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An evaluation of current calculations for safety stock levels

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Abstract

The aim of this thesis work is to evaluate and review the current calculation for safety stock levels and investigate possible changes to secure production. This calculation considers the material supply of the UD Trucks production, but the Bangkok plant also produces Volvo Trucks. Both brands with legacy from early 20'th century are now fully owned by the Volvo Group.

Through a calculation review the authors investigate the ability of a pre-existing calculation method, used to secure the production through safety stock levels to avoid productions stops by shortages. The matter is addressed by looking in to the logic and parameters to evaluate current calculation and later suggest improvements that will increase its dependability and enable to reduce the space used in the warehouse. During the process uncertainties of parameter impact to its own origin, the authors consider a change of method to secure a reliable safety stock level.

The authors discuss the possibilities of combining parameters and its uncertainties. A later suggestion is a calculation method that in its simplest form, by using production data, balances individual safety stock levels for each unique part number.

As a conclusion, the authors suggest to consider a change of calculation method to a statistical method. Providing part individual safety stock levels in an early stage of the calculation. They also recommend to define lead time and secure unison input by evaluating the standard week division to gain full control over the calculations. The last recommendation is to investigate advantages of local suppliers to decrease unnecessary added uncertainties.

Keywords: Safety stock levels, calculation, statistical methods, lead time, parameters

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1 Introduction

This section provides a background for the research and problem area. Furthermore, the purpose of the case and its questions are presented together with a description of the research focus. The section ends with the report's disposition.

1.1 Background

An inventory per definition contains products for future sales. [1, p. 91] With a safety stock the inventory prevents stockouts. Factors as forecast inaccuracy, fluctuating customer demand changeability in lead times from suppliers are possibly stockouts. By determine a safety stock level the intend is not to eliminate all stockouts, but at least majority of them. Some companies can base the safety stock level on gut feelings, portion of cycle stock level or on mathematical calculations. These different methods are described in section two. [2]

Filling a warehouse, along with low usage rate will consequently lead to overflow of parts. The challenge for Volvo Trucks in Bangkok is to reduce the quantity of parts in stock to save space. The high volume of parts depends on, in Volvo's case, several reasons. For example, suppliers provide a minimum order quantity, late changes made both internal and external, uncertain suppliers, misplaced parts that are using unplanned space and finally, high volumes of safety stock.

When launching a new truck model, it becomes important to have updated calculations of safety stock level for the older truck models, whereas both models will share same storage space. A few years ago, UD Trucks launched the model Quester and this spring the new truck model Croner, launched. UD Trucks is a part of Volvo Group and is presented on the market as a high quality, low price truck. The production in Bangkok includes the Volvo brand and UD brand.

A larger inventory than necessary does not only require much space, but also capital. In addition, an undersized inventory will jeopardize production and sales capacity of the company. With that said, stock is needed. For industrial companies, keeping a balance between inventory costs, capital and product availability is preferred, avoiding shortages by using safety stock dimensioned on forecasts. Shortages can be delays from suppliers,

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internal and external misunderstandings, uncertain demands and wrong in the forecasts. Each component has its own individual consumption pattern, which means there is a variation in sale. Typical for safety stock levels are that only some parts have a correct level and other parts have either a too high or too low level. [3, p. 1] Therefore, an adaptable dimension of safety stock level becomes an advantage for different companies.

1.2 Problem statement

To keep inventory in stock is both a cost and a liability and in Volvo's case there is a shortage of space available in the plant. The shortage of space has several root causes. Volvo's aim with this thesis work is to see if improvements of safety stock are possible. Therefore, the research work has an interest to optimize safety stock after actual need to efficiently use space. To untie assets kept in stock and keeping production unaffected of shortages is as well important.

Lack of space in the warehouse is a fact for Volvo Trucks in Bangkok. The need of parts is increasing with higher numbers of products manufactured. Not only higher numbers of trucks but a new model with a vast number of unique parts adds to the stock level. The higher capacity with a vast variety of details required external space to cover stock increase. Lack of space is connected to a variety of in-house issues such as; limitations per square meter in the warehouse due to poor planning during construction, unnecessary package sizes filling the warehouse, replace parts share the warehouse, parts missing due to internal handling, and finally, uncertainty regarding safety stock level during implementation and ramp-up of a new model.

With this stated, Volvo's interests are to audit their current way of calculating their safety stock levels and consider possible adjustments to improve an individual determination of safety stock level, with the aim to handle the space issue by decreasing safety stock level. With a focus on safety stock level, a vast variety of issues connected to supply chain emerges, like supplier's ability to dispatch on time and lead times with following risks at stake and so on. All of them affecting the ability to determine safety stock levels.

1.3 Purpose & research questions

By asking questions to generally answer the need instead of the company's goal, the root cause will be identified. Which in this case, is regarding current calculations of safety stock levels. The questions will simply state if today's problem, lack of space, is an actual need or an effect connected to safety stock level.

The aim is to optimize safety stock levels by evaluating its' current calculation. Therefore, our first question is:

[1] "Do current calculations of safety stock level cover production needs?"

By question the current situation the authors will evaluate and look in to current way of calculating safety stock with the aim to revise and if possible find ways of making it more individually applicable for different part numbers. Therefore, the second question follows:

[2] "What parameters of the current calculation could be revised?"

As mentioned before, Volvo's specific interest is to answer the question about necessary space usage. By that the authors aim to clearly state this by answering the following question.

[3] "Is it possible to reduce the surface used by safety stock through optimization?"

By answering these questions in following order the authors provide Volvo with an evaluation of the current process, how actual needs are connected to space issues and possible improvements that may affect current situation.

1.4 Research focus

As earlier mentioned within the “Problem statement” Volvo wants to reduce usage of space. The space issue is connected to how the warehouse is dimensioned. Generally, there are several different inventories in a warehouse, for example, cycle stock, temporary stock, work-in-progress stock, and safety stock [4, p. 304]. This thesis is strictly connected to the safety stock and Volvo’s ways of calculating and implementing that in the Bangkok plant. This should be applied on a specific truck model to keep it demarcated and in the end, utilize and apply this to all models produced in the Bangkok plant. Research are by that mean directed towards inventory management and safety stock calculations. In regards to variations in lead time, no deeper research has been made on actual delivery precision of preset time schedule. Due to the calculation method later suggested, this issue is considered dealt with within the standard deviation used in the calculation.

1.5 Disposition

The thesis work is introduced with a background and problem statement. Here the reader can get an outline of what area is covered. Followed by aim and questions of this research, which is connected to the background and problem statement. Furthermore, a clearer explanation is described of the area. In section two the basic theories and concepts are presented. The theoretical basics are a corner stones for the research that later is analyzed. Then follows method and implementation in section three, which describes the content and how this thesis work is executed. Section four provides a status report on current situation and how it’s connected to the research. There, the data from the calculation review and other information from the company are presented. The result and theory is analyzed in section five, followed by discussion and action proposals in section six. The final section presents conclusion, validity and reliability of the research work.

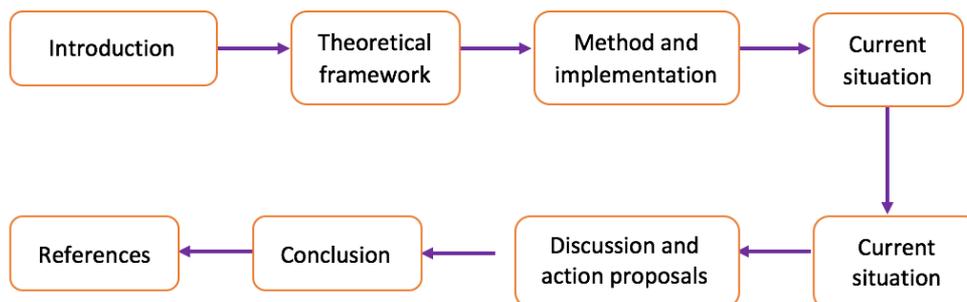


Figure 1- Overview of disposition

2 Theoretical Framework

Within this section, basic theories and concepts used in inventory management and optimization will be presented. The section doesn't entirely cover the full aspect but is adapted to fit the purpose and delimitation of this report.

2.1 Link between research questions and theory

Research questions of this thesis are phrased in a manner to investigate the actual situation and current implementation. By using theories and state of the art science the authors aim to establish verification about the current engagement or possible changes of actions.

[1] “Do current calculations of safety stock level cover production needs?”

The first research question stated above is connected to Volvo's internal data and calculations. By reviewing them in comparison with relevant theories about calculation methods and overview reports from Volvo, conclusions can be made. This will be explained in section 2.2 and 2.3.

[2] “What parameters of the current calculation could be revised?”

The second research question will also be compared with relevant theories about safety stock calculations and safety lead time and the risk of redundancy. To give the reader a deeper understanding this is defined in section 2.3 and 2.4.

[3] “Is it possible to reduce the surface used by safety stock through optimization?”

Finally, the third research question will be a gathered compilation of the other questions. Dependent on what theory and common conclusion there may be alterations to the calculation and effects shown on the possible difference in storage space used. Theories and choice of parameters in the different stages will be presented within this section.

2.2 Material flow

Material flow is a function of the warehouse. It is material movements that can consist of for example, raw material, products and different kind of components. The ideal warehouse has a continual material flow but this is not practically possible. The support of material is not the same as the consumption, basically explained the input and output of material are different. During the material movement, there will be interruptions. All the material is in separate flows because all parts have their own usage rate. To make it possible to divide these flows, inventories are necessary. [4, pp. 303-304]

For these material flows, there are uncertainties of demand and material usage. The situation becomes uncertain when demand and access to material becomes unknown in the material flow. Consequently, there will be uncertainties with the quantity and time. [4, p. 322]

Forecast can easily be misjudged and shortfall of resources from suppliers is not unusual. By understanding the affecting parameters and calculations of safety stock, it's easier to gain control of the material flow and usage. [3] The figure below is presented by the authors Jonsson and Mattson, also the figure is found from the “whitepaper: eazystock” webpage.

Stock-Value

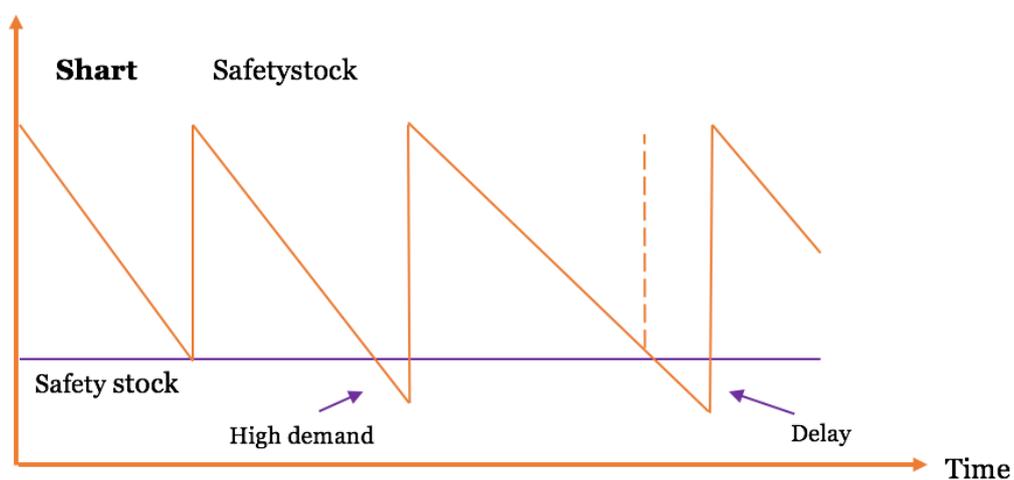


Figure 2- Functions of safety stock [3, p. 305], [2]

2.3 Safety stock level

When there is a high fluctuation in demand, it will bring problems to predict future quantities of need. A similar problem will appear with time and access, when the expected delivery is delayed and there is no access to the material. This is connected to suppliers but also to internal handling and production. To have some precautions against unexpected demand and access, there are two main ways. Either to focus on added quantity in warehouse or by time schedule earlier arrivals of delivery. In the end, both these theories increase stock and are considered as safety stock. [4, pp. 322-323] Some companies use a combination of those two theories to cover fluctuation of demand.

2.3.1 Quantity safeguarding

Quantity safeguarding includes possessing more parts in stock than the expected need as mentioned above, often several parts are lying as a security to eliminate shortage. With safety stock that number can change over time due to factors that alter the predicted level needed. These factors will tune the safety stock level to cover eventual changes from predicted forecasts or any other cause of shortage. There are several ways of doing this efficiently depending what internal target the company wants to achieve. [4, pp. 322-324] More about different means are mentioned below.

As a part of quantity safe guarding, there are several theories such as; economical aspects, manual evaluations, percentage of lead time and desired service level, all contributing to a safety stock level or added quantity. These are processed in section 2.4.

2.3.2 Time safeguarding

To consider a time approach or also known as safety lead time, means to safeguard stock. By consciously order in advance to get inbound goods delivered with a safety margin to the critical point of time when production eventually halts. In other words, have dispatch scheduled earlier from the supplier to increase reliability to receive delivery that doesn't effect on ability to produce without interruptions. [4, p. 322] By altering that margin the company changes the reliability to provide the production with material. This delivery, ahead of time, ads additional safety stock during the margin and are considered as safety stock.

Theoretical framework

N.B. Safety lead time must be separated from lead time; those two terms are distinct. To clarify this, Safety lead time is the time added to create that gap of safety, and lead time is the time from order to delivery or from initiation to execution to make it more universal.

2.4 Calculation of safety stock level

With different factors, safety stock calculations can be individualized and altered to be some sense conservative. Following are some theoretical ways of handling calculations of safety stock levels.

2.4.1 Manual evaluations

This is an evaluation method by gut feeling considering what level of safety stock is needed. Instead of having advanced systems and calculations an easier way of determine safety stock level is by manual estimations based on knowledge and experience. When working with these kinds of estimations, the focus is on different factors. Normally, the factors can be the cost of having stock, consequences that can occur during delays or due to missing parts. Also, this is updated manually, which results in safety lead time and safety stock levels that don't adapt with changes of suppliers or fluctuation of demand. [4, p. 326] This calculation method can provide an overflow in safety stock and thus high costs. The overflow is usually for some parts and for others it will be shortage, in other word some parts will be missing and may affect production or sales. [3] This is a time-consuming task mainly for experienced professionals. This way of handling the issue [5] demands manual labor and are both time consuming and irrational.

2.4.2 Economical aspects

By evaluating costs of shortages and cost of safety stock level or stock level in general, there are consequences of what kind of actions that are made. The general goal is to find a level where the waste of resources and service level (available stock) is kept in a balance. [5] To evaluate actual shortage costs are no easy task. They can contain a variety of missed opportunities and added costs, such as; loss of sales opportunity and loss of income, fines on delays of delivery, residual listing on orders with following added transportation costs.

Theoretical framework

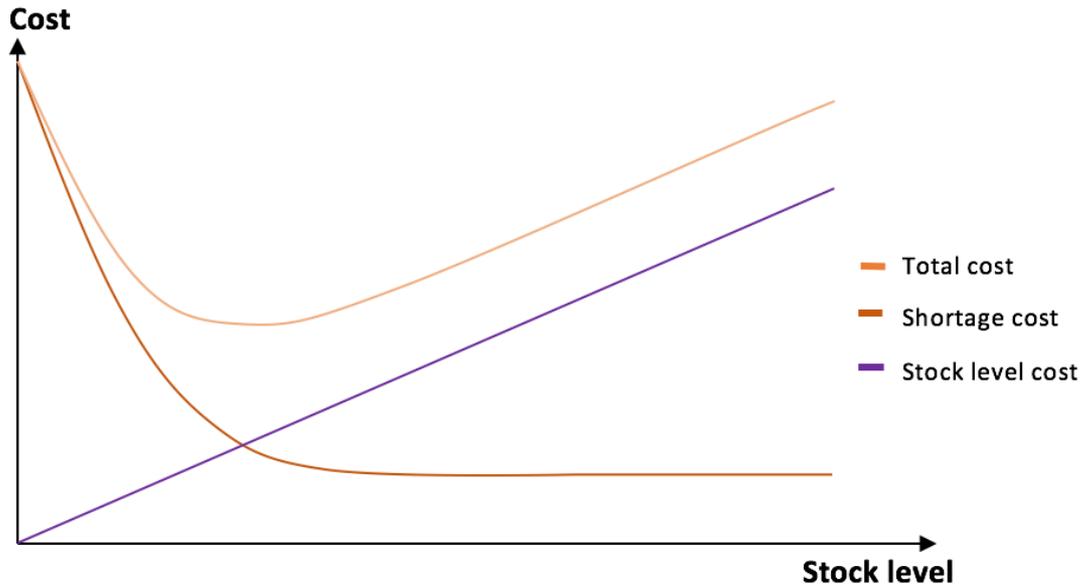


Figure 3- Cost affected by chosen stock level

This kind of shortage may also cause disturbance in the production and reduce the capacity utilization. Implications like this are highly unpredictable and this depends on the specific situation. To achieve an accurate balance between stock level- and shortage-costs, it is common to use a policy-determined service level. That's a determination on what shortage level is acceptable in the warehouse, often measured as a percentage. [4, p. 324]

2.4.3 Percentage of lead time

With a percentage as a factor it's simple to calculate safety stock out of forecasted production of that specific period, this is purely depending on demand and expected lead time. This can be updated in a simple way with those two aspects. The percentage can also be connected to article groups in the enterprise resource planning system (ERP) and changed for those whole groups in an instance, or even simply updated through calculations in excel spreadsheets as input data. To clarify, lead time and safety lead time are two different things, Safety lead time is explained and thoroughly determined during the headline below with the title, "time safeguarding". [4, p. 326]

Theoretical framework

2.4.4 Desired service level

Can be reached with the use of Mean Absolute Deviation (MAD). By statistical deviation, fluctuations can be dealt in a scientific manner. MAD is defined as shown below. [5]

$$\text{Safety stock} = k(\text{MAD}) \times \sigma$$

k = a multiplier for standard deviation of demand from desired service level

σ = The demands standard deviation during lead time. It shows the variation of demand during the time it takes to refill stock.

$$\sigma = \sigma_t \times \sqrt{LT}$$

σ_t = Standard deviation of demand during time

LT = Lead time, time until the stock is refilled

To use safety stock calculations with applied statistical deviation can be done through a multiple based on a desired service level. To decrease probability of shortage and in the same time balancing a more accurate statistically ensured number of safety stock level for each part number based on service level. Also, making it possible of changes and create separate service levels for different article groups. This level can be altered through choice between mean absolute deviation (MAD) or Standard deviation (sigma). [5, pp. 11-12] From the article “safety stock management” the k multiplier is presented below.

Theoretical framework

Tabell 1- Service level and corresponding k multiplier [5, p. 12]

Desired service level (%)	k (MAD)	k (sigma)
50	0.00	0.00
75	0.84	0.67
80	1.05	0.84
85	1.30	1.04
90	1.60	1.28
95	2.06	1.65
96	2.19	1.75
97	2.35	1.88
98	2.56	2.05
99	2.91	2.33
99.50	3.20	2.57
99.90	3.85	3.09
99.99	5.00	4.00
100.00	Infinity	Infinity

This calculation and model can be shown by the illustration in figure 4, where the forecast and actual use during lead time is expressed. Consumption wise, A is maximum, B is Normal and C is Minimum and D is the bell curve, explaining the normal distribution. [4, p. 327] The authors Jonsson and Mattsson illustrates this in the figure below.

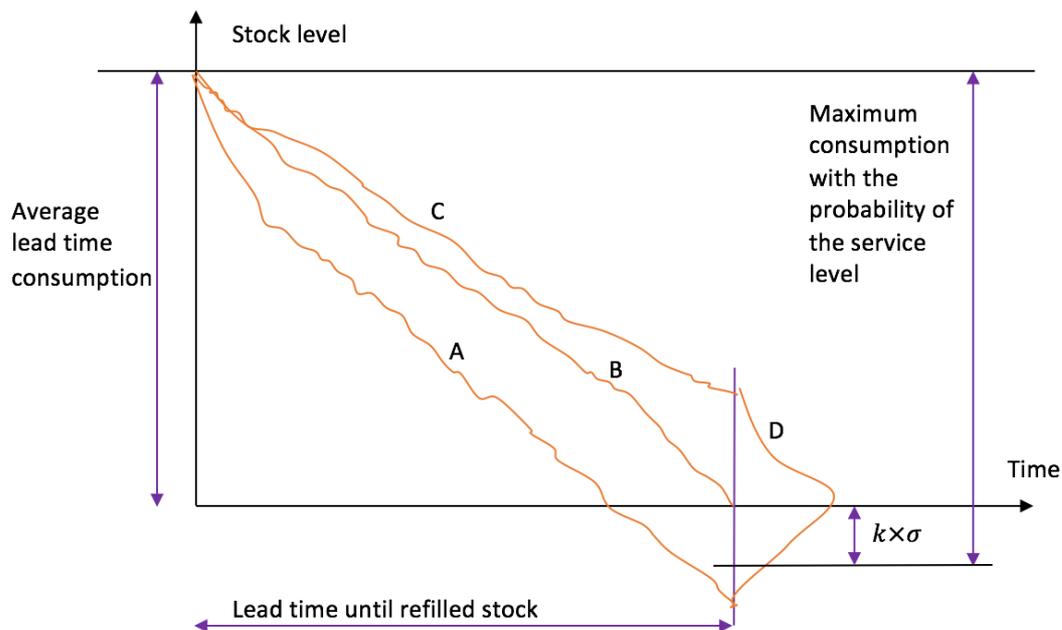


Figure 4- Mean absolute deviation (MAD) [4, p. 327]

3 Method and Implementation

In this following section a variety of approaches and methods are described. How data are collected and analyzed. Also, the validity and reliability is discussed per implementation of this thesis work.

3.1 Link between research questions & method

Information has been gathered and analyzed with reason of answering the three questions that were asked from the beginning of this thesis work. The aim is to answer the questions with proper methods.

The work was divided in two main methods. The first one was to analyze the case and do a case study. The main task of the case study was to define the actual problem and with this find the root cause. By interviewing employees, the case study gained qualitative information needed for all the three questions. It was important to interview employees in different positions and with that information define the actual problem. To make the case study at Volvo complete, existing data was collected and analyzed. Also, calculations were reviewed together with employees from Volvo. Collecting existing data from the company was necessary in addition to understand the case and make progress with all three questions. The second main method is a literature review to gain knowledge of safety stock calculations and the area this thesis is covering. By understanding how safety stock should be calculated and dimensioned the second and third question can be answered.

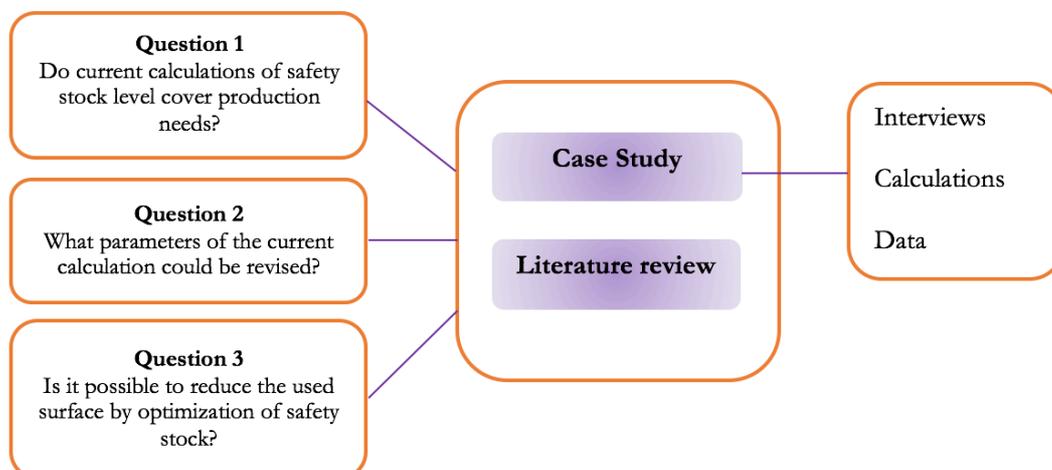


Figure 5 – Overview of the connections between method and questions.

3.2 Work process

The thesis work has been executed during the period of January and May, spring of 2017. This opportunity to perform this case at Volvo was provided through an advisor at Jönköping University, as a part of an exchange term in Bangkok. The introduction at Volvo were held in the end of January. After some initial meetings, the authors presented a possible case to the company. In an early stage a brief overview of the work process was made.

A discussion with Volvo has been ongoing since then. Several meetings with representatives and specialists from many departments have been involved in molding this case. In between those meetings, a firm weekly contact with the advisor has been taking place, to establish the right questions and approach. After some interviews and some puzzling of gained knowledge, figuratively speaking, the authors where able to formulate the problem questions presented in this case. Soon after that, data was collected from Volvo’s material control team. Literature review has been done simultaneously as the analysis and revision of their calculations.

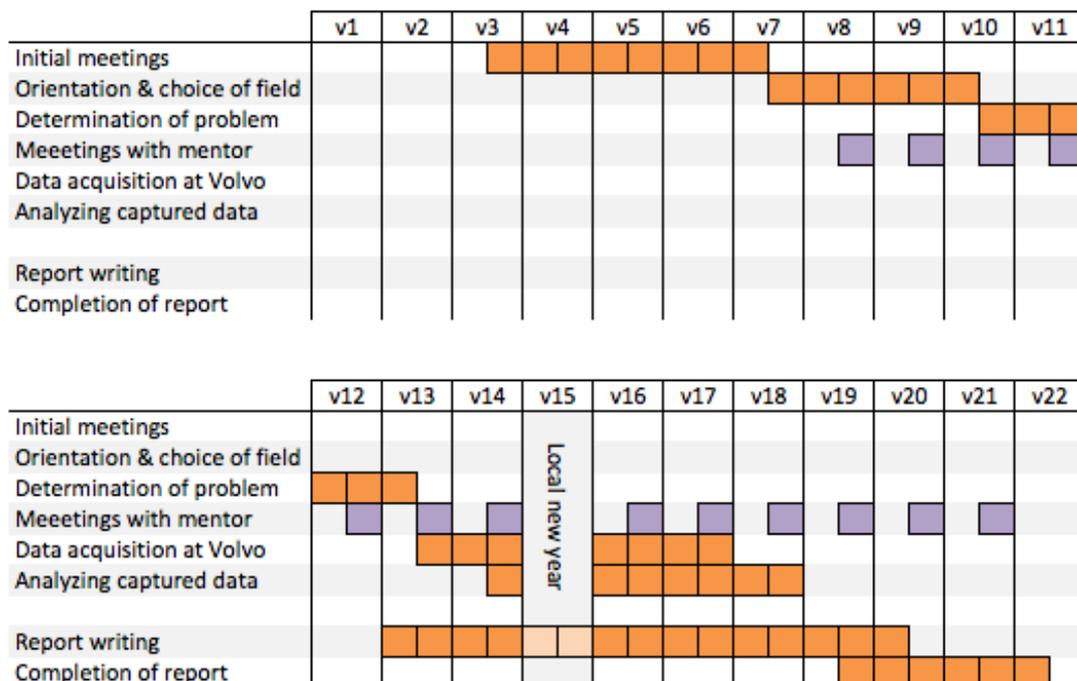


Figure 6 – Overview of work process

3.3 Approach

This thesis work contains of both qualitative and quantitative character. Quantitative orientated research implies statistically processed and analyzed in-data, in this case the calculation overview. Examples of qualitative research are data gathered during interviews and other verbal analyze methods, also included in this thesis to provide comprehension and a wider perspective. [6, pp. 23-25]

Qualitative data gathering has been done by interviews. Mainly with a low grade of structuring to capture open individual answers. [6, p. 82] The form has also been semi-structured with room for creative response to retrieve additive information. [6, p. 76]

For this case, the different research questions demand different approaches. The first question can be handled with an inductive approach. Which means to follow the path of discovery, by exploring the gathered data. The last two questions share that they can be compared with known theories, and are by that mean handled with a deductive approach. In this way, hypotheses of theory will be verified trough comparison with new and historical data. [6, pp. 23-25]

3.4 Case

A case study can contain an individual, a group, an organization, an event, an action or problem. A case has its own time and place. Imagine being in a situation or essentially outside. It is possible to work with a historical case or with something new. It could be a development, for example a new design. [7] This case contains a real situation with a real problem inside an organization.

To follow the aim of this thesis and find proper methods to answer the three questions a discussion was done between the two authors and advisors at Jönköping University. Together with them, a case study was chosen as a method for this thesis.

The case was to understand the actual problem Volvo encounter and which area this thesis work will cover. Participation and attendance at the company was required to find the necessary information. Different kind of data was collected through employees and analyzed together with the second contact person.

3.5 Data collection

Here follows a thorough exposition of data collection. Through interviews, literature review and collaborate calculation review the authors together with Volvo employees define the vital parts of this case study.

3.5.1 Interviews

All the people that were interviewed are employees at Volvo Trucks in Bangkok. The interviews have been structured as guided conversations held in meeting rooms at Volvo. Those meetings included one or two employees, depending on collaborations between departments and the depth of the actual issue.

None of these interviews were recorded. With the reason to make the employees feel comfortable and willing to be open about how they see the situation and increase the possibility to reach what this case should cover. When a situation is recorded, the informant might get uncomfortable, not willing to tell what he or she feels.

Consequently, providing the research work with less information which may alter the result. [8]

Another reason for not recording the interviews is due to confidential information that is preferred to be kept unavailable to public access. The researchers have together with the first contact person, agreed upon that any confidential information must to be handled per a written agreement in between Volvo and the authors.

Most of the questions were naturally asked during the meeting and not in a prepared sequence. The grade of structuring affect the ability of the informant to provide wide answers. [6, p. 76]The aim has been to let each informant develop their thoughts and answers so the researcher can gather qualitative information. With a low grade of structuring the informant can give more than one answer, thus these interviews have been semi-structured. [6, p. 82] Even though every interview has had its own character of unique questions depending on what function the informant had. Four fixed questions have been set up and prepared for the meetings. Also, by sending questions one to five days in advance the employees had time to prepare for the interviews.

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We would like to understand what is your function? Describe what you do.
How are your tasks connected to the material flow?
Do you see any current issues/problems with material flow and production planning?
What is the main parameters that causes problem in your opinion?

Figure 7- Fixed questions that have been asked in all interviews

A variation of perspectives has been important to process at the beginning of the case when the problem was defined. Therefore, employees with different positions and functions in the company have been interviewed. Besides the interviews, there have been several spontaneous and open discussions with employees. This increases the research work validity. [6, p. 102]

Tabell 2- Overview of interviews

Position	Focus Area	Total time (Hours)	2017 Date
Contact person 1	Defining the problem, business & warehouse description, culture, organization structure, review of work	1	2 nd March
Logistics		2	16 th March
		1	12 th May
Contact person 2	Case description, current situation, calculation review and improvements	1	23 rd March
Material control expert		2	29 th March
		2	20 th April
		0,5	24 th April
		1	27 th April
		1	5 th May
	1	12 th May	
Logistics Engineering	Set up structure of material flow from gate to point of use	1	7 th March
		1	9 th March
Material Control	Collecting data, overview of safety stock	1	9 th March
		2	20 th March
Material control + super user GILM	Collecting data, understanding GILM, how production line is supported, updated calculations	1	9 th March
		1	12 th May

3.5.2 Literature review

Literature and current research papers which are connected to safety stock and similar research area has been studied. To create an overview of the field of investigation, the authors used course literature and other case literature together with research articles from this specific field of known research. The gathered data has then been summarized and structured in the theoretical framework section. With reason to make it easy to understand and follow when reading this research paper.

The literature review was critical part in answering the aim and questions of this thesis work, which otherwise wouldn't have been possible. By using two search engines, Google Scholar and PRIMO, research articles and literature could be found on the chosen context.

The literature has been gathered during the making of this thesis and ongoing been analyzed. From the beginning, it's been a mixture of analyzing data and simultaneously searching and studying similar articles of fields. Also, to make this thesis gain ground and find what improvements could be done with current calculations, reference lists were studied from other interesting writings. Consequently, additional articles of interest where to be found.

3.5.3 Calculation review

Current data from Volvo was presented and sent to the authors. It has then been reviewed together with employees for the reason to fully understand how the calculation was computed. Different employees have been involved as mentioned above.

Together with material controller and the second contact person, current calculations have been reviewed and analyzed. With the two first meetings, the data was introduced and discussed to define the problem. The authors went through the data and some literature for a better understanding. The second meeting was a review of the current calculation and all the parameters. Possible changes were also discussed, very briefly. The fourth and fifth meeting was directly connected to the current situation and about the possible changes. The sixth meeting was a new calculation review and to see what calculations have been done. The later meetings, seventh and eighth, were discussions

Method

about improvements. In the final meeting the result was presented together with an overview of the work that has been done.

3.6 Data analysis

The aim and questions of the thesis work was possible to develop during a few weeks thanks to all gathered data. The case study made it easier to understand the current situation at Volvo and with interviews made, an overview of the situation evolved. Also by studying literature of the specific field and close discussions with teacher at Jönköping University, questions could be related to the defined issue. With the literature review, theories could be established. The section with theoretical framework is based on the theories studied. Then the theoretical framework was compared with data from the case study in the section of current situation and a result could be made, furthermore a conclusion and possibilities for improvement.

3.7 Credibility

Considering credibility there are two main areas, validity and reliability. To increase the validity of data collected is done by a reduction of other factors influencing on the measured data. By creating an overview of affecting factors and by stating clear boundaries and delimitations, validity can be increased. On the other hand, reliability considers the ability to gain the same result, independent of performer or how many times it's performed. [6, pp. 101-105]

4 Current situation

This section presents a performance database build from gathered data at Volvo trucks, Bangkok. A short presentation of the Volvo Bangkok Branch followed by presentation of the current situation connected to the safety stock calculations and other fields directly associated.

4.1 UD Trucks Bangkok

UD Trucks is part of Volvo Group, which is one of the leading brand structures of heavy commercial vehicles and diesel engines. UD Trucks was founded in 1935 in Japan. During a few decades UD was known under the name, Nissan Diesel. In 2007 the company was fully acquired by Volvo Group, whom in 2010 decided to recapture the name UD Trucks. UD Trucks is presented in over 60 countries throughout the world. [9]

Within Volvo Group there are several brands, starting with Volvo, Renault Trucks, UD Trucks, Mack, Volvo Penta, Terex Trucks, Prevost and Nova Bus. The four first brands are manufacturers of commercial road legal trucks. Volvo Group also got joint venture and strategic alliances with brands like SDLG, Eicher and Dongfeng Trucks. [10]

4.2 Bangkok plant

The production plant in Bangkok, TSA (Thai-Swedish Assembly) manufacture UD- and Volvo Trucks. The facility handles both part number production and knockdown (KD) production for both domestic and export markets together with KD packaging for export markets. KD kits are simply, kits put together for assembly at another production plant or received to be assembled.

Early on, the logistics manager stated; the plant is exposed to many challenges and referred to the plant location in Bangkok, Thailand. Provided with parts from suppliers locally, and from other countries, even continents, this makes it hard for the company to take proper precautions to cover their productions need. Employees mean that in other places where Volvo has production, they are supported by local suppliers. That makes it possible to work in close collaborations with delivery precisions using just in time (JIT), but that is not the case in the Bangkok plant. For example, Mother Nature can have a say about ships being on time by adding time to transports due to storms and hurricanes.

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This cannot be considered as trucks being stuck on the roads in Europe or USA where goods can easily be rerouted and in the end, barely affect the scheduled delivery. There are more complications related to this region where cooperation in between states and bureaucracy with added document handling, influence the daily flow of goods. To be gentle, as the interviews stated, this kind of affect is more noticeable than in other regions where the company is operating.

4.3 Current calculation parameters

The calculation parameters for the unique part X are gathered in an excel sheet, let's call it New safety stock. The different parameters are expressed in calculations on three other sheets in the excel file. This sheet is linked with other documents to create calculations for many different parts at once the specific parameters will be presented in a table and furthermore explained. Basic structure of the calculation will be shown, but there will be information that isn't revealed e.g. price is one of these in data considered as confidential information and will not be revealed.

4.3.1 Note Sheet

Class	Value	Count P/N	
A	Higher than 5000 THB/PCS	Number of parts	1
B	Between 1000 - 5000 THB/PCS		3
C	Lower than 1000THB/PCS	Number of parts	5

Class	Value	Count P/N	
F	Usage more than 80%	Number of parts	3
M	Usage frequency Between 50%-80%	Number of parts	2
R	Usage frequency lower than 50%	Number of parts	1

A/B/C is a classification for the price of the parts. Whether the parts cost more than, 5000 Baht (THB) or less than 1000 Baht(THB) or in between, it will be noted with A, B or C. Another classification is F/M/R, which depends on what Ratio of usage frequency the parts have. Either a usage ratio over 80 percent, below 50 percent or in between. Only the F/M/R classification is actively used in the calculation today, as additive safety days.

Prepared in the calculation there are a combination of the classifications. This was explained as actively used, but showed being inactive when an overview of the calculation

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was done in an early stage. A short explanation will follow. Depending on what combined class the part get, there will be a parameter for safety days, a few days extra that safety stock should cover a shortage of that part. This added as expected daily usage of a specific part multiplied with the number of days the class implies to cover. For example, a part worth 3000 baht(THB) with over 80% usage frequency, the combination is BF where: $3 \times 3 = 9$ days, times the expected daily usage. Today only used as directly additive to the stock levels as F/M/R of days 3/2/1 times average quantity use expected a day.

Number of parts delivered from their own classified geographic areas, are presented in a chart below and as mentioned above, price is considered confidential and not shown.

Combination	Safety Day of safety stock
AF	3
AM	2
AR	1
BF	9
BM	6
BR	3
CF	15
CM	10
CR	5

	Count P/N	Value THB
China	508	
Asia	8	
Europe	426	
India	80	
Local	83	

4.3.2 Master data

plant&part	PartNumber	Count of Quantity2	Sum of Quantity
------------	------------	--------------------	-----------------

Plant & part are a combination of numbers from company and part number. The needed quantity is shown and the total quantity with all the packages.

Average of Quantity2	OrderNumber1	Row Labels	Count of UsePoint
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The average of quantity is calculated by: $Average\ Q = \frac{Sum\ Q}{Count\ Q}$

Order number is fixed data; row labels explains what row and count of used point is how many used stations one specific part number has.

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4.3.3 Parameters “New safety stock”

Plant&part	Company	Part number	Part name	Supplier	MC	Zone
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Plant & part are a combination of numbers from company and part number. Then the name of the part is presented and directly after the supplier. The supplier shows what location the part is delivered from. If the part is from a local supplier it will not have any safety stock. But if it is from an Asian supplier or oversea supplier it will have a safety stock. Although, it will not change the parameters for safety stock regarding where the suppliers are located outside of Thailand. Zone tells which country the supplier delivers from. MC is the responsible material controller.

A/B/C	Demand PLS	Demand breakdown	Usage average	Count of use point	Ratio Usage
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A/B/C is presented in a different sheet “Note sheet” and with this the parts price is still considered as confidential information. Demand PLS and Demand breakdown are taken from the sheet called “Master data”.

$$\text{Demand PLS} = \text{Sum of count} \quad \text{Demand breakdown} = \text{Sum of sum}$$

Usage average is calculated on number of chassis and part number, basically the average of a specific part number per chassis. Count of use point is from “master data” as earlier. Ratio usage is calculated on Demand PLS, used points and number of trucks produced during three months, which also is confidential information.

$$\text{Ratio Usage} = \text{Demand PLS} / \text{Used points} / \# \text{ trucks produced}$$

F/M/R	Categories	Demand WK5-30	Usage/Month	Usage/week	Use Criteria
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The Ratio usage frequency is classified as F/M/R, stated in the “Note Sheet”, in the excel file. This classification is explained above. Categories are a combination of A/B/C and F/M/R classifications. These are compounded into two letter combinations, for example AF or CM, depending on the parts price and usage. Demand is in the time-interval between week five to week thirty. The demand of three month is divided with 15 to get the monthly usage, which is divided by 4 to get the usage per week. Criteria are the percentage factor of F/M/R classifications.

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Production Rate @ ##unit	Safety Stock Level	Main part no.	SS MAXIMUM	Safety stock 1 week (average)	Safety stock level
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$$\text{Production rate} = (\text{number of trucks}) \frac{\text{units}}{\text{day}} \times \text{Ratio usage} \times \text{Usage average}$$

Number of trucks is the production rate of the plant, for each day. Safety stock levels are calculated in aspects of usage per truck and always rounded up.

$$\text{Safety stock level} = \text{Production rate} \times \text{Use Criteria}$$

Then the main part number is noted for each sub-part and the safety stock maximum that is calculated earlier and included in another excel-file.

$$\text{Safety stock 1 week (average)} = \frac{\text{Usage}}{\text{week}}$$

The final safety stock level can be separated from the computed number in the calculation, even if calculations dictates a specific number, let's say 56 units, the actual safety stock level might be a much higher number due to package size. Boxes with e.g. 100, 500 or 1000 pieces of specific screws, bolts or any other material sold and distributed in unit bulks are cheaper to get in those quantities. By this mean, specific supplier information overrules the calculation, dictating the closest number of full boxes covering the needed safety stock level.

4.4 Root causes

Shortages in production can appear out of several root causes. Below, a list provides different root cause categories that the company uses. There are nine main categories. Due to confidential information, only titles can be presented. The root causes are not directly connected to safety stock. Within the data, availability is presented in percentage and number of missing parts. The two brands, Volvo and UD, are presented separately. The categories for parts are frame, engine, cab trim, chassis, axle and average for cab per chassis and presented as anonymous references A, B, C, D, E, F and G.

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Tabell 3- Types of root causes

No.	Function	Root Cause
1	System	Mtrl handling - Time setting
		Error
		BOM missing
		Demand time
2	Supplier	Shipment delay
		Raw material issue
		Quality issue
		Wrong part
		Commercial issue
		Mixed part in a package
		Supplier not follow PI, Wrong packaging
3	Transportation	Wrong customs document
		Wrong consignee
		Delay pick up
		Vessel delay
		Transportation issue
		Missing schedule
		Cyclone / flood
4	Quality	Quality issue
		Design issue
		DCN issue / Revision issue
		BOM issue / Mismatch Q'ty
		Campaign
		Quality issue
5	Engineer	BOM missing
		Sprint error
6	Production	Not assembled according to AI
7	Warehouse	Unpack delay / Waiting to keep
		Keep to wrong location
		Supply delay / 2-bin
		Wrong supply (P/N, Qty, Station)
		Downsizing delay
		Stock deviation
		Mistake operation / Human error
		Quality issue
		New part / Phase in-out
		Late UCR
8	Logistics	Wrong adjust stock
		Shipment delay
		Parameter issue
		Part list issue
		POU mismatch with actual
		Parameter set up issue
9	Others	Packaging issue
		Supplier issue

4.5 Product availability

Tabell 4 – Monthly update of the product availability

Brand	Shop	Truck produced	Jan-17	Feb-17	Mars-17	Apr-17
UD	A	Chassis produced				
		Missing part				
		% Availability	89,88%	84,14%	70,77%	4,46%
		Waiting time (min)				
	B	Chassis produced				
		Missing part				
		% Availability	99,70%	100,00%	99,58%	89,69%
		Waiting time (min)				
	C	Chassis produced				
		Missing part				
		% Availability	94,26%	82,79%	92,50%	91,46%
		Waiting time (min)				
	D	Chassis produced				
		Missing part				
		% Availability	95,63%	99,53%	98,93%	95,32%
		Waiting time (min)				
E	Chassis produced					
	Missing part					
	% Availability	99,03%	96,28%	92,14%	90,63%	
	% YTD	99,03%	97,62%	95,44%	93,80%	
Average	Chassis produced					
	Missing part					
	% Availability UD	95,49%	92,67%	89,77%	69,53%	
	Waiting time (min)					
		Target	90,00%	90,00%	90,00%	93,00%
Volvo	F	Chassis produced				
		Missing part				
		% Availability	100,00%	100,00%	100,00%	100,00%
		Waiting time (min)				
	E	Chassis produced				
		Missing part				
% Availability Volvo		100,00%	0,00%	100,00%	96,00%	
		Target	90,00%	90,00%	90,00%	93,00%

Analysis

Product availability is connected to the shortages and root causes. The table and graph shows the availability of sex different shops. For each shop, there are different parts included. To be able to use each shop, all parts needs to be available. Quantity and part specifications are confidential information and not presented.

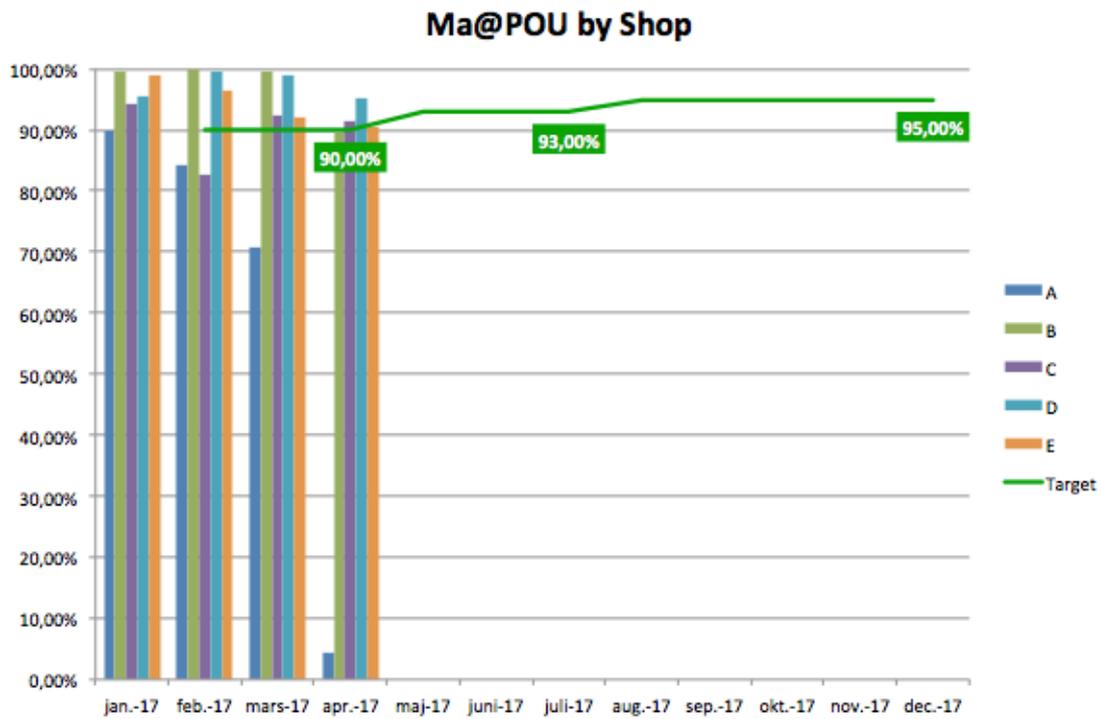


Figure 8- Diagram overview of shops monthly

5 Analysis

In following section, research questions are answered by processing the result and theory from the theoretical framework through analysis.

5.1 Changes in calculation parameters

In the current calculation, there are several parameters that can be changed. These changes have been discussed together with employees from Volvo. The authors have also by literature review gathered knowledge that is connected to safety stock calculations. Relevant theories and changes can therefore be discussed.

5.1.1 Note sheet

This is the part that has mainly been discussed together with the parameters of “new safety stock”, and reviewed due to its late updates. The only parameters that makes a difference are F/M/R classification. The reason for why the combination is not used is basically because the number of parts will be high in the safety stock. This is already a problem and therefore it is not possible to use the high combination numbers, although it is the most logical which the material controller agrees with. As it looks for now, the A/B/C classifications does not affect the final safety stock level at all. Which makes it unnecessary to have as a parameter, it will only be an overflow of information. To make it count in the calculations it could be a lower number which then is multiplied with F/M/R factors. The result will be equal to a lower combination number than it is for now. In the note sheet, there was a table for the different countries where Volvo has their suppliers. From earlier discussions, it has been told that Volvo have safety days for these suppliers. This depends on the lead time. For example, as earlier mentioned, parts from local suppliers will not provide any safety stock, the same is with safety days, because this is considered as zero lead time. Local suppliers are near and are considered to have no use for safety stock level or safety lead time, but when comparing China and Europe there is a difference in lead time. The lead time is not mentioned as a parameter for the safety stock calculation, which it could be. Instead of having safety days and safety stock for the same parts, it is possible to include the lead time when calculation the safety stock. One possibility can be for example looking at standard deviation of demand during lead time [4, p. 327].

Analysis

5.1.2 Parameters “New safety stock”

During the review of this sheet, responsible personnel suggested changes and different parameters that showed signs of possible and necessary actions. For example, the “DemandWK5-30” or demand week five until thirty could be changed to consider another time, preferable to perform better together with longer lead times and parameters of interests. Also, a better fit with the current forecasts, which already stretches over a long period. “Usage/month” and “Usage/week” were calculated from the 25 weeks of demand. Monthly use was claimed to be those 25 weeks divided by 15 and the weekly demand was calculated by dividing the monthly result by 4. By doing this, a month would consist of 1.6 weeks’ demand. And the week would consist of 0.4 weeks’ demand. Commonly known, a month consists of 20-23 workdays depending on month not considering public holidays. The number 15 is part of the calculation and no one could answer on where this number appeared from. Ongoing in the calculation, only the weekly demand was used, not the monthly demand. One question appears, why don’t divide the 25 weeks’ demand by 25 to get the weekly demand. If the calculation is based on actual working days, there would be a need of more precise methods to cope with the fluctuation of holidays, and an actual count of operational days over the coming six-month period needs to be considered.

The parameters have been chosen manually in a way to make the dimensioning of safety stock level custom fitted. This way of calculating safety stock level is based on the experience and knowledge from the employees, mentioned in section 2.4.1. The focus was in usage frequency and not the part costs, which the F/M/R parameters confirm by only being included in the calculation. Because Volvo’s current issue is lack of space, these parameters have been more interesting to focus on than the tied-up capital in stock.

5.1.3 Parameter dependability

As an outcome from interviews, information about delivery performance and the accuracy of that data is questionable. For example, if the delivery performance from a supplier is measured at the arrival in Bangkok plant, those numbers are genuine and are possible to put in use. According to information, some suppliers based in Europe are measured on delivery accuracy by getting the goods into a container on their own

Analysis

enclosure. By this mean, that delivery performance is inadequate to use in calculations of safety stock levels.

5.2 New calculation parameters

After the first review of the current situation where the excel calculations were presented and discussed, some questions appeared in the material control team. On this basis, the calculations were slightly updated and they provided new additive information. The new excel file provided more information for the authors to take in consideration and work with. The updated file contained following information:

1. Part number+part name+ part type (A/B/C, F/M/R)
2. Supplier ID+Country+Delivery performance (%)
3. Transport Lead time + frequency (times/week)
4. Demand for six month (Week 19-43)
5. Part price
6. Average usage per truck
7. Production rate X units/day

Some data in the updated excel file provides similar information as the first one. The main differences are additive information on delivery performance and lead times that opens the possibilities to calculate in new ways, using statistical methods.

With these updated parameters, a new calculation method could be done based on the information from the theoretical framework. By studying calculations for “Desired service level”, connections could be done to newly presented and updated parameters. For this case, forecasts of future demands were available data, but no historical data from previous demand variations due to the production ramp up of the new model. Calculations were done through this statistical method. Required data for the calculations was gathered in a new sheet to be computed. This is presented below to give a better understanding.

Analysis

Plant&Part	Plant	Part No.	Part name	Country	Supplier LT	Frequency delivery	Class	FMR	Q2/2017 ABC/FMR
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These parameters follow the previous layout but are a slightly updated version. For this row, lead time (from suppliers), Class (equal to classification A/B/C) and FMR (use frequency classification F/M/R) are updated. Then there is a combination of the two classifications, which still needs to be revised by company specialists with expertise within this subject, fully connected to the input within the “Note Sheet”. With this layout, the new calculation is consequently elementary and easy to follow.

Sigma time	Average LT	sigma	SS = Sigma * K	ABC (V) value	FMR (F) Frequency	Combi (C)= (F*V)	SS ---> (V/F/C)
------------	------------	-------	----------------	---------------	-------------------	------------------	-----------------

The parameters above are combined to fit a new method based on statistics. The purpose of this equation is reached by using a desired service level, included in the “k”-factor:

$$Safety\ stock = k \times \sigma_t \times \sqrt{LT}$$

$$\sigma_t = \text{sigma time}$$

The standard deviation was calculated on the forecast data for six months and converted to a standard time basis. By using excel and inserting equations the standard deviation could be computed on over 1000 unique parts.

$$LT = \text{Average lead time}$$

The lead time is expressed in days per part and supplier. The days were converted to weeks and calculated based on seven days per week. Even though it is five working days in the plant, transportations in forms of boats, planes and trucks aren’t bound to the same time frame. These parameters are calculated with “k” factor, and this is the chosen service level. By multiplying these parameters, the output is:

$$SS = \text{safety stock}$$

After presenting this calculation method, the contact person at Volvo wanted to include part price or frequency usage. By that mean, earlier classifications were included in the calculation. To differentiate the calculation with factors weighted by value (A/B/C), frequency use (F/M/R) and to combine them together. In the calculation, the different class belongings are shown due to unique part information.

Analysis

By coding with “if”-functions in excel, the company can call for; V=value, F=frequency and C=combination. In the last column, the change will be calculated according to what parameters the company choose to input. To change the calculation, there can be alterations in the “Note Sheet”. The percentage of service level can be altered and the company can choose what should be included in the calculations depending on what kind of stock alterations they aim for, based on usage, price or both combined.

6 Discussion & action proposals

Following in this section, are reflections of analyze and theory connected to the case. Also, followed by action proposals in response to research questions.

6.1 Discussion question 1

“Do current calculations of safety stock level cover production needs?”

Volvo’s own way of calculating their safety stock follows a structure based on forecast. In the calculation, there are several factors taken in consideration that can be used, but right now some of them are at ease. These forecasted calculations consider how frequent parts are used and the expected usage over that specific period. During the first review of the calculation, flaws were found where the responsible team couldn’t explain the input. By this flaw, the whole calculation was inaccurate.

Due to Volvo’s latest experience of overflow in stock, it’s hard to answer the question, especially when the original calculation contained flaws keeping the level lower than a correct version would have done. Although this mistake, there was a high level of stock. This implies that the reason of the overall increase in stock might be of other reasons. If the flaw would be considered amended, there are still questions about how able that calculation was to cover the production demand. For now, the demand is covered when studying latest reports of product availability. But there is some variation between the monthly periods. Especially in April there have been an increase in parts missing. But this can for example depend on the Songkran period in Thailand. Also, known as the local New Year, when everything is closed for one week. If this period isn’t planned, consequently there will be misunderstandings with suppliers. Parts that cannot be stored in safety stock are at higher risk. For example, the engine, because of its huge size and it’s not covered by safety stock. Therefore, it is important to have dependable suppliers that deliver in time.

6.1.1 Action proposal question 1

One possibility is to consider the perspective of studying the production stop failure reports, and follow the root causes to see how often a faulty level of safety stock were part of the cause of specific stops. By those reports presented in section 4.4 and 4.5, there are reasons to believe production needs could be covered without an overflow in

Discussion & action proposals

stock. As of today, production needs are well covered, not 100% in time, but the reports show high availability. Parts that cannot be stored could for example have some extra safety lead time. Also, supplier performance could be enhanced for these kinds of parts. If a supplier is unable to improve their delivery performance, one option is to investigate replacement supplier and to end the relation to that pore supplier.

6.2 Discussion question 2

“What parameters of the current calculation could be revised?”

In the calculation, the company can include worth of stock, and lead time as factors but if they use safety lead time that last one will be superfluous and just add to a greater safety stock level.

Some parameters can be added, but in the way, it's performed, an uncalled increase or decrease of safety stock levels may occur. As an example, in the calculation, the company can include worth of stock and lead time as factors, but if they use safety lead time, the combination of lead time factor and the added safety lead time they use today might be superfluous and just add to a unwanted safety stock level. Another example of parameter combinations is within added safety stock levels by safety days, several parameters can be used. Two parameters might be supplier's delivery precision and part numbers use frequency. If the frequency is high the aim is to increase the day's safety stock levels should cover. Unlike if the delivery precision is high means that the additive number of safety stock levels should be low. To add those would be a mistake leading to superfluous levels. In this example, the higher number of safety days dictated by use frequency, covers the same days needed for delivery precision coverage and doesn't need to be added together. By choosing the highest number, this will cover safety days needed. The beneficial way of doing this, shows when both parameters demands few days of coverage, then there will be a low level of safety stock. On the other hand, where one parameter demands more days the right factor dictates the safety stock level needed. This creates an individual leveling system, where different parameters can affect the outcome. Also by giving a combination of parameters a multiple effect that if all parameters show critical numbers an increase will be added to cope with the higher risk, of in this case, a high usage rate and a low delivery precision.

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Observe, this can be used in the other way around, when extremes are shown in the opposite direction, a high delivery precision and a low usage rate. With other words, few days of production coverage and the outcome could be a multiple that decrease the level of safety stock due to mentioned high delivery precision. The danger of using methods like this is that factors are hard to determine if they affect safety stock levels in the way they are supposed to. Even though both parameters got interesting aspects the individual influences are hard to determine. Therefore, personnel with expertise within material control and safety stock calculations need to evaluate the dimensions. Consequently, they can take a risk and determine the manual calculation. The “note sheet” as mentioned in 4.3.1 are parameters which could easily be changed manually. Risks are that they are superfluous and increase or decrease safety stock levels from the actual needed levels, if they aren’t revised.

By making changes in the current calculation, questions arise how the factors affects each other with aspects of safety stock levels and space use. To understand the effect of changing a parameter accused of root cause, may in the end not be appropriate due to unknown and insufficient influence of that parameter. Even the parameter itself might be insufficient as mentioned in section 5.2.1, under headline “parameter dependability”.

Calculations can be made in many ways; some are scientifically proven to cover demand through forecasts and statistical methods on historical data. Depending on method, the company can achieve a balanced safety stock level. But one thing is certain; however, it’s calculated independent of method, it’s impossible to get this perfectly balanced due to differences in forecasts and actual demand. [4] Employees whom are responsible should be aware of why calculations are made in certain ways. Continuous updates of the calculations need to be done, in addition there will not be any unknown parameters. A desired goal for the company is to include lead time and demand together with frequency usage and price, this led to a new updated calculation that had to be done. Manual factors are not in the author’s area of expertise and cannot be determine, therefore the current “note sheet” mentioned in section 4.3.1 will stay the same, to be improved by company experts. The changes made are:

1. New data regarding demand
2. Updated lead time factors from different suppliers
3. Calculations of standard deviation

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4. Have unison time basis; months, weeks or days by logic choice.

This lead time basis of seven days is founded on lead time containing cargo shipment overseas, which isn't stopping on weekends. Part of this calculation is fluctuation of demand, which can also be changed to be fluctuation of historical data, applied on the current production rate or demand. In this way, the fluctuation of demand or planned production is independent and not affected if the company is running on one, two or three work shifts, even weekend production. Observe, the expected production rate, dictates the demand and makes work shifts insignificant to the calculation. Then there is the tricky part, when considering lead times; If calculated on a seven-day basis, overseas transport is dimensioned in a correct way, but according to the calculation, an average of used parts is dimensioned and spread out on the days of production leading to the number calculated to cover the lead time use. Fluctuation is calculated on variation in between different weeks, which means it's not dependent of five or seven days of production. In that manner, the seven days can be used. It's also considered to be a correct way of handling overseas transportation. The only question is how it affects local suppliers with lead times overshooting weekends. A way of tackling this could be by using varying order point depending on what numbers are in stock and day of the week, due to the specific lead time. Taken in consideration, the order point depends on the calendar days' lead time, with aspect of how many weekends are within the lead time. The order point is then precisely determined by what day and what stock level is needed to cover the lead time e.g. the order is placed on a Monday, the stock level is A but if the order is placed on for say, a Wednesday to Friday, the same order needs to cope with one extra weekend and then the needed stock level must be $A+n$ to cover the missed coverage of weekly usage divided by seven. If these combinations of actions were made possible, the seven days calculation would be the way to go.

Another gap that affects production and ability to keep an undisturbed material flow is holidays and planned production stops at suppliers. This is information that needs to be well known by material control. To be informed and even better, know when suppliers close for local new year's and other religious or national holidays. This kind of information is utterly important to consider when planning and ordering. To increase safety stock levels and common stock momentarily, but most important, avoid being in a situation where orders should be processed immediately and threatens to shut down production.

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National holidays and other days that'll close the production during otherwise normal production days, needs to be taken in consideration during the production planning and safety stock level calculations. During the upcoming period that is considered, the local ability in the plant needs to be overviewed by investigating non-production days and excluded them. By taking this in to consideration, a decrease can be made on safety stock levels by the calculation. This needs to be considered in the forecasts and by that mean be a part of the calculations.

6.2.1 Action proposal on research question 2

Today's calculation basically consists of forecasted demand and a usage ratio that calculates the safety stock level, this calculation is prepared to include both value and usage ratio, as individual factors and as a combination. It wouldn't be hard to prepare the calculation to be adapted to either one of those three; usage ratio, value or as a combination. By making it changeable, a possibility to impact the safety stock level depending on current department goal would occur. There are also possibilities to add factors to make calculations more individualized. N.B. the effect may be hard to predict as mentioned in the discussion above and the authors propose an internal evaluation to consider a continuance or a change in calculation method.

To use a statistical method would force Volvo to change the whole equation, but it creates an opportunity to gain access to individual safety stock levels by part number in an early stage of the calculation, with few affecting parameters. All this depends on the parts unique fluctuation in real numbers from demand or historical data of actual use by the production. Fluctuations together with a percentage service level will give a statistically accurate calculation based on demand. By using this method it's crucial to know every aspect of the lead time data and how it's used as inputs to the ERP and later applied in this equation. Also, to examine the necessity of both safety stock and safety lead time, and the impact on increased safety stock level that might be reduced.

There is a need of routines to consider holidays that might affect production. Both in the suppliers' countries and local. Historically this has been part of why the company runs out of safety stock. This is not considered as a too low safety stock level, but a purchasing and supply chain error that needs to be bridged by information to close the gap.

6.3 Research question 3

“Is it possible to reduce the surface used by safety stock level through optimization?”

When basically just overview the possibilities, there is great potential of decreasing safety stock, but there are questions about what affects may be of those changes. There are a lot of things to consider and the problem is quite complex even in its simplest form. Just by looking at their current calculation and taking in consideration that they already chose to skip some of the factors that can be used, arise the authors' attention.

To reach the aim to decrease used space, there need to be a change in the method calculating safety stock levels. As of today, the calculation covers the needs but thus it over shoot the target by keeping a to high safety stock level. Instead of optimizing through statistical methods and historical in-house data of fluctuation from demand, it's handled by additive safety days depending on usage rate, and not to forget, the safety lead time that's added outside the calculation.

6.3.1 Action proposal on research question 3

To be able to follow up changes and effects of safety stock calculations, it would be beneficial to introduce connections between package sizes and computed safety stock levels. By this mean, used space and volume in the warehouse can be measured and compared in-between current calculation and historical data. Combined in this step, the authors recommend a review of optimized space use to further more achieve an effective space usage.

It would also be possible to reduce space by having more reliable suppliers. As earlier said, the location is a challenge for the Bangkok plant and if the suppliers can support the company in time, stock in warehouse is less necessary, by increase procurement from local suppliers lead time and safety stock levels can be reduced and reliability in the production can be increased, this is also connected to the bridging of information and gap closing step in section 6.2.1. By increasing local suppliers, uncertainties depending on geographical position, supply chain and local customs can be eliminated.

6.4 Discussion about case validity & reliability

The authors have collected data and been part of analyzing the content. By evaluating and questioning data and its' origin, the reliability has been improved by securing a well-known and executed calculation that enhance the possibility to repeat the same computation. Also by studying theoretic methods that confine the use of different factors and affecting the calculations complexity, which increases the studies validity. Together with employees at the company, the authors have executed this case study. In that mean gained an advantage by being well connected to reality and the actual problems and discussions around the case. By presenting results and been given feedback on the subjects, the risk of biased views has been correlate to theoretical methods. This adds to this case's credibility.

7 Conclusions

This section provides a resume of this case study's implications, conclusions and recommendations. Also, closing with proposals on onward feasible works and researches.

7.1 Conclusions & Recommendations

There are many ways to compute safety stock calculations and it's possible to change the current calculation and use it in a slightly different way. By doing that, a common denominator is the unknown within the combinations of parameters used. By this said, the authors suggest Volvo to consider a change in calculation method. By choosing a statistical method, the company gains control by part individual safety stock levels. Another recommendation is to follow up on lead time data to control that all data is unison in their input, to secure the reliability in the calculation, as an example of unison input is to evaluate the standard week to consider computing by five or seven days. Also, a recommendation to investigate advantages of local suppliers to decrease the added uncertainties of long lead time, production abilities and gap of information, all due to the unique plant location in correlation to suppliers.

7.2 Continued work or research

As part of the conclusion suggests, it would be an advantage to investigate more benefits of having suppliers located locally in Thailand and in a close surrounding to the production plant. Also, to investigate the connection between safety stock and safety lead time and the affects they have on each other, and when one or another method is redundant. Another investigation that can be done would be the impact that the five and seven day week entails on lead time and standard inputs in ERP systems. These three suggestions of continued work for the company and can also be done as a research by bachelor thesis work or higher level of researchers.

8 References

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9 Appendices