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ICT in Business and the Public Sector

Analysis and characterization of the Service Control Tower concept

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MASTER'S THESIS

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Abstract

This research is of exploratory nature and provides insight into the general, core Control Tower concept and multiple related concepts. The topics of the Control Tower and the Service Control Tower concept have been receiving increasing attention over recent years. This attention is increasing especially on business sources while also on academic sources, however the academic sources are still scarce to date. Thereby, organizations are increasingly looking for ways to mature both on technology developments (such as data-driven decision-making) as on forms of collaborations within their network (interorganizational setting). This research focuses on which different Control Tower concepts exist, what their differences are and whether there are common denominators. In addition, this research will explore the new, innovative and service-oriented approach of the Service Control Tower concept and focuses on creating an artefact which consists of describing and characterizing the Service Control Tower concept based on the collected data within this research. This characterizing artefact includes figures, tools and methods to visualize these defined elements and aspects of the Service Control Tower (e.g. UML based figures, a SWOT-analysis and a Business Model Canvas). In addition, within this research there is a focus on the service logistics domain and multiple related concepts will be elaborated on.

The main research question is proposed as follows: *What does the concept of a Service Control Tower within service logistics entail and how does it contribute to business value creation?*
The main research question is addressed through five research sub-questions within this research. In addition, there are two research objectives which are stated as follows: the differences in types of Control Towers are clarified, and a concept of a Service Control Tower is developed. The overall approach of this research is Design Science Research (DSR), which consists of five steps. This research explores the different topics and concepts through an extensive literature review and additional empirical research via semi-structured, expert interviews. A total of five interviews were conducted to collect additional data.

The literature review within this research resulted in the different Control Tower types and their differences and similarities. The different Control Tower types which exist are; The Air Traffic Control Tower, later on also called a Virtual Control Tower and a Remote Control Tower. The Transportation Control Tower, Logistics Control Tower, Supply Chain Control Tower, Outsourced Control Tower and Digital Control Tower. After the different Control Tower types, this research proceeds to this new Service-Oriented Approach of a Control Tower, the Service Control Tower concept, which can be seen as a Control Tower specifically for the service logistics domain. As prior research concerning the Service Control Tower concept to date are scarce, there is still a lot unknown and the development of the Service Control Tower is still in early stages. The interviews, conducted with different experts within the service logistics and (Service) Control Tower field, are conducted to achieve more in-depth knowledge on the Service Control Tower concept, what it entails, distinguishes from the other Control Tower concepts and what for instance the drivers and barriers are to implement a Service Control Tower. Multiple elements and questions were raised to acquire additional (high-level and broad) in-depth knowledge on different aspects of the Service Control Tower concept. After acquiring knowledge from the literature review and interviews, a SWOT-analysis, Business Model Canvas and additional elements such as figures towards characterizing and describing a concept of the Service Control Tower were created, verified and validated by an additional semi-structured, expert interview.

The Service Control Tower concept is a promising concept towards organizations' digitalized future and has many opportunities to develop and mature over the years to come; due to technology developments and many organizations which are looking for more collaboration within their interorganizational setting. Furthermore, this thesis stresses that data-driven decision-making and digitalization are two factors which play a dominant role within this research and have a strong connection with the Service Control Tower concept. Through the extensive literature review where the different Control Tower concepts have been distinguished and the focus on the Service Control Tower concept, an additional knowledge base is added to the existing research publications on these concepts. This has also resulted in outcomes of this research being used for writing additional papers on the Control Tower concept(s).

Keywords: Service logistics, Technology, Data-Driven Decision-Making, Collaboration, Digitalization, Control Tower, Service Control Tower.

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Abbreviations

Abbreviation	Explanation
4-C	Cross Chain Control Centre
4PL	Fourth Party Logistics
AI	Artificial Intelligence, Autonomous Intelligence
APA	American Psychological Association
API	Application Programming Interface
ATCT	Air Traffic Control Tower
BMC	Business Model Canvas
CT	Control Tower
DDDM	Data-Driven Decision Making
DSR	Design Science Research
E.g.	Exempli gratia (for example)
ERP	Enterprise Resource Planning
GPS	Global Positioning System
ICT	Information Communication Technology
I.e.	Id est (that is or specifically)
IS	Information Systems
IT	Information Technology
IoT	Internet of Things
MARCONI	MAritime Remote CONtrol tower for service logistics Innovation
ML	Machine Learning
MSE	Manufacturing Service Ecosystem
N.d.	No date
OEM	Original Equipment Manufacturers
PaaS	Planning as a Service
RFID	Radio-Frequency Identification
SC	Supply Chain
SCCT	Supply Chain Control Tower
SCM	Supply Chain Management
SCT	Service Control Tower
SLF	Service Logistics Forum
SOP	Standard Operating Procedure
TMS	Transportation Management System
UML	Unified Modeling Language
WMS	Warehouse Management System

Glossary

Term	Definition
Boolean operators	Make it possible to combine search terms.
Data-Driven Decision-Making (DDDM)	Decisions which are based on the existing and collected data.
Information Communication Technology (ICT)	Consists of the components that enable modern computing, can be seen as an extension on IT.
Information Technology (IT)	Consists of the use of any computer to for instance store and process data and/or information.
Innovation	Applying new ideas such as technology in for instance products or services.
Intralogistics	A branch of logistics which consists of managing (logistical) flows of information and assets.
Logistics	Process of managing resources to their final destination.
Maritime sector	All activities involved in the sea / marine world, for instance manufacturing or repairing a ship.
Original Equipment Manufacturers (OEM)	A company that produces products such as (spare) parts and (original) equipment.
Services	A transaction or labour where a non-physical asset is delivered. Examples are an insurance or a phone subscription.
Service Logistics	Part of Supply Chain Management which focuses on all activities which are providing services in its most efficient ways.
Servitization	Focusing more and more on providing services for others instead of focusing on delivering solely products.
Supply Chain Management (SCM)	Managing the entire (production) flow of goods and/or services to maximize for instance quality and customer experience.

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1. Introduction

Globalization and digitalization have made it possible for organizations to operate worldwide while using for instance innovative ICT components and systems. Over the last decades, technological and ICT developments have grown extensively. According to Provost and Fawcett (2013) organizations are focusing more and more on data related concepts and technologies. In addition, Georgakopoulos and Jayaraman (2016) argue that ICT development has resulted in millions of low-cost yet powerful devices which are used for personal purpose (for instance a smart phone or wearable smart watch) or within businesses (such as an RFID tag on farm animals) to collect data in order to become more efficient.

As technology evolves rapidly worldwide, this is also the case within the fields of Supply Chain Management and Service Logistics. Technological developments are becoming more advanced and complex over the years and there are more to come (Van Houtum, 2010). In addition, data is being mentioned numerous times as an important element for the further development and improvement of service logistics (Arts, Basten, & Van Houtum, 2019; ProSeLoNext, 2021; SLF, 2021; Topsector Logistiek, 2014; Van Houtum, 2010). Therefore, data can be seen as the recurring related concept and common denominator within the ICT development in the field of service logistics.

Organizations are looking for ways to reach a competitive advantage by for instance implementing innovative ICT developments and further align and connect their systems, interfaces and collaboration within new and existing networks (Provost & Fawcett, 2013). Furthermore, recurring aspects and elements which organizations want to achieve are for instance new forms of collaboration, an overview within a complete network, more insight, transparency, visibility of data and system(s) all within the interorganizational setting they are in, working along with many different stakeholders (Hofman, 2014; Liotine, 2019; Maneengam & Udomsakdigool, 2020; Trzuskawska-Grzesińska, 2017; Vanvuchelen, Gijsbrechts, & Boute, 2020). There are elements involved such as a growing complexity within ICT, technologies and data which are increasing and developing more, while increasingly moving towards data-driven and decision-making ways of working and collaborating (ProSeLoNext, 2021; Provost & Fawcett, 2013).

Now that organizations have all this (big) data, questions arise such as how to process, control and manage this, especially within interorganizational settings? Meanwhile organizations also have to and want to collaborate more within a network of organizations, where similar questions arise such as how to control and manage all of this? These are some of the current challenges a lot of organizations are facing. Is there a new, innovative idea, concept or innovation which can facilitate in these questions?

There is a new data and technology related phenomenon which is emerging as of recent years: the Control Tower concept(s). This research is of exploratory nature and provides insight into the core Control Tower concept and multiple related concepts. A first focus is put on the general Control Tower concept and distinguishing the different Control Tower concepts. A second focus is put on the specific service-oriented approach of the Service Control Tower concept which results in creating an artefact for the Service Control Tower concept: by analysing, characterizing and visualizing this concept (e.g. by UML-based figures, a SWOT-analysis and a Business Model Canvas). In addition, there is a focus on the service logistics domain and multiple related concepts will be elaborated on throughout this research.

1.1. Problem statement

There are limited academic sources on the Control Tower topic, even more so is the case for the Service Control Tower concept and (academic) research. Therefore, Control Tower and Service Control Tower developments are still in early stages and there is a need to dive deeper into these topics. In addition, organizations are looking for innovative ways to collaborate within a network of organizations and thereby want to implement ICT solutions to support the growing complexity of collaboration and ICT. Both of these elements are addressed through research on the Control Tower and Service Control Tower topic in the domain of the maritime sector. In addition, Service Logistics is one of the main key stones and domain within this research, as the focus of the Service Control Tower is connected to the Logistics, Service Logistics and Services domain. These key stones are elaborated on further along this research.

1.2. Research context: MARCONI-project

This research will be performed partially within the MARCONI-project. MARCONI stands for MAritime Remote CONtrol tower for service logistics Innovation. The MARCONI-project consists of knowledge institutions (Technical University Eindhoven, University Twente, Maastricht University and Netherlands Defence Academy) and organizations such as Boskalis, Damen, Royal IHC, RH Marine, Thales and Royal Netherlands Navy. All of these organizations are active in the maritime sector. Gordian Logistic Experts is responsible for the project management. Figure 1 visualizes the MARCONI-project and all of the participants.

According to Dinalog (2019a) the MARCONI-project focuses on the development of service logistics control towers, in a maritime setting, in which several chain players participate. MARCONI develops decision support models for planning sailing schedules, ship maintenance and the required resources. The project addresses this control tower from a business and information management perspective (Dinalog, 2019a).

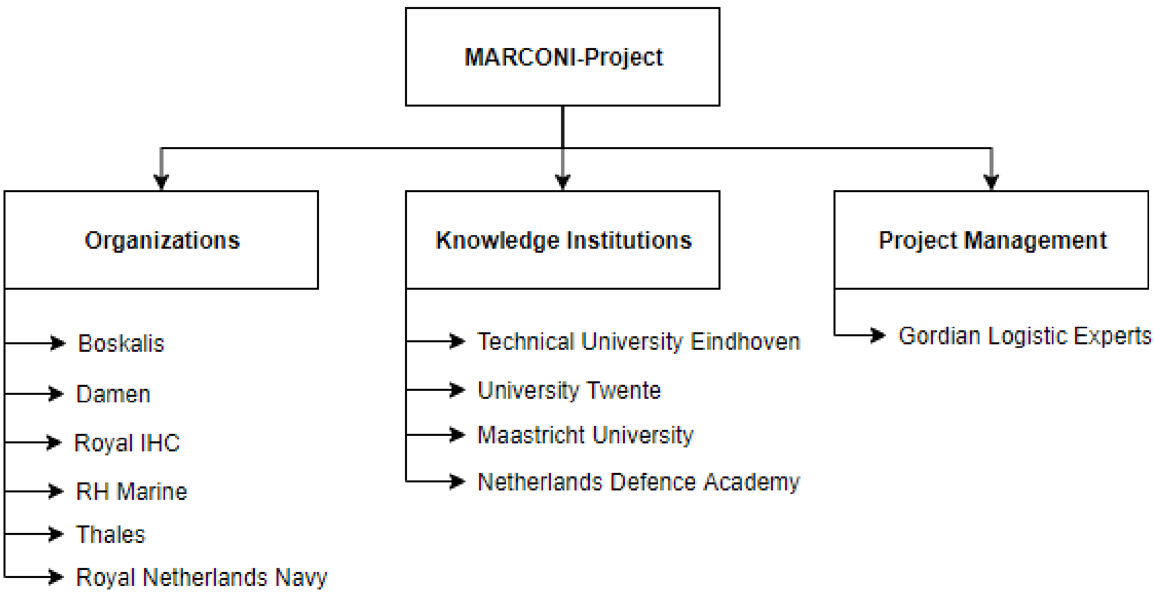

Figure 1 – MARCONI-project participants

1.3. Research gaps

The Control Tower concept has been receiving more attention over the past years, but there are still a lot of gaps which warrant further research. These four gaps are elaborated hereunder and will be researched through this thesis project.

1. The concept of Control Towers has received business attention more than academic attention so far (Accenture, 2015; Bhosle et al., 2011). Thereby, there are very few academic literature sources found which elaborate on Service Control Towers. Next to a white paper (CQM, 2019) and multiple students theses on Service Control Tower, to date there is only one academic source on the Service Control Tower (Topan, Eruguz, Ma, van der Heijden, & Dekker, 2020), (i.e. academic sources are lagging behind on business sources).
2. There is a knowledge gap regarding Control Towers in their possible configurations and future. Companies tend to use Control Towers in different circumstances and with different functions (Trzuskawska-Grzesińska, 2017). Moreover, different names and types of Control Towers are used in literature, where a clear distinction is missing (i.e. an overview of the problem).
3. According to Rustenburg (2016) the term “control tower” is somewhat abstract in nature. A Control Tower consists of IT related systems for the largest part. However, there are more requirements which need to be in place besides the technology, such as organizational sides, processes and the right (trained) people (Bhosle et al., 2011). Furthermore, CQM (2019) stated that the organizational and social level developments should also be considered. Interdependence between both the Information Communication Technology (ICT) and the business value and components are of interest for this research, to encompass a multidimensional view.
4. There is an ambiguity concerning the concept of Service Control Towers. Topan et al. (2020) state the definition and capabilities of Service Control Towers are still evolving in time.

Research goal: Therefore, through this research the Control Tower and related concepts will be extensively researched, after which the Service Control Tower will be researched which will include developing an artefact, by describing and characterizing the Service Control Tower concept. This research will be conducted through an extensive literature review and additional empirical research via semi-structured, expert interviews.

1.4. Research questions

In order to address the research gaps which are described in the previous section, a main research question is proposed:

What does the concept of a Service Control Tower within service logistics entail and how does it contribute to business value creation?

The main research question is addressed through five research sub-questions.

1. Which different Control Tower concepts exist and what are the differences? *[Conceptual RQ]*
2. How is the Service Control Tower concept perceived by various stakeholders? *[Empirical RQ]*
3. What are the drivers and barriers to implement a Service Control Tower perceived by various stakeholders? *[Empirical RQ]*
4. How can the concept of a Service Control Tower be characterized? [*Design RQ*]
5. How can the Services within the Service Control Tower be adapted and evaluated? [*Conceptual RQ*]

1.5. Research objectives

The purpose of this research is to identify the different Control Towers and related concepts, develop and characterize the Service Control Tower concept. The environment and scope of this thesis consists partially of the MARCONI-project, service logistics and the maritime sector.
The formulated research questions align with the following research objectives:

- The differences in types of Control Tower concepts are clarified.
    - Answering sub-question 1 (RQ1).
    - Addresses research gap 2.
- A concept of a Service Control Tower is developed.
    - Consisting of the stakeholder perception of the Service Control Tower concept, the specific characteristics (factors, variables and/or elements), possible drivers, barriers and future developments. The data will be collected from literature review and interviews.
    - Answering sub-questions 2 to 5 (RQ2 – RQ5).
    - Verify and validate the concept with an additional interview and literature review.
    - Addresses research gap 1, 3 and 4.

1.6. Research methodology approach

The overall context of the study evolves around the general Control Tower concept and further along the focus of the thesis zooms into the specific Service Control Tower concept creation. Furthermore, the research field of this research consists of two elements, namely service logistics and the maritime sector. In Figure 2Figure 2 – Research methodology approach the chosen research methods for this research are shown accompanied by the research sub-questions and deliverables.

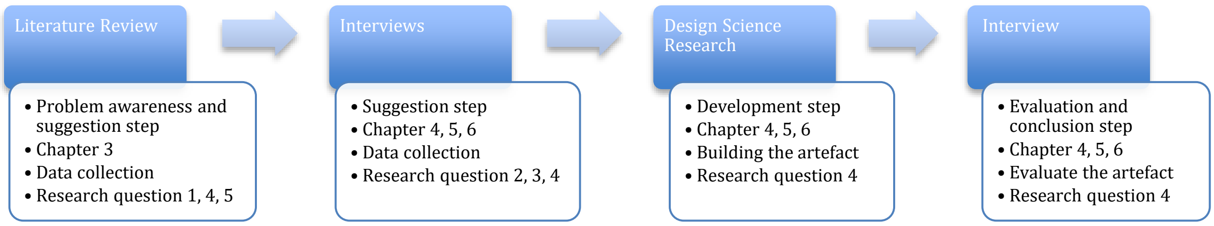

Figure 2 – Research methodology approach

Therefore, this research will start by collecting data through an extensive literature review, followed by interviews, the Design Science Research approach and an additional final interview for building and evaluating.

The overall approach of this research is Design Science Research (DSR) (Hevner, March, Park, & Ram, 2004), which consists of five steps in the process model, each of these steps are elaborated on further in Chapter 2 of this thesis. The first and fifth research sub-question are answered via an extensive literature review. The second, third and (partially) fourth sub-questions are answered via interviews. In addition, the artefact is built, which is based on the collected data from literature and interviews. The artefact will consist of describing and characterizing the Service Control Tower concept, by including figures and applying tools and methods to visualize these aspects of the Service Control Tower (e.g. a SWOT-analysis and a Business Model Canvas). The last step is the evaluation (i.e. verifying and validating) of the artefact which is being done by an additional interview combined with literature review outcome. Furthermore, Chapter 2 elaborates on each selected research method, how the data was collected and analysed throughout this research.

1.7. Structure of thesis

In Figure 3 the chapters of this thesis are outlined including a briefly description of what each chapter contains.

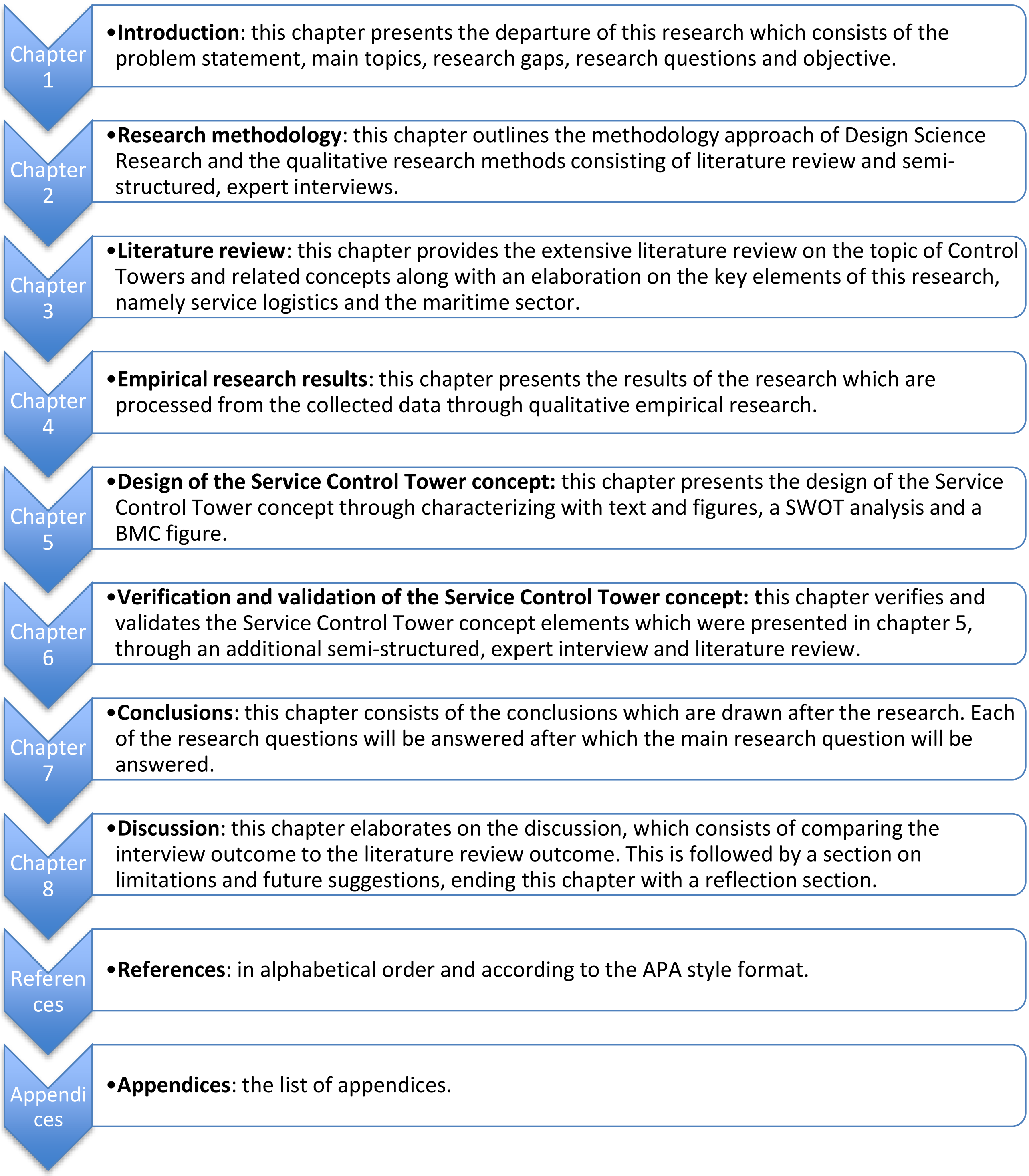

Figure 3 – Structure of the thesis

2. Research Methodology

This chapter consists of an elaboration of the research methods which were applied throughout this research. First, the overall research approach for this study is explained. Second, an explanation is given how Design Science Research, the main approach for answering the research question and for developing the concept of a Service Control Tower, was applied. Third, the data collection methods and steps are elaborated on. Fourth, the data analysis steps that were taken are explained. This chapter closes with a final section on the reliability and validity of this research.

2.1. Research approach

In order to study the Service Control Tower concept and answer the research question, an exploratory research strategy was adopted. Thereby, this research obtained knowledge on a topic which has not been well-studied within the existing academic literature. Due to the exploratory nature and limited academic literature, a theory-supported, qualitative and inductive approach was selected for this research. The qualitative research approach, in general, consists of collecting and analysing mostly first-hand observations (e.g., via interviews or focus groups) in the form of words (non-numerical) such as text or video to gain knowledge for research (Sekaran & Bougie, 2016). Inductive reasoning consists of generating a theory; it is often applied by using qualitative methods (Sekaran & Bougie, 2016). In addition, exploratory research often relies on an qualitative approach (Sekaran & Bougie, 2016). Moreover, they state that an inductive reasoning is commonly chosen when there is limited literature on a specific topic and while selecting a qualitative approach.

The goal of this research was to gain knowledge from the literature that was available, combined with gaining additional in-depth insights through exploratory interviews with various stakeholders (both from within the MARCONI-project as other organizations). The literature that was used in this research provided direction for the empirical research. The empirical research of this thesis was based on semi-structured and expert interviews. In addition, the Design Science Research approach was subsequently applied to build an artefact which consists of describing and characterizing the Service Control Tower concept and evaluate (verify and validate) the artefact through a final interview and literature review.

Table 1 presents an overview of the applied research method for each research sub-question.

Number	Research sub-question	Method(s)
RQ1	Which different Control Tower concepts exist and what are the differences?	Literature Review
RQ2	How is the Service Control Tower concept perceived by various stakeholders?	Interviews
RQ3	What are the drivers and barriers to implement a Service Control Tower perceived by various stakeholders?	Interviews
RQ4	How can the concept of a Service Control Tower be characterized?	Design Science Research, Interviews, Literature Review
RQ5	How can the Services within the Service Control Tower be adapted and evaluated?	Literature Review

Table 1 – Research sub-questions and methods

2.2. Design Science Research

Activities that have to do with design and artefacts have been around for centuries, while the Design Science Research approach (DSR) has been elaborated on as of a few decades. According to Hevner et al. (2004) DSR is initiated to gain knowledge that focuses on the creation and evaluation of new artefacts such as an algorithm, a framework or a concept to solve the identified problem. DSR is fundamentally a problem-solving paradigm, combining knowledge and theory with a practical and often innovative element which is created through an artefact (Hevner et al., 2004).

In addition, Vaishnavi and Kuechler (2004) describe a DSR process model with the following five steps:

1. Awareness of the problem

Contains the start of the research, for instance a problem which needs to be solved including the criteria for evaluating the design. This step has an output in the form of a proposal.

2. Suggestion

Seen as the creative step, where innovative ideas are envisioned and can lead to a Tentative design.

3. Development

This step contains a further development of the tentative design and creating the artefact, where the activities and output may vary because of the different possible nature of the artefact (e.g., an algorithm, concept or model).

4. Evaluation

The evaluation step follows after the artefact is created, where for instance the (acceptance) criteria from the first step are evaluated.

5. Conclusion

This last step contains the end of a research cycle and within this step documenting the obtained knowledge is being done. Researches may follow multiple cycles or go back and forth between the steps in the research process.

Within this research the DSR approach as stated by Vaishnavi and Kuechler (2004) was followed, and thereby applied via the cycle as proposed by Van der Merwe, Gerber, and Smuts (2017). In addition, Van der Merwe et al. (2017) argue a DSR process model which is specifically applied to Postgraduate research reports such as student theses. Thereby, Van der Merwe et al. (2017) base their DSR process model on earlier work of Hevner et al. (2004) and Vaishnavi and Kuechler (2004) among others. According to Van der Merwe et al. (2017) there are multiple scenarios of following the DSR cycles possible, varying from for instance one cycle of design to multiple cycles of design. They argue that the first scenario with one cycle of design contains eight mapping steps to form a research report structure. In addition, they imply that this first scenario is often chosen by students at Master's degree level involved in creating an artefact with a single or a few functions or components (Van der Merwe et al., 2017). This scenario is indicated in Figure 4.

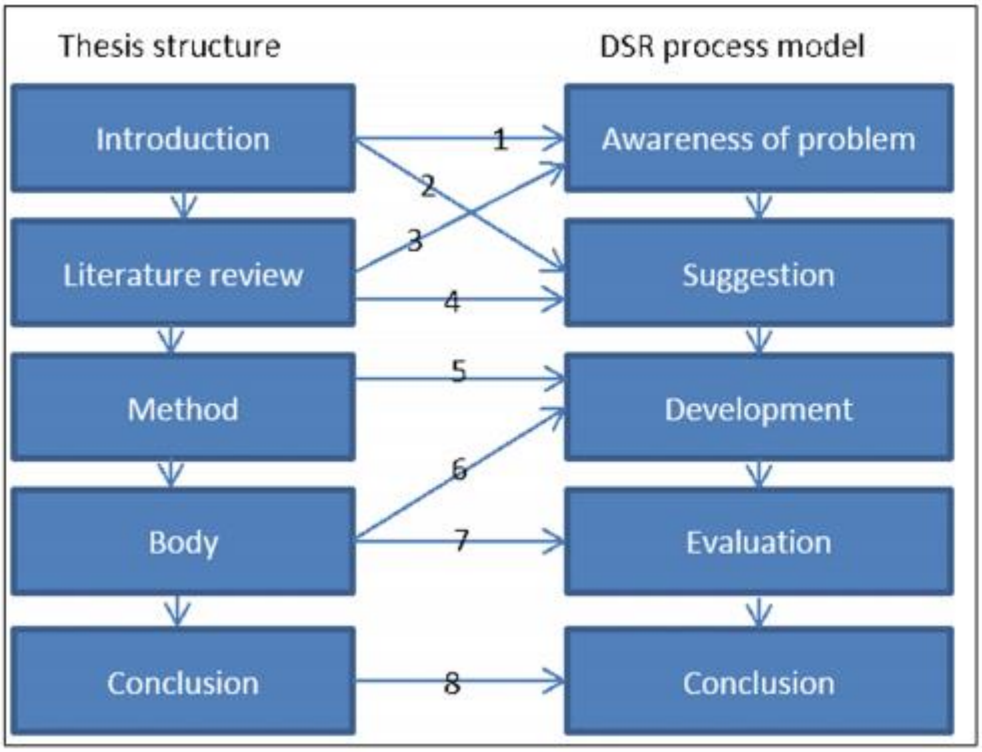

Figure 4 – Mapping for One Cycle of Design (Van der Merwe et al., 2017, p. 301)

In Figure 4, the thesis structure is visualized on the left and the DSR process model on the right side of the figure (Vaishnavi & Kuechler, 2004; Van der Merwe et al., 2017), all of these aspects have been applied within this research.

2.2.1. DSR applied in the context of this research

DSR addresses research through building and evaluating artefacts, with the creation of practical and academic designs which also contribute to the knowledge base (Hevner et al., 2004). In this research there was a strong connection with innovation fields such as IT, Information Systems (IS) and an organizational setting. Thereby, this research focused on building a specific artefact: characterizing the concept of a Service Control Tower and visualization thereof by e.g. UML based figures, a SWOT analysis and a Business Model Canvas. Building an artefact consists of evaluating the design within the research process as well. Evaluation was done through an additional expert interview. Thereby, the DSR approach of Vaishnavi and Kuechler (2004) combined with the mapping structure of Van der Merwe et al. (2017) was applied within this research.

2.3. Data collection

Within this research, data collection took place through two main research methods, namely literature review and interviews. In this research, literature review was applied from the start of the research until the final stage. Interviews have been conducted after the first stages of literature review, to support and add on the existing knowledge base provided by the literature review. For each of the data collection method, the followed steps are elaborated on.

2.3.1. Literature Review

Literature review can ensure the researcher to build on existing knowledge, prevent reinventing the wheel, introduce relevant terminology, give insights in possible research methods that others have used and relate your findings to the findings of others (Sekaran & Bougie, 2016). Within this research, literature review was conducted to gain an understanding of previous research on the research areas, history, terminology, related concepts and technologies.

During the start of this research (i.e. October 2020 to February 2021), there was a workgroup (WP2) within the MARCONI-project involved in researching the Control Tower concept and related concepts. The author of this thesis had been given the opportunity to participate within this workgroup and was able to perform research activities along with them. These research activities consisted mostly of (virtual) discussions about the different related topics and literature reviews, divided into different tasks and over a period of multiple months.

According to Sekaran and Bougie (2016) there are four steps to conducting literature review:

1. Identify the different data sources.
2. Search for the sources.
3. Evaluate the sources.
4. Document the literature review.

These steps for conducting the literature review were executed as follows. The data sources used in the literature review were gathered from multiple online databases: Google, Google Scholar, the Leiden University Library, ResearchGate, Elsevier and ScienceDirect. Multiple data sources were selected such as textbooks, journal and white papers, theses and the public domain on the internet. The key elements within this research were within the fields of Service Logistics, Maritime Sector, ICT development and Control Tower concepts. Therefore, several main keywords searches have been used, such as “Service Logistics”, “Maritime Sector”, “Control Tower” and “Service Control Tower”. These keywords were adjusted according to Boolean operators, combined with one another or with other terms such as “history”, “types”, “development” and “characteristics”.

Evaluating the literature was done by first reading the title, abstract and introduction of the source. Selection criteria used were the language of the article (English or Dutch), the number of citations and a preference for peer reviewed sources. Thereby, both academic sources and grey literature sources were selected from several consulting firms and businesses. Even though these sources are not scientific, including them in the literature review was of value as the academic sources on the Control Tower topic are yet scarce. In addition to the Literature Review and sources that were found, some of the authors of the sources were approached for more information and a short discussion on the topic of the Service Control Tower concept. Furthermore, the snowball method was applied to find more relevant sources within the reference list of the previously found papers at the start of the literature review.

2.3.2. Interviews

Interviews were chosen as a primary data collection method for this research. Interviews are a popular research method and allow the researcher to collect data from human respondents, mostly via a guided conversation between people (Sekaran & Bougie, 2016). There are three types of common interview approaches, namely unstructured, semi-structured and structured interviews. Semi-structured interviews are partially predetermined with questions, which leaves room for asking in-depth questions while the conversation is taking place. Semi-structured interviews combines the structured and unstructured interview approaches (Sekaran & Bougie, 2016).

For this research a qualitative approach through semi-structured exploratory interviews is chosen as this enables the interviewees to elaborate on their answers more extensively. Thereby, the interviewer(s) have room to ask in-depth questions to further explore certain answers during the interview. In addition, the interviewee can share their story and experience. An interview protocol (see Appendix F and Appendix G) was created before the interviews took place and adjusted slightly after interviews were conducted. Every interview followed certain main questions while also leaving room for further in-depth questions.

Three initial interviews were conducted with multiple stakeholders from the MARCONI-project. In addition to the initial three interviews, additional expert interviews with interviewees from other organizations have been prepared. To conclude, one additional expert interview was conducted to verify and validate the artefact that was designed (which was verified and validated by an interview in addition to literature review). The interviews were conducted between October 2020 and August of 2021. Table 2 provides an overview of the conducted interviews and dates. The interviews were of exploratory nature.

Thereby, the goals of the interviews were to get an overview of how the interviewees perceive the Service Control Tower concept and what it entails, for instance what they see as advantages and disadvantages and what would be necessary to set-up a Service Control Tower. The interviews started with an introduction which consisted of a personal introduction and short background of every attending interviewer and interviewee. Thereby, consent for an audio recording of the interviews was requested. After that, the interview protocol was followed and in-depth questions were asked. The interviews were conducted in English or Dutch via Microsoft Teams, an online tool for videoconferences. Furthermore, the interviews each had a duration of approximately 60 minutes. At the end of each interview, participants were asked if there was missing important information or questions, or if they had an addition from their view. Table 2 provides an overview of the conducted interviews including the date of the interview.

Interviewee	Date
Interviewee A	01-10-2020
Interviewee B	13-11-2020
Interviewee C	23-11-2020
Interviewee D	03-06-2021
Interviewee E	31-08-2021

Table 2 – Overview of interviews and dates

2.4. Data analysis

After the collection of the data, the data analysis follows. Data analysis steps and tools were elaborated per research method. This section therefore starts with the data analysis steps of the literature review, followed by the interviews.

2.4.1. Literature review

The fourth step of conducting the literature review is documenting the literature review. Documenting the literature was supported by using the EndNote X9 tool, which can be used for managing references. This tool has been used throughout the research to keep track of all the used literature sources, store and categorize the documents, to take notes and to maintain a clear overview of the literature review. In addition, the tool provides an automated form of creating references such as in the APA style format.

A literature review can serve as the foundation for a research, for instance to identify relevant concepts, themes and significant findings (Sekaran & Bougie, 2016). In this research, from initial keywords and literature sources, additional sources were found and collected based on defined themes for the literature review. As a result, a total of 68 sources were used in this research, divided into three main themes, namely "Service Logistics", "Control Tower" and "Service Control Tower". These main themes were further divided into sub-themes and subsections in Chapter 3 of this thesis.

Table 3 provides an overview of the main themes, chapter sections and the total number of articles per section.

Theme or sub-theme (category)	Chapter	Articles
Service Logistics	2.1	21
Control Tower	2.2	39
Service Control Tower	2.3	8
Total		68

Table 3 – Articles per theme

The complete list of references which were used throughout this research, are listed in alphabetical order in the References section of this thesis.

2.4.2. Interviews

After the collection of the data, the data analysis of the interviews followed. First, the interviews were transcribed manually. Second, the interviews were analysed individually by following general steps in qualitative data analysis. According to Sekaran and Bougie (2016) qualitative data analysis is less established concerning accepted steps and guidelines in comparison to quantitative analysis. However, there is a general approach of analysing qualitative data where three general steps are followed: data reduction, data display and drawing conclusions. This approach by Sekaran and Bougie (2016) is largely based on the work of Miles and Huberman (1994). In addition, Sekaran and Bougie (2016) imply that qualitative data analysis is a continuous iterative process as opposed to a linear step-by-step approach, for instance while drawing conclusions the researcher may step back to revise the raw data for categorising or data display.

The data analysis process was executed by following the steps described by Sekaran and Bougie (2016) and Miles and Huberman (1994):

1. Data reduction is the first step of processing the transcribed interview data, whereby coding and categorising the data is being done. In the coding process the gathered interview data is reduced and rearranged to form into theory, which provides help to be able to draw conclusions about the data. Coding can be done with a variety of coding levels and units, such as words, sentences and themes. The interviews have been coded by reducing the data into categories and subcategories as this provides more manageable data. This step has resulted in going back and forth iteratively to refine and revise the raw data and categories. The interviews were transcribed in a Word-document, after which the coding and categorizing is processed in an Excel-document.
2. Data display contains the visualisation of the data, for instance via quotes, graphs or charts in an organised means. The interviews have been displayed via graphs, tables and quotes such as mentioned phrases have been outlined for each subsection and research sub-question.
3. Drawing conclusions is the last step in the data analysis process. This step is the concluding part where the researcher is able to answer the research questions.

The complete transcribed interviews can be found in Appendices A to D. The Interview data analysis, reduction, coding and categorizing can be found in Appendix E. In addition, data display and drawing conclusions can be found in the upcoming chapters of this thesis.

2.5. Reliability and validity

Assuring research quality and objectivity are reached via reliability and validity, in this research context more specifically within qualitative research. According to Sekaran and Bougie (2016) validity consists of internal and external validity. They argue that internal validity refers to the extent a research represents the collected data accurately, whereas external validity refers to whether or not a research can be generalized in other contexts. In essence, validity guarantees that research measures what it claims to measure.

Validity has been achieved by the following considerations. After permission was requested from the interviewee(s), the audio of the interviews was recorded. The interviews were manually transcribed. All of the interviews had a similar environment, namely via the Microsoft Teams videoconference tool and each interview had a duration of approximately 60 minutes. An interview protocol was created and used as a guideline for the interviews. During the semi-structured interviews, in-depth questions were asked to clarify the answers from the interviewees. In order to further assure the validity, the transcribed interviews are added in the appendices as well as the data analysis and the interview protocol thereof.

Thereby, Sekaran and Bougie (2016) imply that reliability consists of two components: category and interjudge reliability. They argue that category reliability relates to being able to use category definitions to classify the qualitative data. Moreover, interjudge reliability consists of the degree of consistency of the coding of the (same) data and the agreement rates thereof (Sekaran & Bougie, 2016). An in-depth description of the research project can support in assuring the validity and reliability.

Reliability has been achieved by describing, documenting and following the same steps per research method. Thereby, all of the research steps were followed by the guidelines of the chosen methods and sources (Sekaran & Bougie, 2016; Vaishnavi & Kuechler, 2004; Van der Merwe et al., 2017).

The reliability is assured by documenting the collected and analysed data and adding appendices. The interviews are provided in the Appendices A to D, the interview protocol is added in Appendix F. Interview answers were verified during the interviews to increase consistency. Based on the Methodology chapter and added appendices, this research can be replicated by other researchers. Each of the steps taken during this research can be found in this thesis and the added appendices.

3. Literature Review

This chapter provides the theoretical background of this research. First, in section 3.1., the concept of service logistics, the challenges and trends of it in the maritime sector, ICT development and data-driven decision-making will be outlined. Second, in section 3.2., the Control Tower and related concepts such as the different types of Control Tower concepts and other technologies which are combined within Control Towers are researched in order to obtain a thorough review of what knowledge is already established thus far. Section 3.3. starts with an elaboration on the Service Control Tower concept and findings thereof in the existing literature. This chapter closes by summarizing several conclusions which are taken from the literature review.

3.1. Service Logistics

In the existing literature a variety of definitions of the term service logistics is available. Eruguz, Tan, and Van Houtum (2017) define service logistics as the after-sales logistics activities which are needed for assets to keep functioning properly and to be maintained during their life time. In line with the definition of Eruguz et al. (2017), the Topsector Logistiek (2014) defines service logistics as the logistical management from the after-sales service to the end of the life cycle of a product. The Service Logistics Forum (SLF) defines service logistics more extensive as the steering part of the service chain, where the service chain contains all the offered elements such as services for maintenance or repair, from purchase to end of life (SLF, 2021). They argue that the logistics component ensures that all of the elements are available on time and arrive at the right place at the right time. Furthermore they conclude that the orchestration of both the service chain and logistics elements combined are the domain of service logistics. Figure 5**Fout! Verwijzingsbron niet gevonden.** provides a visualization of the service logistics domain.

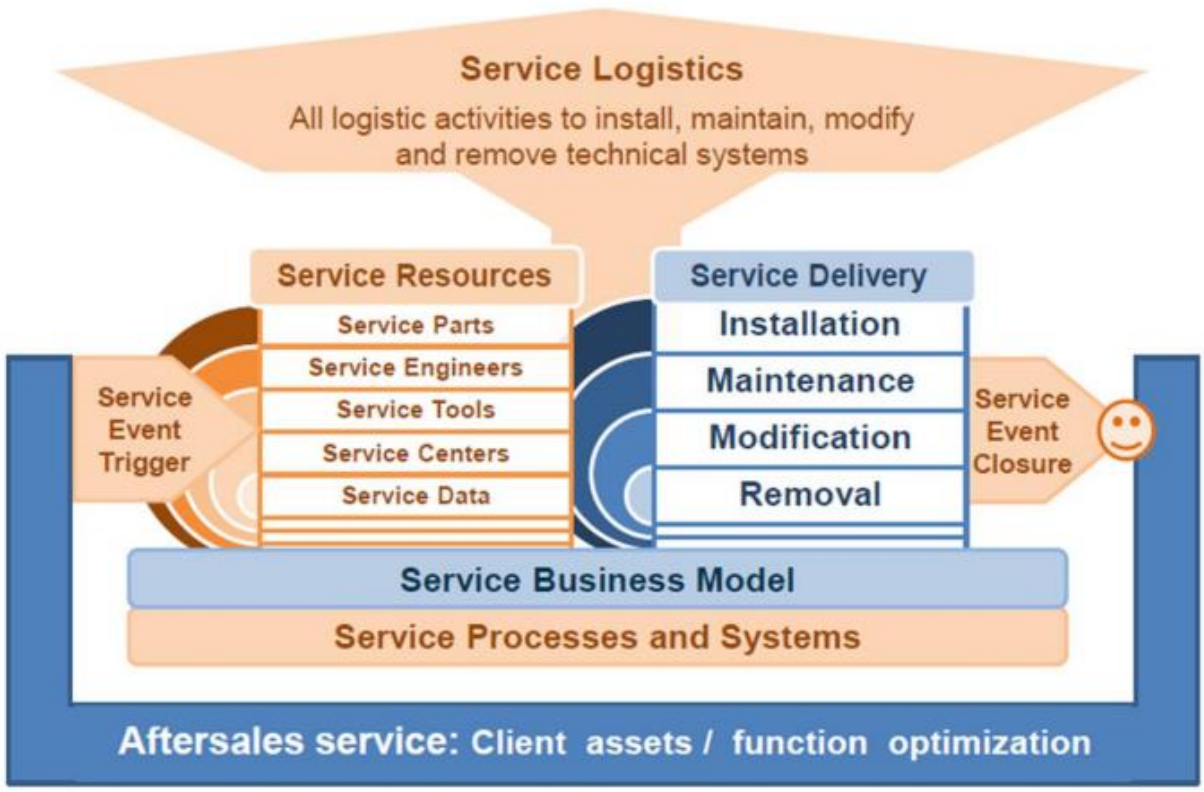

Figure 5 – Service Logistics domain (Gordian, 2015)

Moreover, Dinalog (2019b) refers to service logistics as the strengthening of logistics-related services. The SLF, Topsector Logistiek (Logistics) and Dinalog are well-known Dutch organizations who operate in the (service) logistics field, collaborate with one another and enable research (projects) within the fields of (service) logistics. For the context of this research, the proposed service logistics definition provided by the SLF will be used in this thesis.

Service logistics is also being converged with the maintenance domain in the existing literature. According to Eruguz et al. (2017) maintenance and service logistics management can be combined in order to ensure high availability and reliability during the life time of an asset. An asset could be any kind of resource owned by a person or organization. Similar to this definition, Arts et al. (2019) propose maintenance service logistics in a small sense to all processes for resources' maintenance being at the right place at the right time. In a broad sense they include maintenance processes in order for maintenance to be easier and less costly.

The Topsector Logistiek (2014) state that service logistics connects flows of information to flows of capital goods. Furthermore they propose the following examples of service logistics: maintaining, supplying and reusing assets such as an aircraft or production machine.

3.1.1. Service Logistics within the Maritime Sector

The maritime sector is one of the seven major emerging industries and encompasses companies that are engaged in activities such as: designing, constructing, manufacturing, supplying, repairing, maintaining or operating marine systems (Monfardini, Probst, Szenci, Cambier, & Frideres, 2012).

According to Eruguz et al. (2017) the maritime sector consists of the following main characteristics:

- Multi-actor setting: the network involves multiple stakeholders, for instance an asset owner, an OEM and a (logistics) service provider.
- Maritime assets entail multiple characteristics: system specific spare parts (e.g., obsolescence), multi-indenture systems (e.g., a collection of technical systems), mandatory surveys (e.g., dry-dock surveys), moving assets (e.g., remote and moving locations) and long life-cycles of up to 25 years.
- Multi-echelon structures: e.g. (spare) parts can be held at many different stakeholders and locations such as a vessel, asset owner or OEM.
- Small amount of failure-related data: e.g., limited data due to a small number of similar systems.
- Economic dependency: notable scale effects in maintenance set-up.

Moreover, Eruguz et al. (2017) argue an extensive state-of-the-art, lessons learned and future research directions for each main characteristic from the list hereabove.

3.1.2. Challenges and trends within Service Logistics

Services and service logistics have developed over time and there have been shifts in ways of working and offering solutions. Thereby, the Committee Van Laarhoven (2009) imply that organizations now tend to deliver service concepts more often over products. In line with the Committee Van Laarhoven (2009), Oliva and Kallenberg (2003) state that while organizations are providing services, they are also able to earn more money than by solely offering products, as there are higher margins involved and services tend to have long life cycles. They argue that at the same time, customers are demanding more services. This transition from products to services in order to gain customer value is described as servitization (Oliva & Kallenberg, 2003; Vandermerwe & Rada, 1988).

The concept of servitization was coined in 1988 by Vandermerwe and Rada (1988), who state it is occurring on a global scale in many industries. In addition, Opresnik and Taisch (2015) argue that servitization differs significantly from decades ago and indicates technology as the main driver behind this; they state that technological innovations have made it possible to enable (big) data to be collected via these offered services which has led to combining servitization with ICT development.

In addition, Opresnik and Taisch (2015) state that servitized supply chains require significant collaboration within a network for an increased competitive advantage and that this can be facilitated by ICT. They propose the term Manufacturing Service Ecosystem (MSE) to represent an organized collaboration within servitization. Moreover, they imply that there are opportunities due to the amount of data that has become available through the servitization within MSE environments and value creation could be obtained. In line with Opresnik and Taisch (2015), Kohtamäki, Parida, Patel, and Gebauer (2020) state that on the topic of servitization combined with technological innovations, a new concept has arisen: digital servitization. They argue that digital servitization is shifting organizations towards IoT, smart concepts and improved decision-making.

Service logistics and (digital) servitization both have a lot to do with services in general and with the use of ICT facilitating these processes. Services are transactions of no physical goods, which are transferred from the seller to the buyer and which can consist of organizations or separate consumers. Within the concept of digital servitization, there are processes involved which leads organizations to shift from product-centric to a service-centric business model and logic (Kowalkowski, Gebauer, Kamp, & Parry, 2017). So far, organizations seem to benefit financially by moving towards for instance selling services in addition to solely producing or selling products (Crozet & Milet, 2017).

In addition, increasingly moving towards digital servitization, digitalization and focusing more and more on services, is providing value creation for organizations, which are therefore adopting new strategies, business models and implementing technology-driven concepts such as data analytics and remote activities within their organizations (Kohtamäki et al., 2020; Sklyar, Kowalkowski, Tronvoll, & Sörhammar, 2019). Furthermore, depending on the type of organization (whether or not they are already tech-savvy for instance) and their products, services and collaboration forms, it can be challenging transforming towards digitalization and digital servitization (Sklyar et al., 2019). The concept of servitization often encompasses digital technologies such as IoT and remote monitoring, thereby digitalization enables innovative services and business models (Kohtamäki et al., 2020; Opresnik & Taisch, 2015).

Several studies elaborate on the topics of (digital) servitization, digitalization, collaboration and their interconnections (Kohtamäki et al., 2020; Kowalkowski et al., 2017; Lerch & Gotsch, 2015; Sklyar et al., 2019). To summarize on this subsection in short, services, service logistics, processes, digitalization and (digital) servitization all have significant connections with each other. Services, more specifically within the Service Control Tower concept, is further elaborated in the upcoming subsections of this chapter.

In this subsection a continuation of the challenges and trends within service logistics will be elaborated on further, on the following pages.

When looking in to the research areas and focus of Dutch logistics organizations (SLF, Topsector Logistiek and Dinalog), the following trends and challenges are mentioned. According to the SLF (2021) development within service logistics entails for instance around collecting data concerning the availability of spare parts. They argue that concepts such as corrective maintenance, in the future, will develop even more efficiently into predictive maintenance. According to the Topsector Logistiek (2014) the availability of goods and preventing waiting time is of the essence. They imply that using big data to predict maintenance and improve service logistic demand will lead to more sustainability (less emission) and longer life cycles. Furthermore the research areas of Dinalog (2019b) mainly focus on data related concepts and development as important pillars of (service) logistics research.

There are current challenges for organizations to focus on within the service logistics domain. Within the maritime sector, service logistics contains a significant portion of the overall costs on the one hand, while on the other hand (unexpected) downtimes of assets can lead to great loss of revenues (Eruguz et al., 2017; Van Houtum, 2010). Therefore they argue the availability of assets is an important factor within service logistics. This is not only the case for the maritime sector and assets, but for all capital goods in general as it is a major industry in itself (Van Houtum, 2010).

In line with (Eruguz et al., 2017; Van Houtum, 2010), Arts et al. (2019) also imply that the availability of assets is of great importance, furthermore a long downtime of an asset needs to be prevented to keep overall costs low and gain customer satisfaction. Moreover, they propose that within service logistics many different resources are necessary such as: (spare) parts, service engineers, tools, a service network or service supply chain, and a user network or Original Equipment Manufacturer (OEM) network. They imply that there are many different services possible for assets, which can be agreed upon within a service contract. In addition, Eruguz et al. (2017) state system integrators, asset owners and service providers as supplementary resources within service logistics.

The Committee Van Laarhoven is a workgroup which consists of logistical experts and has been initiated to enforce innovative initiatives. According to the Committee Van Laarhoven (2009) the service logistics domain is also moving into new developments and innovative ICT solutions as these can lead to The Netherlands being a more interesting country to invest in while also contributing to sustainability and reducing emissions and energy consumption. They argue that organizations tend to invest in these market movements. At the same time customers are also demanding service in terms of elements such as sustainability, availability and reliability of assets and systems.

In line with the Committee Van Laarhoven (2009), ProSeLoNext (2021) implies that the vision of the future is to act more on sustainability, reducing emissions and minimize resource consumption.
They conclude that there will be a large focus on data in all sorts of forms while also enabling servitization, collaboration and improvement of for instance monitoring, smart maintenance, predictions together with the use of technologies such as big data, Artificial Intelligence, 3D printing and Machine Learning (ProSeLoNext, 2021).

3.1.3. ICT development in Service Logistics

Over the last decades, technological and ICT developments have grown extensively. According to Provost and Fawcett (2013) organizations are focusing more and more on data related concepts and technologies. In addition, Georgakopoulos and Jayaraman (2016) argue that ICT development has resulted in millions of low-cost yet powerful devices which are used for personal purpose (for instance a smart phone or wearable smart watch) or within businesses (such as an RFID tag on farm animals) to collect data in order to become more efficient.

As technology evolves rapidly worldwide, this is also the case within the fields of SCM and (Service) Logistics. Technological developments are becoming more advanced and complex over the years and there are more to come (Van Houtum, 2010). In addition, Arts et al. (2019) conclude that the developments in ICT enable collection of all sorts of data in one place or even in the cloud.

When zooming in on the technological developments within service logistics in specific, the following list can be disseminated:

- Additive manufacturing (also known as 3-D printing) is being seen as a promising technology to reduce stock while being able to produce necessary parts at the moment they are needed (Arts et al., 2019).
- Smart concepts are rising amongst technological innovations. The Topsector Logistiek (2014) mentions smart software such as plug-and-play-tools. The ProSeLoNext (2021) project elaborates on multiple smart concepts and the use of data as ways to improve service logistics, for example by being able to improve maintenance planning or predictive maintenance. In line with ProSeLoNext (2021), the SLF (2021) mentions smart services, which in combination with IoT devices can result in a lot of big data to be produced to further improve services as a result. A lot of these technological solutions evolve around the data that is collected by the usage, which can be used for data analysis as well (Georgakopoulos & Jayaraman, 2016; Opresnik & Taisch, 2015).
- Big data is being transformed into predictions and advice, could improve predictability of maintenance/repairs, requests of service logistics, combining big data with human decision makers and servitization (Opresnik & Taisch, 2015; ProSeLoNext, 2021; Topsector Logistiek, 2014).
- Developments in sensor technology for enabling more data to be collected at low costs and collecting data in general in one place are growing concepts within service logistics (Arts et al., 2019).

Data is being mentioned numerous times as an important element for the further development and improvement of service logistics (Arts et al., 2019; ProSeLoNext, 2021; SLF, 2021; Topsector Logistiek, 2014; Van Houtum, 2010). Therefore, data can be seen as the recurring related concept and common denominator within the ICT development in the field of service logistics.

According to Provost and Fawcett (2013) organizations are increasingly using data and data enabling technologies (e.g. big data, datamining, data analytics thinking and algorithms) for competitive advantage. In addition, Georgakopoulos and Jayaraman (2016) argue that IoT is drastically enabling data collection and enabling developments such as IoT services and IoT platforms for further use of data-driven concepts. As a result, complete data science teams have been introduced and are growing within organizations over the last several years (ProSeLoNext, 2021). The ultimate goal for data science can be seen as improving decision-making through the principles, process, techniques, analysis, extracting, etc. of data (Provost & Fawcett, 2013). These developments and concepts around data and data science lead to the data-driven decision-making concept.

3.1.4. Data-driven decision-making development

Data-driven decision-making (DDDM) involves making decisions that are based on collected data rather than decisions that are based solely on (human) intuition (Provost & Fawcett, 2013). In general decisions are made at three distinguished levels: strategic, tactical and operational levels. As organizations are increasingly doing more with (collecting and analysing/using) data which results in DDDM, benefits have been measured and shown as well. Organizations which are actively applying DDDM are more productive and there are correlations with higher market value and return on assets (Provost & Fawcett, 2013).

There are many examples of DDDM in business practice. Provost and Fawcett (2013) state that large organizations such as Amazon and Netflix have automated recommendations generated for its customers, based on the collected existing data from customers. In addition, Georgakopoulos and Jayaraman (2016) argue that for instance smart manufacturing development has resulted in improved productivity as from all the different elements data is collected and processed into decision-making.

In the previous section of this chapter smart concepts, IoT, sensor technology and big data have already been mentioned as data-related concepts which are being used and combined within service logistics. These concepts are known to be applied within decision-making processes as well. Moreover, concepts such as big data, data science and DDDM are increasingly being intertwined and applied within organizations (Provost & Fawcett, 2013).

In addition, ProSeLoNext (2021) imply that technologies such as Machine Learning (ML) and Artificial Intelligence (AI) are mentioned as examples of being able to transform big data. They argue that these technologies also enable decision-making going to a next level by still learning from human input while at the same time improving existing algorithms. DDDM has hereby grown into a concept which also applies the convergence of multiple technologies. Business performance can be improved significantly by applying DDDM, big data and data science (Provost & Fawcett, 2013).

In addition to these concepts, there is a new data and technology related phenomenon which is emerging: the Control Tower.

3.2. Control Tower

As stated in the first research gap, the Control Tower concept has received a lot of business attention as for instance professional firms have published white papers (Accenture, 2015; Bhosle et al., 2011). and Control Tower delivers numerous hits on the public internet domain. Meanwhile, the academic attention has been scarce thus far and lagging behind as opposed to the business sources. This section will first address the academic literature on the Control Tower and related concepts in multiple subsections, and will contain a separate subsection on the business sources. First an introduction to what is known on the history and beginning of the Control Tower concept.

The Air Traffic Control Tower (ATCT) may be the most well-known type of control towers, as they can easily be spotted at every airport for being such tall buildings. Due to globalization air traffic for the transport of people and goods has constantly been growing over the last decades. This is where the importance of the ATCT comes in place: to ensure safe and efficient movements of aircraft at the airport, handling all the take-off, landing and ground traffic (Freudenrich, 2001). The Control Tower phenomenon has been compared to an ATCT on many occasions and is seen as an inspirator for the Control Tower concept (Arts et al., 2019; Baumgrass et al., 2014; Cooke, 2014; Meekings & Briault, 2013). The ATCT has been around for decades and more recent developments within ATCT becoming it to be enabled by advanced technologies (Fürstenau et al., 2009; Kraus, 2011; NATCA, 2008; Reynal et al., 2019).

The Control Tower concept was introduced soon after the Cross Chain Control Centre (4-C) concept was also coined (Van Laarhoven, 2009). 4-C has first been initiated by the Committee Van Laarhoven (2009) and can be described as a centre in which multiple supply chains are controlled and coordinated with the use of advanced technology. The 4-C concept is mostly developed within the transport industry and supports organizations to collaborate with each other by controlling multiple supply chains simultaneously (Schijndel & Braat, 2012). As of 2009, the concepts of Control Tower solutions and 4-C have been introduced as emerging solutions of which both would be researched and implemented in the years to follow (Dinalog, 2019b; SLF, 2021; Topsector Logistiek, 2014).

The ATCT and 4-C concepts appear to be the predecessors of the core Control Tower concept, however other academic literature sources were not found regarding the history or beginning of the Control Tower. Both the ATCT and 4-C concept are mainly technology-driven and data-driven. As technology is the main element providing these concepts to function, this is also the case for the general concept of the Control Tower (De Vasconcelos & Kaminski, 2013; Liotine, 2019). The Control Tower concept has progressed in adoption and academic notion in recent years mainly due to technological restrictions before that time (Alias, Özgür, Jawale, & Noche, 2014b). Figure 6 visualizes a Control Tower with its main functions. The following subsection elaborates on the core concept of the Control Tower, including the main functions and characteristics thereof.

Figure 6 – Control Tower (Topsector Logistiek, 2019)

3.2.1. The core concept of a Control Tower and its main characteristics

According to Accenture (2015) a Control Tower acts as a centralized hub that uses real-time data from a company's existing, integrated data management and transactional systems to integrate processes and tools across the end-to-end supply chain and drive business outcomes. This definition already contains some information on the accompanied goals a Control Tower results in. However, Rustenburg (2016) argues that the Control Tower term is somewhat abstract in nature. Topan et al. (2020) argue that the Control Tower is still a novel concept whereby the definition and capabilities are still evolving in time. Moreover Trzuskawska-Grzesińska (2017) defines the Control Tower concept as a system that facilitates a network to continuously and real-time manage processes, resources, corrective and preventive actions. In addition, Liotine (2019) states that the essential capabilities of a Control Tower are visibility, analytics and execution.

Control Towers have been implemented and are operational in a wide range of industries such as the pharmaceutical and healthcare industry (Liotine, 2019), high tech industry and global markets (De Vasconcelos & Kaminski, 2013; Trzuskawska-Grzesińska, 2017), transportation industry (Baumgrass et al., 2014; Vanvuchelen et al., 2020), automotive and defence industry (CQM, 2019). There are a number of main elements or characteristics to the core (general) Control Tower concept which are distinguished. According to Trzuskawska-Grzesińska (2017) and De Vasconcelos and Kaminski (2013) the main elements of a Control Tower are processes, technology and a human organization.

Processes

The processes element is considered as a pre-requisite of setting up the Control Tower environment. Thereby, De Vasconcelos and Kaminski (2013) argue that well-defined and managed processes are important in many activities, of which logistics is a part as well. In addition, they argue that the processes are distributed to all involved stakeholders within a network, which could be done by for instance a Standard Operating Procedures (SOP). They state that a SOP provides a step-by-step instruction of the what, who and when for every part of the processes. Moreover, Trzuskawska-Grzesińska (2017) implies that through the use of SOPs, the Control Tower functions and follows exactly the same defined processes regardless of who is managing or acting on the data output of the Control Tower (for instance when teams and employees are changing, the guidelines and way of working stays the same). More specifically the added value can be considered as the presence of a standardized way, one system and process or 'one truth' within the Control Tower environment (Trzuskawska-Grzesińska, 2017).

Technology and technological convergence within the Control Tower environment

According to De Vasconcelos and Kaminski (2013) a Control Tower is able to function by the means of the technology, therefore the technology can possibly be seen as the most important element involved in the Control Tower environment. Combining multiple technologies within a Control Tower environment has a significant role within the Control Tower concept, which is providing the Control Tower to have more data which can therefore result into improved decision-making (De Vasconcelos & Kaminski, 2013; Liotine, 2019). Control Tower environments highly rely on the collected data, therefore multiple different technologies and concepts for storing data are used. The different technologies are often connected with each other to provide the required data to be gathered in one central (physical or virtual) location (De Vasconcelos & Kaminski, 2013). They argue that after collecting the data through multiple technologies, the data can hereafter for instance be used to monitor and act through decision-making. According to Hofman (2014) Cloud based data can be stored and shared within the different Control Tower components. In addition, Liotine (2019) argues that cloud based technologies within end-to-end Control Towers and supply chains can result in reducing cost, complexity and a fully connected interorganizational integration of for instance operations and strategies within the network. According to Liotine (2019) and Shou-Wen, Ying, and Yang-Hua (2013) the Internet of Things (IoT) technology of all kinds such as sensors and RFID-chips can be applied to collect and process data within the Control Tower. The Control Tower concept consists of monitoring components and (user) interfaces (Baumgrass et al., 2014). Interfaces can be developed with for instance Application Programming Interface (API) which are widely integrated to connect systems with each other (Liotine, 2019). Furthermore, according to Liotine (2019) Global Position System (GPS) can provide location data in real-time. In addition, dashboards are often used for visual representations (Cooke, 2014) and can help in tracking the overall health of the value chain, to react and evaluate based on previous and current or new data (Liotine, 2019).

Control Tower solutions can benefit from Intelligent decision support tools combined with Artificial Intelligence for alert generation for instance (ProSeLoNext, 2021). Moreover, technologies such as Machine Learning (ML), Autonomous Intelligence (AI) and potentially Blockchain (which is still in early stages of development) can all have a value adding role in the decision-making within Control Tower environments (Liotine, 2019). Furthermore, Smart ML algorithms can provide in moving towards more sharing and collaboration between companies (Vanvuchelen et al., 2020). Thereby algorithms, ERP systems, Transportation Management Systems (TMS) and Warehouse Management Systems (WMS) are being integrated within Control Tower environments (Liotine, 2019; Rustenburg, 2016). These systems are in most cases already implemented within organizations as they have been widely used over the last decades. According to Arts et al. (2019) current existing (ERP) systems within organizations will however not suffice, therefore appropriate information systems will need to be in place for a Control Tower to make the right decisions.

The Control Tower concept can shift into a real-time data processing and decision-making concept, which ultimately should provide a holistic end-to-end view across the different stakeholders (Liotine, 2019). In line with Liotine (2019), Shou-Wen et al. (2013) imply that the multiple data elements (e.g. collection and processing) within a Control Tower environment can provide in strategic, tactical and operational levels of management control. By collecting, processing and using the multiple technologies and therewith the amount of data involved, organizations are able to further process and take advantage of this by using analytic technologies as well (Liotine, 2019).

To summarize on this technology subsection shortly, there is a high reliance on technology within a Control Tower environment and numerous technologies are being used and converged with one another. These technologies mainly enable the Control Tower to be operational and to function properly. This high reliance on technology, data and technological convergence factors in a Control Tower can also combinedly be stated as the encompassing term of Digitalization. Digitalization which is also called digital transformation, can be seen as the adoption and increasing usage of digital or computer (ICT) technology by an organization, industry, society, country etc. (Brennen & Kreiss, 2016; Parviainen, Tihinen, Kääriäinen, & Teppola, 2017). Moreover, digitalization concerns rethinking current operations to new perspectives which is enabled by technology (Parviainen et al., 2017).

Furthermore, Sklyar et al. (2019) imply that it is important to differentiate between the terms digitization and digitalization; where digitization can be understood as turning analogue into digital and digitalization can be understood as using digital technology in order to change (current) business models. In addition, the interplay between digitalization, servitization and especially the so called digital servitization is significant (Lerch & Gotsch, 2015), hence these terms and concepts are referred to within multiple sections of this chapter and thesis.

Human organization

The human organization within a Control Tower consists of trained employees (De Vasconcelos & Kaminski, 2013; Rustenburg, 2016; Trzuskawska-Grzesińska, 2017). In addition, De Vasconcelos and Kaminski (2013) imply that educated employees manage and control the technology and processes, this people or human organization element in a sense completes the Control Tower. The employees are a part of the existing organizations within the Control Tower network and for instance operate, manage, control or react on Control Tower activities such as alerts. According to Trzuskawska-Grzesińska (2017) the employees within the organizations are often distinguished in different job roles and each have their own focus within the Control Tower. Furthermore, Rustenburg (2016) states that the employees use state-of-the-art algorithms to conduct their activities within the Control Tower and the employees to closely collaborate with each other.

Together with the processes and technology, the human organization enables the Control Tower environment towards the transition of more and an improved form of collaboration within interorganizational settings (Maneengam & Udomsakdigool, 2020; Vanvuchelen et al., 2020).
In addition, Liotine (2019) implies that a Control Tower serves as a command centre, enabling all the stakeholders within the network to act more closely with each other and provide a more proactive service to their customers. He argues this provides a win-win situation across the network which can ultimately result in financial gains as well. In line with Liotine (2019), Vanvuchelen et al. (2020) argue the transition towards a holistic, collaborative and integrated 'network of networks'.

Thereby, Maneengam and Udomsakdigool (2020) argue that a Control Tower has a neutral decision-making element, which results in an improved mutual trust and enables transparency among all of the stakeholders in the network. They imply that the privacy of data is ensured continuously. They argue that the Control Tower collects all of the important data from the stakeholders within the network, therefore being able to provide visibility and decision-making of all the involved chains. As the Control Tower is a central hub, the benefits of independency, neutrality, trust and privacy ensuring collaboration are reached (Maneengam & Udomsakdigool, 2020). In line with Maneengam and Udomsakdigool (2020), Hofman (2014) and Vanvuchelen et al. (2020) argue that sharing data between stakeholders within the network will become easier within Control Tower environments.

The element of collaboration amongst the stakeholders within the network (or called an interorganizational setting) has a strong connection with the human organization of businesses. Furthermore, without the use of technology, the forms of collaboration and collecting, processing and sharing data will not be possible. Moreover, a Control Tower can act as a hub for supply chain visibility (Cooke, 2014; Liotine, 2019; Trzuskawska-Grzesińska, 2017) and enable decision-making (Arts et al., 2019; Cooke, 2014; Liotine, 2019). Supply chain visibility has a strong connection with (supply chain) complexity, access to and sharing of information and data across supply chains (Caridi, Crippa, Perego, Sianesi, & Tumino, 2010).

Ownership / Control / Distribution / in charge of and managing a Control Tower

When it comes to the ownership, controlling element and setting up the Control Tower, there are multiple possibilities found in literature. Mainly due to the growing (operation) complexity of organizations and their logistics, many processes and activities are handed over to (multiple) external parties (De Vasconcelos & Kaminski, 2013). They state this outsourcing has evolved from First Party Logistics (1PL) to eventually a third (3PL) or fourth party logistics provider (4PL) for specific supply chain related activities to take care of the increasing supply chain complexity. A Control Tower can be managed by an external party (for instance a logistics provider; 3PL, 4PL or an OEM) or an organization within the network (De Vasconcelos & Kaminski, 2013). In line with De Vasconcelos and Kaminski (2013), Arts et al. (2019) state that a Control Tower could be controlled and managed by an OEM or third-party. These external or third-party providers could already be present within the existing network or be a new neutral party (e.g. a 4PL) who operates independently of the existing network and stakeholders. External party providers such as a 4PL are especially beneficial when organizations or multiple organizations within the network contain complex supply chains, which are involving high numbers of other stakeholders, processes, activities and orders or products (De Vasconcelos & Kaminski, 2013). With a growing complexity of supply chains, the need for supply chain visibility increases for organizations as well (Trzuskawska-Grzesińska, 2017).

In addition, Trzuskawska-Grzesińska (2017) implies that organizations can either develop their own Control Tower (e.g. self-organized) or offer Control Towers as a service or purchase it from a service provider. In line with Trzuskawska-Grzesińska (2017), Cooke (2014) states that a Control Tower can be purchased from a vendor, can be set-up on one location by the organization itself (e.g. self-organized), or by external providers (e.g. a 3PL, 4PL or other third-party). Thereby, the vendors can consist of large professional firms who offer Control Tower solutions to organizations, such as Capgemini, Accenture or E2Open (Accenture, 2015; Bhosle et al., 2011; Bleda, Martin, Narsana, & Jones, 2014; E2Open, 2020). In addition, these vendors (e.g. professional firms) offer different types of solutions, implementation phases and agreements depending on the requirements of a specific organization (Accenture, 2015; Bhosle et al., 2011; Bleda et al., 2014; E2Open, 2020). Suitable ownership, setting up and managing a Control Tower may differ for different type of organizations and depending on interorganizational situations and other stakeholders involved. Some organizations may want to stay in control of every aspect within their environment, while others decide on a specific neutral partner to improve elements such as trust and transparency within their existing network (Maneengam & Udomsakdigool, 2020). Depending on the best suitable option for an organization or the network of organizations, it is important to note that all of the data and information needs to be integrated in to Information Systems (IS), therefore requiring high-end technology (Arts et al., 2019).

A summarized list of the possibilities concerning the ownership, controlling and managing of a Control Tower:

- External or third-party; a neutral party such as a 3PL, a 4PL, an OEM
- An organization within the existing network (could also be for instance a service provider or OEM)
- Self-organized, developed and in control
- Purchased from a vendor or service provider

While deciding on how to set up a Control Tower and who is facilitating in this, there are additional findings concerning how to proceed on this. Moreover, a Control Tower can (may even should) expand over time: by starting with a small scope and increasing in processes and activities (Cooke, 2014). In line with Cooke (2014), Trzuskawska-Grzesińska (2017) argues that by expanding the scope (e.g. by adding more supply chains and/or stakeholders), benefits and with those the added value for organizations can be increased. She implies that the scope can thereby be increased by incorporating more levels such as from an operational to a more tactical level. The beforementioned vendors of

Control Tower solutions also imply starting with a limited scope and after that expand by for instance implementation in remaining business departments (Accenture, 2015; Bhosle et al., 2011).

Evaluation of the Core, the General Control Tower concept

The most important terms and elements are condensed from the previous (sub)sections on the Control Tower concept and therefore conclude on elements to what a core or general Control Tower entails from the literature findings thus far. The main terms, characteristic, elements or factors are visualised in an overview in Figure 7.

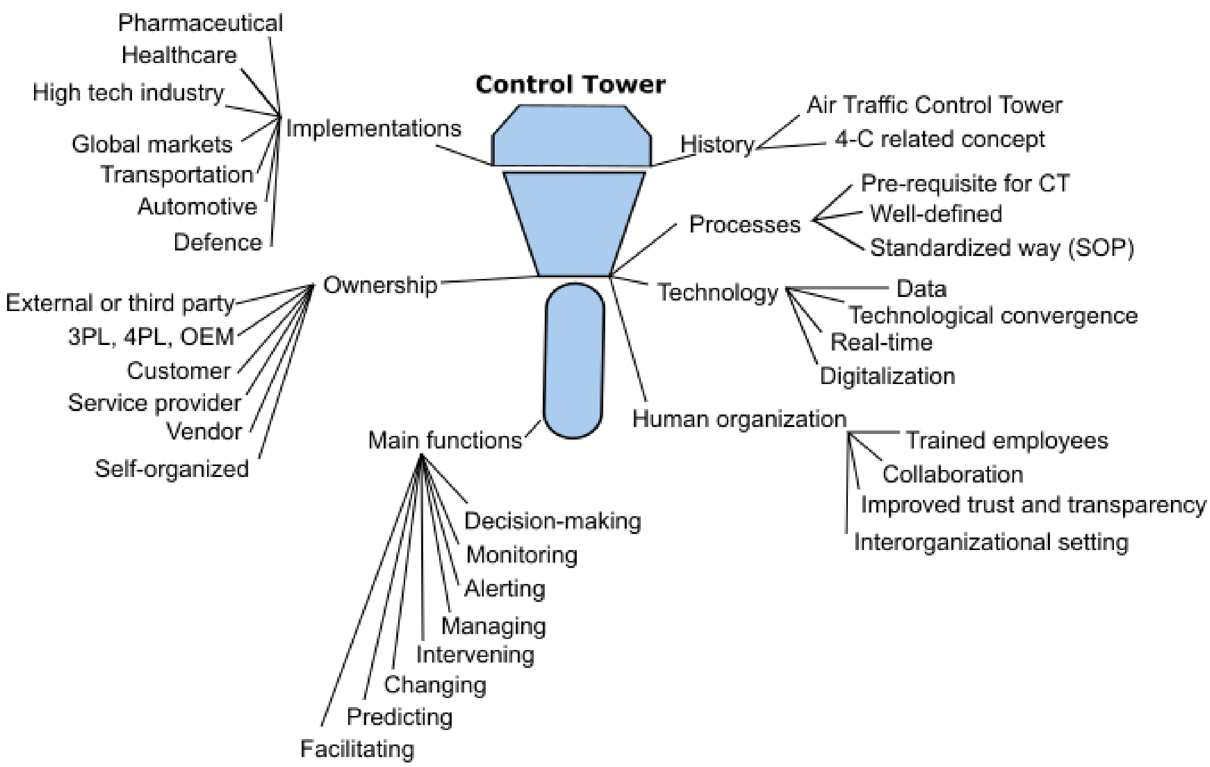

Figure 7 – Core Control Tower concept

Figure 7 visualizes the core Control Tower concept as described thus far. The Control Tower section first explained on the possible history or beginning of the Control Tower concept, where the literature sources mention the ATCT as the original Control Tower and 4-C concept was coined around the same time as the Control Tower concept, these concepts have similarities when it comes to the main functions and capabilities. The Control Tower section of this chapter then elaborated on the main characteristics; Processes, Technology and Human organization. Within the Control Tower elaboration the multiple main functions are also stated, as well as the ownership, controlling and managing of the Control Tower and the known implementations of Control Towers thus far.

A number of academic sources mainly focus on the technology, (real-time) data and technological convergence of Control Towers, while other sources focus more on the human organization; the collaboration and facilitation within a network of organizations. Both of these elements are considered of significant importance as a Control Tower requires technology and therewith has the goal to improve collaboration, facilitation and coordination within a network.

To summarize on the findings thus far, the key stones of the Control Tower concept are as follows:

- Technology, data and technological convergence is a significant part (technology main characteristic). This high reliance on technology, data and technological convergence factors in a Control Tower can also combinedly be stated as the encompassing term of Digitalization. Digitalization which is also called digital transformation, can be seen as the adoption and increasing usage of digital or computer (ICT) technology by an organization, industry, society, country etc. (Brennen & Kreiss, 2016; Parviainen et al., 2017).
- Collaborating within a network is a significant part (human organization main characteristic).

3.2.2. The structure of a Control Tower

According to Shou-wen, Ying & Yang (2013) the basic structure of a Control Tower system can be represented in five layers. From bottom to top, these layers are (Shou-Wen et al., 2013):

1. Supply chain business layer

Can be seen as the basis of the supply chain, which includes the members (suppliers, providers, distributors, users etc.) and major aspects (procurement, transportation, distribution, information services etc.).

2. Information perception layer

This layer is use of IoT technology to achieve real-time sensing and transmission. This can be done by using RFID, sensors, WIFI or Bluetooth for example.

3. Information operation control layer

This layer contains two parts: the supply chain information storage part and the supply chain information control part, both of these parts together achieve the control function of the Control Tower. The storage part can provide information to the control part, where the control part can feedback the results to the storage part. The information is derived from the IoT perception layer.

4. Information service platform layer

This layer can store centrally and update information from the lower layer dynamically to provide transparency and visualization of information. Next to this, real-time monitoring, retrospective and feedback control is achieved in this layer.

5. Information manpower layer

This top layer is the decision-making centre, responsible for the overall monitoring, information control and early warnings. This layer can also be called the integrated "information hub" that provides the overall visibility.

Applying these five layers to a Control Tower enables data collecting, data processing and management control on strategic, tactical and operational levels (Shou-Wen et al., 2013). There is a high reliance on technology and data within Control Tower environments.

Figure 8 visualizes the five layer structure of a Control Tower system (Shou-Wen et al., 2013).

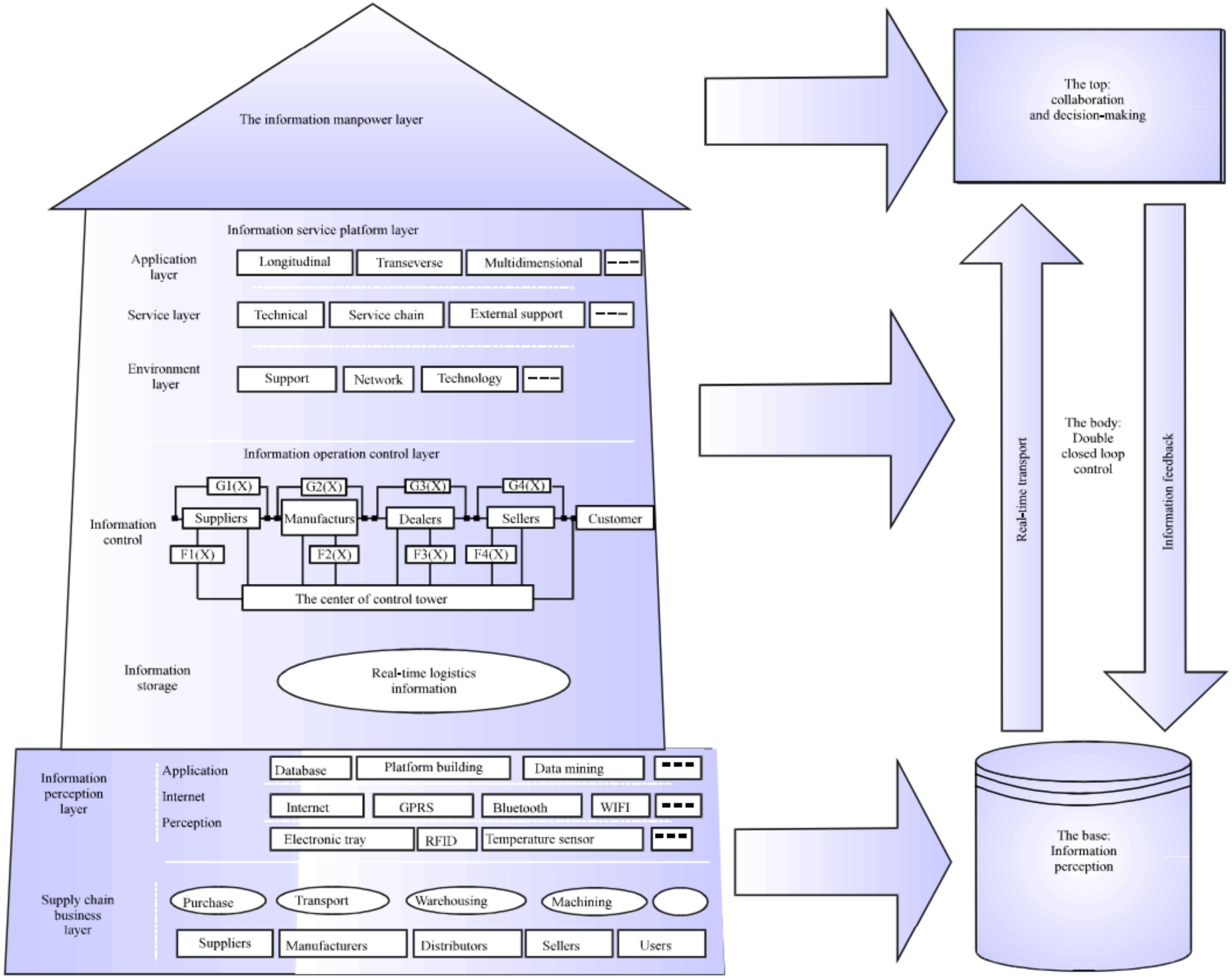

Figure 8 – Structure of a Control Tower (Shou-Wen et al., 2013, p. 8489)

3.2.3. The different types of Control Tower concepts

There is a knowledge gap (number 2) regarding Control Towers in their possible configurations and future. Companies tend to use Control Towers in different circumstances and with different functions (Trzuskawska-Grzesińska, 2017). Moreover, different names and types of Control Towers are used in literature, where a clear distinction is missing. This section will address this research gap and elaborate on the different types of Control Towers and their specific characteristics, while also looking in to similarities and differences. Moreover, the different types of Control Tower concepts will be elaborated on from the oldest found in literature to the newest found and mentioned type of Control Tower. In addition, each type of Control Tower will end with a short evaluation in the form of a table, which will focus on distinguishing the Control Tower type from the core or general Control Tower concept.

Thereby, the following different names and types of Control Towers are noted in literature:

Air Traffic Control Tower (ATCT)

As mentioned at the start of this chapter, the main purpose of an ATCT is to ensure safe and efficient movements of aircraft at the airport, handling all the take-off, landing and ground traffic (Freudenrich, 2001). ATCTs have been around for decades as the first radio technology driven ATCT was introduced in the 1930s, after which developments and number of ATCT quickly progressed as aviation rapidly increased (Kraus, 2011; NATCA, 2008). More recent developments within ATCT consist of Virtual and Remote Control Towers, which use advanced technologies and are not located at one specific airport and are designed to control multiple airports at the same time (Fürstenau et al., 2009; Reynal et al., 2019).

The core Control Tower (and remaining Control Tower types) phenomenon has been compared to an ATCT on many occasions and the ATCT is seen as an inspirator for the different types of Control Tower concepts (Arts et al., 2019; Baumgrass et al., 2014; Cooke, 2014; Meekings & Briault, 2013). ATCT are mainly characterized by overseeing, controlling, managing, intervening every activity concerning air traffic, while also using real-time data and communicating with multiple parties (Freudenrich, 2001; Fürstenau et al., 2009; Kraus, 2011; Reynal et al., 2019).

Table 4 provides an overview of the elements of the ATCT which are distinguished opposed to the core Control Tower concept.

ATCT Virtual CT Remote CT	Main elements distinguished from core concept
	- Air Traffic / Aviation domain. - Physical and/or Virtual location (Remotely). - Services and specific CT functions: overseeing, controlling, managing, intervening every activity concerning air traffic, while also using real-time data and communicating with multiple parties. The main purpose of an ATCT is to ensure safe and efficient movements of aircraft at the airport, handling all the take-off, landing and ground traffic. - Technologies: 'advanced technology'.

Table 4 – Air Traffic Control Tower

Transportation Control Tower

Many stakeholders on different levels (strategic, tactical, operational) are involved in the supply chain process of the transport and logistics domain, which contains challenges in the visibility and availability of the supply chain (Alias et al., 2014b). According to Baumgrass et al. (2014) a transportation control tower can be used by transportation planners to manage and monitor their activities such as transportation resources and orders. They argue that a Transportation Control Tower can support in logistic activities around for instance transportation planning, monitoring and configuration activities and administrative activities such as filling out forms and billing. Thereby, Baumgrass et al. (2014) imply a list with required functionalities which contains for instance real-time (transportation) information, any changes that may occur in the different (transportation) systems and stakeholders, insight into availability of all of the involved partners, executing, tracking and monitoring transportation. In addition, they state that a software architecture is adopted with elements such as user interfaces and planning components.

Control Towers are envisioned as a future tool of supply chain monitoring, however due to mainly technological restrictions the Control Tower developments have really progressed in recent years (Alias et al., 2014b). Moreover, according to Alias et al. (2014b) a Future-Internet-based Transportation Control Tower concept can provide beneficial effects within container transports. Future-Internet is described after a collection of research on the changing aspects of the internet was established and consists of creating a future of the internet by using and combining technologies such as IoT, cloud, Internet of Services and network of the future (Pearson et al., 2012; Tselentis, Domingue, & Galis, 2009).

The functional architecture of the Transportation Control Tower can be characterized by MAPE-K, which stands for Monitoring (processes the collected data via for instance sensors and systems), Analysis (comparison of actual values to expected values, decision-making), Planning (proposes actions), Execution (the interface to the users) and Knowledge base (collecting all of the data as a last step) (Alias, Özgür, Jawale, & Noche, 2014a; Alias et al., 2014b; Kephart & Chess, 2003).

Table 5 provides an overview of the elements of the Transportation Control Tower which are distinguished opposed to the core Control Tower concept.

Transportation CT	Main elements distinguished from core concept
	- Transportation and Logistics domain. - Physically or online/Virtual location. - Services and specific CT functions: can be used by transportation planners to manage and monitor their activities such as transportation resources and orders. support in logistic activities around for instance transportation planning, monitoring and configuration activities and administrative activities such as filling out forms and billing. Real-time (transportation) information, any changes that may occur in the different (transportation) systems and stakeholders, insight into availability of all of the involved partners, executing, tracking and monitoring transportation. A software architecture is adopted with elements such as user interfaces and planning components. - Technologies: Software architecture, interfaces, Future-Internet-Based: IoT, cloud, Internet of Services and network of the future.

Table 5 – Transportation Control Tower

Logistics Control Tower

The Logistics Control Tower has been considered a solution to SCM and supply chain event management as of recent years, mainly as there were technological restrictions before that time, which were noticed for instance in the transport and logistics domain (Alias et al., 2014a). Logistics control can be seen as the central part of SCM (De Vasconcelos & Kaminski, 2013). According to De Vasconcelos and Kaminski (2013) a Logistics Control Tower consists of three main elements namely technology, people and process. Moreover, the Logistics Control Tower can be operational within the Fourth Party Logistics (4PL) concept, for instance in the order and supplier management (De Vasconcelos & Kaminski, 2013). 4PL companies can be seen as managing (significant) parts of supply chains for companies (Jensen, 2010).

Thereby, a pre-requisite is to have well-defined and documented processes (De Vasconcelos & Kaminski, 2013). Furthermore, they imply that technology is providing the Logistics Control Tower to function as it contains, collects and processes data through technology. Examples of technology systems which are used within Logistics Control Tower are for instance ERP and TMS (De Vasconcelos & Kaminski, 2013). In addition, they argue that educated employees manage and control the technology and processes, this people elements in a sense completes the Control Tower.

Another application is the Future-Internet-based Logistics Control Tower concept in intralogistics and more specific in a warehousing environment case study (Alias et al., 2014a). They argue that the (order) picking process of a producing company was evaluated and positive results were noticed in the process by improving the resource efficiency for instance by bundling the order picking. Furthermore Alias et al. (2014a, 2014b) imply that the Future-Internet-based Control Tower concepts could benefit from further implementations specifically when measuring the effect of an interconnection of several control towers at multiple stakeholders.

The functional architecture of the Logistics Control Tower can be characterized by MAPE-K, which stands for Monitoring (processes the collected data via for instance sensors and systems), Analysis (comparison of actual values to expected values, decision-making), Planning (proposes actions), Execution (the interface to the users) and Knowledge base (collecting all of the data as a last step) (Alias et al., 2014a, 2014b; Kephart & Chess, 2003). Moreover, the Logistics Control Tower as implied by Alias et al. (2014a) contains Future-Internet-based technologies, such as IoT, cloud and the Internet of Services. They argue that the goals of the Logistics Control Tower are to optimize order processing, resource efficiency and process robustness. In addition, De Vasconcelos and Kaminski (2013) argue that the Logistics Control Tower can take care of for instance all (purchase) orders and (supplier) management in the 4PL concept. They state that Control Towers are typically set-up for activities within and across supply chains, such as managing, monitoring and measuring. In addition, they argue that the Logistics Control Tower supports in strategic decision-making.

Table 6 provides an overview of the elements of the Logistics Control Tower which are distinguished opposed to the core Control Tower concept.

Logistics CT	Main elements distinguished from core concept
	- Logistics domain. - Physically or online/Virtual location. - Services and specific CT functions: take care of for instance all (purchase) orders and (supplier) management in the 4PL concept, typically set-up for activities within and across supply chains, strategic decision-making. Contains, collects and processes data through technology.

	- Technologies: ERP systems, TMS systems and Future-Internet-Based: IoT, cloud and the Internet of Services.

Table 6 – Logistics Control Tower

Supply Chain Control Tower (SCCT)

In the most recent Gartner Hype Cycle for Supply Chain Strategy, the Supply Chain Control Tower is placed in the Innovation Trigger segment, stating it is on the rise and expected to mature over the upcoming 5 to 10 years (Gartner, 2020). Thereby, the Innovation Trigger segment is the first of five segments, after which follows: Peak of inflated expectations, Trough of disillusionment, Slope of enlightenment and finally the Plateau of productivity.

According to Trzuskawska-Grzesińska (2017) a Supply Chain Control Tower is a planning and execution system, that facilitates a network to continuously and real-time manage processes, resources, corrective and preventive actions. Furthermore, Cooke (2014) argues that a Control Tower for a supply chain can globally monitor aspects such as orders, shipments, forecasts and any activity. In addition, Liotine (2019) states that a Control Tower should fundamentally contain data, alerting, operational functions, automation, decision support and role transformation. They argue that these capabilities should be shared across all of the supply chain stakeholders. Furthermore, Trzuskawska-Grzesińska (2017) implies that organizations can either develop their own Control Tower or offer Control Towers as a service or purchase it from a service provider. In line with Trzuskawska-Grzesińska (2017), Cooke (2014) states that a Control Tower can be purchased from a vendor, can be set-up on one location by the organization itself, or by external providers (e.g. a 3PL or 4PL).
Growing Supply Chain Complexity, moving towards end-to-end Supply Chain Visibility and more Control are challenges organizations are facing. These challenges are named as indicators for deciding on implementation of a Supply Chain Control Tower (Cooke, 2014; Liotine, 2019; Trzuskawska-Grzesińska, 2017).
Examples of technologies which are used within Supply Chain Control Towers are combining multiple technologies for an improved decision-making, such as cloud based technologies, IoT, interfaces, API, GPS, ML, AI and potentially even blockchain (which is still in novel stages) (Liotine, 2019). Trzuskawska-Grzesińska (2017) notes different names such as a Supply Chain Control Tower, a Logistic Services Control Tower and a Reverse Supply Chain Control Tower, and thereby different functions and configurations for Supply Chain Control Towers are used. She argues a clear distinction is missing. Moreover, Trzuskawska-Grzesińska (2017) suggests them to be integrated in to one large combined Control Tower to assure entire supply chain visibility and orchestration.

The Supply Chain Control Tower concept entails applications in many different industries such as the high tech industry and global markets (Trzuskawska-Grzesińska, 2017). According to Cooke (2014) Control Towers are implemented in construction industries, software and multinational companies. In addition, Liotine (2019); Meekings and Briault (2013) imply a Supply Chain Control Tower approach within the pharmaceutical and healthcare industry.

Table 7 provides an overview of the elements of the SCCT which are distinguished opposed to the core Control Tower concept.

Supply Chain CT	Main elements distinguished from core concept
	- Supply Chain Management (SCM) domain. - One physical location by own organization or other organization or a Virtual location. - Services and specific CT functions: a planning and execution system, that facilitates a network to continuously and real-time manage

	processes, resources, corrective and preventive actions. Can globally monitor aspects such as orders, shipments, forecasts and any activity. In addition, a Control Tower should fundamentally contain data, alerting, operational functions, automation, decision support and role transformation. No specific distinguished functions apart from core CT functions. - Technologies: Cloud based technologies, IoT, interfaces, API, GPS, ML, AI and potentially even blockchain (which is still in novel stages of development).

Table 7 – Supply Chain Control Tower

Outsourced Control Tower

Rustenburg (2016) proposes an Outsourced Control Tower, which contains educated planners, algorithms, (real-time) data from ERP systems. This would be a solution for the operational spare parts planning and lead to the availability of spare parts against minimal costs. The Outsourced Control Tower is characterized as "footloose" as the physical location is not relevant, furthermore the connection to the existing ERP system is an important element to extract data (Rustenburg, 2016). He states that for the Planning Services (considered as a form of a Shared Service Centre) he proposes, an Outsourced Control Tower would be suitable. Thereby, he implies that objectives such as increasing planning effectiveness, reducing operational costs and developing an outsourced and independent solution considered as a Planning as a Service solution (PaaS) can all be reached. He implies functions such as forecasting, assortment management, inventory planning, pro-active control and reactive control. In addition, Rustenburg (2016) states that adjusting metrics and parameters are important characteristics, as well as the decision functions which are labelled as strategic or tactical.

Table 8 provides an overview of the elements of the Outsourced Control Tower which are distinguished opposed to the core Control Tower concept.

Outsourced CT	Main elements distinguished from core concept
	- Service Logistics domain. - Outsourced also called 'footloose' as the physical location is not relevant, may even be Virtual location. - Services and specific CT functions: Planning Services, Planning as a Service. Forecasting, assortment management, inventory planning, pro-active control and reactive control - Technologies: ERP systems, algorithms, PaaS

Table 8 – Outsourced Control Tower

Digital Control Tower

Vanvuchelen et al. (2020) suggest to apply Machine Learning (ML) within Digital Control Towers, which would result in improved sharing of (real-time) shipment data, decision-making and collaboration across companies. They argue that Digital Control Towers can address challenges in the logistics industry such as the transformation towards digital logistics and physical internet while also moving towards a more economically friendly ecosystem. Thereby, they state that goals are to optimize supply chains towards a holistic and collaborative "network of networks" while also minimizing transportation and decarbonizing freight transport. These Digital Control Towers require a joint replenishment policy and technologies such as ML algorithms to facilitate collaborative shipping (Vanvuchelen et al., 2020).

Table 9 provides an overview of the elements of the Digital Control Tower which are distinguished opposed to the core Control Tower concept.

Digital CT	Main elements distinguished from core concept
	- Logistics domain - Online CT, Virtual location - Services and specific CT functions: No specific CT functions distinguished apart from core CT functions. - Technologies: ML, digital logistics, physical internet

Table 9 – Digital Control Tower

The different types of Control Tower concepts are visualized in Figure 9.

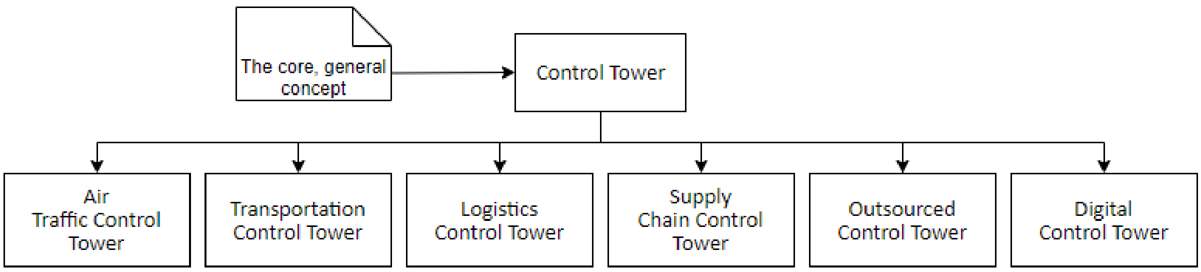

Figure 9 – Different types of Control Tower concepts

Common denominator of the different types of Control Towers (similarities); an evaluation

As the differences between the Control Tower types have been clarified and distinguished in the previous pages, there are also certain similarities and a common denominator that can be stated from the findings thus far. From the core Control Tower concept and the different types of Control Towers, the similarities are in the high-level main characteristics:

- Technology (and Data).
- Processes.
- Human organization.

These elements are of significant importance in order for implementing a Control Tower within an organization or interorganizational setting (within a network). Processes and a human organization are necessary elements within any organization. The technology and data element may even be the most significant in order for organizations to create a Control Tower successfully. According to E2Open (2020) Control Towers grow stronger as IT continues to innovate. This high reliance on technology, data and technological convergence in a Control Tower can also combined be stated as the encompassing term of Digitalization.

Digitalization which is also called digital transformation, can be seen as the adoption and increasing usage of digital or computer (ICT) technology by an organization, industry, society, country etc. (Brennen & Kreiss, 2016; Parviainen et al., 2017). Moreover, digitalization concerns rethinking current operations to new perspectives which is enabled by technology (Parviainen et al., 2017). Each of the elaborated Control Tower concept consists of mainly digitalized concepts. Furthermore, digitalization is the key for providing for instance efficiency in organization in case of new services or offerings to customers (Parviainen et al., 2017).

Figure 10 displays the main similarities (elements) and common denominator which are distilled from the literature thus far.

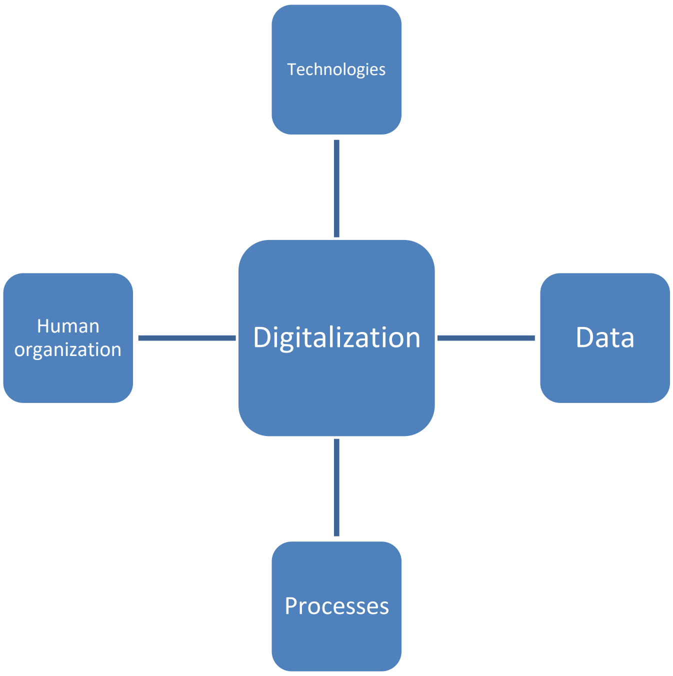

Figure 10 – Control Tower types common denominator: Digitalization

To summarize, this subsection consists of a short evaluation of the common denominator, which is Digitalization, from the different Control Tower types, after their differences have been stipulated. The following subsection elaborated on the challenges, drivers, barriers and opportunities of a Control Tower after which the business literature findings are elaborated on. After that, there is a section on a new, service-oriented approach of a Control Tower, the Service Control Tower concept.

3.2.4. Challenges, drivers, barriers and opportunities of a Control Tower

Challenges

According to Liotine (2019) a challenge within supply chain visibility are current limitations in the novelty of technology, where for instance the interconnectivity between systems and data demand are significant. He implies that new decision-making can have an impact on the organization, supply chain and ICT components. Thereby, he argues that decision-making within Control Towers rely heavily on the data, thus when incomplete or unavailable, this can also become challenging for organizations.

In addition, the novelty of (certain) technology is a challenge due to multiple implications. The Control Tower concept has progressed in recent years and therefore not able in the decades or years before that, because there were technological restrictions for adoption of Control Towers (Alias et al., 2014b). Thereby, implementing technologies such as ML, AI and possibly blockchain in the future, each have their own challenges as these technologies are still in novel stages of development to date, therefore implementing within a Control Tower environment and maintenance by trained employees can both become challenging factors (Liotine, 2019).

In addition, ProSeLoNext (2021) states that technologies such as AI are promising but also are highly difficult to apply within Control Towers. As the Control Tower concept has received limited attention in the academic world to date, this can therefore become a challenge when the research and design of a Control Tower will be established as for instance there are no best practices on this concept found in literature thus far. The beforementioned challenges are in line with trends and challenges found on the service logistics domain, as for instance digital servitization concerns a high reliance on technology and focuses on an improved decision-making as well (Kohtamäki et al., 2020).

Benefits and drivers

The reported benefits of a Control Tower are cost and time optimization while at the same time adding value to customers (Trzuskawska-Grzesińska, 2017). In addition, Rustenburg (2016) implies a better balance between spare parts availability and working capital. Furthermore, a Control Tower enables proactive and/or automatic response (ProSeLoNext, 2021; Trzuskawska-Grzesińska, 2017). In addition, Cooke (2014) states that it enables going from reacting to anticipating. The use of multiple technologies and tools are also perceived as beneficial for Control Towers, as for instance alerts, interventions and combining all the available data in one centralized hub, can result in being able to work more efficiently within organizations and interorganizational settings (Arts et al., 2019; Liotine, 2019; ProSeLoNext, 2021).

The drivers for organizations to (want to) implement a Control Tower are perceived as technology and data related and to improve on collaboration within a network. Moreover, Liotine (2019) argues that the Control Tower concept can lead to real-time data processing and decision-making. Thereby, Vanvuchelen et al. (2020) argue that Control Tower concepts can support the transition towards more collaboration within a network. The beforementioned benefits and drivers are in line with the service logistics domain on the components of the challenges organizations are facing within this domain and what these organizations want to achieve in the future when it comes to servitization, technology, data and data processing (Dinalog, 2019b; SLF, 2021)

Barriers

The required input data of the organization(s) needs to be available in the IS and adapted in a way in order for the employees of the Control Tower, that they can access and act on it (Arts et al., 2019). Especially in the case of multiple organizations within the network who all deal with different IS and may even use (multiple) legacy systems (e.g. outdated systems which are still in use) it could be a significant obstacle to align this in to the desired Control Tower. In line with Arts et al. (2019), Liotine (2019) implies that data quality and integration between organizations requires significant work, as technologies may differ between organizations as well. The changing form of (closer or more) collaboration and increasing data sharing between stakeholders within the network may be perceived as a barrier as well (Maneengam & Udomsakdigool, 2020).

Opportunities

As the concept of a Control Tower is still evolving over time (Topan et al., 2020), several opportunities are stated. While Control Tower concepts promise to solve major challenges within supply chains, today's Control Tower does not yet provide this holistic end-to-end view across all the stakeholders within the network (Liotine, 2019). In addition, Arts et al. (2019) conclude that the development of Control Tower concepts constitutes a great challenge. They state that this will however be key for success. As the Control Tower concept still is in early stages of for instance research, implementation and development, the beforementioned opportunities imply that the concept is evolving and requires significant work in order to become what is intended by different authors.

3.2.5. Business literature findings

This subsection is added to verify whether business and academic sources have reported similar outcomes and findings concerning the Control Tower concept. As mentioned earlier in this chapter, Control Towers have increasingly received business attention over the years (Accenture, 2015; Bhosle et al., 2011; Bleda et al., 2014; E2Open, 2020). Numerous of published white papers, podcasts, blogs and webinars by professional firms can be found in the public domain on internet. This has resulted in multiple businesses (vendors) offering IT solutions for Control Towers, such as Accenture, Capgemini, E2Open and OneNetwork. Capgemini's published white paper dates back to 2011, while Accenture's white papers are published in 2014 and 2015 (Accenture, 2015; Bhosle et al., 2011; Bleda et al., 2014). E2Open has published webinars and podcasts which were created in 2020 (E2Open, 2020).

There is a wider notion of the Supply Chain Control Tower in specific, thereby the focus is on the complete supply chain of organizations (Accenture, 2015; Bhosle et al., 2011; Bleda et al., 2014; E2Open, 2020). In addition, they imply that the Control Tower is an emerging concept and still has an increasing popularity amongst organizations in all industries. Moreover, they argue an increasing supply chain complexity as a significant challenge. Furthermore, the addressed challenges for supply chain managers are: increasing costs and increasing customer demands (Accenture, 2015; Bleda et al., 2014), thereby collaboration and data are increasing which are requiring a more holistic approach (E2Open, 2020).

In addition, Bhosle et al. (2011) emphasizes a Control Tower is enabling companies to move towards supply chain visibility and gain a competitive advantage. They argue that Control Towers combine three pillars: people, process and technology in order to enable strategic, tactical and operational level management control. According to Accenture (2015); Bleda et al. (2014) there are three technological developments which are enabling Control Tower concepts to be implemented, namely: Cloud-based technologies, collecting and connecting data for advanced analytics, and integrating partner technologies such as ERP, planning and WMS. In line with Accenture (2015); Bleda et al. (2014), Bhosle et al. (2011) imply that different technologies are integrated in Control Towers, such as ERP, WMS and TMS which are enabling central monitoring and decision-making. Thereby, E2Open (2020) argues that organizations are looking for technological solutions to bring together all their data. Bleda et al. (2014) suggests to start with a limited scope for a Control Tower, which can expand over time. Moreover, they conclude that the Control Tower can therefore become more mature. Furthermore, Bhosle et al. (2011) argue there are two stages to implement a Control Tower, namely a strategic stage and an implementation stage. According to Accenture (2015) there are five stages, namely: visibility, integration, performance monitoring, horizontal processes and synchronized network.

To summarize, the findings by the business sources on Control Towers align and are in line with the findings of the academic sources.

3.3. Service Control Tower

The first mentioning of a Service Control Tower traces back to the Committee Van Laarhoven (2009). Arts et al. (2019); SLF (2021) imply the Service Logistics Control Tower concept, while CQM (2019); ProSeLoNext (2021); Topan et al. (2020); Van Laarhoven (2009) propose the Service Control Tower concept. The Service Logistics Control Tower and Service Control Tower concept are two names for the same concept, namely a Control Tower environment within the Service Logistics domain. The Service Control Tower name will be used further along this thesis.

Since the first mentioning of the Service Control Tower by The Committee Van Laarhoven (2009), it took 10 years before additional academic sources about the specific Service Control Tower concept were published (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021; Topan et al., 2020). In addition, these sources on the Service Control Tower concept all originate from Dutch oriented organizations and/or researchers (authors).

3.3.1. The concept of a Service Control Tower

According to CQM (2019); Topan et al. (2020) the concept of a Service Control Tower is used for the after-sales service supply chain. In line with CQM (2019); Topan et al. (2020), Arts et al. (2019); ProSeLoNext (2021); Van Laarhoven (2009) imply the Service Control Tower concept specifically for the service logistics domain.

The Committee Van Laarhoven (2009) mentions the Service Control Tower in specific as a new concept for the service logistics domain as: an innovative model to manage the entire service chain from multiple angles, for instance for a specific organization but also for the end-users and/or other organizations within the network. In addition, they state that the Service Control Tower could be based on multi-dimensional collaboration models within interorganizational settings. They argue that the Service Control Tower concept needs to be researched in multiple types of settings such as self-organized or interorganizational.

The SLF (2021) states that service logistics domain is moving towards more efficient ways of delivering services which is eventually leading towards the Service Control Tower concept. This implies that the Service Control Tower is an ultimate goal to reach to while improving within organizations service logistics domain. In addition, Arts et al. (2019) state that Service Control Tower development will be a great challenge but key for success.

According to CQM (2019) the need for a Service Control Tower is determined by two factors: the degree of an organization's servitization and the complexity of organizing the service logistics domain (e.g. after-sales services). In addition, CQM (2019) states that by identifying the need, the scope and depth are also determined by the organization. They imply that there is a continuous form of comparing the current maturity of the Service Control Tower to the desired level, whereas the development and directions can be changed or updated along the way of implementing, adjusting and evolving.

In line with the findings on the core concept of the Control Tower, the Service Control Tower, enabled by multiple technologies, could become an intelligent, real-time hub which will detect, alert and intervene automatically (Van Laarhoven, 2009). Thereby, CQM (2019) argue that a Service Control Tower uses real-time information from multiple sources to (i) monitor aspects of the after-sales service, (ii) anticipate on the after-sales service issues and (iii) support operational service decisions.

In addition, Arts et al. (2019) argue that the following multiple types of information and data can be integrated in the Information Systems (IS) of a Service Control Tower:

- Information on all service contracts.
- The performance for each contract until the current time point.
- The condition of critical components.
- The actual stocks of spare parts.
- Possible problems with the supply of new spare parts.
- Actual positions of service engineer.

In addition, Topan et al. (2020) argue that organizations want to use Service Control Towers to monitor (supply) chains, to generate alerts and provide real-time information. Thereby, they imply that current Service Control Towers lack functionalities such as the impact of interventions and the support operational decisions.

Moreover, Arts et al. (2019) imply that a Service Control Tower could be controlled and managed by an OEM or a third-party. This is in line with the findings on the core concept of a Control Tower where there are different possibilities stated on the ownership, controlling and managing the Control Tower(s). In line with Arts et al. (2019), ProSeLoNext (2021) states that controlling can be done by OEMs as they have the most technological knowledge in place. They argue that this requires servitization which also includes contracts and forms of collaboration within the network.

A Service Control Tower requires data in order to be operational within organizations, this data can for instance come from asset data or analysis systems (CQM, 2019). In addition, Arts et al. (2019) argue that a Service Control Tower can bring together a lot of data from IS to provide for instance predictions and decision-making. According to ProSeLoNext (2021) combining technologies such as AI, intelligent decision support tools and applying data-driven decision logic can all support in activities such as alert generation, interventions and managing resources. Thereby, they imply that interventions within Service Control Towers make most sense close to where customers need resources, in the downstream part of the supply chain.

A main challenge towards successfully developing the (Service) Control Tower is that it contains multiple innovative technologies and until recent years there were technological restrictions (Alias et al., 2014b). In addition, the beforementioned technologies will need trained employees (human organization element) as for instance Data Science specialists, and this specialty has been a growing development of recent years as well. These implications further address the research gaps (number 1 and 4) on the Service Control Tower topic.

3.3.2. The structure of a Service Control Tower

In addition to the five layer structure of the control tower system by Shou-Wen et al. (2013), Topan et al. (2020) suggests to use slightly different names for the layers, providing the structure applicable for the after-sales supply chain from bottom to top:

1. Supply chain business layer

This layer focuses on the supply characteristics in making (operational) decisions.

2. Data perception layer

This layer relates to decisions of tactical and strategic planning, whereas the scope of Topan et al. (2020) was within the operational planning. This layer consists of ICT related components, for instance Information Systems (IS).

3. Data storage and control layer

This layer relates to decisions of tactical and strategic planning, whereas the scope of Topan et al. (2020) was within the operational planning. This layer consists of ICT related components, for instance Information Systems (IS).

4. Data application layer

This layer addresses elements such as metrics, alerts, demand trends and triggers for interventions.

5. Operational planning layer

This layer is the main focus of the research by Topan et al. (2020) and consists of for instance real-time and day-to-day decisions. These five layers of the Service Control Tower system further align with the earlier implications on the significant importance and presence of both data and technology within the Control Tower and Service Control Tower concepts.

The five layer structure of the (Service) Control Tower system, as stated by Shou-Wen et al. (2013) as indicated on the left side and stated by Topan et al. (2020) as indicated on the right side of Figure 11.

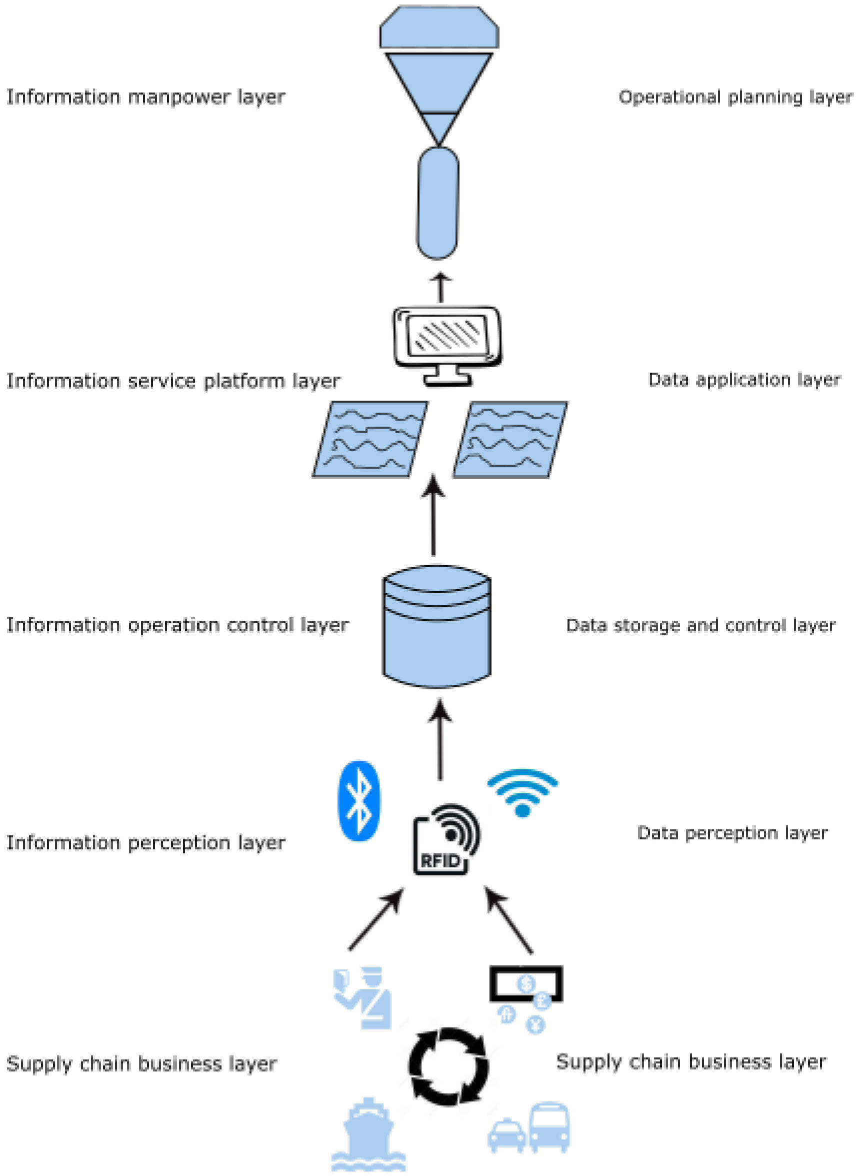

Figure 11 – Structure and layers of a (Service) Control Tower system

Evaluation of the Service Control Tower literature outcome thus far

The Service Control Tower entails a service-oriented approach, where key stones such as Service Logistics, (digital) Servitization and Innovation in combination with Data, Technology, Digitalization and Collaboration (forms) within a network (part of the main characteristic of human organization) come to light, especially within the existing literature on the Service Control Tower concept. When excluding the Service Logistics and Servitization elements, the findings on the Service Control Tower concept are, so far, similar to the findings on the core Control Tower concept.

To summarize thus far, the key stones are as follows: service logistics which includes (digital) servitization, data and technology (digital transformation) or also stated as digitalization and collaboration (within a network).

In Figure 12 the Service Control Tower concept is visualized in a class diagram, in relation with the general Control Tower concept and the multiple different types of Control Tower concepts.

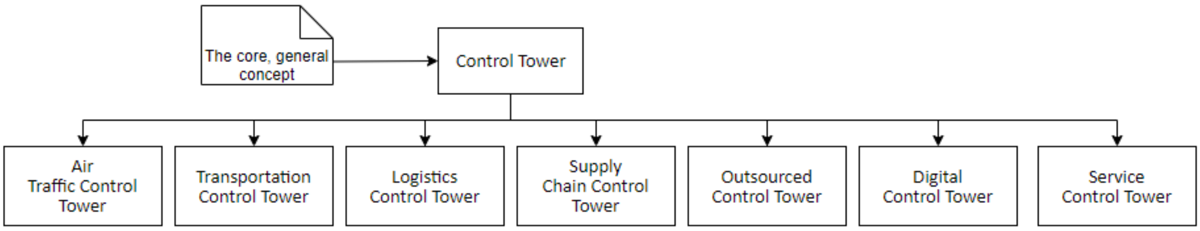

Figure 12 – Service Control Tower concept displayed in relation to Control Tower concept(s)

3.4. Conclusions

Service logistics can be defined as the steering part of the service chain, where the service chain contains all the offered elements such as services for maintenance or repair, from purchase to end of life (SLF, 2021). The logistics component ensures that all of the elements are available on time and arrive at the right place at the right time. The orchestration of both the service chain and logistics elements combined are the domain of service logistics (SLF, 2021).

The maritime sector entails companies that are engaged in activities such as designing, constructing, manufacturing, supplying, repairing, maintaining or operating marine systems (Monfardini et al., 2012). The main characteristics of the maritime sector are a multi-actor setting, system specific spare parts (e.g. obsolescence), multi-indenture systems (e.g. a collection of technical systems), mandatory surveys (e.g. dry-dock surveys), moving assets (e.g. remote and moving locations) and long life-cycles of up to 25 years (Eruguz et al., 2017).

Services and service logistics have developed over time and there have been shifts in ways of working and offering solutions. Challenges and trends within service logistics are servitization, availability of assets, managing costs and customers' demands. In addition, over the years technological developments within service logistics have been focusing more and more on collecting and analysing data which has resulted in numerous concepts which evolve around data and data-driven decision-making. In addition to these data and technology related concepts, there is a new phenomenon which is emerging: the Control Tower.

A Control Tower has been compared to an Air Traffic Control Tower on many occasions and is seen as an inspirator for the Control Tower concept (Arts et al., 2019; Baumgrass et al., 2014; Cooke, 2014; Meekings & Briault, 2013). A Control Tower acts as a centralized hub that uses real-time data from a company's existing, integrated data management and transactional systems to integrate processes and tools across the end-to-end supply chain and drive business outcomes (Accenture, 2015). Main elements of a Control Tower are processes, technology and a human organization (De Vasconcelos & Kaminski, 2013; Trzuskawska-Grzesińska, 2017).

A Control Tower consists of the following main characteristics: the convergence of technologies, supply chain visibility, enable (neutral) decision-making, collaboration within interorganizational settings, sharing data and improving trust and transparency. The following list of technologies have been reported to being combined and used within Control Tower environments: Cloud based data, monitoring components, interfaces and dashboards. Machine Learning (ML) and smart ML algorithms, Autonomous Intelligence (AI) and Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, Application Programming Interface (API), ERP, WMS, TMS systems.

The different types and names of Control Towers which were found in literature are as follows: Air Traffic Control Tower (later on also called the Virtual Control Tower and Remote Control Tower), Transportation Control Tower, Logistics Control Tower, Supply Chain Control Tower, Outsourced Control Tower and Digital Control Tower. There are these different Control Tower types drawn now, and the general or core concept of a Control Tower and narrative thereof in this literature chapter. Now there is a proceeding to this new Service-Oriented Approach of a Control Tower, the Service Control Tower, which can be seen as a Control Tower specifically for the service logistics domain. As the literature sources concerning the Service Control Tower concept to date are scarce, there is still a lot unknown and the development of the Service Control Tower is still in early stages. This paragraph concludes with these stipulated research gaps, in specific number 1 and 4. The following chapters of this thesis will focus on the Service Control Tower concept and add-on to the existing knowledge base.

3.4.1. Answering RQ1: Which different Control Tower concepts exist and what are the differences?

The findings of the distinguished differences between the multiple Control Tower types have been combined and provided in an overview in Table 10 on the following pages.

The different Control Tower concepts which exist are listed in Table 10, classified from old to new as referred to in academic literature:

- Air Traffic Control Tower, later on also called a Virtual Control Tower and a Remote Control Tower.
- Transportation Control Tower.
- Logistics Control Tower.
- Supply Chain Control Tower.
- Outsourced Control Tower.
- Digital Control Tower.

As the differences are clarified in Table 10, there are certain similarities between the different Control Tower types as well. One significant similarity is that the data, the technology or together stated as the most significant part of the digitalization. The digitalization is of great importance, most visible and existent within all of the different Control Tower types. Therefore, digitalization is seen as the common denominator of the multiple different Control Tower types (this is also the case for the Service Control Tower in which this thesis will elaborate on further and separately of these Control Tower types).

Control Tower Type(s)	Services and main functions of the Control Tower	Active domain	Location	Ownership, Controlling, Managing	Technology, Systems	Complexity conclusion
Air traffic CT; Virtual CT and Remote CT	Services: overseeing, controlling, managing, intervening every activity concerning air traffic, while also using real-time data and communicating with multiple parties. Main functions: the main purpose of an ATCT is to ensure safe and efficient movements of aircraft at the airport, handling all the take-off, landing and ground traffic.	Air Traffic / Aviation domain	Physical and/or Virtual location (Remotely)	Local External party	"advanced technology"	Medium to High for the newer ATCT types
Transportation CT **Logistics CT** **Digital CT**	Services: support in logistic activities around for instance transportation planning, monitoring and configuration activities and administrative activities such as filling out forms and billing. Take care of for instance all (purchase) orders and (supplier) management in the 4PL concept, typically set-up for activities within and across supply chains, strategic decision-making. Main functions: real-time (transportation) information, any changes that may occur in the different (transportation) systems and stakeholders, insight into availability of all of the involved partners, executing, tracking and monitoring transportation. A software architecture is adopted with elements such as user interfaces and planning components. Contains, collects and processes data through technology.	Transportation and Logistics domain	Physical, Online / Virtual location	External, 4PL	TMS systems, ERP systems, Interfaces, Software architecture IoT, Cloud, Internet of Services, network of the future ML, digital logistics, physical internet	High
Outsourced CT	Services: Planning Services, Planning as a Service (PaaS).	Service Logistics domain	Outsourced also called 'footloose' as the physical location is not	External party, Third-party, OEM	ERP systems, algorithms, PaaS	High

	Main functions: forecasting, assortment management, inventory planning, pro-active control and reactive control.		relevant, may even be a Virtual location			
Supply Chain CT	Services: a planning and execution system, that facilitates a network to continuously and real-time manage processes, resources, corrective and preventive actions. SCCT can globally monitor aspects such as orders, shipments, forecasts and any activity. In addition a Control Tower should fundamentally contain data, alerting, operational functions, automation, decision support and role transformation. No specific main function distinguished apart from the core CT functions.	SCM domain	One physical location by own organization or other organization (see ownership), Virtual location	Vendor, Service Provider, External, 3PL or 4PL, Self-organized	Cloud based technologies, IoT, interfaces, API, GPS, ML, AI and potentially even blockchain (which is still in novel stages of development).	High

Table 10 – Which different Control Tower concepts exist and what are the differences?

3.4.2. Answering RQ5: How can the Services within the Service Control Tower be adapted and evaluated?

Before answering this research sub-question, there are multiple concepts and elements which are being connected to each other first; services, servitization, digitalization, processes and the Service Control Tower concept. Previously in this literature review, there was a subsection with an elaboration on services, (digital) servitization, digitalization and a subsection on processes. These elements are mentioned within the Service Control Tower concept subsection as well. To summarize shortly on the mentioned concepts and subsections, in order for services to be able to be adapted and evaluated within a Service Control Tower, the following has been stated in the literature review.

Processes, services, servitization and digitalization

Organizations need to have their processes documented and standardized in a certain way, before they can continue to setting up a Control Tower environment (De Vasconcelos & Kaminski, 2013). The processes need to be aligned for all the stakeholders involved in the network, which could be done by a SOP which provides a step-by-step instruction of every part of the processes. Moreover, Trzuskawska-Grzesińska (2017) implies that through the use of SOPs, the Control Tower functions and follows exactly the same defined processes regardless of who is managing or acting on the data output of the Control Tower (for instance when teams and employees are changing, the guidelines and way of working stays the same).

Besides the processes element, there is the services, servitization and digitalization element involved as well. Organizations are shifting more and more towards (innovative) services where there is a significant role for technology-driven solutions (Crozet & Milet, 2017; Kohtamäki et al., 2020; Opresnik & Taisch, 2015; Sklyar et al., 2019). Moreover, servitization and digitalization have a strong interplay with each other and increasingly are being brought together in literature and for instance in decision-making concepts such as the Service Control Tower concept. Several studies are elaborating on servitization and digitalization within organizations, moving towards for instance product-service systems (Crozet & Milet, 2017; Kohtamäki et al., 2020; Kowalkowski et al., 2017; Lerch & Gotsch, 2015; Opresnik & Taisch, 2015; Sklyar et al., 2019). It is noted, that while there are several studies on servitization and digitalization, to date there is one study which partly focuses on servitization and services in specific within Service Control Towers (CQM, 2019).

The Service Control Tower concept has a connection with servitization as it is a factor for determining the need of a Service Control Tower and servitization is required in the process of setting up a Service Control Tower, which also includes contracts and forms of collaboration within a network (CQM, 2019; ProSeLoNext, 2021). The SLF (2021) states that service logistics domain is moving towards more efficient ways of delivering services which is eventually leading towards the Service Control Tower concept. This implies that the Service Control Tower is an ultimate goal to reach to while improving within organizations service logistics domain.

Adaption and Evaluation

The Service Control Tower requires processes and data (organizational data, services data, system data etc.) in order to be operational within organizations, therefore adaption takes place when documenting and standardizing processes within the complete network, and when data is being (or already has) digitalized in a new or existing environment (CQM, 2019; De Vasconcelos & Kaminski, 2013). In order for adaption to take place within the Service Control Tower, the (real-time) data and information are collected and/or integrated into enabling (converged) technology such as IS, AI or analysis systems (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021). Therefore, the Service Control Tower, enabled by multiple technologies, could become an intelligent, real-time hub which will detect, alert and intervene automatically (Van Laarhoven, 2009). In short, the required processes, services and data will need to be integrated in the technology which the organization(s) are going to use within the Service Control Tower environment. Depending on the situation of the organization, adaption can entail changes on many different levels, ranging from using existing (ERP or XML-based) systems to acquiring complete new solutions.

After setting up (and adapting) a Service Control Tower environment, the technology which is used by the organization, can provide for instance predictions, monitoring, decision-making and alerting (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021; Topan et al., 2020; Van Laarhoven, 2009). Based on the outcome of these activities and tasks, the organization can evaluate whether the output of the Service Control Tower is sufficient or needs further adjustments. The need, scope and depth of the Service Control Tower can be determined by the organization before setting up the Service Control Tower (CQM, 2019). There is a continuous form of comparing the current maturity of the Service Control Tower to the desired level, whereas the development and directions can be changed or updated along the way of implementing, adjusting and evolving (CQM, 2019). Therefore, adaption and evaluation are both ensured within the Service Control Tower implementation and growth thereof.

4. Empirical Research Results

This chapter presents the results of the conducted interviews (combined with literature review outcome) and Design Science Research (DSR). First, there is a section which answers the research sub-questions through the conducted semi-structured interviews. Second, the DSR method which consisted of creating the concept of a Service Control Tower, whereby another answering of a research sub-question is conducted. Third, a final section on the evaluation of the artefact is conducted.

4.1. Analysis of the empirical research results

The following subsections of this chapter contain the results of the semi-structured interviews. Interviewee A to C were from within the MARCONI-project, interviewee D was from an organization outside of the MARCONI-project. The answers from the interviewees are displayed and quoted in the following subsections. The complete interviews can be found in the Appendices A to D. On the 12th of May 2021, there was a MARCONI-project Plenary meeting which included group discussions and presentations by stakeholders and students. In this meeting, there were Poll questions raised among the participants.

The first question raised was the following:
"**Can you describe how you envision a Service Control Tower?**"
The varying answers from the MARCONI-project participants were as follows:

- "*Semi shared IT*".
- "*Help make decisions on allocating resources for services and time schedules*".
- "*Overall overview about the health and performance of our vessels*".
- "*SCT creates an overview what's going on in the (service) supply chain*".
- "*Synchronization of services which in addition are entirely customer-focused*".
- "*Optimization of service logistics with IT*".
- "*A tool for collaboration in the supply chain*".
- "*As an operational department*".

The second question raised was the following:
"**What do you see as the biggest challenge for implementing a Service Control Tower?**"

This concerned a multiple-choice question. The answer options and answers are displayed in percentages in Figure 13. The majority of the participants (40%) answered that "*Sharing data*" was the biggest challenge. Elaborations of the "*Other*" option (30%) were: "*Trust*", "*To identify the Scope of the SCT*", "*To agree upon the goals that you would like to achieve*". The option of "*Data protection*" was not chosen by the participants, whereas "*Technology*" (10%) and "*Agreements (contracts)*" (20%) were chosen by a small part of the participants.

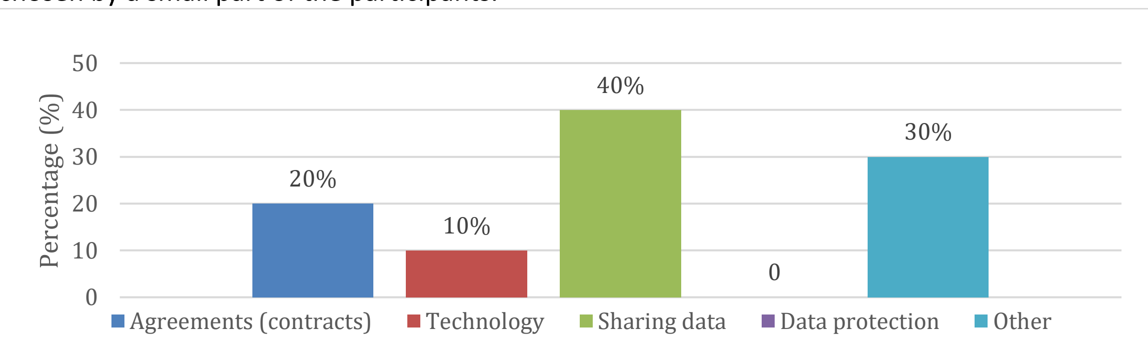

Figure 13 – What do you see as the biggest challenge for implementing a Service Control Tower?

Question	Interviewee A	Interviewee B	Interviewee C	Interviewee D
Summary of Perceive SCT RQ2	Connected to Service Logistics. Increasing complexity. Clear demand to get an overview of all the complete chains with all the stakeholders involved in the chains. An overview of the complete network.	History on Service Control Tower (see full answer in appendix b). Appeared at the 4-C concept, collaborate more efficiently, both horizontally and vertically. Example transport companies sharing trucks. Requires a Contract/Agreement. Central control, joined value of cooperation. Now SCT in particular service logistics and (maintenance) services.	An SCT or a control network, to gain services with our customers by an online connection. More and better access on the systems and share more data required for maintaining and servicing the systems. Sharing that information would be very beneficial for both parties. Or even more than two parties.	SCT is a Central Team or different teams of people. People work with Systems. In the end, these systems should support the people. An overview of the complete network. These teams of people monitor the Network, where Governance is involved as well.
Code name(s) **Code 1-5**	Gain value (1) Overview of network (2) Service logistics (3)	Gain value (1) History of SCT (4) Service logistics (3)	Gain value (1) Overview of network (2)	Gain value (1) Overview of network (2) Teams of People who work with Systems (5)
Summary of Drivers SCT RQ3	Increase availability of parts for customers. Network value proposition, balance in value proposition. Mutual trust.	Collaboration brings joined value. Network value proposition. Collaboration brings more value. Coordination Centre needed, operational coordination and strategic coordination.	Technology is ready. All parties can access and use common data to share. Real-time intervention and maintenance. Long term added value. When there is trust, it may be easier to go for a solution as an SCT.	Visibility for customers. Services for customers. See where things go wrong, reacting to improve.
Code name(s) **Code 6-9**	Customer demand (6) Network value proposition (7) Trust (9)	Network value proposition (7)	Technological developments (8) Trust (9)	Customer demand (6)
Summary of Barriers SCT RQ3	Depends on what the organization gains within a SCT.	Strategic reasons: Natural resistance of not being in control (in case of central control coordination).	Technology will not be a problem. Main concern is about sharing data within a SCT. Scary to share	Organization has a partially outsourced SCT, which can therefore be a risk if customers choose to go for the outsourced

	The core business and business focus is also a factor on if an organization is willing to join. Get information of all stakeholders in the right place (gluing together processes part of interview).	Minimize risks beforehand. Risk of losing market share. Not share too much of your data. It becomes easier when elements such as a form of collaboration and trust are in place e.g. to hand over authority.	too much data, not eager to share. Intellectual Property and financial sides including agreements on this. I think that is one of the main concerns. Is: How do we protect data… that we share with our customer with our competitors or everyone else involved within the Control Tower.	party instead of theirs. However they are working on this as they are re-introducing outsourced tasks (making them internally again).
Code name(s) **Code 10-16**	Gain value (10) Core business, business focus (11)	Strategic – natural resistance of not being in control (12) Strategic – risk of losing market share (13) Strategic – not share too much data, intellectual property (14)	Strategic – not share too much data, intellectual property (14) Financial sides and agreements (15)	Risk of going over to another party (16)
Summary of Characterizing SCT RQ4	Specifically for the Service Logistics domain. Holistic approach: IT layer, IT architecture, value propositions, stakeholders. A holistic approach, a view from different angles (that makes it complex). Discussed main topics: Ownership, stakeholders, adding value for every party, OEM/customer/add value and changes via portals or SCT. Possible future of SCT.	Logistics sectors, in particular now Service logistics and towards (maintenance) services. ASML SCT example for their spare parts control. Requires a Coordination Centre or Supervising Entity, taking care of different interests and data sharing parts for all stakeholders involved. Discussed main topics: Ownership, Data sharing and Collaborating within the network of stakeholders. Possible future of SCT.	Focus on Services. Gaining services with our customers via an online connection. Access and use common data with stakeholders. Discussed main topics: remote support, maintenance, services to customers. All parties accessing and sharing data with each other within the network (collaboration). What is possible from their organization already, technology wise and supporting their customers. Ownership. Possible future of SCT.	You need Governance, People (Teams), Technology; Systems and Data. Discussed main topics: SCT within organization of interviewee and specifics thereof, how it works. Possible future of SCT.

Code name(s) **Code 17-22**	Service Logistics domain (17) Holistic approach (18)	Service logistics (17) Services (19)	Services (19) Access and share data (20)	Governance (people/teams) (21) Technology (22)
Summary of Ownership SCT	Distributed structure (rather than a central organization). Where everyone is owner of a piece of it, and others can get access to that. If central, need a third-party to maintain it. Side note: Maybe even use blockchain technology to organize who can have access to data?	Coordination Centre (supervising entity) that is taking care of the interests and privacy. Who is in control doesn't necessary point to a single person or organization, it should be an independent organization (example of Broker in sales, independent regulator). Could also be a set of agreed rules. It could also be an external organization.	Could be an external party. If looking at sharing data, the intellectual property it might be best to have an external party to set up and control the SCT. Also easier to get Trust with a third-party as opposed to the customer being in control. So, agreement on an equal party in the network, with one goal, one purpose (set up and control).	Not a direct question asked in this interview. In the case of this interviewee, they are managing and controlling the SCT for their customers. The customers are able to log on their system(s) and have insight in to the real-time data. Some of the (logistical) activities are outsourced (to a third-party) by the organization of the interviewee.
Code name(s) **Code 23-29**	Distributed structure (23) Central organization (third-party) (24)	Coordination Centre, independent organization (Broker, independent regulator) (25) External organization (third-party) (26)	External organization (26) Trust easier in third-party, equal party (27)	Self-organized (28) Outsourced activities (29)
Summary of Setting up SCT	First we need to glue together processes with the other organizations within the network, students typically do this work for us. We will have discussions on the value proposition, on how the business model will change and concerning the new type of relationship that will occur (which is the biggest challenge). Make it visible and allowing it to be visible.	There should be a Coordination Centre for the data sharing, intellectual property side. Operational coordination (given a particular service request) and strategic coordination (setting the guidelines on how we are going to collaborate, use each other's services and financial sides). This coordination always needs to happen, similar to large service contracts.	Main concern is protecting data that is shared with the other parties within the network. There should be agreements (contracts) on what to share and how to protect the data. Three aspects: technology (hardly an issue), intellectual property (data sharing part) and there is the financial side to it.	Need Governance, people who look at the complete picture (ideally they are responsible for the SCT and work towards the common goal). Below that, you need Teams to monitor, respond and improve (specialistic knowledge). This means you need People and therefore also Technology; Systems and Data (databases, views) to get an overview of the complete network.

Code name(s) **Code 30-40**	Glue together processes (30) Value proposition (31) Changing relationships (32)	Coordination Centre (33) Intellectual property (34) Operational coordination (35) Strategic coordination (36) Financial agreements (37)	Technology (38) Intellectual property (34) Financial agreements (37)	Governance (39) People (human organization) (40) Technology; Systems and Data (38)
Summary of Future SCT	Clearly a demand for more. Demand on how to share information across all the stakeholders within the network.	Inescapable that the SCT will become more mature and will advance. Reason is that the technology is becoming more complex which demands expertise. The growing complexity of technology and the help/use of technology will increase maturity.	More towards Remote Services and Remote Access in the future. Maintenance and repair from a distance is possible and already being requested.	More towards automation and robotization. Improving customer portals, real-time data. Improving visibility for own organization and customers, looking for new forms of collaborating.
Code name(s) **Code 41-46**	Clear demand – maturity (41) Demand organizations (42)	Clear demand – maturity (41) Technology development and complexity (43)	Clear demand – maturity (41) Towards remote servicing, access and maintenance (44)	Clear demand – maturity (41) Demand organizations (42) Customer demand (45) New forms of collaborating (46)

Table 11 – Analytical framework of the interview data

The analytical framework of the interview data is displayed in Table 11 on the previous pages, which is based on the interview data and provided with a summary of the most important answers from the interviewees, and the added code names. The findings of this research are elaborated on further below, including statements and summaries of the interviewees.

4.1.1. Stakeholder perception on the Service Control Tower concept

A question was raised to the interviewees of how the Service Control Tower concept is perceived (RQ2).

Research findings showed that all four interviewees perceive a Service Control Tower as the means in order for organizations to gain value in certain aspects such as collaboration, an overview within the network and data sharing. One of the interviewees (interviewee B) started its answer with the history of the Service Control Tower by stating the following:

"Originally the SCT concept appeared at 4C, to collaborate both horizontally and vertically. Example hereof are transport companies (in principle independent) which use each other's trucks and they have to collaborate to have higher load and drive less kilometres. This would require a contract and that is where it is all about. Another part of the history is that of the specific Service Control Tower with a central control when implemented within one organization. When different partners should collaborate it becomes a joined value of cooperation and the question is how to distribute this across partners and who is controlling that? That is the aspect of SCT in particular. So it started more with transport, physical distribution centre and more recently the notion found its way in other logistics sectors as well and more particular in service logistics and services maintenance services more general."

Two (Interviewee A and D) out of the four interviewees indicated that a Service Control Tower should provide an overview of the complete network, with all the stakeholders involved in the chains. In line with the answers given by Interviewee A and D, Interviewee C indicated that a Service Control Tower means more and better access on systems and to share more data with each other. One (Interviewee D) out of the four interviewees had a specific and unique vision on the Service Control Tower of which it evolves around the Team(s) of people, they are called the Service Control Tower. Thereby, these people work with systems, these systems should support the people.

Interviewee	Answer
Interviewee A	*"The SCT is connected to Service Logistics. The complexity of supply chains is becoming more complicated because more stakeholders are involved. There is a clear demand to get an overview of all the complete chain with all the stakeholders involved in the chains. So there is a need on board of the ship and maybe there is a spare available somewhere in the chain at a supplier location: how does that fit together and how can a connection be made? At the end it should be an overview of the complete network."*
Interviewee B	*"Some people talk about Control Centres and in particular also now on Service Control Centres within a company. For example, ASML, the manufacturer of lithography systems in Veldhoven, is using SCT for their spare parts control. That is entirely within one cooperation. So you might say there is still a sort of central control. The more interesting part comes when there is no central control, but when actually different partners should collaborate, but each out of their own responsibility. And when you are talking about joined value of cooperation, that is typically the case where you have different partners that achieve, that attempt to collaborate to achieve jointly a higher value. And of course, then the final question is*

	how to distribute that joined value in an appropriate way across partners. But more over is who is controlling that? That is the aspect of SCT in particular.”
Interviewee C	*“A SCT or a control network, to gain services with our customers by an online connection. The CT means that we can get more and better access on the systems and share more data required for maintaining and servicing the systems.“*
Interviewee D	*“A Control Tower is a large Central Team or different Teams of people. Thereby, these people work with Systems. These Systems should support the people (…). In the end you want an overview of the complete network.”*

Table 12 – Main findings of the stakeholders perception on the Service Control Tower

4.1.2. The drivers and barriers to implement a Service Control Tower

A question was raised to the interviewees of what the perceived drivers and barriers to implement a Service Control Tower (RQ3). This subsection will start with the drivers, followed by the barriers as perceived by the interviewees.

Drivers

Research findings showed that drivers to implement a Service Control Tower are based on customer demands (in availability and in visibility), technological developments and Network Value Proposition, an increase of collaboration within the network. In addition, interviewee A and C imply that implementation towards a Service Control Tower increases when there is trust amongst the stakeholders in the network.

Interviewee	Answer
Interviewee A	*“The availability in spare parts, to be at the right place at the right time. We are looking for a value proposition, a balance in the value proposition in the network. So that everyone likes to contribute and gains something. Mutual trust, having no competition so everyone can do their job at best.”*
Interviewee B	*“Collaboration brings joined value and when you talk about Network Value Proposition (NVP), that is exactly the idea: collaboration brings more value.“*
Interviewee C	*“The technology (from our side) is ready to use. The advantage of the CT is that all parties can access and use that common data that we want to share. We can maintain and intervene instantly, real-time, this benefits both the OEM and the customer. For us there is a long term added value. (…). I think it is easier to get Trust with a third-party, than if we get the customer or us for instance as the party that controls the CT.”*
Interviewee D	*“There was a need from both, our own organization as from the customer. The CT grew organically along the years since implementation (which was 20 years ago). Perceived benefits for customers is not having to do all the logistics themselves, we do that for them. Furthermore, you have an overview, insights into the entire network, you see where things go wrong (Visibility), you have a team that reacts to improve things. You don’t have this without a CT.”*

Table 13 – Main findings concerning the drivers to implement a Service Control Tower

Barriers

The barriers to implement a Service Control Tower which are noted by interviewee B and C, consist of mainly strategic reasons. They stated that the natural resistance of not being in control (therefore minimizing risks) is one element, and the intellectual property is another element; it is scary to share too much of your data with other stakeholders. There is also a risk of losing market share, in case of competitors within the same network (and Service Control Tower) this is even more so the case. One out of the four interviewees (interviewee A) argued that organizations may only join when they have something to gain and that it is dependent on the business focus of the entity whether they are willing to join an experiment such as a Service Control Tower. Interviewee D implied the barrier of customers leaving your Service Control Tower for the outsourced (managing) party, which is considered as a risk more than a barrier.

Interviewee	Answer
Interviewee A	*"If there is only a small gain to reach when the SCT is implemented (example of only a small part which is needed once per year). It is also about what is the core business and business focus on each of the entities, are they willing to join such an experiment like a CT."*
Interviewee B	*"Strategic reasons: First, there is a natural resistance of not being in control. That is why the Strategic part is so important, beforehand you should make sure that the risk is minimal. Second, there is also a risk of losing market share, for instance in cases of competitors within the SCT. Third is to not share too much of your data. If there already is a form of collaboration and trust in place, it most likely be easier to go for an SCT and hand over some authority in it."*
Interviewee C	*"It is scary to share your data with other parties, people are not always eager to share data with others. I think that is the main concern about any sharing of data in a SCT. The Intellectual Property and the financial sides and agreements are elements."*
Interviewee D	*"The CT is partly outsourced, which changes boundaries within the organization concerning what to outsource and what not, and where you draw the line. Customers might even think: why not go to the outsourced party straight away? This is being adjusted by re-introducing certain tasks internally again."*

Table 14 – Main findings concerning the barriers to implement a Service Control Tower

4.1.3. Characterizing the concept of a Service Control Tower

In this subsection the research sub-question which will be answered is RQ4: How can the concept of a Service Control Tower be characterized?

Interviewees on describing and characterizing the Service Control Tower concept
The characterizing elements (excluding the elements from the previous subsections concerning perception, drivers and barriers) on the Service Control Tower concept from the conducted interviews are as follows:

- Interviewee A: "*Specifically for the Service Logistics domain. (…). A Holistic approach. IT layer, IT architecture, value propositions, stakeholders. Holistic approach you should have view on that from several angles. That makes it complex."*
- Interviewee B: *"Logistics sectors, in particular now Service logistics and towards (maintenance) services. (…). Requires a Coordination Centre or Supervising Entity, taking care of different interests and data sharing parts for all stakeholders involved."*
- Interviewee C: "*Focuses on Services. Gaining services with our customers via an online connection. (…). Access and use common (shared) data with stakeholders."*
- Interviewee D: *"You need Governance, People (Teams of people), Technology; Systems and Data*."

On the following pages there are multiple subsections elaborated which consists of elements of the Service Control Tower concept and thereby consists of the discussed main topics during the interviews with the stakeholders. These elements consist of the following:

- Ownership / Control / Distribution / in charge of and managing a Service Control Tower
- Setting up a Service Control Tower
- The future of Service Control Towers

After the elaboration of these elements, this chapter continues with a section on the Service Control Tower concept and its main characterizing elements.

Ownership / Control / Distribution / in charge of and managing a Service Control Tower

Research findings showed that a Service Control Tower can be centralized or decentralized. All of the interviewees perceive an external or third-party as an option to be in charge of and setting up the Service Control Tower as a valid possibility. Interviewee C thereby stated that it may be easier to gain trust in case of partnering with a third-party as opposed to one of the participating organizations. The interviewees also noted different opinions and multiple possibilities for the managing of the Service Control Tower. In case of Interviewee A this seems to be dependent on whether there would be a distributed structure or a central organization within the Service Control Tower. On the other hand, interviewee B argued that an independent regulator such as a Broker could be in Control.

Interviewee	Answer
Interviewee A	*"I don't have a clear answer to that, how we can organize that. In my mind it is kind of a distributed structure. Where everyone is owner of a piece of it, and others can get access to that. Then I compare it to what we have in our operating systems of the radar systems, that is also a distributed architecture. That means that there are data sources and data users. When several radars are used, information can come from several of them, and the data with the highest quality is chosen for processing. To a certain extend I was myself thinking about a kind of distributed structure rather than a central organization. (…). Do we do it central or distributed? If you do it central you probably need a third-party to maintain it."*
Interviewee B	*"And a lot of people may feel that there should be a sort of supervising entity which is not the same as a central control let me stipulate that. That there should be a sort of coordination Centre, that is taking care of the different interests of the collaborating partners without revealing all the information to all partners. (…). Who is in Control does not necessarily point to a single person or a single organization, it should be a sort of an independent organization. In sales organizations we often see the system of a Broker. A Broker acts as in between let's say the market and the producers so to speak. And is a sort of independent regulator. But you may even come to a solution in which there is not such an independent person or organization but a set of rules that have been subscribed by all parties in the collaboration." (…). Short discussion in interview about the political element, whether or not one of the customers or service organizations could be controlling the Service Control Tower, or an external organization: "Yes, I can also wonder is there an alternative party who might take that role? I would not know, I was thinking about Company X, for example, the world insurer but don't think they can deliver."*
Interviewee C	*"It could also be an external party. If you look at sharing data and maintaining your intellectual property, perhaps it would even be best to get an external party to set up the SCT and control all the aspects that we just discussed. (...). I think it is easier to get Trust with a third-party than if we get the customer or us for instance as the party that Controls the Control Tower. (…). They can be a sort of equal company within the entire Network. Only they do not provide their systems or their data or users, so they are only there for getting the Control Tower in operation and seeing that all partners work conform the agreements. So, I think they are an equal party in the entire Network. But only with one goal, one purpose."*
Interviewee D	Within the interview there was not a direct question raised concerning the controlling part of the Service Control Tower. The interviewee did disclose that in their existing Service Control Tower their own organization is Controlling and Managing the CT for its customers (self-organized). Customers are able to log into their system and have insight into the real-time data. Customers outsource (logistical) activities to this organization.

Table 15 – Main findings on the Control and managing of a Service Control Tower

Setting up a Service Control Tower

Research findings showed that there is work to be done before organizations can implement a Service Control Tower, which is noted as a prerequisite. Interviewee A argued that within the involved network and stakeholders, they are currently working on 'gluing' or connecting the existing processes to each other. In addition, within the network there will be discussions, agreements and/or contracts made concerning multiple important elements for setting up a Service Control Tower; interviewee A and C stated the element of the Network Value Proposition. Thereby, interviewee B and C argued that the intellectual property, what information or data to share and how to protect this, which are essential when organizations want to set up a Service Control Tower.
Interviewee B and C also stated the financial agreements as an important necessity. Concluding on these necessities to set up a Service Control Tower, interviewee D stated Governance which encompasses elements beforementioned in this subsection in line with statements by interviewee A, B and C.

Interviewee	Answer
Interviewee A	*"We first need to glue together the processes, our processes with that of our collaborating partner, we do that by letting students work together. How is the total flow? And how can that flow be either visible or even improved? And making it visible is with a SCT, and improving it is a matter of doing the right things in the right processes. (…). Making it visible and allowing it to be visible (right now it is still a very closed world). (…) But what I really see is that when you want to go to new solutions, you will have discussion on the value proposition. You will have a discussion on how the business model will change. But last but not least, there will be also another type of relationship, I think there is the biggest challenge to find out what the new relationship is."*
Interviewee B	*"That there should be a sort of coordination Centre, call it that way, that is taking care of the different interests of the collaborating partners without revealing all the information to all partners. That is of course also essential, how much information is needed to share to come to such a collaboration? (…). Operational coordination and strategic coordination; namely the strategic coordination is basically setting the guidelines on how are we going to work together. The operational coordination is much more given a particular service request (examples follow in interview transcript). (…). That sort of coordination is something that always needs to happen. This is also the case in a large service contract in which different partners are involved – but that is typically on the operational part. In strategic part it is much more how much and in what way are we going to collaborate, in which we are we going to make use of each other's services (the joint ship or equipment) and how is that financially then finally compensated."*
Interviewee C	*"I think that one of the main concerns is: How do we protect data… that we share with our customer with our competitors or everyone else involved within the Control Tower. And I think that the concern is therefore, well for all parties. I think that they have got the same concerns about that. I think that is one of the major issues for getting a Control Tower working. (…). Get agreements (contracts) on what to share and how to protect (the data). (…). There are I think three aspects: the technique, which is hardly an aspect. That is the intellectual property (data sharing part), and then there is the financial side or obstacles."*
Interviewee D	*"You need Governance, people who look at the complete "picture". Ideally they are responsible for the complete SCT and work towards the common goal. Below that you need Teams, to monitor, respond, improve processes. If you need Teams you need People and therefore also need Technology; Systems and Data (overview of complete network). Databases, views, visibility."*

Table 16 – Main findings on what is needed to set up a Service Control Tower

The future of Service Control Towers

Research findings showed that all of the interviewees agreed that it is certain that the future of Service Control Towers will mature more. The interviewees mentioned reasons for this mainly as due to technological developments and increasing demand from both the customer and the organizational side. In addition, the interviewees mentioned that sharing (information and/or data) and forms of collaborating within a network is evolving as well.

Interviewee	Answer
Interviewee A	*“There is clearly a demand for more. There is a demand on how to share information across all the stakeholders in the network.”*
Interviewee B	*“It is inescapable that SCT will become more mature and that it will advance. Simply because technology is becoming more and more complex. This complexity demands expertise which organizations will outsource or collaborate with partners they trust. Progress in SCT will be inevitable due to the growing complexity of technology and the help and/or use of technology.”*
Interviewee C	*“More towards Remote Services and Remote Access in the future. Maintenance and repair from a distance is possible and already being requested.”*
Interviewee D	*“Even more towards automation and robotization. Improving Customer Portals, connected to the existing CT and contain real-time data. Improving Visibility within the systems for both our own organization as for the customers. Further into the future possibly moving towards a new collaboration mode with our competitor in case of a shared customer, which would benefit the customer mostly: the customer will be able to see data from both the organizations on only one system (company’s software Suite) where right now the customer has to look into multiple systems (both company A and company B systems). This concerns only sharing the necessary data with each other / organizations within the network.”*

Table 17 – Main findings on the possible future of the Service Control Tower

5. Design of the Service Control Tower concept

This chapter consists of three main design elements of the Service Control Tower concept. The conducted literature review and interviews have made a first elaboration of the Service Control Tower concept within this research which is summarized visually in **Fout! Verwijzingsbron niet gevonden.** and Figure 15 in the upcoming subsection (5.1). Second, the SWOT analysis (5.2) and Business Model Canvas (5.3) are created based on the characterizing elements of the Service Control Tower concept, the literature review and interviews. The SWOT acronym is derived from: Strengths, Weaknesses, Opportunities and Threats, which is a widely used tool to visualize studies or applied within organizations (Sarsby, 2016). The Business Model Canvas (BMC) is created of nine building blocks which can help to visualize, design and understand for instance concepts or tools for businesses Osterwalder, Pigneur, and Tucci (2005).
Both the SWOT analysis as the BMC were chosen as a way to visualize the collected data throughout this research, as they are easy to understand and widely used within all kinds of studies, settings and organizations. Both of these tools are part of the design artefact to help in visualizing, understanding and characterizing the Service Control Tower concept.

5.1. Characterizing the Service Control Tower concept

In this subsection the research sub-question which will be answered is RQ4: How can the concept of a Service Control Tower be characterized?

This section provides a summary of the previous section, where each of the elements and characterization were elaborated on extensively.

Summarized additional data from the interviews (previous section 4.1.3.)

- Service Control Towers are specifically for Service Logistics, services domain.
- The ownership, control, distribution, in charge of and managing of the Service Control Tower can be arranged centralized or decentralized and agreed upon in multiple different scenarios. The interviewees mentioned external, third-party, distributed structure, central organization (coordination centre of supervising entity), and an independent regulator (e.g. Broker).
- On setting up a Service Control Tower there are some prerequisites stated by the interviewees. The processes need to be 'glued together', there are agreements to be made (for instance financial and business models), the Network Value Proposition needs to be clear, the Intellectual Property and Governance were mentioned.
- Mentioned elements which are necessary within a Service Control Tower are Governance, People (Teams of people), Technology; Systems and Data. In addition, a holistic approach was mentioned whereby an IT layer, IT architecture, value propositions, stakeholders will be involved.
- On the future of the Service Control Tower it was stated that it is certain that it will mature more as there is a demand (from both customers as organizations themselves) for more and there are technological developments which can make it happen. In addition, evolving forms of sharing data and collaborating within a network will impact the future of Service Control Towers as well.

Literature review summary on the Service Control Tower

Characterizing elements on the Service Control Tower concept from the conducted literature review:

- Evolves around the Service Logistics domain (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021; Topan et al., 2020; Van Laarhoven, 2009).
- A Service Control Tower could be controlled and managed by an OEM or third-party (Arts et al., 2019; ProSeLoNext, 2021), similar to the core Control Tower ownership possibilities.
- The need for a Service Control Tower is determined by two factors: the degree of an organization's servitization and the complexity of organizing the service logistics domain (e.g. after-sales services) (CQM, 2019).
- The structure of the Service Control Tower consists of five layers; The supply chain business layer, the data perception layer, the data storage and control layer, the data application layer and the operational planning layer (Topan et al., 2020). These five layers of the Service Control Tower system further align with the earlier implications on the significant importance and presence of both data and technology within the Control Tower and Service Control Tower concepts.

Data from Chapter 2: Evaluation of the Service Control Tower literature outcome thus far

The Service Control Tower entails a service-oriented approach, where key stones such as Service Logistics, (digital) Servitization and Innovation in combination with Data, Technology, Digitalization and Collaboration (forms) within a network (part of the main characteristic of human organization) come to light especially within the existing literature on the Service Control Tower concept. When excluding the Service Logistics and Servitization elements, the main findings on the Service Control Tower concept are similar to the findings on the core Control Tower concept.

The Service Control Tower characteristics from literature data and interview data from the previous section 4.1.3. and this subsection combined are visualized in Figure 14 and Figure 15 (both consisting of the same elements, but in a different form of visualizing).

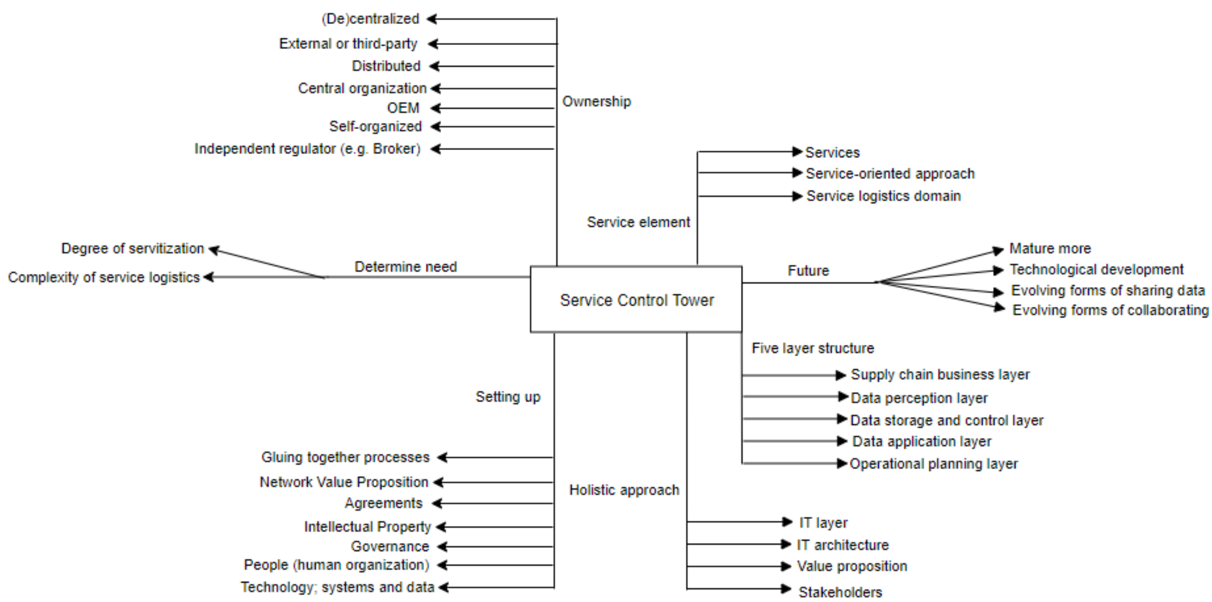

Figure 14 – Knowledge graph of the characteristics of the Service Control Tower concept

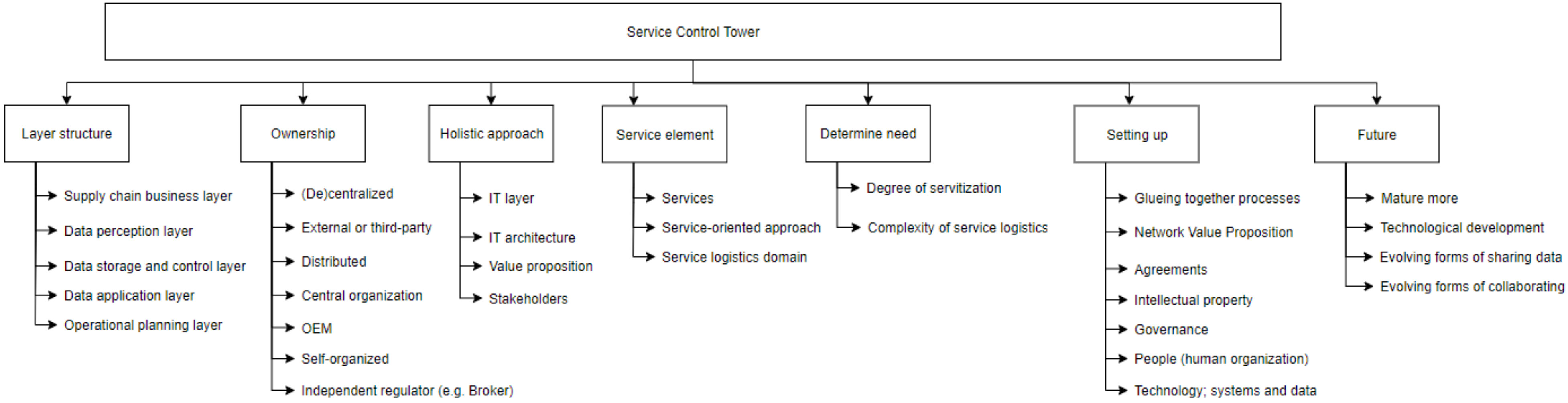

Figure 15 – Service Control Tower class diagram

5.2. SWOT analysis of the Service Control Tower concept

In order to give the Service Control Tower concept more visual context and provide a means to analyse the outcome of the literature review and interviews, a SWOT analysis (matrix) was created in this subsection. The SWOT acronym is derived from: Strengths, Weaknesses, Opportunities and Threats (Sarsby, 2016). He stated that SWOT is a widely used and popular tool, it is used in (business) studies and in organizations. He argues benefits such as SWOT being easy to understand, applicable on multiple levels (SWOT for a whole organization or a product) and it is highly visual. In the context of this research, a SWOT analysis helps to visualize on the Service Control Tower concept thus far, its findings from both literature review and the conducted interviews.

Each of the SWOT indicators contain factors of the Service Control Tower concept in Table 18. After the table, each of the factors are elaborated on. According to Sarsby (2016) Strengths and Weaknesses are internal which implies that these contain factors which organizations have control over. He argues that on the other hand, Opportunities and Threats are external which implies that these contain factors over which organizations have little or no control. Thereby, he states that Strengths and Opportunities are helpful factors as these support success, meanwhile Weaknesses and Threats are harmful factors as these block success.

Strengths	**Weaknesses**
Collaboration Real-time processing/activities	Technology
Opportunities	**Threats**
Technological innovations End-to-end overview Evolving concept Ownership, controlling and managing	Competitors Ownership, controlling and managing Intellectual property

Table 18 – SWOT analysis of the Service Control Tower concept

The Strengths of a Service Control Tower consists of two main factors: Collaboration and Real-time processing of data (such as being able to perform all the activities e.g. monitoring and decision-making). More collaboration within a network of stakeholders or an improved collaboration form or mode can provide the value proposition and this collaboration can result in for instance improved trust and sharing data. The factor of collaboration has been a topic of discussion within the literature review (Hofman, 2014; Liotine, 2019; Maneengam & Udomsakdigool, 2020; Trzuskawska-Grzesińska, 2017; Vanvuchelen et al., 2020) and the conducted interviews (Interviewee A, B and C) as well. The real-time processing and activities within the Service Control Tower consists of the Core function of the concept. The factor of real-time processing and activities has been a topic of discussion within the literature review (Baumgrass et al., 2014; Liotine, 2019; Rustenburg, 2016; Shou-Wen et al., 2013; Trzuskawska-Grzesińska, 2017; Van Laarhoven, 2009) and the conducted interviews (Interviewee C and D) as well. The two strength factors are internal as they are concerned with implementing the Service Control Tower concept, the stakeholders can control them.

The Weaknesses of a Service Control Tower consists of the following factor: Technology. Technology is considered a weakness as a number of different technologies (e.g. ML and AI) are still in a novel phase of development (Liotine, 2019). Moreover, technology was also considered the main reason as to why there were no Control Towers before recent years (Alias et al., 2014b). In addition, there is a high reliance on Technology within a Service Control Tower (Liotine, 2019; Shou-Wen et al., 2013). This can get even more complex when multiple technologies are being used within the environment and several of these technologies are still considered as work in progress or evolving over time (De Vasconcelos & Kaminski, 2013; Liotine, 2019; ProSeLoNext, 2021). When combining these technology-related statements, in current stages of development the factor of Technology is considered as a Weakness within the SWOT-matrix. This factor of Weakness is considered internal, which implies that organizations can control or influence them, for instance by hiring the correctly trained employees taking care of it (e.g. data scientists or managers). Moreover, Interviewee B stated that Technology is becoming more and more complex which demands expertise from employees.

The Opportunities of a Service Control Tower consist of the following main factors: technological innovations, an end-to-end overview, evolving concept and the ownership, the controlling and managing of the Service Control Tower. As stated in the literature review and statements by all of the conducted interviewees, multiple technologies and innovations are still progressing (e.g. ML, AI, blockchain) over the years to come and therefore this brings opportunities for the Service Control Tower concept to evolve along with the technological possibilities (Arts et al., 2019; Liotine, 2019).
This also explains the evolving concept factor, as the Service Control Tower is still such a novel concept and will need more research and development to follow and mature. Both literature sources (Hofman, 2014; Liotine, 2019; Maneengam & Udomsakdigool, 2020; Trzuskawska-Grzesińska, 2017; Vanvuchelen et al., 2020) and interviewees (Interviewee A, C and D) stated that in the end the Service Control Tower concept should provide an end-to-end overview for all the stakeholders within the network. However, this is not yet achieved and therefore can be considered an opportunity. The factor of ownership, controlling and managing the Service Control Tower can result in multiple different options, for instance by a vendor, the OEM or self-organized. This factor is elaborated on both in literature sources (Arts et al., 2019; Cooke, 2014; De Vasconcelos & Kaminski, 2013; Maneengam & Udomsakdigool, 2020; Trzuskawska-Grzesińska, 2017) and statements by all of the interviewees within this research. As there are multiple options and choices of ownership to decide on, this provides opportunities for either stakeholders within the network or for (neutral) external parties. These Opportunities factors are in little control of the involved organizations, which means that they are external.

The Threats a Service Control Tower consist of are the following main factors: possible competitors, the ownership, controlling and managing of the Service Control Tower and the intellectual property. The factor of possible competitors entails two sides; one is the possibility that organizations may go for another similar concept than the Service Control Tower. This could for instance be the 4-C concept which was elaborated on shortly in the literature review chapter of this thesis (Van Laarhoven, 2009). The other side to the competitor factor is based on an interview outcome, where interviewees (Interviewee B and C) mentioned that organizations may not want to go for a Service Control Tower concept as this entails more data sharing within the same network and there may be multiple competing organizations active in the network. This implies a risk of losing market share for those organizations, which is considered as a significant barrier. The second factor is the Ownership, controlling and managing of the Service Control Tower, which is also a factor which has been elaborated on in both the literature review as by the interviewees within this research. This factor indicates the issue of not being in control of something yourself, which is considered as a barrier to implement a Service Control Tower within a network. Depending on who is going to control and manage the Service Control Tower, this can become more threatening to organizations when the party in control is within their network and they are not eager to share their data with each other. This threat has a partial overlap with the Intellectual property factor, where the not being eager to share data with each other is also the perceived barrier. These factors have to do with organizations wanting to minimize risk; going for a new concept such as the Service Control Tower, might bring more change than they intend. These factors can therefore possibly block success and are considered external as organizations would have to make a decision on implementing a Service Control Tower within their network.

5.3. Business Model Canvas of the Service Control Tower concept

The Business Model Canvas (BMC), as proposed by Osterwalder et al. (2005) consists of nine building blocks: key partners, key activities, key resources, value propositions, customer relationships, channels, customer segments, cost structure and revenue streams. Osterwalder et al. (2005) state that combining these blocks is for the main purpose of helping to visualize, design and understand for instance concepts and tools for businesses and their business models or business logic. In this research, the BMC was created to visualize what a Service Control Tower entails.

The BMC of the Service Control Tower concept is shown in Figure 16**Fout! Verwijzingsbron niet gevonden.** and was created based on the literature review outcome as provided in Chapter 3 and the interview findings as provided in the previous sections of this chapter. This includes both findings from the core Control Tower concept (the aspects that the core and Service Control Tower concept both have in common) as finding from the Service Control Tower concept.

Key partners
The key partners or partner network consist of the complete network which is involved in the value proposition (e.g. concept in this case) (Osterwalder & Pigneur, 2010). Within a Service Control Tower the key partners may vary, depending on the type of network (such as intraorganizational or interorganizational) and industry (in this thesis for instance the maritime sector stakeholders). In the context of this research, the key partners are based on the interorganizational stakeholders (as stated in literature sources and the conducted interviews) and are as follows: Customer, Asset owner, OEMs, Logistics service provider, External party (e.g. a third-party or vendor), 3PL and/or 4PL.

Key activities
The key activities are considered the main activities of the BMC subject (Osterwalder & Pigneur, 2010). There are main activities to the core Control Tower concept which are also applicable to the Service Control Tower concept, whereas the activities within the Service Control Tower concept are more specified for the service logistics domain (e.g. actual stock of spare parts or supply of new spare parts (Arts et al., 2019)). The key activities are mostly enabled by data and technology and consists of the main functions of the Service Control Tower: the continuously and real-time activities of data collection, data processing, monitoring, decision-making, corrective and preventive actions, facilitation and coordination within the network of stakeholders. This list of activities apply to the core concept of the Control Tower as well as they are kept broad and applicable for both (when specifying more, distinguishing between different Control Tower types can be done).

Key resources
The key resources consist of all the necessities which are required to offer and deliver the BMC or business model element (Osterwalder & Pigneur, 2010). In the context of the Service Control Tower concept there are three main elements which are required in order for the concept to be implemented: Technology (e.g. ICT infrastructure, data, technologies), Human organization and Processes. These elements are main elements for both the core Control Tower as for the Service Control Tower concept.

Value proposition
The value proposition consists of the elements of which a company (or concept) brings value to the customer or user (Osterwalder & Pigneur, 2010). The value proposition elements are based on the findings from both the literature review and the conducted interviews and combined entails the following list of value adding elements:

- Supply chain visibility (Cooke, 2014; Liotine, 2019; Trzuskawska-Grzesińska, 2017) and stated by Interviewee A and D.

- Transparency (Maneengam & Udomsakdigool, 2020) and stated by Interviewee D.
- Sharing data amongst stakeholders within the network (Hofman, 2014; Vanvuchelen et al., 2020) and stated by all of the Interviewees.
- Availability (e.g. of products in the chains at the right time)(Rustenburg, 2016) and stated by Interviewee A.
- Improved trust (Maneengam & Udomsakdigool, 2020) and stated by Interviewee A, B and C.
- More collaboration and maybe in different new forms and modes, all of the interviewees elaborated on collaboration, on which Interviewee D elaborated on the most.
- A central coordination and hub (Accenture, 2015; Maneengam & Udomsakdigool, 2020) and stated by Interviewee B.
- More efficiency as data and technology are combined in the Service Control Tower (Alias et al., 2014a; Parviainen et al., 2017) and stated by Interviewee B, C and D.
- And may even bring lower costs and/or a higher revenue for organizations within the network (Eruguz et al., 2017).

Customer relationships
The customer relationships consists of how the relationships with the customer segments are agreed upon and how it has a connection with the business model (Osterwalder & Pigneur, 2010). In the context of the Service Control Tower concept, the customer relationships are amongst the stakeholders within the network. Automated / robotized is a factor involved as the Service Control Tower contains a lot of ICT-related components (this factor could also be named as Technology), whereas certain parts can completely be technology-driven and no manual or personal activity is involved (e.g. Interviewee D stated completely automated calls and alerting to be done by robots). Moreover, collaboration within the network is a visible and important factor, with collaboration a certain amount of (to be determined) sharing information and data is involved as well. Based on the preferences by the organizations which are involved in the network, collaboration can entail multiple forms as for instance they can be self-organized, set-up a community or co-create for a long-term possibility of collaborating within the Service Control Tower.

Channels
The channels block consists of the ways a company communicates with the customer segment (Osterwalder & Pigneur, 2010). In the context of the Service Control Tower concept, the channels of Online and (Project) Meetings are noted as these two channels will be necessary to discuss, agree and implement a Service Control Tower concept. Multiple meetings will usually take place in order to implement such a significant change for organizations within a network. Meetings can either take place in person or online, as well as the sharing of meeting notes, documentation and agreements which are the results of these meetings.

Customer segments
The customer segments refers to the different groups (e.g. people, organizations) that the BMC subject wants to reach (Osterwalder & Pigneur, 2010). In the context of this research, the customer segments can consist of different types of groups which may vary. This could entail groups within the maritime sector (e.g. OEM, asset owner, user or customer) but also a (logistics) service provider, 3PL or 4PL or even a large professional firm (vendor) if chosen for this direction as the ownership of the Service Control Tower. Moreover, government could also be involved in the interorganizational setting of the Service Control Tower and therefore be within the customer segment. Customer segments can vary based on specific situations, settings and stakeholders.

Cost structure
The cost structure consists of all the costs that are necessary to operate the business model (Osterwalder & Pigneur, 2010). In the context of the Service Control Tower there are three types of costs distinguished: the purchase of the Service Control Tower for the implementation phase, the Maintenance of the Service Control Tower and the Servicing of the Service Control Tower. These types of costs are agreed upon in an official (service) contract.

Revenue streams
The revenue streams block consists of the ways the financial sides are taken care of and generated from the customer segments (Osterwalder & Pigneur, 2010). In the context of the Service Control Tower there are three different types of revenue streams defined: the Setting up of the Service Control Tower costs, the costs of the maintenance of the Service Control Tower and the licensing or also called the contractual agreements and costs stipulated in those agreements. These types of revenue streams are agreed upon in an official (service) contract.

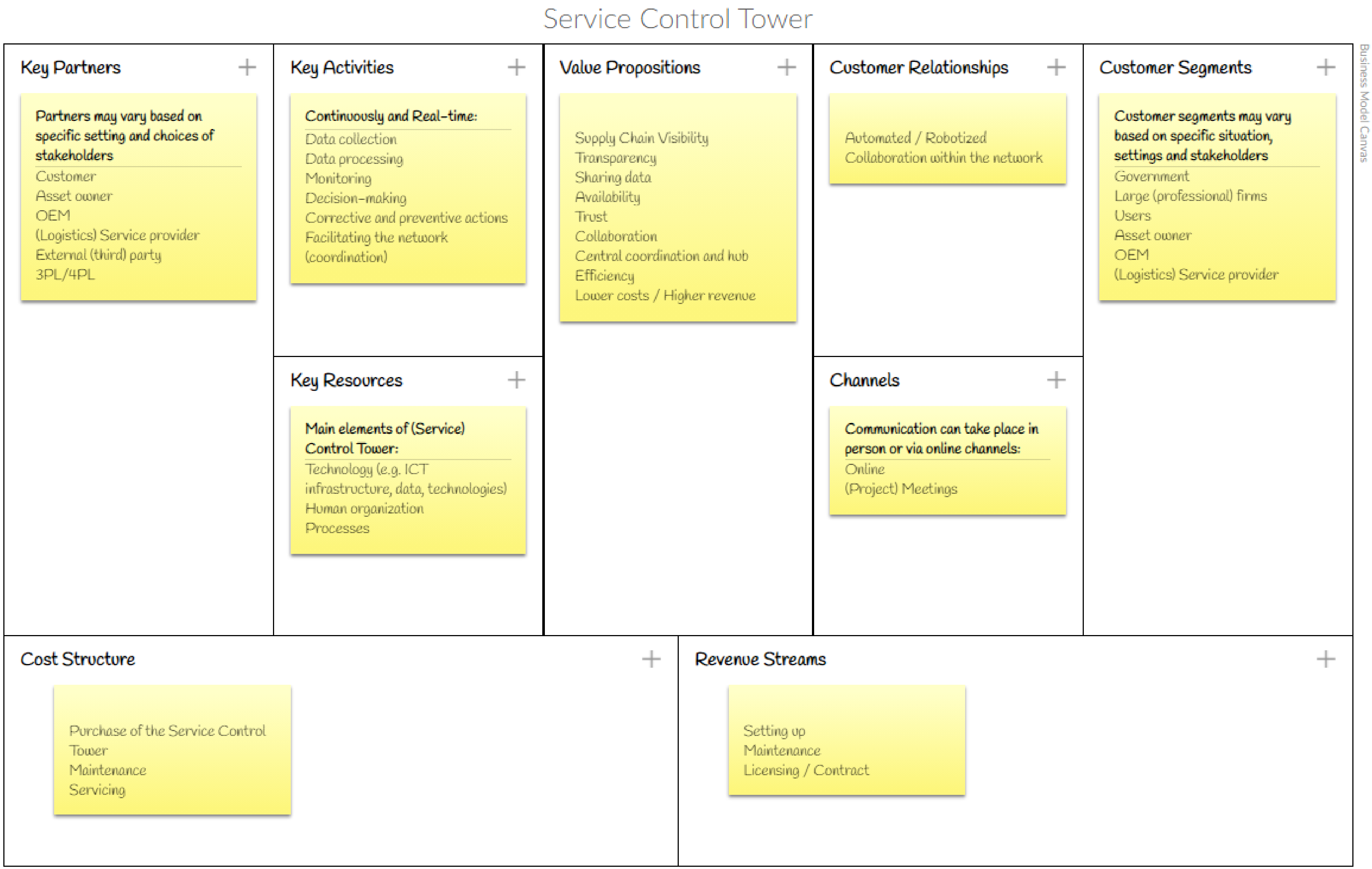

Figure 16 – Business Model Canvas of the Service Control Tower concept

6. Verification and validation of the Service Control Tower concept

The previous chapter elaborated on the Service Control Tower outcomes from the conducted interviews and designing an artefact (i.e. describing and characterizing the SCT concept, creating a SWOT and BMC) based on the interviews and literature review from within this research.
This chapter consists of the verification and validation of the total outcome of the Service Control Tower concept. Through an additional interview (Interviewee E) and literature review, the final verification and validation of the Service Control Tower concept was conducted.

6.1. Verification and validation from additional interview data, Interviewee E

The final conducted interview was conducted to verify and validate the most important aspects and elements as elaborated on extensively within the previous subsections. This final interview was partially prepared by questions, but also focused on an open conversation and discussion. Interviewee E is a consultant who operates in the Control Tower domain with organizations within The Netherlands and is a researcher concerning the Control Tower domain amongst other domains. Interviewee E confirmed the Service Control Tower concept within services (e.g. service decisions, spare parts planning, maintenance and management), the service logistics sector and did note that thus far it is a mainly Dutch oriented research field with mainly Dutch publications in literature. There were no additional main specific characteristics other than service logistics domain and the three known Control Tower main characteristics (processes, technology and human organization). The ownership, distribution and managing of a Service Control Tower was discussed shortly, where there was a confirmation provided on that there are multiple ownership possibilities where the desired ownership is dependent on the specific situation, governance and setting of the organization(s). The possible future of the Service Control Tower was also discussed and the main conclusion of Interviewee E was that this is very speculative and uncertain. However, it was stated that Interviewee E also has the assumption that due to technology-driven, data-driven and decision-making developments and technologies such as big data, AI and ML, concepts such as the Service Control Tower still have a lot of room to mature and develop.

On the created SWOT-analysis, Interviewee E found it difficult to provide additional elements but did have small remarks and tips for further improvement. As the SWOT-analysis was based on both literature review and interviews, all of the elements in the SWOT-analysis have been referred to and confirmed. Interviewee E mostly had small additions and tips to further improve the SWOT-analysis and elaborated text of the SWOT subsection. There were no main elements added after the answer by Interviewee E.

For the BMC of the Service Control Tower, the first explanation of Interviewee E was similar to the SWOT, it was hard to add large additional elements or remarks as the outcome of the BMC was based on specific research through literature review and interviews. Within the interview all of the nine building blocks were shortly reflected on by Interviewee E. For the key activities block, interviewee E stated that the core Control Tower and specific Service Control Tower elements could be separated instead of combined in one list. In addition, possibly elements such as alerting and planning could be added. For the key resources it was mentioned that the list was incomplete, which has been corrected after the interview (human organization and processes were missing and were mentioned in the provided text of the BMC). Value Proposition block had the remark that it could be smaller or a broad look can be applied, instead of the current detailed list. A number of blocks had elements which are specific and can change when applying a Service Control Tower within a specific organization or network of organizations. Additional remarks by Interviewee E consisted of mostly small additions and tips to re-write some parts and lists within the BMC and text thereof, to look at it again critically and improve earlier findings for the final version of this thesis. The BMC could be improved by either creating more notes for the elements or choosing for instance different colours to indicate and visualize the figure more efficient. Final remark was to go over the elements within the BMC once more before submitting the final version. For the complete summary of the interview, see Appendix H.

6.2. Verification and validation from literature review and Interviewee A to E

The verification and validation of the Service Control Tower elements as described and visualized in the previous subsections of this chapter, has partially resulted from the initial literature review which was conducted within this research. Therewith, the literature sources are stated continuously. As an additional verification and validation of the literature review and the conducted interviews, the following list of characterizing the Service Control Tower has been assembled:

- Service Control Tower concept is specifically connected to the Service Logistics domain.
    - Literature verification and validation: either the after-sales service supply chain in specific was mentioned (CQM, 2019; Topan et al., 2020), or the broader service logistics domain (Arts et al., 2019; ProSeLoNext, 2021; Van Laarhoven, 2009).
    - Interview verification and validation: Interviewee A, Interviewee B and as an extra confirmation also clearly confirmed by Interviewee E. Three out of the five interviewees mentioned the service logistics domain in specific.

- The element of Ownership of the Service Control Tower has been elaborated on extensively within the previous subsections, therefore this section will contain a summarized version.
    - Literature verification and validation: A Service Control Tower could be controlled and managed by an OEM or third-party (Arts et al., 2019; ProSeLoNext, 2021), similar to the core Control Tower ownership possibilities which can be found on a separate subsection.
    - Interview verification and validation: For the answers by Interviewee A to D, the analytical framework in Table 11 and the ownership subsection are elaborated on.
    - Interviewee E verification and validation: The ownership, distribution and managing of a Service Control Tower was discussed shortly, where there was a confirmation provided on that there are multiple ownership possibilities where the desired ownership is dependent on the specific situation, governance and setting of the organization(s).

- The element of Setting-up the Service Control Tower has been elaborated on extensively within the previous subsections, therefore this section will contain a summarized version.
    - Literature verification and validation: The first subsection on the core Control Tower concept included statements from literature sources and what is needed for setting-up. For instance well-defined and managed processes are needed, as well as technology, data and a human organization (De Vasconcelos & Kaminski, 2013). For the Service Control Tower these elements are necessary as well. In addition, the need, depth and scope of the Service Control Tower have to be determined (CQM, 2019).
    - Interview verification and validation: For the answers by Interviewee A to D, the analytical framework in Table 11 and the setting-up subsection are elaborated on.
    - Interviewee E verification and validation: Interviewee E had no additional statements on setting-up the Service Control Tower.

- The element of the possible future of the Service Control Tower has been elaborated on extensively within the previous subsections, therefore this section will contain a summarized version.
    - Literature verification and validation: As currently the possible future of this new concept is still novel and speculative, the literature did not have any conclusive statements concerning this topic. However, Arts et al. (2019) did state that Service Control Tower development will be a great challenge but key for success.
    - Interview verification and validation: For the answers by Interviewee A to D, the analytical framework in Table 11 and the future subsection are elaborated on.
    - Interviewee E verification and validation: The possible future of the Service Control Tower was also discussed and the main conclusion of Interviewee E was that this is very speculative and uncertain. However, it was stated that Interviewee E also has the assumption that due to technology-driven, data-driven and decision-making developments and technologies such as big data, AI and ML, concepts such as the Service Control Tower still have a lot of room to mature and develop.

- SWOT analysis of the Service Control Tower
    - Literature review and interview verification and validation: For the SWOT elements which are retrieved from the extensive literature review and answers by Interviewee A to D, the analytical framework in Table 11 and the SWOT subsection are elaborated on.
    - Interviewee E verification and validation: On the created SWOT-analysis, Interviewee E found it difficult to provide additional elements or remarks. As the SWOT-analysis was based on both literature review and interviews, all of the elements in the SWOT-analysis have been referred to and confirmed. Interviewee E mostly had small additions and tips to further improve the SWOT-analysis and elaborated text of the SWOT subsection. There were no main elements added after the answer by Interviewee E.

- BMC figure of the Service Control Tower
    - Literature review and interview verification and validation: For the BMC elements which are retrieved from the extensive literature review and answers by Interviewee A to D, the analytical framework in Table 11 and the BMC subsection are elaborated on.
    - Interviewee E verification and validation: For the BMC of the Service Control Tower, the first explanation of Interviewee E was similar to the SWOT, it was hard to add large additional elements or remarks as the outcome of the BMC was based on specific research through literature review and interviews. Within the interview all of the nine building blocks were shortly reflected on by Interviewee E. For the key activities block, interviewee E stated that the core Control Tower and specific Service Control Tower elements could be separated instead of combined in one list. In addition, possibly elements such as alerting and planning could be added. For the key resources it was mentioned that the list was incomplete, which has been corrected after the interview (human organization and processes were missing and were mentioned in the provided text of the BMC). Value Proposition block had the remark that it could be smaller or a broad look can be applied, instead of the current detailed list. A number of blocks had elements which are specific and can change when applying a Service Control Tower within a specific organization or network of organizations. Additional remarks by Interviewee E consisted of mostly small additions and tips to re-write some parts and lists within the BMC and text thereof, to look at it again critically and improve earlier findings for the final version of this thesis. The BMC could be improved by either creating more notes for the elements or choosing for instance different colours to

indicate and visualize the figure more efficient. Final remark was to go over the elements within the BMC once more before submitting the final version.

For a complete summary of all of the interviews, see the attached appendices at the end of this thesis. For the analytical framework of interviewee A to D, see Table 11 or Appendix E. The complete literature review can be found in Chapter 3. The findings of this subsection were all based on the conducted literature review and interviews throughout this research.

7. Conclusions

This research investigated the different Control Tower types and the Service Control Tower concept. This chapter presents the conclusions of the research results as displayed in the previous chapters. In this chapter the main conclusions per sub-question is presented, after which the main research question is answered to conclude this chapter.

7.1. The different Control Tower types and their differences

The first research sub-question is as follows: **Which different Control Tower concepts exist and what are the differences?** (RQ1)

This research has shown that the different Control Towers concepts, are listed as follows, from old to new as provided in academic literature: the Air Traffic Control Tower, later on also called a Virtual Control Tower and a Remote Control Tower, the Transportation Control Tower, Logistics Control Tower, Supply Chain Control Tower, Outsourced Control Tower and Digital Control Tower. These Control Tower concepts are visualized in Figure 17.

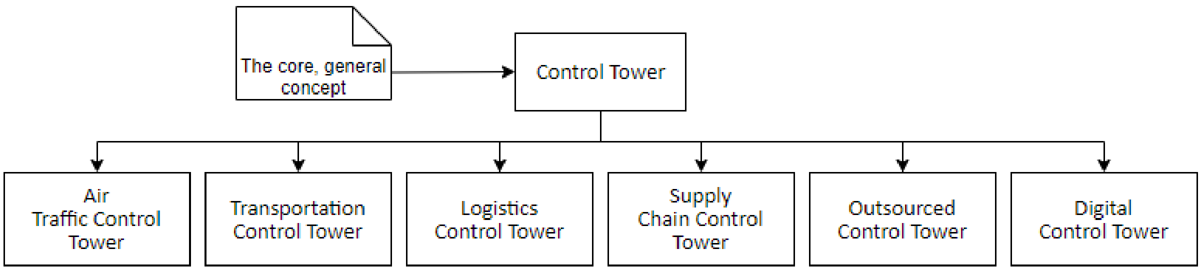

Figure 17 – Different types of Control Tower concepts (for reference only; identical to Figure 9)

Moreover, while analysing the available knowledge on the different Control Tower types, there were a number of elements or factors determined in which the Control Tower types had different options or settings. The factors which were distinguished are: services and main functions (e.g. processing real-time data and communicating with multiple parties or to support in transportation planning), active domain (e.g. a Control Tower specifically active in the Aviation domain or the Transportation domain), location (e.g. a physical location or virtual location), ownership (e.g. self-organized or external party), technology and systems (e.g. ERP systems, IoT or cloud) and a complexity conclusion (e.g. medium or high) based on the beforementioned factors.

Each of the differences between these Control Tower types were identified on the following factors and differences per Control Tower or per combined group of Control Towers (when an answer applies to multiple Control Towers):

Control Tower(s)	Services and main functions
Air traffic CT (Virtual CT and Remote CT)	Services: overseeing, controlling, managing, intervening every activity concerning air traffic, while also using real-time data and communicating with multiple parties. Main functions: the main purpose of an ATCT is to ensure safe and efficient movements of aircraft at the airport, handling all the take-off, landing and ground traffic.

Transportation CT, Logistics CT and Digital CT	Services: support in logistic activities around for instance transportation planning, monitoring and configuration activities and administrative activities such as filling out forms and billing. Take care of for instance all (purchase) orders and (supplier) management in the 4PL concept, typically set-up for activities within and across supply chains, strategic decision-making. Main functions: real-time (transportation) information, any changes that may occur in the different (transportation) systems and stakeholders, insight into availability of all of the involved partners, executing, tracking and monitoring transportation. A software architecture is adopted with elements such as user interfaces and planning components. Contains, collects and processes data through technology.
Supply Chain CT	Services: a planning and execution system, that facilitates a network to continuously and real-time manage processes, resources, corrective and preventive actions. SCCT can globally monitor aspects such as orders, shipments, forecasts and any activity. In addition, a Control Tower should fundamentally contain data, alerting, operational functions, automation, decision support and role transformation. No specific main function distinguished apart from the core CT functions.
Outsourced CT	Services: Planning Services, Planning as a Service (PaaS). Main functions: forecasting, assortment management, inventory planning, pro-active control and reactive control.

Table 19 – Services and main function per Control Tower

Control Tower(s)	Active domain
Air traffic CT (Virtual CT and Remote CT)	Air Traffic / Aviation domain
Transportation CT, Logistics CT and Digital CT	Transportation and Logistics domain
Supply Chain CT	Supply Chain Management (SCM) domain
Outsourced CT	Service Logistics domain

Table 20 – Active domain per Control Tower

Control Tower(s)	Location
Air traffic CT (Virtual CT and Remote CT)	Physical and/or Virtual location (Remotely)
Transportation CT, Logistics CT and Digital CT	Physical, Online / Virtual location
Supply Chain CT	One physical location by own organization or other organization (see ownership), Virtual location
Outsourced CT	Outsourced also called ‘footloose’ as the physical location is not relevant, may even be a Virtual location

Table 21 – Location per Control Tower

Control Tower(s)	Ownership, Controlling, Managing the Control Tower
Air traffic CT (Virtual CT and Remote CT)	Local External party
Transportation CT, Logistics CT and Digital CT	External, 4PL
Supply Chain CT	Vendor, Service Provider, External, 3PL or 4PL, Self-organized
Outsourced CT	External party, Third-party, OEM

Table 22 – Ownership, controlling, managing per Control Tower

Control Tower(s)	Technology and Systems (ICT elements)
Air traffic CT (Virtual CT and Remote CT)	"advanced technology"
Transportation CT	ERP systems, TMS systems and Future-Internet-Based: IoT, cloud and the Internet of Services
Logistics CT	Software architecture, interfaces, Future-Internet-Based: IoT, cloud, Internet of Services and network of the future
Supply Chain CT	Cloud based technologies, IoT, interfaces, API, GPS, ML, AI and potentially even blockchain (which is still in novel stages).
Outsourced CT	ERP systems, algorithms, PaaS
Digital CT	ML, digital logistics, physical internet

Table 23 – Technology, systems used per Control Tower

Control Tower(s)	Complexity conclusion
Air traffic CT (Virtual CT and Remote CT)	Medium to High for the newer ATCT types (Virtual CT and Remote CT)
Transportation CT, Logistics CT and Digital CT	High
Supply Chain CT	High
Outsourced CT	High

Table 24 – Complexity conclusion per Control Tower

In addition, this research has shown that the common denominator of the different Control Tower types (including the Core Control Tower concept) is stated as digitalization.

7.2. The stakeholder perception on the Service Control Tower concept

The second research sub-question is as follows: **How is the Service Control Tower concept perceived by various stakeholders?** (RQ2)

This research has shown the stakeholders' perception on the Service Control Tower concept. A Service Control Tower should provide an overview of the complete network with all the stakeholders that are involved in the chains. This implies that a Service Control Tower should provide more and better access on the IS and should enable data to be shared more with all the stakeholders that are involved within a network. The Service Control Tower should provide for organizations to gain value in certain aspects, such as collaboration, data sharing and an overview of the complete network.

7.3. The drivers and barriers to implement a Service Control Tower concept

The third research sub-question is as follows: **What are the drivers and barriers to implement a Service Control Tower perceived by various stakeholders?** (RQ3)

Drivers to implement a Service Control Tower are that it is based on customer demands (in availability and in visibility), technology developments and the Network Value Proposition, an increase of collaboration within the network. In addition, there is a driver, which is (the amount of or increasing) trust amongst the stakeholders in the network.

This research has shown a number of barriers to implement a Service Control Tower. The barriers are mainly related to strategic reasons; there is the natural resistance of not being in control, the intellectual property and it is scary to share too much of your data with other stakeholders within the network. In addition, there is also a risk of losing market share, for instance, in case of competitors within the same network as the amount of sharing data is increased.

7.4. The characterization of the Service Control Tower concept

The fourth research sub-question is as follows: **How can the concept of a Service Control Tower be characterized?** (RQ4)

Characterization of the Service Control Tower concept was based on the outcome from both the literature review and the conducted interviews within this research:

- The concept of a Service Control Tower can firstly be characterized by the additional Service(s) element, the Service Logistics domain, this new service-oriented approach.
- Secondly, the views on the ownership of the Service Control Tower, setting-up the Service Control Tower and the future of the Service Control Tower were topics of interests within both the literature review and the conducted interviews. This research has shown that on the ownership of the Service Control Tower concept there are multiple possibilities: decentralized or centralized, an external or third-party, distributed or a central organization, self-organized or an independent regulator (e.g. a broker). This research has shown that setting-up a Service Control Tower requires gluing together processes, a network value proposition, agreements (contracts), intellectual property, governance, people (a human organization) and technology such as systems and data. In addition, this research has shown that on the future of the Service Control Tower concept, it is certain that it will mature more in the years to come. The main reason for this is the enabling Technology factor, which is moving organizations towards the increasing digital transformation, which is also in connection with the servitization and digitalization element within the Service Control Tower concept.
- Thirdly, based on the literature review and interviews within this research, a SWOT analysis and BMC of the Service Control Tower concept were created, verified and validated. Both the SWOT analysis and the BMC figure contain the most notable characterizations of the Service Control Tower concept as determined and stated within this research.

When summarizing the findings thus far, Figure 18 is added to visualize on the Control Tower, different types of Control Towers and the Service Control Tower with its main elements.

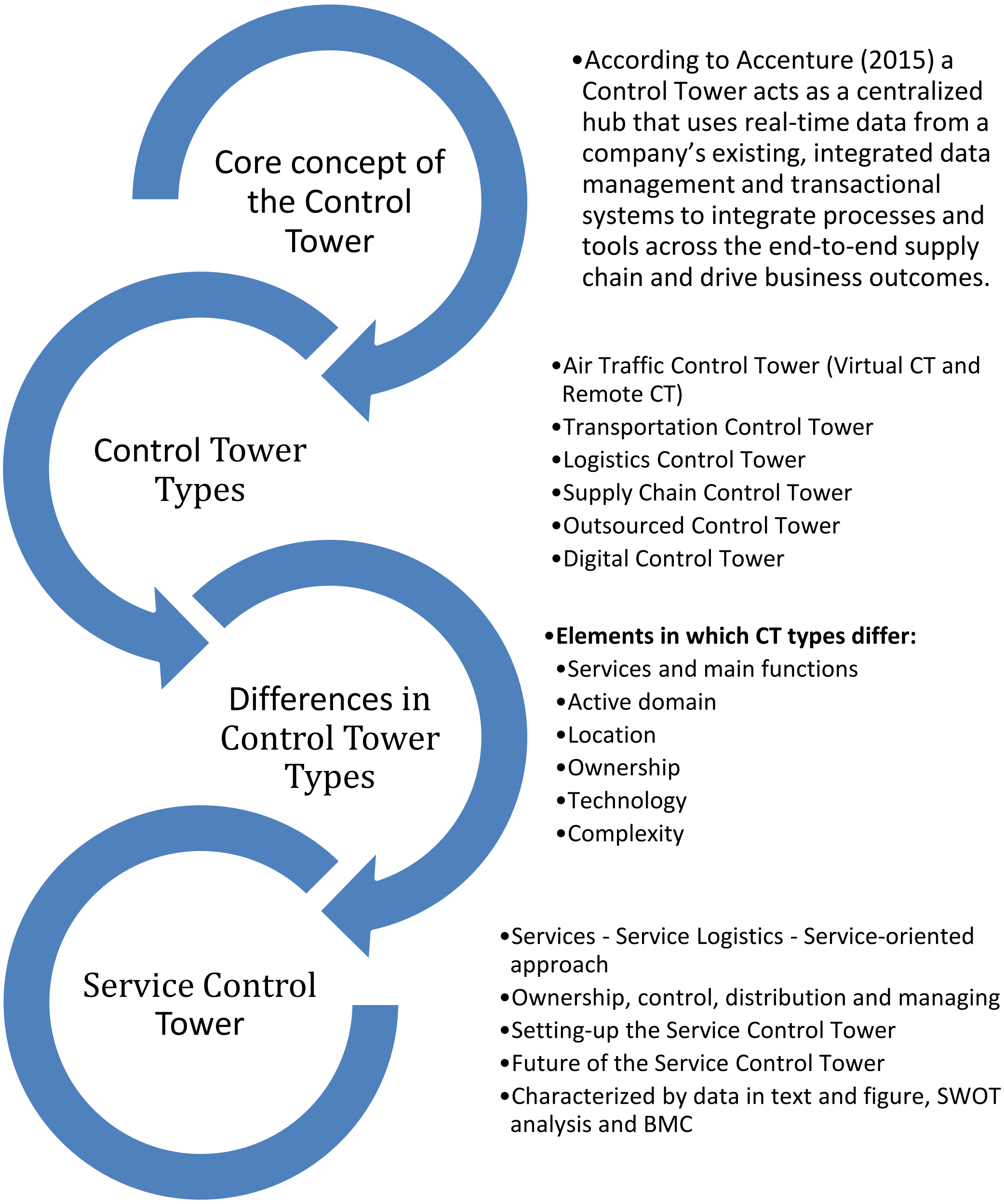

Figure 18 – Summarized findings of this research, structure of the overall thesis

7.5. The adaption and evaluation of the Services within the Service Control Tower

The fifth research sub-question is as follows: **How can the Services within the Service Control Tower be adapted and evaluated?** (RQ5)

Bringing together the services, servitization, digitalization and processes elements within the Service Control Tower environment is what leads towards adaption and evaluation of the Services within the Service Control Tower. The adaption and evaluation of the Services within the Service Control Tower is being enabled by:

- A prerequisite is that the organization (or network of organizations) has their processes documented and standardized, for instance by using SOPs, before they can continue setting up their (Service) Control Tower environment (De Vasconcelos & Kaminski, 2013). This is seen as a part of the adaption of the Services.
- Services, servitization and digitalization all have a role within setting up the Service Control Tower environment, enabled by (multiple) technology and evolving around providing services.
    - Adaption takes place as (well-defined and standardized) processes and all kinds of (real-time) data are required for the Service Control Tower to function (CQM, 2019; De Vasconcelos & Kaminski, 2013). The (real-time) data and information are collected and/or integrated into enabling (converged) technology such as IS, AI or analysis systems (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021). In short, the required processes, services and data will need to be integrated in the technology which the organization(s) are going to use within the Service Control Tower environment.
    - After setting up (and adapting) a Service Control Tower environment, the technology which is used by the organization, can provide for instance predictions, monitoring, decision-making and alerting (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021; Topan et al., 2020; Van Laarhoven, 2009). Based on the outcome of these activities and tasks, the organization can evaluate whether the output of the Service Control Tower is sufficient or needs further adjustments.
    - The need, scope and depth of the Service Control Tower can be determined by the organization before setting up the Service Control Tower (CQM, 2019). There is a continuous form of comparing the current maturity of the Service Control Tower to the desired level, whereas the development and directions can be changed or updated along the way of implementing, adjusting and evolving (CQM, 2019).
    - Therefore, adaption and evaluation are both ensured within the Service Control Tower implementation and growth thereof.

7.6. Answering main research question

The main research question of this research is as follows:

What does the concept of a Service Control Tower within service logistics entail and how does it contribute to business value creation?

As the research sub-questions have been answered, the last question to be answered is the main research question of this research. The main research question can be broken down into two parts or two questions. The first part of the main research question concerns what the concept of a Service Control Tower within service logistics entails. Therefore, this research has shown that the Service Control Tower has close connections and is interlinked to the Core Control Tower concept and the multiple distinguished Control Tower types.

For instance, the main functions of the Core Control Tower concept apply to the Service Control Tower concept as well, which are: decision-making, monitoring, alerting, managing, intervening, changing, predicting and facilitating (Baumgrass et al., 2014; De Vasconcelos & Kaminski, 2013; Hofman, 2014; Liotine, 2019; Shou-Wen et al., 2013; Trzuskawska-Grzesińska, 2017). In addition, the main elements of a Control Tower concept which exist of processes, technology and a human organization (De Vasconcelos & Kaminski, 2013; Trzuskawska-Grzesińska, 2017), also apply to the Service Control Tower concept, as well as the digitalization factor which has a significant role in every different Control Tower concept. However, the Service Control Tower concept entails specific distinguished elements as well, which are visualized in Figure 19.

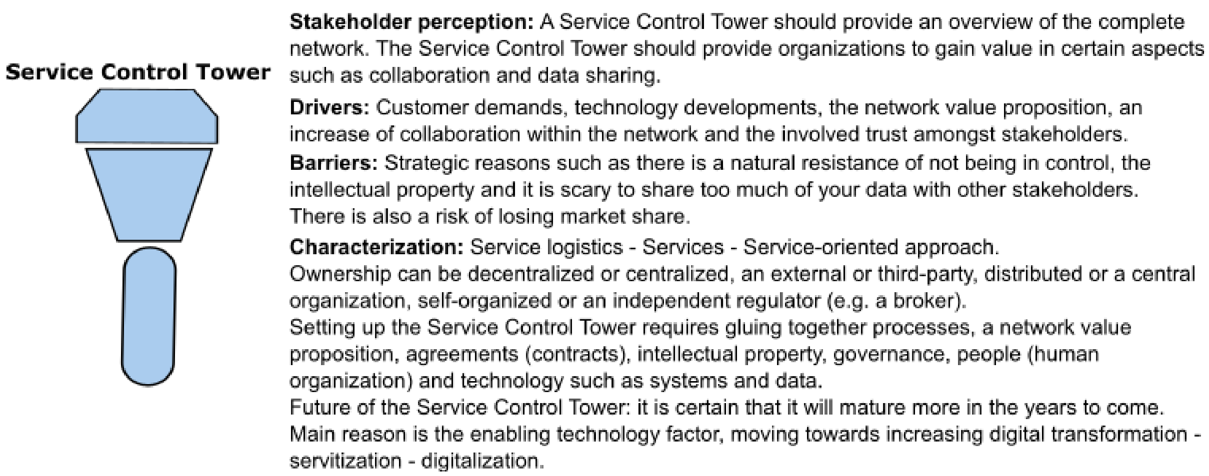

Figure 19 – Service Control Tower within service logistics

The specific elements of the stakeholder perception, drivers and barriers of the Service Control Tower concept are derived from the semi-structured expert interviews. The summarized outcome is displayed in Figure 19 and the complete answers from the interviews concerning the stakeholder perception can be found in subsection 4.1.1, the drivers and barriers in subsection 4.1.2 and the characterizing of the Service Control Tower concept according to the interviewees in subsection 4.1.3. The characterization has been described from the interviews as well as the literature review that was conducted (which has also been summarized in subsection 5.1). For instance, the Service Control Tower concept entails this new Service-Oriented Approach of a Control Tower, which can be seen as a Control Tower specifically for the service logistics domain (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021; Topan et al., 2020; Van Laarhoven, 2009). On the ownership and controlling of the Service Control Tower concept, Arts et al. (2019) and ProSeLoNext (2021) imply that this could be done by a third party or especially by OEMs as they have the most technological knowledge in place.

To answer the first part of the main research question in short, the statement is as follows. The Service Control Tower concept within service logistics entails a hub or entity which focuses on the services domain, which in addition has the goal to enable for instance interorganizational data sharing, collaboration and optimization of processes with the use of multiple technologies.

The second part of the main research question concerns how the Service Control Tower contributes to business value creation. The value adding elements of the Service Control Tower within organizations has been elaborated on both in the literature review as in the conducted interviews.

The literature sources elaborated on business value creation and value adding elements such as sharing more data and an improved collaboration between companies (Vanvuchelen et al., 2020), after which organizations can provide a more proactive service to their customers, shifting the concept into a real-time data processing and decision-making concept, which ultimately should provide a holistic end-to-end view across the different stakeholders (Liotine, 2019). Moreover, Service Control Tower can enable the transition towards a holistic, collaborative and integrated 'network of networks' (Vanvuchelen et al., 2020). In addition, the SLF (2021) states that the Service Control Tower concept leads to more efficient ways of delivering services.

The interviewees elaborated on business value creation elements such as mainly the importance of the Network Value Proposition (Interviewee A and B); evolving around an increased availability of products, an improved collaboration within a network which brings value and mutual trust. In addition, Interviewee C mentioned the data sharing element, real-time intervention and maintenance and mentioned a focus on a long term added value where trust also plays a role. Moreover, Interviewee D mentioned the visibility and services for customers, to be able to see where processes or activities go wrong and to react and improve on those aspects.

Therefore, this research has shown that the business value creation of the Service Control Tower concept is most active and visible within the factors of increasingly sharing data, collaboration within a network (where trust is important), providing a holistic (real-time) end-to-end overview and more efficient ways of delivering services.

8. Discussion, limitations, suggestions and reflection

This chapter consists of discussing the research results as presented in the previous chapter, thereby, connecting and comparing these results to the existing literature. On multiple aspects, concepts and topics that have to do with the (Service) Control Tower, both the literature review as the interviewees elaborated on similar concepts and outcomes thereof. This chapter will start with the discussion section, followed by the limitations and suggestions for further research, whereafter this chapter ends with a scientific and personal reflection of this research.

8.1. Discussion

This research provided interesting insights on topics such as Digitalization, Processes, Technology, Human organization (forms of collaboration) and Blockchain technology within Control Tower environments. Moreover, especially while comparing the literature outcome to the interview outcome, there were both differences as similarities found concerning these topics. For each of these topics, there is an elaboration in this subsection.

Digitalization
As mentioned in the Literature Review chapter, the high reliance on technology, data and technological convergence factors in a Control Tower are recurring aspects within this research. The term or phenomenon of digitalization has not been specifically mentioned by the interviewees during the interviews. However, when looking in to what Digitalization encompasses and what it is defined as according to the existing literature, aspects of digitalization have certainly been discussed with multiple interviewees. Digitalization, also called digital transformation, can be defined as the adoption and increasing usage of digital or computer (ICT) technology by an organization, industry, society, country etc. (Brennen & Kreiss, 2016; Parviainen et al., 2017). Moreover, digitalization concerns rethinking current operations to new perspectives, which is enabled by technology (Parviainen et al., 2017). Each of the elaborated Control Tower concept consists of mainly digitalized concepts. Furthermore, digitalization is the key for providing for instance efficiency in organization in case of new services or offerings to customers (Parviainen et al., 2017).

This research showed that digitalization is a significantly visible and present topic and aspect of the core Control Tower and the specific Service Control Tower. The interview data showed that there are different approaches to digitalized forms of working with customers and collaborating within a network. Interviewee C stated that they want to go towards more and more Remote Access, Support and Maintenance, as this contains benefits from both the customer as their organization; Financial benefits as the costs are less for both the organization as for the customer, as well as a benefit in saving time as the customer can receive faster service which also increases customer satisfaction. Especially in times such as these, were there is a pandemic (COVID-19), which involves lockdowns and certain restrictions, there are increasing benefits to being able to support and service customers remotely. In addition, Interviewee D had an unique approach to one of many possibilities within these significantly digitalized organizations. Interviewee D stated that his organization was looking into possibilities for his customers to have the possibility to have one encompassing overview and visibility into their data from two large organizations with very similar services. Therefore, their biggest competitor would allow their data to be included in their organizations system and their mutual customers would only have to look into one system which will contain data on all of their data (from both of the organizations combined). In addition, Interviewee D stated that customers have a lot of benefit on this future possibility, however they are still working on this new approach to digitalized collaboration with their customers and competitor. These are the two most outstanding examples from this research when it comes to digitalized forms of working and collaborating. These practical examples by the interviewees are in line with the existing literature which stated on the numerous opportunities and the high reliance on data and technology which is moving towards Digitalization within organizations and Service Control Towers (Baumgrass et al., 2014; Cooke, 2014; Liotine, 2019).

Processes

In the literature review chapter of this thesis, there was a section on Processes, as multiple academic sources elaborated on the processes element within a Control Tower environment. According to De Vasconcelos and Kaminski (2013) the processes element is considered a pre-requisite of setting up the Control Tower environment and well-defined, managed processes are of importance within many activities. In addition, they argue that the processes are distributed to all involved stakeholders within a network, which could be done by for instance Standard Operating Procedures (SOP). They state that a SOP provides a step-by-step instruction of the what, who and when for every part of the processes. Thereby, Trzuskawska-Grzesińska (2017) implies that with the use of SOPs every process and function will follow the same defined process, regardless of who is managing or acting on the data within the Control Tower. In addition, she argues that there is 'one truth' within the Control Tower environment when the processes are defined and documented in a standardized way.

During the interviews the processes element was also a topic of interest. Interviewee A mentions in particular that processes between their company and the company of the collaborating partner within the network are being 'glued together'. In the specific situation of Interviewee A the gluing together is typically done by students. Reason for this gluing together is that they want to know how business is running on the other side, how processes go through the whole chain. In addition, they are improving what is being done and aligning the businesses to each other. In the end the vision is that all of the 'islands' are glued together within the Service Control Tower, having one definitive way of working together and visibility of flows. This way of working is in line with the knowledge from the literature sources, as they state 'one truth' within processes, defined and documented in a standardized way within the network (De Vasconcelos & Kaminski, 2013; Trzuskawska-Grzesińska, 2017). To conclude on the processes aspect, this research, from both the literature sources and the interviews, shows that it is very important for organizations to have their processes aligned and documented properly in order for the (Service) Control Tower environment to function successfully.

Technology

This research showed that due to technological innovations, developments and possibilities the Control Towers are becoming more mature and increasingly more complex in time as well. This is also the case due to the increasing involvement of interorganizational settings within the Control Towers, while including more organizations within the environment the complexity of for instance the different technologies which are involved also increases. A (Service) Control Tower is able to function by the means of technology (De Vasconcelos & Kaminski, 2013). Multiple literature sources elaborated on the (Service) Control Tower containing the important factor of data, combining multiple technologies (convergence of technology) and the importance of connecting these to each other (De Vasconcelos & Kaminski, 2013; Liotine, 2019). In line with the findings of connecting and enabling multiple technologies within the encompassing (Service) Control Tower environment, the interview findings let to the same conclusions. Interviewee A stated that the technology is becoming very complicated and therewith the need of specialists is increasing as well. In addition, the demand and complexity of technology is increasing as well. Interviewee A stated that right now certain aspects are still very traditional and underestimated, therefore specialists are needed, not only to connect systems and have knowledge of new technology, but especially to take care of other factors, effects and complexities within the (Service) Control Tower environment. In addition, Interviewee B stated that the technology is becoming more and more complex and therefore the maturity of the Service Control Tower will increase over time. Interviewee B stated that organizations will implement Service Control Towers due to the Complexity of Technology and the Help of Technology. Thereby, Interviewee C stated that their technology is very developed and they are already ready to implement such a high demanding technology encompassing Service Control Tower, as they for instance also have the technology in place to perform Remote Access and Maintenance. For Interviewee C there is no technological difficulty as opposed to what Interviewee A and B stated.

Human organization

The findings of this research showed some different views on the significance and role of the human organization within the Service Control Tower environment. According to literature, the human organization was one of the three main elements of a Control Tower, together with technology and processes (De Vasconcelos & Kaminski, 2013; Trzuskawska-Grzesińska, 2017). Interestingly, Interviewee D had a specific and unique view on the Service Control Tower of his organization, where they see the Service Control Tower as the Central Team. In their envisioning, they see the People, the Team as the Service Control Tower, where in addition these people work with Systems. The systems should support the people (teams of people). To summarize, Interviewee D sees the people, the human organization as the Service Control Tower itself. This vision differs from the earlier findings on the human organization, the people element as elaborated on in the existing literature (De Vasconcelos & Kaminski, 2013; Trzuskawska-Grzesińska, 2017) and by the other interviewees. This different vision is for instance clearly stated by De Vasconcelos and Kaminski (2013) as they imply that the (educated) employees manage and control the technology and processes, therefore the human organizations in a sense completes the (Service) Control Tower. In addition, Trzuskawska-Grzesińska (2017) states that the employees each have their own focus within the Control Tower.

In addition to these research findings, within the human organization aspect the element and necessity of Trust was mentioned by multiple interviewees, namely Interviewee A, B and C. They stated that in order for the Service Control Tower to work for all the organizations involved, they need to have (mutual) Trust; an increased trust also increases the chances of success within the Service Control Tower and the ability to share more data within the environment. In line with the findings of these interview findings, Maneengam and Udomsakdigool (2020) argue that a Control Tower has a neutral decision-making element, which results in an improved mutual trust and enables transparency among all of the stakeholders in the network. In addition, Hofman (2014) and Vanvuchelen et al. (2020) argue that sharing data between stakeholders within the network will become easier within Control Tower environments.

Blockchain technology within Control Tower environments

The findings of this research showed an innovative possibility when it comes to the novel Blockchain technology. Both the literature (Liotine, 2019) as well as an interviewee (Interviewee A) stated blockchain can be a promising development and addition to the Control Tower environment in the (near) future. Interviewee A stated the following on blockchain:
"*I am not completely aware of what is possible in blockchain. Maybe too much overhead. But what I understand from blockchain is that it is also a mechanism to organize who can have access to which data but I don't know if it applies. It is not something I have studied yet. But I have heard the main principles of blockchain. But by not making it too complex, I would shift that into the future*".
In line with Interviewee A, Liotine (2019) also mentions blockchain technology as of use within Control Tower environments and to add value, while also noting that blockchain technology is still in novel stages of development. He implies that blockchain can add value on aspects such as Control Tower visibility and data sharing. More specifically, he states that blockchain technology can potentially contribute to aspects such as facilitating access and updates of products such as movements within the supply chains without the need of a central intermediary. As both an existing literature source and interviewee A mentioned blockchain technology for possible future endeavours, it can be hereby noted as a promising research direction for the future. The concept of blockchain within Control Tower environments can be researched separately for aspects such as applicability, readiness and maturity.

8.2. Limitations and suggestions for further research

Within this research there was a limited time frame and possible amount of hours to perform all activities in. During the research, there were multiple decisions made on what to research and what not to research. It was not possible to research every aspect on a topic in the scope of this thesis. This subsection provides an elaboration of the chosen limitations and suggestions for further research on the Service Control Tower topic.

This research had an overall exploratory nature and high-level, broad scope on the (Service) Control Tower topic. Through this research a first knowledge base on the multiple different Control Tower concepts were described as they were not clearly distinct before, which addressed both organizational as ICT-related views. In addition, both differences as common denominators were described. Moreover, a high-level approach for the Service Control Tower concept was chosen as this topic is still in early stages of research and development. Therefore, within this research the known information about the Service Control Tower concept has been elaborated on (Arts et al., 2019; CQM, 2019; ProSeLoNext, 2021; Topan et al., 2020; Van Laarhoven, 2009). Where possible, the most important main elements or key stones of the Service Control Tower topic have been looked into more extensively via literature review and additional exploratory knowledge with expert interviews. However, there was limited room to research every main element or key stone and to really dive in to the known aspects.

Therefore, the suggestion for further research is twofold. First, every main element or key stone to the Service Control Tower can be looked in to further in much more detail, for instance by conducting interviews, case studies or surveys. Second, in addition to the in this research chosen high-level, broad scope, the suggestion for further research can entail on focusing on one specific level or side to the Service Control Tower concept. An example could be to look in to the technological level (or layer) or to focus on solely the organizational aspects to implementing a Service Control Tower (for instance solely on the collaboration aspect of a Service Control Tower in an interorganizational network). In addition, within this research the possible legal aspects and domain were out of scope. Therefore, this specific domain can be studied and can entail many different legal aspects and implications (e.g. researching the legal aspects concerning privacy and/or data sharing implications within a network of stakeholders).

The literature review had a limitation in language, only Dutch and English sources were eligible as other languages were not possible as they are not included in the language knowledge of the researcher. It could be possible that when including other languages, the scope or outcome of this research would have been different. However, it is noted that there was only a limited amount of literature sources found throughout this research that were written in another foreign language. This suggestion for further research is to expand to (or include) languages other than Dutch and English. For instance there was a Russian publication found on the first page of Google Scholar (when searching for “Control Tower”) which could expand the knowledge base (Дыбская & Сергеев, 2019). This suggestion could expand the current knowledge base and therefore add value to prior research.

The interviews in this research had limitations as well. As the interviews were conducted with experts in the field, there were a limited amount of experts eligible and willing to be interviewed (invitations were send to multiple optional candidates, but responses were not received in all cases). Therefore, the first interview limitation is the small amount of interviewees, more specifically the single confirmatory (verification and validation) interview that was conducted. The interviews have been conducted amongst stakeholders from the MARCONI-project and an additional interviewee from one other organization. The conducted interviews were of exploratory nature and provided the first insights in to what a Service Control Tower on different aspects can entail, for instance on technology, collaboration and an organizational aspect.

The suggestion for further research is to perform a thorough case study (or multiple) within an organization which has an implemented, operational Service Control Tower. A case study can provide more in-depth knowledge on what the Service Control Tower entails, as opposed to the conducted interviews of 45-60 minutes. Another suggestion hereby is that organizations from other domains and industries could be approached. For instance knowledge on seven major industries and what they entail can be found in (Monfardini et al., 2012). Instead of a case study there could be a decision made to conduct a survey, to gather data from more organizations at the same time.

8.3. Reflection

The reflection of this research consists of two types of reflection: first, a scientific reflection and secondly, a personal reflection. This is the final section of this thesis whereby the main experience and decisions along this research are reflected upon in a short elaboration.

8.3.1. Scientific reflection

The Control Tower and especially the Service Control Tower topics are novel concepts whereas there is not yet a lot of published academic literature available on it. The first research goal was to create an overview of what is exactly known in existing literature and what is yet to explore through additional research methods. It seemed like a lot of different names were being used for more or less the same concept and therefore required a structured way of working, thinking and documenting, and extensive time by performing literature review. The scarcity of academic literature was a challenge at first, but later on turned out to be a good thing as it made it easier to get a clear overview on both the similarities and differences of the different literature sources and their research goals. The academic literature combined with a small section on business literature, provided in enough material to create a thorough knowledge. In addition, the conducted interviews and different views of the participants provided in a knowledge base of different Control Tower concepts, their differences and common denominators, and a high-level characterization of the Service Control Tower concept. More academic publications on the Control Tower and Service Control Tower concepts will add to the limited existing knowledge base to date.

The second part in the novelty of this topic and research was that it turned out to be hard to find interview candidates from outside of the MARCONI-project. Actual implemented Service Control Tower organizations were hard to find and when connected with them, in multiple cases, they were unable to conduct an interview with, as their Service Control Tower was not yet implemented and still in very early stages of development. This has resulted in a limited number of possible, accepted and conducted interview candidates, however enough for the conducting of expert interviews with in-depth insights and questions within the scope of this research. Therefore, from a scientific point of view, this topic was interesting and added value to existing research. A higher number of conducted interviews would have additionally strengthened this research and outcome, which can be considered for further research suggestions.

To conclude on the scientific reflection and while reflecting on this conducted research, the research results contribute to existing literature concerning the Service Control Tower concept, such as by CQM (2019) and Topan et al. (2020). These literature sources were published also due to literature review in combination with interviews at different stakeholders. Similar findings were found when it comes to the characteristics of the Service Control Tower concept and more specific when it comes to the scope (service logistics and/or the maritime domain) and these researches were also conducted with a scope within The Netherlands and a focus on Dutch organizations. In addition, this research focused on the different Control Tower concepts and distinguished these concepts from one another, which contributes to the missing distinction as indicated by Trzuskawska-Grzesińska (2017). These literature sources were sources of inspiration and provided in possibilities for further research on the Control Tower and Service Control Tower concepts.

8.3.2. Personal reflection

This research project first and foremost was a learning by doing experience for me. Before this research experience, I had no prior practical experience when it comes to performing research activities such as (academic) literature review or conducting interviews with a clear goal and by following certain guidelines and methods. For each step and activity throughout this research, I needed significant time to prepare the work and keep a clear overview and log of what I was doing at all times, to prevent myself from losing the overview. Working this structured way was also a learning experience for me, which I hope to continue in my future work life. I have started this research with a focus group in which we all performed certain literature review and discussed findings and outcomes on a regular basis. This provided guidance to me and let me to directions in what specific research questions I could research for my thesis and how to actually do it.

The literature review in particular has cost a large portion of this research project in total, whereas many notes have been made during the process of what I thought would be useful input for this thesis. However, when looking back to the notes, it turned out that a large portion of these notes have not been used in the end product of this thesis and can be seen as redundant or unnecessary work. Therefore, a significant amount of work could have been prevented when the structure would have been better monitored from the start of this research project and the work hours could have been more efficient looking back on it. The writing of the literature review part took me the longest amount of time during this research, looking back I would have decided earlier on to write a lot of drafts for each section instead of doubting on what to write and endless reading up and taking notes of the literature, which included a lot of going back and forth between these activities. Looking back, this could have saved a lot of time. However, going through the red lines of my research and thesis writing, I would have done most of the activities and workhours on it, exactly as I did now.

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Appendices

Appendix A: Summary of interview on 01-10-2020: interviewee A (confidential)

Appendix B: Summary of interview on 13-11-2020: interviewee B (confidential)

Appendix C: Summary of interview on 23-11-2020: interviewee C (confidential)

Appendix D: Summary of interview on 03-06-2021: interviewee D (confidential)

Appendix E: Coding results: processing of interviews A to D, Analytical Framework

This appendix starts with the most important summaries of each of the research sub-questions, after which the different categories or so called code names are added and numbered. The end of this table consists of summarized input for the Discussion chapter of this thesis (this was not included in Table 11).

Question	Interviewee A	Interviewee B	Interviewee C	Interviewee D
Summary of Perceive SCT RQ2	Connected to Service Logistics. Increasing complexity. Clear demand to get an overview of all the complete chains with all the stakeholders involved in the chains. An overview of the complete network.	History on Service Control Tower (see full answer in appendix b). Appeared at the 4-C concept, collaborate more efficiently, both horizontally and vertically. Example transport companies sharing trucks. Requires a Contract/Agreement. Central control, joined value of cooperation. Now SCT in particular service logistics and (maintenance) services.	An SCT or a control network, to gain services with our customers by an online connection. More and better access on the systems and share more data required for maintaining and servicing the systems. Sharing that information would be very beneficial for both parties. Or even more than two parties.	SCT is a Central Team or different teams of people. People work with Systems. In the end, these systems should support the people. An overview of the complete network. These teams of people monitor the Network, where Governance is involved as well.
Code name(s) **Code 1-5**	Gain value (1) Overview of network (2) Service logistics (3)	Gain value (1) History of SCT (4) Service logistics (3)	Gain value (1) Overview of network (2)	Gain value (1) Overview of network (2) Teams of People who work with Systems (5)
Summary of Drivers SCT RQ3	Increase availability of parts for customers. Network value proposition, balance in value proposition. Mutual trust.	Collaboration brings joined value. Network value proposition. Collaboration brings more value. Coordination Centre needed, operational coordination and strategic coordination.	Technology is ready. All parties can access and use common data to share. Real-time intervention and maintenance. Long term added value. When there is trust, it may be easier to go for a solution as an SCT.	Visibility for customers. Services for customers. See where things go wrong, reacting to improve.
Code name(s)	Customer demand (6)	Network value proposition (7)	Technological developments (8)	Customer demand (6)

Code 6-9	Network value proposition (7) Trust (9)		Trust (9)	
Summary of Barriers SCT RQ3	Depends on what the organization gains within a SCT. The core business and business focus is also a factor on if an organization is willing to join. Get information of all stakeholders in the right place (gluing together processes part of interview).	Strategic reasons: Natural resistance of not being in control (in case of central control coordination). Minimize risks beforehand. Risk of losing market share. Not share too much of your data. It becomes easier when elements such as a form of collaboration and trust are in place e.g. to hand over authority.	Technology will not be a problem. Main concern is about sharing data within a SCT. Scary to share too much data, not eager to share. Intellectual Property and financial sides including agreements on this. I think that is one of the main concerns. Is: How do we protect data… that we share with our customer with our competitors or everyone else involved within the Control Tower.	Organization has a partially outsourced SCT, which can therefore be a risk if customers choose to go for the outsourced party instead of theirs. However they are working on this as they are re-introducing outsourced tasks (making them internally again).
Code name(s) **Code 10-16**	Gain value (10) Core business, business focus (11)	Strategic – natural resistance of not being in control (12) Strategic – risk of losing market share (13) Strategic – not share too much data, intellectual property (14)	Strategic – not share too much data, intellectual property (14) Financial sides and agreements (15)	Risk of going over to another party (16)
Summary of Characterizing SCT RQ4	Specifically for the Service Logistics domain. Holistic approach: IT layer, IT architecture, value propositions, stakeholders. A holistic approach, a view from different angles (that makes it complex). Discussed main topics: Ownership, stakeholders, adding	Logistics sectors, in particular now Service logistics and towards (maintenance) services. ASML SCT example for their spare parts control. Requires a Coordination Centre or Supervising Entity, taking care of different interests and data sharing parts for all stakeholders involved.	Focus on Services. Gaining services with our customers via an online connection. Access and use common data with stakeholders. Discussed main topics: remote support, maintenance, services to customers. All parties accessing and sharing data with	You need Governance, People (Teams), Technology; Systems and Data. Discussed main topics: SCT within organization of interviewee and specifics thereof, how it works. Possible future of SCT.

	value for every party, OEM/customer/add value and changes via portals or SCT. Possible future of SCT.	Discussed main topics: Ownership, Data sharing and Collaborating within the network of stakeholders. Possible future of SCT.	each other within the network (collaboration). What is possible from their organization already, technology wise and supporting their customers. Ownership. Possible future of SCT.	
Code name(s) **Code 17-22**	Service Logistics domain (17) Holistic approach (18)	Service logistics (17) Services (19)	Services (19) Access and share data (20)	Governance (people/teams) (21) Technology (22)
Summary of Ownership SCT	Distributed structure (rather than a central organization). Where everyone is owner of a piece of it, and others can get access to that. If central, need a third-party to maintain it. Side note: Maybe even use blockchain technology to organize who can have access to data?	Coordination Centre (supervising entity) that is taking care of the interests and privacy. Who is in control doesn't necessary point to a single person or organization, it should be an independent organization (example of Broker in sales, independent regulator). Could also be a set of agreed rules. It could also be an external organization.	Could be an external party. If looking at sharing data, the intellectual property it might be best to have an external party to set up and control the SCT. Also easier to get Trust with a third-party as opposed to the customer being in control. So, agreement on an equal party in the network, with one goal, one purpose (set up and control).	Not a direct question asked in this interview. In the case of this interviewee, they are managing and controlling the SCT for their customers. The customers are able to log on their system(s) and have insight in to the real-time data. Some of the (logistical) activities are outsourced (to a third-party) by the organization of the interviewee.
Code name(s) **Code 23-29**	Distributed structure (23) Central organization (third-party) (24)	Coordination Centre, independent organization (Broker, independent regulator) (25) External organization (third-party) (26)	External organization (26) Trust easier in third-party, equal party (27)	Self-organized (28) Outsourced activities (29)
Summary of Setting up SCT	First we need to glue together processes with the other organizations within the network, students typically do this work for us. We will have discussions on the value proposition, on how the	There should be a Coordination Centre for the data sharing, intellectual property side. Operational coordination (given a particular service request) and strategic coordination (setting the guidelines on how we are going to	Main concern is protecting data that is shared with the other parties within the network. There should be agreements (contracts) on what to share and how to protect the data.	Need Governance, people who look at the complete picture (ideally they are responsible for the SCT and work towards the common goal). Below that, you need Teams to monitor, respond and improve (specialistic

	business model will change and concerning the new type of relationship that will occur (which is the biggest challenge). Make it visible and allowing it to be visible.	collaborate, use each other's services and financial sides). This coordination always needs to happen, similar to large service contracts.	Three aspects: technology (hardly an issue), intellectual property (data sharing part) and there is the financial side to it.	knowledge). This means you need People and therefore also Technology; Systems and Data (databases, views) to get an overview of the complete network.
Code name(s) **Code 30-40**	Glue together processes (30) Value proposition (31) Changing relationships (32)	Coordination Centre (33) Intellectual property (34) Operational coordination (35) Strategic coordination (36) Financial agreements (37)	Technology (38) Intellectual property (34) Financial agreements (37)	Governance (39) People (human organization) (40) Technology; Systems and Data (38)
Summary of Future SCT	Clearly a demand for more. Demand on how to share information across all the stakeholders within the network.	Inescapable that the SCT will become more mature and will advance. Reason is that the technology is becoming more complex which demands expertise. The growing complexity of technology and the help/use of technology will increase maturity.	More towards Remote Services and Remote Access in the future. Maintenance and repair from a distance is possible and already being requested.	More towards automation and robotization. Improving customer portals, real-time data. Improving visibility for own organization and customers, looking for new forms of collaborating.
Code name(s) **Code 41-46**	Clear demand – maturity (41) Demand organizations (42)	Clear demand – maturity (41) Technology development and complexity (43)	Clear demand – maturity (41) Towards remote servicing, access and maintenance (44)	Clear demand – maturity (41) Demand organizations (42) Customer demand (45) New forms of collaborating (46)
Input Discussion Chapter	Blockchain technology possibility was spoken about in the interview. Gluing together processes was also large part of discussion.	Vision on Technology element in SCT, enabler, complicator and help of technology. More and more complex of technology.	Developed technology, remote access and maintenance. Mentioned COVID-19 as opportunity to explore new ways of collaborating and sharing data.	Unique approach and vision of SCT (People are the SCT). Data sharing possibilities and new ways of digitalized collaborating (with competitor).

Appendix F: Interview protocol SCT semi-structured

Interview protocol – Dutch version (English translation can be shared on request)

Doel van het interview: Informatie krijgen over de SCT die binnen de organisatie is (of wordt) geïmplementeerd, wat het inhoudt en wat de toekomst van SCT kan inhouden. Ontdek hoe en waarom deze SCT worden geïmplementeerd en welke toegevoegde waarde de SCT oplevert voor organisaties.

Introductie van aanwezigen, toelichting geven over interview.
Verzoek om het interview op te nemen, het interview zal ongeveer 45 tot max 60 minuten in beslag nemen.

Inleidende vragen:

- Wat is uw rol binnen de organisatie waar u voor werkt?
- Hoe ziet u een (S)CT voor u? Kunt u een SCT omschrijven, dit kan een definitie zijn of een metafoor, een vergelijking.
- Wat is uw ervaring met SCT?

Zoom in op de SCT van de organisatie van de geïnterviewde:

- Controle vraag: Welk type CT heeft uw organisatie geïmplementeerd?
(Toelichting: er zijn verschillende CT-types gevonden in de literatuur, bijvoorbeeld: Supply Chain CT, Service CT, Outsourced CT, Logistics CT, Transportation CT, Digital CT, Air Traffic CT etc.)
- In welk stadium van implementatie bevindt uw SCT zich? (bijvoorbeeld nog in aanbouw of al operationeel)
- Hoe is de SCT geïmplementeerd → eerst een paar processen / elementen / systemen en daarna gegroeid of complexer? Is daar informatie over bekend?
- Zijn er meerdere partijen/stakeholders betrokken bij/in de SCT?
    - Zo ja, hoeveel? Hoe zijn zaken als afspraken / contracten en relaties / beperkingen in bijvoorbeeld het delen van data geregeld?
- Wat waren de drijfveren/redenen (binnen de organisatie) om de SCT te implementeren?
- Wat waren barrières/uitdagingen om de SCT (succesvol) te kunnen implementeren?

Aanvullende vragen over SCT implementatie en toekomst:

- Wat ziet u als belangrijke kenmerken / karakteristieken / elementen van een SCT?
- Wat is er nodig om een SCT op te zetten?
- Wat ziet u als meerwaarde van het implementeren van een SCT?
- Toekomst van SCT: Wat ziet u als verbeteringen of verdere Maturity (volwassenheid of groeimogelijkheden) stappen in de bestaande SCT?

Appendix G: Interview protocol for verifying and validating SCT artefact

Interview protocol – Dutch version (English translation can be shared on request)

Doel van het interview: Een open (groeps-) discussie voeren over de ontworpen artefacten van het Service Control Tower concept. Inzicht krijgen in de mening van expert(s) op het gebied van (Service) Control Towers en afwegen wat de sterke en zwakke punten/aspecten/elementen zijn van de ontworpen artefacten. Er worden meerdere experts uitgenodigd en indien mogelijk op korte termijn, wordt er eenmalig een gesprek ingepland met meerdere participanten. Doel is het verifiëren en valideren van de ontworpen artefacten, karakteristieken en beschrijving van de SCT zoals in de scriptie uitgewerkt is.

Introductie van aanwezigen, toelichting geven over dit interview / (groeps-) discussie.
Verzoek om het interview op te nemen, het interview zal ongeveer 45 tot max 60 minuten in beslag nemen.

Vooropgestelde vragen (ter leidraad, doel is een discussie waardoor niet elke vraag direct gesteld zal worden maar afhankelijk is van de loop van het gesprek):
1. Verifieer SCT omschrijving, karakteristieken, concept op basis van literatuur en interview uitkomst (inclusief figuren die gedurende scriptie gemaakt zijn)

- Wat onderscheid het Service Control Tower concept het meest van het generieke Control Tower concept? Wat voegt het Service component toe aan het CT concept?
- Uit het literatuur onderzoek en interviews is het volgende gekomen m.b.t. SCT:
  - Beeld bij wat is een SCT;
  - Drivers/Barriers SCT;
  - Opzetten van een SCT, wat is er nodig?;
  - Meerdere mogelijkheden omtrent Ownership / Distribution / Controlling en Managing SCT;
  - Beeld bij de toekomst van de SCT;
- Klopt dit met het beeld dat jullie hebben bij de SCT, wat wel en wat niet?
- Doorvragen zoals bijvoorbeeld: Zijn er inderdaad meerdere Ownership mogelijkheden, zo ja welke? Of zou er één beste oplossing voor zijn? (centraal/decentraal)
- Zouden jullie hier zelf nog elementen of karakteristieken aan toevoegen vanuit jullie kennis over de SCT?

2. Verifieer SWOT analyse SCT, tabel en tekst (open gesprek, meerdere vragen te stellen).
3. Verifieer BMC SCT, figuur en tekst (open gesprek, meerdere vragen te stellen).

- Zijn er ontbrekende elementen / elementen die je zelf zou toevoegen?
- Wat komt er wel en niet overeen met de aspecten die jullie zelf onderzocht hebben of een beeld (aannames, gedachten e.d.) over hebben?

4. Overige vragen of discussie met betrekking tot SCT concept, mogelijke punten voor verder onderzoek.

Bovenstaande vragen zijn opgesteld als leidraad, het gesprek wordt open gevoerd waar plaats is voor ieders visie en mening, resultaten van dit onderzoek worden gedeeld waarop elke mening gewenst is.

Appendix H: Summary of interview on 31-08-2021: interviewee E (confidential)