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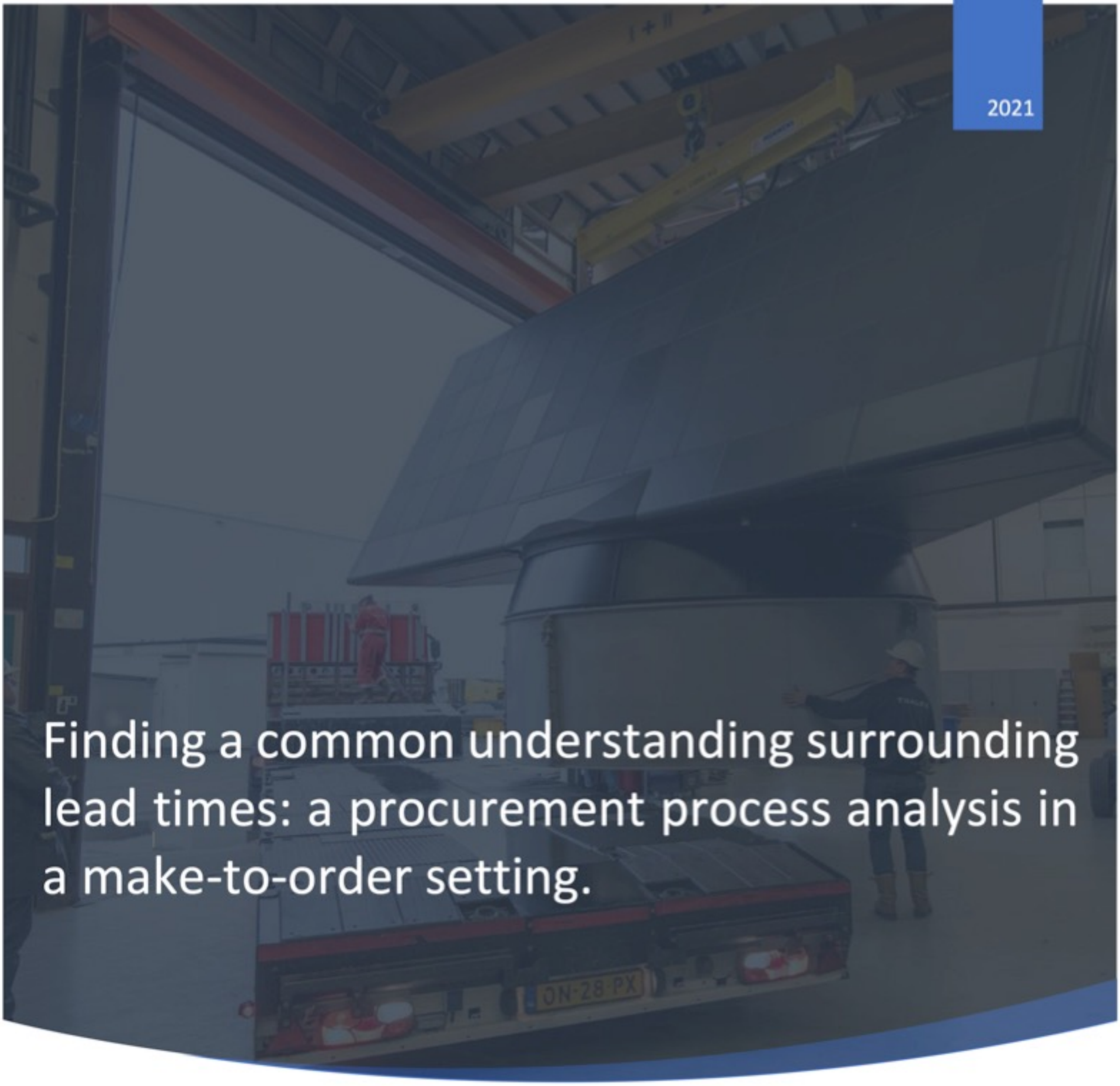

Finding a common understanding surrounding lead times: a procurement process analysis in a make-to-order setting.

BSC THESIS INDUSTRIAL ENGINEERING AND MANAGEMENT

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Preface

Dear reader,

This document contains the result of my thesis assignment for my bachelor Industrial Engineering and Management at the University of Twente. For the past six months I've been working with Thales to complete this assignment during this weird time. For Thales specifically, it was a busy period as well. Nevertheless, I got the opportunity to work within the organization on a real problem closely together with the people directly involved. Diving in and discovering more about this topic has been immensely exiting and valuable to me. I've learned a lot about the organization and its unique strengths and challenges, doing research but also myself. For that, I think a few words of thanks are in order.

Firstly, I want to thank Hazar Turkmen for his guidance and support, but also confidence in me. He made sure that I stayed on track and within the boundaries, but at the same time I experienced a lot of trust from him to make my own calls. This atmosphere helped in making this thesis the best it could be. Secondly, I want to thank Makbule Caglayan for always being there when I had trouble and helping out. I also want to thank the countless people within the organization that shared their insights with me and helped shape this thesis to what it is. Everyone I spoke to was happy to help out which made doing this research at Thales a truly enjoyable experience.

I would like to thank Patricia Rogetzer for her everlasting enthusiasm and clear and helpful insights while being my UT supervisor. Her feedback on the research and report really helped in making clear how to proceed with each meeting that we had. Furthermore, I want to thank Ipek Seyran Topan for being my second supervisor, but also for her help in the preparation of the assignment.

Lastly, I would like to thank my family and friends that gave their support and thoughts on the thesis. During an individual project like this, it really helps to be able to talk to someone about your work and I'm lucky that many of my family and friends were open to this. A special thanks goes out to Wieneke Jansma, who provided extensive feedback and was always there when I don't know what to do.

Management summary

The following research has been performed at Thales Netherlands in Hengelo at the behest of the supply chain department. Thales is one of the leading manufacturers of naval radars for defense purposes. Because of the success of the company, it is expected that production will have to increase capacity drastically in the coming years. The unclarity that lives around lead times makes this scaling difficult because of the implications uncertain lead times have on inventory and production planning which both need to be reduced. Therefore, the goal of this research is based on the action problem defined as:

"The lead times in the procurement process at Thales Hengelo need to become transparent and unambiguous instead of non-transparent and ambiguous."

To aid in solving this action problem, the context of the problem was researched and five research questions were defined which determined the focus of this particular research project, namely:

1. Which best practices and methods exist to manage and optimise lead times in a procurement process?
2. What does the current procurement process at Thales Hengelo look like?
3. How do the different actors in the process interpret and communicate the lead times?
4. How reliable are the defined lead times across the different procured items?
5. Which lead times in the process are the most variable and considered significant to the process?

From literature, it could be concluded that there are two main perspectives of dealing with lead time uncertainty being applied in practice, namely transactional and relational governance. Furthermore, quantitative methods have been proposed in literature to cope with this uncertainty as well. It was also determined that these quantitative methods have been hard to apply in practice since in the context of a make-to-order low volume company, data for the models could be hard to get.

Information about the procurement process was gathered by organising semi-structured interviews with process actors (tactical buyers, master planners, warehousing and support staff), and by sending out a survey to the suppliers of Thales. From this, a clear description and business process model of the procurement process could be created, but a lot of variations were also identified. An effort was made to take note of all these variations and find out how often these are applied. The most notable variations took place during lead time updating, determining of need-by dates, determining of lead times and order point determining. Impressions and opinions on the process from process actors were also gathered.

A data analysis was performed on historic orderlines to quantify what was obtained in the interviews, and deepen the understanding gained from them. From this, it came forward that most things mentioned during the interviews in terms of variations could be traced back to the data. From the data, the determining of need-by dates and order point determining are the most clearly visible issues.

From the research a lot of interesting phenomena and concepts were identified that could be of use for the organisation to decrease the uncertainty around lead times and therefore make it easier to scale production. These are outlined in the report, alongside context from the interviews, survey and data analysis results as well as from literature. The topics that are considered most interesting are lead time updating, safety times, the "outdated" status of items, documentation of lead times and the

operationalisation of orders. Based on these points of interest, the following actions are proposed to solve the core problem identified in the beginning of the research:

1. Instate a standard updating check for lead time before the planning of an item.
2. Create a field to allocate safety lead time for items separate from other fields in the ERP system.
3. Change the conditions for allocation of the "outdated" status to consider older lead time data.
4. Enable documenting historic lead times, or multiple lead times for items to capture and communicate variability.
5. Discuss the rigidity of the operational planning and suggested order dates between planning and tactical buying to reach a common understanding.
6. Reduce the number of items that get operationalised with the "outdated" status.

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List of Abbreviations

BOM	Bill of Materials
BPA	Blanket Purchasing Agreement
BPM	Business Process Model
BPMN	Business Process Model and Notation
DFT	Days-From-Today
ERP	Enterprise Resource Planning
OTD	On-time delivery
PO	Purchase Order
TBSS	Thales Business Support Services

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Readers guide

The following report is the result of the graduation thesis performed at the procurement department of Thales Netherlands in Hengelo. The report is structured in the following manner.

Chapter 1: Context and problem assessment

The first chapter offers insight into the context of the research. A short description of the company is given, along with the reason for why the research was commissioned. The chapter then goes in depth into the problem assessment and concludes with the core problem on which the rest of the research is focused.

Chapter 2: Research design

Within this chapter, the way the research has been executed has been outlined. The different research questions are defined, and the methods for answering them are described alongside the intended results, and possible limitations to the research.

Chapter 3: Literature review

The results of the systematic literature review that was performed in order to gain insight into the ways of dealing with supplier uncertainty that exist in literature.

Chapter 4: The procurement process

This chapter outlines the procurement process on a general level. The chapter discusses the way the process is organised, which data and documents are in use and which subprocesses exist. Only the general steps are discussed in this chapter.

Chapter 5: Variations in process

The procurement process as described in Chapter 4 knowns many variations and exceptions that came to light during the research. The steps in the process that know variation are discussed in this chapter.

Chapter 6: Impressions from process actors

During the research a lot of impressions on the process, how it performs, and what could be done better were gathered from interaction with various process actors. The most noteworthy ones are mentioned in this chapter, and context from the broader research is included where relevant.

Chapter 7: Recommendations

By answering the research questions, a lot of points have been identified which could be significant in solving the core problem. These improvement points are outlined in this chapter, alongside context and other points of attention for the company to consider.

Chapter 8: Conclusion

This chapter includes the conclusions to the research questions, as well as a short overview of the recommendations made to Thales. The limitations of the research are also discussed, as well as the opportunities for further research that have been identified.

1. Context and problem assessment

The following chapter will present the context in which the thesis was written. First the company will be introduced, alongside the reason behind the research. After that the different problems that were identified will be presented, and the choice for the core problem will be elaborated upon.

1.1 Thales NL

Thales Netherlands, based in Hengelo (hereafter referred to as Thales, Thales Hengelo or Thales NL), develops and builds radar equipment, cyber security solutions, transportation systems, communication equipment and a variety of other products at various locations in the country. The assembly of radar equipment for naval applications takes place at the facilities in Hengelo, but is supported by a worldwide network of suppliers that deliver general and specialised parts, but also elaborate subassemblies. The radars build in Hengelo are highly specialised and rarely ordered in high quantities. Therefore, these are built on a make-to-order basis. The manufacturing of these radars can span multiple years, depending on the type and configuration. These projects are overseen by the planning department, which allocates Thales' own production resources across these projects, and consequently also determines when certain parts or subassemblies are needed in production that are not manufactured by Thales themselves. This information is passed on to the procurement department, where the tactical buyers communicate with the relevant suppliers about the required parts. Potential problems are sorted out by the tactical buyers, in coordination with the suppliers, planners and if needed engineering. The parts are then ordered by the tactical buyers to arrive in time for them to be incorporated into the product in Hengelo.

1.2 Research context

In recent times, Thales has been faring quite well, and it's projected that in the coming years more orders will keep coming in. This means that the production has to be scaled up in order to accommodate for all the new orders. In some cases, Thales has to move away from a project basis towards batch-like production. The preparations for scaling the production process are currently underway but here the supply chain department has run into some issues. It appears that, given the current way of functioning, production cannot simply be linearly scaled. Thales will not be able to handle the associated inventory in this case, both monetarily as well as physically. Furthermore, the throughput time of the projects needs to be drastically decreased. On top of this, management also wants to control late deliveries before scaling, to avoid this from becoming a larger issue. It is believed that both the amount of inventory, as well as the long and uncertain lead times are because the supply chain comprises too much uncertainty. A lot of this uncertainty can be brought back to procured goods. This project will therefore be focussed on the procurement department.

1.3 Problem assessment

Out of preliminary talks with the managers, planners and buyers it appears that a few factors create uncertainty within the procurement department. Due to the complexity of parts, sometimes a part of subassembly is not created up to specifications, or the specifications have been changed after the order had been put in. This means that a part would have to be remade, essentially doubling the lead time and causing delays. Furthermore, due to the fact that parts are sourced worldwide and have to be shipped certain risks also exist in the logistics of procuring the parts. Most of all however, it appears that from the perspective of planning and management, the procurement of parts is often erratic and hard to predict. When talking to the tactical buyers, a few phenomena seem to cause this unpredictability. According to them, a lot of "specials" are asked for, meaning a deviation from standard designed parts. This means a lot of communication has to be done between internal departments like engineering and project management, and the supplier to make sure the right things are ordered under the right conditions. Another remark that was made was that at times, planning puts through a request that would be impossible to fulfil. As anecdotal evidence for this a story was presented where a part was requested for the week thereafter, which would normally take 9 months to manufacture at the supplier. It also appears that the dockdate, the date which planning would want the part to be delivered at Thales seems to change erratically after the initial request has been put through. However, it also became apparent that throughout this whole process it was hard to find out which lead time was being discussed at that time. In communication between the departments and the suppliers many different times were used, without a clear direction on how these different values were determined. This makes it hard to identify where exactly delays and buffers come from. This in turn causes redundant delays to be planned in, or planning deciding when a part needs to arrive based on wrong, too optimistic data.

All of this combined leads to the problem cluster depicted in Figure 1, which takes the origin of the research, namely that Thales is not able to upscale it's production, as a starting point.

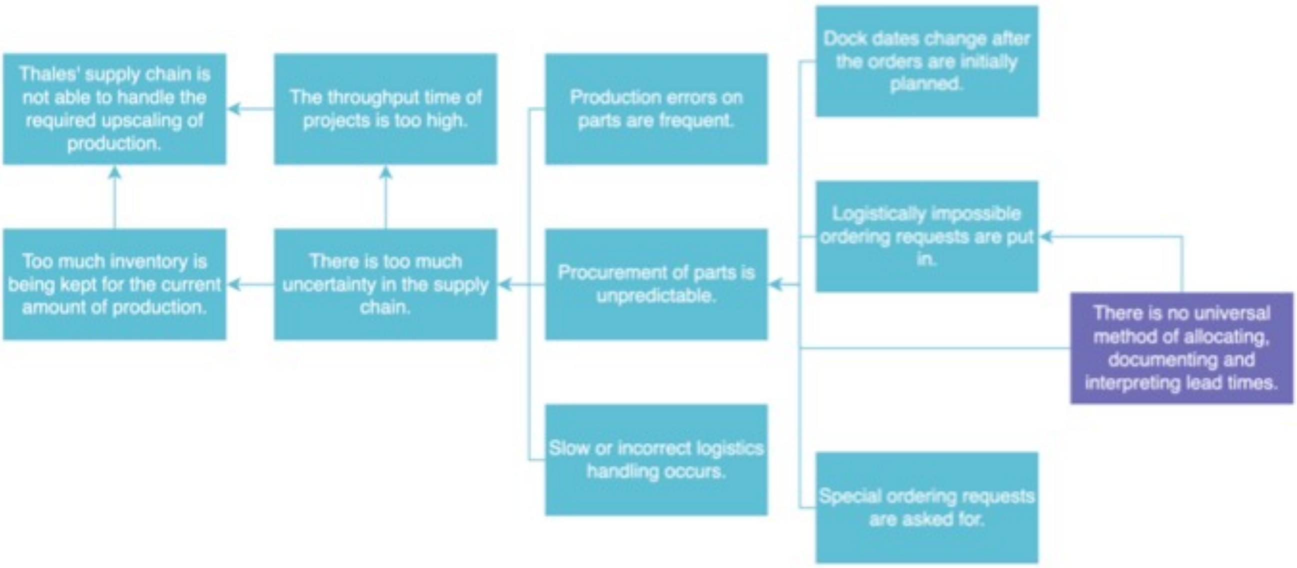

Figure 1: Problem cluster

1.4 Core problem

When evaluating all the identified problems, multiple potential core problems were found. However, the one that will be the focus of this research is "There is no universal method of allocating, documenting and interpreting lead times.". This problem is chosen over the other potential core problems because it's the most effectively influenceable problem, and also believed to give the most positive impact on the procurement process as a whole. When this problem is solved, it will also be clear for management where other improvements can be made. The problem of changing dockdates was not chosen because, while its origin in the Enterprise Resource Planning (ERP) system is unknown, dockdates are hardly changed in such a way that they negatively impact the planning. Thus, while solving this problem might pose an interesting challenge, it will not yield a large improvement. The problem of special ordering requests that was identified will also not be treated as the core problem in this research. This is partly because these requests are inherent to the work that Thales does, since the products need to have some form of customisation as well. Furthermore, while this

communication might lead to extra work for the buyers and engineering, it does not lead to immense changes in the lead time of the items.
To phrase the core problem as a difference between the desired norm and the reality:

"The lead times in the procurement process at Thales Hengelo need to become transparent and unambiguous instead of non-transparent and ambiguous."

2. Research design

This chapter will focus on the way the previously determined core problem was be solved in the executed research. The problem is divided into separate research questions, important concepts will be defined and the theoretical perspective of the research will be elaborated on. After this, the different research methods will be discussed in depth, along with the planning and intended results. Validity and reliability issues, and limitations will also be discussed.

2.1 Research questions

To solve the core problem formulated in the previous section, the following knowledge problems needed to be solved:

1. Which best practices and methods exist to manage and optimise lead times in a procurement process?
2. How does the current procurement process at Thales Hengelo look like?
3. How do the different actors in the process interpret and communicate the lead times?
4. How reliable are the defined lead times across the different procured items?
5. Which lead times in the process are the most variable and considered significant to the process?

2.2 Theoretical perspective

Variables

The situation at Thales can be seen as the relationship between two distinct variables, one being the lead time ambiguity, of which the size is determined to be one of the core problems behind the problems that Thales wants to solve. The other is the procurement process actor behaviour, which is the variable that influences the lead time ambiguity. By handling specific tasks in a certain way, or communicating in a particular way, the procurement process actors either decrease, or increase lead time ambiguity depending on the situation. This is expressed in the conceptual model in Figure 2.

Figure 2: Conceptual model

Theoretical framework

To research the relationship between procurement process actor behaviour and lead time ambiguity, the process was analysed by ways of Business Process Management. This is a method of charting, analysing and designing business processes. The practice of Business Process Management focusses on mapping processes in a company in such a manner that all stakeholders can understand the process, from an operational, managerial as well as technical level. For this the Business Process Model and Notation (BPMN) standard has been used (Object Management Group, 2011). BPMN is designed to be a graphical, flowchart-based standard that aims to bridge the gap between IT and Business analysis. This standard is chosen because its widely supported and documented (Ko, Lee, & Lee, 2009), and because the level of detail in steps and decision making made possible by this standard is applicable to the way we wish to analyse the process. By creating a model of the procurement process in BPMN 2.0 it can be made very clear which decisions are made by which process actors in certain process steps, and what influence this has on the different data objects of lead times that are in use in the systems of Thales.

When analysing the suppliers, this can be done in the context of Kraljics' matrix, a tool often used in sourcing and supply chain management (de Boer & Telgen, 2018). Kraljic advocates for classifying your procured goods, or supplier portfolio on the variables value and risk. High value, high risk items should receive ample attention by creating long standing relationships and encouraging collaboration, while low value, low risk items should be streamlined as much as possible. When looking towards supplier governance regardless of items, this was done with the theorem of the combination of transactional and relational supplier governance models (Clauss & Spieth, 2016). Transactional governance is characterised by strict goal setting and individual responsibilities, while relational governance focusses on dialogue and shared responsibilities and benefits. Clauss and Spieth advocate for employing more relational governance at riskier, key, or future key suppliers, without forgoing transactional governance elements entirely. This is because while transactional governance will encourage suppliers to perform on their own, complex products and supply chains require more innovation and collaboration in able to become optimal.

To assess the lack of transparency between the different process actors in the context of the usage of the ERP system and other methods, Business Process Integration theory is applied alongside theory on performance measurement in supply chains. Business Process Integration means how well a process and associated systems are adopted and executed by an organisation. Often times, the quality of the integration is highly dependent on the quality of the information flows. When looking at the factors that play into the quality of information flows, these can be categorised as timeliness (how up-to-date information is), accessibility (how easy the information is to find), granularity (how much of the total information can be stored or learned) and transparency (how clear it is what is meant) (Berente, Vandenbosch, & Aubert, 2009). In order to then make the right decisions when working with these systems and processes one should consider the right data measures. These measures can often be categorised in cost, time, capacity, capability, productivity, utilisation and outcome. More specifically capacity can be further specified into effectiveness, reliability, availability and flexibility (Chan & Qi, 2003). It is important to consider which category the information you wish to consider falls into, and check if this is aligned with what is actually being measured. If this falls in a different category, the wrong conclusions and decisions might be reached.

2.3 Methods

To solve the first knowledge problem (*What best practices and methods exist to manage and optimise lead times in a procurement process?*), a systematic literature review was conducted. Both qualitative papers about methods and the current scientific status quo on procurement management, as well as papers outlining quantitative methods were considered. This is to find an overview on what existing norm is in this field, as well as find potential methods to apply at Thales. It can also help to find context for Thales to compare itself to. The results of the literature review are included in chapter 3.

The second and third knowledge problems (*What does the current procurement process look like?* and *How do the different actors in the process interpret and communicate the lead times?*) have been solved by conducting a combination of interviews and surveys. The second knowledge problem will be discussed in Chapters 4 and 5, and the third in Chapters 5 and 6. The interviews were held with all actors involved in the procurement process, meaning the tactical buyers, planners and logistics staff. Furthermore, the managers and support staff (quality control and data management) of these departments have also been interviewed. In total 10 tactical buyers and 9 other process actors where individually interviewed for around an hour per person. To maximise the insight that can be gained from the interviews, they were conducted in a semi-structured fashion. This way it was ensured that every topic which we require was addressed, while maintaining the possibility for the interviewee to add insights or perspectives that had not been previously thought of. The interviews with the tactical buyers and planners also involved specific questions regarding their decision process on attributing lead times to items. This will offer a deeper understanding of their actions and the reasons behind them. The results of the interviews were sorted per question or topic and compared. To ensure the anonymity of interviewees, the literal results have been omitted from this document.

A selection of the suppliers was asked to fill out a survey concerning their cooperation with Thales. The basis of this was the suppliers that supplied Thales in both 2020 and 2019. This choice was made to exclude suppliers that are only involved with Thales since recently, or have only fulfilled one order due to exceptional reasons. At the same time this keeps in the suppliers that only do limit amounts of orders, but have been supplying Thales for multiple years. At the request of Thales some suppliers were omitted as well due to the nature of the relationship, or ongoing negotiations for example. This leaves 175 suppliers to which the survey was send, of which 73 filled it in. The survey included a set of multiple choice and rating questions to be able to create an overall picture of supplier disposition about their cooperation with Thales. The survey however also included open questions to gain insight into the suppliers' role in the process and their thoughts on it. This created a good overview about the current procurement process, and the behaviour. It also serves to highlight certain areas for later stages of the research. The full questions and results of the survey can be found in Appendix E.

The last two knowledge problems (*How reliable are the defined lead times across the different procured items?* and *Which lead times in the process are the most variable and significant to the process?*) where dealt with by conducting a data analysis on primary sources and elaborated on in Chapters 5 and 6. The records of procured items from the past three years were used for this analysis, which was acquired via a custom request in the business intelligence system of Thales. From this period of time, all characteristics of individual order lines, such as the internal need-by date (meaning the day that the item is required in production), suggested order date, promised arrival date and realised arrival date were taken into consideration. These values were compared to more general characteristics of the item type such as the in-system lead time and the lead time communicated in the yearly blanket purchasing agreement. Due to the removal of data in the ERP system, some checks could only be done on currently active order lines. With this, findings can be done about patterns in lead times of suppliers, categories of parts and time periods. Next to this, an analysis can also be done on the different lead times that are in circulation, and the differences between them. Significant deviations in these lead times can also be pointed out this way, along with where they seem to occur. Methods that were found in the literature review can also be applied to the dataset to gain even further conclusions.

2.4 Definitions

During the thesis the following terms will be used extensively. This part aims to define the terms in detail for further use in the project.

Make-to-order

Thales manufactures their products on a make-to-order basis, which is a way of categorizing when production starts relative to the point that the customer places the order for the product. Make-to-order products are classified as products manufactured on a unique basis so as to meet specific customer requirements (Handfield & Pannesi, 1995). The companies producing them typically handle low volume production and great variability in demand quantity and mix.

Procurement process
The focus of this thesis is the procurement process at Thales. This process includes all the actions of and interactions between the different actors in the process from the moment that a demand for an item that will not be manufactured in-house has been identified until the moment that this demand has been fulfilled at the production site. The actors include staff from the procurement, planning and logistics departments of Thales, but also actors such as suppliers.

2.5 Results
From the interviews with the actors in the process, a business process model (BPM) of the current procurement process has been created. This also includes the steps in the process at which certain lead times are determined and which considerations process actors make at this step. Highlighting the points of attention in this model can then serve as basis for the other investigations as well. The insights gained from the interviews as well as literature also served as input for suggested changes to the process in the form of a new BPM for the to-be situation. Next to the BPM, the interviews and surveys yielded more information that is of interest. The way tactical buyers and planners currently handle the decision making for lead times is systematically outlined. This thought process is important to know, as they might contain reasons for choices that are unknown to management. Furthermore, making an overview of all methods used can result in a unified methodology. Any other general findings are included as well.

The results of the data analysis will point out which stages in the process are most impactful in creating uncertainty and high lead times. Consequently, these conclusions also point out how much can be gained by handling the problems that cause this type of lead time. Furthermore, the data analysis can also aid in confirming or disproving any suspicions that may arise from the interviews. Any other noteworthy patterns will also be reported on, combined with potential actions to improve the process using this information.

2.6 Validity, reliability and limitations
While this thesis aims to gain the most extensive and accurate insight into the procurement process of Thales as possible, it is important to keep in mind that there are limits to this research that must not be forgotten.

Conducting interviews poses a potential threat to the validity and reliability of the thesis. Interviews are inherently subjective, as every participant has its own perception on the topic at hand. It is also well known that in interviews people might not always tell the whole story, either accidentally or on purpose. This might be because of the inevitable tension that someone might experience in an interview, or because of miscommunication. During the interviews an effort was made to make it as clear as possible what the intentions of the research are, what the participants can expect and that the participant will not suffer any harm for participating. Furthermore, the interviews were held with a fairly large population of participants. Therefore, the results can also be compared to each other to see if something is truly out of the ordinary. Nevertheless, it is important to stay critical about the validity and reliability of interview results.

The same counts for the survey results. As the suppliers filled these surveys unsupervised, there is no way to factually know whether they've given truthful answers. Furthermore, it is not too far-fetched to imagine that a supplier might try to make their answers in the survey sound more positive, as they might think that this will benefit their relationship with Thales. A supplier will not easily give critical feedback to Thales if they only wish to please Thales. Therefore, to check if the results of the survey are reliable, they were also be compared to the factual data that Thales possesses. Furthermore, the questions ranking Thales will be treated as potentially skewed towards positive for Thales when analysing.

While the data analysis aims to be as objective and factual as possible, it is important to note that some data present in the data set has been manually inputted by staff at Thales. Therefore, the reliability of some lead times might not always be perfect. This is, however, one of the focus points of this research. The unreliable values were compared to undisputable factual data as much as possible, and a large part of the research will be dedicated to finding out the decision factors for determining these potentially unreliable lead times.

Lastly, it is important to keep in mind that this research is done within a limited time span. To ensure that every step in the process is carried out with care and attention, the research is limited to the procurement process, with the largest focus on the tactical buyers. The other processes in the supply chain will not be considered in detail, and other staff of Thales was involved in the interviews if they are a stakeholder in the procurement process. This is done to avoid having to rush over necessary steps due to having a too broad scope for the limited time available in mind.

3. Literature review

The knowledge problem *"Which best practices and methods exist to manage and optimise lead times in a procurement process?"* is solved by conducting a systematic literature review, the details of the systematic process can be found in Appendix D.

Throughout the years a lot of researchers have shown interest in dealing with uncertainty in supply chains by concentrating on procurement issues. While supply chain management in general has been well versed in literature, the focus on procurement has only been worked out later. However, in the context of make-to-order firms the procurement of materials has been identified as the part of the supply chain that can yield the biggest result when improved (Handfield & Pannesi, 1995).

3.1 Governance mechanisms

For a long time in practice procurement improvement was seen as uncertainty avoidance (Gadde & Wynstra, 2018) with low interaction between suppliers and buyers. These transactional governance mechanisms, which they are called by Clauss & Spieth (2016) focus on managing a relationship with suppliers by having strict obligations and unrefutably contracts. This mechanism sees the procurement process as the buyer setting terms and the supplier fulfilling them with minimal interaction. This way of governing a supplier has since been challenged by relational governance, which puts emphasis on different levels of collaboration between suppliers and buyers to increase overall effectiveness. Many examples of ways that information sharing, long-term focus and cooperation have benefitted companies exist (Asmus & Griffin, 1993; van der Vaart & van Donk, 2003). The overarching idea is that by being more aligned with each other, the buyer and supplier can work out ways in which they can anticipate on the other parties needs more quickly and eliminate misdirected efforts. While many of these success stories have been documented, criticism also exists against its widespread application, with some evidence suggesting that in some cases it might even work aversely (Sullivan, et al., 2006). Some authors also argue for employing different levels of supply chain integration for different situations (van der Vaart & van Donk, 2003).

Others suggest treating the transactional and relational mechanisms as non-exclusive to each other. According to Clauss & Spieth (2016), the transactional model has proven to give the most effective results in terms of direct results, but hinders innovation and problem-solving capabilities in the collaboration. Therefore, they argue for applying both mechanisms at the same time. In practice this could imply holding your suppliers to strict obligations, but also sharing necessary operational information with them to improve their planning. The authors argue that this should count even more so for key-, future key- or troublesome suppliers. Asmus & Griffin (1993) give multiple examples of projects conducted with this category of suppliers in a joined effort with buyers.

3.2 Quantitative methods

While a lot of articles point towards improving procurement processes by more engagement with suppliers, quantitative methods of dealing with supplier lead times and uncertainty have also been proposed. Although safety stocks are the most prominent methods of dealing with uncertainty in a supply chain, for assembly systems it is more effective to apply safety lead times (Hegedus & Hopp, 2001b).

Many methods have been proposed to efficiently calculate these safety lead times, but the scientific community is yet to find a most ideal method to apply to large quantities of items. A few things that hinder this is that it has proven difficult in practice to determine exact backlogging costs in complicated assembly projects, that because of the low volume of orders not enough data exists to create reliable distributions for all items and that processing these models takes a large amount of time and resources (Dixit, Srivastava, & Chaudhuri, 2014; Borodin et al., 2016). Determining the exact safety lead times for individual items instead of a blanket safety lead time does however appear to yield significantly better results (Hegedus & Hopp, 2001b).

In the meantime, the subject of supplier lead times has also been approached from different sides. While not extensively written about, some papers propose models for suppliers to determine their internal due date compared to the requested due date from the buyer, based on internal factors and delay costs. While these models would serve more purpose in the context of a project executed at a supplier, it is relevant to note that while these models optimize the results for suppliers, the introduction of delay costs by a buyer can radically change the decisions put forward by the model (Hegedus & Hopp, 2001a).

While also not extensively researched, interest from the oil and gas industry has been expressed in models that calculate whether it would be beneficial to pre-emptively buy capacity at suppliers without knowing exact demand for this period (Silver & Jain, 1994).

3.3 Conclusion

By identifying both the governance mechanisms as well as quantitative methods that exist in literature, the first research questions could be answered. It appears that governance methods have traditionally been split between the older transactional mechanisms, and the newer relational mechanisms, but in recent years hybrids have been proposed. Quantitative methods in the context of make-to-order firms do exist, but appear to know several limitations at this time, mostly concerning the way lead time data and cost data is handled.

4. The current procurement process

The following chapter gives an overview of the procurement process. This is started by introducing all the process actors and stakeholders, and how they relate to each other in the organisation. The data objects in use are also defined both on item as well as on order level. The main subprocesses are then described.

4.1 Organisational structure

The procurement department of Thales has two main types of buyers, the category buyers and the tactical buyers. The category buyers focus mainly on relationship management with suppliers and the overarching agreements with these suppliers, whereas the tactical buyers handle most of the day-to-day buying activities. The tactical buyers are supported in the buying activities by Thales Business Support Services (TBSS), which is service providing department for the whole Thales group and is situated in Portugal. While the tactical buyers focus on the communication with the supplier and the managing of orders and items the practical tasks are delegated to TBSS by the tactical buyers. This includes actually creating and sending purchase orders (POs) via email, and inputting the information received from the suppliers. Next to the buying roles, the procurement department knows numerous supporting roles like item maintenance, process and tools and supplier performance management.

The tactical buyers mostly work based on the needs expressed by the master planners from the planning department, who oversee the overarching timeline of upcoming and running projects. This means they plan inhouse production, and consequently schedule when procured items need to be available in production. The way all the mentioned departments and functions relate to each other is outlined in the organisational chart in Figure 3.

Figure 3: Organizational Chart

The planning department works from a project perspective, meaning that the master planners and production planners are divided over different projects, and try to manage these on a case-by-case basis. Where the production planners focus on internal manufacturing in detail, the master planners plan the overall projects and the items that will be procured instead of manufactured. The procurement department however, is organised from an item perspective. This means that the tactical buyers are divided over different item categories, or over specific suppliers. This enables the tactical buyers to combine requests from multiple projects into single orders at suppliers, which enables economies of scale and makes quantity discounts possible, as well as reducing shipping costs by minimising the amount of individual shipments and enabling other tactical benefits of the supplier relationship.

Most of the administration and communication between these department works via the ERP system Oracle, but various reoccurring Excel files are also in use. Oracle contains a tactical environment in which the master planners draft the upcoming planning, and an operational environment which must be seen as the planning that is being executed. From both these environments reports are made that are used by the tactical buyers. The records of possible items to order are also kept in Oracle, as well as the records of the different orders.

4.2 Data attributes

The ERP system of Thales maintains data that is relevant for the procurement department on two levels: item level and order level. The item level contains all the generic information of items which can be procured in arbitrary quantities for various projects. This includes information like technical specifications, export classification, preferred supplier and a lead time. At the order level, the different orderlines are kept. This means that all individual instances of items that will be, are being or have been procured exist individually in this environment. The specific information about these items include the project they're being procured for and specific planned dates for this particular item. In this paragraph the characteristics relevant for this research will be elaborated upon. The way these attributes relate to each other in a standard order is outlined in Figure 4.

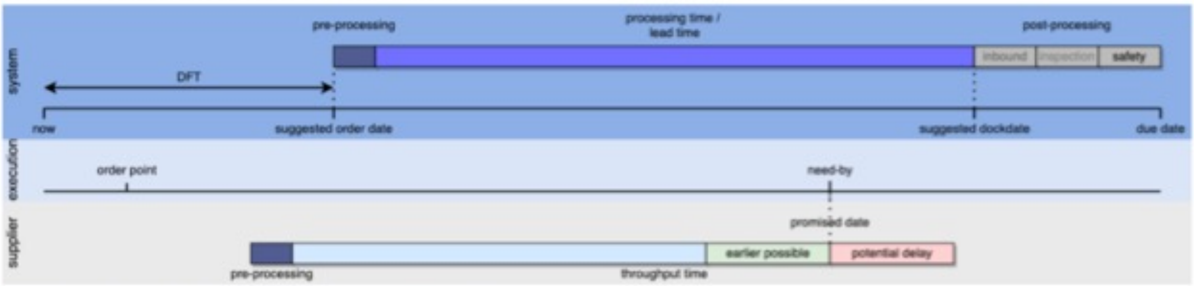

Figure 4: Overview of attributes in procurement process.

4.2.1 Item level

In the ERP system of Thales, items are parts that can be either procured at suppliers or manufactured in-house, for them to ultimately be incorporated into a larger subassembly (which in itself is also an item), a product which will be sold to a customer, or sold directly to the customer as a repair or spare part. While the parts also appear in different systems that focus more on the technical specifications and manufacturing details, the items in the ERP system are used in a supply chain setting. As said, items can either be procured or manufactured, these are referred to as "buy" and "make" items respectively. For the intents of this research we will focus on the "buy" items.

The items that will be procured are defined by a unique identifier (referred to as a "12NC") and contain various details that are of interest. Next to being linked to the technical specifications for the item in a different software package, on first introduction the items generally have a category, a responsible category buyer and tactical buyer, and preferred supplier. Should a preferred supplier be found, then the details of the agreement with this supplier will also be included in the item data. Among these are the price, minimum order quantity, quantity discount structures and other pricing and condition characteristics. The logistical and customs consequences of procuring the item at this supplier are also included. For example, it's marked whether the item needs customs or other clearances from the country of origin, or from the Dutch government.

Among the vast amount of information available for each item, the following characteristics are of most importance for this research:

Processing time/supplier lead time

The processing time, within Thales more commonly referred to as the lead time, is defined as the time that the supplier will need to manufacture, or otherwise process the item in order to have it ready for hand-off to Thales. In most cases, this also includes the transportation times, as the supplier is most often responsible for timely delivery at Thales' facility. The processing time is entered and updated manually in the system by the tactical buyer who is responsible for that item and can vary widely for the different items.

Pre-processing time

The pre-processing time is the time that is intended for all the steps that have to be taken before the supplier can get to work with the order, from the moment that the item has been cleared by planning. This includes all the order-specific communication between the tactical buyer and supplier, and if needed engineering and finances. Within Thales, the pre-processing is set to five days for all items that have to be procured, regardless of type, supplier or country of origin.

Post-processing time

The post-processing time is most commonly referred to in the company as "dock-to-stock" and covers all the steps that still have to be performed when an item has arrived at Thales' facility before it can be used in production. The post-processing time depends on whether the item is procured in the European Union or outside (in which case the item has to run through customs checks), but also on whether Thales has to perform other quality or conformity checks on the item. Furthermore, two days will be allocated to post-processing time by default to account for processing at the inbound warehouse from Thales. As a safety precaution, five days are also added by default to the post-processing time to account for irregularities bringing the total to seven days.

Item status

Each item has a status characteristic that gives information on how this item should be treated. While more statuses exist, the most relevant ones for procurement are "approved" and "outdated". In order for an item to be procured, it should have the status "approved", which means that there's no objections to procure this item. If during the planning stage it turns out that this is not the case, actions should be taken to make sure that the items becomes "approved". One of the main causes of this is that the item has the status "outdated", which the item will get if it has not been procured in the past two years, and the Blanket Purchasing Agreement (BPA) information has not been filled in this timeframe as well. An item can also be marked as "obsolete", meaning that this item canot be delivered by the current supplier, and should be re-sourced.

4.2.2 Order level

Due date

The due date (in the planning environment referred to as the material availability date) is the latest date at which the item is required in order to carry out further steps in the process. This is set by the planning department before the item is passed on to the procurement department.

Suggested dockdate
The suggested dockdate is the date at which the item is advised to arrive at Thales' facility, taking into account all the steps that need to be performed before the item can actually be used. The suggested dockdate is calculated by taking the due date and subtracting the item specific post-processing time from this.

Need-by date
The need-by date is the date that will appear on the PO which will be send to the supplier. The supplier is expected to deliver the item to Thales at this date, or be able to present the item to Thales' transportation partner depending on the type of agreement that is applicable. By default, the need-by date is equal to the suggested dockdate.

Suggested order date
The suggested order date is calculated by taking the suggested dockdate and subtracting the item level processing and pre-processing time. This yields the date at which the tactical buyer would need to start the process of ordering the item for it to arrive at the suggested dockdate.

DFT
DFT, or days-from-today is the amount of days from the present day to the suggested order date of the item. Should the suggested order date be in the past, the DFT will stay at 0.

Promised date
The promised date is the current date at which the item is scheduled to arrive at the facility of Thales. This is the date that has been communicated on the order confirmation that was initially received at the beginning of the process. However, due to a multitude of circumstances from both the supplier as well as Thales' side this date can be changed when the initial order confirmation has passed up until the moment that the order is fulfilled.

Original promised date
For performance measurement reasons, the original promised date is documented. This is the promised date as communicated on the first order confirmation. Should a supplier have to delay delivery due to unforeseen circumstances, the promised date will change so that the planning department can work with the more accurate date. However, the supplier performance will be measured to the original date, since missing this date constitutes to a lack of performance.

Revised original promised date
Next to unsanctioned changes in delivery dates from the supplier side, it can also happen that Thales wishes to delay delivery due to changes in planning, or that Thales and the supplier reach a mutual understanding on a new promised date. In this case the revised original promised date is used, which is then used as a basis for performance measurement. This is to prevent these types of mutual agreements from negatively influencing the supplier performance rating.

4.3 Documents
Within the procurement department, a set of lists are periodically created from data in the ERP system and made available to the process actors. A few lists that are of importance for the process that will be discussed in this research will be elaborated upon here.

Man80

At the beginning of every year a forecast is made of which items will be needed in the upcoming time. With the suppliers of various key items or item groups BPAs are drawn up.
These agreements consist of prices, quantity discount structures and lead times for the items that Thales thinks it wants to procure in the upcoming year. When the category buyers have settled this with the suppliers, the item information for each item that has been included in the BPA list (called man80) is then requested by the tactical buyers and put into Oracle. This can be partly done by automatically loading a list provided by the supplier into the system. However, some items have to be entered manually, and most crucially, the lead times of items also have to be entered manually as the loading tool only works for the prices of items.

Man113

The man113 list contains all the parts which are included in the bill of materials (BOM) of projects that are confirmed to be executed at Thales NL. This means that from the moment that Thales knows for sure that a project will be performed, the items needed for this project will be included in the man113 list.

Man67

As mentioned before, the planning of the actual projects happens either in the tactical or operational planning environment. The items that have been placed in either of these planning environments will show up in the man67 list, with their projected due dates and other characteristics. It should be noted that while this list still exists, during the execution of the research a directive has been put out to discourage use of this list in favour of the man113 in an effort to use less different files in the procurement department.

KPI ASCP

The "KPI ASCP" list, more commonly referred to as the "aansturing", includes all the items that have been fully planned in the operational planning environment. This means that these items are ready to be procured by the tactical buyers. Generally, once an item appears in this list, the ordering process for this item will start.

4.4 Sub-Processes

he most important sub processes will be discussed in the following paragraphs. These sub-processes are outlined on the full BPM of the procurement process on the next page in Figure 5.

Figure 5: Full BPMN with indication of sub-processes

4.4.1 Item maintenance

One of the side processes in the procurement department is item maintenance. This is done when interest is expressed by a master planner in a certain item which has lacking or outdated information. The full process is outlined in the partition of the BPM shown in Figure 6. This sub process can be triggered in various situations, namely:

- The item is new. This means the item has been newly introduced by the engineers, and its basic information (technical specifications, responsible tactical buyer) has been included into Oracle by the item maintenance controllers. It, however, does not have supplier information at this point.
- The item entry in Oracle lacks information. For various reasons an item can miss information that is crucial for planning it in the production/procurement schedule.
- The item does not have a supplier anymore. Sometimes suppliers seize production of a certain item, or seize to exist entirely. The item will then still exist in Oracle but logically would need a new supplier. The search for a new supplier starts as soon as a new demand for the item has been discovered.
- The item has been marked as "outdated". Even if the information for a certain item is complete, after the price has not been changed for two years, the item will be automatically marked as "outdated" in Oracle. This means that the information cannot be regarded as up-to-date, and should be verified again before continuing planning this item.

In most cases, the items for which one of these situations is the case will be automatically included in a generated list (man67) that is distributed weekly among the tactical buyers as soon as the items are placed in the tactical environment. However, the master planners can also request the information to be updated manually. Furthermore, the tactical buyers can request and update this information on their own discretion. Some tactical buyers indicated that they use the man113 list for this, which contains all the items that will have to be procured in the future, but for which an exact demand date has not been determined. For the future, the plan is to use the man67 less and instead focussing on the man113 in an effort to use less files throughout the department.

According to some process actors, it's however a common occurrence that when an item is planned to be ordered, the item has not been updated yet. The updating process is then done right before the ordering of the item takes place. These steps can therefore also be found in the actual ordering process.

To update the information about items, the tactical buyers contact the suppliers and request a new price, lead time and quantity discount model for the item. They then update this in Oracle. The master planners should be able to work with the item further after this has been done.

Figure 6: Item maintenance sub-process. Activities are performed by tactical buyer.

4.4.2 Ordering process

At a certain point, the master planners will confirm the planning of certain aspects of projects and therefore officially create a demand for an item. This starts the ordering process, which is outlined in Figure 7. Each week the items that have been newly confirmed will be added to an Excel list designated as “KPI ASCP” but commonly referred to as the “aansturing”, as well as linked to the relevant tactical buyer in the form of a planned order. This planned order includes the date the item is needed in production (referred to as the due date), the date the item needs to arrive at Thales (the suggested dockdate), and the date at which the item needs to be ordered at the latest moment, taking into account the lead time that has been registered for the item in Oracle, as well as the pre- and post-processing times. This is then also linked to the DFT characteristic, which is the amount of days before the latest moment at which the item can be procured and arrive in time. This is based on the item level lead times.

Planned orders with DFT 0 will be handled first by the tactical buyers as they are urgent. This also includes requisition orders with a negative DFT (which is theoretically possible when the order point is in the past), although – should this occur – the DFT will remain 0. The other requisitions will be handled at a moment that the tactical buyer sees fit. As a rule of thumb, all planned orders with a DFT smaller than 365 should be procured immediately. Various methods of determining the order moment of these other planned orders are in use, and this greatly depends on the price of items, the minimum order quantities or discounts for buying in bulk. Many tactical buyers also take the supplier risk into account when determining this point, meaning that supplier which they do not fully trust will be contacted earlier about orders than others. This is up to the tactical buyers' own discretion.

Figure 7: Item ordering sub-process. Activities are performed by tactical buyer

When handling a planned order, the tactical buyer will use an automatically pre-filled form in Oracle to create a PO for the supplier. If needed, the tactical buyer will add information to the form like export codes and technical drawings. The form will also include a "need-by" date for the supplier, which is based on the suggested dockdate from planning. This is the date that will be included on the PO. Once this form has been fully filled, the planned order is transferred to TBSS, which will finalise the PO and send it to the supplier this is shown in Figure 8.

The supplier will then send an order confirmation to TBSS as well, which TBSS will put into Oracle. This includes the details of the order, as well as the communicated delivery date for the order by the supplier, which is stored in Oracle as the promised date.

Figure 8: PO creation and confirmation sub-process. Top activities performed by TBSS, bottom activities by supplier.

From this point onwards the tactical buyers manage the orders until they arrive at Thales NL. The way this is handled varies greatly between the different tactical buyers, as well as suppliers and item groups. Some suppliers provide Thales with weekly updates on running orders, while others have to be contacted by Thales. At the end of the day it's the responsibility of the tactical buyers to ensure that the orders arrive on time and they have their own methods of checking for this with their suppliers.

4.4.3 Conflict handling

There are a few situations that occur frequently which deviate from the standard process, but have a standard way of being handled.

Negative DFT

It sometimes occurs that items will be requested by planning of which the order point has already expired, meaning at the moment the order was made, the standard lead time would already miss the date at which the item is needed in production. For these items, the tactical buyers will inquire at the supplier whether this due date can still be reached by way of a rush order. If this is possible, the order is put through in the usual manner. If this is not possible, the tactical buyer will contact the master planner, who will try to reschedule the production in such way that the due date of the project can still be met while accommodating the changed promised date of the item in question. If this is also not an option, a special procedure will be started according to an "escalation model" which involves various steps and options to still make the order work, by involving the category buyer as well.

Promised arrival date exceeding need-by date

It can occur that, even though the DFT has not yet reached zero, the supplier confirms the order to be delivered at a later date than requested. This can be both because of inaccurate data about the lead time of the item on the side of Thales, or because of an exception to regular operations at the supplier. The way of sorting out the negative DFT cases will be applied here as well.

4.5 Conclusion

By giving an overview of the organisational structure, data attributes and documents that are in use, and the main sub-processes this chapter answers the research questions *"What does the current procurement process look like?"* for a large part. The chapter provides the context in which the process takes place and with which tools, and the main steps from demand creation to order fulfilment are discussed. However, from the interviews many variations to the process were identified. These were not discussed in this chapter to provide a clear basic understanding of the process, and will instead be discussed in the next chapter.

5. Variations in current process

Although the overarching process is described in the previous chapter, the procurement process at Thales knows quite some variations in certain steps. This is not uncommon in big size, make-to-order manufacturing companies like Thales (Zennaro, Finco, Battini, & Persona, 2019). The following chapter is dedicated in pinpointing the steps in the process where variation exists, and outlining which different variations on the step are in use by the process actors.

5.1 Lead time updating

In the Chapter 4.4.1 numerous moments are listed for when the lead times can be updated. However, it is incorrect to assume that for every item, each of these moments is utilised.

Overview of moments

In the interviews with the tactical buyers, it turned out that the distribution of which lists are used is as follows:

Table 1: Lead time updating moments as indicated in tactical buyer interviews.

Moment	*TB 1*	*TB 2*	*TB 3*	*TB 4*	*TB 5*	*TB 6*	*TB 7*	*TB 8*	*TB 9*	*TB 10*	*amount*
BPA/man80	x	x	x	x	x	x	x	x	x	x	10
Outdated in man113				x		x			x		3
Outdated in man67		x			x			x			3
On request						x					1
When lead time in system appears incorrect				x	x						2
Own accord							x				1
New offer (all variations)	x		x		x	x	x		x		6
New offer with new lead time					x	x	x		x		4
New offer with longer time	x										1
New offer with new "standard" time			x								1

From Table 1 it can be seen that while the yearly BPA is utilised uniformly across the department, for the other moments it varies greatly when lead times are updated. Only a few tactical buyers mentioned that they would actively use the man113 list to initiate lead time updating. The same holds true for the man67 list. While the majority of tactical buyers confirmed that they update lead times when they receive a new offer from the supplier, some did point out that they did not take these new offers on face value, with some buyers opting to only change the lead time if it had become longer, or only changing the lead time if the supplier confirmed that this new lead time would become the new standard for all future orders. A minority of tactical buyers talked about actively pursuing new lead times on their own accord, and only a single tactical buyer confirmed in the interview that he/she received direct requests from elsewhere in the supply chain to look into lead times of specific items.

Man80

Even though every tactical buyer uses the man80 list to determine which items to request updated information for, not every item in this list is requested. As this was not known until later in the research, an overview of reasons for this could not be created. However, from impressions of the files and from conversations it came forward that it is common practice to not always request all items in the man80 list. Reasons for this are for example the fact that Thales possesses enough stock of the item for the upcoming years, or because of a specific situation with the supplier. For some items it's decided that information will only be requested when demand has been formulated. The status of the item does not appear to be a factor in the decision of whether to request information for the item or not. Another remark that has been made is that the accuracy of the man80 causes hesitation in making the decision to request information. It's regarded as uncomfortable to request information for items, which in the end will not be procured.

When comparing the items present in the man80 list of 2020, and the results of ordered items in 2020 in Table 2 we can see that indeed a substantial amount of the items in the man80 list were not procured in the year the forecast was intended for.

Table 2: Comparison of items included in man80 list and items procured in 2020.

	Procured in 2020	Not procured in 2020	sum
In man80	[redacted]		
Not in man80		confidential	
sum			

Of the in total [redacted] items in the man80 list, for [redacted] the decision was actively made and communicated to not request information. For the rest of the items, no information on the decision is documented. This means that for [redacted] items the information was actually requested. When making the aforementioned comparison again (which can be seen in Table 3), with now only including the items that have been requested, we can see that for [redacted] items the decision to not request the item could be justified, since they were not needlessly requested. However, [redacted] items, for which the decision was made to not request the information, were in fact procured in 2020 as the number of requested and procured went down from [redacted] to [redacted].

Table 3: Comparison of items requested from man80 list and items procured in 2020.

	Procured in 2020	Not procured in 2020	sum
Requested	[redacted]		
Not requested		confidential	
sum			

The specific accuracy of the man80 based requests did increase from 29.7% to 33.3% by deciding to omit certain items. This means less items were requested without good reason. However, when looking at the bigger picture, this was at the cost of a reduction in information about required items from 36.2% to 32.0%. In total, 16.3% of the omissions from the set of requested items was in hindsight unnecessary. This might bring up the question whether the omissions are a good thing in the larger picture. While doing omissions means that less unnecessary information is requested at the supplier, it also means that less information is known about items that have to be procured. The trade-off in this is something that Thales has to make based on where their priority lies.

When looking at the end results, the man80 based requests meant that for 32.0% of the items that were going to be procured in 2020 the information became updated by this action. This leaves around two thirds of the items to be updated in the other moments described.

Survey findings

When asked to indicate at which points in the process they have contact with Thales, of the 73 suppliers that filled in the survey, 45 checked the option "Periodically, regardless of purchase orders.", with the other options pertaining to either a concrete demand or running order. This indicates that around 60% of the respondents get contacted by Thales about the collaboration without having a specific order in mind. Conversely, 40% of suppliers are only in contact with Thales when it's about new orders for that moment, or about running orders. This means that these suppliers never have communication with Thales about lead times until the item in question is being procured and thus has already been planned. It should be noted that while 73 suppliers completed the survey, 14 suppliers checked no options at all at this question, thus in terms of suppliers that gave more attention to the survey all together the ratio of suppliers that have periodic contact regardless of purchase orders is higher. On the other hand, one could suspect that the suppliers that choose to fulfil this survey in the first place, and pay more attention to the survey in general are the supplier that have a more close-knit relationship with Thales overall. Thus, the more critical suppliers, or suppliers with a more distant relationship might not be fully included in this figure.

5.2 Determining of need-by date

The formal definition of the need-by date is that it should have the same value as the suggested dock date. The difference between these two being that the need-by date is the date communicated with the supplier, and the suggested dockdate is the date that is calculated as a consequence of the planning process in Oracle. The Oracle form that is used for PO creation therefore also automatically fills in the suggested dockdate as the need-by date. In practice, the need-by date, however, is not seen as a direct consequence of the suggested dockdate.

Interview findings

Only two of the ten interviewed tactical buyers confirmed that they use the suggested dockdate directly as need-by date. A few tactical buyers stated that they make the need-by date earlier than the suggested dockdate in an order of magnitude of a few weeks, while the overwhelming majority spoke of advancements of months, up to three or four months. One of the factors that was often mentioned for determining the size of the advancement was price, with cheaper items being more easily ordered for an earlier date.

From a few interviews it turned out that in a small amount of cases, the need-by date will be set to the lead time starting from the current day, in essence making it an order for direct delivery. Some also opted for this method, but included a few weeks slack as to not unnecessarily rush the supplier.

There were various reasons that came up during the interviews for setting the need-by date earlier. The most prevalent will be summed up here:

- One of the most commonly expressed reasons is the security of having an item that is needed for a project already in stock. Suppliers themselves have complex supply chains and production processes, which from the experience of the tactical buyers at Thales often results in delays or rework. Many of the tactical buyers explained that they felt that it would do less harm to have the item a bit earlier, than to have the risk that production could be halted because the item did not arrive in the tight timeframe.
- According to multiple tactical buyers, the suggested dockdate of items would sometimes unexpectedly change after the item had already been placed in the operational planning, and in some cases had thus already been ordered. This was also mentioned as a reason to move the need-by date forward. In the case that the suggested dockdate moves forward a few weeks or days after the order has been put through, this buffer prevents the need to have to reschedule the order to adhere to the new suggested dockdate.
- Earlier need-by dates are particularly applied to soft pegged items by some tactical buyers. Soft pegged items are items that are not bound to specific projects, and can thus be easily collected by manufacturing personnel in the warehouse. According to the tactical buyers, this causes

Oracle to not always have the most accurate data on these items. Anecdotally, when a project requires 5 screws in Oracle, in practice manufacturing personnel will collect a full box of screws to place at the manufacturing site. Thus, what happens digitally and what happens in the real world does not line up. Therefore, in order to prevent unexpectedly running out of stock, these items are procured for an earlier date than Oracle prescribes.

It can also occur that the suggested dockdate of the item is not realistic anymore given the current date and the lead time of the item. As mentioned before, the tactical buyers will then discuss this with the master planners and the supplier to reach a suitable new need-by date or other solution. In the cases that the master planners can work with a later delivery date, the need-by date will be filled to the fastest date that the supplier can deliver the item on in most cases. A few tactical buyers explained that in the cases of these rush orders, they keep the original need-by date, or a new need-by date that's earlier than what the supplier can achieve on the purchase order, to encourage a sense of urgency with the supplier.

Data analysis

To see how the need-by date relate to the suggested dockdate, an analysis was done on a set of [redacted] orderlines. These are all the orderlines that were still open at the time that the dataset was created (half of February 2021), as the suggested dockdate is deleted as soon as the order has been fulfilled. On average, the need-by date is placed [redacted] days earlier than the suggested dockdate, with a standard deviation of [redacted] days. Of the [redacted] orderlines only 26.41% had need-by dates that were the same as the suggested dockdate. In 64.43% of the instances the need-by dates were earlier than the suggested dockdate. The remaining orders have need-by dates later than the suggested dockdate, which are all rush orders. In 49.65% of the orderlines considered, the need-by dates were 30 days earlier than the suggested dockdates. As can be seen in Table 4, no substantial difference was found when only considering low valued items (orderliness with a value of less than 25 euros). However, for more expensive orders (above 5,000 euros) there seems to be a larger average difference, with a higher percentage exceeding 30 days as well. The details of the analysis can be also found in Table 4. Further visualisations can be found in Appendix 3.

Table 4: Overview of orderlines with need-by dates earlier than suggested dockdate.

	Whole set	Purchase price <€25,-	Purchase price >€5,000,-
Number of orderlines	[redacted] confidential		
Average of days earlier	[redacted] confidential		
Standard deviation	[redacted] confidential		
# need-by equal	[redacted] confidential		
% need-by equal	26.41%	27.16%	11.79%
# need-by earlier	[redacted] confidential		
% need-by earlier	64.43%	66.67%	79.73%
# <30 days earlier	[redacted] confidential		
% <30 days earlier	49.65%	44.44%	6.69%

From this, we can say that what was said during the interviews, namely that the need-by dates are often placed earlier than the suggested dockdates, can be verified in the data available. The average difference of more than a month also ties in with what came forward in most interviews. However, there appears to be no significantly different treatment for low value items. On the contrary, for larger orders it appears that more safety time is allocated.

5.3 Determining the lead time of items in Oracle

The step of putting the lead time stated on the offer by the supplier into Oracle knows some variation as well. The lead time, or processing time in Oracle should constitute to the full amount of time that the supplier needs to get the item ready for Thales. The majority of tactical buyers take the lead times straight from the offer by the supplier and put these dates into the system. However, the interviews yielded a few reasons why not to take over the values on the offer 1-on-1 as well.

Interview findings

A few of the tactical buyers explained that in case they receive a time range for the lead time (instead of a specific date), they use the longest value given for safety reasons. Next to the ranges of lead times, sometimes suppliers also offer different lead times depending on whether an item is in stock, or has to be produced from scratch. These can differ greatly, and suppliers cannot guarantee that an item will always be in stock. In this case, the tactical buyers also prefer putting in the lead time for from-scratch production. The reasoning given was that the tactical buyers want to avoid situations where lead times are planned which cannot always be achieved.

A few tactical buyers also attested to documenting longer lead times in Oracle compared to what was communicated by the supplier on the offer. The first reason for this is the fact that according to the tactical buyers, in their experience some suppliers consequently "overpromise" on their lead times. In the opinion of the involved tactical buyers, it would be illogical to document a lead time which strays too far from what the supplier can actually achieve. Some tactical buyers therefore do this for suppliers that they know from experience perform badly. In one interview it came forward that the tactical buyer does this for every supplier that they manage, with the extension being a week at most. Another tactical buyer explained that they also consequently add 5 days to the lead time in order for there to be time to process the ordering and handling of the item.

Survey findings

From the survey it came forward that indeed only 10% of the suppliers consider their lead times to always be constant, with about 47% percent saying that this is true most of the time, as shown in Table 5. This means that about 43% percent of the suppliers consider their lead times to not be constant in most scenarios. This coincides with the observation of the tactical buyers that variations do in fact exist.

Table 5: Answers to survey statement "Our company's items have a constant lead time.".

	Never	Sometimes	Half the time	Most of the time	always
Our company's items have a constant lead time.	5.48%	17.81%	20.55%	46.58%	9.59%

When focussing on the way lead times are determined most suppliers identified the statement "It's important to ensure that our promised dates can surely be achieved." as most applicable to them, followed closely by "before we communicate lead-times to Thales NL, we have to verify this with our own planning." (39% and 31% respectively) as can be found in Table 6. This shows that a large part of the suppliers recognises the variability in their lead times, and also have a risk-averse approach of communicating lead times to Thales. On the other hand, about 24% of suppliers favoured the statement "It is our goal to offer the most competitive lead-times we can achieve" over the previous risk-averse statements. Therefore, the observation that some suppliers are, either consciously or unconsciously more risk seeking and ambitious in their communications also appears to be grounded in reality. The two statements that would indicate a more universal approach to communication from the suppliers ("We know all the lead times of items that Thales NL procures in advance." And "The lead times that we communicate with Thales NL are an average of what we can perform.") scored lowest of all in this set of statements. This indicates that for the largest part, there appears to be variability of the lead times in almost all suppliers involved with Thales.

Table 6: Survey results on question "Rank the following statements by how relevant the statement is for your company" (1=most relevant).

Rated as #	1	2	3	4	5
It's important to ensure that our promised dates can surely be achieved.	38.89%	34.72%	20.83%	5.56%	0.00%
Before we communicate lead-times to Thales NL, we have to verify this with our own planning.	30.56%	30.56%	19.44%	15.28%	4.17%
It is our goal to offer the most competitive lead-times that we can achieve.	23.61%	19.44%	31.94%	13.89%	11.11%
We know all the lead-times of items that Thales NL procures in advance.	5.56%	11.11%	9.72%	37.50%	36.11%
The lead-times that we communicate with Thales NL are an average of what we can perform.	1.39%	4.17%	18.06%	27.78%	48.61%

5.4 Ordering point determining

While Oracle does prescribe a suggested order date for each item that needs to be procured, this is not set in stone. The tactical buyers have the freedom and flexibility to order items at moments that are most tactically beneficial, for example by procuring multiple items from different projects at the same time, or procuring after a new pricing agreement has been reached. Throughout the procurement department a few common and some more uncommon practices were identified during the interviews. These findings were verified with a data analysis.

Practices found during interviews

A rule of thumb has been coined to order all items with DFT>365 immediately. The reasoning behind this is that this will result in getting concrete promised delivery dates from supplier early on. The data quality on lead times is seen as untrustworthy enough that the procurement department wants to know all promised dates early enough to react to potential pitfalls that may come apparent when the supplier confirms their timeline. For example, a supplier might confirm a way longer lead time than expected, but because the request was put in early enough, this has no impact on the delivery date. Although this rule of thumb was mentioned by management, it was only mentioned by a few tactical buyers, with no-one describing it as a set-in stone rule.

One thing that all tactical buyers share is the approach to DFT 0 items, which need to be procured as soon as possible in order to arrive on time for production according to the item-level lead time. Most of the tactical buyers mentioned that while handling the DFT 0 items they also looked for other items that need to be procured at the same supplier with a longer DFT. These items are then procured at the same time as the DFT 0 item to achieve quantity discounts, less transport costs or other benefits. A minority of the tactical buyers did not automatically combine items of other DFT values with the DFT 0 orders, instead opting to save all these items until a larger order could be filled to achieve quantity discounts at the supplier.

A minority of the tactical buyers mentioned that they follow the rule of thumb to order all items with a DFT between 0 and 100 days. This was agreed upon at some point for all tactical buyers that buy mechanical components. All of the tactical buyers that employ this rule of thumb also try to combine items for the same supplier together with the DFT 0 to 100 items.

A few tactical buyers explained that they order all soft-pegged items as soon as they come in as well. This is for the same reason as that the need-by dates were moved forward for soft-pegged items. For these tactical buyers, the soft-pegged items run out of stock so unpredictably, and so different from what Oracle prescribes that they want to have them in as soon as possible. Some of the tactical buyers also noted that these items are almost always small and cheap, which makes the decision to order earlier easy to make. In one instance, a tactical buyer mentioned in the interview that he/she procures all items with a low price right after the planned order comes through, regardless of the DFT value.

A very select group of tactical buyers confirmed that they procure all items as soon as possible regardless of the DFT value. It should be noted that from the interviews the impression was created that for these instances the orders were almost always on shorter notice than for the other tactical buyers.

Some tactical buyers mentioned that they do not necessarily work with a very strict ruleset of deciding an order point for items with a larger DFT. Often items would already be ordered when they can be combined with other items with a shorter DFT at the same supplier. One thing that came up in a few interviews was the fear for technical revisions to the items. This caused a few tactical buyers to opt to wait a bit longer with ordering items. According to some (although not all) of its users this is also the basis for the DFT 0 to 100 rule of thumb. A select few took the technical revisions into account from their own intuition and experience.

Data analysis

An analysis was performed on all the POs for which a suggested order date was available. As the dataset did not contain a suggested dockdate or processing time for all POs in the set (as this data is deleted after delivery of the order), this test could only be done on [redacted] POs. The notable results can be found in Table 7 and Figure 9 below, and the full distribution is included in Appendix 2. Of the POs considered, almost 18 percent were procured with a suggested order date closer than 100 days from that point, which would be done if the DFT<100 rule of thumb was followed. An additional 55% was procured up to a year in advance, as would be done following the DFT<365 rule of thumb as described by management. Another 20% was procured even further in advance, with some items being procured more than two years in advance. Only a minority of the POs was created in the week surrounding the suggested order date.

Table 7: Overview of PO creation dates in relation to suggested order date.

Purchase orders considered	[redacted]	100%
Created on suggested order date		0.22%
Created within 2 weeks of suggested order date		1.29%
Created with DFT<100 days	confidential	17.97%
Created with 100 days < DFT<365 days		54.98%
Created with DFT>365 days		19.80%
Created after suggested order date passed		6.72%

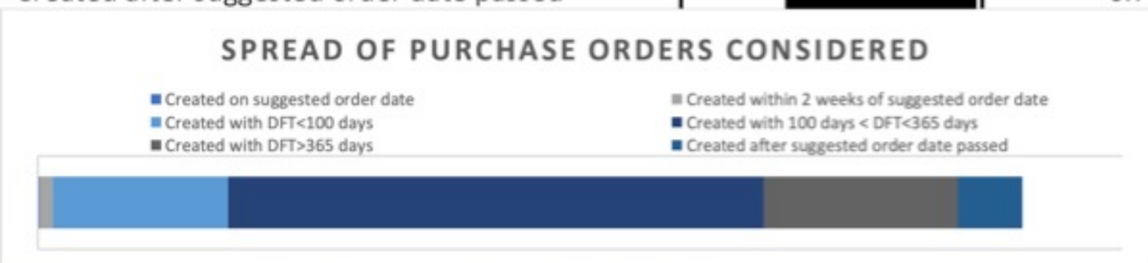

Figure 9: Overview of PO creation dates in relation to suggested order date.

From the data analysis we can see that for the majority, the two known rule of thumbs of DFT<100 and DFT<365 are followed. As also attested to in the interviews, the POs are also often created earlier than that, with 20% of the PO being created more than a year before the suggested order date. We can also see that almost 7% of all purchase orders are created after the suggested order date has already passed. This means that these orders will all become rush orders, as the lead time as documented for the item will not suffice anymore to get the item on time.

Survey findings

In the survey the suppliers where asked whether they receive their orders a long time in advance from Thales NL. 26% of suppliers answered "very true" and 43% of suppliers answered "true" to this statement. This means that a majority of suppliers seems satisfied with the timeframe they get from Thales between ordering and expected delivery. However, 22% answered neutral to this question, while 1% and 7% answered "very untrue" and "untrue" respectively. Combining the knowledge that some suppliers could possibly shy away from outing too much criticism to Thales because of the relationship, and the fact that around 30% does not seem fully pleased with the timeframe that Thales gives off creates the impression that a substantial amount of suppliers experiences discomfort from the timeframe given for the orders.

When looking at the timeframes indicated by the suppliers for throughput times of their items and the time interval between an order and expected delivery, on average there appears to be 13 days of buffer time between these two. This means that orders are put in on average 13 days before the processes at the supplier need to start. However, the spread of these times was large, both between the different suppliers as well as within the ranges that the suppliers put in the survey. This creates some potentially worrisome situations. When looking at averages, for 8 of the 58 suppliers that filled out the survey the throughput time exceeded the timespan between ordering and expected delivery. However, when looking at the maximum throughput time, for 29 suppliers this would exceed the timespan between ordering and expected delivery.

The consequences of this can be seen back in the opinions of suppliers on the orders of Thales. 11% of suppliers were of the opinion that the need-by dates of an order at the moment that it's put through are only sometimes realistic. 12% are saying that this is only the case in about half of the instances. This means that while a majority (57% "most of the time" and 19% "always") thinks that the timeframes given by Thales are realistic, there is a significant number of suppliers that do not share this opinion.

When asked whether Thales orders items at the last possible moment, 29% of suppliers said that this never happens. 49% indicated that this sometimes happens and 12% filled in that this happens half of the time. A minority of 8% said that most of the orders they receive are last minute, with one supplier going as far to say that all the orders that they receive are last minute without this supplier falling under exceptional circumstances.

Overall, it appears that while certainly not the case for most, or even the majority of suppliers, there is a significant portion of suppliers that experience discomfort in terms of the time period made available to them by Thales to fulfil an order.

5.5 Post-processing time

From the interviews with process actors from the planning department, it came to the attention that in some cases additional safety times are included in the post-processing time of the items by planning staff. This comes on top of the five days that are already included in the internal communication that is used as a guideline. It is unclear how, when and why these safety times are added. Crucially, in the interviews with the tactical buyers, the post-processing time was never perceived as variable. Some tactical buyers did mention that inspections are included in this value, but for most part, the post-processing time was perceived as fixed according to the diagram. This gives the impression that the tactical buyers are not aware of the presence of these safety times.

Data analysis

When looking at all the POs that have been put through in 2019 and 2020, 19 different post-processing times can be identified. Of the [redacted] orders considered, [redacted] did not have a post-processing time which is outlined in the rulebooks about post-processing times (7,17 or 27 days). However, in only very few cases the post-processing lead time was longer than one of the outlined post-processing times. Notably, quite some items had a post-processing time of 0 days allocated to them as well.

5.6 Compensating for inbound delay

In a few interviews with the tactical buyers, it came forward that in some cases they would change the promised date of an item to not influence the on-time delivery (OTD) rating of the supplier unjustly. This happens when the tactical buyer has received confirmation of delivery of the item on a certain date, but the item has not been booked into the system yet at that date. According to the tactical buyers this was done so that the supplier is not held responsible for the delay of the inbound warehouse as negative influence on their OTD. Therefore, the revised promised date is moved forward a few days to avoid negative influence on the DFT. It should be noted that the OTD measurement inherently already has five days of slack in its measurement, so this action would be unnecessary.

5.7 Conclusion

This chapter covers all points at which variations in the procurement process exist which were identified from the interviews. Where relevant, the survey findings or data analysis findings were used to give context to, or quantify the variations. Most notably, the moments of lead time updating and the determining of lead times, the need-by dates and order points were discussed. Variations in Post-processing time and inbound delay were also discussed. The biggest variations where identified in the moments of lead time updating and the determining of need-by dates and order points.

6. Impressions from process actors

To help answer the third knowledge problem *"How do the different actors in the process interpret and communicate the lead times?"*, and broaden the overall perspective and understanding surrounding the procurement process and lead times, this chapter will address some of the most common and interesting impressions gained from the interviews. These impressions will be contextualised with information from the data analysis, as well as from literature.

6.1 Process actor trust in lead times

From the interviews with the process actors other than the tactical buyers, the pattern was found that the trust in the lead times stated in the system is quite low. This also brought up the thought with many of the interviewees whether faster than what was in the system would be possible. According to some of the process actors more involved with planning, based on experience from other projects many items could actually be procured faster than what was documented in Oracle. Others find it hard to pin down the actual lead time, since there is no indication of the last update of the lead time in the system. Some commented that often the lead time is only revealed to be not correct anymore after the planning has already been carried out, and the purchase order has already been planned.

6.2 Restrictions on order point determination

Some of the process actors pointed out that the tactical buyers would put in orders earlier than necessary. This causes unnecessary order maintenance work according to some because the order will run longer at the supplier thus requiring more check-ins. Others remarked that this also makes re-planning of items more difficult. The first suggestion that was given was to trust the system more, and stick more closely to the suggested order date. Another remark was made that the decision of when to place an order should not be up to the tactical buyers in the first place. At the moment, as soon as the item is made available in the operational planning the tactical buyers can choose to procure it. However, from a planning standpoint the operational planning is not always set in stone. Thus, it creates difficulties when an item has already been procured while the planning can still change. It was therefore argued that there should be more control on the point of ordering to prevent these situations.

6.3 Large amount of rush orders

From almost all the process actors interviewed across the supply chain it came forward that currently there are too many rush orders being placed at procurement. Finding the reasons why this happens is out of scope for this research, but reasons named are the orders of spare parts, repairs orders and broken items in production. However, a large part of the rush orders does not always seem to have a direct explanation. Some of the tactical buyers remarked that they are more often dealing with rush orders than with regular orders for items, which creates a lot of pressure on the suppliers, as well as the tactical buyers.

Data analysis

The weekly KPI ASCP file, which contains all the items have been placed in the operational planning and that should be procured by the tactical buyers, was analysed to look into this. From the items that had been added the week the file had come out, on average [redacted] had a DFT value of 0, meaning that they'd have to be considered a rush order. This is taken based on a sample of 10 weeks spanning

November 2020 to January 2021 which can be seen in Figure 10. The full results can be found in Appendix 3.

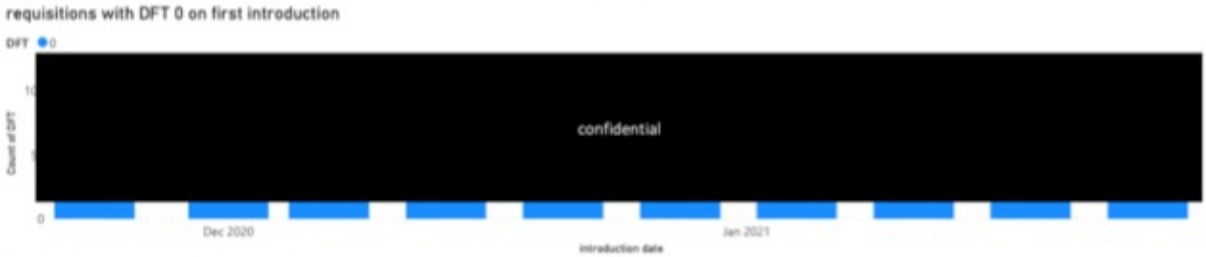

Figure 10: Orders with DFT 0 on introduction per week.

6.4 Need for a "one way of working"

A remark that came through from numerous interviewees that work with different tactical buyers, was that they had the impression that there is no "one way of working" approach within the team of tactical buyers. They get the impression that every tactical buyer currently uses their own approach and methods on orders, data updating and handling conflicts. According to some, this made it hard to make a judgement on how accurate data could be, or what the progress of certain orders is.

Survey findings

Contrary to the process actors, the suppliers experience the process much more uniformly. To the statement "Thales NL is consistent in the way of handling ordering." 53% responded with "very true" and 34% with true, making up a vast majority. It appears therefore that if differences between tactical buyers exist, this would be dependent on a supplier-to-supplier basis, with tactical buyers sticking to one approach for a certain supplier. This coincides with what was mentioned by a few tactical buyers, namely that according to them, some suppliers require vastly different approaches than others. To paraphrase from an interview: "the way I talk to an American multinational is very different than how I treat the local supplier that does one or two orders per month.".

While the desire to have clarity on the procurement by way of standardisation is understandable, the reasons brought forward by the tactical buyers can be understood as well. In practice, a lot of organisations thrive when applying a multitude of collaboration methods with their suppliers, as a "one-size fits all" method often results in compatibility issues or suboptimal performance (Whipple & Russel, 2007). With suppliers from dozens of countries, and order magnitudes ranging from a few cents to hundreds of thousands of euros, variations in the collaborations would seem unavoidable. Nevertheless, this does not downplay the importance of having a clear line of communication as currently there appears to be ambiguity about the progress in the procurement department.

6.5 Desire for more future perspective

When asked what could benefit the collaboration between Thales and them the most, almost half of the suppliers that partook in the survey placed "if Thales NL communicated more about expected orders in the near future." at the top of their list. This was followed by "if Thales NL ordered items earlier.". In the open section the most prevailing theme was the wish for the sharing of forecasts with the supplier. This indicates that suppliers have a wish for more perspective from the side of Thales. This again shows in the ranking of the statement "Orders by Thales are predictable." Which is ranked by 20% of suppliers as "never", and as "sometimes" by 28% of suppliers. This form of information sharing is commonly sought after in buyer-supplier relationships that maintain a relational governance model (Clauss & Spieth, 2016), which is seen by many as the best way to maintain a buyer-supplier relation concerning critical parts.

6.6 Too much focus on minor tasks

According to the process actors, currently, too much time is spent on minor, insignificant tasks. Non-crucial items would currently take up most of the work load while the focus should be on key items for projects. On the other hand, some of the tactical buyers also remarked that they have to perform a lot of manual tasks that could either be performed automatically by an ERP system, or by TBSS since they do not contain very important checks or decision moments but rather just filling in things or copying information.

These remarks are in line with one of the most common schools of thought to supply management as described in the Kraljic's matrix. Kraljic's widely accepted theorem emphasises to focus efforts on strategically important items, meaning items with a high relevance to operations and a complicated supply market. Non-critical items should take the least amount of time, to save time and resources for the more critical items. To achieve this, Kraljic also calls for simplifications to the process by way of further automation of processes (Kraljic, 1983).

6.7 High use of documents and low traceability

From outside of the tactical buyer group the remark was often made that the tactical buyers would use a lot of spreadsheets and other documents, instead of working directly with Oracle. The problems with decentralized data according to some, is that the information being worked with might not be up-to-date. Other groups within the supply chain department remarked that this also gives them only limited insight into the progress of orders. With the exception of the promised date, not a whole lot could be deduced according to them, while more information could be useful. This leaves them with the choice to either invest extra time in finding out the information via email or phone, or make assumptions on the data that is available. The remark that the promised date would also more often than not be incorrect was also made. While being the concrete source of discomfort in this instance, it seems from the interviews that in other departments there is a wide usage of spreadsheets in favour of the ERP system as well.

From a business process integration perspective, this ties in with the fact that information accessibility is often the biggest hurdle for successful integration (Berente, Vandenbosch, & Aubert, 2009), with successful integration meaning the minimisation of communication and coordination effort between activities of a process. The fact that documents are used which are only created periodically does not seem very harmful in most organisations, but rather the fact that this means that information is being held at a more difficult place to reach for both people inside as well as outside of the main process. As apparent from the interviews, the fact that a lot of information is located in files creates a lot of time spend on communicating and sorting out unclarities.

6.8 Conclusion

In this chapter, the impressions from process actors on the lead times and procurement process in general were discussed. The most notable impressions and opinions where outlined, and where relevant literature, survey findings or data analysis findings were used to give context to the impression. These impressions serve to solve the knowledge problems stated for the thesis, but also form a basis and context for the recommendations to Thales, which will be discussed in the next chapter.

7. Recommendations

By looking into and answering the five research questions, a lot of improvement possibilities about the process came to light. The most significant ones will be discussed in this chapter. The focus will lie on the most impactful findings and related potential improvements. First, lead time updating will be discussed, after that the chapter will focus on safety times. Then the allocation and interpretation of the "outdated" status will be highlighted, as well as the documentation of lead times. The chapter then focus on conflicts in planning changes after ordering and the premature operationalisation of items. A few minor findings that might be of note to the organisation are outlined. The concrete recommendations for improvements to the process will be listed at the end of the chapter. The complete overview of recommended changes to the process steps are outlined on the BPM in Appendix A, but all changes are included in the figures of this chapter, and discussed.

7.1 Lead time updating

An interesting phenomenon to note is that many process actors attested that the fact that a lead time is not up to date is often only discovered after the order acceptation and planning phase has finished. When looking at the points at which lead times get updated, many of these points and documents do fall after these phases. The exceptions being the BPA/man80 and the man113. This can be seen in Figure 11, with before planning indicated in green, and after planning indicated in red. While all tactical buyers update according to the man80, this only results in new information for 32.0% of all the items, as was the case in 2020. This means that about two thirds of all items that are being procured do not have a fixed moment where all tactical buyers update the information of the item. Instead, this widely varies and is hard to keep track off.

It could even happen that during the updating of the prices for the BPA, the lead times are not included. It has been remarked that for updating the BPA, lead time is not a mandatory field, as well as that the outdated status is not triggered by having a lead time that has been unchanged for too long. When talking about the man80 effort that is done each year, this is explicitly seen as a price oriented effort. Furthermore, even if an item is marked as outdated in the man80, this does not imply that its information will be updated in this moment. It could also very well be that the lead time was in fact updated when the BPA was handled (at the beginning of a calendar year) but has changed since then due to circumstances at the supplier, while the price has remained the same to the price listed on the BPA.

The man113 list is used as a criterium to update lead times in only a minority of cases. This list does certainly include all the parts that need to be procured for a project and is therefore more complete and more up to date than the man80. The argument could therefore be made to promote the use of the man113 for item updating. This means that the items still only get updated after order acceptation has already been completed, but it would help in preventing items from being planned based on the wrong lead times. However, since the man113 is potentially created a long time before an item will be planned, the lead time of the item is at risk of already being different again when the moment is there to plan the item. Therefore, this is also no definitive solution.

Currently, updating of lead times often happens when the item is included in the man67 list, however, this means that the item has already been included in the tactical planning and in some cases even the operational planning. At this point therefore, the planning has been made with potentially incorrect lead time information. Ideally, to avoid surprises for the master planners when the new lead times come in after the planning has been made with the old ones, the updating of the lead times would be done before the planning process has started. It should be noted that, during the execution

Figure 11: Division in item updating moments shown on BPM.

of this research an effort was started to phase out the use of the man67, and instead promoting the use of the man113.

This means that in the ideal situation, a new start to the item updating sub-process would be instated that takes place more closely to creation of the order, but before the planning of the item as shown in Figure 12. The exact way this should be implemented will have to be discussed with all parties involved. An option would be to base this on the man113, as this contains items that will be procured for sure, instead of the lower accuracy of the man80. A condition should then be found for the items in this list that indicates that they will be planned soon, so that the information can be requested before the planning of the items. Since the planning process was out of scope for this research, this exact condition cannot be recommended for now.

Figure 12: suggested changes to item maintenance sub-process

Because the tactical buyers mainly focus on achieving the suggested dockdate by way of allocating spacious need-by dates and procuring well before the suggested order date, the item level lead times are not of tremendous importance to their work. It's not uncommon that documentation that adds no value to the direct process is viewed as less critical (Berente, Vandenbosch, & Aubert, 2009). Some tactical buyers also remarked in the interviews that the item lead times must be right, but don't really matter for their own work. Some unclarity also exists among tactical buyers about what is exactly done with the lead time data in other departments. On top of creating a standard moment for lead time updating, creating more awareness of the importance of the lead time data, and the way this impacts procurement could improve the quality because more attention is paid to them.

7.2 Safety times

Safety times are a theme that came through in the interviews as well as in the data analysis. However, the allocation of these times knows a lot of unclarity. It appears that these times are currently allocated with good intentions, but no infrastructure exists to support communication and dialogue about these safety times. Therefore, ambiguity exists.

Need-by dates earlier than suggested dockdate

As thoroughly described in Chapter 5, the need-by dates communicated to suppliers are often earlier than the suggested dockdates in the planning. This is done as a safety measure to ensure that at the end of the day the item surely arrives on the suggested dockdate, meaning in time for production. The fact that this is [redacted] days on average, with more than half of the items having a safety buffer of more than 30 days shows that this is common practice. However, since this buffer is allocated by changing fields in the ordering environment in the ERP system, it is very hard to see for other process actors that this is happening, let alone see why it happens or what the patterns and reasons for it are. The fact that need-by dates are earlier is also one of the causes of the fact that PO's are created before the suggested order date. After all, the order date should be the need-by date minus processing time of the supplier and pre-processing time.

Safety time in post-processing time

As discussed in Chapter 5, there's a safety time of 5 days included in the post-processing time that has been allocated purely for safety on top of the 2 days inbound processing time, and – where applicable – inspection times. Additionally, for some items longer safety times are considered in the post-processing time. The data analysis, as summarised in Figure 13, has shown that currently for [redacted] items the post-processing time deviates from the standards (7, 17 and 27 days), though with many not exceeding the maximum predetermined value of 27 days. A full overview can be found in Appendix 3. No discernible pattern could be identified to what characteristics warranted these deviating lead times, but for future conversations it could be interesting to discuss. Even though (potentially) insignificant in the scale of other safety times being allocated to orders in the advancement of need-by dates, which sometimes is done in terms of weeks or months, it is something to note. This safety time is taken into account without other actors in the supply chain realising that it has been included and calculated with. By not knowing or realising that these safety times are already considered, it could potentially mean that the tactical buyers put even larger safety times on top of these already existing ones. This creates a situation where safety times are considered multiple times, creating redundancy. Yet, because they are allocated in separate fields (post-processing time and difference between need-by date and suggested dockdate), this redundancy is not easy to spot or remove.

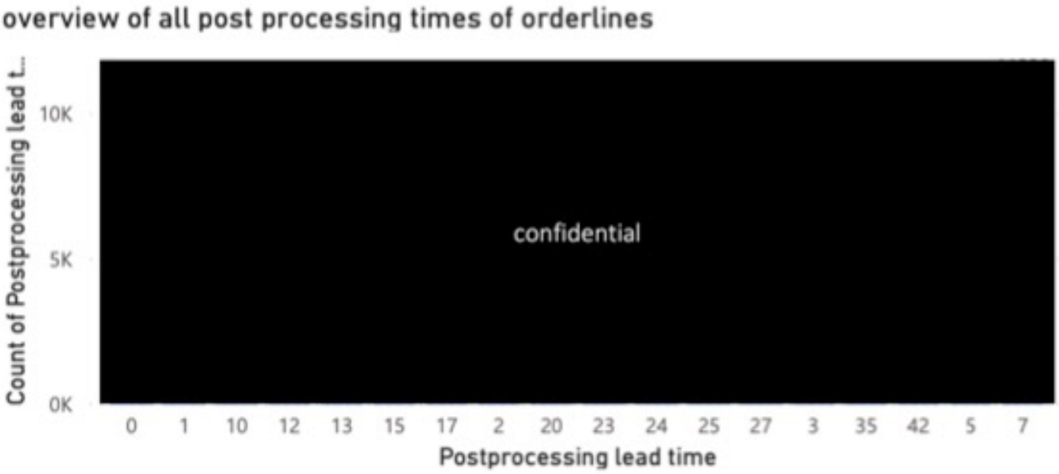

Figure 13: Overview of post-processing times found in data.

Overarching allocation

To improve the transparency of the safety times allocated to items, a suggestion would be to create a single, separate field where safety times can be defined, as shown in Figures 14 and 15. This will make it clear how uncertainty is being dealt with in an overarching way, and thus remove the feeling that the process actors need to account for uncertainty on an individual level. The field would be best placed as additional step after the suggested due date and current "hard" suggested dockdate, in essence creating a new suggested dockdate which takes into account risk which can be used one-to-one as a need-by date. This would require the planning and procurement department to come to one conclusion about how much safety time should be allocated. In make-to-order manufacturing, over the past 20 years a shift has occurred from focus on only internal production planning, towards an external and supply chain perspective (Zennaro et al., 2019). This means that generally, planning is not only concerned with internal resources, but actively managing supply and production uncertainty as a whole.

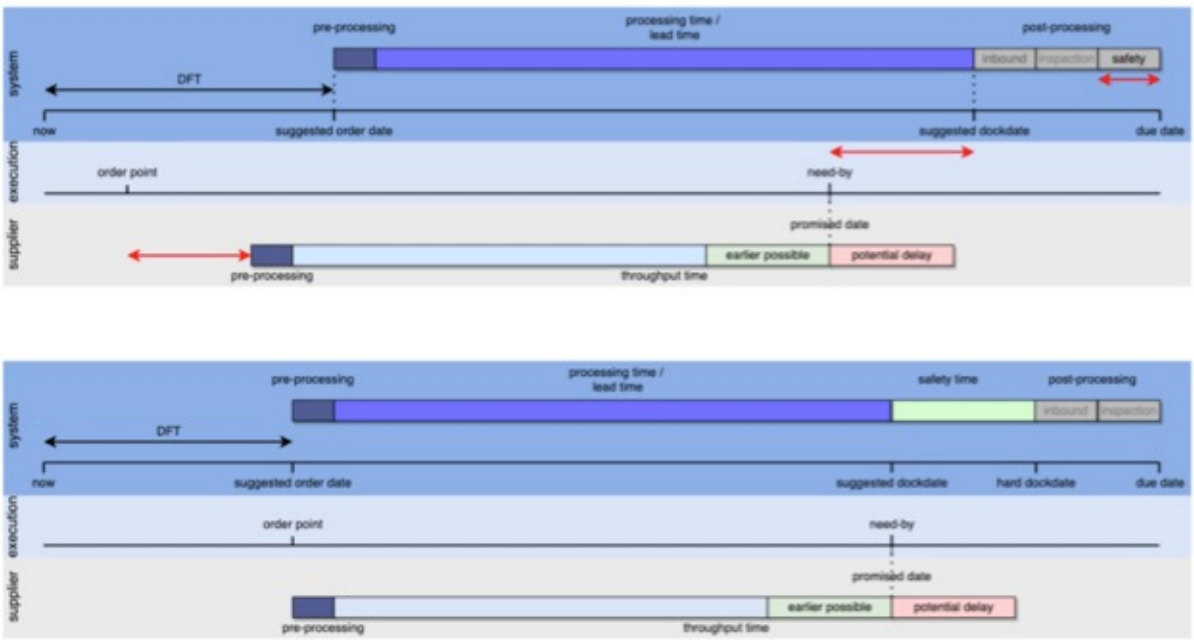

Figure 14:Current (top) and proposed (bottom) situation regarding safety times.

Figure 15: Suggested changes to ordering process expressed in BPMN.

Overarching allocation would imply that planning and procurement have to find a way together to determine adequate safety times for items and allocate them. Various ways can be proposed on how to determine these safety times. Numerous quantitative methods to optimise this exist in literature, though this would require an approximation of the costs of a hold up in production in some way or form. This could be done by determining backlogging costs, using fuzzy numbers or instead pursuing a service level for item availability (Borodin et al., 2016; Dixit, Srivastava, & Chaudhuri, 2014). These methods would also require accurate statistical distributions on supplier lead times. The current way of keeping track of orders limits the ability to create these distributions, since lead time data on item level is not logged and the throughput time of orders is based on order point vs promised date which does not say something about the actual throughput time at the supplier. Therefore, it might be better to consider best practices and rules on safety times based on what are considered acceptable risks and costs. These rules can be based for example on the OTD performance of suppliers. While the OTD score does not give a complete insight into the process and lead time variability, it does say something about the reliability of the supplier. This could for example point out how the reliability of suppliers has increased drastically in the last years (as it has for many suppliers when looking at historic OTD data), which might not be considered right now when thinking of a safety time. When lead time data becomes more accurate, quantitative methods could be implemented.

Transactional vs. relational governance

The allocation of safety times is a practice that would typically fall under the transactional governance methods (Gadde & Wynstra, 2018) However, for make-to-order firms that strive for Just-In-Time delivery of orders it appears to be more successful to apply relational governance (Handfield & Pannesi, 1995). As apparent by the survey, it would seem that the suppliers also prefer to engage in a relational manner with Thales, since the most suggested improvements include more information sharing and collaboration. Currently, Thales is well underway with multiple relational efforts like long term agreements, KPI sharing, forecast sharing and supplier development programmes. However, these efforts are executed by the category buyers in the procurement department, with seemingly little involvement of the tactical buyers. Even though some scholars advocate for using both relational and transactional methods coherently (Clauss & Spieth, 2016), improvements to the way this is currently handled at Thales could be considered. Currently, the category buyers are engaged in relational efforts, while the tactical buyers try to overcome issues by applying transactional efforts. Involving the tactical buyers more in the improvements efforts of the category buyers can create more alignment in the governance of suppliers. For example, when a relational improvement effort has taken effect and starts yielding results, transactional efforts like safety times can be reduced by the tactical buyer immediately.

7.3 Allocation and interpretation of the status "outdated"

Various explanations could be found for the fact that items receive the status "outdated":

- The item has not been procured in two years.
- The item has not been procured in two years OR there has been no BPA update in two years for the item.
- The item price has not been changed in two years.

A lot of ambiguity exists on these conditions among the interviewed people. However, in the definitive way it happens in the ERP system, it would seem that the lead time has no influence on the allocation of this status. According to the programmed rules, an item becomes outdated when it hasn't been procured in two years, or the price value hasn't been changed in two years. This means one could procure the item periodically and allocate actual promised dates in relation to the order dates on an order level, yet never update the lead time on an item level. When discussing filling in the BPA data, it came to light that the lead time is in fact not a field that has to be mandatorily updated when processing the new information that was received as well. Thus, it is very well possible that only the prices are updated when processing the BPA, or any other updating moment and the lead times remain what they were without influencing the status of the item.

In terms of perception, most of the people involved in the procurement department viewed the "outdated" status as something that mostly has to do with pricing of the item. It was most important that the prices and order quantities were in order, with the lead time not being of a lot of significance for this status update. Furthermore, the importance of having accurate lead times is sometimes also downplayed by the fact that even though the lead times may not be accurate, from a procurement perspective an item can still be arranged to arrive on time by changing the need-by dates, and/or creating an order earlier than calculated in the ERP system.

When the lead times indeed do not influence the allocation of the "outdated" status, this could be one of the reasons why inaccurate lead times are discovered at such a late point in the process. After all, in almost all cases, the tactical buyers pointed out that they only start the updating process for items that appear in the man113 or man67 if they have the status "outdated".
In contrast to the perception in the procurement department, from the interviews with the planning department it came forward that the status of the item is taken into consideration to verify the accuracy of the data. From their perspective, having an item which has the status "approved" implies that price and lead time are accurate, not only the price.

A concrete improvement would be to change the way the "outdated" status is attributed to also be dependent on lead times that have not been updated in a long time. Currently, there's no real focus on the lead times in the item updating process, and also no real focus on the lead time in the ordering process, as they're not of utmost significance to the tactical buyers. However, as pointed out throughout this report, having accurate lead time data is important for the entire organisation. Lead time influences planning, the time at which the item needs to be ordered and thus also the time at which the item needs to be operationalised and placed in the hands of the tactical buyers. On top of the advice of having more periodic and systematic efforts to update lead times, taking lead times into account when attributing the "outdated" status can help ensure that less lead time data is inaccurate without anyone knowing this. Furthermore, in line with the current directive to update "outdated" data, this will also increase the moment at which lead time data is updated.

7.4 Documentation of lead times as variable instead of fixed

In the ERP system of Thales, items can only be attributed a single value for processing lead time. However, from the interviews it came forward that in practice these lead times are not always fixed. Furthermore, less than 10% of suppliers say that their lead times are fixed, with 38% saying they are only fixed half of the time or less and 5.5% even confirming their lead times are never fixed. This might be because of stock that is either kept or not, or because of variations in demand affecting the internal planning of the supplier. In most cases, the tactical buyers would then always want to input either the currently achievable lead time or the worst-case scenario lead time into the ERP system. However, this might be a stark contrast to what usually can be achieved in some instances. It came forward that the master planners on the other hand, would prefer to work with the faster lead times, viewing the worst-case scenario lead times as in-accurate as well since in the past faster lead times might have been achieved. These issues of granularity, where information is not of an adequate level of detail and further investigation (or assumption) is necessary, are a sign of bad process integration of the ERP system, and have been identified literature as such (Berente, Vandenbosch, & Aubert, 2009).

When looking at it from both sides, it appears that the current way of storing lead time information is too shallow to be able to effectively work with. The lead times are too variable and subject to too many factors to be boiled down to one single number. The tactical buyers are forced to distil the complex factors that can influence what lead time a supplier can offer at a certain moment, and what their experiences are with that supplier to one single number. Thus, valuable information does not get stored and communicated. On the other side, the master planners have to either assume that the one number that is communicated is an absolute truth, or they have to fill in the blanks themselves with assumptions or educated guesses. In both cases this gives a suboptimal basis for the master planners to make decisions on.

By finding a way to more accurately represent the variability of the lead times in the cases where this is applicable, the discrepancies between procurement and planning can be solved. Furthermore, when historic lead times can be traced back, more accurate analysis can be done on the behaviour of suppliers. This can be done in the context of supplier performance measurement, to see if communicated lead times are achieved for the orders that were set out at that time. This can also be used in the context of risk management, by analysing whether suppliers over- or under-promise and account for this, or by analysing the statistical variations from suppliers and allocating safety times accordingly.

7.5 Conflicts in planning changes after ordering

One of the reasons named for communicating earlier need-by dates is that the suggested dockdates can potentially move to an earlier point in time after the item had already been planned. This partly happens for unknown reasons due to errors in Oracle, as had been discussed by previous internal research. The suggested dockdates of items can also be changed by the master planners in the operational environment. At that point, however, it could be that the item has already been procured by the tactical buyer for the previously known suggested dockdate. Enforcing ordering at the suggested order date was suggested as one way to prevent problems which arise when an already placed order has to be changed due to planning changes. Contrastingly, the tactical buyers mention this as one of the reasons why they choose to deliberately order for at an earlier need-by date than the suggested order date.

Planning and tactical buying appear to have a different understanding and interpretation of the suggested order date and the rigidity of the operational planning environment. The planning department is under the impression that until the suggested order date, the items planning is still unfixed and can be changed freely since ordering will for sure happen at the suggested order date. However, the tactical buyers see the suggested order date as a final point to order at, but do not hesitate to order earlier to achieve quantity discounts, or to employ other tactics to gain an advantage at the suppliers. In this perspective, the tactical buyers assume that from the moment that the items are in the operational planning, it is definite and can be procured without a doubt.

As a consequence of the lead time date potentially not being accurate, the suggested order date, which is a direct consequence of the lead time might also not be accurate. This is a potential reason for why the suggested order date is not seen as an important date to stick to for tactical buyers. Furthermore, the fact that the need-by dates get moved forward from the suggested dockdate also logically imply that the order date has to be moved forward as well, as shown in Figure 16. By improving the lead time data accuracy (and thus the suggested order date), and eliminating the need to change the need-by date respective to the suggested dockdate the suggested order date will remain closer to real life and thus reduce this issue as indicated in Figure 16 as well.

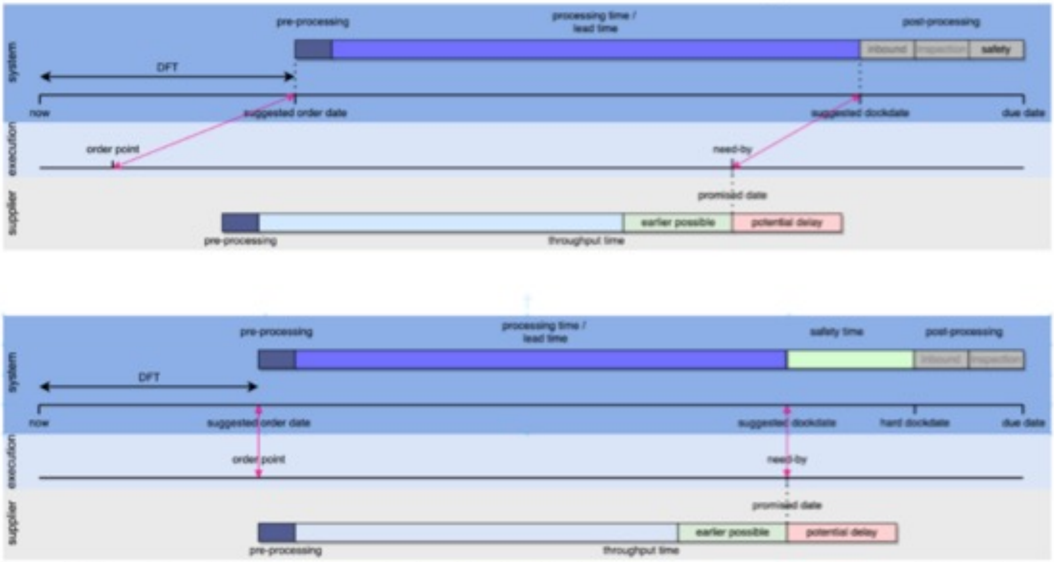

Figure 16: Overview of lead times in current and desired situations with arrows indicating connection and disconnection of figures.

The question remains however, whether fully eliminating the deviation from the suggested order date will improve the overall performance, as these deviations are often done to gain a tactical advantage at the supplier (quantity discounts or other). Thus, even with these measures taking effect, an argument can be found for still having flexibility in determining the order point. Overall, it would be useful for the organisation to talk about the meaning of the suggested order date and operational planning and come to one interpretation of them. By having the same understanding of time periods in which orders can be placed and the rigidity of the planning a lot of conflicts can be avoided.

7.6 Premature operationalisation of items

In a various situations it occurs that items are to be procured while their status is still outdated. This is troublesome, since this means that pricing and lead time data could very well be inaccurate.

Items with "outdated" status

Items get transferred the operational planning even when the item still has the status "outdated". From our understanding of the standard processes, items can only be operationalised when given the status "approved", since this means that the information on the item is verified to be true. Reasons why these items are being operationalised without this step were not concretely discussed with the relevant process actors. However, from all the interviews the impression is gained that this is done might stem from items with close suggested order date, or with an order date that has already passed, meaning the items need to be rushed through.

Procuring directly from tactical environment

In some instances, tactical buyers receive instructions to procure items directly out of the tactical environment. This is also done because of fast approaching or already passed suggested order dates. It is unknown why some items appear in the planning at a late date so that they need to be procured in such a rushed manner. Should an item be directly procured out of the tactical environment, it implies that the condition of an item having to have the "approved" status is by-passed. Thus, the potential situation where the actual lead time is vastly different from the "outdated" date will only come to light after the order has already been put through and planned with.

Data analysis

When looking at the newly requisitioned items for each week over a period of ten weeks, on average [redacted] items were included that donned the status "outdated". There were, however, large differences between the weeks, as can be seen in Figure 17. It can be said that this phenomenon happens almost certainly each week for at least a few items, with excesses of up to more than a hundred items being operationalised without having been updated.

Figure 17: Items with outdated status upon introduction to "aansturing" per week.

In both these situations, a lot of pressure is perceived by tactical buyers to work through the item maintenance process steps and order the item in time. Furthermore, after the information is requested it often turns out that the information on which the master planners made their decisions was not accurate, which means that the rescheduling subprocess has to be enacted. This is time consuming as well. Although exact reasons for why this happens are not the focus of this research, it would benefit the organisation if a conscious effort could be made to reduce the amount of cases where this happens.

7.7 Minor remarks

Inbound delay compensation

Currently, the post-processing time for all items includes two days that are intended for inbound processing. However, according to the warehouse it hardly ever takes two full days to process the items, and in most cases, it will only take one day. While considering the worst case scenario for internal use is logical, the performance measuring of the suppliers by way of the KPI "on time delivery"

(OTD) includes a five-day window after the promised date in which the item will still be marked as "on time". This means that currently the OTD measurement is too optimistic for the suppliers as they experience no negative impact from delivering up to 5 days late. What skews this picture even more is that sometimes the tactical buyers change the promised date to a date further in the future when an item has already been sent by the supplier, but not yet booked into the system. OTD measurement comes from this revised promised date, so the window for suppliers is then even larger.

OTD measurement

Currently, OTD measurement is done by comparing the receipt date with the (revised) original promised date of the item. This KPI serves well in measuring the performance of suppliers in the sense that they're fulfilling the order specific promises. However, the measurement could also be considered flawed. As mentioned before, the revised original promised date can be changed to new agreements when discussed, and sometimes also gets changed unjustly. This could skew the measurement of the KPI to favour suppliers. Furthermore, while the KPI suffices in observing whether the promised dates are achieved and thus whether the supplier is on a desired quality level, OTD says nothing about the wider perspective. There is currently not enough focus to whether the received date of the item upholds to the suggested dockdate, which is ultimately the figure that will impact overall supply chain performance. From a performance of activity perspective, currently only the reliability (the performance under stated conditions) of the ordering activity is being focussed on, but the effectiveness (the ability to achieve an intended or desired effect) is not (Chan & Qi, 2003). The authors of this paper argue that having a too narrow perspective in terms of measurement can blindsight an organisation. One could argue that this is what we also see at Thales currently.

Awareness of pre-processing time

In some instances, it became apparent that the intention of the pre- processing time is not always fully known to people. In some minor cases it came forward during the interviews that when documenting a lead time on item level, some slack was also allocated in this figure to account for the handling of the order as a tactical buyer. This should, however, of course be redundant since the 5 days of pre-processing time should account for this. It should be noted that this only came up in a minority of the interviews. However, it does show that the knowledge of the intention of certain figures is not always from a level that one might expect.

7.8 Concrete recommendations

From various points brought up in this chapter the concrete recommendations that will aid most in solving the core problem *"The lead times in the procurement process at Thales Hengelo need to become transparent unambiguous instead of non-transparent and ambiguous."* Are as follows:

1. Instate a standard updating check for lead time before the planning of an item.
2. Create a field to allocate safety lead time for items separate from other fields in the ERP system.
3. Change the conditions for allocation of the "outdated" status to consider older lead time data.
4. Enable documenting historic lead times, or multiple lead times for items to capture and communicate variability.
5. Discuss the rigidity of the operational planning and suggested order dates between planning and tactical buying to reach a common understanding.
6. Reduce the number of items that get operationalised with the "outdated" status.

In cooperation with Thales a consideration has been made on the impact of each recommendation if it were to be acted upon, as well as the amount of effort it would take to implement. This ratio can be seen in Figure 18. The placement of the recommendations on the matrix has the following reasoning behind it:

Recommendation 1

Recommendation 1 requires some managerial effort to organise this moment, and will also increase the workload of the tactical buyers. However, in return, a lot of time will be saved in terms of handling items with incorrect lead time data (requesting new data, re-scheduling/re-negotiating etc.) in the ordering process for both the tactical buyers as well as planning.

Recommendation 2

Recommendation 2 will require changes to the ERP system, as well as a method of deciding on the safety times that is supported by both tactical buyers as well as planning. Depending on the detail level of the safety time allocation this will not take tremendous amounts of time for all of the items to do. In return, a lot of uncertainties will be taken away from the process and the communication between departments.

Recommendation 3

For recommendation 3, a slight change to the rules in the ERP system are required, without a lot of extra effort required. The change will give some more clarity about the lead times, but the most impact will only be achieved when this recommendation is combined with other measures and not implemented stand-alone.

Recommendation 4

Recommendation 4 would require sizable changes to the ERP system, since the data types for lead times in the system need to change drastically to be able to implement this. This would in turn give a lot more insight into the decisions that can be taken surrounding the lead times of items. However, this is only part of the solution since the actual decisions need to happen in a good way as well. The recommendation thus does not give a direct large impact on the process. It should be noted that especially for the future perspective it could be very useful to the organisation to possess this data for other uses than solving the problems stated in this research as well.

Recommendation 5

Discussing the points addressed in recommendation 5 would be relatively easy to do, and will easy a lot of conflicts that arise because of the different interpretations that exist. However, the easing of these conflicts only represents a minor part of what can be improved in the procurement process.

Recommendation 6

Reducing the number of items that get operationalised with the "outdated" status is a matter of changing the mentality towards these items and thus would we relatively easy to implement. However, it would yield a noticeable reduction in workload and stress for the tactical buyers. Perhaps more importantly, it will also reduce the number of items for which hindsight the data was inaccurate in turn reducing the number of times that orders need to be rushed or rescheduled.

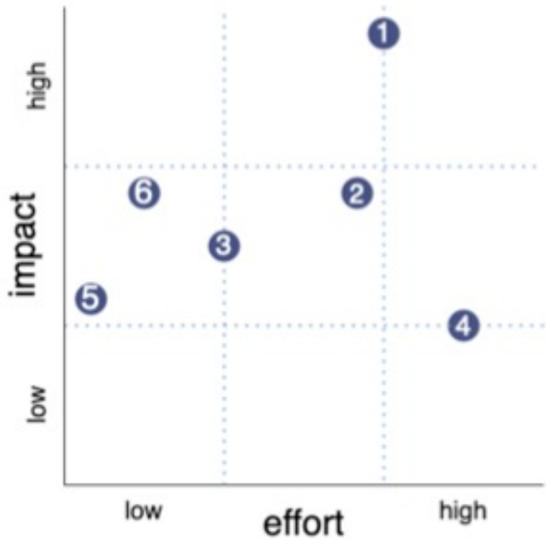

Figure 18: Impact/effort matrix of recommendations

8. Conclusion

By answering the research questions, and outlining the points of interest to the organisation alongside recommendations for improvement in Chapter 7, this research can aid Thales in solving the core problem defined *as "The lead times in the procurement process at Thales Hengelo need to become transparent and unambiguous instead of non-transparent and ambiguous."*. In turn, this will easy the process of scaling the supply chain for Thales. This chapter will briefly reflect on the original research questions as stated in the research design, as well as its recommendations. Next to this, a few other shortcomings of this research will be pointed out in this chapter as well. It's also important to note that not all practicalities and details for implementation were covered in this research and thus the recommendations should be seen as directional.

8.1 knowledge problems

The results as outlined in Chapters 3 to 6 serve to solve the original knowledge problems that were defined at the start of the project as follows:

1. Which best practices and methods exist to manage and optimise lead times in a procurement process?
2. How does the current procurement process at Thales Hengelo look like?
3. How do the different actors in the process interpret and communicate the lead times?
4. How reliable are the defined lead times across the different procured items?
5. Which lead times in the process are the most variable and considered significant to the process?

Knowledge problem 1

From the literature review we can see that managing procurement processes and suppliers specifically is generally done in line with two schools of thought, relational and transactional governance. Furthermore, it appears that the most effective way of dealing with uncertainty in supply for Thales as a make-to-order low volume producer would be by applying relational governance methods to their suppliers, and by instating safety lead times. The size of these safety lead times comes down to the balance between inventory and cashflow costs and the costs and risks of a stockout which could halt production. Various quantitative methods have been proposed to optimise this, which require accurate figures for lead time, stock out costs and inventory costs.

Knowledge problem 2

The procurement process at Thales spans multiple groups of process actors, namely tactical buyers, master planners, item maintenance, TBSS, suppliers and warehousing. The details of the process in the form of a BPM can be found in Appendix 1, and are also outlined in Chapter 4. Throughout the research, it became apparent however, that at certain points on the process variations exist in how this step is being handled by the process actor. These variations are outlined in Chapter 5.

Knowledge problem 3

The interpretation of lead times is hard to pin down as there are various ways of communicating lead times, which differ from each other. On an item level, the processing time of the item is considered the lead time to plan with for this item by planning. The lead time that is being actually performed on an order level however, does not necessarily have to be identical to this. By deciding on the order dates and need-by dates of orders, the tactical buyers assure the timely arrival of these items, but this does mean that there is not a direct correlation with the item level lead time. Consequently, the item level lead time is seen of less importance as well. It appears that when looking at the item level lead times, the master planners interpret this as worst-case scenarios, while in general the tactical buyers try to communicate the most recently communicated lead time from the supplier. Because of these discrepancies, a lot of different impressions exist on the lead times as well, as outlined in Chapter 6.

Knowledge problem 4

Since it is not being recorded when lead times have been changed over time, or what the past values were, it is very hard to make a judgement on the validity of the lead times. This counts for this research, but more perhaps more importantly also for the process actors themselves. There currently is not enough surrounding and historic data to make a judgement on the lead time values. Furthermore, because the updating process is not triggered for all items at set moments, it is also hard to judge the accuracy based on knowledge of the process. In this sense, one could argue that the lead times currently are not very reliable.

Knowledge problem 5

As pointed out in the data analysis, the largest differences between lead time values is the difference between the need-by date and suggested dockdate. This in itself is not currently treated as a lead time, but serves the function of a safety time. This created safety time knows a wide range of values, spanning from 0 to up to more than two years. Another factor that appears to vary greatly is the order creation date in relation to the suggested order date. Although the latter has around the same level of variety, the former has more consequences for the process as this variety causes a lot of uncertainty for the progress of orders, and causes actions to not be aligned to what's expected timewise

8.2 Recommendations

From the research, a selection of concrete recommendations was formulated which has implications for the process, the way data is stored and the way process actors interact. Thales is encouraged with these recommendations to improve information flow and communication between departments and treating the situations discussed as overall supply chain issues, rather than planning or procurement issues. Next to the list, various points are brought up which deal with the view or interpretation of process actors in certain situations. The list is formulated as follows:

1. Instate a standard updating check for lead time before the planning of an item.
2. Create a field to allocate safety lead time for items separate from other fields in the ERP system.
3. Change the conditions for allocation of the "outdated" status to consider older lead time data.
4. Enable documenting historic lead times, or multiple lead times for items to capture and communicate variability.
5. Discuss the rigidity of the operational planning and suggested order dates between planning and tactical buying.
6. Reduce the number of items that get operationalised with the "outdated" status.

8.3 Limitations

As lead times are only stored as a single value per item without historic data or date on which they have been changed last, an analysis on the variations and accuracy of item-level lead time data was hard to perform. Even though ample time was spent on this topic during the interviews, it is hard to verify whether what was mentioned in the interviews is true, and on what scale different phenomena are happening.

Since the need-by date and moment of ordering are up to the discretion of the tactical buyer to decide on, it is hard to determine the actual throughput time of items at the supplier. It could for example be that an order is put in at the supplier three months in advance, but production starts two months in advance and takes one month. Because of this, it was deemed hard to draw conclusions out of these timeframes. Therefore, an analysis comparing the timeframe between PO creation and promised date or receipt date and the item level lead times was ultimately not performed.

Even though the survey to suppliers was filled by a relatively large group of suppliers, some remarks must be made on the accuracy of the results. The participating suppliers where a good reflection of the total supplier portfolio based on order volume, duration of the relationship and throughput time of items. Nevertheless, the fact that these suppliers chose to fill in the survey signals that they have a healthy and responsive relationship with Thales. 179 suppliers were considered in scope for the research based on the fact that they supply items used in production (as opposed to for example services or office equipment. Of these, 38 were left out because of requests from Thales based on the situation with these suppliers like ongoing negotiations or termination of collaboration. Of the 141 remaining suppliers, 73 filled the survey, meaning 68 suppliers did not. It is a logical assumption that these suppliers might give other results than received now. Even though the research takes this bias into account when drawing conclusions, it would still be interesting to know the perspective of suppliers with a somewhat looser relationship with Thales.

8.4 Contributions

In this section the theoretical and practical contributions of this thesis will be discussed.

Theoretical

This thesis contributes a systematic literature review which combines dealing with lead time uncertainty from both a quantitative as well as governance perspective. Furthermore, it applies Business Process Management and Business Process Integration theory in a supply chain and procurement setting, combining it with theory from this field as well. Phenomena identified in theory regarding information flows and supplier governance methods are identified in practice alongside reasoning from individuals about this behaviour. Furthermore, the supply chain difficulties for make-to-order firms often named in literature are linked to a real-life situation as well.

Practical

The practical contributions of the thesis are the recommendations formulated in Chapter 7, with which Thales can improve their procurement process and overall supply chain. Furthermore, the thesis also offers insight into the way the process is organised and data is being interpreted and handled. This can aid the organisation in their efforts of improving business intelligence and data management, but also help process actors with better understanding the process and other process actors.

8.5 Further research opportunities

Due to time restraint the research focusses on the procurement process and process actors that have the most direct influence on it. However, many of the points of interest and recommendations are also of relevance for the planning department. This department has not been analysed in detail, but doing so could offer insight into how to best improve the whole supply chain. For example, by finding a moment for item updating before an item is planned, or finding a way to decrease the operationalisation of outdated data.

Even though not considered in this research, it could still be interesting to compare the achieved lead times of supplier to what is stored on item level. A way would have to be found to find the actual lead times of suppliers. This can be done by analysing offers sent by suppliers, logging the lead times in Oracle or by logging the lead times manually. An argument could be made to use the data of the survey that was part of this research for this, however this only covers part of the suppliers and therefore would not give a wholistic impression.

In general, this research has not focussed on the supplier landscape from a sourcing perspective, instead opting to treat them as a group of process actors. Even though this gives a lot of insight into the procurement process, it should be remarked that the supplier landscape is very diverse and is therefore worth investigation on its own. Not every supplier has trouble with on-time delivery, and not every supplier has often changing lead times. Finding out these differences can serve to direct specific improvement efforts for these suppliers or item groups on top of the improvement efforts to the procurement process in general.

The fact that the procurement department works from an item perspective, whilst the planning department works from a project perspective is something that was addressed in the thesis. However, except for the direct implications to lead times and the procurement process this transition from perspectives between departments was not explored. The thought behind the perspectives was explained by both departments with logical reasoning. However, this practice was not verified in extensively discussed, compared to other organisations or researched in literature. Researching this dynamic can yield both interesting insights for theory, as well as for practical improvements at Thales.

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Appendix A: Business process model

Figure 19: Full BPM of current process.

Figure 20: Full BPM with suggested changes to process (blue).

Appendix B: Overview of lead times

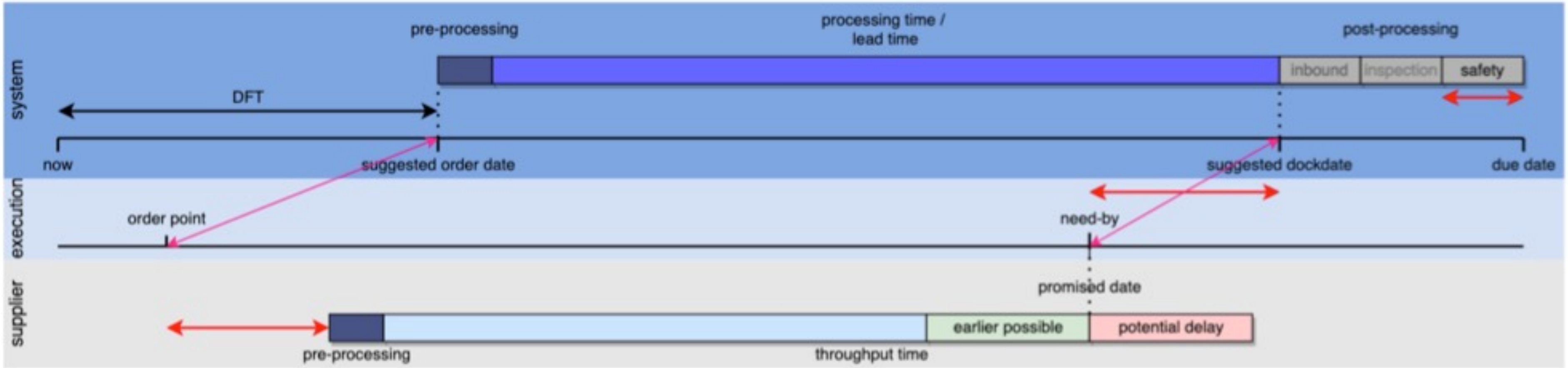


Figure 21: Overview of lead times in current situation, with buffers indicated in red and misalignments indicated in pink.

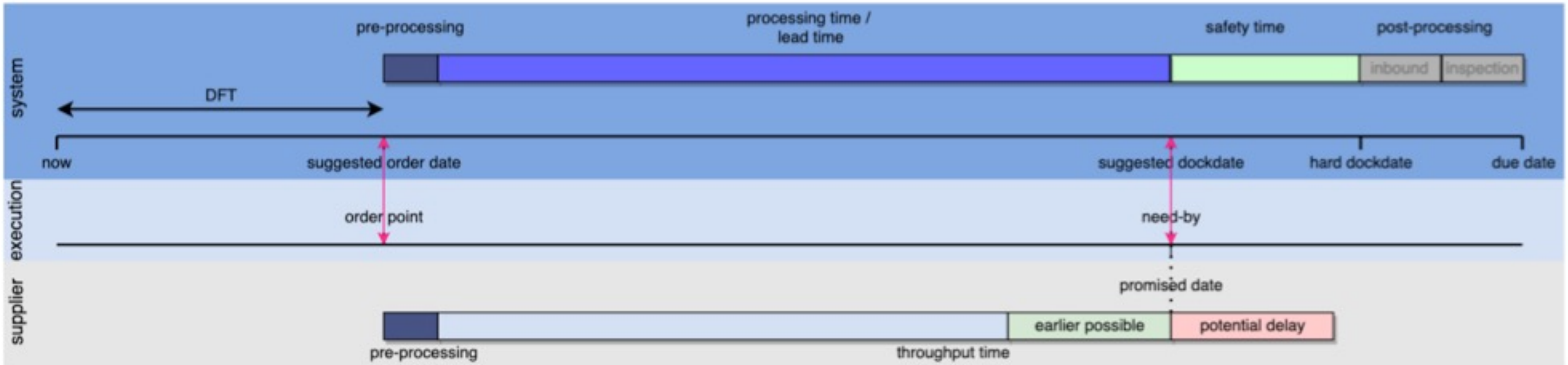
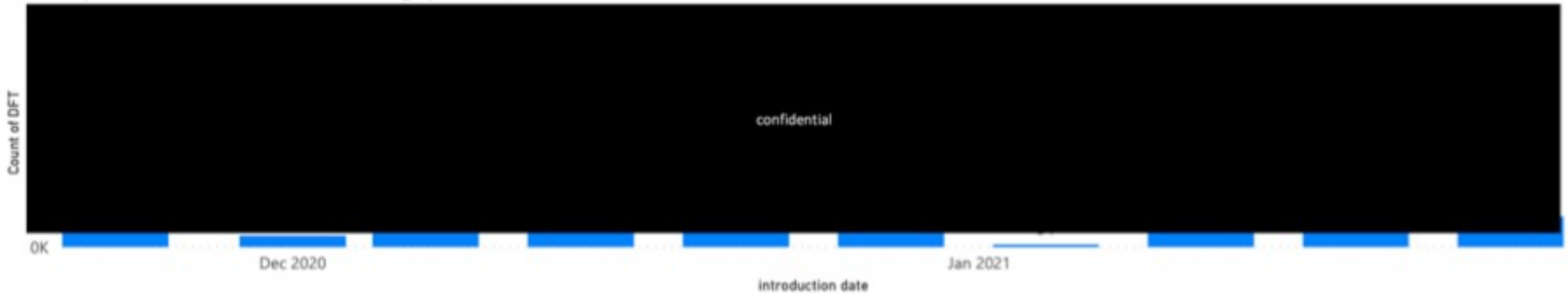


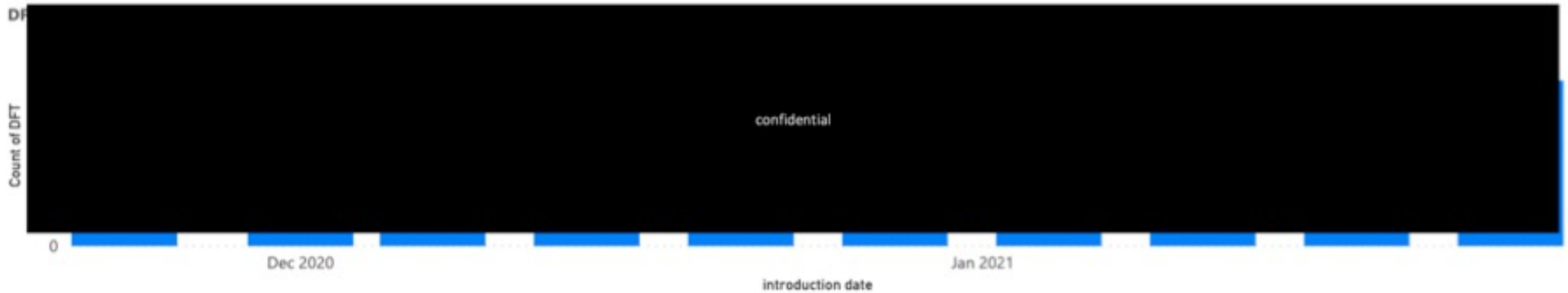
Figure 22: Overview of lead times with recommended changes, with re-alignment of moments indicated in pink.

Appendix C: Data analysis reports

new requisitions received in "aansturing" per week



requisitions with DFT 0 on first introduction



items with outdated data in "aansturing"

Category ● OUTDATED DATA

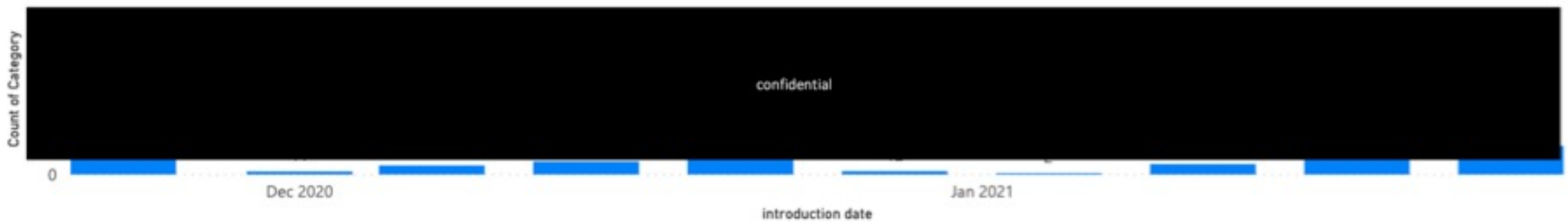


Figure 23: Results of analysis on new planned items per week from end of November 2020 to January 2021.

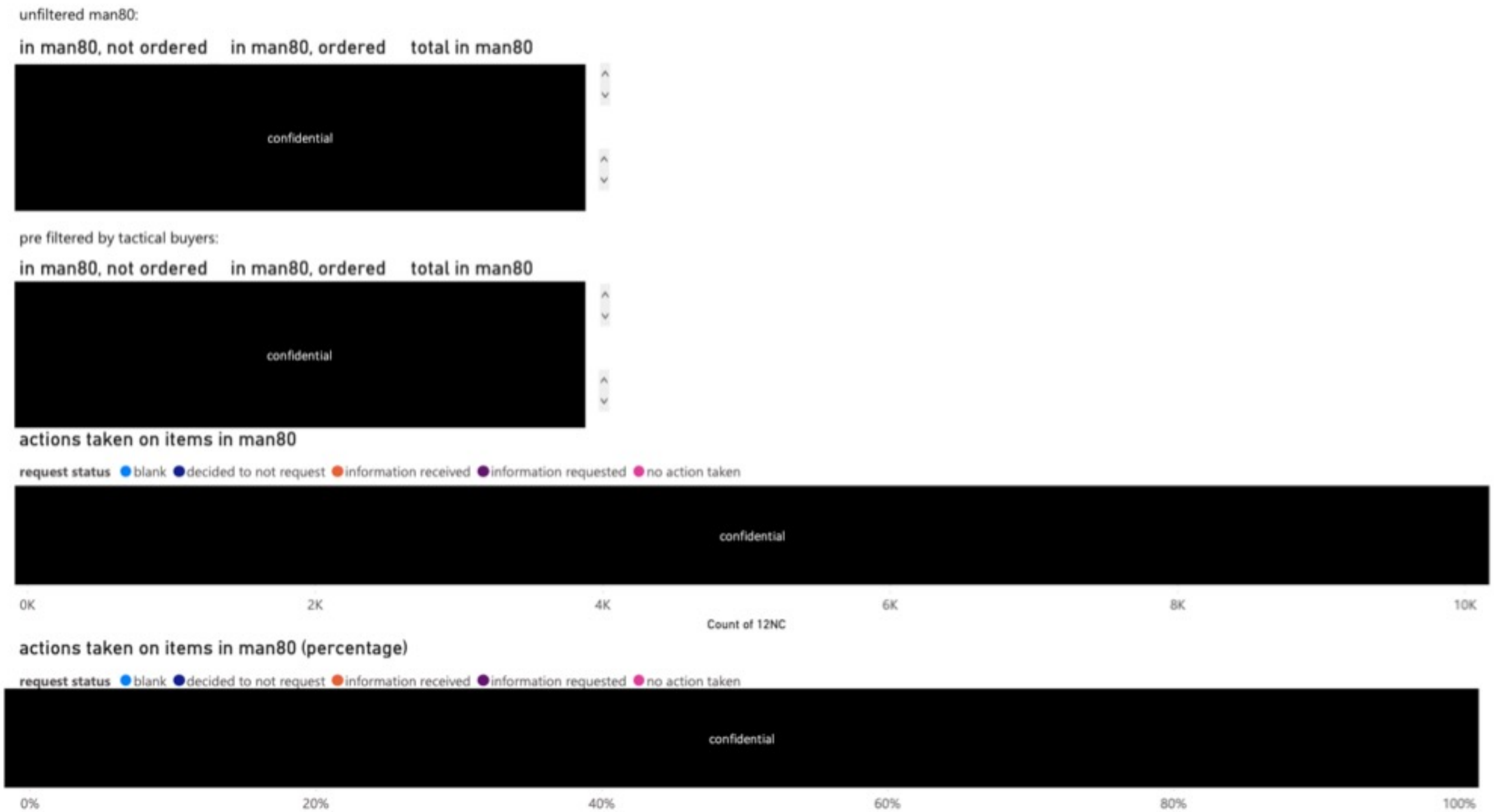


Figure 24: Results of analysis on items present in the 2020 man80 list when compared to all ordered items of 2020.

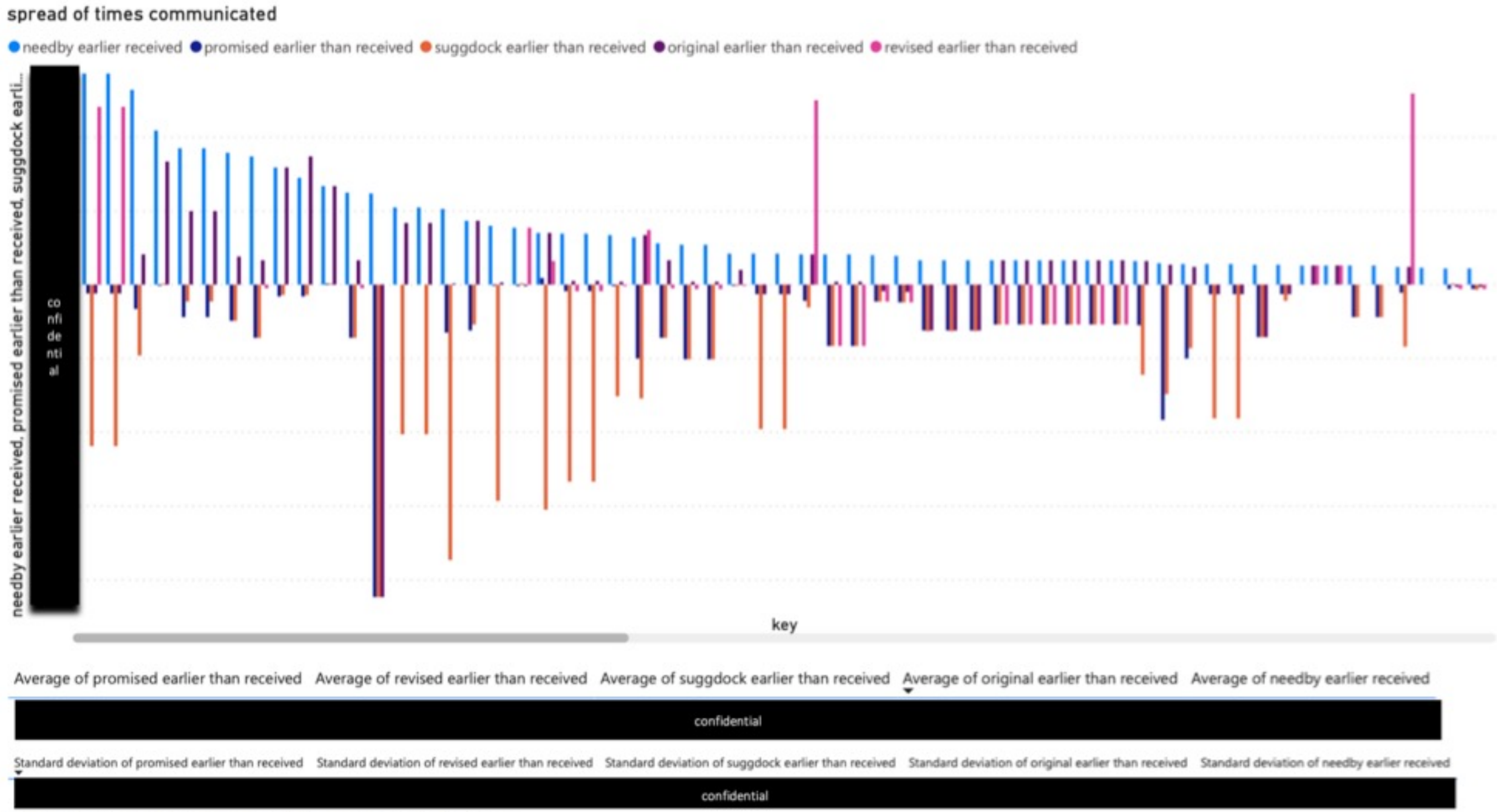


Figure 25: Report of analysis on all time figures of individual orders.

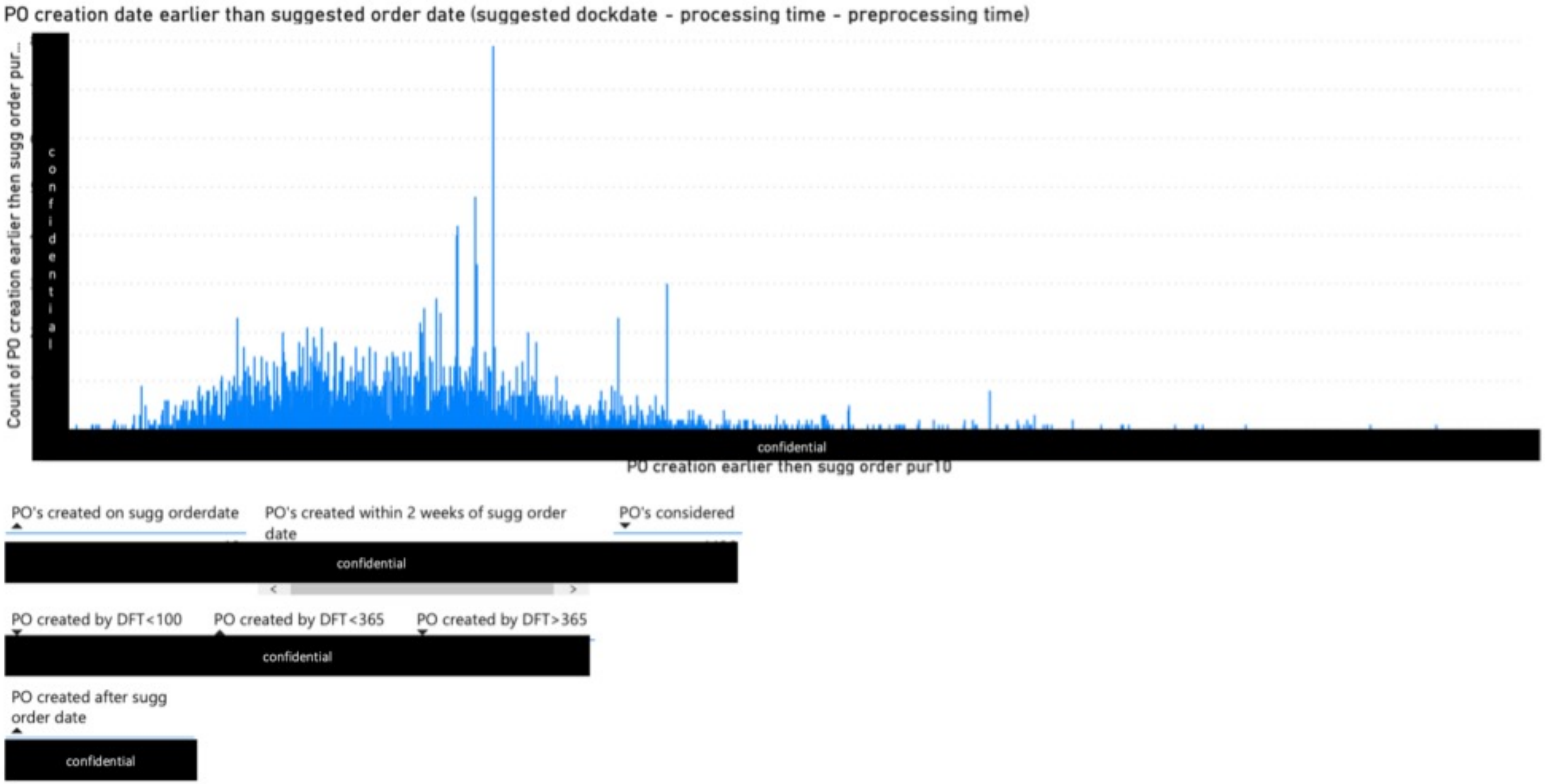


Figure 26: Report of analysis on PO creation date when compared to the suggested order date of planned orders.

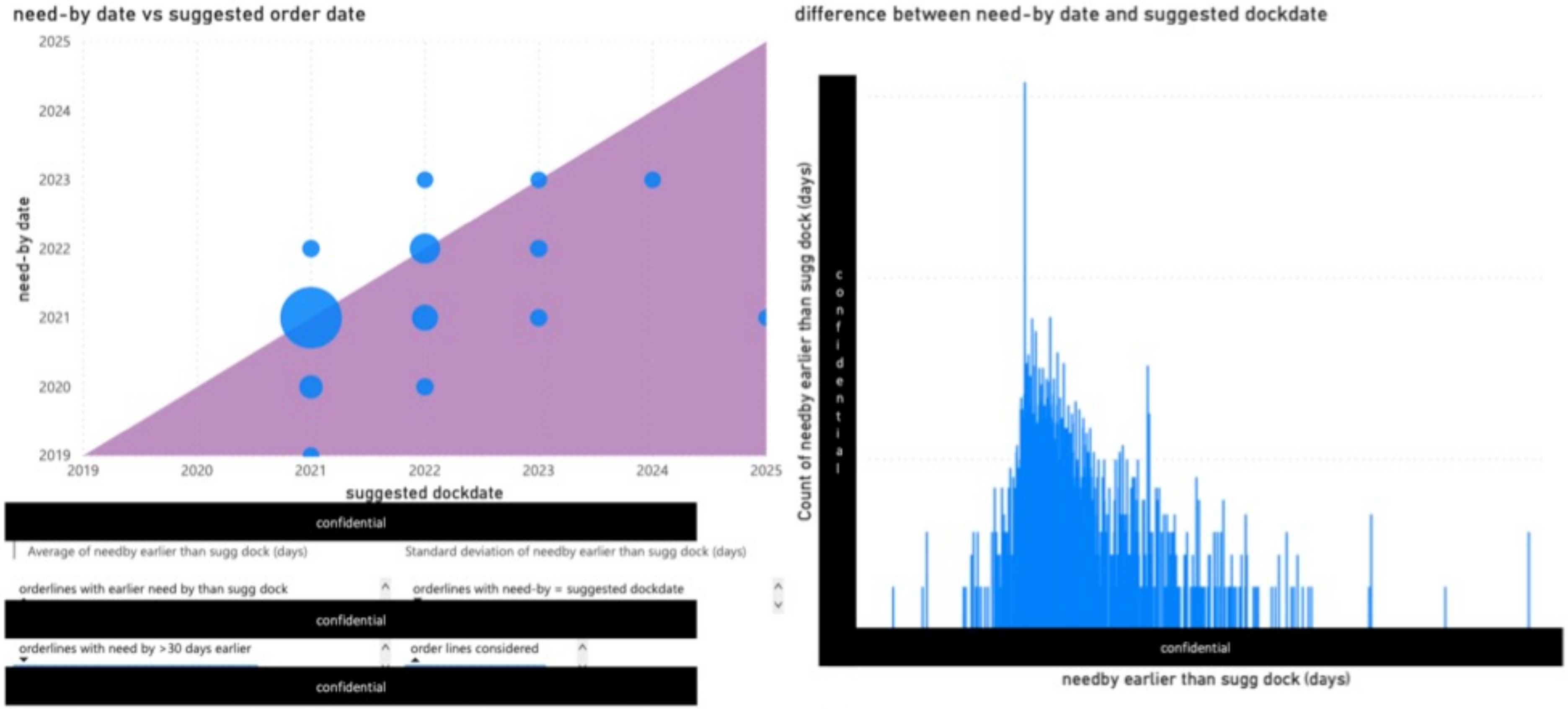


Figure 27: Report of analysis on need-by dates compared to suggested order dates of all planned orders.

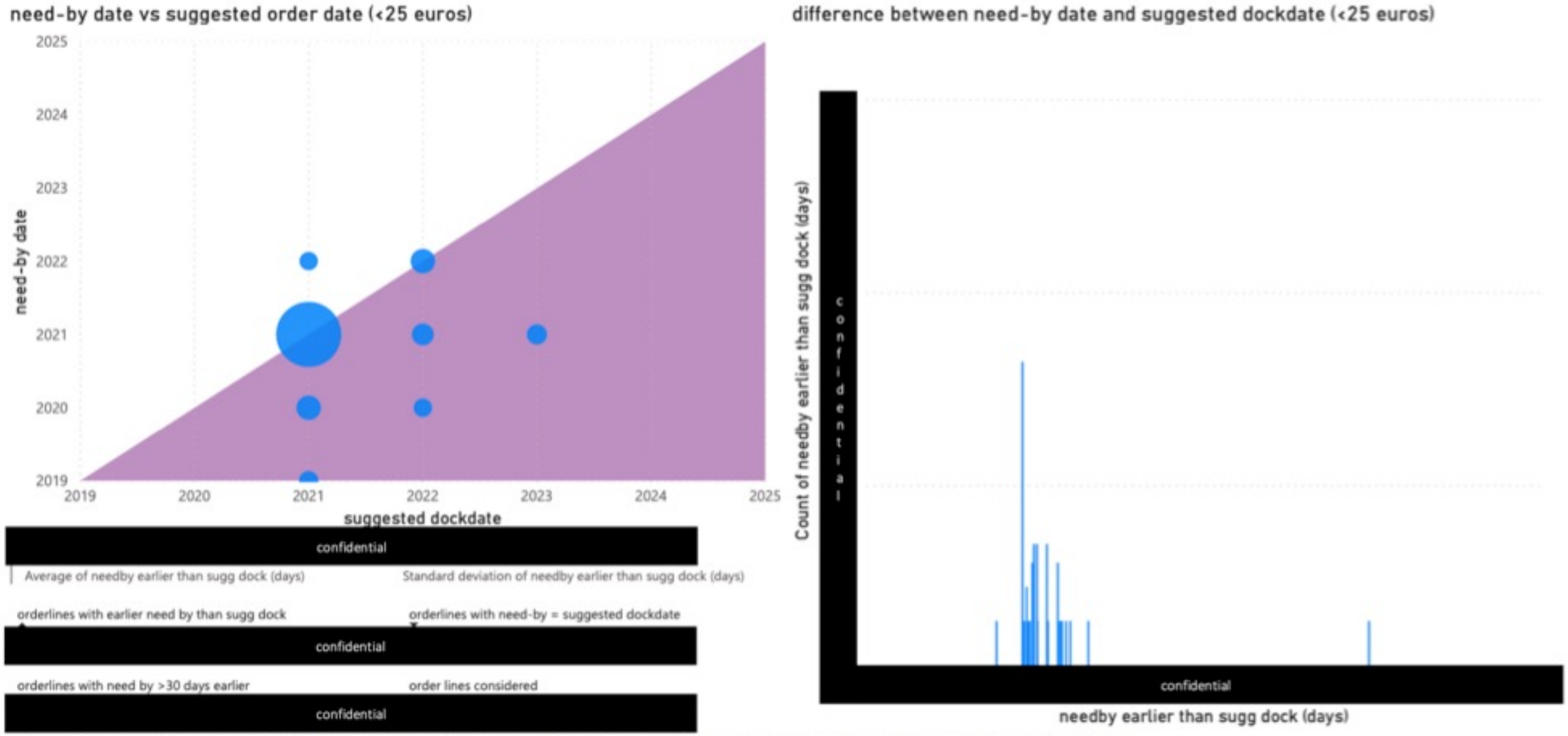


Figure 28:Report of analysis on need-by dates compared to suggested order dates of planned orders with a purchase price lower than 25 Euros.

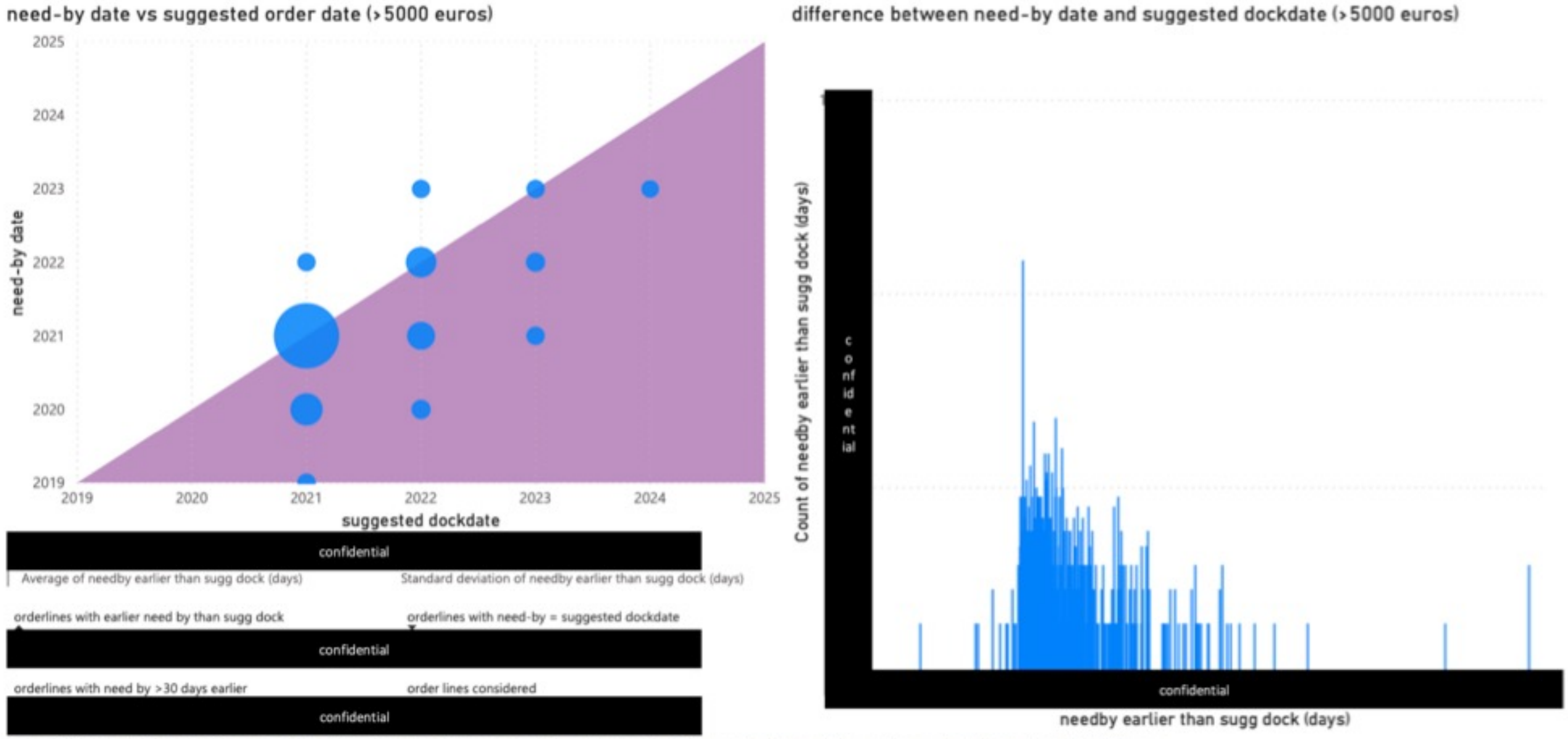
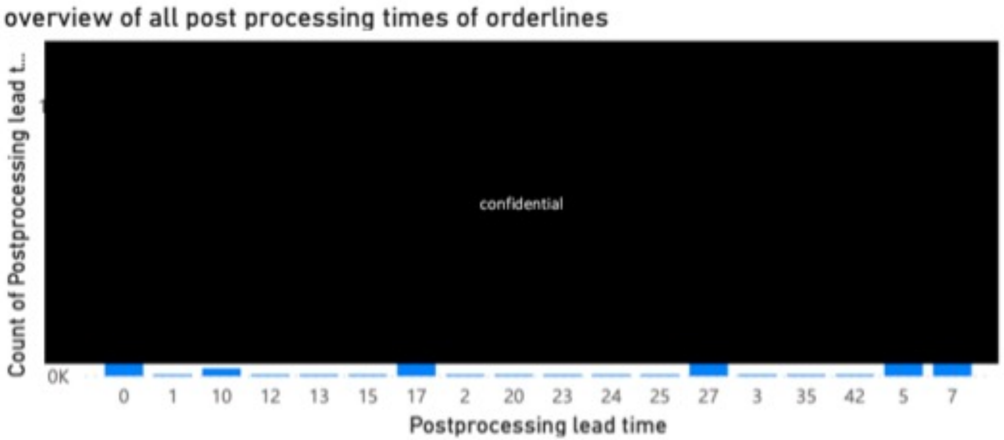


Figure 29:Report of analysis on need-by dates compared to suggested order dates of planned orders with purchase price higher than 5000 Euros.



Postprocessing lead times considered
post processing deviating from codes
confidential

different values
post processing larger than codes
confidential

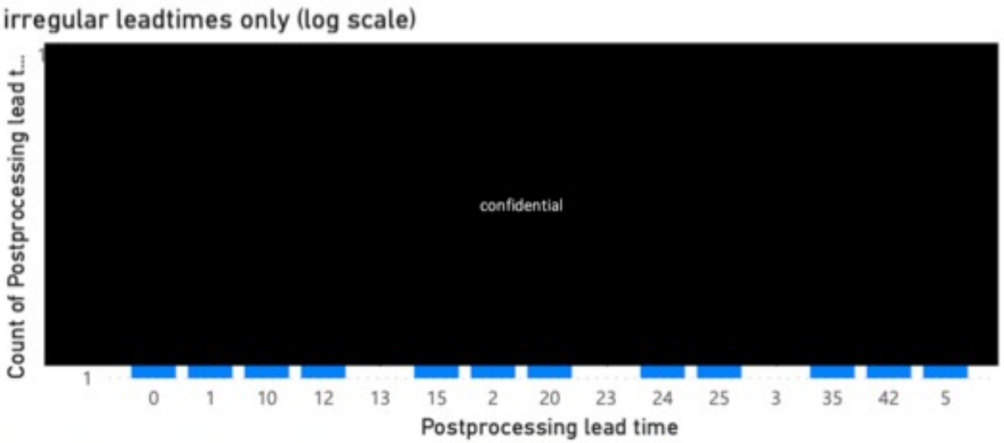


Figure 30: Report of analysis on Post-processing times of active orderlines.

Appendix D: Systematic literature review

The knowledge problem *"Which best practices and methods exist to manage and optimize lead times in a procurement process?"* will be solved by conducting a systematic literature review.

Criteria

For this systematic literature review, the following inclusion criteria have been identified:

Nr.	Content	reason
1	Stochastic lead times	This criterium is believed to indicate quantitative methods.
2	Optimization	This criterium will lead to articles that focus on improvement.
3	Processes	This will bring forth articles focused on processes.
4	Best practices	This will result in articles outlining the state of the art and current understandings in the field.

Combined with the following exclusion criteria:

Nr.	Content	reason
1	Mass production	As Thales does not do mass production, techniques used in this field are not always relevant.
2	Safety stocks	Since Thales works via make-to-order, it cannot hold safety stocks for the parts that are the biggest cause of the problems.
3	EOQ/economic order quantity	As Thales works on a make-to-order basis with specialized parts, for the largest part of the procurement catalogue there is no pattern in demand. Thus EOQ methods are not applicable.
4	Pre-1980 articles	The context of the articles should be relatable to the complex, high-tech supply chain in question.
5	Medical/Social topics	Not relevant for industry
6	Construction/public works	Not relevant for industry
7	Design/engineering	Changing the design of products or parts to improve the supply chain is considered out of scope for this research.

Source types

The review focusses on sources that are primarily systematic reviews of certain fields, to find out the best practices and current understanding of the subject. Sources that focus on specific management of optimization methods can also be considered.

Databases

The Scopus database will be considered for this review as it contains the most peer-reviewed sources in most fields. Furthermore, Business Source Elite (BSE) will also be used, as this database focusses on the management field which is applicable to this research. This database might also include more on the state of art for this field.

Search matrix

To aid in defining good search terms, the following search matrix has been created focussing on the most important constructs for the research question.

Constructs	Related terms	Broader terms	Narrower terms
Lead times	Order date, delivery date	Waiting	Processing time
Procurement	Purchasing, ordering	Buying	Fulfilment
Optimisation		Improvement	Efficiency
Stochastic	Risk	Uncertainty	
Management	Leading, decision making	Leading, guiding	Planning, instructing

Exploratory searches

To get an impression of how much literature is available on the subject, and which search terms will yield the best results, a few exploratory searches were performed. The results of this were:

date	database	search term	scope of search	entries
24/11/2020	Scopus	procurement management	TITLE-ABS-KEY	16,580
24/11/2020	Scopus	procurement management lead times	TITLE-ABS-KEY	4
24/11/2020	Scopus	procurement AND management AND lead time*	TITLE-ABS-KEY	25
24/11/2020	Scopus	(procurement OR buying) AND management AND lead time*	TITLE-ABS-KEY	27
24/11/2020	Scopus	(procurement OR Buying) AND lead time*	TITLE-ABS-KEY	63
24/11/2020	Scopus	(procurement OR Buying) AND (lead time* OR ("lead time*"))	TITLE-ABS-KEY	516
24/11/2020	Scopus	(procurement OR buying) AND (lead time* OR ("lead time*"))) AND uncertain* AND NOT inventor*	TITLE-ABS-KEY	92
24/11/2020	BSE	(procurement OR buying) AND (lead time* OR lead time*)	TITLE-ABS-KEY	653
24/11/2020	BSE	(procurement OR buying) AND (lead time* OR lead time*) AND process	TITLE-ABS-KEY	345
24/11/2020	BSE	(procurement OR buying) AND (lead time* OR lead time*) AND process AND uncertain*	TITLE -ABS-KEY	64
25/11/2020	BSE	(procurement OR buying) AND (lead time* OR lead time*) AND process AND (uncertain* OR risk) AND NOT demand	TITLE -ABS-KEY	37
25/11/2020	BSE	(procurement OR buying) AND (lead time* OR lead time*) AND (process OR practice*) AND (uncertain* OR risk) NOT demand NOT "safety stock"	TITLE -ABS-KEY	36
25/11/2020	Scopus	(procurement OR buying) AND (lead time* OR lead time*) AND (process OR practice*) AND (uncertain* OR risk) NOT demand NOT "safety stock"	TITLE -ABS-KEY	99
01/12/2020	BSE	(procurement OR buying) AND (lead time* OR lead time*) AND (process OR practice* OR management) AND (uncertain* OR risk) NOT demand NOT "safety stock"	TITLE -ABS-KEY	47

Final selection

The knowledge gained from the exploratory searches led to the formulation of the final search term, which was used in Scopus as well as BSE. After the final search results were in, the duplicates were removed. Then the remaining papers were judged on the exclusion criteria by reading titles and abstracts. Of a few papers a full version could not be acquired, even after a request was put through to the authors. A selection of papers was also removed after they were read fully based on the exclusion criteria which were not apparent from the abstract. Two papers were added manually which were often cited by the other sources that were taken into consideration, but did not appear in the initial search results. This led to the following reduction of papers that were considered:

database	search term	results
BSE	(procurement OR buying) AND (lead time* OR lead time*) AND (process OR practice* OR management) AND (uncertain* OR risk) NOT demand NOT "safety stock"	47

Scopus	TITLE-ABS-KEY ((procurement OR buying) AND (lead AND time* OR lead time*) AND (process OR practice* OR management) AND (uncertain* OR risk) AND NOT demand AND NOT "safety stock")	141
total		188
after removing duplicates:		172
after removing medical and social topics:		122
after removing construction/public works:		100
after removing engineering-only papers:		73
after removing mass production:		29
after removing unattainable papers:		26
after full reading:		9
manually added:		2
final total:		11

Conceptual matrix

The remaining papers were extensively read, which lead to the creation of the following conceptual matrix:

Journal	Author (year)	Methodology	Goal of research	Relevant findings
The McKinsey Quarterly	Asmus, D.& Griffin, J. (1993)	surveys send out to companies that are leading in their market in terms of supply management, combined with public statistics	give an overview of ways companies used their suppliers to gain a strategic advantage	identifies trends in successful companies such as supplier consolidation, and more investment into supplier relationships via long-term agreements and mutual goal setting
International Journal of Production Research	Handfield, R. & Pannesi, R., (1995)	Interviews with 40 managers in make-to-order companies from 9 industries were used to find the effectiveness of a range of methods.	The authors intend to develop a framework for analysing four supply chain management strategies in make-to-order markets which can lead to cycle-time reduction.	The authors argue that in modern production companies the biggest improvements can be made in procurement of materials, rather than internal production. The authors also identify just in time purchasing, involvement in supplier performance improvement, and to a lesser extend supplier involvement in design as effective methods of improving cycle times in make-to-order markets.
International. Journal of Production Economics	van der Vaart, T. & van Donk, D.P. (2003)	a literature study combined with illustrative cases about supplier integration	The authors want to outline the emergence of buyer focus in supply chain management as a new step in supplier integration where suppliers actively pursue the needs of one buyer.	The paper outlines the different states of supply chain integration that are observed in the business world, and divides them over different stages: transparency, commitment and coordination, integrative planning and buyer focus.

Journal	Author (year)	Methodology	Goal of research	Relevant findings
IMP Journal	Gadde, L. & Wynstra F., (2018)	The paper uses a literature review of the development of purchasing and supply management over time, and indicate their relation to uncertainty and dependence.	The paper is intended to analyse the role of uncertainty in purchasing and supply management and the changes of this role over time.	The paper describes two eras of purchasing management, with literature before 1970 focusing mainly on uncertainty avoidance characterised by low involvement relationships, and literature after 1970 focussing on more close, long-term relationships and cooperation.
Annual ARCOM Conference	Sullivan et al. (2006)	By analysing the weekly reports of the US Army Corp of Engineers and US Medical Command while introducing a new, more concentrated method of delivering information the methods effectiveness is tested.	Proving the hypothesis that in communication with contractors, the amount of information communicated to the contractor should be minimized.	The authors argue that, contrary to the general consensus, decreasing the amount of information shared with contractors on projects can decrease inefficiency, confusion, improper performance measurement and lack of accountability.
R&D Management	Clauss, T. & Spieth, P. (2016)	Based on an extensive literature review as well as survey data from the aviation industry the authors aim to outline the effectiveness of different governance mechanisms.	outlining the misalignment of governance mechanisms in buyer-supplier relationships that limit strategic innovation orientation	The paper identifies two schools of governance mechanisms: transactional, which focusses on strict obligations and relational, which focusses on collaboration. The authors argue that while transactional governance increases the effectiveness of the collaboration, it decreases the growth potential of suppliers, and therefore companies should strive for a combination of the two mechanism for key-, or future key suppliers.

International Journal of production Research	Hegedus, M. & Hopp, W. (2001b)	Creating a practical method of applying safety lead-times based on stochastic lead-times and a service level constraint based on previous works from various authors.	devising a practical method for setting safety lead-times for purchased components in assembly systems with uncertainty in the supply process of a computer manufacturer	The paper emphasises the option of using safety lead times over safety stocks in situations of lead time uncertainty in assembly systems. It also highlights that, even in perfect supplier situations, safety lead times could be beneficial due to the flexibility in production that it yields. The paper also proves empirically that setting a universally optimised safety lead time across all items will yield a significantly less optimal result than dedicated safety lead times.

International Journal of Production Economics	Silver, E. & Jain, K. (1994)	Devising a stochastic dynamic program to optimise production costs by deciding on reserving and using capacity over multiple periods with stochastic demand and capacity.	Creating a method to determine capacity reservation and usage decisions over multiple periods given uncertain buyer requirements and supplier capacity in the oil and gas industry.	The authors explore the possibility of reserving capacity at suppliers while still uncertain of the exact amount of capacity needed from this supplier. While not providing evidence of its benefit, it shows that there is demand from companies in this line of thinking.
Journal	Author (year)	Methodology	Goal of research	Relevant findings
Computers & Industrial Engineering	Hegedus, M. & Hopp, W. (2001a)	Creating a two-staged model that determines an optimal due date by balancing delay and inventory costs.	To propose a new method for quoting due dates in make-to-order environments in relation to the requested due date by the customer.	The paper offers an insight into the supplier side of a situation similar to that of Thales. It shows how suppliers can and will make the consideration between inventory costs and delay costs. It also concludes that while most often it is most beneficial to optimise the item throughput and inventory costs, increased delay costs can have significant impact on the optimal solution.
Computers & Industrial Engineering	Dixit, V., Srivastava, R., Chaudhuri, A. (2014)	Devising a procurement scheduling method with stochastic lead times,fuzzy inventory and shortage costs to offer an alternative to various existing stochastic methods.	To create a method of optimising procurement scheduling in long cycle assembly projects like manufacturing/ producing aircrafts and boats.	The authors argue that it's often hard to find good statistical distributions to work with for projects in this scope because of the lack of historical data, and outline a few proposed methods that suffer from this limitation. The authors attempt to bypass this by working with fuzzy numbers. The author however also cautions that this is computationally heavy and not yet fully applicable. This shows that while quantitative methods for this type of scenario exist, they are at the moment quite limited.
International. Journal of Production Economics	Borodin, V., Dolgui, A., Hnaien, F., Labadie, N. (2016)	Devise a new stochastic programming model based on earlier works.	Create a model to optimise a single-level multi-component inventory control problem for assembly systems with stochastic lead times.	proposes a method for determining required safety lead times in similar situations as Thales both on the basis of backlogging costs as well as service level requirement, but argues that due to the difficulty of determining exact backlogging costs a service level requirement would be more practical to use in real life. The paper warns however that this does bring some slack into the model.

Integration of theory

Throughout the years a lot of researchers have shown interest in dealing with uncertainty in supply chains with the eye on procurement. While supply chain management in general has been well versed in literature, the focus on procurement has only been worked out later. However, in the context of make-to-order firms the procurement of materials has been coined as the part of the supply chain that can yield the biggest result when improved (Handfield, R., Pannesi, R., (1995)).

For a long time in practice procurement improvement was seen as uncertainty avoidance (Gadde, L., Wynstra F., (2018)) with low interaction between suppliers and buyers. These transactional governance mechanisms, which they are called by Clauss, T., Spieth, P. (2016) focus on managing a relationship with suppliers by having strict obligations and unrefutably contracts. This mechanism sees the procurement process as the buyer setting terms and the supplier fulfilling them with minimal interaction. This way of governing a supplier has since been challenged by relational governance, which puts emphasis on different levels of collaboration between suppliers and buyers to increase overall effectiveness. Many examples of ways that information sharing, long-term focus and cooperation have benefitted companies exist (Asmus, D., Griffin, J. (1993), van der Vaart, T., van Donk, D.P. (2003)). The overarching idea is that by being more aligned with each other, the buyer and supplier can work out ways in which they can anticipate on the other parties needs more quickly and eliminate misdirected efforts. While many of these success stories have been documented, criticism also exists against its widespread application, with some evidence suggesting that in some cases it might even work aversely (Sullivan et al. (2006)). Some authors also argue for employing different levels of supply chain integration for different situations (van der Vaart, T., van Donk, D.P. (2003)).

Others suggest treating the transactional and relational mechanisms as non-exclusive to each other. According to Clauss, T., Spieth, P. (2016), the transactional model has proven to give the most effective results in terms of direct results, but hinders innovation and problem-solving capabilities in the collaboration. Therefore, they argue for applying both mechanisms at the same time. In practice this could imply holding your suppliers to strict obligations, but also sharing necessary operational information with them to improve their planning. Clauss and Spieth argue that this should count even more so for key-, future key- or troublesome suppliers. Asmus, D., Griffin, J. (1993) give multiple examples of projects conducted with this category of suppliers in a joined effort with buyers.

While a lot of articles point towards improving procurement processes by more engagement with suppliers, quantitative methods of dealing with supplier lead times and uncertainty have also been proposed. Although safety stocks are the most prominent methods of dealing with uncertainty in a supply chain, for assembly systems it is more effective to apply safety lead times (Hegedus, M., Hopp, W. (2001b)).

Many methods have been proposed to efficiently calculate these safety lead times, but the scientific community is yet to find a most ideal method to apply to large quantities of items. A few things that hinder this is that it has proven difficult in practice to determine exact backlogging costs in complicated assembly projects, that because of the low volume of orders not enough data exists to create reliable distributions for all items and that processing these models takes a large amount of time and resources (Dixit, V., Srivastava, R., Chaudhuri, A. (2014), Borodin, V., Dolgui, A., Hnaien, F., Labadie, N. (2016)). Determining the exact safety lead times for individual items instead of a blanket safety lead time does however appear to yield significantly better results (Hegedus, M., Hopp, W. (2001b)).

In the meantime, the subject of supplier lead times has also been approached from different sides. While not extensively written about, some papers propose models for suppliers to determine their internal due date compared to the requested due date from the buyer, based on internal factors and delay costs. While these models would serve more purpose in the context of a project executed at a supplier, it is relevant to note that while these models optimize the results for suppliers, the introduction of delay costs by a buyer can radically change the decisions put forward by the model (Hegedus, M., Hopp, W. (2001a)).

While also not extensively researched, interest from the oil and gas industry has been expressed in models that calculate whether it would be beneficial to pre-emptively buy capacity at suppliers without knowing exact demand for this period (Silver, E., Jain, K. (1994)).

Appendix E: Survey results

Survey Suppliers Thales NL

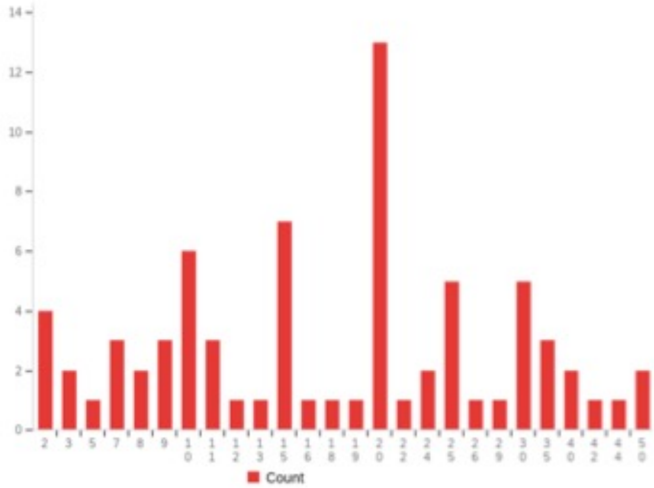
March 15th 2021, 4:01 am MDT

Q1 - What is the name of your company?

[redacted]

Q3 – How long has your company been supplying Thales NL? (number of years)

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How long has your company been supplying Thales NL? (number of years)	2.00	50.00	19.04	11.38	129.52	73

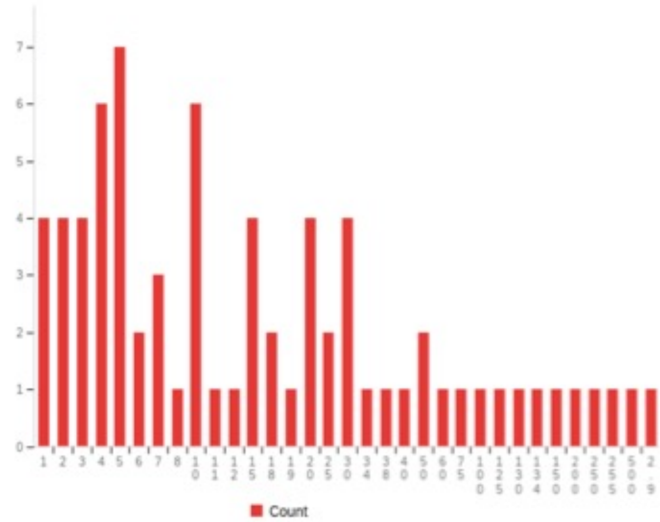


Q4 – How many orders do you fulfil to Thales NL each year? (estimated)

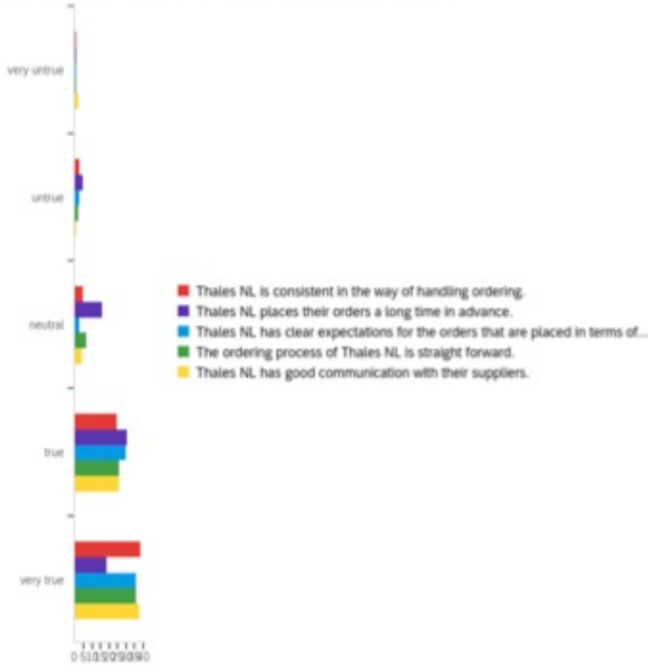
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	minimum (can be zero)	0.00	134.00	13.96	25.83	667.30	73

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	on average	1.00	500.00	37.89	76.21	5807.89	73

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	maximum	1.00	800.00	67.38	145.08	21047.96	73



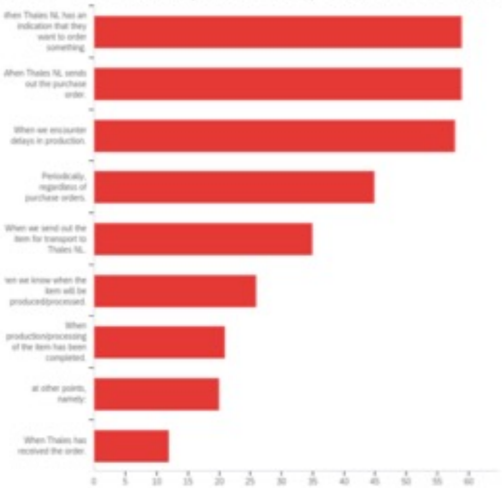
Q5 – Please rank the following statements:



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Thales NL is consistent in the way of handling ordering.	1.00	5.00	4.34	0.88	0.77	73
2	Thales NL places their orders a long time in advance.	1.00	5.00	3.86	0.93	0.87	72
3	Thales NL has clear expectations for the orders that are placed in terms of delivery dates.	1.00	5.00	4.33	0.84	0.71	73
4	The ordering process of Thales NL is straight forward.	1.00	5.00	4.31	0.86	0.74	72
5	Thales NL has good communication with their suppliers.	1.00	5.00	4.37	0.88	0.77	71

#	Question	very untrue		untrue		neutral		true		very true		Total
1	Thales NL is consistent in the way of handling ordering.	1.37%	1	4.11%	3	6.85%	5	34.25%	25	53.42%	39	73
2	Thales NL places their orders a long time in advance.	1.39%	1	6.94%	5	22.22%	16	43.06%	31	26.39%	19	72
3	Thales NL has clear expectations for the orders that are placed in terms of delivery dates.	1.37%	1	4.11%	3	4.11%	3	41.10%	30	49.32%	36	73
4	The ordering process of Thales NL is straight forward.	1.39%	1	2.78%	2	9.72%	7	36.11%	26	50.00%	36	72
5	Thales NL has good communication with their suppliers.	2.82%	2	1.41%	1	5.63%	4	36.62%	26	53.52%	38	71

Q15 – At which points do you have contact with Thales NL?

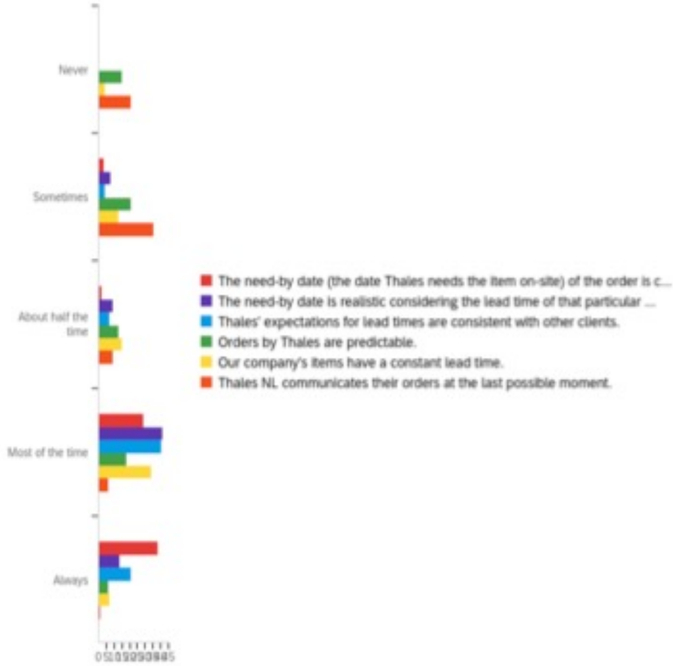


#	Answer	%	Count
1	When Thales NL has an indication that they want to order something.	17.61%	59
2	When Thales NL sends out the purchase order.	17.61%	59
4	When we encounter delays in production.	17.31%	58
8	Periodically, regardless of purchase orders.	13.43%	45
6	When we send out the item for transport to Thales NL.	10.45%	35
3	When we know when the item will be produced/processed.	7.76%	26
5	When production/processing of the item has been completed.	6.27%	21
9	at other points, namely:	5.97%	20
7	When Thales has received the order.	3.58%	12
	Total	100%	335

Q15 at other points, namely:

at other points, namely: - Text
Business Development certain solutions
Development
weekly call
When licensing questions occur, When we are late delivering...
To solve technical issues
Projectmeetings
Discuss designs, collect payments
early supplier involvement during R&D phase
Military Goods Export Licencing processing
project based meetings
In case of unclear information in documentation
weekly review call
factory visits
when Thales needs goods earlier than requested in the first place
Periodically to inform them of new products
regularely during product design
Weekly status meetings
Monthly Progress meeting (telecall)
Technical matters regarding the order
Technical spec.

Q7 – In your own words, please explain what steps are performed when Thales NL wishes to order something at your company.
[redacted]
Q6 – Please indicate how often the following can be said about the need-by dates and lead times of orders from Thales NL:



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The need-by date (the date Thales needs the item on-site) of the order is clear.	2.00	5.00	4.42	0.74	0.55	73
2	The need-by date is realistic considering the lead time of that particular item.	2.00	5.00	3.85	0.85	0.73	73
3	Thales' expectations for lead times are consistent with other clients.	2.00	5.00	4.08	0.77	0.60	73
4	Orders by Thales are predictable.	1.00	5.00	2.71	1.27	1.60	73
5	Our company's items have a constant lead time.	1.00	5.00	3.37	1.05	1.11	73
6	Thales NL communicates their orders at the last possible moment.	1.00	5.00	2.04	0.93	0.86	73

#	Question	Never		Sometimes		About half the time		Most of the time		Always		Total
1	The need-by date (the date Thales needs the item on-site) of the order is clear.	0.00%	0	4.11%	3	2.74%	2	39.73%	29	53.42%	39	73
2	The need-by date is realistic considering the lead time of that particular item.	0.00%	0	10.96%	8	12.33%	9	57.53%	42	19.18%	14	73
3	Thales' expectations for lead times are consistent with other clients.	0.00%	0	5.48%	4	9.59%	7	56.16%	41	28.77%	21	73
4	Orders by Thales are predictable.	20.55%	15	28.77%	21	17.81%	13	24.66%	18	8.22%	6	73
5	Our company's items have a constant lead time.	5.48%	4	17.81%	13	20.55%	15	46.58%	34	9.59%	7	73
6	Thales NL communicates their orders at the last possible moment.	28.77%	21	49.32%	36	12.33%	9	8.22%	6	1.37%	1	73

Q17 – Please rank the following statements by how relevant this statement is for your company. (drag and drop)

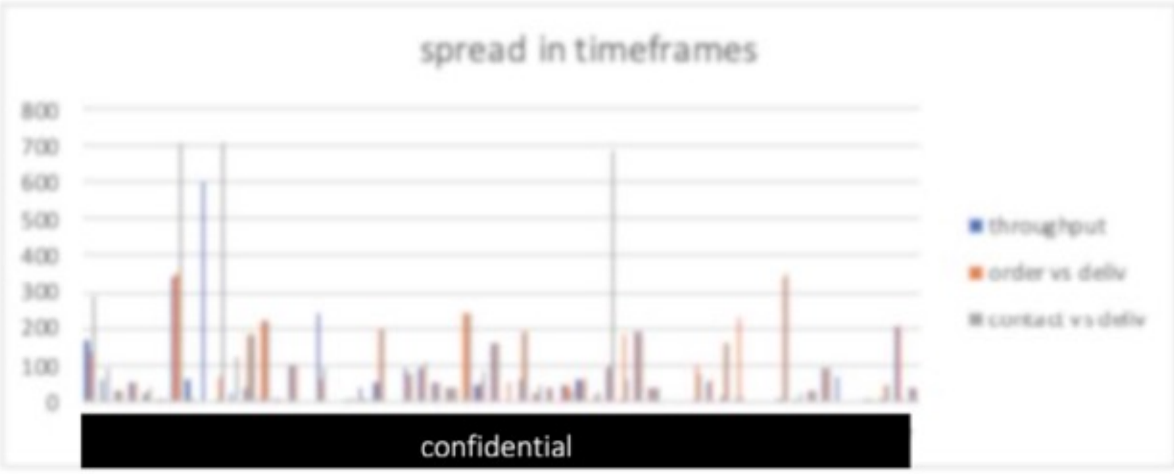
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	It's important to ensure that our promised dates can surely be achieved.	1.00	4.00	1.93	0.90	0.81	72
2	Before we communicate lead-times to Thales NL, we have to verify this with our own planning.	1.00	5.00	2.32	1.18	1.38	72
1	It is our goal to offer the most competitive lead-times that we can achieve.	1.00	5.00	2.69	1.28	1.63	72
4	We know all the lead-times of items that Thales NL procures in advance.	1.00	5.00	3.88	1.18	1.39	72
5	The lead-times that we communicate with Thales NL are an average of what we can perform.	1.00	5.00	4.18	0.96	0.93	72

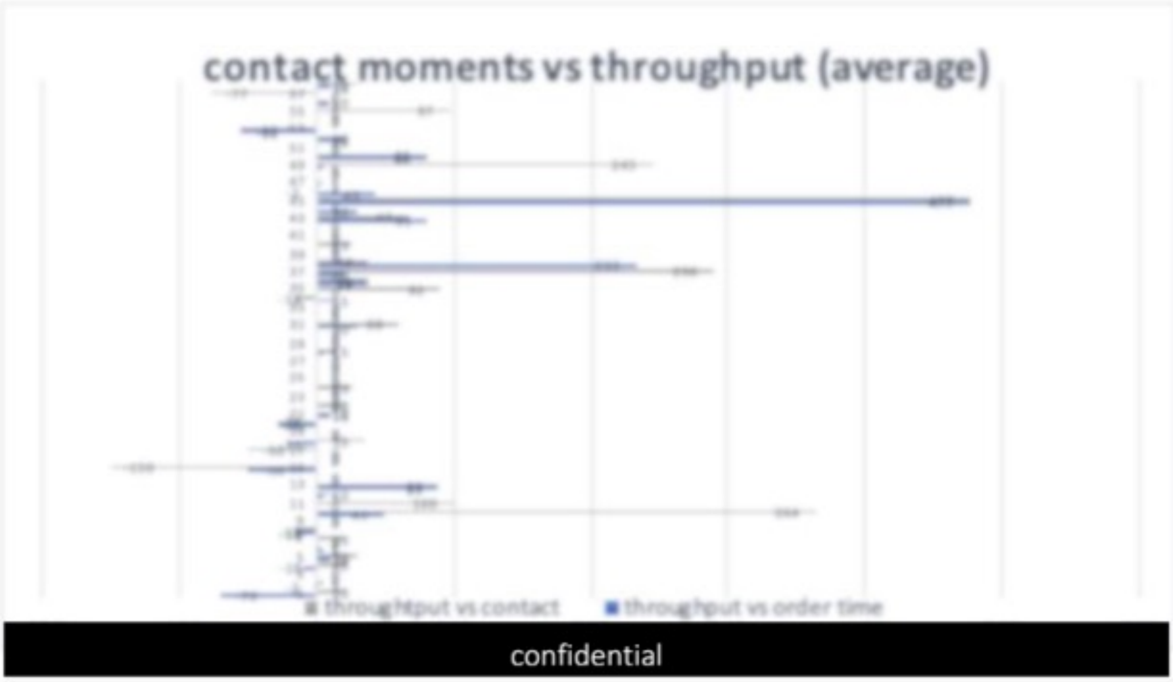
#	Question	1		2		3		4		5		Total
3	It's important to ensure that our promised dates can surely be achieved.	38.89%	28	34.72%	25	20.83%	15	5.56%	4	0.00%	0	72
2	Before we communicate lead-times to Thales NL, we have to verify this with our own planning.	30.56%	22	30.56%	22	19.44%	14	15.28%	11	4.17%	3	72
1	It is our goal to offer the most competitive lead-times that we can achieve.	23.61%	17	19.44%	14	31.94%	23	13.89%	10	11.11%	8	72
4	We know all the lead-times of items that Thales NL procures in advance.	5.56%	4	11.11%	8	9.72%	7	37.50%	27	36.11%	26	72
5	The lead-times that we communicate with Thales NL are an average of what we can perform.	1.39%	1	4.17%	3	18.06%	13	27.78%	20	48.61%	35	72

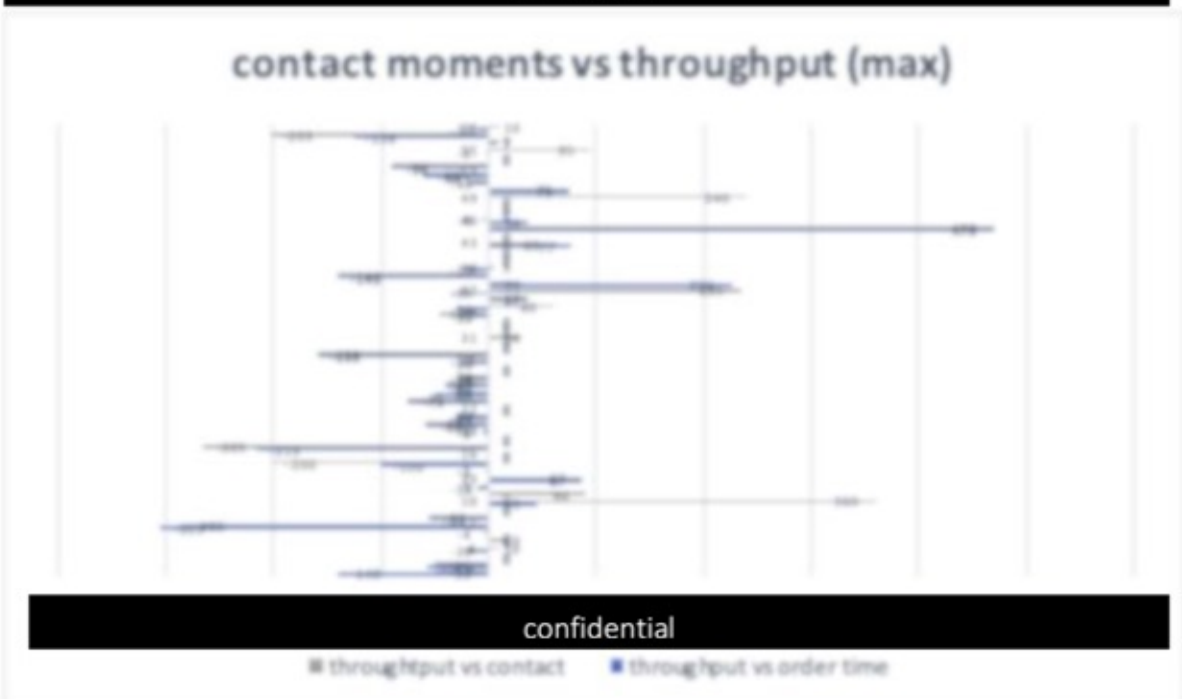
Q8 – Please indicate the (estimated) length of the following timespans concerning ordersby Thales NL in number of business days.

	throughput time			between order and expected delivery			between first contact and expected delivery		
	minimum	average	maximum	minimum	average	maximum	minimum	average	maximum
	[redacted] confidential								
average									
s.d.									

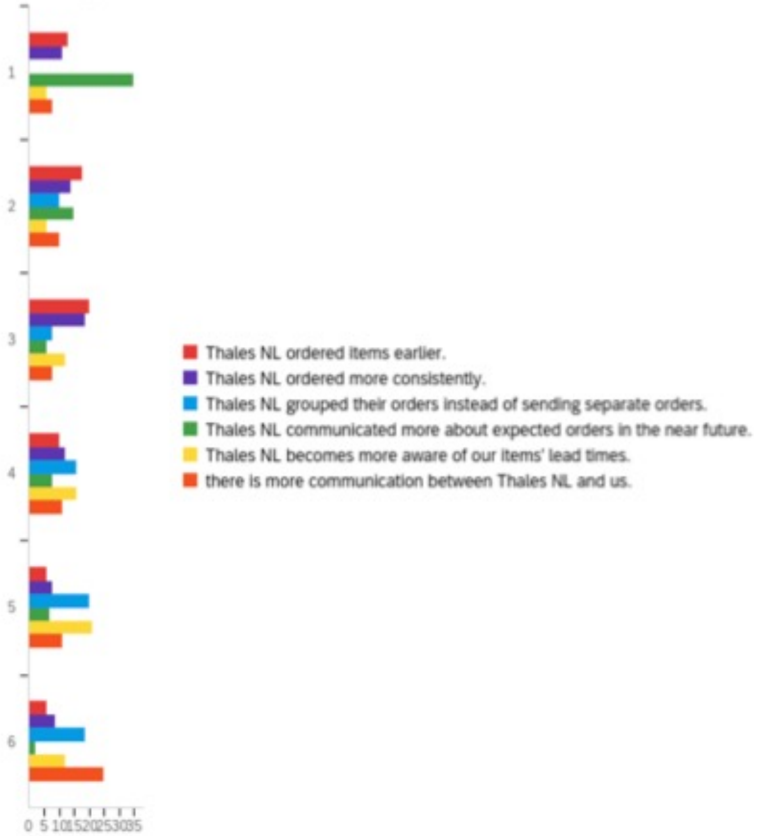
	spread throughput	averages order vs deliv	contact vs deliv		difference throughput vs order	averages throughput vs contact		difference throughput vs order	max throughput vs contact
	[redacted] confidential								
average									
s.d.									
				# negative :	8	8		29	25


spread in timeframes
800
700
600
500
400
300
200
100
0
throughput
order vs deliv
contact vs deliv
confidential


contact moments vs throughput (average)
throughtput vs contact
throughput vs order time
confidential


contact moments vs throughput (max)
confidential
throughtput vs contact
throughput vs order time

Q9 – please rank the following statements: "Our cooperation with Thales NL would improve the most if..." (drag and drop)



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	Thales NL communicated more about expected orders in the near future.	1.00	6.00	2.22	1.50	2.25	73
1	Thales NL ordered items earlier.	1.00	6.00	2.95	1.47	2.16	73
2	Thales NL ordered more consistently.	1.00	6.00	3.26	1.56	2.44	73
5	Thales NL becomes more aware of our items' lead times.	1.00	6.00	4.04	1.48	2.18	73
6	there is more communication between Thales NL and us.	1.00	6.00	4.12	1.77	3.15	73
3	Thales NL grouped their orders instead of sending separate orders.	2.00	6.00	4.41	1.34	1.80	73

#	Question	1		2		3		4		5		6		Total
4	Thales NL communicated more about expected orders in the near future.	47.95%	35	20.55%	15	8.22%	6	10.96%	8	9.59%	7	2.74%	2	73
1	Thales NL ordered items earlier.	17.81%	13	24.66%	18	27.40%	20	13.70%	10	8.22%	6	8.22%	6	73
2	Thales NL ordered more consistently.	15.07%	11	19.18%	14	26.03%	19	16.44%	12	10.96%	8	12.33%	9	73
6	there is more communication between Thales NL and us.	10.96%	8	13.70%	10	10.96%	8	15.07%	11	15.07%	11	34.25%	25	73
5	Thales NL becomes more aware of our items' lead times.	8.22%	6	8.22%	6	16.44%	12	21.92%	16	28.77%	21	16.44%	12	73
3	Thales NL grouped their orders instead of sending separate orders.	0.00%	0	13.70%	10	10.96%	8	21.92%	16	27.40%	20	26.03%	19	73

Q10 – Is there any other advice you would give Thales NL by which they can improve the way they procure items?


actual
cooperation
item
delivery
supplier
parts
contact
future
early
provide
time
long
procure
order
supply
clear
forecast
easy
orders
chain
moment
lead
base
answer
communicate
business
expect
customer
communication

[redacted]