Service Control Tower framework for spare parts service

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This thesis is intended for Thales Netherlands and the examiners at the University of Twente.

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Because of confidentiality issues the appendices are left out of this report. If you would like to see them, you can contact Thales Nederland or Rogier Harmelink.

Preface

Dear reader,

In front of you is my bachelor thesis. I did my research at Thales with a lot of fun. I worked four days per week at Thales and one day from home per week for a total of eleven weeks. I got to learn Thales as a company in which colleagues very much like to help each other. It did not feel like being a trainee, but I felt like an equal colleague. All my colleagues were very helpful and shared a lot of information with me. Out of these I was able to come up with answers for several investigative questions which help me find the answer on my core question.

I want to thank Berend Jongebloed for all his help during my period at Thales. As my mentor you gave me a lot of information about Thales and especially about the supply chain network I was focusing on. Whenever I needed more details you helped me to find the right people to talk to. It was a pleasure to work with you. I also want to thank Bert Untied for getting me introduced with ArchiMate and Thales' customer portal. Thank you for the several hours we spend together which I learned a lot from. I always looked forward to each meeting and being overwhelmed by your enthusiasm every time. Thirdly I want to thank Simon Huijink. When I started at Thales you were finishing your master thesis here. Together with Jos van den Bosch you came up with a new inventory management. You modeled all the business processes which would be included in this new inventory management. I used these models as a base for my research. Thank you for always be willing to explain your models to me and brainstorm about the opportunities for my research. Lastly I want to thank everyone else who helped me during my time at Thales.

Besides I did not only get help from people at Thales, but also from my mentor at the University of Twente, Rogier Harmelink. Thank you for making it possible for me to work on my bachelor thesis at Thales and for always finding time to help me out when I was struggling to find my next steps. We met several times during my period at Thales. Our meetings were very pleasant and engaged with great enthusiasm from both sides. I wish you all the best with the MARCONI project.

Daniël de Vries

Management summary

Currently Thales is offering a spare parts service towards Directie Materiële Instandhouding (DMI) which is part of Commando Zee Strijd Krachten (CZSK). CZSK is part of the Royal Netherlands Navy. CZSK operates the ships which have Thales' radar systems on board. In order to have a high system availability CZSK needs amongst others a sufficient delivery of spare parts. Thales believes that sharing data with the use of service control tower will improve their spare parts service towards CZSK. This could be done with the use of a Service Control Tower. As part of the MARCONI-project this research focuses on how processes can be facilitated with an IT infrastructure. Currently very few shared data is used in the supply chain network concerning the spare parts service towards CZSK which possibly causes that the system availability is not as high as it could be. This could be solved with the use of a Service Control Tower. Therefore the following research question is defined:

"How can a Service Control Tower improve usage of shared data in the supply chain network concerning Thales' spare parts service towards CZSK for both stakeholders?"

In order to come up with an answer for this research question a methodology had to be chosen. The research cycle which is described by Heerkens & Van Winden (2012) is used in this research since the research question includes a management problem caused by lack of knowledge or insights. Also The Open Group Architecture Framework is used in combination with the research cycle.

In this research only the spare parts service towards CZSK was investigated and no other services that may be provided. Also only the collaboration with CZSK (DMI + CZSK-OPS) is part of this research and not the collaboration with the suppliers of Thales. The information for this research was required through amongst others existing literature and interviews with Thales' employees.

Thales' role in the overall performance is to give reliable promises on delivery dates, to give reliable lead times and to reduce these lead times when possible and reasonable. In order to do so, Thales needs a sufficient inventory management which is also very depending on a sufficient demand forecast. To have a sufficient demand forecast they need data from their customers, which CZSK is one of. The relevant data to receive are feedback on failure rates, failure modes and inventory levels. Combining this with the spare parts order history would give the possibility to predict orders more accurately than without this data. On the other side it would be good for CZSK to have updated failure rates and up-to-date lead times to be able to order in time which would benefit their inventory management.

A Service Control Tower would have all this data and could give information to Thales on when to expect orders and the SCT could improve CZSK'S inventory management. In order to do so the SCT would recommend orders based on previously defined states. Thales would have insights in when to expect an order since they will see when an order will soon be recommended. For CZSK the order recommendation would make sure they order in time. In a future stage it would be possible to have fixed pricing and to remove the onshore inventory of CZSK. This could save both money and time, but it will introduce some risks as well. Also recommending the orders would be easier since less human factors would be involved.

At the moment the data there is too little data available, but the data that is available is not used. The SCT would have all useful data for the other party and the usage of this data would also be improved since the SCT will be recommending orders to CZSK which would benefit both parties.

Contents

Abbreviations

- CZSK – Commando Zee Strijd Krachten
- CZSK-OPS – Operations (on-board crew of CZSK)
- DMI – Directie Materiële Instandhouding
- DMO – Defensie Materieel Organisatie
- RNLN – Royal Netherlands Navy
- SCT – Service Control Tower

1. Introduction

You might be familiar with the concept of a Control Tower. Each international airport has one or more. They are used to control air traffic and should make sure that each airplane can land at the airport or take off from the airport, that each plane has a place to stay until its next flight and to make sure that airplanes which are close to the airport do not hit each other while in the air. In order to control air traffic they need a lot of information. Amongst others current locations, directions, heights and specifications of airplanes are needed to optimally control air traffic.

Now compare an airport to a supply chain network. In the same way that airplanes arrive and depart, also products can arrive after they are ordered and depart because they are used or send to another company or station in the supply chain network. A plane that has to wait until its next flight can be compared to a spare part in a warehouse waiting for the next action. Monitoring the air traffic from airport to airport can be compared to monitoring spare parts on their way from warehouse to warehouse.

In this research we investigate if a control tower approach can be useful for the after-sales spare parts service of Thales towards CZSK. What can be improved for the stakeholders? Based on that, what should it look like?

This research will consist of an identification of the problem and how to solve it, a literature review, a description of the current situation followed by a description of the preferred situation and a way of implementing this preferred situation. Also these findings are validated with an expert panel. In the end will be a conclusion, discussion and recommendations.

1.1 Thales

Thales Group was founded on 6 December 2000 (Thales, 2005). This was short after the acquisition of Racal Electronics plc by Thales' predecessor Thomson-CSF which was established more than a century ago. Nowadays it has over 80000 employees worldwide. Thales Group is participating in different industries, namely in aerospace, defense, transport and security. They design and build electrical systems and offer services for these industries. Since the company is operating worldwide, they have departments in different countries. One of them is Thales Netherlands.

Thales Netherlands was not started from scratch. It was originally called Hollandse Signaalapparaten B.V. which started in 1922 in Hengelo. It was established to produce fire control equipment for two new ships of the Royal Netherlands Navy: Hr.Ms. Sumatra and Hr.Ms. Java. During World War II a lot of employees flew to the United Kingdom to proceed their workings there. After the World War II the factory was empty and abandoned. The Germans confiscated all they could use. The Dutch government recognized the importance of Thales and made sure the company could continue after World War II. In 1956 Philips became main shareholder and by the end of the eighties it had over 5000 employees with customers in over 35 countries. After the cold war, it was taken over by Thomson-CSF which later became Thales. Nowadays Thales Netherlands produces radar systems, infrared devices and fire-guided systems. They are located in Hengelo, Delft, Eindhoven and Huizen.

2. Problem identification

This chapter will start with clarifying why this research is relevant followed by a description of the problem and the research question. Then the methodology which is used for this research will be described. Lastly several research questions are formulated as well as the research design.

2.1 Relevance

This research is part of the MARCONI-project. MARCONI stands for Maritime Remote Control Tower for Service Logistics Innovation. The MARCONI-project focuses on developing SCTs, in a maritime setting, in which several chain players participate. Four knowledge institutes (Technische Universiteit Eindhoven, Universiteit Twente, de Nederlandse Defensie Academie and Universiteit Maastricht) and seven companies (IHC, Boskalis, Damen, RH Marine, Thales and the Royal Netherlands Navy) are participating in this project. Gordian Logistic Experts manages the project.

Within the project are three work packages which should help in developing the control tower. This research is part of one of these three work packages, which is called 'Secure and adaptive control tower architecture' and focuses on how processes can be facilitated with an IT infrastructure.

We will focus on applying a control tower approach. The chain players that participate in this Service Control Tower are Thales and the Royal Netherlands Navy (CZSK & DMO sea). This research should help in giving a better view on what a SCT could look like. Currently very few information is available on this topic, which gives a lot of opportunities in designing such an environment.

2.2 Problem cluster & research question

To start we have to identify the problem. As part of the MARCONI-project Thales wants to increase not only their own performance but also the performance of their customers. They want to do this by having a high reliability for their on-time delivery, a high reliability of their lead times and by reducing the length of their lead times when possible and reasonable. Thales is offering an on-demand spare parts service towards CZSK, which can be seen as the sale of spare parts. Lotfi, Mukhtar, Sahran, and Taei Zadeh (2013) state that information sharing may bring a significant amount of advantages to manufacturing sector such as inventory reduction and efficient inventory management, cost reduction (…). On the other hand, there are some barriers to sharing information as well (p. 4-5). Theory like this convinced Thales to believe that sharing data could lead to supply chain optimization. Sharing data can be done with the use of a SCT. This research will focus on what a SCT will look like and which problems it can solve. To understand which problems can be solved with the use of a SCT, we take a look at what problem is occurring and therefore causes a lower system availability than might be possible for the end-user of the radar systems, namely CZSK-OPS which is part of CZSK. A visualization of this is in Figure 1.

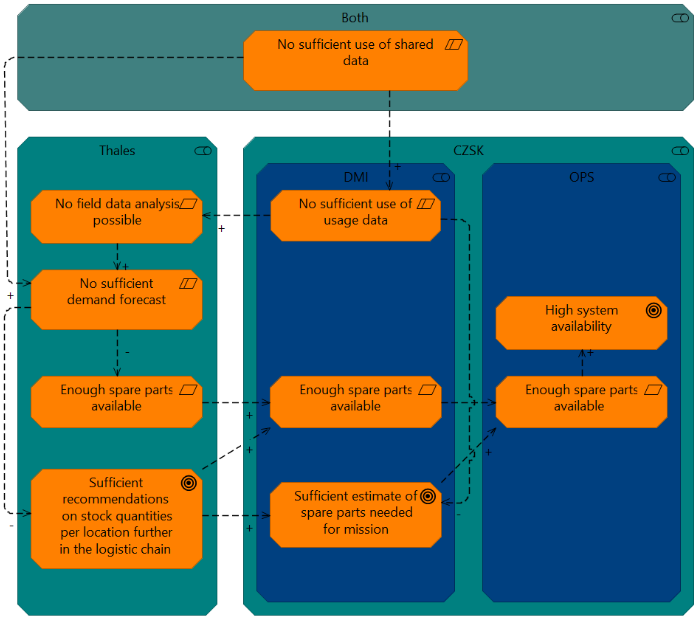

Figure 1 - Problem cluster

In the problem cluster we see that the goal of CZSK-OPS is to have a high system availability. As can be seen a lot has to happen to make sure that CZSK-OPS has a high system availability and some problems occur which results in having a lower system availability than might be possible. The cause of these problems is an insufficient use of shared data in the logistic chain. Therefore this is the core problem of this research. To solve this problem a research question is stated. This is the following question:

''How can a Service Control Tower improve usage of shared data in the supply chain network concerning Thales' spare parts service towards CZSK for both stakeholders?''

2.3 Methodology

In order to come up with an answer for the research question a methodology has to be chosen. Since we are dealing with a management problem the management problem solving method (Heerkens & Van Winden) should be useful. Heerkens & Van Winden (2012) describe two methodologies for solving management problems. One is meant for action problems and one for knowledge problems. Finding out how a SCT can improve usage of shared data in the supply chain network can be seen as a knowledge problem. Therefore the methodology for knowledge problems is used and not the methodology for action problems. In case of an action problem there would be perceived discrepancy between the norm and the reality. For this problem defining a norm and reality is hard which causes that this problem cannot be treated as an action problem. The problem can however be treated as a knowledge problem, since there is a lack of knowledge or insights. The procedure to solve a knowledge problem is called a research cycle. This procedure consists of the following eight phases:

1. The objective
2. The problem statement
3. The research questions
4. The research design

5. The operationalization
6. The measurements (the collecting of data)
7. Processing the data
8. Drawing conclusions

With a SCT the business processes, the collaboration between information systems and the technological architecture would change at Thales and CZSK. An enterprise architecture is a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure (Lankhorst, 2009, p. 2-3). In other words a SCT would change the enterprise architecture. The new enterprise architecture (explained in chapter 3), that results from using a SCT, will be modeled and should show how a SCT can improve usage of shared data in the supply chain network. First the current enterprise architecture should be modeled and then changing this version to the new enterprise architecture will be an important part of coming up with a solution for the research question. It should improve the results if this is implemented in the methodology. A method that is used to develop an enterprise architecture is The Open Group Architecture Framework. The TOGAF® Standard, a standard of The Open Group, is a proven Enterprise Architecture methodology and framework used by the world's leading organizations to improve business efficiency. It is the most prominent and reliable Enterprise Architecture standard, ensuring consistent standards, methods, and communication among Enterprise Architecture professionals (The Open Group, 2009). The Open Group Architecture Framework can best be explained with the use of Figure 1.

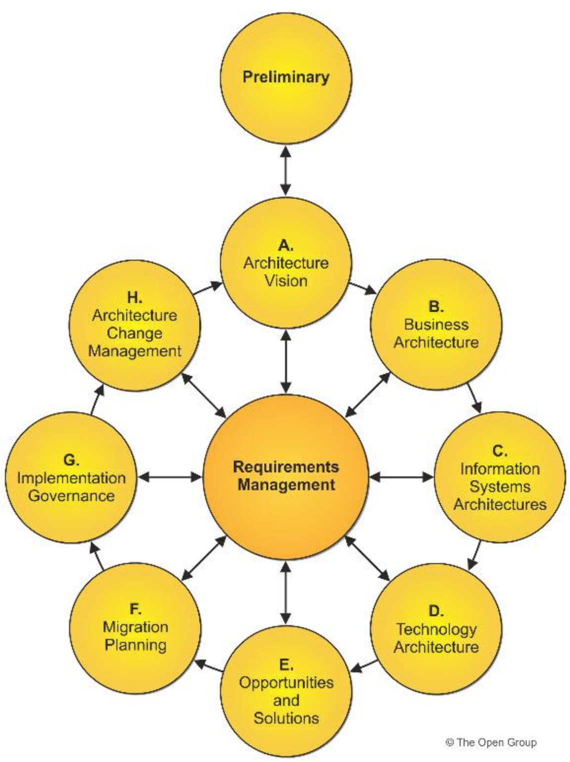

Figure 2 - The Open Group Architecture Framework (The Open Group, 2009)

TOGAF is made for the development of an enterprise architecture as described earlier. The development of a new enterprise architecture will be part of coming up with a solution for the research question. Since a methodology is used to come up with a solution for the research question, the development of a new enterprise architecture should be part of the methodology. Probably this will also happen when following the eight phases of the research cycle, but using TOGAF should give better results, since it is meant for it. TOGAF overlaps with phase 4 up to and including phase 7 of the research cycle, since this part of the research cycle includes the development of the enterprise architecture. Therefore the research cycle is used, but these four phases are combined with TOGAF. Table 1 will visualize this.

Table 1 - Research cycle and TOGAF

Research cycle	TOGAF
1. The objective	N/A
2. The problem statement	N/A
3. The research questions	N/A
4. The research design	A. Architecture vision
5. The operationalization	B. Business Architecture C. Information Systems Architectures D. Technology Architecture
6. The measurements (the collecting of data)	E. Opportunities and Solutions
7. Processing the data	F. Migration Planning G. Implementation Governance H. Architecture Change Management
8. Drawing conclusions	N/A

The first two phases of the research cycle are already treated in 2.1 & 2.2, so below will be continued with the third phase of the research cycle.

2.4 Research questions

The third phase of the research cycle is to define the research questions. Already one research question has been mentioned which will be used to solve the core problem, but in order to be able to answer this question other questions are needed. These questions are stated below. They are in chronological order and based on literature, current situation, combining literature with the current situation and the desired situation. The questions will be answered by amongst others reviewing literature and doing interviews with people involved.

Question 1: What is the concept of service logistics?
Delivering spare parts is part of service logistics. In order to understand Thales' spare parts service knowledge about service logistics is required.

Question 2: What is servitization?
Thales is interested in servitization (Product Services Manager, 2020, see Appendix E). What are the main principles?

Question 3: What is enterprise architecture?
Introducing a SCT will change the enterprise architecture of Thales. For understanding this change knowledge about enterprise architectures is required.

Question 4: What is an ERP system?
An ERP system contains a lot of corporate data. Since sharing data between companies is important in this research, it should be known what an ERP system is.

Question 5: What is ArchiMate?
ArchiMate is the tool that will be used to explain the current enterprise architecture at Thales and how the enterprise architecture would look like when the SCT is implemented. This tool is already used at Thales. Therefore using ArchiMate will make it easier for Thales' employees to understand this research and to use the models. Still there are people who do not know ArchiMate and therefore it has to be explained.

Question 6: What is a Service Control Tower?
This research is about the use of a SCT, but what is a SCT?

Question 7: What does the supply chain network look like?
Since Thales believes data sharing through a SCT could lead to supply chain optimization, it is important to know what the supply chain network looks like.

Question 8: What does the selected service that Thales provides to CZSK look like?
In the supply chain network we see Thales is providing services towards CZSK and not towards CZSK-OPS which is the end user of the radar systems. In this research the service that is focused on is the spare parts service. In order to see how Thales can improve this service, knowledge about this service is required.

Question 9: What is the role of Thales for the overall performance of this network concerning the spare parts service?
In order to understand how usage of shared data in the supply chain network can be improved from the supplier side, insights in Thales' role for the overall performance of the supply chain network need to be acquired. This might generate ideas in how usage of shared data can be improved.

Question 10: What does the business architecture and the information systems architectures look like in the supply chain network for the spare parts service?
This contains both phase B and C of TOGAF. Before being able to change the enterprise architecture, the current enterprise architecture has to be modeled.

Question 11: What does the technology architecture look like?
Modelling the technology architecture will finish the enterprise architecture. When a SCT is modeled, also this part will change. This is step D of TOGAF.

Question 12: Which data does each stakeholder the supply chain network need from other stakeholders to improve their performance?
The results of this question will come from interviews with Thales employees. This is phase 6 of the research cycle. Opportunities and solutions will arise here. Therefore this is also seen as phase E of TOGAF.

Question 13: How can this data be used in a service control tower environment?
Also as part of phase 6 a solution will be defined in which (parts of) the data described in question 12 will be included in the SCT.

Question 14: How will the introduction of the SCT change the enterprise architecture?
The introduction of the SCT will change the enterprise architecture. Having a SCT will change the collaborations between the organizations. Some business processes will become unnecessary and some business processes will be added. Modelling this will be the last part of phase 6 of the research cycle.

Question 15: How can the SCT be implemented?
The solution will obviously bring some changes with it. These have to be implemented, but this will not happen from the one day to the next. There has to be looked at the implementation governance which is part of TOGAF.

Question 16: Is a SCT really necessary?
Before the start of this research it was already determined that there should be a SCT. What the SCT should solve was not even known yet. Unknown was if the use of a SCT is really the best way to solve current problems at Thales. Because of that also alternatives should be taken into account.

2.5 Research design

Phase 4 of the research cycle is the research design. It is important to define a scope and research goal before the start of a research. Also the way of collecting information should be known. This is done below.

2.5.1 Scope

Since this research has a timespan of three months it is important to define a scope. In this research the scope is the spare parts service that Thales offers to CZSK during the life-cycle of the installed system on board of the ships of the Royal Netherlands Navy. Only the collaborations between Thales and CZSK (DMI & CZSK-OPS) will be taken into account. The collaborations with other parties, for examples Thales' suppliers, are excluded from this research.

2.5.2 Research goal

The goal of this research is to find a way of how a SCT can improved usage of shared data in the supply chain network concerning the spare parts service towards CZSK. This is done to find possibilities to improve their spare parts service which might benefit themselves in terms of financial improvements or benefit their customers in terms of higher system availability and/or financial improvements.

2.5.3 Collecting information

There are different ways to collect information. This can be done through observation, interview, surveys or content analysis (Heerkens & Van Winden, 2012). This research will collect information mainly through interviews. A survey will also been done to verify the findings. Besides there will be documents available at Thales and existing literature from other researchers that will be used.

3. Literature review

After the research design follows the operationalization. We know what is investigated and how this is done. Now we will look at different concepts and the current situation at Thales. In this chapter research questions 1 to and including 6 are answered. All the questions are about different concepts that are important for this research. These concepts are service logistics, servitization, enterprise architecture, ERP system, enterprise architecture and service control tower. In order to define the concepts existing literature is used.

3.1 Service logistics

Davis & Manrodt (1991) define service logistics as the management of activities which respond to customers on an individual basis. Service logistics is involved in reducing lead time between the scheduling, the performance and the evaluation of the procedure. Service logistics requires rethinking the way the service organizations interact with customers. Eruguz, Tan and Van Houten (2017) stated that maintenance and service logistics support (i.e. after-sales logistics activities needed to enable capital goods to be maintained and function properly) are essential to ensure high availability and reliability during the asset life time. Jayaraman and Srivastava (1995) believe service logistics aims at the most efficient utilization of facilities, thus minimizing the cost of excess capacity, while making the service more responsive to customer demands. Ketikidis, Koh, Gunasekaran, Cheung, Chan, Kwok and Wang (2006) partially overlap with this last statement since they also concluded that effective service logistics can lower the cost, but besides they found out that it would increase service value by improving customer satisfaction and loyalty.

3.2 Servitization

Servitization is about the transformation in which manufacturers increasingly offer services integrated with their products. This can be on a low level like offering relatively conventional services or on a high level in which they move almost entirely into pure services (Baines & Lightfoot, 2013). Jovanovic, Engwall and Jerbrant (2016) suggest that "for some companies, servitization can be approached as a progression based on the interaction between the design of the service delivery system and the product operation (Figure 3)" (p. 35). Jovanovic et al. (2016) define the first step into servitization as starting with the sales of spare parts after selling a product. This step can then be followed if desired by adding generic service personnel. From this moment customers can ask the product firm whenever they want to maintain a certain part of the product at a specific moment in time. At the third step service contracts are introduced. This service support will be beyond standard warranty contracts and include a periodic fee. The service will be done by more advanced and professionalized personnel. Besides the service

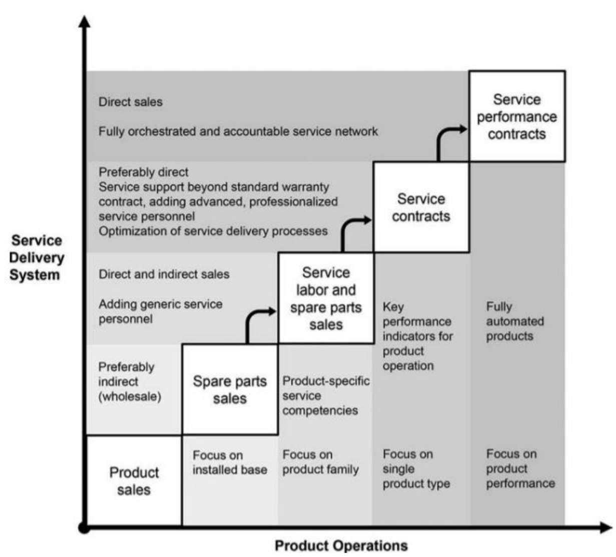

Figure 3 - The relationship between product operations and the service delivery system (Jovanovic et al, 2016)

delivery processes will be optimized. Also key performance indicators for product operation are added. This will be narrowly focused on single product types and therefore the back office needs to be professionalized by adding specialized service personnel. That leaves us with the last step and most advanced level of servitization which introduces service performance contracts. This is quite similar to service contracts, but the difference is that the product firm is stimulated to deliver a high performance, since they are payed based on the performance they realize. Therefore the product firm needs to focus a lot on their product performance and to build a service network they can rely on.

In this explanation of servitization we see that in all levels the product is in possession of the customer. It can also happen that a company decides to remain owner of their product and only sell a service. An example of this is 'Swapfiets'. Customers of Swapfiets do not pay for the bike itself, but pay a periodic fee for the use of the bike. When you have a subscription, you get a bike from Swapfiets. When it breaks down, you can call Swapfiets and they bring you a working bike and take the broken one with them or they repair the bike on the spot. In this case you will (almost) always have a working bike.

3.3 Enterprise architecture

Lankhorst (2009, p. 2-3) explains the definition of enterprise architecture by first explaining the individual words. In which he explains architecture as fundamental concepts or properties of a system in its environment, embodied in its elements, relationships, and in the principles of its design and evolution. Followed by the explanation of an enterprise as any collection of organizations that has a common set of goals and/or a single bottom line. Combining these definition he concludes an enterprise architecture is a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure. Including information systems and infrastructure is not possible in a business process model. A business process model is a network of graphical objects, which are activities (i.e., work) and the flow controls that define their order of performance (White, 2009). This only includes the business processes. Especially the business processes and information systems are important for this research. Therefore this research will develop a new enterprise architecture and not a new business process model.

3.4 ERP system

Monk & Wagner (2012) describe Enterprise Resource Planning (ERP) systems as core software programs that companies use to integrate and coordinate information in every area of the business. Organizations can manage company-wide business processes with the help of ERP programs, using a common database and shared management reporting tools. In this case a business process is defined as a collection of activities that takes one or more sorts of input and creates an output, for example a report or forecast, that is of value to the customer. Business processes normally become more efficient when tasks related to sales, marketing, manufacturing, logistics, accounting, and staffing-throughout a business are integrated into the ERP software. Examples of ERP systems suppliers are Oracle, SAP and Acumatica.

3.5 ArchiMate

The Open Group (2019) explains the language structure of ArchiMate in their Archimate 3.1 Specification which helps in a better understanding of the ArchiMate Enterprise modeling language. This language is designed to be as small as possible, but still usable for most Enterprise Architecture modeling tasks. In Figure 3 you will find the top-level hierarchy of ArchiMate concepts. A model is a collection of concepts. Each concept is always an element or a relationship. At the same time an element always is a behavior element or a structure element.

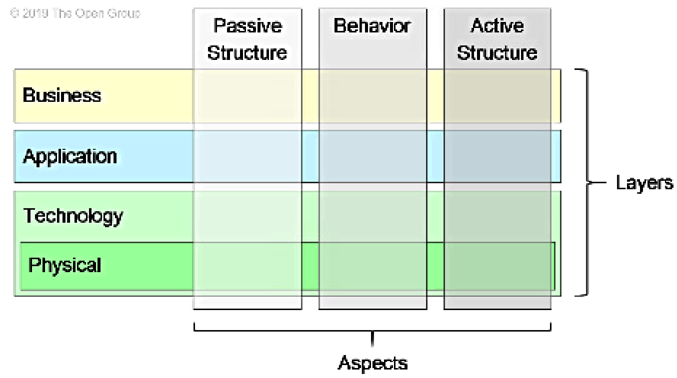

Figure 4 - ArchiMate Core Framework (The Open Group, 2019)

As The Open Group (2019) explains there are different types of elements. An internal active structure element represents an entity that is capable of performing behavior, an external active structure element, called an interface, represents a point of access where one or more services are provided to the environment, an internal behavior element represents a unit of activity that can be performed by one or more active structure elements, an external behavior element, called a service, represents an explicitly defined exposed behavior and lastly a passive structure element represents an element on which behavior is performed.

The language defines a structure of generic elements and their relationships, which can be specialized in different layers. Three layers are defined within the ArchiMate core language as follows:

1. The *Business Layer* depicts business services offered to customers, which are realized in the organization by business processes performed by business actors.
2. The *Application Layer* depicts application services that support the business, and the applications that realize them.
3. The *Technology Layer* depicts technology services such as processing, storage, and communication services needed to run the applications, and the computer and communication hardware and system software that realize those services. Physical elements are included for modeling physical equipment, materials, and distribution networks to this layer.

The general structure of models within the different layers is similar. The same types of elements and relationships are used, although their exact nature and granularity differ.

3.6 Service control tower

A SCT acts as a centralized hub that uses real-time data from a company's existing, integrated data management and transactional system to integrate processes and tools across the end-to-end supply service chain and drives business outcomes. (Accenture, 2015 as cited in Topan, Eruguz, Ma, Van der Heijden & Dekker, 2019).

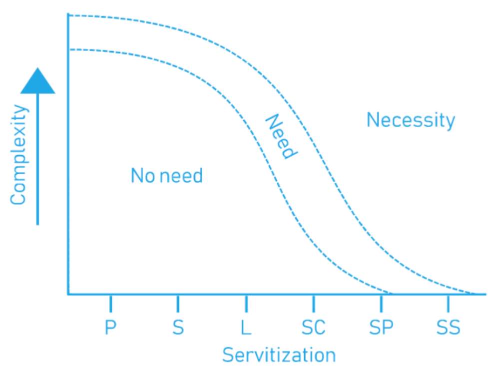

Figure 5 - The relation between servitization, complexity, and the need for a service control tower – Retrieved from 'Consultants in Quantitative Methods (CQM)'

According to Topan et al. (2019) companies uses these SCTs for monitoring the supply chain and for the generation of alerts. These alerts can be time-driven or event-driven. Examples are triggers for stock level changes, fulfillment of a part request, arrival of a replenishment order and information updates about expected timing of supply or demand. An alert is generated when actual demand (or supply) deviates significantly from expected, usually when a predetermined threshold is exceeded.

The drivers for the need of a SCT are complexity and servitization. As can be seen in Figure 5 the higher the complexity of the collaboration, the greater the need for a SCT. The higher the level of servitization, the greater the need for a SCT. A SCT can contain a lot of different information. Examples of this information are according to Topan et al (2019) current inventory on hand, pipeline stock, number of parts in repair or return, process completion time estimates, short-term demand forecasts, time order spent in a supply stage, age and/or condition of installed units and expected delivery time and advance demand information derived from condition monitoring and preventive maintenance plans.

There is few information available on what a SCT should look like. What a SCT should look like very much depends on the services that are provided and the company these services are provided too. In this research the very broad explanation above will be used in order to leave space for innovative implementations.

4. Current situation

Now we gained knowledge through existing literature, we can dive more into the situation at Thales. This is still phase 5 of the research cycle. Questions 6 up to and including 10 mentioned in chapter 2.4 will be answered. Answers on these questions are needed before can be decided how the core problem can be solved.

4.1 The supply chain network

Figure 5 is a visualization of a part of the supply chain network. As we can see the Royal Netherlands Navy consists of CZSK and DMO sea. CZSK can also be separated into two departments namely DMI, which is the maintainer of the asset, and CZSK-OPS which is the user of the asset. CZSK-OPS is the user of the radar systems, since they use the ships. The one who is responsible for the purchase of the ships is DMO sea. Their department called ‘Directie Inkoop’ does this. When maintenance is required the asset manager is addressed. This is a department of DMI called ‘Maritieme instandhouding’. DMI will try to repair broken parts. Repairing broken parts is the task of their department called ‘Techniekgroep Sensor en Wapensystemen’. If a part cannot be repaired, another department of DMI will take action. This department is called ‘Maritieme logistiek’. They will either order a new part or send the broken part for repair to a supplier. Here several parties can be addressed. One of them is Thales. Thales can either repair the broken part or send a new one. Sometimes DMI decides to let another supplier do this, but this is only for low level repairs. When it occurs that the part can be repaired, but a spare part of this part is needed, ‘Techniekgroep Sensor en Wapensystemen’ asks ‘Maritieme logistiek’ to buy these parts from Thales or another supplier. Thales will then buy parts from their own suppliers or take it from their current inventory. It can also happen that DMI needs a distributor item, which will be later explained in chapter 5. These items are bought directly from a supplier of spare parts and/or components for radar systems.

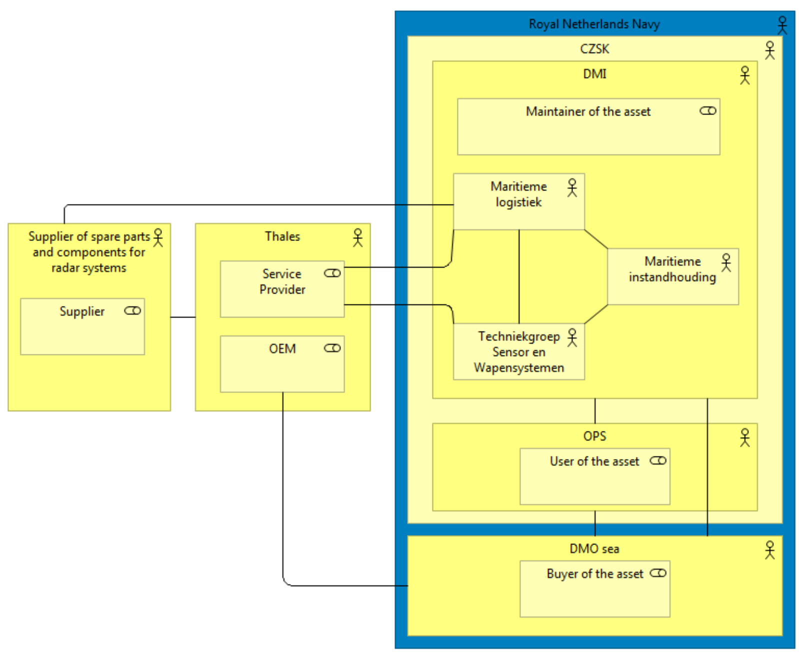

Figure 5 - Supply chain network radar systems

4.2 Spare parts service

Thales is offering maintenance services, supply chain services, optimization services, capability improvement and information letters for their in-service support. All these services are examples of service logistics, which Davis & Manrodt (1991) defined as the management of activities which respond to customers on an individual basis. Not all of these services are currently provided towards the Royal

Netherlands Navy. The spare parts service is provided towards RNLN and is part of the supply chain services.

Before diving into a broader explanation of this service, better understanding of the collaboration between Thales and CZSK is required. Currently almost all services selected are on-demand. This means the services are ordered on a case-by-case basis. There are almost no long-term contractual obligations and whenever a service is required, it is requested by CZSK. The collaboration is still low on the servitization staircase, which concept is explained in chapter 3.2. Every time a service is requested short-term contractual agreements have to be made which always leads to administration delays and subsequent longer delivery times. Because of the changes in costs financial planning is hard.

Let us dive more into the spare parts service. In order to overcome failures during operation missions by CZSK-OPS, it is necessary to have a sufficient amount of spare parts available in the supply chain. This will help to resolve a failure in a short period of time when it occurs. When this failure does occur, DMI comes into play. CZSK-OPS tells them a failure occurred and they want it to be fixed. Defective parts are replaced, removed from the ship and returned through the supply chain to be repaired or replaced. Discarded items and items beyond economic repair should be replaced. If DMI does not have the spare part, they will look for a supplier who does. For specific parts in the radar systems Thales will be this supplier. DMI can buy subsequent spares from Thales to replenish the supply chain. Diving into the business processes will give a better view on this service.

At the moment Thales is having high lead times and low reliability of those lead times. Because of this low reliability approximately only 60% is delivered on-time. In this case on-time does not mean when the customer wants the spare part, but is the moment Thales thinks they can deliver it. This is caused by the absence of an own inventory. Outsourcing is cheaper, so Thales is outsourcing approximately 80% of all spare parts. The 20% they make themselves also need parts. Out of this another roughly estimated 80% is outsourced. Summing it all up a large percentage of the parts is outsourced. Outsourcing itself is not the problem, but the combination with not having an inventory causes great dependency.

Therefore Thales is currently developing a new inventory management to improve their spare parts service. In this situation they will have their own inventory which should lead to lower lead times and higher reliability of those lead times. This research is using the future state of this new inventory management.

4.3 Thales' role in the overall performance of the supply chain network

Whenever a spare part needs to be replaced, DMI asks Thales to send them a new spare part. This is the first step of servitization which is about spare parts sales (Jovanovic et al, 2016). Their first role is to deliver a sufficient radar system for each ship the Royal Netherlands Navy is using. Their second role is to make sure there are spare parts that can be used by CZSK in order to have a high uptime for CZSK-OPS. This second role is concerning the spare parts service which is focused on in this research. Their role in the overall performance is to give reliable promises on delivery dates, to give reliable lead times and to reduce these lead times when possible and reasonable.

4.4 Business architecture and information systems architectures

We now get to phase B & C of TOGAF. To understand the spare parts service better, an enterprise architecture has been made. As described earlier an enterprise architecture is a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure (Lankhorst, 2009,

p. 2-3). This enterprise is made in ArchiMate. A description of this program is in chapter 3.5. The entire service is divided in six parts: ‘Operation and maintain’, ‘Quotation process part 1’, ‘Quotation process part 2’, ‘Sales order release’, ‘Pick & Send parts’ and ‘Requisition to receipt and put away’. These models are based on the new inventory management. The business layer (yellow part) was already constructed and is only specialized for the collaboration with CZSK. This layer contains the business processes that have to be completed in order to deliver services to CZSK. A business process is the combination of a set of activities within an enterprise with a structure describing their logical order and dependence whose objective is to produce a desired result. Business process modelling enables a common understanding and analysis of a business process. A process model can provide a comprehensive understanding of a process. An enterprise can be analyzed and integrated through its business processes. Hence the importance of correctly modelling its business processes (Aguilar-Saven, 2004). Out of this description we can conclude that analyzing the business processes can give us a better understanding of how the services are provided by Thales to DMI and CZSK-OPS in succession. This will give insights in ways to improve the service levels.

Also it is important to see which data is involved in these business processes which is in the information systems architectures. Therefore these architectures have to be modeled together. The information systems architecture is modeled in the application layer. The application layer (blue part) is newly constructed. This is done in a simplified way in the models in ArchiMate. ArchiMate is explained in chapter 3.4 and its documentation is in Appendix A.

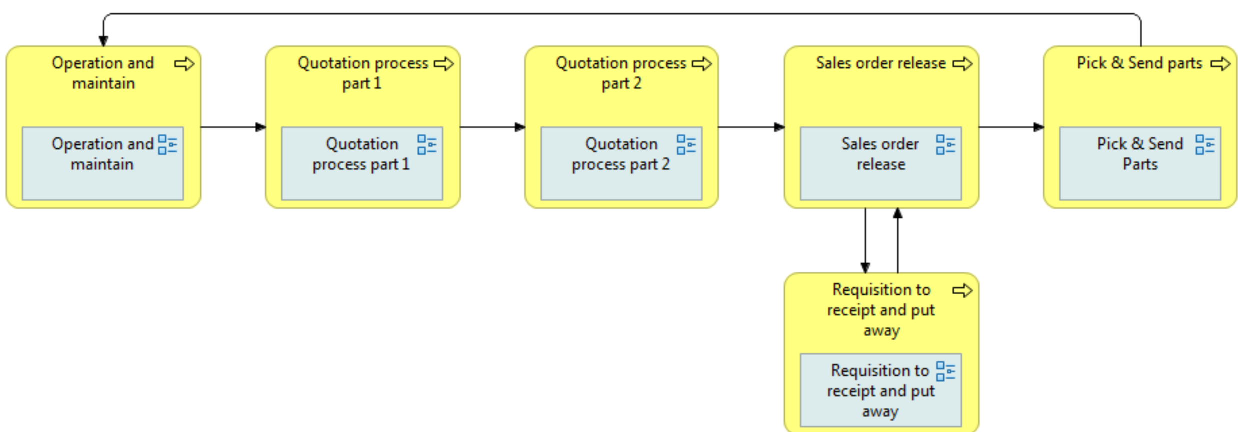

Figure 6 – Spare parts service divided into six parts

Each part will be explained individually, starting with ‘Operation and maintain’. Figure 7 shows the model of this part of the spare parts service. This part mostly describes collaboration of CZSK-OPS and DMI. We see CZSK-OPS is the user of the asset and DMI is the maintainer of the asset. Also there is an inventory on each of the ships and DMI has an onshore warehouse. When a new part is required, DMI fills in a request for quotation in the customer portal and sends this to Thales. After all parts of the spare parts service are completed, we also see that DMI receives the service part and puts it away in their onshore warehouse as can also be seen in the Figure.

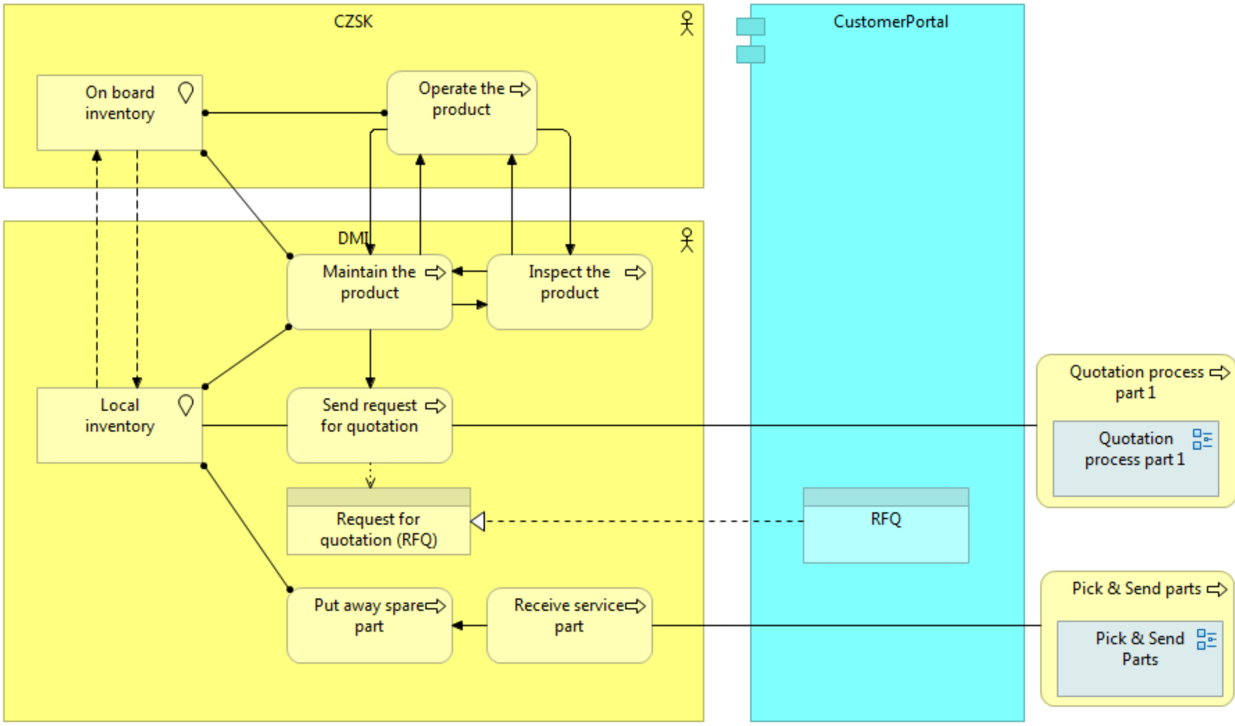

Figure 7 - Operation and maintain

After 'Operation and maintain' 'Quotation process part 1' (see Appendix B.2) comes into play. This part of the spare parts service consists of mainly administrative processes. Thales receives the RFQ coming from DMI and makes sure they have all information needed to be able to fulfill an order. If it is the case that DMI should buy a part from a distributor, Thales will tell them. These parts are called distributor items. An example of this is a screw which can also be bought at the local construction market, but DMI might not be aware of this. When it is a service part that Thales can provide to DMI, we continue to quotation process part 2. All exchange of information is done through the customer portal and important information is saved in the ERP system of Thales called Oracle. As mentioned earlier, Monk & Wagner (2012) describe Enterprise Resource Planning (ERP) systems as core software programs that companies use to integrate and coordinate information in every area of the business.

Logically after 'Quotation process part 1' follows 'Quotation process part 2' (see Appendix B.3). This part starts with two different routes, one route is only for 'other parts' and the other route is for spare parts and 'other parts'. A spare part is a part of which is expected that it will fail at some point in time. An 'other part' is a part which is not expected to fail because of natural causes. However it might fail because of someone spilling coffee over it. Before an order proposal can be made for the other parts, the information has to be checked and possibly be extended. Then Thales categorizes the request which can directly result in not doing a bid at all. It can also occur that Thales decides to continue with the project. If it is a complex request they go to the bid management. Here a bid is decided on. It is still possible in this part that Thales decides to send a no bid or best of effort announcement. In the case of a non-complex request (note that: the exact differences between a complex and non-complex request is not relevant for this research) Thales proceeds to the binding process in case of a request in which they expect the customer to actually send a purchase order. In the case Thales does not expect a purchase order they proceed to the ROM process in which they roughly estimate a price that is definitely profitable and use this price for the order proposal without spending too much time on it. When this part is done, two routes again appear. In each case the quotation process is completed and an order proposal is sent to DMI. Also a decision is made on doing a pre-release or not. If the chance is high that the order proposal will be accepted and turned into a purchase order, a pre-release is done. What this means, will become clear in the next part of the spare parts service.

In quotation process part 2 the start of the order process and the pre-release can be seen. These are the starting points of the part called 'Sales order release' (see Appendix B.4). The one who starts first, as the name says, is the pre-release, but this will only start if an order is expected as described above. The start of the pre-release will trigger the creation of a sales order. All information on the order will now be monitored in the ERP system. Also a project will be made and managed. This is done to decide on a budget for the project. This data is added to the sales order when finished and then a sales order is scheduled. At the same time in case of a spare part, which is most likely when the order is on pre-release the spare inventory is checked and a spare part will be reserved. This is in collaboration with the inventory management. In the case of an other part Thales will forecast to plan the other part. This might include the introduction of a new product. After the forecast to plan the requisition to receipt and put away will be triggered. This process will be explained after the sales order release.

When the purchase order is received the order process is started. First it is checked if the pre-release is done. If that is the case the purchase order must be matched with the pre-release. If that is not the case, a sales order should be created and all processes mentioned above for the pre-release will take place. Also after the check for a pre-release a purchase order receipt confirmation is made and send. In case of a pre-release probably the sales order is already scheduled and in combination with the confirmation sent a sales order is booked. When the sales order is not yet scheduled, further actions will not be taken until this is the case. After the sales order is booked, Thales ensures the end-user certificates are fine and then makes and sends a sales order confirmation. Once this is done and the spare part that is reserved for this sales order is in the service inventory, Thales continues to the export hold. Thales checks if the export licenses are right. Also the customer inspection hold will occur. In this process a check is done if the customer really wants this part. When both checks are done the sales order is released and we continue to the picking and sending of the parts.

Before we can look at the part called 'Pick & Send parts', we should take a better look at the 'Requisition to receipt and put away' (see Appendix B.5). 'The forecast to plan', a series of processes which not have to be understood, triggers the creation of a purchase requisition. This should be approved before the buyer workloads are managed. Then they will analyze to agree and return the requisition. This will trigger the creation of a purchase order, that then will be approved and communicated with the supplier. Then it is ordered, the purchase order is maintained and eventually Thales will receive the parts. These sometimes have to be inspected first and can be rejected. If they do not have to be inspected or they are inspected but not rejected, the parts will be put away. At this point it can happen that they directly flow to the warehouse, but it can also happen that they have to be assembled and tested afterwards. Then they will eventually also been put away in the warehouse.

Once the sales order is released, a series of tasks is released to the warehouse of Thales in the view called 'Pick & Send Parts' (see Appendix B.6). The load picking and drop picking will follow before the material can be prepared for shipping. Once the spare part is prepared for shipping, the spare part will be shipped to DMI. Afterwards Thales will send an invoice which will result in the case being closed in the customer portal. Of course the financial department will still be monitoring if the invoice is payed. When the payment is not made in time, Thales will send a reminder. Once the payment is sent by DMI and received by Thales, we are done and coming full circle. We can namely see that in the part called 'Operation and maintain', where we started, the service part is received.

4.5 Technology architecture

The technology architecture is modeled in the technology layer of ArchiMate. This is phase D of TOGAF. As explained in chapter 3.5 the technology layer depicts technology services such as processing, storage, and communication services needed to run the applications, and the computer and communication hardware and system software that realize those services. Physical elements are included for modeling physical equipment, materials, and distribution networks to this layer.

Thales and DMI have contact with the use of a customer portal which contains confidential information from several customers. Only Thales and its customers should be able to access it. Therefore a firewall is needed to make sure no one else gets in. This firewall is a Web Application Firewall (WAF).

The customer portal is in the Thales Netherlands collaboration zone and is using information from Thales that should not be visible for their customers. Therefore a firewall is needed in between the collaboration zone and the other zones. In one of these other zones is the ERP Oracle. Thales should not want that DMI can see the data in the ERP, but data does has to flow towards the SCT. Therefore the firewalls are needed. In Appendix B.7 this situation is modeled, but this is a very limited view, because of a lack of information on this topic. Future research should look at the exact details.

5. Preferred situation

In the previous chapter is looked at the current situation to create insights on Thales' spare parts service towards CZSK. This chapter includes the start of phase 6 of the research cycle, the measurements. The results in this chapter are coming from the interviews or existing literature. This can also be seen as phase E of TOGAF. Also phase 7 is in this chapter as well as the remaining phases of TOGAF.

5.1 Information from other stakeholders

Stakeholders might be able to improve their performance if they receive certain information from other stakeholders. Below we take a look which information each stakeholder can use from other stakeholders within the scope of this research to improve their performance.

Thales

At the moment Thales is using failure rates which are calculated when a radar system is produced. There is no feedback on these failure rates from CZSK. Therefore they do not know if these rates are accurate. Despite this fact, Thales is using them for the recommended inventories on the ship and at the base. Since there is almost no feedback on these failure rates coming from CZSK, there is the possibility that these calculated recommended inventories are wrong and the inventory at Thales, DMI and CZSK-OPS can be too high or too low. When there will be feedback on these failure rates, Thales might be able to improve their demand forecast (ILS Manager, November 21, 2019, see Appendix E). This feedback can be given by providing the amount of operating hours per spare part.

Also the reason for a failure, the failure mode, can be useful for Thales once they are receiving this feedback. Thales should know if they should use a certain number in their failure rate calculations. A part can break down due to 'natural' causes, but also due to a rare cause, like for example someone spilling coffee over a radar system. Only the failure rates of the break downs due to 'natural' causes are interesting for future failure rate calculations, since you will never be able to predict human failure like spilling coffee on a machine.

Not only failure rates and modes but also other data can be useful for Thales. One of them is current inventory levels at the base and on the ships. Access to supply chain inventory status can contribute to lowering the total inventory level in the supply chain (Whang, 2000, p. 3). Also Thales will notice when CZSK is not using the recommended inventory levels or when parts fail earlier than expected. Sharing these inventory levels can also benefit CZSK in another way. CZSK might have spare parts or components in their inventory they cannot use for their current or future radar systems. It is possible another customer of Thales can use these parts. If Thales locates the parts that are not useful for CZSK, they can be returned through the supply chain and sold to another customer. In such way CZSK can reduce inventory costs and also gain money by selling the parts.

Other usage data can also be useful to forecast demand better, but since currently almost no usage data is given, inventory levels, operating hours per spare parts and failure modes are good to start with. In the future there will be Health Usage Monitoring Systems (HUMS). These will monitor the condition of the spare parts of a radar system and should give better information to forecast demand than currently available.

CZSK

Currently it is not always known at CZSK if a part is a spare part, a distributor item or an other part (Service designer, November 8, 2019, see Appendix E). Time can be saved if these differences are better known in an earlier stage (Product Manager Services, November 20, 2019, see Appendix E). Now it is the case that the request for quotation is done and a service employee at Thales will first have to check this request and then has to tell CZSK that this part should be ordered at a distributor or ask them if they are sure they need that part since it should not fail. Time at Thales can be saved. Saving that time will automatically result in lower transit times which benefits CZSK.

Also it would be useful for CZSK to get updated failure rates from Thales, since Thales has more customers to get feedback on failure rates from. CZSK can use these to plan their inventory management better, since they will know better when to expect failures.

Lastly updated lead times are important to get from Thales. Otherwise CZSK might order spare parts too late or too soon. This can give temporary useless inventory or cause stock outs.

5.2 The SCT

The data that is needed to improve processes described above show us that especially Thales needs a lot of data. Data that should help them to know when CZSK will order spare parts. Especially failure rates, lead times and inventory levels are almost continuingly changing which causes that this data is harder to use. Both parties can benefit from better failure data and knowing each other's inventory levels, so they can keep the inventory of the total supply chain low and create higher system availability for the end-user.

Therefore the SCT should recommend orders to improve usage of shared data in the supply chain network concerning the spare parts service towards CZSK. This will give Thales insights in when they can expect orders and will make sure that CZSK orders in time based on the latest failure rates, lead times, spare parts order history and inventory levels at both Thales and CZSK. The data that should be used better are the up-to-date failure rates, lead times and inventory levels by using them in an integrated planning.

In order to be able to recommend orders, the SCT should at least have data on failure rates. These will be the failure rates that are calculated when a spare part is designed, but these rates should be improved with the use of operating hours per spare parts provided by CZSK (and other customers). Also inventory levels of all stations (CZSK-OPS, DMI and Thales) should be in the SCT. Lastly spare parts order history can be used to improve the failure rates and therefore should be available.

Note that not all orders can be recommended. Especially mechanic parts have failure rates and therefore an order for these parts can be recommended. There are also electronic parts which have the same change of failure on each points in time, but it can still be useful to know for Thales if such a part is available at CZSK or that they can expect an order directly when it fails.

5.3 New enterprise architecture

As part of phase 6 the new enterprise architecture has to be modeled. These models are divided into two stages. The first stage is for applying a SCT on the current situation and the future stage is for applying a SCT on a possible future situation.

The first stage

In this stage we will have an extra application which is responsible for monitoring all inventory levels, failure rates, failure modes and spare parts order history in order to recommend orders. This application will be the SCT.

The minimal required data that Thales needs in order to recommend orders are the operating hours per spare part, which is used to determine the failure rate. These are not the same since it depends on the reason why it failed how it will influence the failure rate. Currently only the total of operating hours are available in the defect reports, which are saved in the logs of the radar systems and can be seen by maintainers, so there have to be made changes in the radar systems to record the operating hours per spare part. It would not require a lot of work to record this, but some software has to be changed (Software component engineer, December 12, 2019, see Appendix E). When this is done, CZSK will get the opportunity to register this information in their ERP SAP. This information can be linked with the SCT.

The SCT will have previously defined states for when an order has to be recommended. These states are as earlier mentioned based on the latest failure rates, inventory levels and lead times. When one of these states is reached, automatically a request for quotation in the customer portal will be filled in and DMI will be sent an alert which should let them either authorize the request for quotation or close the case. How these states are defined, for example with a smart algorithm or generic heuristics decided on by Thales and/or CZSK, has to be investigated in further research. With the order recommendation the opportunity to manually send a request for quotation will still be available. In order to not have this application send an alert when a part is already on its way, the spare parts order history will also be monitored by this application.

The changes mentioned for this stage will change one view, namely 'Operation and maintain'. The new model can be found below in Figure 9. The models of the current situation can be found in Appendix B.1.

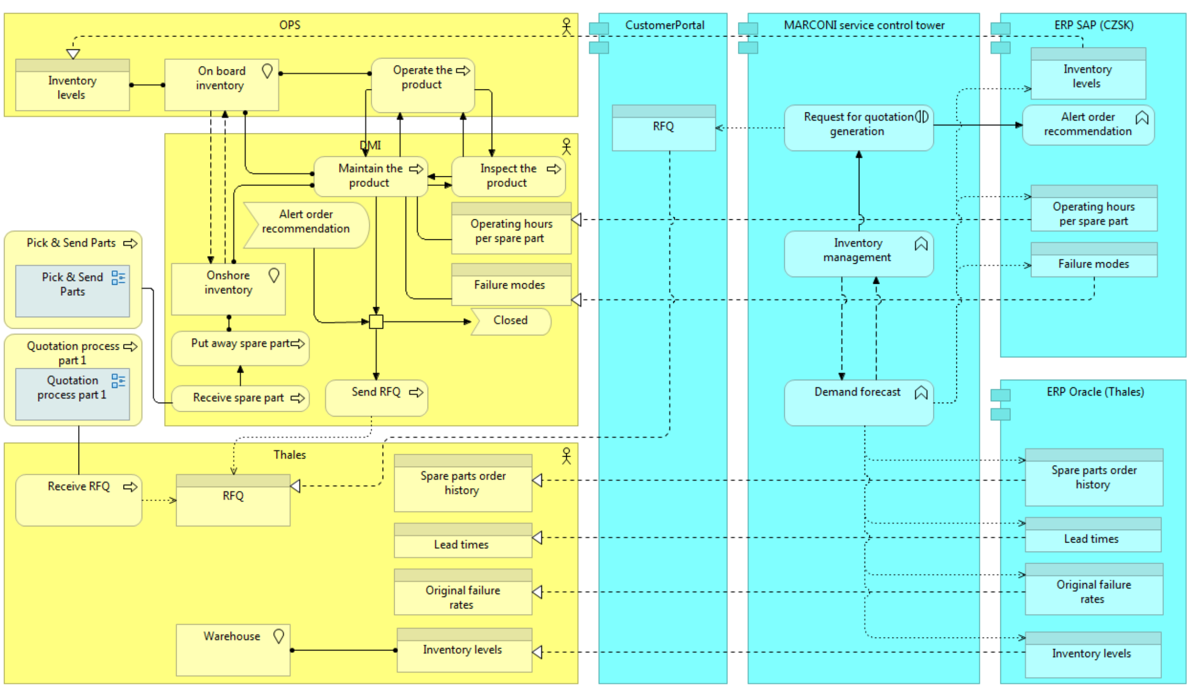

Figure 8 – First stage: Operation and Maintain

In the model can be seen that the SCT will generate a filled in request for quotation based on the previously defined states and send an alert towards the ERP SAP of CZSK. DMI can then decide if they want to send the RFQ or close the case. This decision is represented by the box in the model. It can be closed, because for example DMI wants to save money. When they do decide to send the RFQ, this is received by Thales and the processes will continue in the same way as if a RFQ is received nowadays.

Future stage

In the future stage Thales might have long term agreements with CZSK, since they are interested in servitization (Product Service Manager, 2019). This might include having fixed prices and move the onshore inventory to Thales. Thales will in that case directly send spare parts to the ships. This is very speculative, but a possible future stage when looked at their ambitions. It still can happen that a request for quotation is handed in through the customer portal, but this is not modeled. In this case the quotation processes can be skipped, since the prices are already discussed on. The new situation for the view 'Operation and Maintain' is visible in Figure 10.

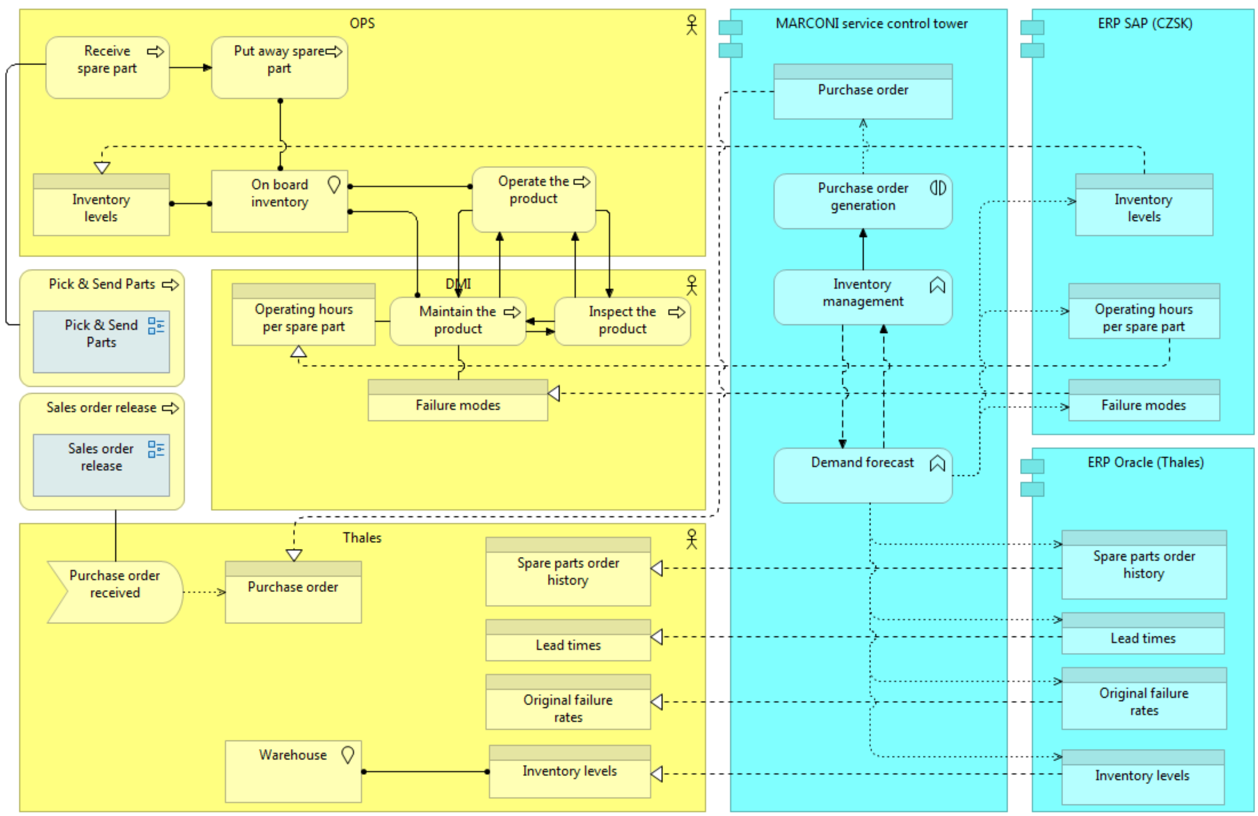

Figure 9 - Future stage: Operation and Maintain

Also the view called 'Sales order release' will change in this situation (see Appendix D.2). This is caused by the deletion of the other parts. This cannot be generated by the SCT, since other parts are not expected to fail. Also the pre-release is deleted, since this is activated when a RFQ is expected to be followed by a purchase order, but the purchase order will be there always in this case and does not have to be waited for.

Lastly the view called 'Pick & Send Parts' (see Appendix D.3) will change since the spare part is send towards CZSK-OPS and not towards DMI. Therefore receiving the parts is done at CZSK-OPS instead of DMI.

In the case that an other part is needed, the old model still suffices. The forecasts will not expect these parts to fail. Also it can occur that a part fails earlier than expected and also then this can be ordered. In that case this will happen as described in the first stage of the SCT.

5.4 Validation

In order to validate the findings of this research an expert panel has been held with six Thales' employees who are involved in the spare parts service towards CZSK and other customers. After a presentation about this research, a survey was held in which they were given several statements regarding this research and asked if they agree on these wit a scale from 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree". Also they were asked to give comments on the different parts of this research. These comments were used to improve this research and are therefore where possible included in the final version. The results are shown in Appendix F.

The first statement was 'This research gave me new insights on the collaboration between Thales and CZSK'. Five of the six respondents ranked this statement with a 4 which stands for 'agree' and one respondent was neutral about this statement. The one possible improvement mentioned in the comments is that it would be good if responsibilities of Thales and CZSK in their collaboration would be clarified.

The second statement was 'I recognize the situation described in the problem cluster of this research'. Four people agreed with this statement, one person even strongly agreed with it and one responded neutral. One of the respondents however thought that if CZSK would give better information towards Thales, Thales should not have to lower the prices, since it will give CZSK the opportunity to have lower stocks which already saves them money. This is therefore changed in the problem cluster of this research.

The third statement was 'I agree with the conclusion of this research'. Four respondents agree with this and two are neutral. In this conclusion there was no difference between mechanical parts and electronical systems which was one of the comments. This is included in the final version of this research.

The fourth statement was 'I agree with the suggested implementation of this solution.' Four persons responded neutral on this statement and two persons agreed with it. One of the respondents commented that it was too vague. Attention has been spent on this and changes have been made for the final version of this research.

The fifth statement was 'I agree with the discussion of this research.' Here we see the respondents differ in their opinion. Two of them disagree, another two is neutral and the last two agree with it. Especially the introduction of Slim4 Software in the discussion brought up questions for the two respondents that disagree with this statement. This software is used by CZSK, but Thales was not aware of this. This became clear in the last period of this research. The experts at Thales were told that CZSK is using Slim4 Software during the expert panel and this influenced their response. Therefore some statements in the discussion have been toned down.

The last statement was 'I agree with the recommendations of this research.' One of the respondents strongly agree with this statement, two others agree with it and the last three remain neutral. Also the recommendations were considered a bit vague, so they have been made more specific for the final

version of this research, for example clarifying the additional value for Thales.
After this expert panel changes has been made in this research. How these changes were made is not checked with the experts, which causes a risk that they still do not (entirely) agree with how it currently is stated in this research. Also it is not checked if the experts agree with the recommended changes by the other experts. This too causes risks. We can say after this expert panel that the core of this research has been validated, but their might still be some expects the experts do not agree on, so we cannot say it is fully validated.

5.5 Implementation

Before it is possible to improve usage of shared data in the supply chain network concerning Thales' spare parts service towards CZSK with using a SCT, changes have to be made. These changes will be mentioned below in an implementation plan. This implementation plan is only for the first stage of the solution, since the future stage is too speculative.

1. Set up a framework agreement with CZSK
Both parties are putting in information and adapt their inventories based on information out of the SCT. When CZSK suddenly decides to buy certain spare parts at another supplier, Thales might have useless inventory. If this step is not accomplished, both parties could still start with the next step, but it would cost more money, because the uncertainty has to be taken into account.

2. Register the data
The available data might differ per spare part. Maybe operating hours per spare part are not even registered. That has to change. All important data for the SCT has to be registered in CZSK's ERP system and made available for the SCT. What might cause a problem is that the information of CZSK is to a certain level confidential. They might not be willing to share data like operating hours. This is necessary to be able to use a SCT. Therefore Thales and CZSK have to discuss with each other how this can be done.

3. Choose an application to use for the SCT
This application should have the capabilities as described earlier in this research.

4. Build the SCT
When all data is ready and agreements are made, it is time to build the SCT. All functionalities as described in chapter 5.3 for the first stage should be included.

5. Link the data with the SCT
The SCT needs a lot of data. This can be drawn out of the ERP systems either manually or automatically. Since it is preferable to have up-to-date data, it would be better to connect the ERP systems with the SCT automatically. Both parties could program this if desired. When this is done. The SCT is ready for use.

6. Conclusion, discussion and recommendations

This chapter consists of several parts. First of all the conclusion of this research. The conclusion will give an answer to the research question. Then the findings of this research are discussed. Is a SCT really necessary? Lastly recommendations for further research are made.

6.1 Conclusion

In this research several questions have been answered in order to find an answer for the research question. The research question is:

''How can a Service Control Tower improve usage of shared data in the supply chain network concerning Thales' spare parts service towards CZSK for both stakeholders?''

Data usage is a very broad concept. The data that Thales could use from CZSK is feedback on the failure rates by for example sharing the operating hours per spare part, the failure modes per spare part and lastly the inventory levels. If they would combine this data with their spare parts order history it would be easier to predict an incoming order. On the other side it would be good for CZSK to have updated failure rates and up-to-date lead times to be able to order in time.

Both parties could use data from each other to improve their processes. We see that it is hard for Thales to know when CZSK will order and that CZSK could improve their inventory management with updated failure rates and up-to-date lead times. A Service Control Tower would have all this data and could give information to Thales on when to expect orders and the SCT could improve CZSK's inventory management. In order to do so the SCT would recommend orders based on previously defined states. This would give Thales insights in when to expect an order since they know the current states and the previously defined states so they can plan better when the order will come in. For DMI there would be up-to-date lead times and they would know better when a spare part is going to fail, because of better failure rates.

In a future stage it would be possible to have fixed pricing and to remove the onshore inventory of CZSK. This could save both money and time, but it will introduce some risks. Also recommending the orders would be easier since less human factors would be involved.

At the moment the data there is too little data available, but the data that is available is not used. The SCT would have all useful data for the other party and the usage of this data would also be improved since the SCT will be recommending orders to CZSK which would benefit both parties.

6.2 Discussion

The RFQ process makes it hard to have a SCT. The SCT is in principle combining the inventory management of CZSK with the demand forecast of Thales. Currently there is still a RFQ process of which is unknown how much time it will take, because of the human factor coming from discussing on a price. Therefore the time between the rise of a demand and the delivery of a spare part is fluctuating, while the time after a purchase order is placed might be easier to predict. When a SCT is used, it would be very much preferable to minimalize human involvement, since this makes predictions more reliable.

This problem can be solved if fixed prices in the use of framework agreements is introduced for the delivery of all spare parts. With fixed prices the RFQ process can be skipped and a purchase order can directly be placed. The lead times will be more reliable and it will be easier to have a sufficient order recommendation.

Also the failure behavior is different for all spare parts and therefore cannot be generalized as is done in this research. In the recommendations further actions for this will be suggested.

The necessity of a SCT can be questioned. CZSK is currently using Slim4 Software for planning their orders. A similar effect as the SCT might be reached by giving Thales insights in the Slim4 Software calculations and sharing failure modes and operating hours per spare parts so failure rates can be improved. The failure rates might also improve the Slim4 Software.

Still a SCT is also a sufficient way to do this and also a solution with a lot of potential. It can contain a lot more information than is shown in this solution as also concluded by Topan et al. (2019) like pipeline stock, number of parts in repair or return, process completion time estimates, short-term demand forecasts, time order spent in a supply stage, age and/or condition of installed units and expected delivery time and advance demand information derived from condition monitoring and preventive maintenance plans. Also it is possible to add other stakeholders, like other customers of Thales or suppliers of either CZSK or Thales. This will increase the amount of information and makes it possible to integrate schedules. Lastly other services that Thales provides towards CZSK can be added like repairs or maintenance. In order to create awareness about states in the supply chain network a SCT might not be necessary, but it does have a lot of potential.

Lastly when Thales wants to have a SCT, the SCT should be compatible with more than one customer and not only with CZSK. This research had only the collaboration between Thales and CZSK as a scope, but CZSK might differ from other customers. However, a pilot with CZSK is a good option before introducing the SCT to other customers.

6.3 Recommendations

First of all Thales should make sure that CZSK (and other customers) know(s) the differences of part types. A way to do this is with the customer portal. When a purchaser fills in the item type in the request form, it should show what type of part it is. In case of a distributor item it should recommend to order it elsewhere, in case of an other part it should ask if you are sure you need that and in case of a spare part it should not do any of those.

Secondly the opportunities of framework agreements should be investigated. With framework agreements the request for quotation can be skipped, which will save time. Also it will make it easier to manage inventory, since the time that is spend on the quotation does not have to been taken into account. This time has an unreliable length, because of the human factor and therefore is hard to forecast.

Thirdly the legal aspects of the SCT should be looked into. There is a lot of confidential information in the SCT. Who is the owner? Or can it be the case that not all information is seen by both parties? This is very important to be able to have a SCT.

Besides failure rates should be registered and feedback on these should be communicated better by CZSK. Thales might have the opportunity to make this easier for them by changing their software in the radar systems. This should be investigated.

Also Thales states that their KPI's are reliability for their on-time delivery (OTD), reliability of their lead times and the length of their lead times. Research should be done on the current states of these KPI's and how a SCT would influence them.

Lastly the processes at CZSK should be investigated. In the models in this research is already visible that it is very less detailed than the processes at Thales. When these processes are modeled as well, they can be lined up with the processes at Thales. This might show bottlenecks in the collaboration between CZSK and Thales, which are not visible in this research, but might affect the SCT.

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