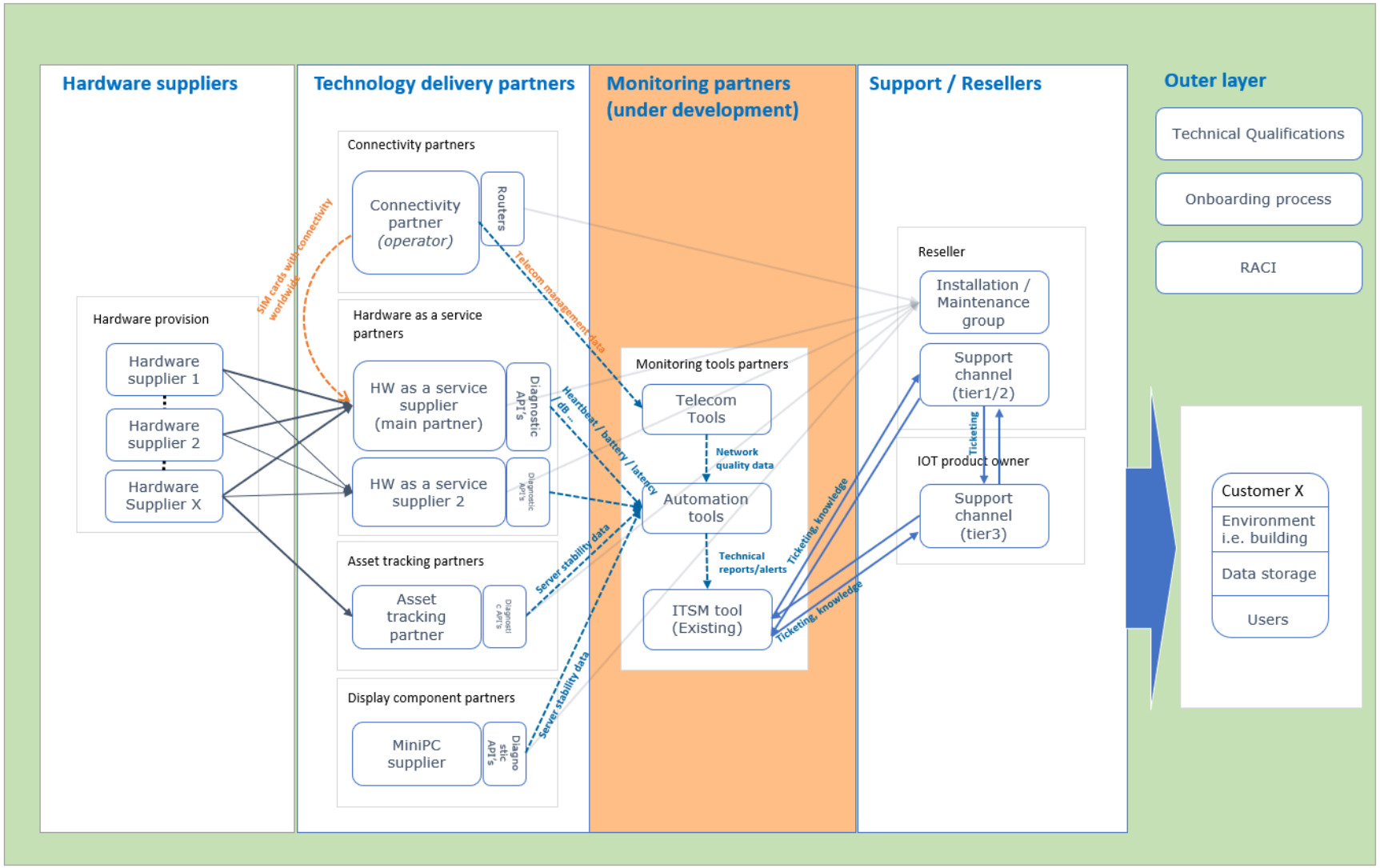

Figure 2. Supply Chain Process Mapping

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3.3 Outcome of the Current State Analysis

This section reports about the outcomes from the current state analysis.

3.3.1 The Management Expectations Concerning the Current Supply Chain Process

The management expectations towards supply chain process improvement was also gathered for this study. Data was collected through a one-on-one interview with the case company's product owner.

First, when the topic of improvements was discussed, the product owner mentioned that the supply chain process in general is of highest priority, pointing out that supply chain process automation is a matter of business scalability. Secondly, due to a growing supply network amount of responsibilities the case company is taking is continuously growing which leads to a necessity of distributing these responsibilities more logically, transparently, and evenly throughout the supply network members. That will potentially decrease the load on the ITSM level. Also, management pointed out the importance of the KPIs to be able to add predictability to the operation of the business. Lastly, the management expected to have a simpler, faster and standardized onboarding process to be able to keep up the market competition of solution suppliers, allow faster growth of the supplier network and to secure the customer demand. Since standardization is required, possibly following ISO alike standard will benefit in the evaluation of the product quality. Nonetheless, management expects onboarding to be a competence of the partner.

3.3.2 The Strengths of the Current Supply Chain Model

This section discusses the strengths of the current supply chain process based on the internal documentation review and the interview with the case company's product owner.

Totally, four strengths were identified during the data collection process that supports achievement of the management expectations. Firstly, the product owner has declared a high readiness of ITSM tools for possible change towards automation. The tools are already operating, a process of support functions is existing and ready to allow a new model of the supply chain process. Secondly, the availability of technical resources for the possible change was confirmed, which might save time for the change deployment.

Thirdly, based on the documentation review, from the current demand perspective supply network seems to be self-sufficient. Nonetheless, competition, scalability, and innovation angle require continues sourcing of new partners and suppliers. Lastly, the product owner has confirmed high support from the organization towards the change.

3.3.3 The Weaknesses of the Current Supply Chain Model

During the interview and documentation review, weaknesses of the current supply chain process mentioned in section 3.2 were also challenged and shared among the participants.

At first, it was identified that the current supply network is missing certain partners to manage certain Empathic Building's supply chain components such as security, quality, and tech data. Hence, there is additional manual work found, due to impossibility of outsourcing issues related to these components. Additionally, it creates a certain gap in the division of responsibilities between solution suppliers and the case company. Secondly, the current responsibilities division between the case company and a hardware as a service supplier presumes that case company takes full responsibility for hardware logistics in case they act as a reseller. Practically, it means that the case company takes care of receiving, storing, and distributing hardware if the company performs direct sales. Logistics responsibility is directly connected to the third weakness identified, which is the status of the current RACI matrix. The current RACI matrix, which is used throughout the supply network is used to set up the responsibilities and roles between each member/group involved in the supply network. Therefore, the product owner identified that the RACI matrix is currently missing integral connections between some technology providers, as well as missing risk management process that should be the basis for the way to move risks and problems evenly throughout the supply network and fill missing gaps such as the one with logistics. Next, one of the issues raised by the product owner during the one-on-one interview was the time needed to onboard a new partner/supplier, which appeared to be very long, in some cases reaching six months. Thus, one of the weaknesses came to be an unstandardized onboarding process, which can be divided into two categories, which are RACI, covered in this section and technical product evaluation. By product owner's assessment RACI is missing generalization, creating gaps due to example of individual approaches of creating RACI matrices per partner/supplier. Technical product evaluation is a subject of the same problem, when a case company in some unique cases has to adopt to the supplier's technical specifications not following their

own, which creates additional risks and loosens the quality requirements of the supplied product. Lastly, critical components to manage customers were mentioned. They are probability evaluation, risks, time needed. All of the three components are supposed to be part of the performance measurement that could potentially be digitized in the CRM tool. Nevertheless, processes related to these components need development.

3.4 Summary of the Current State Analysis

This sub-section provides an overview of all findings identified during the current state analysis. A summary of the findings is presented in Table 3.

Mainly, after a thorough analysis of the interview and internal documentation it can be concluded that the main weaknesses of the current supply chain process are related to an unstructured responsibility and role distribution (RACI), lack of risk management, and unstandardized process of onboarding new partners/suppliers into the supplier network. When it comes to the weaknesses related to ITSM and logistics it became more obvious after analysis that such issues might appear to be under RACI improvement process not requiring any separate development. Regarding the onboarding process, it became clear that the main weakness is the time spent per partner/supplier, thus again RACI readiness is being questioned as well as the generalization of the technical product evaluation process.

Considering strengths, the data collection process proved high readiness of the organization to move towards changes, especially towards automation backed up by technical resource availability, suppliers and their tools readiness and support received from the company. From the interview it was also clear that the internal ITSM platform is already operating and is likewise ready to move towards automation allowing the supply network to start using the tool for the supply chain process improvement.

Complete summary of the findings, including strengths and weaknesses as well as the management's expectations is presented in Table 3.

As for the management expectations, they were fully aligned with the results of the documentation review, pointing out three prospects that are highly preferable to achieve. On a high level, the management expects the supply chain process around the IoT product to become more automated, meaning the case company should spend less resources

maintaining it. Further, to achieve such an automation, the management expected risks to be more evenly spread around the supply network members, onboarding to be simple and fast.

SUMMARY OF CURRENT STATE ANALYSIS		
SUMMARY OF WEAKNESSES	**SUMMARY OF STRENGTHS**	**MANAGEMENT EXPECTATIONS**
• Missing partner network for security, tech data and quality. • Case company takes end-to-end responsibility for hardware logistics. • RACI matrix is missing connections between different solution providers as well as missing responsibility components that have to be moved to hardware suppliers and respective parties. RACI requires generalization. • Onboarding process is not standardized, thus requires too much time investment per new supplier / partner. Onboarding process is missing common RACI approach and generic technical product evaluation method. • Supplier performance measurements is missing.	• ITSM platform is already there. All the tools for problem resolution are already operating, process is existing and well developed. • Technical resources are available • From the current demand perspective supply network is noted to be self-sufficient. Nonetheless, competition, scalability, and innovation angle require continuous sourcing of new partners and suppliers. • Case company supports the change	• Supply chain should be automated • Risks should be distributed evenly throughout the supply network • Onboarding process should be simple and fast, but preferably not the competence of the case company • Supply chain processes should be transparent • KPIs to be implemented • Product evaluation should have ISO alike standard

Table 3. Summary of the findings

4 Existing Knowledge in Supply Chain Management

This section explores best practices on managing supply chain and supplier network found from literature. Due to the complexity of the supply chain in IoT this section also includes practices of integral components such as supply chain strategy selection, onboarding method, risk management practices and technical product evaluation standards. This section has five sub-sections. Sub-section 4.1 briefly describes the supply chain strategy and tendencies. Sub-section 4.2 reports about the onboarding practices used for supplier onboarding as well as presents the supplier selection process. Sub-section 4.3 covers the risk and problem management process. Additionally, the RACI matrix method is introduced and aligned with the supply chain topic. Sub-section 4.4 de-demonstrates methods to perform a technical product evaluation using ISO standards. Process is then supported with adaptation of the standard by giving it goal-orientation. Lastly, sub-section 4.5 introduces the conceptual framework and its description. Each section is logically linked to the supply chain strategy selection by coherent deepening into the elements of supply chain management process, such as risks, onboarding, and product evaluation.

4.1 Supply Chain Strategy and Tendencies

To understand the nature of supply chain challenges within the Empathic Building product it was decided to align the existing supply chain strategy with existing strategies found in the literature. Additionally, the market tendency within the supply chain context was studied to draw a parallel between challenges in the Empathic Building product and the challenges existing on the market. From best practices, there are many existing frameworks and strategy selection guides, for example from the automotive industry, that partially could be aligned with the IoT product's supply chain strategy. For the context of this thesis, a Framework for choosing supply chain strategies developed by Ambe and Badenhorst-Weiss (2011) was selected to better describe the selection process based on various parameters.

4.1.1 Supply Chain Transformation and Challenges

In recent decades, supply chain management has been transforming from mass production strategy (Zhang and Chen 2006: 668), relying on company's ability to predict the

demand, towards mass customization strategy, when a company's operations (i.e. manufacturing process) are initiated by a customer's order rather than the forecast. Christopher (2006: 3) state that in ideal scenario supply chains are created from "customer backwards" rather than the classical approach which is "factory outwards". Keeping that in mind, with the supply chain strategy evolution it is wise to remember that a typical supply chain might not work for all the businesses. Ambe and Badenhorst-Weiss (2011: 13391) argue that a typical supply chain strategy aims at achieving a smooth flow at a minimum cost, while cost-saving for one does not mean cost saving to another.

With a constantly evolving supply chain new challenges also appear forcing companies to shift their operational priorities based on the market demand. McKinsey (2010) has identified three trending challenges in supply chain management that have been growing within the last three years. The first challenge is the increasing the volatility of the customer demand due to consumer spending. The second challenge is an increased consumer expectation about customer's product or service quality. The last challenge is an increasing cost pressure in logistics/transportation. Practically, all three challenges are highly inherent to the IoT industry. Other criteria review in the McKinsey report (2010) are the company goals for the SCM presented in Chart 1.

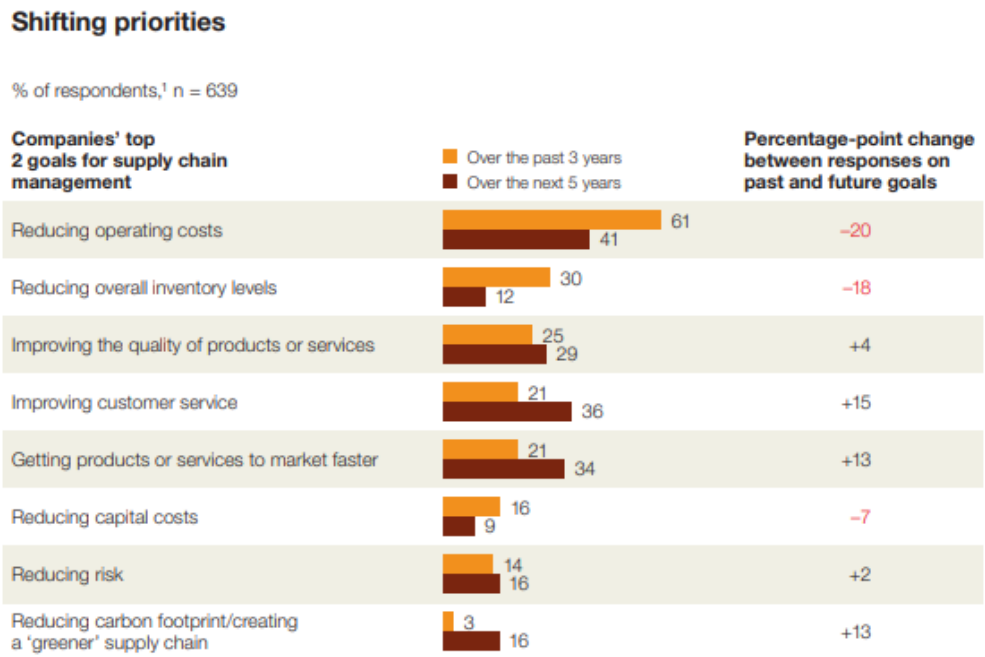

Chart 1. Company's goals for the supply chain management. Based on McKinsey Global Survey results. The challenges ahead for supply chains. (McKinsey 2010).

As shown in Chart 1 there are growing attempts to reduce operating costs of the supply chain as well as a need to reduce overall inventory levels. From the thesis context, it is relevant to mention that risk reduction is also identified to be one of the goals for top management, though relevancy has been falling during three years of analysis. In general, the McKinsey report (2010) also shows that there are expectations from top management that risks within the supply chain will grow further. Ambe and Badenhorst-Weiss (2011: 13390) additionally identified two core sources of challenge not covered in the McKinsey report (2010). The first source of the challenge are low levels of collaboration and not reacting to market changes. The second source of challenge is a necessity to make supply chain lean. All the rest sources of challenges were matching in these two reports.

4.1.2 Supply Chain Strategy Selection

A supply chain strategy should be chosen based on the nature of the specified products and by matching the strategy to the unique parameters of the market and products. Based on Ambe and Badenhorst-Weiss (2011: 13392) the framework strategy selection process consists of three steps. The first step is understanding the market and the nature of customer demand. The second step is determining competencies and capabilities of the company. Step three is choosing the applicable strategy. The framework for selecting supply chain strategy is presented in Figure 3.

As can be seen the biggest challenge identified by McKinsey (2010), which is volatility of the customer demand, is matching the first step of the supply chain strategy selection introduced by Ambe and Badenhorst-Weiss (2011). Customers are becoming more demanding thus it takes more effort and resources to not just understand the product quality aspects but also the effects on the supply chain brought by such a demand. Hines (2006) has identified six key market variables that define the supply chain strategy. They are volume, time, variety, service level required, price and rate of change. Additionally, it is important to segment customers to therefore determine similarities between segments to make the supply chain efficient (Hines 2006).

According to Fawcett el al. (2007) new products are strongly affecting supply chain uncertainty due to the need for production processes to evolve, which is applicable to IoT industry products and services.

In the second step, core competencies and capabilities of the company (supplier) are identified. On a high level, the supply chains surely have different characteristics, but all the supply chains have two integral components, which are cost and service (Ambe and Badenhorst-Weiss 2011: 13393). The supply chain capabilities include a wide range of functions, including the ability to cope with different demand levels, meet short lead times, build innovative products, meet high service level and handle supply uncertainty. To identify such a capability of the company's supply chain a trade-off between responsiveness and cost is required (Hines 2006).

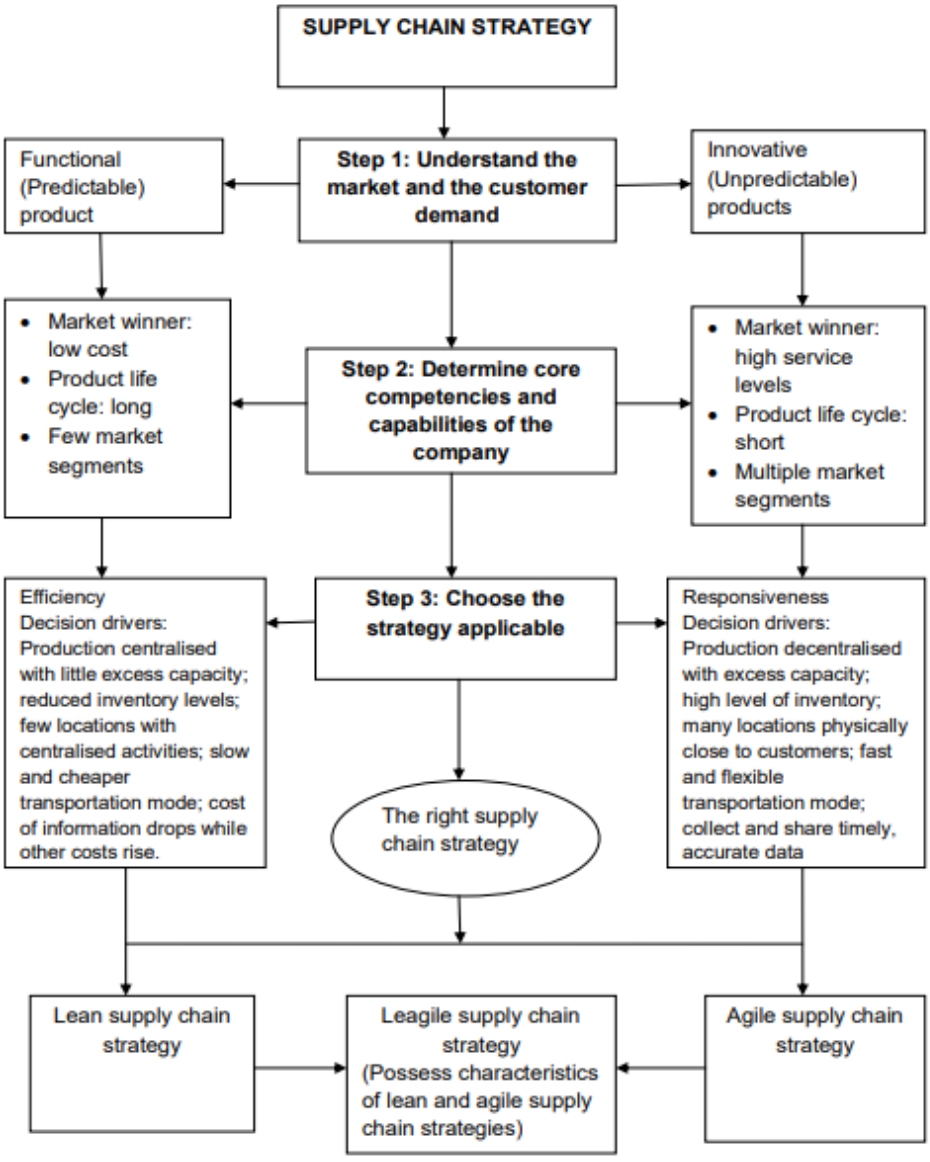

Figure 3. Framework for supply chain strategies. (Ambe and Badenhorst-Weiss 2011: 13395)

According to Figure 3, at the last third step, after customer's demand and the market have been understood and capabilities identified the supply chain strategy can be selected. Ambe and Badenhorst-Weiss (2011: 13395) have identified two possible supply chains to select from. The first one is efficiency-based, which focuses on delivering products at a lowest cost with centralized production and reduced inventory levels, making that supply chain cheaper but slower. The second one is a responsiveness-based supply chain, which contrawise keeps production decentralized keeping stock big. That makes faster transportation but higher costs.

Therefore, there are two main supply chain strategies that are lean or agile. Based on Krishnamurthy and Yauch (2007: 591) they can be integrated in different ways creating a combination called leagile supply chain, which brings a competitive advantage in cost, service, and quality.

4.2 Supplier (or vendor in this section) Onboarding and Selection Practices

In the business literature and from best practices, different methods to onboard suppliers were identified. The methods are mainly dependent on the business industry, business area, offered products and services, operational models, etc. Supplier onboarding, as part of the supply chain process, is about approving new vendors into supply chain in a standardized and systematic way, considering all the risks, time criteria, responsiveness of the supplier and the product quality. The supplier onboarding process is performed through gathering supplier data and aligning it with the company's onboarding workflow. Supplier onboarding is part of supplier relationship management. According to Aberdeen Group (2015) report "companies that are leaders in supply chain management are over 30 percent more likely to accelerate supplier onboarding and use that business intelligence to refine processes".

4.2.1 Supplier Evaluation and Selection Process

Proper supplier onboarding process mitigates risks and mistakes by providing a linear approach to supplier validation, which is performed at the supplier selection stage. Based on Smartsheet report (2020) there are seven possible mistakes in the supplier onboarding process. They are failure to get buy-in from top-management, failure to assign responsible team members, failure to plan, failure to train, failure to complete due diligence,

failure to communicate and failure to build flexibility. To avoid possible mistakes the onboarding process should be formal and standardized. According to Smartsheet report (2020) “all vendor relationships benefit from a formal onboarding process that clarifies requirements”.

To properly denote the starting point of the supplier onboarding process, end-to-end supplier evaluation and selection process was studied and presented in Figure 4.

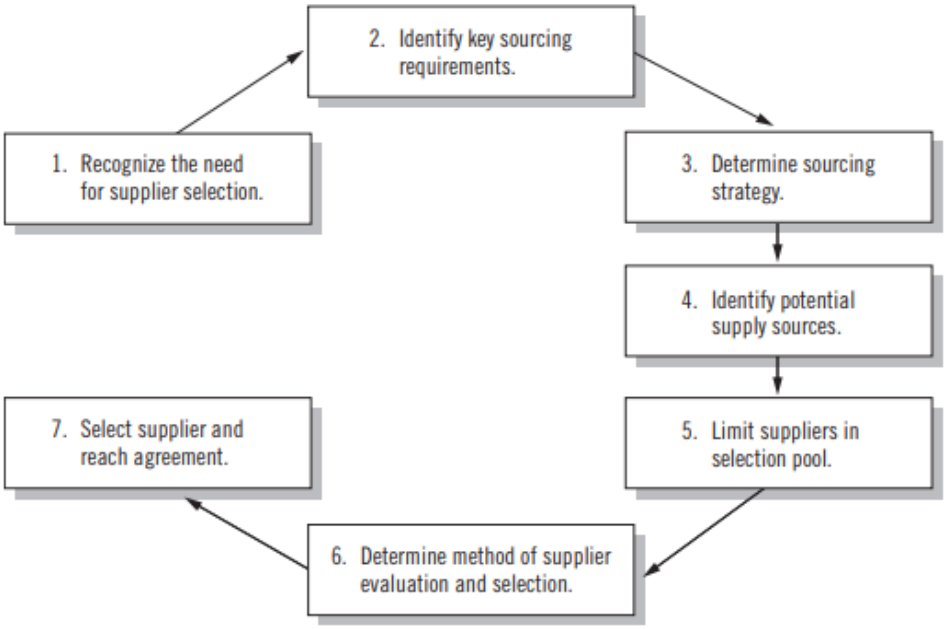

Figure 4. Supplier evaluation and selection process (Monczka et al. 2011: 237)

According to Figure 4 supplier evaluation and the selection process consists of total seven steps: Recognizing the need for supplier selection, identifying key sourcing requirements, determining sourcing strategy, identifying potential supply sources, limit suppliers in the selection pool, determining the method of supplier evaluation and selection and lastly selecting a supplier and reaching the agreement. Based on Monczka et al. (2011: 245) before committing time to evaluate any supplier further, the supplier should satisfy certain entry qualifiers which are to be considered before step 1. Researchers have identified in total five entry qualifiers to transfer the supplier to the first step of supplier evaluation. They are: Financial strengths of the supplier, appropriate business strategy, strong supportive management, proven manufacturing capabilities, and design capability.

4.2.2 Supplier Onboarding Process

For the context of this thesis, an assumption is made that product requirements and supplier's entry qualifiers have already been evaluated, thus the onboarding process should be studied separately from the supplier selection process. It is wise mentioning that Monczka et al. (2011: 237) based supplier selection process does not fully disclose the process of supplier onboarding and how exactly to prepare a standardized workflow in case of a complex supply chain model. According to Monczka et al. (2011: 247) "The buyer and seller may have to conduct detailed negotiations to agree upon the specific details of a purchase agreement."

Based on Smartsheet report (2020) vendor onboarding process should follow a continuous improvement model, to be able to refine the onboarding practices based on collected data from the suppliers. Figure 5 presents a continuous improvement model for vendor onboarding workflow, keeping all processes looped.

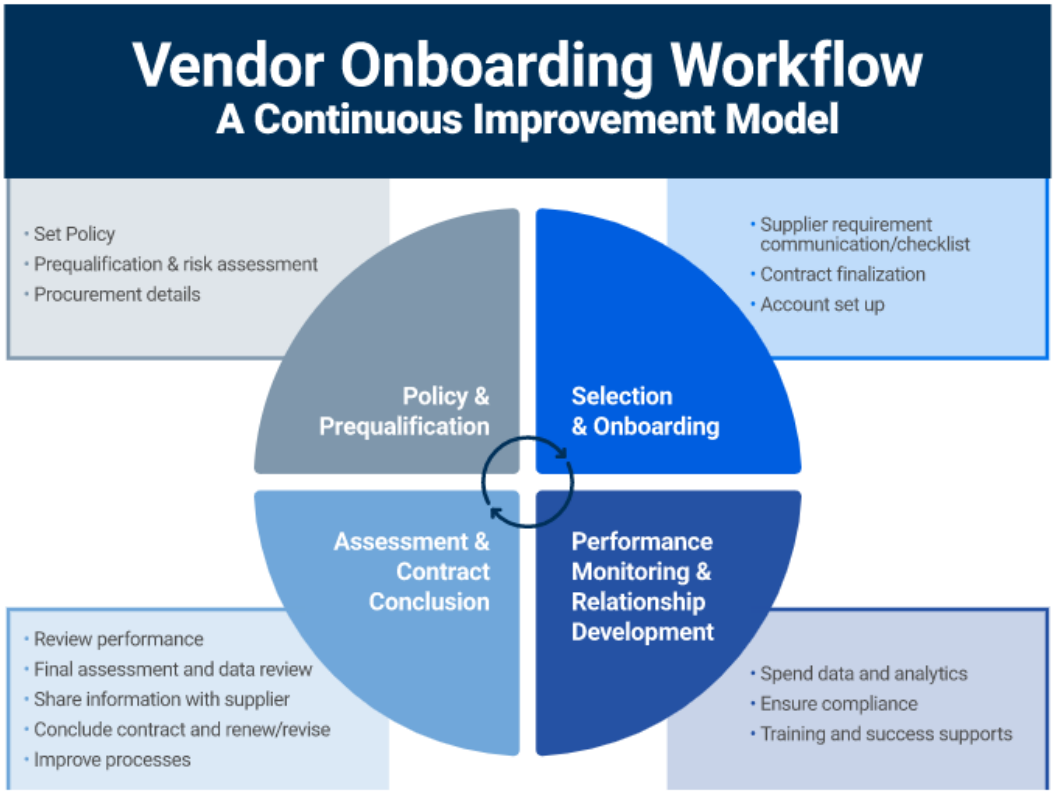

Figure 5. Continuous improvement model for vendor onboarding workflow. (Smartsheet 2020)

Based on Figure 5 there are in total four onboarding steps to approve the vendor. They are: Policy & Prequalification, Selection & Onboarding, Performance Monitoring & Relationship Development and Assessment & Contract Conclusion.

A. Policy & Prequalification

The first step begins with setting up policies relevant to regulations within the company. There might be existing processes and policies already in place. The prequalification step allows the company to assess the risk based on entry qualifiers mentioned in section 4.3.1, based on Monczka et al. (2011: 245). Procurement details allow structuring contracts at the early phase by reviewing vendor needs.

B. Selection & Onboarding

In the second step company must refine product/service needs and develop a checklist for potential suppliers based on identified requirements. For supplier evaluation the company might use some common tools as vendor evaluation template, vendor risk assessment template, RACI matrix, and vendor onboarding policy template. Contract finalization is made straight after the vendor was selected. Thereafter, the vendor should be added to the vendor portal.

According to Monczka et al. (2011: 247) there are five specific rules or selecting a supplier within the IT industry. First, the company should aim at building a supply chain with small suppliers never having only one supplier of big size. Second, the company should evaluate supplier's technology and product roadmaps. Third, supplier selection should be based on the value creation and not only on the purchase price. Fourth, smaller suppliers are more motivated to provide innovation. Lastly, the company should understand how exactly the supplier is using the internet for their development, manufacturing, service or distribution.

C. Performance monitoring & Relationship Development

In the third step, the company starts to track vendor's performance based on the data collection method. Performance can be measured by key performance indicators defined by the supply chain strategy. Thereafter, based on the performance company

should provide training to the vendor and perform performance auditing. Vendor performance is typically reported in vendor performance scorecard format. Providing a performance scorecard to the supplier is significant for further supplier performance improvement. With the help of supplier portals, data measurement can be automated and enabling continuous improvement approach.

D. Assessment & Contract Conclusion

In the last step, vendor performance gets reviewed and rated according to the company metrics. That allows the company to decide whether the contract should be renewed or revised before renewal.

4.3 Risk and Problem Management. Impact on RACI

For a case company, it is not enough to identify which party is responsible for one problem or another. Instead, it is necessary to set up a process or part of it for risk management to get a full image of possible risks related to the supplier's product or service. It is important to keep risks within the supplier network transparent, keeping risk knowledge on the same level between the supplier and the case company. Due to an ever-changing industry of IoT, the risk management process should be following the logic of continuous improvement, similar to the onboarding process model described in section 4.3.2. It is also vital to understand whether an existing approach of the RACI matrix can fulfil the needs of responsibility distribution for efficient risk management. Lastly, the RACI approach should be evaluated for it to be a standardized onboarding component.

4.3.1 Risk Management Process

When exploring risk management it is important to briefly introduce the concept of risk management, how to structure it and plan the process. It is also critical to understand how to identify risks and therefore mitigate them.

"Risk can be defined as uncertainty of outcome whether positive or negative. The control and containment of risk is critical to project success and it is the task of risk management to manage a project's exposure to risk." (Office of Government Commerce 2002: 239)

The general definition of risk management based on Merna and Al-Thani (2011) is that it is an art to identify risks specific to an organization and to respond to them in an appropriate way. They also identified that risk management is a continuous process rather than a linear process. Also, it was stated that all levels of an organization need to be included in the risk management for it to be effective.

Based on Office of Government Commerce (2009) risk management process is categorized by risk analysis and risk management phases. The risk analysis process starts with risk identification. Then, analysis of a risk probability and its impact is made, called risk assessment. After the risk assessment phase risk response should be identified and selected. Thereafter, the risk management phase comes into force, the selected response should be planned and resourced. Lastly, risk mitigation should be monitored, and the results reported. Figure 6. Represents the risk management process based on Office of Government Commerce (2009).

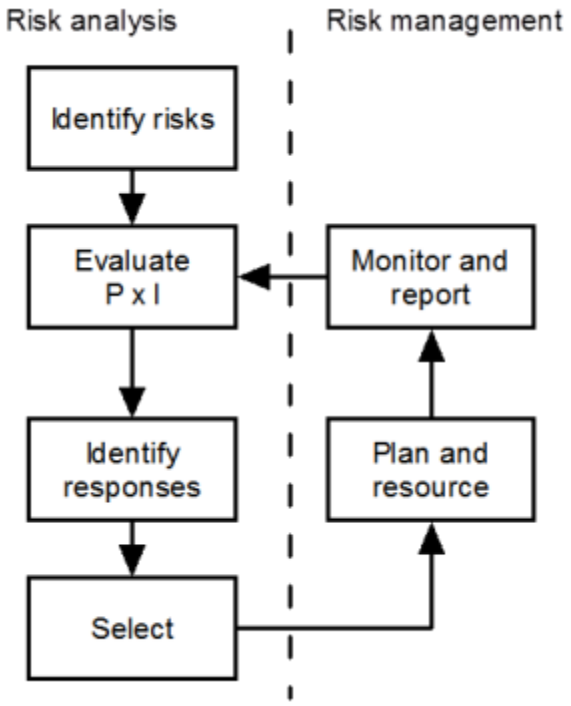

Figure 6. Risk Management Process. Based on Office of Government Commerce (2009)

A. Identify risks

According to Figure 6 the simplest way to identify risk is following six questions addressed to all the stakeholders (suppliers, partners, project team, etc.) within the supply

network: What could go wrong? What could prevent this from happening? What can harm us? What is the worst-case scenario? What threats do we face? What opportunities could we find? The questions are worth asking at every phase of cooperation with the supplier, meaning before the onboarding, during and after. Risks can be identified by checklists, assumption analysis, SWOT analysis, etc.

Once potential risks have been identified they should be classified. According to Office of Government Commerce (2009) and Hopkin (2010: 349) a method called PESTLE helps to identify what threats or opportunities could be faced. PESTLE is used to categorize the type of risk. P – Political, E – Economic, S – Socio-cultural, T – Technological, L – Legal, E – Environmental.

Conforming to Merna and Al-Thani (2011) risk identification using historical and current data is a necessary step in the early stage of project appraisal. Inputs to risk identification could be product or service description, work breakdown structure, cost and times estimates, specification requirements, historical information.

B. Evaluate risk probability and impact (risk assessment)

Cooke and Williams (2006: 76) suggested eight step risk assessment process that is supposed to be summarized by registering a risk in a risk register/risk log. A risk register is defined as the document used for recording risk management process for identified risks, based on ISO Guide 72. Its purpose is to facilitate the management and ownership of each risk. The risk assessment process starts with the identification of the hazard caused by the risk. Then, one should identify who or what might be harmed. In the third step, the risk gets assessed using one of the techniques. Cooke and Williams (2004) described a simple risk assessment calculation technique: Severity x Likelihood. Figure 7 shows the risk assessment matrix according to Cooke and Williams (2004). Next, control measures must be determined. Therefore, remaining risks should be assessed to prevent cascading failure. Once risks are assessed they should be recorded to a risk assessment sheet. Then, based on the sheet contingency plan is created to prevent risk in the future. Lastly, risk assessment gets adjusted and reviewed.

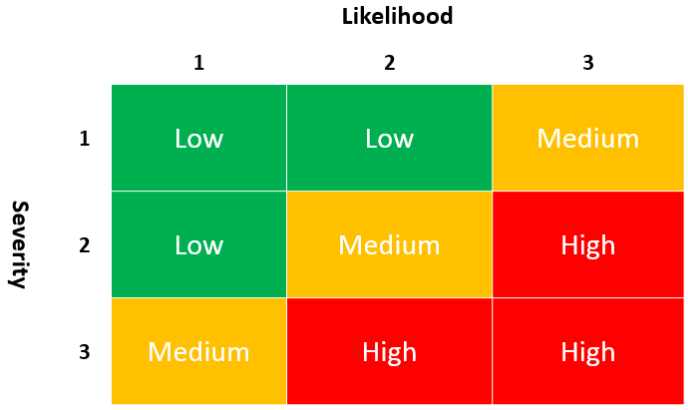

Figure 7. Risk assessment matrix based on Cooke and Williams (2004).

C. Identify responses

According to Office of Government Commerce (2009) risks can be either threats or opportunities. The response to a given risk should reflect the risk type, the risk assessment and the organization's attitude to risk.

Based on Office of Government Commerce (2009) Risk response to threats might by following: Avoid – the risk is avoided by changing the project, Transfer – risks are transferred to the 3rd party, Reduce - action is taken to reduce the likelihood of the risk or the risk's impact, Accept – the risk may be accepted if the impact or likelihood is low, Contingency – there is a plan to respond on the risk.

On the other hand, if the risk created opportunities then the response should be different: Share – opportunity is shared with the partner or supplier, Exploit – the project can be adjusted to take the advantage, Enhance – action is taken to increase the positive impact or likelihood, Reject – no action is taken.

Once all the assessment steps are done and reported, risk assessment phase proceeds to the risk management phase.

D. Plan and Resource

Once the risk assessment is done and risk response is selected the risk management action planning is needed in case it is required by the risk response. As it is stated by

Hopkin (2010: 39) planning activities include resourcing controls, to ensure that all the processes are in place to mitigate the risk and reaction planning/event management based on the risk assessment. In the case of the highly hazardous risks, the planning phase includes disaster recovery and business continuity planning.

E. Monitor and report

By monitoring the risk, the manager can ensure policies and procedures are followed. Monitoring of the risks should be a continuous process, performed on a timely basis depending on the probability of the risk. The highest probability risks might need to be monitored daily.

According to Hopkin (2010: 40) monitoring has to be applied to risk performance indicators, actions and events. Another crucial task at this phase is communicating risk issues to management team. Additionally, as reported by Merna and Al-Thani (2011) risk management is a continuous process, therefore similarly to opinion based on Hopkin (2010: 39) risk management team must improve the core risk management processes of an organization at that phase by constantly analyzing, monitoring and reviewing all the risks.

Lastly, according to Hopkin (2010: 40) risk management process concept, the complete architecture of risk management should be supplemented with a constant information and experience feedbacks gathered during the whole process.

4.3.2 RACI Chart/Matrix

As it was identified during the current state analysis in section 3.2.4 the case company is using the RACI matrix to manage all the risks within the supply network. Nevertheless, more detailed familiarization with the RACI approach was decided to be studied to gain a broader understanding of RACI functions and limitations and how exactly it can help manage risks and responsibilities within the supply network.

RACI chart/matrix is a diagram, that identifies responsibilities and corresponding roles against tasks within a project or supplier in case of the case company. Based on the Aris Community (2020) RACI is a method typically used during the project startup phase, reorganization procedures or during the business process modelling. Additionally, they

identified RACI as a useful tool for conflict resolution. From the communication perspective, according to Elhady and Abushama (2015: 216) RACI is a language to talk with the project team in a more precise way about their roles.

RACI is an acronym of the following words: R – responsible, A – accountable, C – consulted and I – informed. RACI matrix example is presented in Table 4.

Example RACI Chart					
Project Deliverable (or Activity)	**Project Manager**	**Strategist**	**Designer**	**Front End Developer**	**Back End Developer**
Design site map	C	R	A	I	I
Design wireframes	C	A	R	I	I
Create style guide	A	C	R	C	I
Code templates	A	I	C	R	C

Table 4. RACI matrix example. Based on Harned (2019).

Therefore, to properly understand all the levels of task responsibilities, presented in Table 4, each of those tasks was studied separately:

A. Responsible

According to Elhady and Abushama (2015: 216) “Responsible” task identifies the person who is assigned to get the work done. It is also stated that only one person is responsible. Brett Harned (2019) states that more than one person can take responsibility for the task. Brett Harned’s (2019) statement is confirmed in many business articles when RACI is to be used in vendor management.

B. Accountable

Conforming to Montgomery (2019) “Accountable task” is a responsibility of a person who is held accountable for the success of the task and is the decision-maker. Elhady and Abushama (2015: 216) suggest that there may be more than one person responsible for the task.

C. Consulted

Elhady and Abushama (2015: 216) are telling that the “Consulted” task defines people who contribute to work by providing consultancy. According to Smith and Erwin (2007) “Consulted” is a two-way communication task, requiring the other party’s input.

D. Informed

Elhady and Abushama (2015: 216) explain “Informed” as a task that exists for people that need to be informed about something but are not contributing. This means the role is not active.

Additionally, it is important to study the rules related to using the RACI matrix, since they might put limitations to using it in the supplier network management case. According to Brett Harned (2019) there are 5 fundamental rules to follow: First, every task should have at least one responsible person. It is an important criteria since the case company’s responsibility matrix was identified to have a so-called “grey zones” in responsibility ownership. Second, there is only one accountable party assigned to each task. Third, No team members are overloaded with too many “Responsible” tasks. Fourth, every team member has a role in each task. It is a doubtful rule in case of the supply chain management, since projecting such a rule to a supplier network might overload the suppliers with unneeded tasks and will slow down the project, even if it is only informing. Nonetheless, there are some business reviews, for example Morris (2009) presenting an opposite opinion, showing that not all roles will be involved in all the tasks. Fourth, if there are too many “Consulted”, or “Informed” tasks manager should simplify the way to keep them informed not to overload the project.

RACI creation process is another critical component to properly set responsibilities and corresponding roles. Following the structure created by Haworth (2018), the RACI creation process consists total of six steps: The first step, identify project roles. A manager should make a list of everyone somehow involved in the project. The second step identifies project tasks and deliverables. The project should be broken down into tasks and deliverables at that stage. The third step, RACI components should be assigned to each role and task following the RACI rules mentioned before. The fourth step, all the decisions should be aligned with the team. Feedback should be continuously collected during the RACI creation process. The fifth step, all the decisions should be communicated to

all the stakeholders/groups involved in the RACI matrix. The last step, RACI should be useful. A responsible manager has to keep RACI updated along the way of its usage. There are many changes that can affect the RACI matrix, linkage to risk management is a good example when RACI could change due to new risk assessment. The first and second phase by default could be turned around following the concept of the ideation process where everything starts with the problem. In the context of RACI, it is task identification to start with. According to Smith and Erwin (2007: 6) role creation starts at phase three and has to include not only people but groups as well, such as suppliers, customers, etc. Therefore, following their study, the first and second steps are intended for the identification of the work process and determination of the activities and decisions to the chart.

4.3.3 Problem Management Impact on RACI Matrix

Most of the studies show usage of the RACI matrix as the way to assign responsibility for some task or activity to one of the roles. The supply chain perspective and especially the innovative technical aspect requires adaptation of the RACI matrix towards specific risks identified during the risk management process. That is because innovation brings new and unpredictable risks, which might not be detectable immediately. Therefore, an assumption can be made that despite having RACI with tasks only, risks or corresponding outcomes could additionally be introduced to the matrix. Thus, “tasks” as a component of RACI should be supplemented with “risks” or “problems” to therefore identify who is responsible, accountable, consulted and informed both about the “risk” and the” task”. On the other hand, every risk could be transformed into a task of solving a potential risk. Due to the way the case company is using the RACI matrix, thinking from risk perspective is more natural than from the task perspective. That said, more deeper understanding of risk transformation into a task is needed. Also, understanding the connection between the risk and the problem will help to define responsible roles in advance. Such an approach might additionally require separating RACI templates for supplier network management and problem resolution management.

There are business reports available which address the question of risk and issue difference. Based on Project Management Institute (2013) risk can be defined as an uncertain condition that results in a positive or negative effect on a project. While an issue (a problem in the context of this thesis) can be defined as a condition that has already happened

and has impacted or currently impacting the project. Also, risks are defined to be future-focused while problems are defined to be present-focused.

Beginning with the risk definition, and whether it can be part of the RACI matrix or not, an accurate explanation of the transformation process from risk to problem is needed. Following Piney (2012) an issue is the limiting case of a risk, where the uncertainty disappears, and the situation therefore becomes certain.

Since the case company is already using ITSM tools to manage all the problems, ITSM knowledge can be used to represent the concept of problem transformation into a task. According to Yale University (n.d.: 18) problem resolution can be visualized as a linear process. The problem management state transitions are presented in Figure 8.

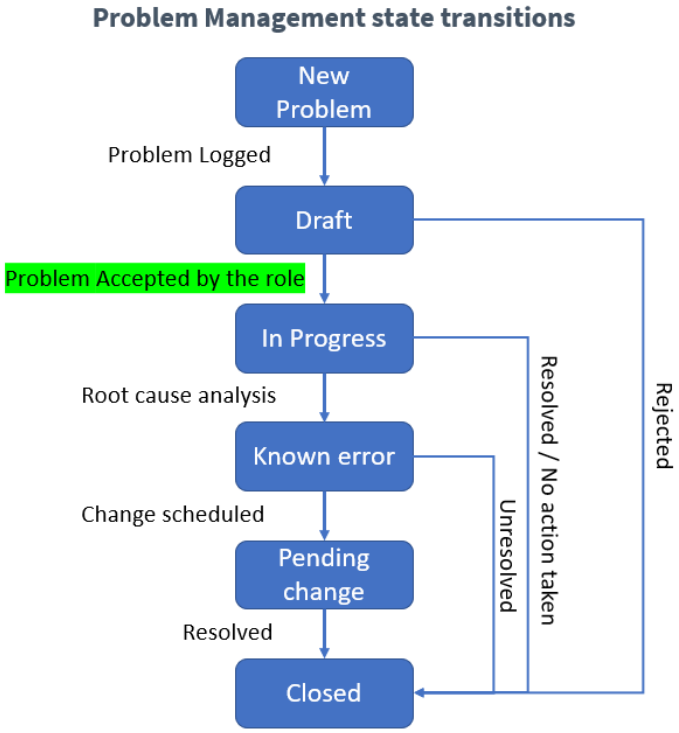

Figure 8. Problem Management state transitions. Based on Yale University Problem Management Guide.

According to Figure 8 and once the problem is detected it does not immediately get assigned to the owner. As mentioned, it is a linear process consisting of additional four steps, which happen between the “New problem state” and “Problem Accepted by the role state” according to Figure 8. First, the problem has to be recorded and submitted for consideration. There can be a variety of sources for a problem, even ones defined during

the risk management phase. Secondly, the problem gets assessed by the Problem Manager, to understand the nature of tasks and in what order they will be addressed. The third step is to categorize the problem by all the relevant details as problem details, priority, associated incidents, incident affects, etc. Lastly, the Problem manager assigns the problem to an owner, person with the “Responsible” task in RACI matrix.

It is worth mentioning that above-described method is mainly used in the ITSM (Information Technology Service Management) process, which is not directly connected to RACI, though the study provided gives a clear input into the transformation of risk into the problem and then into the task.

4.4 Technical Product Evaluation Process. Setting up Standards.

The identification of certain risks might require additional knowledge of the product or service. For example, to understand risks related to sensor industry one needs to understand how sensors operate and how exactly they are used in the customer environment. Risks on the sensor side of the business do not necessarily mean risks on the end-customer side, and vice versa. To avoid such technical risks related to product or service, technical product evaluation should be performed in the early phase. Technical product evaluation is processed by the supplier by following predefined technical evaluation template provided by the supply chain manager/owner. In the business literature, there are many existing technology evaluation processes as well as product evaluation methods used in product management. Another existing approach that can be adopted to the case company needs is the product market fit framework.

Based on iAuditor (2020) Product evaluation is the process of assessing a manufactured product’s suitability and safety for use by consumers. In terms of case company consumer is the end-customer. Product evaluation is processed due to two reasons. Firstly, to ensure that a specific product or service follows relevant standards of the customer. Secondly, to identify and remove manufacturing or design defects.

Another mentioned product evaluation principle mentioned above is product-market fit. Olsen (2015) defines product-market fit as the end-game where a startup has built a product that creates significant customer value. Leibson (2018) categorizes product-market fit into 6 steps: Determining target customer, Identifying underserved customer

needs, Defining value proposition, Specifying minimum viable product prototype, testing minimum viable product with customers.

Even though the product-market fit is mainly dedicated to startups and early phase businesses, it provides very specific input into the value creation process as one being most important for the product to fit customer needs. It might not necessarily fit case company's evaluation process but it gives valuable parameters to consider when evaluating the product fit into case company's IoT product.

Following ISO 9126: 1991, 5.3 the software product evaluation process consists of three stages and it can be applied at any phase of the life cycle for each component of the software product. Considering the nature of the case company's product hardware is highly interconnected with software components, as it is seen from the case study, thus ISO 9126: 1991, 5.3 gives sufficient input into the evaluation process of hardware components.

A. First Phase. Quality Requirement Definition.

The purpose of the initial phase is to specify the quality characteristics requirements. Such requirements express the demand of the environment of the product or service. The first phase is performed before development. In terms of the case company, the first phase is performed before implementing the technology.

B. Second phase. Evaluation Preparation.

The idea of the second phase is preparation the basis for product or service evaluation. This phase consists of three components. The first component sets the quality metrics to establish metrics that correlate to the characteristics of the product. The second component defines the rating levels to quantify the quality metrics. The third component indicates the creation of assessment criteria definition. Complete assessment of product quality could be performed in a form of the decision table.

C. Third phase. Evaluation Procedure.

The last phase of the evaluation process is the evaluation procedure. It is divided into 3 steps, including measurement, rating, and assessment. For measurements, selected

metrics (generating values) are applied to the product. Next, the rating level gets determined for a measured value. At the last step, assessment is processed by creating a statement of the quality of the product. Lastly, summarized quality is compared with all the other aspects such as time and cost, allowing a manager to make either acceptance or rejection decision.

To give an additional input into the standard of quality metrics ISO 9126: 1991, section 5.3 introduces the concept of checklisting of features (or specifications). According to the standard, checklisting is the method of measuring Boolean (presence/absence of feature) attributes. Checklisting is supposed to be done by the evaluator.

To give a broader input into the process of product evaluation ISO 14598 can additionally get introduced. Based on Punter et al. (2004: 138) ISO 14598 is the successor of ISO 9126, which initially identified the evaluation process. Nevertheless, according to authors both standards complement each other: the ISO 9126 gives the vocabulary for defining the software product quality and ISO 14598 presents the evaluation process. An overview of the ISO 14598 evaluation process is presented in Figure 9.

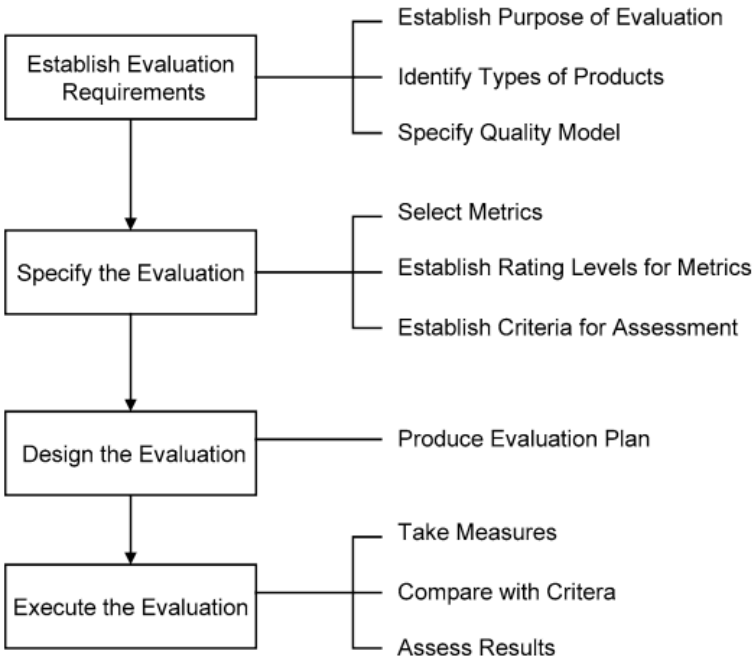

Figure 9. Overview of the ISO 14598 evaluation process.

As can be seen in Figure 9 there are slight differences between standards. One important addition to ISO9126 is the establishment of the evaluation purpose complemented with the identification of the product which seems to be missing in the standard ISO9126.

It is critical to consider possible problems with the standard. According to Punter et. al. (2004: 139-140) combined problems are a reason of a lack of goal-orientation of the standard. The authors suggest extending the standard with additional guidelines: identify the business goal, identify and involve stakeholders, define the evaluation goal and prioritize the evaluation goals.

4.5 The Conceptual Framework of the Thesis

This section presents the findings of the literature review accomplished in Section 4. The result is shown in the form of conceptual framework for the supply chain risk minimization by standardizing the onboarding process. The conceptual framework shown in Figure 10 was built from five elements identified during the literature review phase.

The first element is about aligning the existing supply chain strategy in the case company with ones existing on the market at the moment. Additionally, tendencies in terms of challenges and management's goals in the supply chain future are studied to get a perception of the supply chain industry evolvement. This element also covers the process of supply chain strategy selection establishing a strong link between an ongoing strategy and the challenge of selecting and therefore onboarding new suppliers.

Thus, the supply chain strategy section helps to realize the importance of every element in the strategy selection process and shows its impact on the overall performance of the supply chain, including the onboarding process. The Conceptual framework presents the components which are logically linked together, creating a solid literature structure for risk minimization process.

The second element is about defining the practices on how to onboard a new supplier and how not to make mistakes during the process. This element of the conceptual framework gives a broader understanding of the process of onboarding as well as presents the process of supplier selection, which naturally comes before the onboarding

process. Especially the supplier evaluation part reveals necessary components to categorize the suppliers and set five entry qualifiers to either get accepted to the supplier pool or not.

The third element presents the process of the risk and problem management and can be considered as the starting point to prepare the RACI matrix activities. It establishes the framework for the risk assessment and therefore risk management. The third element reveals the process of transformation of the risk into the problem, making it possible to assume that risks can be part of the RACI matrix.

The fourth element introduces the RACI matrix, presenting the way of using it, setting up rules to follow while using the matrix, and gives an input into RACI matrix creation process. The fourth element is technically connected to the third element as according to the literature review it additionally introduces the ideas needed to replace the RACI matrix human roles into group roles (i.e. developer to supplier).

Based on Figure 10, the last, fifth element describes the process of technical product evaluation using ISO standards for software products. The fifth element is intended to support the second element, which is the onboarding process, by providing the steps needed to evaluate the product. Technically, the evaluation process has to be performed before the supplier selection. The literature review confirmed that the process has to be standardized by the case company, by creating the evaluation plan for all the suppliers.

After the literature review and presentation of the outcome in the form of the conceptual framework, the framework was used to build the proposal for minimizing supply chain risks at the case company, presented next in Section 5.

Supply chain risk minimization process

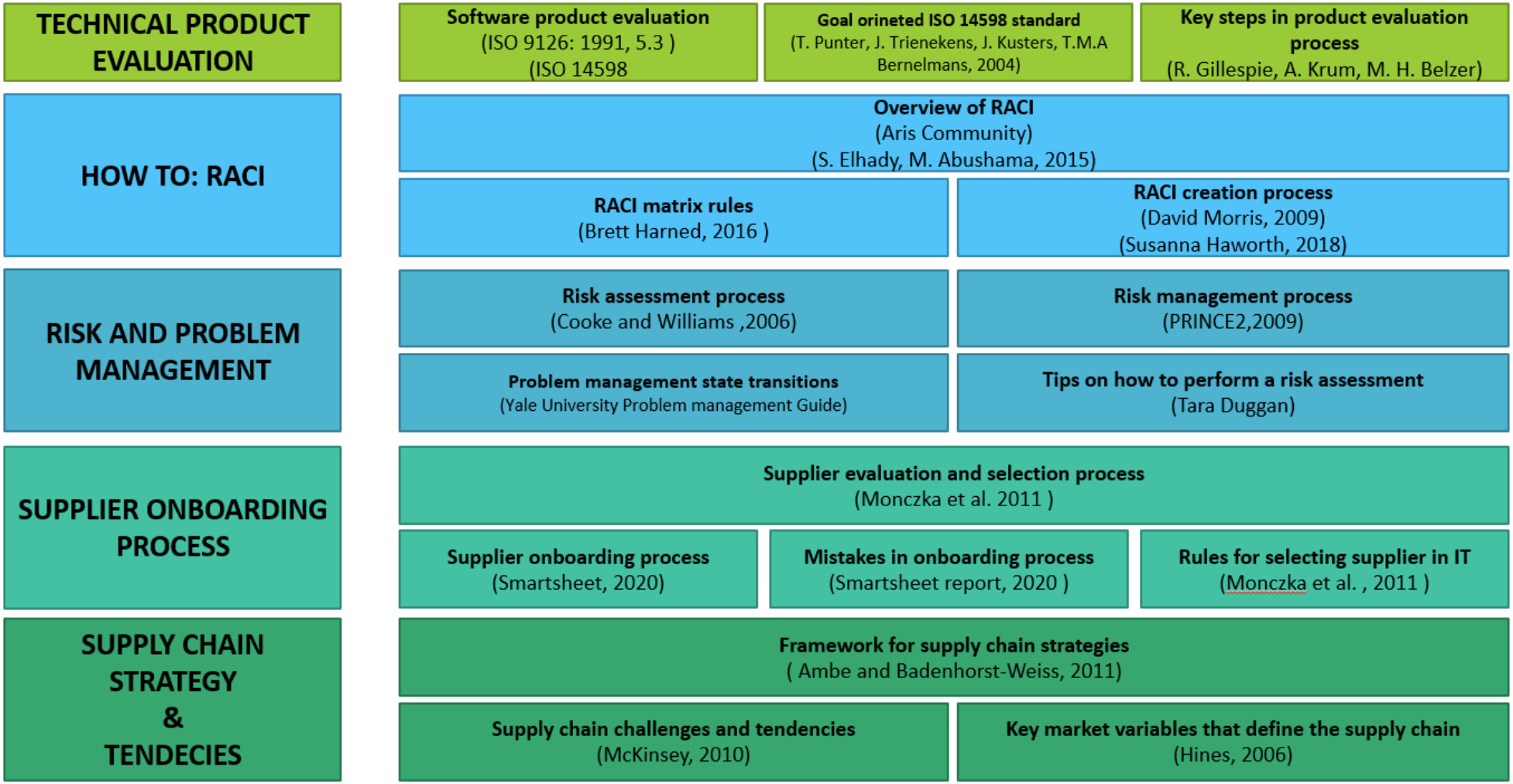

Figure 10. Conceptual framework

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5 Building Proposal for the Supply Chain Risk Minimization Process for the Case Company

This section describes the proposal building of the supply chain risk minimization process for the case company's IoT product. The proposal was built based on the information gathered during the data collection phase, the knowledge gained through literature review, and the experience of the operating supply chain in the case company's department. This section contains an overview of the proposal building.

5.1 Overview of the Proposal Building Stage

The objective of this study was to develop a process to minimize risks within the existing supply chain of the IoT product. During the CSA phase, organized with the stakeholders, it was identified that the main weaknesses of the supply chain process are coming from the existing methodologies used to maintain the supply chain. Fundamentally it means that connections between those methods are missing, creating unnecessary manual work and additional responsibility ownership. In a larger sense, it is reflected in the supplier onboarding process. At the moment the supplier onboarding process was noted to be partially manual due to a lack of standardization. Nonetheless, during the CSA phase it was identified that the onboarding process includes such methods as RACI matrix, adopted per supplier, SLAs which are expected to be delivered by the supplier in the future, and technical product requirements per technology category, which are partially considered as means of standardization and way of risk minimization. Additionally, CSA made it possible to understand the connections between all the partners within the supplier network. The discussion of the supply chain weaknesses was then supplemented with the expectations to develop a standardized onboarding process, including and connecting all the above-mentioned methods.

For the objective of the thesis it was decided to build an end to end process for the supplier selection and onboarding, which will result in risk minimization within the supply chain. The main aim is to establish a method to control the risks within the supply chain, minimize the time needed for a new supplier to get onboarded and establish standards to distribute the responsibilities and present standards for risk management. For the development purposes, an interview with the product owner was organized to collect the suggestions.

The supply chain risk minimization process will be performed by implementing risk identification as part of the supplier selection and onboarding process, having all the standards built into the process of onboarding. The process is described in 5 phases with an additional continuous improvement phase, that is presented in Figure 12 of the proposed supply chain risk minimization process.

The high-level view of the logic building for the proposed risk minimization process built into the onboarding process is presented in Figure 11.

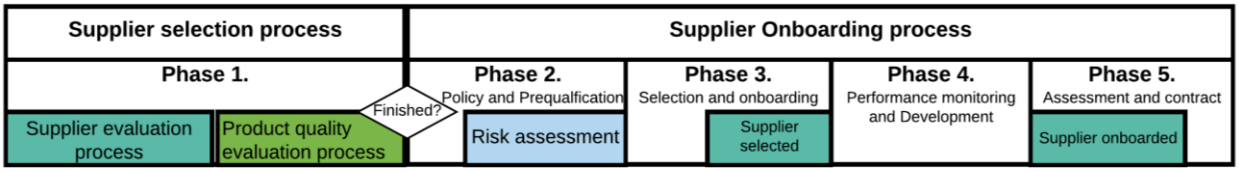

Figure 11. Proposal building logic for risk minimization process built into to onboarding process

Further, following Figure 11, the five-phase end-to-end onboarding process consists of total seven sections. Section 5.3 introduces the onboarding process. Section 5.4 presents the supplier selection process. Section 5.5 – risk assessment. Section 5.6 - Final selection and onboarding. 5.7 introduces the performance monitoring of the selected supplier. Section 5.8 – Final assessment and contract. Lastly, section 5.9 supplements the onboarding process with continuous improvement approach.

5.2 Findings of Data Collection 2

For building the supply chain risk minimization process, this study gathered additional suggestions from the product owner that resulted in finding ideas to enhance the key focus areas identified during the CSA phase. The key focus areas with the additional ideas are: Onboarding process enhancement, Responsibilities (RACI), Supply chain core roles distribution and process standardization. The ideas and suggestions are grouped by focus areas and shown in Table 5.

	Key focus area from CS (from Data 1);	*Suggestions from the product owner, categorized into groups (Data 2)*	*Description of the suggestion*
1	Onboarding process enhancement	a) The process should be transparent b) The onboarding should be a competence of the partner c) Onboarding is missing standards	a) Onboarding process should be transparent to make all the members aware of the process as much as possible, allowing the supplier network to act more cohesively. b) Even though the onboarding process is part of the case company's operation, ideally onboarding should be the responsibility of the partner. c) It is suggested to standardize the onboarding process by combining currently unlinked components (RACI, SLA, technical qualification etc.)
2	Responsibilities (RACI)	A. Risks need to be expanded in RACI B. KPIs needed to add predictability (for example for support functions) C. Partners should provide SLAs	A. It was suggested that all empty activities within RACI should be distributed by applying the standardization and risks added to the RACI. B. KPIs need to be available to track the performance of the supplier and his products, as well as to allow the supplier network to keep track of the overall performance C. SLAs (Contracts) are expected to be provided by the supplier. Nevertheless, negotiations of the contract are part of joint responsibility in the onboarding process.
3	Supply chain core roles distribution and process standardization	a) There should be standards in the supply chain management process b) Resellers should be part of the ecosystem c) Case company can act as the owner of the eco-system d) The supplier evaluation process should set high logistics requirements	a) There are known standards in the software product business, but there are lacking ISO alike standards for IoT products in the hardware segment. It would be worth checking if some of them could be applicable to the case company, for example for product quality evaluation. b) Resellers are suggested to be part of the eco-system, having control over supplier network. c) From the responsibility SCM perspective it was advised to structure the risk minimization process considering case company as the owner of the eco-system. d) Due to the existing risks in stock and storage it was advised to create a principle or partner requirement, that goods will be shipped directly to the customer.

Table 5. Product owner suggestions for proposal building (Data 2) in relation to findings from the CSA (Data 1) and the key elements CF.

As shown in Table 5, there were some additional ideas from the product owner related to each focus area. Briefly, the onboarding process was suggested to be enhanced more by enabling transparency and keeping the whole process opened for the supply network. The need for standardization was once again confirmed with the product owner, adding that the connection of methods is needed to increase efficiency. From the responsibility focus area, it was suggested that there should be no empty activities in RACI, and KPIs should be added to track performance. Lastly, the supply chain management was suggested to be improved by allocating resellers into the supplier network and declaring ownership of the eco-system to the case company. The supplier evaluation process was advised to have special requirements for logistics.

In the next section 5.3, all these ideas and suggestions from the product owner are built into a proposal for the supply chain risk minimization.

5.3 Supplier Onboarding Process Introduction.

The challenges related to the Supplier onboarding process, which are too big time investment and too big customizations per supplier, pointed to a more general explanation of the problem, which is a lack of standardization within the onboarding process. By the chain effect, the poor onboarding process is a result of the uncontrolled occurrence of new risks which in some cases appear to be under no-one's responsibility. During the literature review phase, it was studied that most of the risks should either be identified during the onboarding phase or they should be continuously monitored and reported after the process. As one of the identified rules, there should always be someone responsible for the existing activities, meaning no empty activities are theoretically allowed. A key perspective based on the literature review is the need to consider the whole supply chain operation as a continuous improvement process. Thus, standardizing processes is essential to make the improvement measurable and effective for the whole supply network. As a result, a combination of frameworks allows creating a connected process consisting of elements such as product evaluation, risk assessment, performance measurement, contract negotiation, making all of the elements interdependent. The whole end-to-end onboarding process is presented in Figure 12.

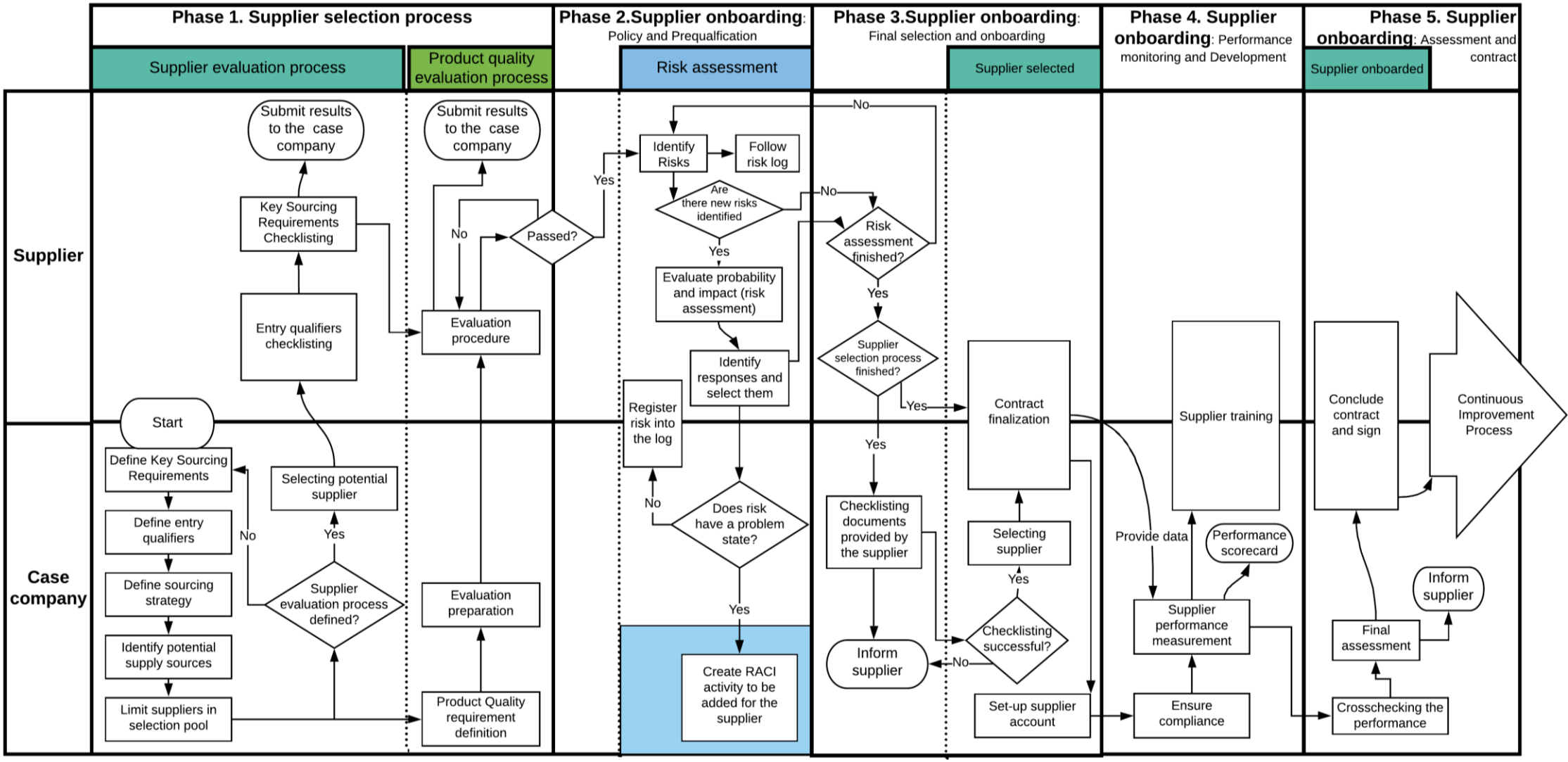

Figure 12. Proposed end-to-end onboarding process

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5.4 Phase 1. Supplier Selection Process

One of the key findings from the literature review phase, introduced by Monczka et al. (2011) and confirmed by Smartsheet report (2020) was a requirement to set up the supplier selection process as part of the onboarding process, to achieve the creation of standards for potential suppliers, to be able for them to qualify to the onboarding phase. Such standards include the supplier evaluation process and product evaluation process (including quality evaluation). Both evaluation processes imply passing a benchmark, evaluating whether the supplier is aligned with the case company's requirements or not. By studying methods to benchmark the suppliers, it was identified that standard ISO 9126: 1991 suggests a method called checklisting. The concept of this method is to create a list of requirements and allow the supplier to self-evaluate the company and the product. The whole process flow of the supplier selection is presented in Figure 12.

5.4.1 Supplier Selection Process. Supplier Evaluation.

According to the study, the supplier evaluation process is divided into two core activities, which are distributed between the case company and the supplier. It is the process of the case company's preparation for the evaluation process and then the process of supplier's self-evaluation using the checklisting method.

For the case company, preparation for the supplier evaluation process is theoretically a one-time task, though needing a continuous improvement if requirements change. The task is to create the requirements in the form of checklisting documents. Such documents should include Key sourcing requirements and Entry qualifiers. Additionally, as it was concluded in the CSA phase, the onboarding process does not follow any predefined process flow, thus requiring a high level of adaptation per supplier. Considering that, creation of standard documents will allow supplier evaluation (passed/failed) process to proceed almost without any interaction between the case company and the supplier, saving time resources as the result.

To optimize the time needed for onboarding the supplier it was decided to perform the first phase of the onboarding process, which is Policy and Prequalification, during the supplier selection process, assuming that onboarding begins when prequalifications are passed.

The initial step of the supplier evaluation process is performed by the case company, by defining the key sourcing requirements and entry qualifiers, documenting them and providing to the potential supplier for self-evaluation. Also, in case the selection process is not continuous it would require defining the sourcing strategy, identifying the potential supply sources and limiting suppliers in the selection pool. The case company is considering the supplier selection process as continuous, constantly looking for new suppliers and partners, therefore once the documents are prepared the supplier takes the task of self-evaluation.

Key sourcing requirements documentation

The initial step of the process is defining key sourcing requirements related to the supplier's business. Sourcing requirements are a set of rules and needs applicable to the potential supplier, identified by the case company. Such requirements include a variety of categories including price and terms requirements, communication performance, volume performance, service performance, logistics requirements, etc. Additionally, sourcing requirements can include technology-related rules, for example what is the list of product functions required, product performance indicators, technical characteristics, etc. Nevertheless, since Data 1 has shown that there are challenges related to setting up the technical product quality requirements, it was decided and suggested by the product owner to verify if applying ISO standards can optimize the process of product quality evaluation. Therefore, it is advised to separate functional requirements evaluation, performed in the key sourcing requirements checklisting phase, with the product quality evaluation, which is performed at the product evaluation phase. Another concern raised by the product owner during the data 2 collection stage was related to the product stock issue, requiring changes in logistics logic towards supplying the goods directly to the customer and not to the warehouse. With that said, such requirements directed to the supplier should be logically linked to the key sourcing requirements document identified before the supplier gets onboarded, so that logistics logic becomes a rule and responsibility from the very beginning of the cooperation between the supplier and the case company.

From the scope of this thesis, it was not planned to develop a key sourcing document template due to time limitations and need for large data analysis. Nevertheless, the literature review phase together with the current state analysis helped to generate core principles to follow while building the key sourcing requirements. Firstly, to set up a standard

for the supplier evaluation process checklisting method is suggested as a standard of the supplier data gathering, handling and evaluation. Checklisting could be performed through the digital platform or simply in a Microsoft Excel. Such a method will allow the case company to save time resources, as it was the identified concern during the CSA. Secondly, the CSA phase has shown that one of the strengths existing in the case company is an already deployed ITSM platform, which has a functionality of the knowledge base. Practically, it means that the case company has been collecting supplier-related knowledge since the moment the ITSM platform was deployed. Such knowledge includes information regarding the suppliers, their products, operation of the products, product troubleshooting, trainings, logistics issues, billing, and everything else what was once registered in the base. With that said, knowledge base can be an ultimate input source for preparing the sourcing requirements document based on the data available. Thirdly, it is beneficial to consider the requirements from all the divisions of the case company product organization. Gathering data from all the relevant sources can guarantee the harmonization of the requirements between different parties such as partners, supply network, or team.

The key sourcing requirements document is considered as the component of the onboarding standardization process, optimizing the evaluation process by collecting the information in a generalized way for all the potential suppliers.

Entry qualifiers documentation

Once the key requirements document is prepared the case company has to set the requirements for the supplier's business. Such requirements are called entry qualifiers and can be considered as part of the supplier evaluation process. As stated in section 4.2.1 the supplier has to satisfy certain entry qualifiers to proceed to the next phase of the onboarding process. Compared to the key sourcing document, the entry qualifiers phase does not collect any product or service-related information. Entry qualifiers are mainly used to gather business operation information in the form of a questionnaire or a checklist of specific business thresholds (i.e. current ration parameter). According to the literature review, entry qualifiers include a variety of measures such as financial strengths of the company, business strategy, is management supportive or not, what are the manufacturing and design capabilities. Entry qualifiers act as the basis of the supplier business evaluation. The evaluation gives the case company confidence that it is safe to do business with the potential supplier. The entry qualifiers phase intention is to protect the case

company from dealing with the suppliers, which don't show trust, financial confidence, and support. The document creation logic regarding entry qualifiers is presented in Figure 13.

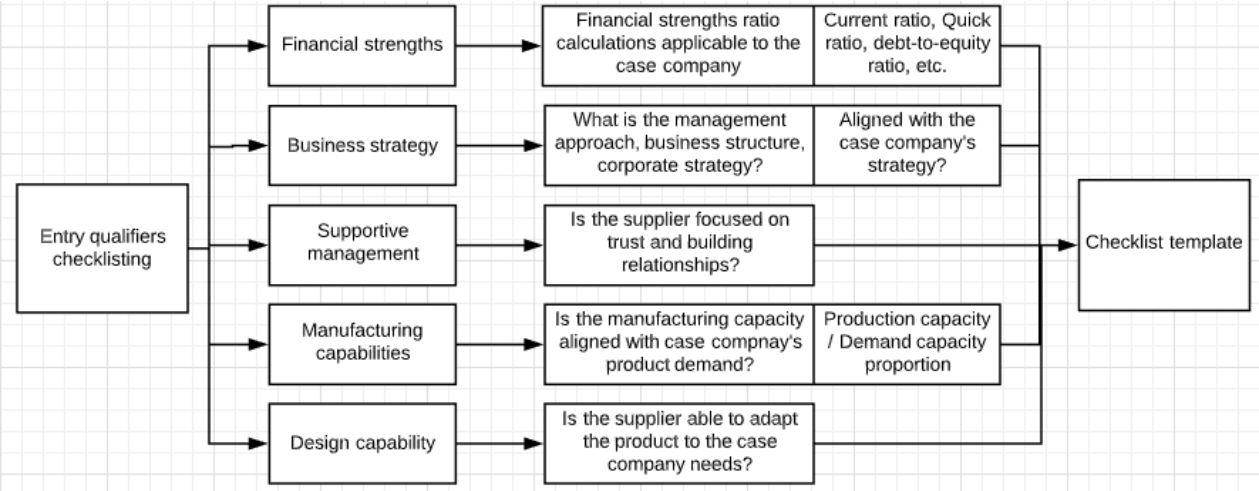

Figure 13. Document creation logic regarding entry qualifiers

As presented in Figure 13 the result of entry qualifiers is a checklist document with all the business operation concerns the case company has. It is suggested aligning the entry qualifiers according to the whole organization's existing requirements set for the new suppliers.

The entry qualifiers document is equally considered as the component of the onboarding standardization process, allowing the case company to evaluate the potential supplier's business in the early phases and in a generalized way.

Supplier's responsibilities related to the supplier evaluation process.

The evaluation phase from the supplier perspective consists of self-evaluation by checklisting the entry qualifiers requirements and key sourcing requirements. As can be seen in Figure 12 entry qualifiers checklisting goes first in the list of tasks. That is due to the fact that the entry qualifiers document includes high-level information related to the supplier's business, allowing the supplier to quickly verify whether their company fits the requirements before they proceed to a more intensive task of key sourcing requirements checklisting. Once both checklisting tasks are accomplished, the supplier is responsible for returning the documents to the case company.

5.4.2 Supplier Selection Process. Technical Product Evaluation

According to the current state analysis, the case company has the challenge of setting up quality requirements for the supplier's products. Following the data 2 collection, it was questioned by the product owner whether the ISO alike standards could be applicable to the quality of the IoT solutions, which the case company is sourcing. Therefore, during the literature review phase, it was identified that ISO 9126 and identical ISO 14598 standards, applicable for software product quality evaluation could be partially aligned with the IoT solutions, which case company is using.

It is important to mention that a product's quality evaluation is the consequent step after the evaluation of functional requirements performed by the potential supplier once those requirements are identified by the case company at the initial phase of preparations and registered in the key sourcing requirements document.

According to literature, the first phase of the product evaluation starts with the definition of the quality requirements (criteria). That task is performed by the case company in the form of the checklisting document. Even though the ISO 9126 standard is applicable to the software products common grounds with the IoT product's quality evaluation were found. During the CSA phase supply chain architecture with corresponding suppliers and their products were studied to ensure that quality requirements could be aligned with the studied standards.

Therefore, six identified quality criteria measures (characteristics) were aligned with the ISO 9126 and adopted to the category of the products under the study. They are:

A. Portability. How easy it is to transfer the solution to another environment?

B. Functionality. Are the required functions available in the solution?

C. Reliability. How reliable is the solution?

D. Usability. Is the solution easy to use?

E. Efficiency. How efficient is the solution?

F. Maintainability. How easy it is to modify and maintain the solution?

All the covered questions act as a basis for defining sub-characteristics of the product category quality requirements. Each sub-characteristic measure should be aligned with the quality criteria defined in the ISO9126 standard. Once quality definitions are set the-case company proceeds to the second task, which is the evaluation preparation. According to the literature review, the evaluation preparation phase is designed to transform each quality criteria into a measurable rating to therefore allow the potential supplier to self-evaluate using a checklisting method.

The intention of the evaluation preparation phase is to determine the ways how the supplier's product or service quality could be assessed to fit the case company's IoT product quality. The importance of that procedure was initially identified during the CSA phase when it was stated that the supplier's product quality directly affects the end-user satisfaction. Therefore, the implementation of the numerical quality approach is highly recommended. As with the previous step of the selection process the result of this step is an accomplished checklisting document. Table 6 presents the proposed way to create a quality evaluation checklisting document.

Quality requirement definition		Evaluation preperation				Evaluation procedure	
Quality criteria (According to ISO9126)	**Sub-characteristics (requirements)**	**Quality metrics**	**Rating levels (bad/ moderate/ good)**	**Must (assessment criteria)**	**Weighting (in %) Importance ratio**	**Supplier entries**	**Checklisting (passed/failed)**
Portability	*Solution coexistance with other solutions (interoperability)*	yes/no	(no,-,yes)	yes	2	yes	✓
	Replaceability of the solution	yes/no	(no,-,yes)	yes	2	yes	✓
	Installability			????	10		
Functionality	*Maximum devices per gateway*	amount of devices	(50/100/150+)	100=>	10	150	✓
	Update frequency	minutes	(5/3/1)	<=3	15	5	X
	Security			????	10		
Reliability	*Battery life*	years	(1/2/3+)	2=>	10	3	✓
	Warranty	years	(-/2/2+)	2=>	5	2	✓
	System availability	%	(<98/99/100)	99=>	10	95	X
Usability	*Time needed to deploy the device*	minutes	(10/5/2)	<=5	5	10	X
	Learnability of the solution (complexity)			????	2		
Efficiency	*Human-resource utilization per 100 device installation*	people count	(2+/2/1)	<=2	5	1	✓
	Time behavior (from installation to operation)	minutes	(20+/15/10)	<=15	2	10	✓
Maintainability	*Time needed to change the battery*	minutes	(10/3/1)	<=3	5	5	X
	Time needed for troubleshooting	minutes	(10+/10/5)	<=10	2	10	✓
	Analyzability of the data			????	5		
					100%		

Table 6. Proposed product quality evaluation checklisting document. Based on refined ISO9126 quality attributes. The example presents imaginary sensor device quality criteria measures.

According to Table 6, document preparation is a linear process that begins with the case company's responsibility of quality definition and preparation of quality measures. Such measures include the quality metrics, rating levels of each criteria, the assessment criteria, which defines the minimum limit of the requirement, and lastly the importance of the requirements on a percentage scale. In the proposed document, the last step of the evaluation process is the evaluation procedure performed by the supplier.

As it was stated in the CSA, the onboarding process is a missing generalization and requires standardization. To support the suggestion, it is advised to keep the same documentation approach within all the steps of the supplier evaluation process. Similarly to other documents, quality evaluation procedure document follows the logic of checklisting requiring the supplier to self-evaluate their product or service quality by filling in the document, while aligning their product's specifications with the requirements case company has prepared. The result of this phase is a delivered document to the case company.

5.5 Phase 2. Supplier onboarding. Risk Assessment.

One of the business challenges in the process of supply chain management was identified to be an inability of taking the responsibilities for the IoT supply chain, specifically meaning an end-to-end responsibility for hardware logistics. It was also identified that the RACI matrix is missing connections between parties creating "empty activities" in the matrix as a result. By the nature of the product such "empty activities" create unpredictable risks and therefore problems to the case company's business and operation of the supply chain. Such activities were suggested to be distributed. By reviewing the literature, it was determined that in order to categorize such risks, fill the "empty activities", and assign the owners for all the responsibilities, risk and problem management process should be introduced to the current supply chain process.

It is worth mentioning that according to Office of Government Commerce (2009) the risk assessment process is the initial stage of the risk management process, which is considered as the continuous improvement process, constantly adopting by gathering feedback and therefore applying it again to the risk assessment steps. Additionally, it is important to understand that any identified risk has a potential to become a problem, lead-

ing to the conclusion that the risk management process should be explored and implemented from the very early stage of risk identification to the latest stage of problem transformation into the task.

As an improvement proposal, proposal of the risk management process is made, presented in Figure 13, the suggestion is to begin sharing risk management responsibilities between the supplier and the case company, as well as to make risk management process as part of the onboarding process, allowing the case company to study potential risks before the supplier gets onboarded.

The proposed risk management process is based on the combination of two process frameworks, they are the risk management process framework, described by Office of Government Commerce (2009) and the risk assessment process described by Cooke and Williams (2006). Additionally, to supplement the process with a measurable way of gathering risk information, types of supporting documentation are described, such as risk register, risk log and RACI. As a part of this thesis, such supporting documentation regarding the risk management was created to fulfill the needs of standardization of the whole onboarding process. All the documents function as the prequalification material for the suppliers, while continuously supported and improved by the case company.

The risk management process presented in Figure 14 is an exploded view of the end-to-end onboarding process presented in Figure 12, with the additional component presenting the continuous improvement model of the risk management process.

The risk assessment and management processes are consisting of a number of tasks that are divided between the supplier’s and the case company’s responsibilities.

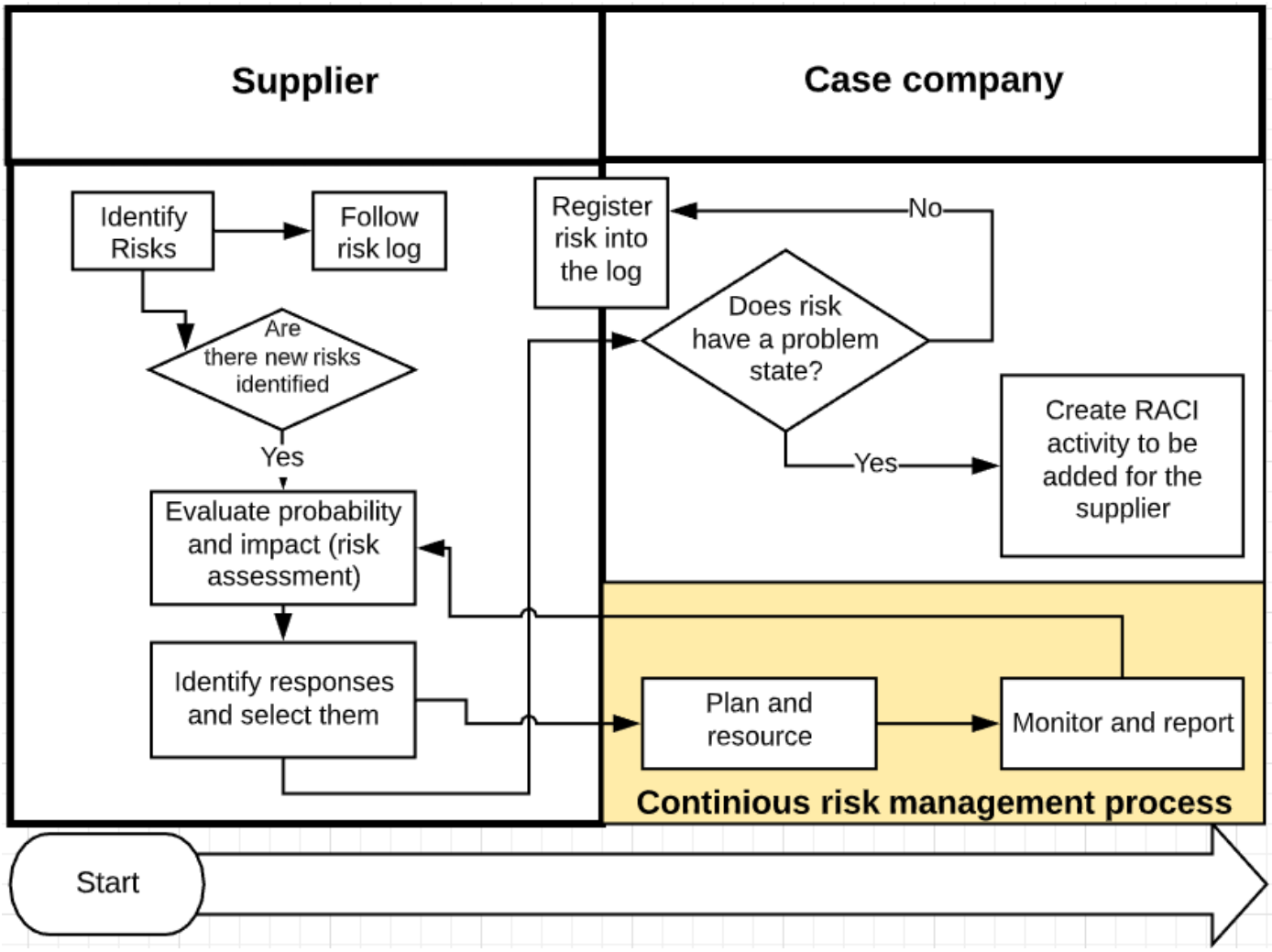

Figure 14. Proposed risk management process.

As shown in figure 14, the risk assessment process starts with the supplier's responsibility of identifying potential risks caused by the offered product or service. The case company, as the requirement of the risk assessment process is supposed to provide a risk log to the supplier with all previously recorded risks related to the category/type of product under investigation, to ensure that there are no identical risks registered. Additionally, to standardize the risk identification process, the case company is obliged to provide a standardized risk identification method (i.e. questionnaire), so that all the potential suppliers get evaluated in the same way. Figure 15 provides an example of the questionnaire for risk identification.

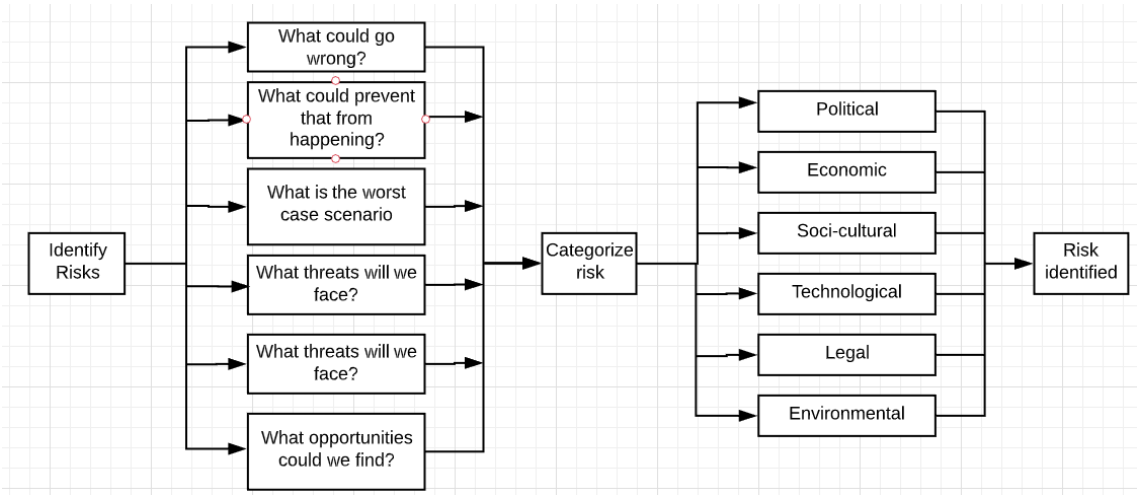

Figure 15. Example of risk identification questionnaire.

As seen in Figure 15 result of the risk identification process is the identified risk in the form of answers for standardized questions.

In case new risks were identified the risk assessment process continues with the evaluation of risk probability and impact using the calculation method: Severity x Likelihood (Cooke and Williams, 2006). Calculation of the probability and impact will later get registered into the log.

Next, once the risk is identified and probability with impact calculated, responses are then identified to get an understanding on the action plans performed by the supplier in case the risk becomes a problem. As it was studied before, the response to the identified risk can be: Avoid, Transfer, Reduce, Accept, Contingency. Therefore, the process of response identification sets the requirement for the supplier to have a concrete risk response strategy, not allowing to keep it empty or unowned. Risk response is set to be the responsibility of the supplier even in a situation when the case company's service is needed. Such activity will guarantee the case company that the supplier takes end-to-end ownership of any possible risk caused by the supplier's product or service. Further steps will present the way how to implement risk into the RACI matrix in case risk becomes a real problem.

Due to the fact that there were already existing "empty activities" that remain unsolved, it was additionally needed to separate the concepts of risks and problems. That is why it

is suggested to keep problem management separate from risk management. Furthermore, in case there is an already existing impact on the business from some of the activities, even not empty ones, it means it is not anymore a risk, it is a problem. Thus, the process should be handled separately from the risk management process.

Thereafter, before the risk can be registered into the log, a manager is supposed to track whether a newly identified risk has ever been in a state of a problem. In case a similar type of problem was reported before it should be transformed into a task/activity, which should be then added to a RACI matrix with all the relevant activity roles to handle the problem. Based on literature, it is a problem manager who is responsible for transferring the problem into the RACI matrix and for assigning the owner of the problem task. It is important to note that the process of risk-problem state evaluation should be a continuous process to ensure that no risks or problems remain under “empty activities”. Running risk-problem state evaluation continuously guarantees the case company an ultimate way of managing the RACI matrix without any unowned activities, as it is happening at the moment according to the current state analysis. Also, continuous risk-problem evaluation will guarantee a continuous addition of risks directly into the RACI matrix. Furthermore, according to the CSA the RACI matrix is missing generalization in terms of the whole supply network responsibilities, meaning the case company is handling unique RACI matrices per each supplier. Considering the desired transparency within the supply network, enabling a shared RACI matrix within the supply network members, who have interdependent products and services, will result in the generalization of the RACI matrix by filling empty responsibility activities appearing between these interdependent products.

In case the identified risk cannot be classified as the current problem, meaning there is no impact to the business from that risk, the risk can be now registered into the risk register. All the measures as well as the developed template to register the risk is presented in Table 7.

ID	Date Raised	Risk Description	Likelihood	Severity	Risk rating (based on likelihood x severity)	Risk	Risk Owner	Risk Category	Risk Response strategy	Mitigation actions
Logistics category										
1	01.01.2020	Logistics delays due to the limited component production	1	3	3	Undesirable	Supplier	Technological	Reduce	Action is taken to reduce the likelihood of the risk
2										

Table 7. Risk register template

As shown in Table 7, the risk register template is intended for storing all the measures from the risk assessment phase. Once risk is registered into the log, the risk assessment phase could be considered as finished.

Additionally, following the recommendations from the product owner, risk register template, as well as the questionnaire results, the generic RACI matrix should be openly available within the whole supply network to enable transparency between each member. That type of openness enables better visibility of existing problems and potential risks to possibly affected members of the supply network.

5.6 Phase 3. Supplier Onboarding. Final Selection and Onboarding.

Phase 3 of the onboarding process could be considered as initiated when all the evaluation processes are finished, and all the evaluation documents are submitted by the potential supplier to the case company. Document submission additionally means that all the requirements are passed and risk assessment is accomplished, categorizing potential suppliers by the principle of business fit, product fit, and risk assessment, keeping all the unqualified suppliers outside of the onboarding process. Furthermore, the CSA has shown that the onboarding process takes too much time, therefore allowing self-evaluation by the supplier lets the case company to save time.

If the case company has received all the standard documents from the supplier, a product manager from the case company has to perform a checklisting of the provided documents. It is done to crosscheck all the identified requirements with the information provided by the supplier. It is critical to align all known information about the supplier with the data that was recorded. Such information may include datasheets, specifications,

website information, etc. In case inconsistencies are found the potential supplier has to be informed to provide further information or corrections.

When a standard document checklisting has succeeded the supplier gets selected into the supply network.

One of the last steps before Phase 4 is contract finalization. As it was suggested by the product owner in Data 2 collection, the case company is expecting all the future suppliers to provide the contracts, so that the case company can only review them and sign. Nevertheless, to align all the possible future plans and current situation stated in the CSA, the proposed framework suggests having a contract finalization task as the shared responsibility between the selected supplier and the case company, no matter which party provides the contract. Such a suggestion will provide additional control to the case company of the potential risks related to the contract. Since risk minimization is at the core of the proposition joint responsibility of the contract finalization is advised.

Lastly, once all the contract details are concluded, the selected supplier's account is set up. The supplier account includes information regarding the contact details, address, currency of the business, banking details, etc.

5.7 Phase 4. Supplier Onboarding. Performance Monitoring and Development.

Even though the supplier is now considered as part of the supply network, there are still tasks left to rollout the supplier in full production mode. The intention of Phase 4 is to define the key performance indicators applicable to the selected supplier. Such performance could be categorized into two groups: Pre-production performance measurements – to verify the performance for the supplier to get fully onboarded, and Production – real-time performance measurement to improve the overall performance of the supplier during the whole process of the cooperation between the supplier and the case company. In the context of this thesis only pre-production performance is taken into account, though the performance indicators could be applicable to the production environment as well. Then, once the performance measurement process is accomplished, supplier training is performed to ensure the supplier is capable of delivering the products or services according to the case company's needs.

Following the conclusion of Phase 3, once the supplier account is set up, the case company ensures that the supplier passes the compliance.

Thereafter, according to Figure 12 it is proposed to implement the performance measurement practice to ensure that all possible root causes of the supply chain processes could be resolved in everyone's benefit. Additionally, performance measurement at the pre-production phase will provide extra confidence in the supplier's capability of fulfilling the case company's needs within the agreed requirements.

The provision of the performance data is mainly the responsibility of the selected supplier. Nevertheless, it is suggested to follow a standardized list of performance indicators generated by the case company. Such performance indicators could be retrieved from a variety of data sources. Figure 16 shows an example of a Performance scorecard creation process.

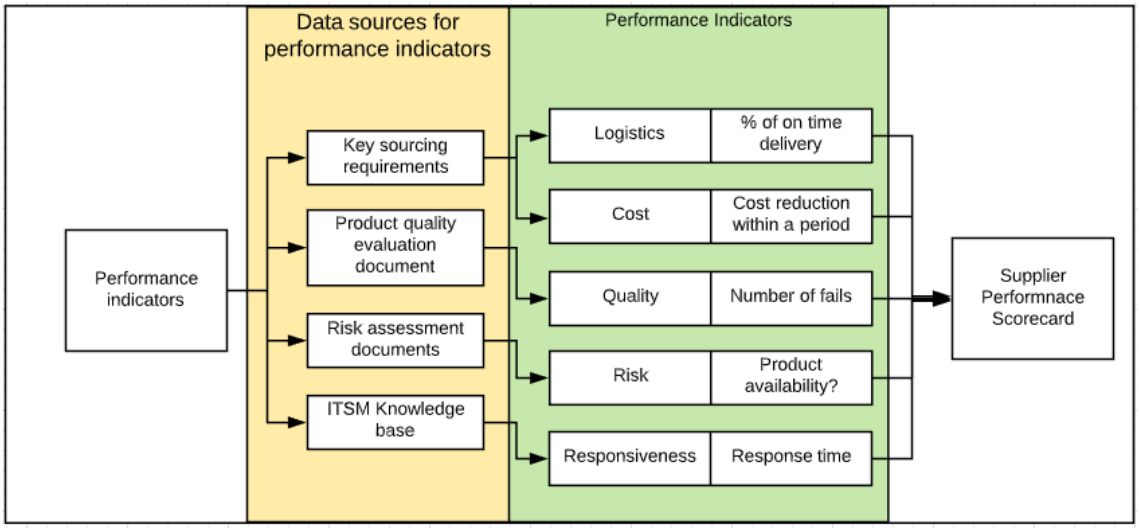

Figure 16. Example of Performance scorecard creation process

As it is shown in Figure 16 the result of the data collection from the listed data sources results in revealing of the performance indicator groups, which in turn, leads to the creation of different performance measures. All that is concluded in the Supplier performance scorecard, which is later being reviewed by the case company for the last assessment of the supplier. It is important to mention that Figure 16 does not present all the performance indicators applicable to the case company. Rather, it shows the way to retrieve the needed indicators for the scorecard.

The last step before the final assessment is the supplier training, which is a joint responsibility of the supplier and the case company. Supplier training ensures the case company that the deployment of the supplier's goods is performed in a standardized way. Such a standardization could come from the previous experience working with a similar category of the suppliers. According to the CSA, ITSM platform has been used for a while, therefore an assumption could be made that such experience could have been registered in the knowledge base. Supplier training though might include a variety of processes that need training between the supplier and case company. Such trainings include technical concerns, financial processes, business operation concerns, etc.

5.8 Phase 5. Supplier Onboarding. Assessment and Contract.

In order to summarize the process of onboarding and to cross-check the performance measurements, Phase 5 is performed. Phase 5 is initiated at the moment when a performance scorecard is generated. Similarly to other assessments, performance validation is performed through checklisting the performance indicators in the performance scorecard generated during Phase 4. Once the performance scorecard is checked the case company takes the responsibility of the final assessment of the selected supplier. The final assessment is performed by reviewing all the supplier onboarding phases and its results. The decision based on the final assessment is then communicated to the supplier.

In case both parties are satisfied with the result of the selection and onboarding process, the last joint responsibility before the supplier gets fully onboarded is a conclusion of the contract. Due to the fact that after contract finalization in Phase 3, when performance measurement study was performed, it is necessary to make one more verification of the contract in case the performance review has identified inconsistencies compared to the original delivered information. Such inconsistencies could affect the contents of the contract. Adding an additional contract verification step will significantly decrease supply chain risks resulted by too early contract signature.

Supposing that the contract details are verified, and they satisfy both parties of the onboarding process the contract gets signed. At this stage the supplier is considered onboarded.

5.9 Summary of Risk Minimization Process by Standardizing the Onboarding Process.

The objective of this thesis is to minimize risks within the supply chain of the case company's IoT product. The approach selected to minimize risks is based on the idea that risks should be considered before the cooperation between the supplier and the case company begins. That is why the idea taken to minimize risks was accomplished by improving the selection and onboarding processes, assuming that most of the risks could be identified before the supplier starts to deliver their products or services. Therefore, all 5 phases of the process strongly prioritize the identification of various risks by analyzing different sources of these risks. The sources of risk identification include product quality evaluation, sourcing requirements definition, risk assessment, and performance measurement. Altogether, such risk identification sources cover all possible risk segments identified by the case company, according to the document review in Data 1.

Nevertheless, while the proposed end-to-end onboarding process is expected to deliver a standardized way to identify and manage risks, it is still critical to consider the constantly changing environment of the industry under consideration in this thesis. Also, it is critical to mention that risk identification, standardization and supply chain management is an ongoing process not ending in Phase 5. Practically it means that most of the standardizations introduced in previous sections should be continuously reviewed for improvement purposes. Such improvements might include new technical product specifications, newly identified risks that have to be considered by the future suppliers or simply growing demand, which affects the performance. Even though the onboarding process introduced in Figure 12 has a start and the end, it is suggested to implement the continuous improvement approach and the sources of improvement to some of the proposed standards. Practically, it means that after the supplier is onboarded it is a joint responsibility to improve all the standards and processes for future performance improvement.

According to the CSA, there are four groups of supply chain members. They are hardware suppliers, technology delivery partners, support/reseller group and monitoring partners. All these groups are part of the supplier network. Therefore, keeping in mind the idea of transparency in the supply chain, suggested in Data 2 collection, it is proposed to consider the whole supply network as the source of feedback for improvement purposes. As suggested by the product owner in Data 2 collection, the reseller should also be part of the supply network, therefore the reseller can also act as the data source for supply chain improvement.

Therefore, it is advised to follow the idea of feedback gathering every time any of the standardized documents gets updated by new potential suppliers or existing suppliers. It would also be a good idea to establish a practice of organizing the workshop within the supply network to gather updates on newly identified specifications, risks, performance indicators. Another possible source of improvement is maintaining the knowledge base, which will be most correct to make as a joint responsibility of every supply network member.

Next, Section 6 contains the validation of the initial proposal through the interview conducted with the case company's product owner to form the final proposal with the prioritized implementation recommendations.

6 Validation of the Proposal

This section reports on the results of the validation stage and points to further developments to the initial Proposal. At the end of this section, the final proposal and recommendations are presented.

6.1 Overview of the Validation Stage

This section reports on the results of the validation stage based on the initial proposal developed in Section 5. In Section 5 the proposal was presented as a gradual onboarding process, describing every phase and approach to solving the challenges gathered in CSA. The initial proposal was built by combining the knowledge gained in CSA, suggestions from the product owner presented in Data 2 collection, with the most suitable supply chain practices studied in the literature review. The initial proposal was then validated by mapping the SWOT analysis for the whole proposal based on the assumptions and collecting the feedback from the product owner concerning every phase developed during Section 5. Based on the gathered feedback the final proposal was then developed together with the recommendations concerning the implementation of the process, combined with the prioritization of each activity needed for implementation.

Validation was mainly conducted by presenting each phase separately and then recording the answers for pre-defined questions related to each phase of the process. Some suggestions are based on the theoretical assumption performed by projecting the proposed onboarding process on the existing suppliers to therefore realize the strengths, weaknesses, opportunities, and threats of the initial proposal. Projection results are concluded in the SWOT analysis. Then, all recommendations are linked to the key focus areas gathered in CSA. Additional suggestions were collected in another session, after the presentation of each phase (also available as a complete list in Data collection 3 table).

The main goal of this section was to try testing the proposal from the perspectives of the case company's IoT product and the level of suppliers existing in the supply network.

6.2 Findings of Data Collection 3

Data 3 collection was performed by mapping the SWOT analysis for the whole process and gathering the suggestions in a series of interviews. The first result of the Data 3 collection is a SWOT analysis presented in Figure 17, showing the validation of the initial proposal from the perspective of strengths, weaknesses, opportunities, and threats.

Figure 17. SWOT analysis for Proposal validation.

As seen in Figure 17 the slightly modified SWOT analysis resulted in the identification of four segments which present the overall evaluation of the Proposal. The first segment shows the main strengths identified within the five processes. The second segment shows weaknesses explored within five processes. The third segment presents the identified opportunities to adopt the process. Lastly, the fourth segment, presents potential threats on the way of adopting the process.

The second result of the Data 3 collection are the suggestions for each key focus area presented in Table 8.

	Key focus area from CS (from Data 1);	*Suggestions from the product owner, categorized into groups (Data 3)*	*Description of the suggestion*
1	Onboarding process enhancement	a) Sourcing requirements need to be prioritized and defined more thoroughly	a) As key sourcing requirements document covers most of the requirements directed to the potential supplier it is suggested to expand the coverage of the requirements by introducing potential requirements and their categories. Categories should include for example logistics, procurement, functional requirements, etc.
2	Responsibilities (RACI)	a) Consider the fact that RACI is often fixed in the contract for 2 years	a) Lawyers tend to make RACI as a fixed appendix being active during the duration of the contract. That type of approach does not allow the supply network members to change responsibility owners in short time. It is suggested to consider that concern and check whether any other method like RACI could work, or there is an approach to have RACI a flexible appendix.
3	Supply chain core roles distribution and process standardization	a) Segregate the supplier performance measurements by the supplier maturity level	a) Based on theoretical simulation it was identified that due to the different levels of supplier maturity the performance measurement process could differ for a small supplier compared to a mature, big supplier. It is advised to separate performance indicators depending on the maturity level of the company. It can be separated by the lightweight version of the performance scorecard and on having more demanding performance requirements.

Table 8. Findings from Data 3 collection.

As shown in Table 8, a small amount of suggestions was reported per each focus area. These suggestions are aligned with the SWOT analysis to improve the initial proposal.

Briefly, the findings in general indicate that the initially proposed end-to-end onboarding process was developed in a suitable way for the case company and there are no major changes to the process. Nevertheless, additional concerns regarding some components existing in the process were identified. The findings for focus area 1, Onboarding process enhancement, suggest that key sourcing requirements document should be highly prioritized as it is the main document to collect requirements. For area 2, Responsibilities (RACI), it was suggested to study the possibilities of transforming the RACI matrix from

being a fixed appendix towards flexible. Lastly, for area 3, Supply chain core roles distribution and process standardization, it was indicated that generalizing the performance measurement could create challenges depending on the maturity of the supplier. It was suggested to apply segregation for the different categories of suppliers.

Next, the findings from the product owner are further discussed and built into the final proposal of the end-to-end onboarding process.

6.3 Developments to the Proposal Based on Findings of Data Collection 3

In the validation phase, only minor suggestions were made by the product owner not affecting the proposed onboarding process, but rather suggesting improving some of the components to improve requirements definition, responsibility management, and performance measurement.

Key Sourcing Requirements definition

Firstly, the validation result for the focus area 1, indicates the need to define key sourcing requirements more thoroughly as well as creating and expanding the document with the additional categories of the requirements to cover all possible sources of requirements existing in the case company's business. Therefore, to follow the idea of standardization it is suggested to structure key sourcing requirements document in a similar way as the product's quality evaluation document was structured. Additionally, as mentioned in Section 5, both documents are following the principle of checklisting for the supplier evaluation. According to the suggestion in the Data 3 collection, all the requirements need to be categorized. Therefore, following the supply chain architecture mapped in the CSA and possible categories studied in the literature review phase, six categories were identified as most important to be part of the key sourcing requirements document. They are Logistics, Service, Price and terms, Volume requirements, Functional product requirements, and Information performance. All these categories by default may have an unlimited number of requirements.

Further actions proposed to expand the coverage of the requirements are: Creating requirements ratios to introduce the numerical measure of each requirement, Creating the requirement's accepted level for each requirement to show the threshold needed to pass

the evaluation, Creating importance ratios to therefore calculate the weight of each requirement. The proposed key sourcing document with the categorization is presented in Table 9.

Key sourcing requirements		Requirement ratios			Checklisting	
Category	**Requirements**	**Measure**	**Accepted level**	**Weighting (in %) Importance ratio**	**Supplier entries**	**Checklisting (passed/failed)**
Logistics	*Direct shipping of goods to customer*	yes/no	yes	?		
	Delivery place flexibility	yes/no	yes/no	?		
	Lead time	months	<=3	?		
	Flexible scheduling for delivery date	yes/no	yes	?		
Service	*Customer service response time*	hours	<=2	?		
	Speedy processing	weeks	<=2	?		
Price and terms	*Packaging cost*	% of total device cost	<=5	?		
	Advance payment	% of total cost	<=20	?		
	Payment terms	?	?	?		
Volume requirements	*Minimum delivery*	qty	<=200	?		
	Volume flexibility	yes/no	yes/no	?		
Functional product requirements	*Frame size*	cm	<=10x10x10	?		
	Sensor type	type	PIR/C/H/CO2	?		
	Frame color	Color	Any	?		
	Frame material	ABS/PLA/Metal	Any	?		
	Powering method	Wired/Wireless	Wireless	?		
	Data protection	yes/no	yes	?		
Information performance	*Data protection*	yes/no	yes	?		
	R%D capacity	yes/no	yes/no	?		
	Failure logs availability	yes/no	yes	?		
	Communicability in case of failure	yes/no	yes	?		
				0%		

Table 9. Proposed key sourcing requirement document with the categorization of the requirements and method to checklist the requirements.

As seen in Table 9, the proposed key sourcing document is made similar to the product's quality evaluation document to follow the idea of document standardization.

RACI as a flexible appendix

Secondly, the validation result of the focus area 2, suggests the need to consider the RACI matrix from the perspective of the agreement's appendix, as it seems to be fixed for a contract duration period not allowing to reassign the ownership of the responsibilities, as commented by the product owner. Additionally, it was suggested to consider other options than RACI if needed.

Based on the challenge created by the fixed appendix and the fact that the contract gets signed for a long period of time with no option of revisiting it, it is suggested to consider the perspective of the agreement as such and not only the RACI appendix. The currently

used SLA format by the case company does not imply the possibility of implementing the flexibility of the appendices or even deliverables presented in the agreement. It is therefore suggested to move a so-called fixed SLA towards a dynamically changing SLA which will allow changing the agreement based on the identified change. Such a change is either requested by the supplier in case there are changes in the deliverable product or service, or by the case company, in case the continuous improvement process has identified changes to the responsibilities existing in the agreement. Accordingly, to make a transformation from a fixed SLA, change identification and respective dynamics of the agreement should be added to the existing SLA as a shared responsibility.

Supplier performance by the supplier maturity level

Thirdly, the result of the validation for the focus area 3, showed a need to segregate the performance measurement among the potential suppliers based on the maturity level of the supplier. While the suggested change sounds logical, there is a risk of creating too many customized performance indicators. Additionally, it creates an additional risk of not following the principles of standardization to therefore decrease the requirements threshold for passing the evaluation process. Therefore, it is suggested to implement the segregation within the introduced performance measurement standard. Practically, it means that no separate performance indicators are needed. Rather, it is suggested to follow the principle of key sourcing requirements and product quality evaluation by adding the additional measure of “weighting” into every performance indicator. That will categorize the performance indicators by importance and allow the suppliers with for example low production volume to pass the performance assessment phase. It is critical to mention that such an implementation will require a case company to categorize the suppliers by importance and demand of the deliverable product or service to prevent the onboarding of low maturity level suppliers into the network of major suppliers.

Putting together the results, the suggested changes did not introduce any major changes to the proposed onboarding process. The final proposal is presented in Section 6.4.

6.4 Final Proposal

An end-to-end onboarding process was presented to the case company’s product owner to then gather feedback and make a SWOT analysis of the initial proposal, presented in Data 3 collection. As a result, the suggestions mostly emphasize on improving the usage

of the components introduced in Section 5 rather than changing phases within the process. First, the improvement actions have expanded the functionality of the key sourcing requirements document, by enriching the requirement listing using categorization and measurement techniques. Secondly, the suggestion to make RACI appendix flexible was revised towards the improvement of the existing SLA approaches, suggesting the implementation of the Dynamically changing SLAs to prevent the fixation of any component existing in the agreement. Lastly, Performance measurement was supplemented with the "weighting" measure to enable the segregation of the suppliers by their maturity level.

Furthermore, the projection of the onboarding process to the existing suppliers through SWOT analysis has introduced additional opportunities existing in the case company to simplify the onboarding process adaptation. At first, it was identified that there are plenty of potential small suppliers who could test the onboarding process acting as a test case. Secondly, it was identified that the existing ITSM tool could move most of the onboarding activities online, enabling automation. On the other hand, the SWOT analysis has also shown possible threats to adopting the onboarding process. Possible threats are complexity of balancing between the time needed for the process to be adopted and the resources available. Also, the disagreement of the existing suppliers to adopt the new onboarding process was detected as one of the possible threats.

Overall, the process worked well considering the type of validation selected. The SWOT analysis has confirmed the effectiveness of the Proposal. It was stated that Phase 1 ensures full automation of the selection process, including the quality evaluation, being one of the challenges stated in CSA. Phase 2 was confirmed as a viable method to keep zero empty activities, thus creating a generalized method to handle responsibilities through RACI. Lastly, the continuous improvement process presented the way to keep the supply chain up-to-date and standardized. However, the process requires further development and participation of the whole supply network.

6.5 Recommendations for Implementation of the Proposal

The interviews with the case company product owner resulted in the recommendations for the implementation of the onboarding process. Due to the complexity of the proposed process it was decided to prioritize the activities by the importance for the case company's supply chain. The recommendations are shown in Table 10.

	Activity	*Priority*	*Role*	*Description*
1	Key sourcing document creation	Highest	Whole team	To achieve standardization in the onboarding process documentation development is the highest priority to avoid too customized selection approach for every potential supplier.
2	Entry qualifiers document creation	Highest	Supply chain manager	
3	Creation of the Product quality evaluation document	Highest	Engineers	
4	Implementing risk management (Phase 2)	Medium	Problem manager	Due to the existence of “empty activities” it is suggested to pay attention to the risk identification process to prevent risks becoming problems. The problem manager should set up the process for shared risk management where the supplier takes initiative in risk identification in his product or service.
5	Setting up performance indicator measurement process	Medium	Whole team / Supply network	To evaluate the maturity level of the supply network members it is suggested to start gathering performance indicators to therefore determine what are the most critical indicators affecting the case company’s business. The team and supply network can be a source of performance indicators.
6	Implementing the onboarding process into ITSM platform	Low	ITSM manager	To achieve full automation, it is recommended to start implementing onboarding process activities into the existing ITSM platform. ITSM manager defines the process flow.

Table 10. Prioritized activities as the recommendations for the proposal implementation.

As shown in table 10, the recommendations are divided by three priority levels. The highest priority for the case company is to standardize the onboarding process which can be achieved by creating documentation needed for the supplier checklisting. As a medium priority it is recommended to start implementing the risk management process which is a component of Phase 2. It will guarantee the case company the resolution of “empty activities” problem. Also, another medium priority recommendation points to the need of the performance indicator measurement to start categorizing the supplies by the maturity level. Lastly, the onboarding process is suggested to be automated by integrating it into the existing ITSM platform.

The next section finalizes the study with conclusions, including an executive summary and recommendations for next steps.

7 Conclusions

Section 7 summarizes the whole thesis with the executive summary, followed by a discussion of the next steps and recommendations toward implementation, and evaluation of the results. Lastly, closing words conclude the study.

7.1 Executive Summary

The objective of this study was to minimize supply chain risks in the case company's IoT product called Empathic Building. The need for this study arose due to the identified correlation between business scalability and supply chain automation. Additionally, existing supply chain practices create difficulties with taking responsibilities for the hardware and its logistics, to set up quality requirements, and lastly, it takes too much time to onboard new suppliers due to an unstandardized onboarding process. To tackle these challenges, the study placed its focus on exploring the existing onboarding process frameworks to therefore improve it for the need of risk minimization in the existing supply chain.

In this study, the selected research approach is the Design approach. It was selected because the purpose of the thesis is developing and improving components that solve existing challenges in the case company. The qualitative data collection method was used to get in-depth insights of the supply chain topic by interviewing the product owner of the Empathic Building. The proposal was developed based on three data collection rounds. First, the current state analysis was performed to gather the strengths and weaknesses of the existing supply chain practices. Next, the literature review was conducted to find the best fitting supply chain practices solving the challenges found. Lastly, the proposal for the end-to-end onboarding process was co-created and then validated together with the case company's product owner.

Based on the weaknesses gathered in the current state analysis, three main challenges were identified related to the risk minimization of the case company's supply chain. The first challenge is the unstructured responsibility and role distribution (RACI). The second challenge is a lack of risk management. The third challenge is an unstandardized process of onboarding new partners/suppliers in the supply network. It was additionally identified that the onboarding process standardization acts as a basis/core for solving all the listed challenges.

The literature review phase has revealed the best fitting practices to standardize the onboarding process as well as automate the individual components within the cycle of the process. First, to understand the case company's supply chain strategy, the framework for selecting the supply chain strategy was found that creates a separation of the strategies by functional parameters (Ambe and Badenhorst-Weiss 2011). Second, to standardize the onboarding process several practices were found: a seven-step supplier selection process (Monczka et al. 2011) and a four-step onboarding process (Smartsheet 2020). To supplement the standardization technical product evaluation process was also studied. To implement quality control in the selection process ISO 9126 standard was found and then improved with the goal-orientation approach (Punter et. al. 2004). Third, to set up the process of risk management, the process provided by the (Office of Government Commerce 2002) was studied that suggests a continuous approach to managing risks. Since the risk management process is initiated with the risk assessment, the process developed by Cooke and Williams (2006) was taken into consideration to standardize the way how case company could assess the risk within the onboarding process. Additionally, to secure the separation between the risk and the problem, problem management state transitions were introduced (Yale University 2020). Lastly, to assure that all the existing risks are managed and owned, the overview of the RACI matrix was studied (Elhady and Abushama 2015).

In the proposal, the end-to-end onboarding process was co-created with the product owner of the Empathic Building product to minimize supply chain risks at the stage of the supplier selection and onboarding. All studied practices were built into a five-phase onboarding process. First, to create the basis for decision making, the checklisting method was introduced for self-evaluation to minimize the time needed to onboard the supplier. Key sourcing requirements document, entry qualifiers document, and quality evaluation documents were introduced for standardization of the selection process. Second, the risk management process was implemented with the division of responsibilities between the supplier and the case company. Additionally, the process of risk identification and logging was introduced as well as the way how to transform the problem into a RACI activity to avoid unneeded risk ownership. Third, a contract finalization phase was suggested and confirmed with the product owner as a joint responsibility. Fourth, the Performance scorecard creation process was developed and approved by the product owner, that it would provide a standardized way to measure the performance of every supplier. Fifth, the process of the final assessment was introduced to verify all previous onboarding steps. To ensure that the case company will keep all the standards up to

date the concept of continuous improvement was introduced and confirmed by the product owner. Lastly, recommendations for the implementation of the end-to-end onboarding process are given with the priority levels to optimize time investment.

The validation was performed by theoretically projecting the proposed onboarding process to the existing suppliers as well as gathering feedback from the product owner. The received feedback was positive and was used to improve the initial proposal. The final proposal had only minor improvements such as a more detailed key sourcing requirement document, the proposal to implement Dynamically changing SLAs and adding weight indicator to the performance scorecard.

The outcome of this study is the end-to-end onboarding process that should minimize the supply chain risks at the stage of the supplier selection and onboarding. The result of the proposal should decrease the time needed to onboard the supplier, eliminate unneeded responsibilities, and create standards to follow when sourcing new suppliers.

7.2 Next Steps and Recommendations toward Implementation

The proposed end-to-end onboarding process, combining a variety of components needed for standardization, is to a great degree different from the current process within the case company. That is why it might require an extensive amount of time to fully deploy the proposal. Therefore, recommendations with prioritization were created, in Section 6.5, to mark the most critical components in solving the challenges. Nevertheless, there are other managerial tasks that have to be accomplished before the initiation of the proposal implementation.

First, the proposed end-to-end onboarding process requires a large amount of data to be able to set up the requirements needed to evaluate and onboard the supplier. It would be completely impossible to start imagining the requirements without the comparison of existing suppliers versus the expectations. Thus, it is critical to set up the process of practical simulation of the proposed onboarding process by organizing workshops with the existing suppliers and then evaluating them with a new approach by following the five phases of the proposed onboarding process. This will help developing documentation with qualified and real data. Also, the simulation will reveal the quality of the existing products and potentially it will help distributing some unwanted responsibilities on the early stage.

Second, some of the components in the onboarding process are part of the continuous improvement process (risk management, documentation, performance measurement), thus it is partially the responsibility of the case company to support and improve the existing standards. Since most of the standards are still inexistent it would be wise to begin using some of the proposed components internally as a standard. Such processes could include risk identification and logging, performance measurement, and the improvement of standard documents introduced in the proposal. These activities before the implementation of the proposal will help creating the basis for standardization.

7.3 Thesis Evaluation

The objective of the thesis was to minimize risks in the IoT product's supply chain in the case company through automation of the onboarding process. At the moment, the case company does not have an existing standard for supplier onboarding. The proposal clearly reaches the objective by introducing the end-to-end onboarding process with built-in risk minimization practices. Such practices cover all the identified challenges and ensure that the case company will be able to set up the standards for new suppliers. However, it could have been better if the theoretical assessment performed in Section 6 was done practically with the existing supplier, to ensure the reliability of all the phases. In this section, the evaluation of the thesis is performed by evaluating it according to the four criteria of validity, reliability, relevance, and logic.

According to Kananen (2017: 189), validity means that correct things are researched. In design research, for the result to be valid, data collection needs to be planned, results documented and data to be collected from multiple sources. In this thesis, data was collected through interviews with the product owner, theoretical simulation and documentation review. The validity was crosschecked with the product owner at every point of the thesis development to get constructive feedback. Intermediate results were used to improve the proposal. The final proposal was also validated with the product owner. The collected data at every phase was utilized for triangulation to ensure the results meet the expectations.

Reliability ensures that, if the research is replicated, the same results can be obtained (Kananen 2017: 189). In this study, to ensure the reliability, the data was collected from the interview with the product owner and then crosschecked with the documentation created by other stakeholders, so that the product owner's view did not interfere with the

data in the documents. Such an approach ensures that the product owner's opinion is aligned with the reality reported in the documents.

The next criteria is relevancy, judged by an assessment of the importance of the topic within its field and what contribution it makes. This thesis is based on a real business challenge in the case company and was co-created with the case company's product owner involved in every phase of this study. The result of co-creation indicates that the case company wants to proceed with the implementation of the proposal, meaning the proposal is relevant to solving the challenges. Additionally, to ensure relevancy, most of the sources used to develop the conceptual framework are based on grounded and proven facts.

Lastly, logic refers to taking coherent steps to address the business challenge. This thesis is structured in a way that every section of the thesis is logically linked to the next section. Firstly, the result of the current state analysis leads to the literature review, where existing knowledge is gathered according to the weaknesses identified in CSA. Next, once the conceptual framework is ready it leads to building the initial proposal of the end-to-end onboarding process. Lastly, the initial proposal gets validated through the interview to create the final proposal.

7.4 Closing Words

The growth of the case company's Empathic Building business had put pressure on the supply chain operation, creating a need to move unneeded responsibilities away from the company. In this context, the case company wants to standardize the onboarding process, which will allow to start managing risks at early phases of the relationships with the supplier, it will also enable better quality control and more optimized process of supplier evaluation.

The proposed end-to-end process offers a solution for the case company to incorporate components needed to solve all the challenges within one process to leave any customizations away. The proposal combines a variety of different proven practices such as quality evaluation following ISO standard, risk management, performance measurement, etc. Also, the proposal takes continuous improvement concept into account, ensuring that standards are up to date and that there are practices to keep them updated.

While this thesis proposes a rather demanding implementation of the onboarding process, it allows the case company to follow prioritization of the activities needed to implement it, saving time while implementing the most influential components of the onboarding process.

The proposed end-to-end onboarding process will be a one step forward in achieving the goal of the fully automated risk-free supply chain.

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