FORSVARET

Forsvarets høgskole

Command and control in the modern supply chain

Implications of emerging technologies on the supply chain of land forces

Christiaan J.G. Bartholomé

master's thesis

Forsvarets høgskole

Autumn 2017

Preface

Before you, lies the master's thesis "Command and control in the modern supply chain", a search for implications of modern technology on an army's supply chain. It adds on my study at the Command and Staff Course which I attended at the Norwegian Defence University College in 2014-2015 and on my privileged position as Dutch exchange officer in the Norwegian Army. The thesis fulfils the graduation requirements of the part-time Master of Military Studies program at the Norwegian Defence University College in Oslo.

Writing it has been an interesting and challenging process, putting just-in-time management to the test, combining research, work and a young-family life while living abroad. Fortunately, I could depend on my tutor, prof. dr. Glenn-Egil Torgersen, who always was available and willing to answer my questions and gave me the necessary feedback and motivation.

I would like to thank those supporting me in my research. First of all, my respondents, without whose willingness I would not have been able to do this research. Furthermore, to my colleagues and friends supporting me during the process. Especially Lars-Erik, Anders and Arjen, thank you guys!

A particular note of thanks goes to Elisabeth, my wife, for her patience, motivating words and for running the family while I locked myself up to study.

Oslo, 27 November 2017

Christiaan Johan Gerard Bartholomé

Summary

This master's thesis studies the implications of introducing modern technology in the army's supply chain on the command and control of this supply chain. It has been a qualitative study using both literature and a survey among a limited group of subject matter experts.

The theoretical framework for this thesis is based on organisational theory, especially on the Mintzberg model of organisation configurations. Furthermore, elements of Strategic Technology Management add to this framework. In order to define emerging technologies promising for the army's supply chain, a survey of several government and commercial documents has been done. Based on expected influence on the command and control of the supply chain two of these were chosen for further analysis.

Research findings point out that command and control of the army supply chain will shift from the Army to a more centralised organisation outside of the army. It is expected that coordination and de-confliction of activity on land will remain the Army's responsibility. Depending the technological developments, this can eventually be automated as well. Furthermore, mutual trust and integrating suppliers in comprehensive planning and training are indicated as important criteria for success in supplying the Army.

Table of contents

List of figures and tables

1 Introduction

1.1 Background

In military logistics, especially in the last part of armies' supply chains, also known as the tactical level, technology has not had a large impact yet. Modern Enterprise Resource Systems have been introduced and some try to change from push supply towards a more pull orientated supply. Nevertheless, today's tactical army supply chains have not revolutionary changed from the Cold War era supply chains. It is still about delivering supplies to the troops based on expected consumption and it still involves manual calculation and even gut feeling. One might wonder why and even become worried. In a testimony before the Senate on April 16, 1997, US Army Chief of Staff General Dennis Reimer stated: *"There will not be a revolution in military affairs unless there is a revolution in logistics."* The desire to revolutionise military affairs implies need for revolutions in military logistics. Implementing modern technology could support this kind of revolution.

Modern technology is changing our lives incredibly fast. From the early home computers and cell phones in the 1980's to the modern-day tablet computer and smart phones, things technology has developed incredibly fast. From a few connected mainframes in the 1970's to one billion webpages in 2014 (news.com.au, 2014). Over the last three decades, computers, cell phones, the internet, etc. have all become a part of our daily life, as well in work as in our social lives. For the generations born from the 1990's the use of technology is as normal as turning on an electric light bulb by pushing a switch on the wall, or maybe even on the smart phone.

Technology enables us to be connected to the world 24/7 with anyone in the world. People are no longer hedged by geographic location or social position and are able to meet in topic based communities. In addition to this, people changed from being a recipient of information into being in a more active role where they choose which information they want to receive. Looking at command and control, especially in the Army's supply chain, there are several levels of command each with its own discretion and responsibility. Is this still necessary in an era where data can be processed automatically and information can be made available for everyone who needs it at any given moment? Perhaps it is time to think different. It appears credible to think of emerging technologies in logistics as a way to innovate both management

and organisational structures. Nowadays, if you order a book via your smartphone on Amazon.com today, it will be printed and sent tonight, and delivered tomorrow. In some years, it might even be delivered by a drone. Why is the staff sergeant still filling out paper reports?

This master's thesis will provide insight in the effects of emerging technology on the Army's supply chain. Based on military and civil documents, it will broadly present the most promising technologies for the Army's supply chain and determine possible implications to military supply chain management, better known as command & control of the supply chain. At the same time, it will study the relation between the military (logistical) organisation an emerging technology in the light of organisation theory, with a focus on Mintzberg's configurations, and research from modern technology management and innovation theory.

Besides the use of literature, this master's thesis is based on the author's experience in the logistical field of the Royal Netherlands Army. In the past three years, he has been appointed as exchange officer in the staff of the Norwegian Army. From that position, he has had the opportunity to observe the Norwegian Army from the inside. In order to mitigate the risk for bias, literature, theory and interviews with authority in the field of army logistics are used. Given the authors foreign background, a focus on the Norwegian Army's supply chain will decrease the risk for bias even further.

1.2 Previous research

Although there is not much research done on the military supply chain (Listou, 2015, p. 16), some studies touch upon the subject. Listou's dissertation *"Supply Chain Designs for Preparedness"* is one of the few available recent studies on military supply chains. Furthermore, Piggee (2002), as well as several non-academic papers written by government agencies write on innovation in logistics. None of the known research combines innovation with command and control of the supply chain.

1.3 Main research question

In 2002 US Army Lieutenant Colonel Aundre F. Piggee (2002, p. 3) wrote that future logisticians would be empowered by information technologies to provide the right support at the right time at the right place. They would no longer rely on "historical" data. Today in 2017 expert experience prove the contrary. According to interviewed experts, supplying the

troops in battle is still heavily relying on historical data and “gut feeling”. How come? Why does not the Army benefit from technological development in supplying the troops in battle? Is it not yet possible technically, not desired or did we not prioritise necessary investments in this field?

The commander has a crucial role in both identification and implementation of technology (LeMay, 2009, p. 14). This implies that commanders in control of the Army’s supply chain should foster the positive effects of technological advance. Based on this it would be interesting to investigate the implications on command and control of the supply chain, when introducing modern technology. introducing modern technology in the army implementation of modern technology and thus improve the Army’s supply chain. This leads to the following main research question:

How does modern technology influence the command and control of the Army’s supply chain?

1.4 Research questions

In both qualitative and quantitative studies a thesis is followed by several research questions. These questions are used as guidelines through the research and the writing of the report (Creswell, 2014). In this research, the following research questions were used:

(1) What is command and control of the supply chain?

(2) What are the characteristics of military organizations from an organisational theoretical perspective?

(3) How can organisations handle new technology?

(4) How is today’s supply chain and its command and control organised?

(5) Which emerging technologies are most promising for the Army’s supply chain?

(6) What are the disadvantages of implementing modern technology?

1.5 Definitions

Before proceeding, the following paragraphs will explain the central phenomena supply chain and technology as used in this master's thesis, linked to the central question and research questions.

Supply chain

Mentzer et al. (2001, p. 4) describe the supply chain as the three or more entities directly involved in all the upstream and downstream flows of products, services, finances, and/or information from a source to a costumer. On the other hand, Monk and Wagner (2013, p. 109) focus on the activities that occur during the transferring from raw materials into finished and delivered products. From the military perspective, the latter seems more suitable, because supply is not the only task for the entities in the military. But when taking a closer look, it is the first definition which fits better. This is confirmed by the Norwegian directive for logistic activities (Forsvaret, 2014a) which defines the levels[1] within logistics and the supply chain as units and individuals. In his doctoral dissertation Listou (2015) uses a definition adapted for the defence organisation. Since it has the elements of the definitions by Mentzer et al. (2001) and Forsvaret (2014a) and it translates the supply chain definition into a more suitable one for armed forces:

> *"…the physical, monetary and information flows and other relevant flows within a defence organisation, between defence organisation and other defence organisations in specific contexts such as e.g. multinational forces, and between defence organisations and their non-military supply chain partners." (2015, p. 7)*

Technology

The word technology originates from the Greek language. It consist of the word *techne (τέχνη), "art, skill, cunning of hand"* and the suffix *-logía (-λογία)*, the study of something (Liddell & Scott, 1993). According to Oxford Living Dictionaries Technology is *"the application of scientific knowledge for practical purposes, especially in industry".* In its most narrow explanation it is about crafting tools for daily use, but technology is mostly used in a broader context. Especially in combination with the adjective 'modern' it points at an

[1] Level 1, the individual soldier; level 2, the unit; level 3, service-based organic logistics units; level 4, enhanced logistics support organised in deployable or stationary logistics bases and level 5, civil suppliers or producers (Forsvaret, 2014a, p. A2).

application of knowledge in a revolting way seen from a certain point in time. In a military context, one could say that mechanisation (technology) has revolutionary changed warfare in only a century (LeMay, 2009, p. 2). Regarding supply, one can easily point at the invention of railway as a revolutionary technology at its time.

In this master's thesis, the expression modern technology is used to indicate the use of technology that recently has become available or that is to become available in the near future.

1.6 Delimitations

This master's thesis is in search of the influence of modern technology on command and control in general and especially on the supply chain. It focuses on command and control of/in the supply chain of a deployed army. Supply chains are often designed for specific situations. One can find differences between the supply chain to support army units deployed in a mission in Afghanistan and the supply chain to support army operations on national of NATO territory. This thesis will focus on the general doctrine of the supply chain in the national context. Although the Army's supply chain not necessarily stops or starts in the area of responsibility of the Army, the thesis focuses on activities in the Army.

The thesis does not analyse the details of the technical use of technologies within the supply chain, although it might be touched upon in order to explain the implications for command and control.

In choosing promising technologies for the supply chain, the focus has been on technologies with an obvious influence on command of control of the supply chain. Other technologies, although promising have been set aside. Technologies without influence on the command and control have been excluded as well. An example of these is the introduction of electric vehicles. Although an introduction of electric (fighting) vehicles in the Army would have a huge impact on the supply of fuel, this impact is foremost on the amount of fuel and not necessarily on the design and the command and control of the supply chain. Another example would be the introduction of additive manufacturing, which will influence the complexity of the spare part product range, but not the supply chain as such.

1.7 Structure of the report

Chapter 2 describes the research design and method used. After this, a theoretical basis of the Army's supply chain and its command and control is presented in chapter 3. Subsequently, chapter 4 will provide a theoretical framework from the perspective of organisational science and strategic innovation management. After this, the observations from the expert interviews will be presented in chapter 5. Next, chapter 6 introduces emerging technologies and designates the promising technologies for the Army's supply chain. The effect of these on the command and control of the Army's supply chain will be discussed in chapter 7. Chapter 8 will discuss the researches findings and answering the research questions and finally give an answer on the main research question. Finally, chapter 9 summarises and concludes this master's thesis.

2 Research design and method

This chapter will provide insight in the thesis' research model. In his dissertation, Listou (2015) stated:

> *"Phenomena, such as supply chains, are social constructions that cannot be understood without simultaneously understanding their contexts and the individuals constructing these social phenomena." (p. 12)*

Therefore, this research is done using the hermeneutic paradigm. Hermeneutists acknowledge that the social world is changing constantly. As a result, it is almost impossible to use or formulate laws like in for example physics or mathematics. In hermeneutics, no objective reality is presented, but rather several interpretations of reality (Jacobsen, 2015, p. 27) based on variables like for example cultural aspects or period in history.

In order to understand the 'reality' this research started using an inductive approach while gathering information. This information was used in a deductive way to answer the thesis.

Using a theoretical basis in organisation theory, this master's thesis starts with an analysis into today's command and control of the Army's supply chain using organisation theory. After this, a survey of emerging technology which can be considered promising for the Army's supply chain is done. The survey is based on several (foreign) technology and future trend surveys. Subsequently, the implications of these technologies on command and control in the supply chain are determined. As a result, expectations on future change and/or improvement of the Army's supply chain command and control are presented. Figure 1 visualises this research design

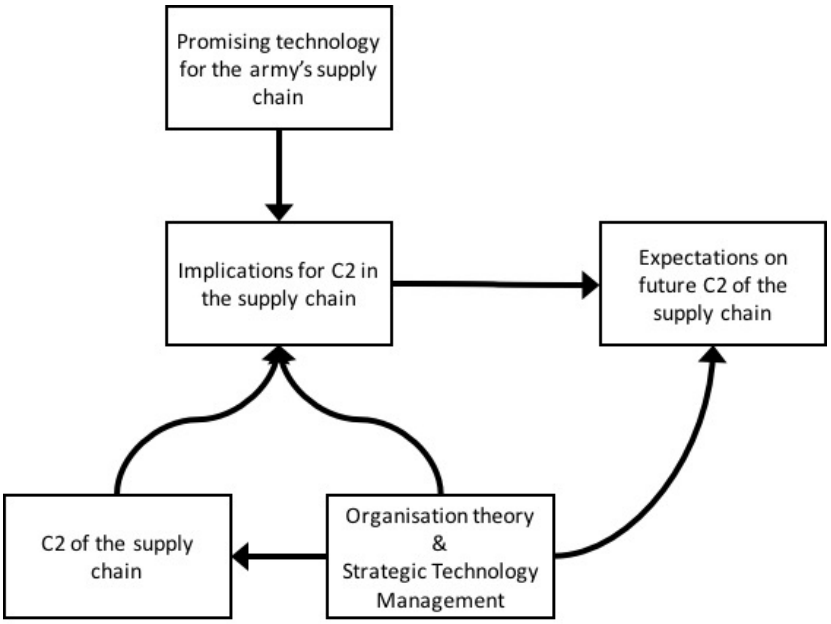

Figure 1, research design

2.1 Collection of data

Collecting data from unique sources is an important condition in research. In order to find theory suitable for this master's thesis, the Norwegian Defence University College's library and the internet proved to be important and valuable starting points. Furthermore, the tutor gave valuable advice on relevant literature. With a subject which has both a long scientific history on the military and organisational part and a rather young history on the technology part, finding scientific literature was both trouble-free and challenging. The latter illustrated by Listou (2015, p. 16), "*[l]ittle academic literature exists on defence logistics",* and almost four decades earlier, by Van Creveld (1977, p. 231) who concluded the same when he wrote that;

> *"Hundred books on strategy and tactics have been written for every one on [military] logistics, and even the relatively few authors who have bothered to investigate this admittedly unexciting aspect of war have usually done so on the basis of a few preconceived ideas rather than on a careful examination of the evidence." (Van Creveld, 1977, p. 231)*

2.2 Sampling and procedure

Respondents for the interviews were chosen based on their experience and position in, or relation to the supply chain. As Jacobsen (2015) describes, experts can be chosen based on the expectance of the quality of information. The number of respondents is kept to five. Partly because not all the intended respondents were able to participate, partly in due to the limited time in which the research took place. The participating respondents were from Brigade North, the Operational Support Unit[2] and the National Logistic Command / Norwegian Defence Logistic Organisation.

The research has been reported to the data protection authority for scientific research (NSD Personvernombudet for forskning) and is registered as project number 57019.

2.3 Questionnaire

The interviews were held using an interview guide or questionnaire. This list of questions functions as a check-list and helps the interviewer asking the right questions in reaction on earlier answers. It helps the interviewer to stay focussed on what the respondent is saying. In this way, the interview is more or less held as a conversation.

Each interview had a duration of approximately one and a half hour. It consisted of 13 main items and 15 sub items. The interviews were semi structured, which gave the opportunity for the researcher to stimulate long and in-depth answers (Ringdal, 2013). When necessary, the researcher used extra questions to get more in-depth answers. Three (sub)items were quantitative questions where the respondent was forced to give a metric evaluation. The metric answers on these questions were not used for any statistical analysis. The questions functioned as a trigger for the respondents to actually evaluate and explain their evaluation, as well as it gave the interviewer a way of evaluating coherency with other given answers.

No recording device was used during the interviews. This deliberate choice, since the transcription of recorded interviews is a time-consuming method. Furthermore, experience from other master students was that a recording device kept respondents from speaking freely. The researcher made notes in key words during the interview. Immediately after the

[2] The Operational Support Unit is translated from Norwegian; Operasjonsstøtteavdelingen

interview, a report was written based on these key words. Subsequently the report was shared with the respondent to check for accuracy.

Transcripts were made with the research questions as a directing factor as mentioned by Kvale, Brinkmann, Anderssen, and Rygge (2015). Both the raw data and transcriptions are approved by the respondents. The transcriptions were transformed and bundled per research question in appendix B. The interview guide or questionnaire is attached as appendix A.

2.4 Sources of error

In research on social constructions, both theory and interpersonal relations or factors are involved. In such cases, it is important to consider and evaluate various sources of error.

The theoretical part of the thesis is based on both established and relatively new literature. It is important to acknowledge that every person has his own experience and understanding when met with new literature. Text may be interpreted in a different way than the author of the text intended.

Interaction between people can be a source of error as well. Identical to written word, spoken word is also interpreted by the listener. The interviews held in this research have been conversations in which misunderstandings could have occurred. During the interviews, not only the spoken word was payed attention to, but also the non-verbal signs which everyone uses were observed and used to verify the content of the spoken word.

During the interviews, respondents were asked on their expectations of new technology. This implies a certain understanding of the term ‘technology’. In order to mitigate differences in the understanding of the word, this was explained before starting the interview.

2.5 Reliability and Validity

Research must meet requirements for reliability and validity. Reliability implies that another researcher is able to come to the same results while using the same instruments. The results of a research are valid if the researcher has been measuring the phenomena he or she intends to research (Jacobsen, 2015; Ringdal, 2013, p. 96).

It cannot be denied that the author’s experience within the field of army logistics, especially supply influenced the outcome of the research. For this reason, any use of personal experience

is clearly pointed out, as well as other sources are clearly referred to. This should give the reader a fair possibility to evaluate the reliability of these experiences and drawn conclusions.

Depending the activity, the respondent was doing prior to the interview, the emotional state of a respondent can influence the answer given in an interview. Given the little number of interviews, such a temporarily emotional situation can have a large effect on the research's reliability. In an attempt to mitigate this, the researcher asked the respondents to read and acknowledge the written reports which were made after the interviews. These were sent out the day after the interview. In that way, the respondents had the possibility to adjust any statement made based on an emotional state of mind. This respondent validation is considered a common method to validate ones findings (Jacobsen, p. 233).

Having only a few respondents gives another reliability issue as well. As Jacobsen (2015) describes, even researchers with knowledge on the population tend make a biased samples (p. 182). This would result in a misrepresentation of reality. Before sampling, the author tried to identify the best respondents by discussing whom to choose with colleagues working in the logistical field. Furthermore, this risk has been decreased by using theory and official documents in order to cross check the validity of answers.

As described earlier, there seems to be no academic tradition in military logistics. As such, this should not be a problem for the research reliability, since many of the used theories and methods are similar to the ones in the civilian world.

In order to strengthen the master's thesis validity (have the intended phenomena been researched?), it uses a common conceptual framework. The questionnaire is designed and analysed based on the thesis' theoretical background.

The definitions of the supply chain and new technology were determined first and supporting theory has been chosen. Mintzberg is used as one of the classic organisational theory scholars, since his model of configuration suits the research best. Alternatively, among the large amount of theories on organisational behaviour, the four-frame model of Bolman and Deal (1991) could for example have been used. However, their four-frame-model does not have the same detail as presented in Mintzberg's configurations model. Therefore, the latter was chosen as theoretical framework.

3 Supply theory in relation to Command and Control

This chapter will firstly try to find an answer on the first research question. What is command and control of the supply chain? It will start describing the Army's supply chain based on formal documents. This will partly answer on research question four as well, but that answer will be completed after the analysis of the observations in chapter 5. After the description of the supply chain command & control and Supply Chain Management (SCM) are described and compared. This leads to the answer on research question one. The chapter will conclude with a short evaluation of whom is executing command & control in the supply chain.

3.1 The Army's supply chain[3]

While briefing a group of future army recruits, the author was once asked to explain what supplying an army was all about. The answer started as follows:

> *"While doing their jobs in the front line, soldiers and units consume goods. After a while they want these goods to be resupplied. They write down their needs and give this note to the ones with the goods, us. We take their note, together with an empty box into our warehouse and fill the box with the things they need. After that we'll get a truck to deliver the box to the soldiers in the front line and in the meantime, we ask our suppliers to resupply our warehouses…"*

Although a very simple explanation of the work done in the supply chain, it is actually the basis of the supply chain. Army units start operations with a certain level of supply present on and in their systems. Depending the operation and the actual use, they will get supplies from the Army's supply chain.

The Norwegian Army uses Standard Days of Supply (SDOS) in its supply philosophy (Forsvaret, 2014a, p. 10). A SDOS is based on a unit's organisation (size, material, etc.) and operational requirements. It is primarily used in the supply of bulk goods in class I and III[4].

[3] The draft concept for supplying the Norwegian Army (Hæren, 2015) is a classified document. In order to keep this master's thesis publicly releasable this paragraph will give an overview of the supply chain in the army. It is based on the available open sources, interviews and the author's own experience. Classified information is not included, but used only as background information while writing.

[4] Class I: Items of subsistence, e.g. food and forage, which are consumed by personnel or animals at an approximately uniform rate, irrespective of local changes in combat or terrain conditions.
Class III: Petroleum, oil and lubricants (POL) for all purposes, except for operating aircraft or for use in weapons such as flame-throwers, e.g. gasoline, fuel oil, greases coal and coke. (NATO, 2012, p. 27)

Multiplied by variables based on e.g. weather, terrain and combat intensity, it defines the amount of supplies being pushed forward to the Army's units without them having to order these.

As described in paragraph 1.4, a supply chain starts at the origin of the raw materials and ends as soon as the final product reaches its end user (Listou; Mentzer et al.; Monk & Wagner). The scope of this master's thesis is the Army's supply chain, but for an understanding of the chain, a more comprehensive description of the supply chain is necessary.

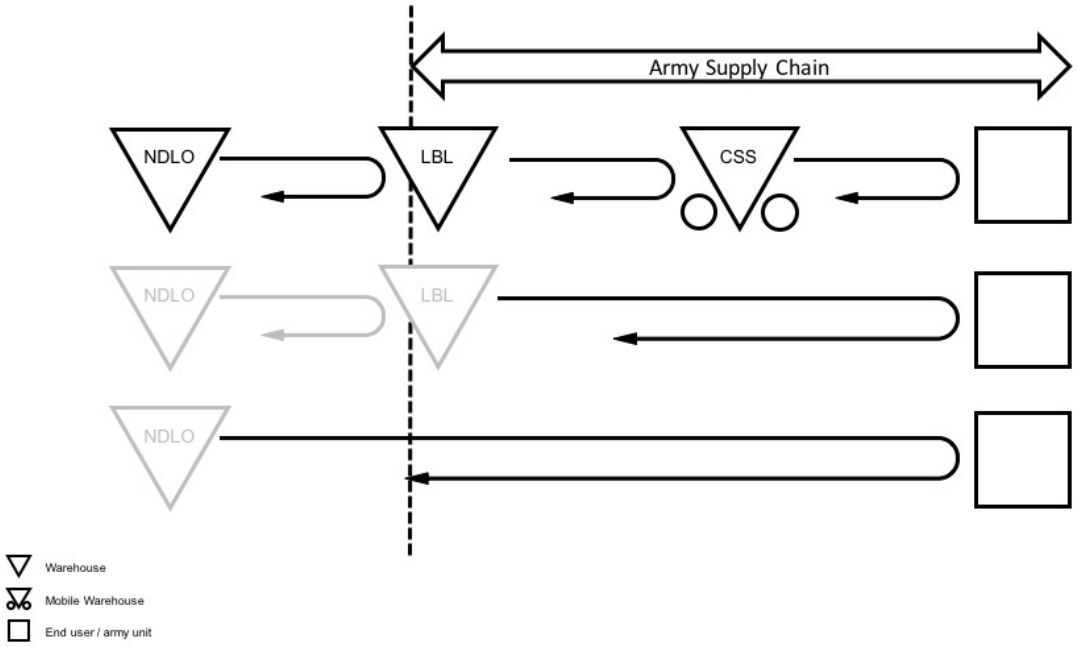

Figure 2, the Army's Supply Chain.

The upper part visualises the basic supply chain, where goods are delivered through every entity in the chain. The middle part visualises the exception where units are directly supplied from Logbase Land. This can be both units from Brigade North, thus supply bypassing the CSS battalion, or units outside the brigade, which are not supported by the CSS battalion. The lower part visualises direct supply to units from the NDLO or a civil supplier.

Supplies are in principle delivered to the end user. The Norwegian Defence Logistic Organisation (NDLO) is responsible for the procurement and delivery of supplies to the Army's Logistic Base (Logbase Land / LBL). As primary entry point into the Army, LBL acts as the interface between the more civil oriented part of the supply chain and the more military orientated part of the supply chain. Supplying the troops is mainly conducted by military assets, although under favourable conditions direct and/or civil supply from NDLO warehouses or civil suppliers towards end users is a possibility.

From LBL, supplies are forwarded towards the army Combat Service Support unit's, mainly by the CSS battalion serving the Norwegian Brigade North. This will take place in the entire geographic area of operations, which will expose supplying units for comparable threats as to which combat units are exposed. It is for this reason that the Army leaves this role to military units trained and equipped for this environment.

3.2 Command and control

When used in a military context, most soldiers have an understanding of what is meant with the term command and control. But are these understandings the same? And how is this outside the military context. More than enough reason to elaborate on what command and control is.

Maybe the most obvious document to look for a definition of C2, at least from a western soldiers perspective, is NATO's Glossary of Terms and Definitions, AAP-06 (2013). Interestingly enough there is no definition for C2 listed in this document. It defines command and control separate. The first is defined as

> *"The authority vested in an individual of the armed forces for the direction, coordination, and control of military forces." (p. 2C8),*

the latter as

> *"The authority exercised by a commander over part of the activities of subordinate organizations, or other organizations not normally under his command, that encompasses the responsibility for implementing orders or directives." (p. 2C13)*

The Dutch Armed Forces use NATO's definitions but give a broader explanation of them in the doctrine publication on C2. 'Command' is seen as the art to decide, to convey intend and to impose will to subordinated troops. Having command implies having the responsibility to decide and lead. After a decision is made, a commander has to organise, direct, follow and guide his subordinated units; 'control'. It describes 'command' as the authority the commander has and 'control' as the execution of this authority. (Ministerie van Defensie, n.d., p. 14). The Dutch Armed Forces use the word "commandovoering" for the term C2. This word fits to the broader definition of C2 used by the Norwegian Armed Forces. They describe it as one of the joint functions being the term for planning and leading operations. It consists

of the organisation, its processes and procedures and the systems enabling the commander to lead and control the forces (Forsvaret, 2014b, p. 222).

The above appears to be confirmed by Pigeau and McCann (2002) publishing their definitions of command and control as:

> *"control: those structures and processes devised by command to enable it and to manage risk"* and *"command: the creative expression of human will necessary to accomplish the mission."*

An interesting observation in the definition of control by Pigeau and McCann (2002) is that it is the entity in command who determines the control structures and processes. In other words, it is the organisation or commander to decide on how to execute control.

In search of a universal definition of C2, Vassiliou, Alberts, and Agre (2014) combine 'command' and 'control' into C2 as follows:

> *"Command and Control (C2) denotes the set of organizational and technical attributes and processes by which an enterprise marshals and employs human, physical, and information recourses to solve problems and accomplish missions."*

This definition will be used in this master's thesis to describe command and control.

3.3 Supply Chain Management or Command & Control?

Now that both the supply chain and command and control have been defined, the question is how these two interact. What is command & control of the supply chain? When managing a supply chain people will tend to think of Supply Chain Management (SCM). Although commonly used by theorists and practitioners, SCM is interpreted different among authors and logisticians (Mentzer et al., 2001, p. 2). A short analysis of the words implies that it is about managing the supply chain. This seems to be in line with the definition used by Mentzer et al.:

> *"…supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole" (2001, p. 18).*

Although this is a very thorough definition it focuses mainly on business logistics. From the military operations perspective, more focus on getting effective results and on fulfilling the mission is desirable. This is underlined by NATO (2012, p. 65) in its Logistics Handbook, distinguishing between commercial and 'just in case' business. The difference is described even clearer by Pagonis and Cruikshank (1994, p. 210) stating; *"The military focuses on life and death, whereas business measures profit"*

As part of the joint function[5] sustainment (Forsvaret, 2014b, p. 145), supply is one of the preconditions for success on the battlefield. A closer look at the relations between these joint functions places Command and Control as the coordinating function between all joint functions. These relations are showed in the figure below:

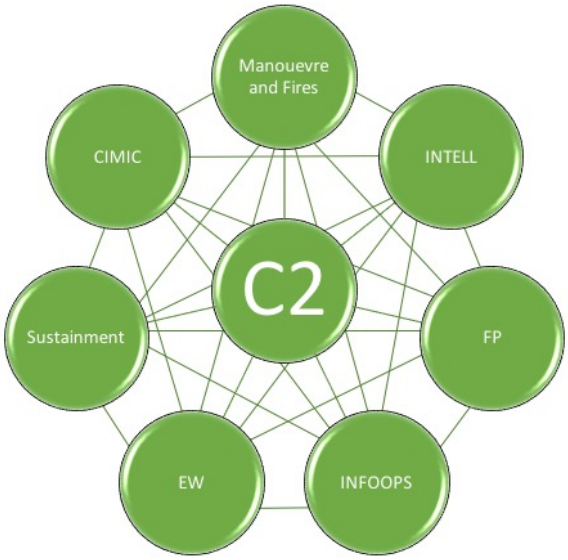

Figure 3, C2 at the core of the joint functions

When projected on the supply chain C2 as defined before is similar to the definition of SCM by Mentzer et al. The difference lies in the focus on problem solving and mission accomplishment. In order to clarify the distinction between a focus on efficiency in the civil supply chain and effectiveness in the Army's supply chain, this master's thesis uses the term command and control instead of SCM.

[5] The Joint Functions translated from the Norwegian Joint Doctrine: Command and Control (C2) (kommando og kontroll), Intelligence (INTELL) (etteretning), Manouevre and Fires (operasjonell manøver og ild), Force Protectionn (FP) (styrkebeskyttelse), Information Operations (INFOOPS) (informasjonsoperasjoner), Electronic Warfare (EW) (elektronisk krigføring), Sustainment (understøttelse) and Civil Military Cooperation (CIMIC) (sivil-militært samvirke) (Forsvaret, 2014b, pp. 125-161).

In answer on research question one, command & control of the supply chain can be defined as the set of organisational and technical attributes and processes used to organise and execute supply of (army) units synchronised with the other joint functions, in order to support the military mission.

3.4 Who has C2 over the supply chain?

As described earlier, forecast based supply is the preferred form of supply in the Norwegian Army (Hæren, 2015). This term might need some clarification. Forecasting, in supply, is a systematic method to predict a future demand (Persson, 2011, p. 30). There are four different kinds of forecasting according to Persson (2011); long-term, which has a horizon up to five years; medium-term, with scope between 1-3 years ahead, short-termed with a time span of 3-12 months ahead and day, week or hour forecasts with a timespan between 6 hours and 4 weeks. The Army, being at the tactical level uses the latter (Kress, 2002). These forecasts are primarily based on standardised consumption data per (weapon) system or unit (Standard Day of Supply) multiplied by factors based on the type of operation, terrain, weather, etc. During an operation forecasted resupply requirements are adjusted based on a daily reporting regime through the Army's chain of command.

The reports originate in the (combat) units based on input from individual systems and combat squads. The logistic branch in a battalion (S4) accumulates these inputs into logistic situational reports and logistic assessment reports and sends these to the brigade headquarters logistic branch (G4). With use of NATO's Logistics Functional Area Services (LOGFAS)[6] this information is shared with the other stakeholders in the supply chain and the chain of command.

Remarkably enough Kress (2002, p. 127) claims that there is "*hardly any systematic forecasting activity"* at the tactical level. Logisticians at the tactical level have to focus on the practical side of supplying army units by using Tactics, Techniques and Procedures (TTPs). The fact that the NDLO, by its National Logistic Command, decides on which supplies are being forwarded to the Army, based on the reporting of the Army units confirms Kress claim.

[6] *"LOGFAS is NATO's logistic tool that allows for data exchange and reporting between NATO's Headquarters, Units, and Troop Contributing Nations in all phases of planning and execution of logistic operations by use of an integrated series of computer programmes. These programmes use the same database format and therefore data can be shared easily."* (NATO, 2012, pp. 75-76)

This leads to the conclusion that the Army does not have C2 over the supply of goods, but only over the tactical execution done by army logistic units. Thus, in practice, the Army is not executing C2 of the supply chain or Supply Chain Management, it is in the hands of the NDLO.

4 Organisation theory & innovation

In order to determine the influence of modern technology on the command and control of the supply chain, a closer look on military organisations is necessary. What are the characteristics of military organisations from an organisational theoretical perspective? (research question 2). A second question related to organisations and innovation is how technology can be handled (research question 3). Using classical organisational theory and theory on strategical technology management, this chapter answers on both research questions.

4.1 The armed forces as a bureaucracy

If one would ask a random person to describe the organisation structure of any armed forces in one word, he or she will most likely answer with hierarchic. This reflects, at least partially, the organisation structure. Hierarchic organisations organise their workforce or employees in order of rank, grade or class (Peter & Hull, 1969). Today's hierarchical structure of armed forces originates from, among others, Fredrik the Great[7] (1712-1786). He reformed the Prussian Army inspired by Roman legions and mechanical inventions. He introduced ranks and distinguishing uniforms, regulations, discipline, standardised equipment, command language and a new way to train soldiers; the drill. Furthermore, he separated the planning officers from those commanding the force, thus creating the line-staff organisation. By doing this he made the Army into an excellent war fighting machine. All the separate parts working together as a machine (Morgan, 1998).

A hierarchical structure is one of the characteristics of the bureaucratic ideal described by the German social scientist Max Weber (1864-1920). Beyond this hierarchic and permanent structure, Weber describes the characteristics of the ideal bureaucratic organisation as being formal organised, obedience to superiors, impersonally and based on rules (Veiden, 2010). In many ways, this seems to fit to a military organisation with a line-staff structure, documented doctrines and procedures on how to conduct war and even own military disciplinary law. One can easily come to the conclusion that the organisation structure of armed forces resembles the bureaucracy.

[7] Others claim that it was Prince Maurice of Orange (1567-1625) who startet reorganising his troops and using drill and excersice inspired by the ancient Greeks and Romans. This could be an interesting topic for historic research on modern military bureaucracies.

It would be short-sighted to define the organisation structure as a bureaucracy alone. Of course, many attributes of the bureaucracy seem valid, especially in peace-time where New Public Management has found its way into the military organisation as well. Formalised reports, budget rules, training compendia, fixed planning cycles etc. cover most of a soldier's day in peace time. But there is more.

First of all, like most western armed forces, the Norwegian Armed Forces leadership philosophy is based on a form of Mission Command[8]. This means that a commander has an intention with the orders he assigns to his subordinates. It is this intention that is to be considered as the most important guide line while executing the orders. Assignments in Mission Command are more about the goals to achieve then about how to achieve them. Although the way in which Mission Command is used in the Norwegian Armed forces has its hierarchical and bureaucratic features as Plischke (2016) points out in his master's thesis. It is also about showing leadership and breaking the rules of bureaucracy when they do not serve the goal. Or as General George S. Patton said: *"A leader is a man who can adapt principles to circumstances."*

In real life, other adjustments to the ideal Weberian bureaucracy have been made, in civil society as well as in the military. One of them is a democratisation of the hierarchy by 'Works Councils' (Heijnsdijk, 1994). Another is the use of peer commanders with a coordinating authority over the other. To describe the organisation of the Norwegian Armed Forces a closer look at it appears necessary, using Mintzberg's theory as a framework.

4.2 The armed forces from a Mintzberg point of view

One way to describe the several different attributes of an organisation is presented by Henry Mintzberg. His generic model of organisations consists of six basic parts as shown in figure 4. At the base of the organisation, the executing part of the organisation is found, the *operating core*. At the very top of the organisation the management or leadership is found in the "*strategic apex"*. The larger an organisation gets; the more managers and middle managers are needed. These are placed in the *"middle line*" as *"a hierarchy of authority between the operating core and the strategic apex".* Further, especially when organisations become more complex, Mintzberg acknowledges the need for a group of workers doing planning, control and other supporting duties. This part, often referred to as 'staff' he calls the

[8] Mission Command translated from the Norwegian 'Opdragsbasert ledelse'

"technostructure". Besides this, most organisations have units to support the internal processes of the organisation, such as ICT offices, office building receptions, etc. This staff is called the *"support staff"*. The last and sixth part consists of the "ideology". It consists of the traditions and beliefs, also referred to as the organisations culture or soul. It distinguish one organisation from the other. (Mintzberg, 1989).

One can easily associate military organisations, for example the Norwegian Brigade North, with this model. The operating core are the soldiers in the battalions. The brigade commander is in the strategic apex. Between the soldiers and the brigade commander, battalion commanders, company commanders and platoon commanders can be seen as the line managers. Most of the brigade staff acts as the technostructure, supporting the brigade commander and line managers on planning and control tasks. The command sergeant majors, administrative officers, etc. form the support staff.

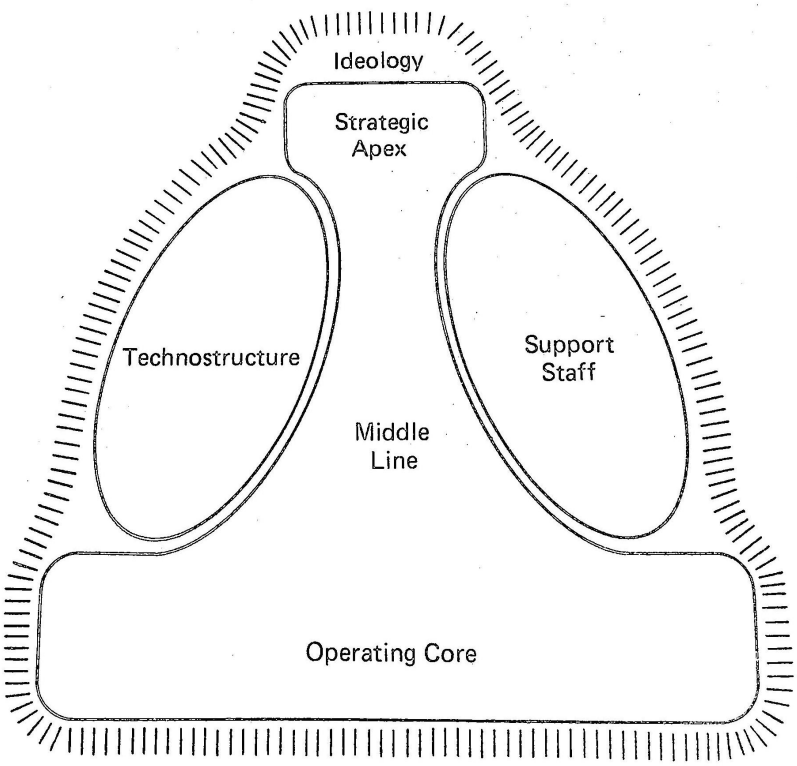

Figure 4, Six Basic Parts of the Organisation (Mintzberg)

In order to get the basic parts of the organisation working together, Mintzberg describes two requirements any organisation has to fulfil. The division of labour into various specialised tasks and the coordination of these tasks. The structure of the organisation is described by the way tasks are divided and coordinated. The coordination of tasks is divided in 6 different

coordination mechanisms, most which will be found within in almost every organisation. (1) *"Mutual adjustment"* is simply people informally talking to each other coordinating tasks. (2) *"Direct supervision"* is coordination trough orders, i.e. a sergeant giving instruction to his squad. (3) *"Standardisation of work processes"*, i.e. by means of Standing Operating Orders, drills or standardised planning processes such as NATO's Comprehensive Operation Planning Directive. (4) *"Standardisation of output"*, with a focus on the result of the work done. (5) *"Standardisation of skills"*, e.g. by setting identical training requirements or having military officer schools setting the standard. (6) *"Standardisation of norms"*, where it is the set of beliefs, morals or culture influencing the way the work is done.

Combining these coordinating mechanisms with the way decision power is distributed in an organisation, Mintzberg concludes with six structural configurations of how organisations can be explained, as mentioned before. These configurations are not templates, but rather a way of explaining the dynamics inside the organisation, organisations or at least parts of them will fit more than one configuration. Mintzberg's configurations are listed in table 1.

Table 1: Mintzberg's structural configurations

Configuration	*Prime Coordination Mechanism*	*Key Part of Organisation*	*Type of Decentralisation*
Entrepreneurial organisation	Direct supervision	Strategic apex	Vertical and horizontal centralisation
Machine organisation	Standardisation of work processes	Technostructure	Limited horizontal decentralisation
Professional organisation	Standardisation of skills	Operating core	Horizontal decentralisation
Diversified organisation	Standardisation of outputs	Middle line	Limited vertical decentralisation
Innovative organisation	Mutual adjustment	Support staff	Selected decentralisation
Missionary organisation	Standardisation of norms	Ideology	Decentralisation
Political organisation	None	None	Varies

Given the vast amount of regulations, Standing Operating Procedures, drills, etc. as mentioned before, armed forces can be categorised as a machine organisation. On the other hand, as Mintzberg calls training *"a key design parameter in all the work we call professional"* (Mintzberg, p. 104), the focus on standardisation by skills would point in the

direction of the professional organisation. Although this might seem contradictory, both formalisation and training will lead to standardisations or, in other words bureaucratisation. Bureaucracies, especially in the view of Weber, are ideal organisations. Especially in large organisations which are divided in smaller units with each a line manager, executing predictive tasks with well trained personnel, bureaucracy works well. In fact *"...bureaucracy prevails, first and foremost, because it works"* (Benveniste, 1987, p. 6). In many cases, having routines, and rules to get the work done will empower organisations. In view of the successes of Fredrik the Great, after his implementation of regulations, discipline, hierarchy, etc., one can conclude that the phenomenon bureaucracy also functions well in the armed forces. However, in situations where tasks get unpredictable and/or rules no longer seem to apply, discretion is necessary (Benveniste). In these situations, professionals have to be given discretion and trust in their professional knowledge and ability to bring solutions. In other words; in these situations, the professional configuration seems to be more suitable. Mintzberg on the other hand, says that both the machine and the professional organisation have difficulties when they are confronted with change or innovation (Mintzberg, pp. 151 and 190-191). So how can organisations handle change and innovation?

4.3 Confronting change and innovation

It is often said that people in general oppose change. But, as Dent and Goldberg (1999) describe, it is more complicated. Individuals do not oppose change as such. Different consequences of change for individuals might make systems, in other words organisations, to oppose change. With this perspective in mind, confronting change by the machine- and professional organisation is given a closer look.

One of the characteristics of the machine organisation is it focus on control. This is why organisations in the business of control tend to organise as machine organisations. As well as organisations with a special focus on safety (Mintzberg, p. 138). When engaging in combat, an infantry unit cannot pause and have an informal group discussion with the commander on whom is to engage which target.

The tasks in the machine organisation are coordinated by rules, regulations and standardisation. As soon as new situations occur, the first reaction is to use standardisation by new rules or regulations. When these don't fit the new situation, the issue has to be pushed up in the hierarchy. The strategic apex, being the only element which can oversee the complete

organisation, has to decide. This might work in relative stable situations, but as soon as new situations occur more often the strategic apex will get overloaded. Especially in times of (rapid) change. Being separated, the workers have the knowledge on how to change, while the management has the power to decide. In this way, the top management is the bottleneck for change. Mintzberg gives two possible solutions for this bottleneck. Either, the organisation has to make a temporarily shift towards an entrepreneurial organisation by taking detailed lead for change from the strategic apex, or it has to empower the operating core to make the change. This would be a shift towards the innovative organisation. The machine organisation as such seems not suitable to handle change. This, as Mintzberg puts it, should not be surprising as*: "[a]fter all, machines are specialized instruments, designed for productivity, not for adaption"* (Mintzberg, p. 150).

Knowing that the machine organisation handles change poorly, how about the other, the professional organisation? In the professional organisation, coordination is achieved through standardisation of skills. Professionals have a high level of discretion within their own expertise, since the way they execute their tasks is regulated through accredited education and experience. As long as situations can be handled from the professionals standardised approaches, problems get solved in the operating core. Problems arise as soon as a new situation does not fit the standardised sets of approaches. In these cases, a single professional (or a group of professionals working together) identifies the need for a solution. Since the problem exceeds the set of skills of the professional, he has to coordinate with others developing possible solutions. Subsequently a complex selection of the best solution has to be done, trying to get consensus even in situations of conflicting interest. Besides this, Mintzberg describes the professional as loyal to his profession, but not to the place he is practising it. This loyalty, combined with the given discretion leads to reluctance to cooperate with others.

Since innovation require a comprehensive approach while the professional organisation is compartmentalised, innovation is difficult for such an organisation. As Mintzberg puts it: *"... the reluctance of the professionals to cooperate with each other and the complexity of the collective process can produce resistance to innovation"* (Mintzberg, p. 190).

4.4 Summarising on organisation theory

Summarising the above, the armed forces show aspects of both the machine and the professional organisational configuration of Mintzberg, both of which seek standardisation. It

can be concluded that the armed forces, and thus the Army, resemble the bureaucracy. Despite the vast number of rules and regulations to standardise either the work or the workflow in the armed forces, some instruments are in place to bypass this standardisation. One of the most eye-catching is the use of Mission Command and the discretion given to break certain regulations if they do not fit the situation.

Nevertheless, both organisation configurations tend to handle innovation poorly. A (temporarily) shift towards a more entrepreneurial organisation might solve this. The questions remain, whether this is feasible and how this can be done. In the next part a possible approach is discussed in search for the answer on research question three.

4.5 Strategic Technology Management and innovation

'Innovate or die' is a motto that is heard often in both business, non-profit and government sectors. But as Getz and Robinson (2003) show, one should not step over a thorough analysis and plan on what to innovate on and how to use technology. No innovation just for the sake of innovation.

This is where Strategic Technology Management (STM) surfaces. As Gregory (1995) describes, STM *"…addresses the effective identification, selection, acquisition, development, exploitation and protection of technologies needed to maintain a stream of products and services to the market".* Although this definition clearly focuses on the profit sector, most of it is valid for the non-profit sector as well. In the military setting it would not be about maintaining a stream of products or services, but maintaining fighting power. An adjusted definition for use in a military context would be; 'the effective identification, selection, acquisition, development, exploitation and protection of technologies needed to maintain the armed forces' fighting power.'

One could say that the goal of STM is to innovate. Accordingly, these two terms are combined into Strategic Management of Technological Innovation. Schilling (2017, p. 1), defines technological innovation as *"The act of introducing a new device, method, or material for application to commercial or practical objectives."* In order to improve technical innovation Schilling argues that companies or organisations should have a comprehensive strategy including a strategy for technological innovation (pp. 1-9).

Pointing at several other studies, Schilling claims that small organisations often outperform larger ones on innovation. For this reason breaking up the larger entity into smaller subunits and promote an entrepreneurial culture in these is seen as a method to deal with this disadvantage larger organisations have (Schilling, p. 215). This seems to be in accordance with the observation that visionary leadership turns strategy into organisation in the entrepreneurial organisation (Mintzberg).

Based on this observation, it seems tempting to organise technological innovation decentralised in subunits, with this entrepreneurial approach stimulated. However, there are some downsides with this approach. First of all, decentralising will make the innovation customised to this decentralised subunit. The question in that case is whether the technology serves the organisation as a whole. Furthermore, the possibility for redundancy and even ambivalence will increase. Centralising on the other hand, can have positive effects regarding to coherency of innovation. A centralised organisation with a tight command and control structure, e.g. the armed forces, is more able to impose change through the entire organisation. The downside of this is that adjustments or changes in the technological innovation have to go through the entire chain of command, which will slow down innovation (Schilling, p. 217).

The choice whether to centralise or decentralise technological innovation seems to be unresolved. *"[I]n some cases, centralization can enable significant innovation to occur more rapidly, and in other situations, decentralization fosters more innovation by enabling managers to respond quickly to local needs."* (Schilling, p. 230)

As seen with Mintzberg's machine and professional organisations, a high level of formalisation and standardisation lead to a high level of bureaucracy. This is very alike the term "*mechanistic*[9]*",* used by Schilling. Concluding that these kinds of organisations are not suitable to facilitate innovation, the alternative could be the *"organic*[10]*"* organisation. This organisation structure has an extreme low level of bureaucracy and structure, but this kind of (non-)structure seems unsuitable for larger organizations (Schilling, p. 220).

[9] *Mechanistic: an organization structure characterized by a high degree of formalization and standardization, causing operations to be almost automatic or mechanical.* (Schilling, p. 218)
[10] *Organic: an organization structure characterized by a low degree of formalization and standardization. Employees may not have well-defined job responsibilities and operations may be characterized by a high degree of variation.* (Schilling, p. 218)

A solution that certain companies, especially in the production industry, developed is the ambidextrous organisation. This kind of companies have a more mechanical organisation in their production divisions, while the divisions which focus on the radical technological innovation show a more organic structure (Schilling, p. 220). In organisations or situations where technological innovations lead to organisational change, it is hard to imagine that this is a preferable organisation. Based on this observation an ambidextrous organisation seems not always suitable for improving and implementing innovation in the armed forces.

So how can bureaucratic organisations handle modern technology? The answer on research question three seems not that obvious. It appears that, depending the kind of implications a technology has, the organisation has to choose between a central guided development and implementation or a more decentralised approach. If technology can be applied locally, a decentralised approach could be the most effective, in case of a technology with effects for the entire organisation, the central guided approach is more appropriate. Given the bureaucratic organisation as a starting point for this decision, a technology strategy in the top management is crucial.

5 Results of observations

In pursuance of research questions number three, four and five, experts working with a role in the supply chain of the Norwegian Army were interviewed. Although too few experts (5) were interviewed to do a statistic analysis of their answers, the interviews give an overview of the organisation and command & control of the supply chain, as well as an interesting indication of how they look at implementing modern technology in the supply chain. In order to analyse the results, the interviews have been transcribed in light of the research model (appendix B). Using an interview guide, the interview focused on the design of today's supply chain, C2 in the supply chain and the expectations of modern technology for the improvement of the supply chain and its C2. The following part will analyse the answers given.

5.1 The supply chain, design and C2

First of all, research question four: How is today's supply chain and its command & control organised? Referring to Listou (2015), describing supply chains as social constructions, the overview of the supply chain and its C2 given in paragraph 3.1 is not enough. In this part, the respondents' reality of the social construction is presented. All respondents gave a nearly equal description of the supply chain. Three of them chose to describe C2 starting at the National Joint Headquarter (NJHQ), the two others focused on the part they work with in practice. This section gives an overview of the respondent's perception of the supply chain and its C2. Figure 5 visualises the supply chain in the composite view.

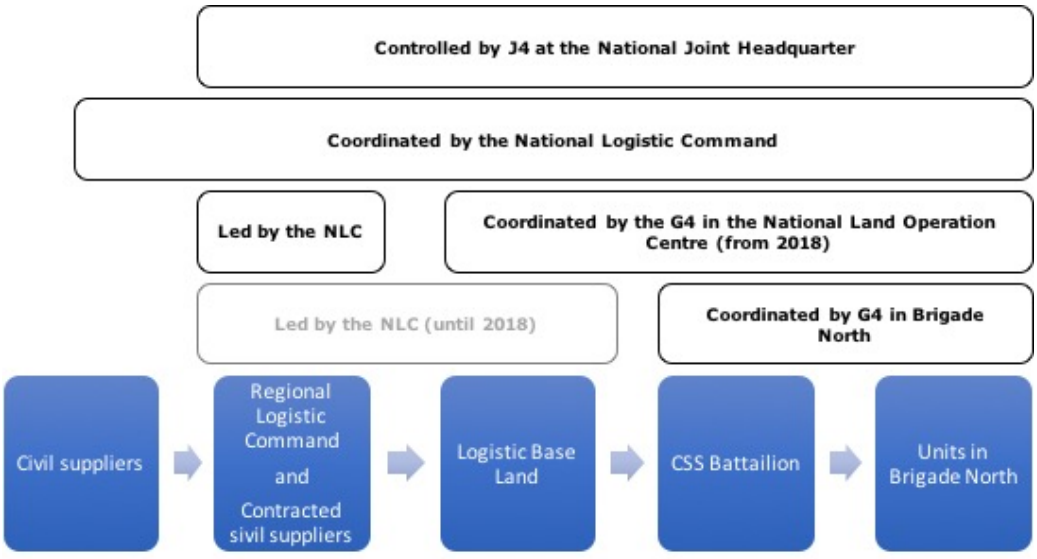

Figure 5, the supply chain described by respondents

All logistics, including supply, is controlled by the J4 branch at the NJHQ, since the Chief NJHQ is commanding all armed forces in operations. J4 is responsible for incorporating logistics into the operational plans. Based on operation plans and established standards, the bulk goods (fuel, ammunitions, potable water, field rations) supply is planned and incorporated in the operation plans.

The NJHQ has given coordinating authority[11] over logistics to the National Logistic Command (NLC), more or less enabling the NLC to execute logistics on behalf of commander NJHQ. The NLC is the executing body of the NDLO within the command structure of the Armed Forces. In the near past, the NLC led both Regional Logistic Commands and Logistic Base Land. Most respondents pointed out that from 2018, Logistic Base Land (LBL) will be a part of the Army, as described in the Defence White Paper (Forsvarsdepartementet, 2016, p. 81). Until 2018, the G4 branch in Brigade North's headquarter is coordination all logistic. From 2018, a tactical headquarter for the Army, the National Land Operation Centre, will be established (Forsvarsdepartementet, p. 56). Although it has not been decided on a new distribution of responsibilities yet, four respondents expect the Chief of the Army to take lead in the supply chain through a new G4 level at the tactical headquarters.

All respondents call for a clarification of responsibilities in the chain. At the same time, there is a general expectation that the new structure of the armed forces, as given in the White Paper, will result in in more clarified roles and responsibility. An interesting observation, stated by three respondents, is the fact that the supply chain has never been put to the test. Thereby it remains a theoretical construct, its functioning never been tested in real life.

One respondent pointed at another topic in the White Paper. The Norwegian Government intends to review the entire support structure of the Armed Forces, including logistics. The desire is to rely more on civil suppliers. In his point of view, this askes for an adequate interface between the civil and military part of the supply chain.

[11] The authority granted to a commander or individual assigned responsibility for coordinating specific functions or activities involving forces of two or more countries or commands, or two or more services or two or more forces of the same service. He has the authority to require consultation between the agencies involved or their representatives, but does not have the authority to compel agreement. In case of disagreement between the agencies involved, he should attempt to obtain essential agreement by discussion. In the event he is unable to obtain essential agreement he shall refer the matter to the appropriate authority. (NATO, 2013, p. 2C15)

Summarising and answering research question three, one can conclude that the respondents' reality of the supply chain corresponds largely with the description given in paragraph 3.1. Nevertheless, the respondents point out the need for more a clear distribution of responsibilities among the actors in the supply chain. In general, they expect the establishment of a tactical command at army level to partly solve this issue.

5.2 Expectations of modern technology

As part of the survey to identify promising emerging technologies for the Army's supply chain, the respondents were asked questions related to research question five; Which emerging technologies are most promising for the Army's supply chain? Naturally these questions were combined with research question six; What are the disadvantages of implementing modern technology? This paragraph summarises the observations.

The highest expectations of modern technology were on improving forecast abilities. Four of the five respondents reported high expectations in this field. Expectations vary from the improved use of existing data technology, up to automated reporting from weapon systems into the supply chain. This improvement would increase the logistical situational awareness, also known as the recognised logistical picture (RLP). Four respondents believe that making better use of the current Enterprise Resource System (ERP), would be a tremendous step forward in improving the supply chain.

> About a decade ago, SAP was chosen as the new integral ERP system for the Armed Forces. Its implementation started in 2002 and is spread over several sub-projects. The latest project, FIF 3.0 is focused on logistics, including a joint solution for acquisition, supply, maintenance, material management, finance and deployable solutions. It started in 2011 and became available for users in 2016. It is meant to give better access to logistical information across the Armed Forces by sharing it across branches and disciplines, while data only needs to be registered once. (Forsvaret, 2015)

The lack of (secure) bandwidth when deployed is given as one of the reasons why SAP has not yet given the expected improvements. Furthermore, one respondent stated that the basic information needed to forecast supplies is not up to date, it is partly based on experience dating from the last century. According to this respondent, the effect of this out-of-date information is that executing supply in the Army often is based on "gut feeling".

Two other respondents took forecasting one step further. They expect it to become possible to connect weapon systems into the logistical network. In this way, it would become possible to have the weapon system reporting on fuel consumption, ammunition, needed repairs and spare parts, etc. Combined with shared information on its location and activity, a sophisticated computer program could be able to predict the system's supply needs and the best location and moment of resupply.

All respondents point out rigidity around information security and network security as a constraint when taking into use data tools. The high demands on information security exclude several systems available on the open marked, since these often use relatively open connections over the internet. As one respondent summarised:

> *"The Armed Forces have a special need for classifying and shielding information. In practice, many of the available and network-based logistics solutions are not approved by the Norwegian National Security Authority (NSM)*[12] *and/or the Defence Security Department (FMA)*[13]*."*

Other respondents exclaimed similar constraints linked to the use of network based logistic data systems. The constraints associated with security are obstructing implementation of modern data tools in the logistical field according to two respondents.

All respondents have a strong believe that modern technology eventually will improve the supply chain. At the same time, they point at the increased vulnerability of the supply chain due to reliance on networks and digital products. They urge for redundancy and a back-up-plan for situations where the support system is off line or compromised by enemy actions.

5.3 Other findings

Besides expectations on clarification of responsibilities and on technological based progress, four respondents reported that the supply chain has not been tested to its full extent. During exercises the focus is on combat units, leaving the supply chain to cover the real-life support of the exercise. They have the feeling that exercising the supply chain, either in real life or in simulated environments would improve both the supply chain itself as well as the general

[12] The Norwegian National Security Authority (NSM) is a cross-sectoral professional and supervisory authority within the protective security services in Norway.
[13] The Defence Security Department (FMA) focuses on security and counterintelligence within the department of defense.

officer's understanding of supplying an army. One respondent reported that during a simulated exercise in 2016, the volume of supply and transportation for the first time became clear to most of the present participants, all experienced planning officers.

This points clearly at competence as an area of improvement. But not only competence as a general understanding of supply in the Army has been mentioned by the respondents. Many answers given point at the need to build competence and experience in the use of SAP as a supporting tool in the supply chain. Both in order to convince people of the need to fill the system with accurate data, as well as to use its reporting possibilities in planning and executing for supplying.

As mentioned before, one of the respondents pointed at the White Paper and a more civil engagement in supplying the Norwegian Armed Forces. He clearly pointed out the framework agreement with civil corporations for supply of the Norwegian Home Guard (Skipsrevyen, 2015) and (Forsvaret, 2016). By contract, these two civil corporations have become responsible for setting up and supplying Home Guard units directly in their assigned geographical location in case of a national crisis. If these agreements are to become a model for the future supply of army units, the respondent argued that the focus of C2 in the Army's supply chain has to be on the interface between the civil and military world. Both in the information domain as well in the physical domain.

Another issue brought up by two respondents was the threat to large logistical and stationary, installations. According to threat analysis and experiences from e.g. the battles in Ukraine (also acknowledged by the Dutch study on the development of logistics (Koninklijke Landmacht)), any unit which is stationary for longer than 2 hours will be attacked with long range precision weapons. This askes for *"a compromise between maximising mobility and security versus physical protection".* In other words, small mobile units with a high level of independence.

6 Identifying promising technology

This chapter seeks an answer on research question five; Which emerging technologies are most promising for the Army's supply chain. In an attempt to identify these most promising emerging technologies the following set of different documents and expert opinions is used to get an overview on available and recognised technologies.

- The Logistic Trend Radar, by DHL (Kückelhaus & Chung, 2016);
- The Australian DoD scoping study on automated and autonomous systems for CSS (Ivanova, Gallasch, & Jordans, 2016);
- A Dutch study on smart and robust logistics in the land domain (Koninklijke Landmacht, 2017);
- Globale Trender mot 2040; FFI-rapport 2015/01452 (Beadle & Diesen, 2015);
- Answers on question number 10 of the interview guide.

Based on this overview and the expected influence on command & control of the supply chain, research question six will be answered.

6.1 Logistic Trend Radar

The Logistics Trend Radar (Kückelhaus & Chung) is one of the most comprehensive reviews of future trends, projecting both social and technological trends. It is periodically issued by DHL Trend Research, a division of Deutche Post DHL Group. Although not an independent source, it is seen as *"...an inspiring benchmark for strategy and innovation"* (Cichosz, Goldsby, Knemeyer, & Taylor, 2017). The DHL Logistic Trend Radar shows 12 technology

trends, divided in high, medium and low impact technologies arranged two groups. The first those with expected impact within 5 years, the second with expected impact beyond 5 years.

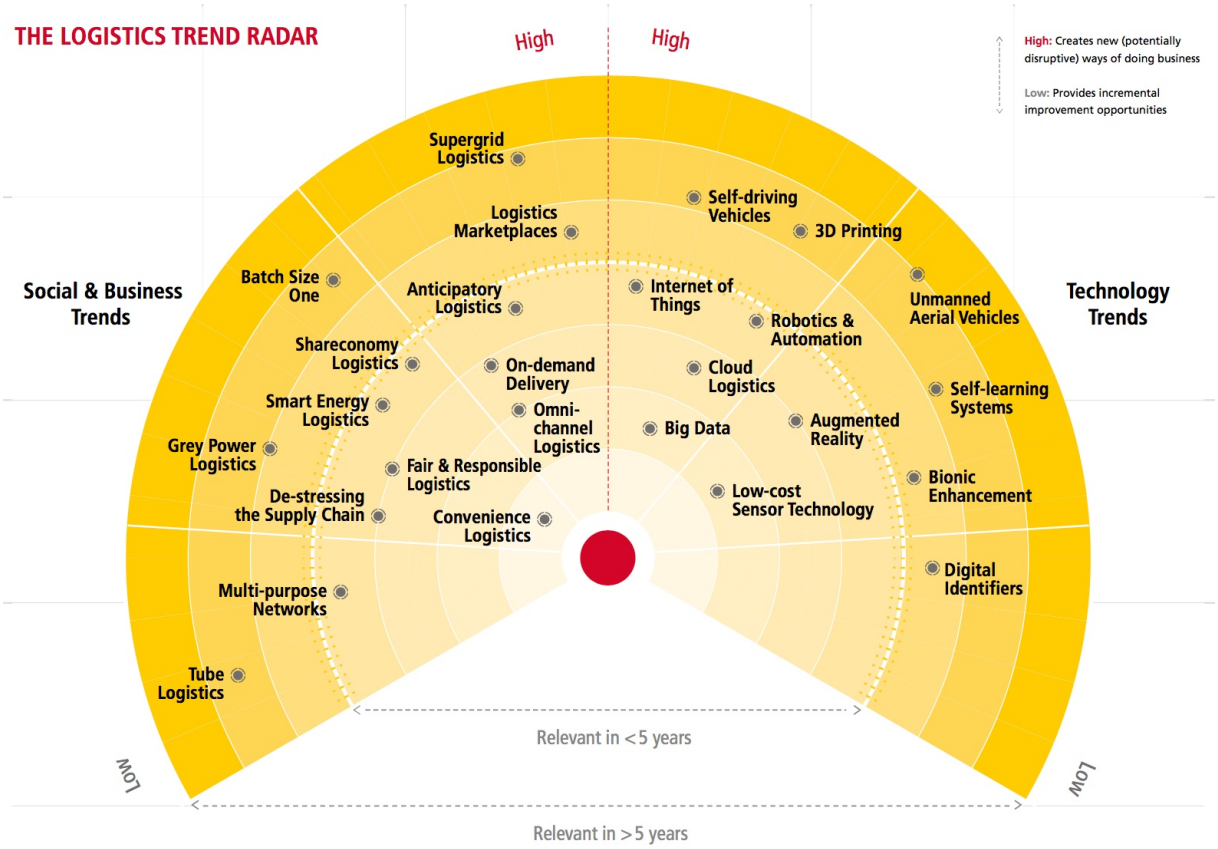

Figure 6, the logistics trend radar by DHL (Kückelhaus & Chung)

Naturally, the DHL Logistic Trend Radar has a focus on business logistics. Nevertheless, a lot of the described technologies could have impact in a military supply chain as well. Especially those with high impact (close to the centreline of figure 4). A short description of the technologies with high impact will be given.

Big Data: Large amounts of data are being used in logistics. It is expected that analysing this data can have the potential to improve the supply chain, optimising *"capacity utili[s]ation"* (p. 17) and reduce risk.

Internet of Things: Combined with Low-cost Sensor Technology, this will enable systems to be an active part in the supply chain by generation orders automatically. As well as automated monitoring of supply goods in stock and on the move.

Robotics & Automation: Combined with Self-Driving Vehicles and even Unmanned Aerial vehicles, this might enable a more reliable logistic process and open opportunities for delivery even in the most hostile environments, without putting a man's life on the line.

6.2 Australian Department of Defence: Automated and autonomous systems for Combat Service Support[14]

In 2016, the Australian Department of Defence conducted a study on opportunities for the use of automated and autonomous systems within Combat Service Support (Ivanova et al.). The study started with a technology scan resulting in a large number of emerging technologies in logistic field. This number was narrowed down through a review of military technology reports, discussions with Australian Defence Force logistic officers and finally through a workshop with Australian Army subject matter experts on logistics. This resulting in three promising technologies for the Army's supply chain:

- Predictive analytics
- Unmanned Aerial Systems for last-mile logistics
- Semi-autonomous convoys

6.3 Smart and robust logistics

As part of the Further Development of the Armed Forces[15] the Netherlands Army Logistic School conducted a study on the development of logistics in the land domain (Koninklijke Landmacht, 2017). Promising technology for the Army's supply chain was not presented as such, nevertheless it is clear that it takes the following emerging technologies as starting point for describing future army supply chains:

- Electric drive
- Autonomous systems for supplying the troops (UAV/UGV[16])
- Predictive analytics
- Additive manufacturing or 3D printing

[14] The support provided to combat forces, primarily in the fields of administration and logistics. (NATO, 2013)
[15] Translated by the author from Dutch: "Doorontwikkeling Krijgsmacht" (DOKM), a comprehensive study by the Dutch Department of Defence on the Development of the Armed Forces.
[16] UAV: Unmanned Aerial Vehicle, UGV: Unmanned Ground Vehicle.

6.4 Globale Trender mot 2040

The Norwegian Defence Research Establishment's report 'Globale Trender mot 2040' (Beadle & Diesen) is a comprehensive report on global trends for the development Norway's security and defence strategy. As such it is not meant to give insights in specific technological developments in the field of logistics. Nevertheless, it foresees two technologies which also have its implications on the supply chain. Firstly, the further development of information technology. Until now this technology has been used to improve existing materiel and concepts. In the next 10 to 20 years information technology will supposedly change the way the military (and thus the military supply chain) works. This prediction is based on the expected synergy effect between (1) improved sensor technology, (2) improved real-time information and communication technology and (3) improved guiding of long range weapon systems. The latter of course has little direct relation to the Army's supply chain.

Secondly Beadle and Diesen (2015) foresee an increased focus on unmanned systems in all domains (land, maritime and air). Although motivated by the wish to reduce own losses, it can have interesting implications for the supply chain.

6.5 Norwegian Subject Matter Experts

Although a more extensive transcript of the interviews has been given in chapter five, a short repetition of the subject matter experts opinion on promising technology. As part of the survey on emerging technologies, the respondents were asked to list promising technologies from their point of view. Although other technologies were mentioned, the two of which they have the most expectations are predictive analytics (also mentioned as automated ordering) and unmanned vehicles in the supply chain.

6.6 Summary

To find an answer on research question five, the different expectations of new technology have been classified based on resemblance. This resulted into four categories of technology: Information Technology, autonomous vehicles and/or drones, Additive Manufacturing and 'Other Technologies'. Table 2 lists the technology expectations in the field of logistics, especially CSS from all sources.

As described in the first chapter, additive manufacturing technology lies beyond the scope of this master's thesis. The category 'Other Technologies' is too diverse to result in further general implications for command and control in the supply chain. Thus, answering on research question six, two categories remain as the most promising technologies for further analysis of their influence on the C2 of the supply chain; Information technology, especially predictive analytics and forecasting, and autonomous aerial and ground vehicles.

Table 2: technology expectations in CSS

	Common denominator			
Source	*Information technology*	*Autonomous vehicles and/or drones*	*Additive Manufacturing*	*Other Technologies*
Australia	- Predictive Analytics	- Unmanned Aerial Systems for distribution in the 'last tactical mile'		
Netherlands	- Predictive Analytics	- Autonomous systems for supplying the troops	- 3D Printing	- Electric Drive
Interviews	- Predictive Analytics / forecasting - Automated ordering	- Autonomous Vehicles	- 3D Printing	- Solar Energy - Simulation
Globale Trender FFI	- Information technology will change military organisations and concepts.	- Increased focus on unmanned systems.		
Logistic Trend Radar (DHL)	- Big Data - Internet of Things - Low-cost Sensor Technology	- Self-Driving Vehicles - Robotics & Automation - Unmanned Aerial Vehicles	- 3D printing	- Augmented Reality - Bionic Enhancement - Digital Identifiers

7 Promising technologies further examined

Before discussing the influence of information technology and unmanned vehicles on command & control of the supply chain, a closer look at these two technologies is necessary. What do they imply? This chapter will elaborate on these two technologies, before chapter eight discusses the influence on C2 of the supply chain.

7.1 Information technology

As described before, the expectations on information related technologies are high. Chapter six and paragraph 5.2 show high expectations especially on Data Science, Predictive Analytics and Big Data (DPB). Before analysing the consequences and possibilities of DPB in the C2 of the supply chain, a closer look at the terms Predictive Analysis and Big Data is necessary.

Being a relative new field of research, there is little literature and no consensus on the terminologies involved in DPB and its implication for SCM or C2 of the supply chain yet (Gunasekaran et al., 2017; Provost & Fawcett, 2013; Schoenherr & Speier-Pero, 2015; Waller & Fawcett, 2013). The next part will deal with the definitions of Data Science, Predictive Analysis and Big data. In the light of the scarce number of publications on the topic, these are mainly, but not entirely, based on the publication of Waller and Fawcett (2013).

Data Science

Provost and Fawcett (2013) describe Data Science as *"a set of fundamental principles that support and guide the principled extraction of information and knowledge from data"* (p. 52). This includes data-mining, but also the ability to analyse business problems from a data perspective. Applying Data Science requires both analytical skills and profound knowledge of the business in which it is applied, also referred to as domain knowledge (Waller & Fawcett). This connection and requirement for domain knowledge led to a proposed definition for SCM Date Science by Waller & Fawcett:

> *"SCM data science is the application of quantitative and qualitative methods from a variety of disciplines in combination with SCM theory to solve relevant SCM problems and predict outcomes, taking into account data quality and availability issues." (p. 79)*

This definition seems to be the best available at the moment, although the authors welcome any research to either verify, adjust or reject their definition.

In a military context, the requirement of domain knowledge in order to be able to apply Data Science requires employees with both knowledge and experience on military (logistic) operations as well as a wide set of analytical skills. Given the fact that there are very few organization apart from the Armed Forces where one can gain experience on military operations, this leads to the conclusion that the use of SCM Data Science in the military context has to have a military component. Data scientists with experience in military logistic operations seems to be a prerequisite for the use of Data Science in the Army's Supply chain.

Predictive Analytics.

In their article, Waller and Fawcett (2013) propose a definition for Supply Chain Management (SCM) predictive analysis:

> *"SCM predictive analytics use both quantitative and qualitative methods to improve supply chain design and competitiveness by estimating past and future levels of integration of business processes among functions of companies, as well as the associated costs and service levels." (p. 80)*

Although this definition focuses on commercial business, it can be used for non-profit or military use as well. Its focus is on the improvement of SCM or in the military context on the C2 of the supply chain. Even though this could be a way to use predictive analytics, the expectations for use in the military supply context are more on using predictive analytics in order to improve the execution of supply. In that context, the proposed definition of logistics predictive analytics seems more suitable:

> *"Logistics predictive analytics use both quantitative and qualitative methods to estimate the past and future behaviour of the flow and storage of inventory, as well as the associated costs and service levels" (Waller & Fawcett, p. 80)*

Both definitions point at quantitative and qualitative methods as the tools used for an analysis which leads to an estimate on future (and past) behaviour. Shmueli and Koppius (2011) use the predictive analytics for the building and assessment o models aimed at making empirical decisions. Whereas 'empirical' points at the use of facts as the basis for predictions about future behaviour or observations. Both Shmueli & Koppius and Waller & Fawcett point out statistic and data mining as disciplines used in predictive analytics. The latter extends the list

of disciplines with forecasting, optimisation, discrete event simulation, applied probability and analytical mathematical modelling. It is underlined that these disciplines are related to predictive analytics, but they seem less comprehensive. Statistics is a quantitative discipline whereas predictive analytics is both quantitative and qualitative as described in the given definitions. The same with forecasting, which is about the future, whereas predictive analytics is about the past and the future (Waller & Fawcett).

The question arises what a military supply chain can do with predictive analytics. The answer seems obvious; to predict future behaviour or consumption based on a given scenario and/or plan for the operation. But what are these analyses built on? What is the input for predictive analytics? This is where ‘big data’ comes into play.

Big data

Big data is a widely used term, often used to describe terms as defined above. In a literal sense, it points at the infinite amount of available data which has become available since the beginning of the digital age. In one of his video lectures, Hilbert (2015) elaborates on the term big data using five characteristics. He explains it being a lot of data (1), which becomes available as a result of our (digital) activity, a ‘digital footprint’ (2). Given the fact that human activity is not recorded comprehensively, not every database is complete, but the amount of big data makes it possible to fill information gaps from one database with information from another. Databases are complementary to each other by using ‘data fusion’ (3). Another characteristic is the nearly real-time availability (4) of big data. Hilbert describes the effect the vast amount of data has had on machine learning as a fifth characteristic, but one can discuss on whether this is a characteristic or a result.

Summarising, big data is exactly what the words say. A vast amount of available data, often generated in real time by every entity with a role in the digital world (both humans and machines). Given its magnitude big data can be ‘internally’ complementary.

As described above, big data is the basis for predictive analytics. As such, the next question that arises is if and how much big data is available in the military supply chain. This will be discussed in chapter 8.

7.2 Autonomous vehicles

Before the influence of autonomous vehicles on C2 of the supply chain can be discussed, one has to define what these systems are. As such, unmanned vehicles are nothing new. After the World War I, the Russian Army experimented with a radio-controlled tank, the 'Телетанк'. These vehicles were remotely controlled from other tanks and were used in the 1939 Soviet-Finnish war (Forsvarets forskningsinstitutt, 2016, p. 12; Телетанк). In modern wars and operations, the use of unmanned, but remotely piloted vehicles, both on ground (UGV) and in the air (UAV) has become quite common. Examples of these are remotely piloted vehicles to dismantle bombs and ordnance, the Black Hornet Nano, the MQ-1 Predator, etc.

The real emerging technology is the autonomy of movement. Using modern technology, it has now become possible to let the vehicles move autonomous to their destination. Autonomous systems not only move automatically, but they are able to react intelligent on unexpected situations (Forsvarets forskningsinstitutt, p. 12). The last fifteen years, scientists and industry have been developing this technology and readiness is almost met. The remaining problems are connected to the perception of the environment (Anderson et al., 2014, p. 74). On these issues, there seems to be a difference between aerial and ground vehicles. The environment in the air tends to be less complex than on the ground. On aerial systems several solutions are under development, already in 2013 there were successful trials with the 'AirMule' (Tactical Robotics Ltd, 2013), an autonomous aerial vehicle that can evacuate two casualties.

Although in the civil world autonomous cars are developed at high pace, e.g. Google's Driverless Car initiative (Anderson et al.), in the military context, where vehicles go off-road, autonomy is still under development. Nevertheless, the technology is promising.

It is expected that the development of automated and autonomous ground vehicles in logistics will be done by civilian corporations first, before the armed forces will implement them. These might either be self-driving trucks, delivering goods in a convoy with people-driven vehicles, smaller vehicles autonomously delivering goods to soldiers on remote and non-permissive locations or any other variant suitable for the military (Forsvarets forskningsinstitutt, p. 15).

8 Discussion

In this chapter, the influence of the identified emerging technologies on the command and control of the supply chain is discussed. The discussion will be structured along, and based on the research questions. Discussing the presented theory and research findings, this chapter will finally answer the main research question:

> **How does modern technology influence the command and control of the Army's supply chain?**

8.1 C2 of the supply chain

What is command and control of the supply chain? It is defined as the set of organisational and technical attributes and processes used to organise and execute supply of (army) units synchronised with the other joint functions, in order to support the military mission. Although one might say that this is very similar to the definition of Supply Chain Management, the difference lies in the synchronisation with the other joint functions and the emphasis on supporting a military mission. Unlike most civilian supply chains, the military supply chain is designed to function in 'just-in-case' scenarios as part of a military organisation. It is designed to function in situations where everything else has come to a halt. This is reflected in the motto of the Dutch Army: *"Doorgaan waar anderen stoppen"* (Mediacentrum Defensie, 2016); translated: *"To continue where others halt"*.

Considering the increasing reliance on commercial concepts e.g. outsourcing, partnering and Performance Based Logistics (PBL) (Listou, p. ix), SCM could be considered a more appropriate term. However, being a just-in-case organisation, the armed forces use the term C2 instead of management. With respect to the link with the other joint functions and to refer to common military terminology, the term command & control is concluded as preferred instead of the term Supply Chain Management.

8.2 Characteristics of military organisations

What are the characteristics of military organisations from an organisational theoretical perspective? Applying Mintzberg's model of configurations, military organisations have aspects of both the machine organisation and the professional organisation, both of which are

organisations using standardisation and can be characterised as bureaucracies. The Army uses a large set of rules, regulations, job descriptions, etc., to standardise. Meanwhile, instruments to circumvent these when necessary, such as Mission Command, are in place. Nevertheless, based on the Army being either a machine- or a professional organisation, organisational change is handled poorly. The vast set of rules, regulations and standing operation procedures have become a kind of culture in the military. Things are done in ways they always were done. This has been confirmed by one of the respondents stating: *"The organisation's institutional memory will hamper the implementations of new technology"*.

On the other hand, the tools like e.g. Mission Command and the encouragement to take initiative should make it easier to innovate. On the tactical level, especially in smaller units, this might be true. Deployed units often show a 'can-do' approach, where they solve issues by creatively making use of the means available. During missions abroad, the researcher was more than once impressed by the ingenious solutions of military logisticians in order to get things done or to improve daily work. But this is a balancing act when in military operations. When engaging combat, either deliberately or as a result of enemy initiative, there is no room for informal discussions on how to react. In those situations, the drill, training, standard operating procedure has to take over in order for the "machine" to function.

On a larger scale, when changing environment meets the entire organisation, innovation meets the current set of regulations and rules. If innovation does not fit into these, which naturally is the case with innovation, the issue has to be raised to the strategic apex. In the machine organisation, the amount of information in the strategic apex will be too large to make timely decisions in the top, in the professional configuration, the strategic apex will lack the knowledge to decide. Both situations will at the least slow change down.

The armed forces can be characterised as bureaucratic, with characteristics of both the machine organisation (standardisation of work processes) and of the professional organisation (standardisation of skills). Since the armed forces are rather centralised in organisation, the machine organisation configuration is the more appropriate one to describe the Army. Although in some highly specialised areas the organisation is more decentralised, possibly more resembling the professional organisation configuration.

Back to the research question. What are the characteristics of military organisations from an organisational theoretical perspective? Based on the Army resembling the machine

organisation most, it can on one side be described as efficient, reliable, precise and consistent. On the other side, it has an obsession with control which eventually leads to adaptation problems at the strategic apex. It has a resistance to change and might need a (temporarily) switch to an innovative configuration to overcome this (Mintzberg, p. 132).

8.3 Handling technology

How can organisations handle new technology? It appears that, depending the kind of technology, the organisation has to choose between a central guided development and implementation or a more decentralised approach. Since the machine organisation is the dominant configuration of the Army, there is probably a preference for central guided development. But is this effective?

As LeMay (2009) wrote, the commander has a critical role in identifying and implementing new technology, acknowledging the role of a central leader in handling technology. Regarding logistics, or supply, commanders like General Dennis Reimer seem to underline this by calling for a revolution in logistics. On the other hand, based on experience, not every commander is equally concerned of logistics, possibly resulting in a reduced focus on implementing new technology in the supply chain. Nevertheless, there are many reasons why technology implementation should be handled centrally.

If the technology is going to have an effect in the entire organisation, the only entity in the machine organisation with the authority to imply change is the strategic apex. Furthermore, especially in cases where characteristics of a professional organisation come to play, there is need for a central guidance in order to define the technology to implement. If not, professionals might end up sub-optimising in search of the best solution for their expertise. Resulting in increasing costs and delayed implementation. This is illustrated by one of the respondents during the interview.

> *"In the [Norwegian] Armed Forces we have had a tradition to modify every acquired system to a 'Norwegian' model. This increases the products costs and delays the delivery, since the adjustments often require a lot of time. The result of this often is delivery of (near) obsolete systems by the time they are ready developed.*

Followed by:

> *"We should buy of the shelf and only make small reasonable adjustments. As a result, we might have to, and must adjust routines, regulations, etc."*

Referring to the former reason, authority is needed to change routines, regulations, procedures, etc. Besides the above, as another respondent said, *"[i]mplementing new technologies requires often retraining of employees, which is a time-consuming process"* as well as costly. In machine organisations, expenditure has to be approved in centralised budget processes, which askes for central leadership.

However, as Schilling (2017) found, it is not always centralisation which is the best way to implement new technology or in other words, to innovate. Based on the conclusion that (large) machine configured organisations are not as able to adapt or innovate as smaller, more entrepreneur configured organisations, an ambidextrous approach was presented to innovate within machine organisations. In organisation, the 'normal' work is done as it used to be, while separate parts or divisions with an organic structure focus on technological innovation. The low level of bureaucracy and structure in organic organisation tends to foster innovation, because this opens for experimentation and improvisation (Schilling, p. 218). This bypassing of bureaucracy and hierarchy is also signalised by respondents. One of them said:

> *"We are used to sticking to our old habits, like dinosaurs. Perhaps it's time to bring our younger colleagues into play, without staying too hierarchical. The dinosaurs do not realise yet they are going extinct"*

This indicates a certain will to use the 'digital natives', the younger generations[17] that already are immersed in modern technology (Vassiliou et al.). Empowering them with a level of authority or direct support from the strategic apex can circumvent the filtering layers of 'dinosaurs' in the technostructure. In a way, this is a form of centralisation as well.

The down-sides of isolating innovation within the organisation cannot be denied. Being isolated, teams can get tunnelled in their vision, developing solutions that no longer support the organisation's goals. Further, depending on the composition of the innovating team can be one-sided, leaving valuable experience aside. Additionally, the more innovation is developed

[17] In this case, younger generations are not necessarily younger in age. It is the acquaintance with modern technology which defines the 'generation'.

in an isolated environment, the more resistance it might provoke on implementing in the organisation. No dinosaur likes being told he is going extinct.

Concluding, it can be said that involvement of leadership at the strategic apex is essential for successful implementation of modern technology, also known as innovation. Both in a centralised, as well as in a more ambidextrous organisation of innovation leadership's role is essential. Being a machine organisation in nature, it is up to leadership to decide on how to organise implementation of new technology. Choosing which organisation configuration fits best to the organisational needs, depending the kind of technology and based on a technology strategy.

8.4 The supply chain

How is today's supply chain and its command and control organised? As shown in figure 2, the supply chain design within the Army is quite straightforward. Based on prognoses, goods are pushed through a chain of installations. Starting at NDLO/NLC warehouses, through LBL, the CSS battalion and eventually ending when delivering supplies to army units. The reality however, is more complicated.

First of all, not all supply goods are delivered based on prognoses and Standard Days of Supply. Especially spare parts and ammunition consumption is hard to predict. One of the reasons for this is the calculation tools not being up to date. Another reason is that consumption will vary depending the kind of combat intensity. Calculations based on consumption will first become available after battle, too late for prediction. As a result, the need for communication and coordination in the chain increases. Unpredictable consumption has to be ordered, causing unanticipated demands. Secondly, not all deliveries follow the chain. As mentioned by the respondents, goods will be delivered directly from civil suppliers to army units, bypassing one or several stations in the supply chain. This also, will increase the need for communication and coordination. As one of the respondents expected the LBL to become the central entry point for supply goods, others point out that supplying the Army might become even more outsourced, referring to the supply concept of Home Guard units. An issue confirmed in the Defence White Paper (Forsvarsdepartementet).

The authority to design the supply chain is given to the director of the NDLO, on behalf of the Chief of Defence (Forsvaret, 2014a). During operations, the chief of the NJHQ, assisted of its

J4 branch, holds command and control over the supply chain. The NJHQ integrates logistics (and thus supply) together with the other joint functions into synchronised operational plans. Executing and coordinating supply to all branches is been delegated to the NLC, which is a part of the NLDO. On the tactical level, commanding both the brigade with its CSS battalion and the operational support unit with its LBL, the Chief of the Army seems to have command and control over the army part of the supply chain. As concluded in paragraph 3.4, this is only C2 over the tactical execution of supply. The command and control of the supply chain is in the hands of the NDLO/NLC.

Although the command and control relations are described in formal and draft documents (Forsvaret; Hæren), one can easily see room for misinterpretation and confusion based on the summary above. All respondents identify the ambiguity in command and control of the supply chain. The establishment of a National Land Operation Centre with a G4 branch at the army level is seen as a possible solution to solve this ambiguity. In this way, the Chief of the Army could take command of control over the army part of the supply chain. In that way, being the custodian on land operations, he can take responsibility for all activities on land.

Whether this is true remains to be seen. Another respondent pointed out a more clearly defined role for the NLC as 'single point of service' in supply, confirming the NLDO/NLC should remain to have command and control over the supply chain. Starting with the provisions on increased reliance and use of civilian logistical solutions in Prop 151 S. (Forsvarsdepartementet), the armed forces will be forced towards more intensive contact with civil suppliers. Having major parts of the logistics outside hierarchical control, requires civil inclusion in military decision making processes (Listou). With its experience, network and focus on the civilian side of the supply chain already today, the NLDO is the more appropriate entity having C2 over the supply chain. This requires trust between the Army, as a customer ordering and receiving supplies and the NLDO as entity coordinating (civil) delivery. Investigating governance mechanisms in network relations Haugland and Grønhaug (1995) conclude: *"If the actors are dependent upon each other, trust may be the most dominant governance mechanism"*(p. 378). There is only one way to develop mutual trust in military operations; intensive training over time. Again, a reason to include (civil) suppliers.

Back to the research question. How is today's supply chain and its command and control organised? Concluding one can say that both the supply chain and its command and control

are described in official documents. In practice, there is divergence in how this is executed, leading to an ambiguous situation. Although no agreement between respondents, the NDLO is the most appropriate entity to have command and control over the supply chain. Leaving the Army to have the responsibility and authority over the tactical execution of supply operations. Siting one of the respondents: *"The CSS battalion concentrates on the tactics of delivering the supplies and has no active role in C2 of the supply chain"*.

8.5 Most promising technologies

Which emerging technologies are most promising for the Army's supply chain? A survey of research on emerging technologies combined with expert expectations resulted in two promising technologies with expected influence on the supply chain. The first is information technology in form of Data science, Predictive analytics and Big data (DPB), the other the introduction of autonomous vehicles in the supply chain.

The three elements in information technology cannot be seen separated from each other. Data science describes the science of analysing data in order to solve (SCM) problems. Data scientist analyse data, based on knowledge of their business and their analytical skills. It can be seen as a prerequisite for predictive analytics. Both data science and predictive analytics build on the availability of big data, generated by our digital activity. Are these technologies implementable in the Army's supply chain?

Being a prerequisite for both data science and predictive analytics, big data has to be available if these technologies are to be used. Does the Army generate enough data to call it big data? Many systems in the Army are digitalised or will be digitalised in the future. The best example of this is the infantry fighting vehicle CV90, which has a large number of different sensors and computers, able to generate data on e.g. location, expected maintenance, fuel level, remaining rounds of ammunition, etc. It is to be expected that other future systems will have similar possibilities in generating data. At this moment, there is a development project ongoing in the Dutch Army to equip soldiers with sensors that can report on location, health, available rounds in the personal weapon, etc. Other sources of big data are more common. One can think of information on weather and terrain characteristics, enemy weapon systems, availability of civil infrastructure, etc. Based on this, one can conclude that there is a technical possibility to generate big data. On the other hand, compared to the huge client databases of companies like e.g. Amazon.com or Facebook, any database generated by the Norwegian

Armed forces cannot be considered a big database. Before starting to invest in information technology an analysis of the size or available databases has to be considered. Another option would be to share information with the big data of suppliers to the armed forces. This could enable them to act proactively on during operations. The downside of sharing information with suppliers is the increased security risk as described by Bestum (2016, p. 52).

In order to analyse big data and use it both in data science and predictive analytics, the armed forces will need personnel with adequate analytical skills. However, analytical skills alone are not sufficient as Waller and Fawcett (2013) and Provost and Fawcett (2013) proved. Data science and predictive analytics require both analytical skills and profound knowledge of the business in which it is applied. Although this domain knowledge could be experience within the field of supply in general, given the characteristics of military logistics, profound knowledge of military operations will be necessary. Does this mean only soldiers can apply for functions as predictive analysts? On the one hand, in the short term, this might be true, but in the longer term there might be another possibility as well. Given the right quality of big data, it could become possible to program automated algorithms or even self-learning artificial intelligence that can predict consumption and automatically order the right supplies in advance.

Autonomous vehicles open a complete other realm of possibilities for the supply chain. Although civil corporations like Google, Audi, Tesla and several more are researching and developing autonomous driving vehicles, these are not available yet. Nevertheless, it does not require much imagination to understand that these kinds of vehicles are on the verge of entering commercial markets. How can these be used in the Army's supply chain? Based on the progress of technology, it is possible today to use these kinds of vehicles in the convoys traveling from (civil) warehouses towards the forward installations of the LBL or CSS battalion. A next step will be automated vehicles moving to (remote) locations without having to rely on road infrastructure. Technology has made the most progress in using aerial vehicles for this purpose. A commercial example is the DHL Parcelcopter (Kückelhaus & Chung, p. 45). In military context progress is being made on this as well, as e.g. the earlier mentioned 'AirMule' (Tactical Robotics Ltd). But robots/vehicles with enough stability to go off-road are being developed at high pace, such as e.g. Boston Dynamics (2017) its models.

Autonomous vehicles have the advantage of lacking a person operating the vehicle. This will remove ethical and trust issues in situations where civil suppliers deliver directly to army units in hostile environment. Interview respondents showed hesitation on having civil suppliers too close to the battlefield. In the first place, the drivers delivering goods are non-combatants entering a war zone with all the ethical implications. Secondly, truck drivers in logistics come from all over Europe, which make one wonder if they would be loyal enough to a country to enter these dangerous situations at all. Removing the human from delivering vehicles will remove these disadvantages as well.

A further development step might be the combinations of sensors in the Army updating the 'army big data cloud', generating predictions on consumption and an artificial intelligence system anticipating and sending out autonomous vehicles without any person intervening this process. But in 2017, this might be a conceptual bridge too far yet.

8.6 The other side of modern technologies

Before answering the main research question, the last research question remains: What are the disadvantages of implementing modern technology?

Assuming, for the sake of argument, the data generated by the armed forces is big enough to call it big data, can it be used in analysis? In order to analyse data, it has to be collected in accessible databases. Collection will partly be done in real time over available networked connections. Even if this is technologically possible, it will increase the broadcasting signature a deployed unit has, making it easier to detect by the enemy. Furthermore, as one of the respondents said, many of the available technologies are based on civil network standards. It is doubtful if the FSA and/or NSM will approve these in the armed forces. Additionally, containing all kinds of data on armed forces, databases will become true gold mines for analysts, both own and those working for opposing intelligence services. On the other side technology is under constant development. Using block-chain technology, the integrity of digital currency seems to be unhackable and alternatives for transmitting data are being developed, e.g. using laser light. With the proper tools to mitigate security risks, information security should be no reason not to innovate.

As pointed out by several respondents, implementing new technology implies a greater dependence on e.g. networks, computers, digital communication means and electricity. For

the supply chain, relying more on modern technology results in a greater dependence on these supporting structures. This makes the supply chain vulnerable in cases where the supporting structures are under pressure by for example enemy Counter Network Operations. Autonomous vehicles, deciding what to do and where to go based on algorithms and big data may become target of these kind of activities as well. Hacking into the positioning system might for example make these vehicles to deliver to the wrong locations.

Redundancy in supplies and means to supply is often seen as a solution for unexpected events. A certain surplus in both transportation means and supplies is maintained in order to react swiftly on unexpected change in consumption or other issues. Implementing civil based technology in the supply chain might threaten this redundancy. Cutting out redundancy in order to make the supply chain leaner is often the motivation for commercial corporations to use modern technology. The 'just-in-time' concept is an example of this approach, cutting out stocks at various levels in the supply chain. In the military context, redundancy translates into a certain robustness which makes the military supply chain fit for the 'just-in-case' scenario's. Cutting out redundancy might threaten the ability to be a 'just-in-case' organisation.

8.7 Influence on C2 of the supply chain

Conclusively, after having discussed research data and having answered the research questions, answering the main research question remains. This thesis' main research question was:

> **How does modern technology influence the command and control of the Army's supply chain?**

In an attempt to make SCM more recognisable for soldiers and to underline the link with the other joint functions, the thesis uses the term command and control of the supply chain instead of SCM.

Based on Mintzberg's theory on organisation configurations, the military organisations, and thus the Army, resemble the machine organisation configuration. The Army can be described as efficient, reliable, precise and consistent, while on the other hand having an obsession with control, leading to problems adapting to change. In situations which need change, a

(temporarily) switch to a more innovative configuration can overcome this adaptation problem (Mintzberg, p. 132).

Leadership has a central role in implementing modern technology in organisations. Both while implementing innovation centralised, as well as in an ambidextrous innovation structure. Since the strategic apex is the only entity in a machine organisation able to make changes in the technostructure, it is up to top leadership at the strategic apex to decide on which innovation strategy fits the organisational requirements. In other words, strategic management of technological innovation, as part of a comprehensive organisational strategy (Schilling, p. 1 until 9).

Today's organisation of the supply chain and the way command and control is executed is described in various official documents (Forsvaret, 2014a, 2014b; Hæren, 2015). Interview results show that there is discrepancy between these documents and the opinion on how this is executed, leading to an ambiguous situation. Nevertheless, the NDLO, including the NLC, is the most appropriate entity to have command and control over the supply chain. This implies the Army not having any command and control over the supply chain, except for the execution of actual supply operations on the tactical and technical level, in order to synchronise these with the Army's operations.

Combining these two conclusions; the NDLO being the most appropriate entity to have command and control over the supply chain and the need for a top down innovation strategy, acknowledges the director of the NDLO as the custodian for all supply chain related issues in the armed forces.

Data Science, Predictive Analysis and Big Data (DPB) and autonomous vehicles are considered having the highest impact on command and control of the supply chain. If the armed forces generate and collect the right amount and quality of big data, data science and predictive analytics will enable a proactive supply chain, without intermediate levels having to interfere. In the future, combined with artificial intelligence, this could even fully automate the ordering of supplies.

Autonomous vehicles are no science fiction anymore. Several commercial companies are developing and deploying autonomous vehicles both for civil and military application. Based on available technology today, autonomous convoys over infrastructure are possible. The

development of autonomous systems to reach remote locations has come a long way already. Functional prototypes are just around the corner (Boston Dynamics). Autonomous systems will, apart from a reduced need for soldiers to operate trucks in the supply chain, remove ethical and security issues when using civil contractors in the last tactical mile. Combined with DPB, autonomous vehicles might even be able to make large parts of the supply chain completely proactive and autonomous. Delivering resupplies even before a unit knows it needs them.

However, new technology comes with downsides as well. The more digitalised an organisation becomes, the more dependent it is on supporting structures like e.g. data networks and power supply. Under normal circumstances these tend to be available. Though, in the degraded environment armed forces must be able to operate in, these are not guaranteed. Even worse, given the dependency on these supporting structures, they can become a target for adversaries, aiming at disrupting the Army's supply. Furthermore, collecting big data and combining it in databases, used for data science and predictive analytics comes with a similar kind of risk. These databases contain valuable information for an enemy as well, making it interesting targets for hacking, espionage or deception.

Furthermore, in commercial business, implementing technology is often used to make the supply chain leaner. Minimising costs while maximising profit by eliminating redundancy. In military organisations, this redundancy is often in place to cope with disruption. Cutting out redundancy will make armed forces less robust and suitable for crisis situations.

Based on the previous, several conclusions can be drawn on the implications of modern technologies on the C2 of the supply chain.

Firstly, in the future, due to the implementation of DPB, the Army no longer will be concerned with command and control of the supply chain. Based on the possibilities of DPB, supplies will be ordered automatically based on the big data generated by the Army's systems. In extremis, army units could get resupplied directly by companies or organisations using autonomous vehicles without having to request these. This enables the Army to focus on its main task, (combat) operations on the land domain. However, based on being custodian for land operations, the Chief of the Army remains responsible for the coordination and synchronisation of technical and tactical activities concerning resupplying army units. Coordination mechanisms either automated or by human interfaces should stay in place.

Secondly, while the Army no longer will be concerned with C2 of the supply chain, the NDLO's role as custodian for the supply chain will be strengthened as a result of implementing new technology. The NDLO, with the NLC as executive body, will be at the centre of supplying the armed forces. Doing so, it will be able *"[to view at] the supply chain from an overall system perspective" ... "more accurately called a Supply Chain Orientation* (Mentzer et al., p. 11).

Finally, being dependent on external organisations for supply, trust becomes the most important governance mechanism (Haugland & Grønhaug, p. 378). This askes for embedding suppliers in (operational) planning processes, even though sharing information can be difficult from the security perspective. To build trust, the supply chain has to be trained as a whole, in order to improve and test the chain and to build on mutual trust.

One of the respondents summarised:

> *"The system should be based on 'push' information. That implies among other things a reform from a bureaucratic system towards a system based on trust, combined with risk acceptance and a common understanding of responsibilities and authority."*

One important remaining question is if the Army is willing to give up its active role in the command and control of the supply chain. Even though, given functioning supporting systems, sufficient trust between the NDLO (including civil suppliers) and the Army is acquired, what if the system breaks down? Shouldn't the current layered structure and C2 arrangements act as redundancy? This asks for a thorough risk analysis, as part of the technological innovation strategy.

9 Summary and conclusion

The intention with this thesis was to analyse the implications of emerging technology on the management of the Army's supply chain. In the previous chapter, the research data has been discussed in search for an answer on the main research question:

> **How does modern technology influence the command and control of the Army's supply chain?**

To answer this question, six research questions were developed as a guidance during research based on the research's design:

(1) What is command and control of the supply chain?

(2) What are the characteristics of military organizations from an organisational theoretical perspective?

(3) How can organisations handle new technology?

(4) How is today's supply chain and its command and control organised?

(5) Which emerging technologies are most promising for the Army's supply chain?

(6) What are the disadvantages of implementing modern technology?

After analysis, the study has come to the following main findings:

(1) Command & control of the supply chain can be defined as the set of organisational and technical attributes and processes used to organise and execute supply of (army) units synchronised with the other joint functions, in order to support the military mission.

(2) Based on the Army resembling Mintzberg's machine organisation configuration most, it can be described as efficient, reliable, precise and consistent, while at the same time confronting adaptation problems when confronted with change.

(3) Depending on the kind of implications of new technology has, an organisation has to choose between a central guided development and implementation or a more

decentralised approach. If technology can be applied locally, a decentralised approach could be the most effective, in case of a technology with effects for the entire organisation, the central guided approach is more appropriate. Given the bureaucratic organisation as a starting point for this decision, a technology strategy in the top management is crucial.

(4) Both the supply chain and its command and control are described in official documents. In practice, there is divergence in how this is executed, leading to an ambiguous situation.

(5) Two categories of technology are identified as promising and having influence on the command and control of the supply chain: Information technology, especially predictive analytics and forecasting, and autonomous aerial and ground vehicles.

(6) Implementing the modern technology as described in this thesis increases the dependency on supporting structures e.g. power supply and communication networks. These can become a new Achilles heel of the armed forces. Redundancy seems inevitable.

Based on these findings, it is reasonable to assume that implementing modern technology in the supply chain will force the Army to hand over the command and control of the supply chain to a central organisation, presumably the NDLO with the NLC as its executing body. Coordination and de-confliction of activity in the land domain will remain within the Army's responsibility, since the Chief of the Army is the custodian for land operations. Depending the technological developments, this can eventually be automated as well.

Finally, as the Army gets more dependent on other actors for supply, trust becomes an even more important governance mechanism which has to be nurtured by planning, training and operating comprehensively over time.

9.1 Further research

In general, repeating the observation made by Listou (2015, p. 16), *"little academic literature exists on defence logistics"*. Based on this information, any new research on defence logistics will be welcomed by scholars in this field.

Based on the conclusion that trust will become an important governance mechanism in military logistics, further research on the dynamics of trust in interdependent relationships is advised. Especially in the ‘just-in-case’ scenario’s.

The research touches upon one of the downside of implementing new technologies. Reliance on supporting structures is increasing. What if these systems break down? Shouldn’t the current layered structure and C2 arrangements act as redundancy? This asks for a thorough risk analysis, as part of the technological innovation strategy.

Abbreviations

C2	Command & Control
CIMIC	Civil Military Cooperation
CSS	Combat Service Support
DoD	Department of Defence
DPB	Data Science, Predictive Analysis and Big Data
ERP	Enterprise Resource System
EW	Electronic Warfare
FP	Force Protection
FSA	Forsvarets sikkerhetsavdeling; Defence Security Department
G4	Logistic Branch at a tactical land headquarter
INFOOPS	Information Operations
INTELL	Intelligence
J4	Logistic Branch at a joint headquarter
LBL	Logistic Base Land
LOGFAS	Logistics Functional Area Services
NDLO	Norwegian Defence Logistic Organisation
NJHQ	National Joint Headquarter
NLC	National Logistic Command
NLOC	National Land Operation Centre
NSM	Nasjonal sikkerhetsmyndighet; The Norwegian National Security Authority
PBL	Performance Based Logistics
RLP	Recognised Logistical Picture
SAP	Systeme, Anwendungen und Produkte in der Datenverarbeitung; (Systems, Applications & Products in Data Processing)
SCM	Supply Chain Management
SDOS	Standard Day of Supply
STM	Strategic Technology Management
TTPs	Tactics, Techniques and Procedures
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle

Bibliography

Anderson, J. M., Nidhi, K., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, O. A. (2014). *Autonomous vehicle technology: A guide for policymakers*: Rand Corporation.

Beadle, A. W., & Diesen, S. (2015). *Globale trender mot 2040 : implikasjoner for Forsvarets rolle og relevans*. Kjeller: Forsvarets forskningsinstitutt FFI.

Benveniste, G. (1987). *Professionalizing the Organization*. San Fransisco, California: Jossey-Bass Inc., Publishers.

Bestum, J. A. (2016). *Logistikk i en Cyberkontekst : Hvordan påvirker økt bruk av sivile aktører i forsyningskjeden informasjonsdelingen mellom Forsvaret og sivile leverandører?* Oslo: Forsvarets høgskole.

Bolman, L. G., & Deal, T. E. (1991). *Reframing organizations* (4th ed.): Jossey-Bass Publishers San Francisco.

Boston Dynamics. (2017). Changing your idea of what robots can do. Retrieved from https://www.bostondynamics.com/

Cichosz, M., Goldsby, T. J., Knemeyer, A., & Taylor, D. F. (2017). Innovation in logistics outsourcing relationship–in the search of customer satisfaction. *LogForum, 13*(2).

Creswell, J. W. (2014). *Research design : qualitative, quantitative, and mixed methods approaches* (4th ed.). Los Angeles: SAGE Publications.

Dent, E. B., & Goldberg, S. G. (1999). Challenging "resistance to change". *The Journal of Applied Behavioral Science, 35*(1), 25-41.

Forsvaret. (2014a). *Direktiv for logistikkvirksomhet*. Oslo: Forsvarssjef.

Forsvaret. (2014b). *Forsvarets fellesoperative doktrine*. Oslo: Forsvarsstaben.

Forsvaret. (2015). *LOS-programmet i Forsvaret.* Retrieved from https://forsvaret.no/fakta/organisasjon/los-programmet

Forsvaret. (2016). *Sivile aktører skal støtte oss i krise og krig.* Retrieved from https://forsvaret.no/hv/aktuelt/nyhetsartikler/sivile-stottespillere

Forsvarets forskningsinstitutt. (2016). *VITEN*. (2. 2016). Retrieved from https://www.ffi.no/no/Rapporter/16-01028.pdf.

Forsvarsdepartementet. (2016). *Kampkraft og bærekraft - Langtidsplan for forsvarssektoren*. (151.S (2015-2016)). Retrieved from https://www.regjeringen.no/contentassets/a712fb233b2542af8df07e2628b3386d/no/pdfs/prp201520160151000dddpdfs.pdf.

Getz, I., & Robinson, A. G. (2003). Innovate or die: Is that a fact? *Creativity and innovation management, 12*(3), 130-136.

Gregory, M. (1995). Technology management: a process approach. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 209*(5), 347-356.

Gunasekaran, A., Papadopoulos, T., Dubey, R., Wamba, S. F., Childe, S. J., Hazen, B., & Akter, S. (2017). Big data and predictive analytics for supply chain and organizational performance. *Journal of Business Research, 70*, 308-317.

Hæren. (2015). *Konsept for logistikk i Hæren (utkast) [BEGRENSET]*. Bardufoss: DocuLive.

Haugland, S. A., & Grønhaug, K. (1995). Authority and trust in network relationships. In I. Snehota & H. Håkansson (Eds.), *Developing relationships in business networks* (pp. 368-381). London: Routledge.

Heijnsdijk, J. (1994). *Vitale organisaties: aanzet tot integratie van organisatie-en informatiekunde*: Wolters-Noordhoff.

Hilbert, M. (Producer). (2015, November 14, 2017). *What is Big Data?* [Video] Retrieved from https://youtu.be/XRVIh1h47sA

Ivanova, K., Gallasch, G. E., & Jordans, J. (2016). *Automated and Autonomous Systems for Combat Service Support: Scoping Study and Technology Prioritisation*. Retrieved from https://www.dst.defence.gov.au/sites/default/files/publications/documents/DST-Group-TN-1573.pdf

Jacobsen, D. I. (2015). *Hvordan gjennomføre undersøkelser?* (3rd ed.). Oslo: Capellen Damm Akademisk.

Koninklijke Landmacht. (2017). *Studie Slimme en Robuuste Logistiek in het Landdomein*. Soesterberg: Opleidings- en Trainingscentrum Logistiek - Kenniscentrum.

Kress, M. (2002). *Operational logistics : the art and science of sustaining military operations*. Boston: Kluwer Academic.

Kückelhaus, M., dr., & Chung, G. (2016). *Logistics trend radar, Delivering insight today. Creating value tomorrow!* Retrieved from http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_logistics_trend_radar_2016.pdf

Kvale, S., Brinkmann, S., Anderssen, T. M., & Rygge, J. (2015). *Det kvalitative forskningsintervju* (3. utg., 2. oppl. ed.). Oslo: Gyldendal akademisk.

LeMay, R. R. (2009). *Operational Leadership and Advancing Technology*. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA502937

Liddell, H. G., & Scott, R. (1993). *A Lexicon Abridged from Liddell and Scott's Greek-English Lexicon*: Clarendon Press.

Listou, T. (2015). *Supply chain designs for preparedness : a case study of the Norwegian defence.* (Doctor), Lund University, Lund.

Mediacentrum Defensie. (2016, April 5th). 'De prijs voor vrijheid werd me thuis ingeprent'. *Landmacht*. Retrieved from https://magazines.defensie.nl/landmacht/2016/03/06_afscheidsinterview-c-las

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics, 22*(2), 1-25.

Ministerie van Defensie. (n.d.). *JDP 5 Commandovoering*. Den Haag: Audiovisuele Dienst Defensie.

Mintzberg, H. (1989). *Mintzberg on management : inside our strange world of organizations*. New York: Free Press.

Monk, E. F., & Wagner, B. J. (2013). *Concepts in Enterprise Resource Planning* (Fourth Edition ed.). Boston: Cengage Learning.

Morgan, G. (1998). *Organisasjonsbilder : innføring i organisasjonsteori* (D. Gjestland, Trans. [Ny utg.]. ed.). Oslo: Universitetsforlaget.

NATO. (2012). NATO Logistics Handbook. Brussels: NATO Headquarters.

NATO. (2013). *AAP-06 NATO Glossary of Terms and Definitions*. Brussels: NATO STANDARDIZATION AGENCY.

news.com.au. (2014). *Website tally hits one billion, Internet Live Stats shows.* Retrieved from http://www.news.com.au/technology/website-tally-hits-one-billion-internet-live-stats-shows/news-story/c4e37eadf566351b1936be91f452183c

Pagonis, W. G., & Cruikshank, J. L. (1994). *Moving mountains: Lessons in leadership and logistics from the Gulf War*.

Persson, G. (2011). *Logistikk og ledelse av forsyningskjeder* (H. Virum Ed. 2. utg. ed.). Oslo: Gyldendal akademisk.

Peter, L. J., & Hull, R. (1969). *The peter principle*. London: Souvenir Press.

Pigeau, R., & McCann, C. (2002). *Re-conceptualizing command and control*. Retrieved from

Piggee, A. F. (2002). *Transformation-revolution in military logistics*. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA401039

Plischke, J. F. (2016). *Sind OBL und Führen mit Auftrag das Gleiche? : Eine Analyse unter besonderer Berücksichtigung der Führungstechniken der deutschen und der norwegischen Armee*. Oslo: Forsvarets høgskole.

Provost, F., & Fawcett, T. (2013). Data science and its relationship to big data and data-driven decision making. *Big Data, 1*(1), 51-59.

Ringdal, K. (2013). *Enhet og mangfold : Samfunnsvitenskapelig forskning og kvantitativ metode* (3rd ed.). Bergen: Fagbokforlaget.

Schilling, M. A. (2017). *Strategic management of technological innovation* (5th ed.). New York: McGraw-Hill.

Schoenherr, T., & Speier-Pero, C. (2015). Data science, predictive analytics, and big data in supply chain management: Current state and future potential. *Journal of Business logistics, 36*(1), 120-132.

Shmueli, G., & Koppius, O. R. (2011). Predictive analytics in information systems research. *Mis Quarterly*, 553-572.

Skipsrevyen. (2015). *Beredskapsavtale mellom Forsvaret og Wilh. Wilhemsen-gruppen.* Retrieved from https://www.skipsrevyen.no/beredskapsavtale-mellom-forsvaret-og-wilh-wilhemsen-gruppen/

Tactical Robotics Ltd. (2013). AirMule Achieves Major Milestone on the Path to Full Mission Demonstrations. Retrieved from http://www.tactical-robotics.com/category/2013

Technology. *Oxford Living Dictionaries*. Oxford: Oxford University Press.

Van Creveld, M. (1977). *Supplying war : logistics from Wallenstein to Patton*. Cambridge: Cambridge University Press.

Vassiliou, M. S., Alberts, D. S., & Agre, J. R. (2014). *C2 Re-envisioned : the future of the enterprise*. Boca Raton: CRC press.

Veiden, P. (2010). Max Webers idealtype: Et ordensprosjekt. In G. Ladegård & S. I. Vabo (Eds.), *Ledelse og styring* (pp. 39-51). Bergen: Fagbokforlaget.

Waller, M. A., & Fawcett, S. E. (2013). Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management. *Journal of Business logistics, 34*(2), 77-84.

Телетанк. (n.d.). *Академике.* Retrieved from https://dic.academic.ru/dic.nsf/ruwiki/271017

Epilogue

In the period when I was researching for this thesis, I saw a TV commercial for a new type of vacuum cleaner which allegedly was equipped with a digital motor. I did not understand the point of that feature, neither do I know what it is, so I asked my wife. She came with a convincing explanation: *"Almost everybody with a household owns a vacuum cleaner, in order to increase profit, they will have to convince everybody that these are not good enough. For that they use technology, it is all about increasing profit"*. Although a bit sceptical, one should keep this in mind when presented new, improving technology.

Appendix A; interview guide (Norwegian)

Innledning

Dette er et intervju for å samle inn data til en masteroppgave ved Forsvarets høgskole. Oppgaven ser på hvordan Hæren bør/kan tilpasse kommando og kontroll i forsyningskjeden for å kunne møte og bruke «21st century» teknologi.
Oppgaven gjennomføres stort sett som kvalitativ litteraturstudiet kombinert med intervjuer av fagpersoner i forsyningskjedens nøkkelorganisasjoner. Dette for å kunne bekrefte eller avkrefte funn i litteraturstudiet samt å kunne gi motvekt for forskerens eget bilde basert på sin erfaring innen fagfeltet.

Formalia

- Intervjuet er semi-strukturert. Det gjør at vi kan være fleksible i hvordan intervjuet utvikler seg. Jeg har ansvar for å få svar på alle mine spørsmål.
- Jeg tar notater under intervjuet, ikke noe lydopptak. Etter intervjuet transkriberer jeg notatene og får du tilsendt de for gjennomlesing og eventuelle kommentarer.
- Under intervjuet vil jeg prøve å gi sammendrag av det jeg noterte, både for å kontrollere om jeg noterte alt du sa og forsto det riktig.
- Varighet er omtrent halvannen time.
- Anonymisering; navnet ditt vill ikke bli brukt i oppgaven, kun avdelingen vil kunne bli brukt.
- Oppgaven er ugradert, svar som er graderte noteres ikke. Forskeren har klarering til hemmelig.
- Du kan når som helst trekke deg fra intervjuet.
- Studien meldes til Personvernombud for forsking, Norsk samfunnsvitenskapelig datatjeneste AS.

Spørsmål

1. Kan du beskrive dagens forsyningskjede i Hæren?
    a. Hvilke avdelinger har en rolle i forsyningskjeden?

2. Kan du beskrive din / din avdelings rolle og oppdrag i forsyningskjeden?
    a. På en skala fra 1 til 10, hvor misfornøyd/fornøyd er du med denne rollen / dette oppdraget? (1 = Svært misfornøyd, 10 = Svært fornøyd)

3. Hvordan er rolle- eller oppdragsfordelingen til de andre avdelingene i kjeden?
    a. Hva er rollen og oppdraget til de nivåene over deg / din avdeling?
    b. Hva er rollen og oppdraget til de nivåene under deg / din avdeling
    c. Synes du rollene er fordelt på en riktig måte
    d. Har du forslag til en forbedret rollefordeling?

4. Hvem styrer forsyningskjeden ifølge deg?
    a. Er dette slik det bør være? Hvorfor (ikke)?

5. På en skala fra 1 til 10, hvor fornøyd er du med dagens forsyningskjede i Hæren? (1 = Svært misfornøyd, 10 = Svært fornøyd)

6. Hva er de (største) utfordringene til/i Hærens forsyningskjedens innretning?
    a. Hvilken av de er den største / mest problematiske? Hvorfor?
    b. Har du forslag til forbedring av dette?

7. Kan styring av forsyningskjeden være et av forbedringsområdene og kan du begrunne det?

8. Hvis vi tar styring av forsyningskjeden som en av utfordringene, har du forslag til forbedring?

9. Gitt en fungerende kommunikasjonsløsning, informasjon er tilgjengelig på alle ønskelige nivåer. Hvor mange nivåer bør forsyningskjeden i så fall ha?

10. Tror du at bruk/innføring av moderne teknologi kan forbedre forsyningskjeden? Hvorfor?
    a. Hva legger du inn i begrepet moderne teknologi?
    b. Hvilke moderne teknologi tror du vil påvirke framtidens forsyning? På hvilken måte?
    c. Om hvilken av de har du størst forventning?

11. Bør forsyningskjeden tilpasses denne teknologien eller omvendt?
    a. Kan du forklare hvorfor?
    b. Hvilke utfordringer koblet til en slik tilpasning forventer du?
    c. Hvilken av de vil være størst og hvorfor?

12. På en skala fra 1 til 10, hvor sannsynlig/lite sannsynlig tror du at moderne teknologi kommer til å forbedre forsyningskjeden? (1=svært lite sannsynlig, 10=svært sannsynlig)

13. Hvilke problemer tror du eventuelt moderne teknologi kan medføre i forbindelse med forsyningskjeden?

Appendix B; interview transcript (transformed statements)

Respondent	(3a) How is today's supply chain organised?	(3b) How is today's C2 of the supply chain organised?	(4) Which emerging technologies are most promising for the Army's supply chain?	(5) What are the disadvantages of implementing modern technology?
A	Supply is based on prognosis. Deliveries from the National Logistic Command (NLC) are largely based on Standard Days of Supply (SDOS). A problem with this is that the program for calculating is not up to date. Furthermore, it has no possibility to forecast the consumption of ammunitions and spare parts. In these cases, much of the forecasting is done based on experience. The RLC delivers supply goods to the Logbase Land (LBL). LBL keeps a large part of the stocks for the army/brigade. LBL takes in deliveries and makes the goods transportable in the military part of the supply chain. In some cases, supply goods are directly delivered to the using units, either by personnel from the RLC or civilian suppliers. Many of these truck drives do not have the Norwegian nationality and the respondent is in doubt of this concept suits a crisis situation. LBL delivers the goods to the CSS battalion which on its turn executes the tactical resupply of the (combat) units.	On the national level, NJHQ J4 manages the supply chain. At this level logistics is incorporated in the operational planning cycle. In execution, NJHQ has given coordination authority to the NLC in order to coordinate the execution of supply on its behalf. Within the NLC, the execution of supply is delegated to the Regional Logistic Command (RLC), but this command is not always given the same situational awareness. The RLC coordinates the delivery from suppliers and run the regional ammunition warehouses. The NJHQ gets daily updates on the Recognised Logistical Picture (RLP) which it uses to adjust current plans and as input for future plans. These daily updates are sent to the NLC as well. In the army, the brigade staff G4 manages the supply chain in the army's area of responsibility. (note: in 2018, a National Land Operation Centre will be established, this will probably imply a G4 functionality at army level as well. The hope is that this will not lengthen the communication lines in logistics). The brigade staff G4 is divided into a part which leads the supply in current operations and another part that takes part in (logistical) planning for future brigade operations. The G4 gets daily logistical updates from the battalions and uses these to plan future operations, to adjust current plans (prioritising) and to inform J4 (RLP).	Proper tools for forecasting / predictive analytics and the proper use of these tools. Is seen as the most promising technology. Track and Trace systems Automated reporting by weapon systems/platforms. Making use of sensors in the system, these will automatically report on the amount of fuel, ammunition and technical status. Thus, generating data to plan with in the supply chain. Simulation software to use in training scenarios in order to increase the overall competence of people working in and with the supply chain.	Costs and effort related to the customisation of systems are often high and take a lot of time. Therefore, the army / armed forces have to accept the systems as they are, even though this might imply an adjustment of the way of working. This can prove to be difficult after a long period where people have been working mainly based on experience and gut feeling. It will probably be difficult to turn this around and start to rely on technology. Many of the available technologies (related to DPB) will be based on civil network standards. It is doubtful if the FSA and/or NSM will approve the use of these in the armed forces. When implementing modern technology, a system gets more dependent on supporting structures such as network, electricity, etc. With this, an increased need for redundancy and/or manual back-up procedures arises. These have to be trained as well.

Respondent	(3a) How is today's supply chain organised?	(3b) How is today's C2 of the supply chain organised?	(4) Which emerging technologies are most promising for the Army's supply chain?	(5) What are the disadvantages of implementing modern technology?
		The actual distribution of goods is coordinated horizontally between the logistic specialists. For example, between the G4 and the Regional Logistic Command(RLC), between the RLC and Logbase Land (LBL), between LBL and the CSS battalion, etc. The chain of command is only used when professional coordination is not sufficient of when prioritising is necessary. An improvement would be a more clearly defined role as a "single point of service" for the NLC.		
B	In general, supply goods are delivered from the RLC or civil suppliers to the LBL. From the LBL goods are transported to the CSS battalion, which transports them to the units in the brigade. Every unit in the army has its own supply capacity which receives supply goods to the unit. Some goods, like for example spare parts or ammunitions are delivered directly to the CSS battalion.	The NJHQ (executed by the J4 branch) is responsible for the supply chain. The coordination/management of the supply chain is delegated to the NLC. Within the Army/Brigade, the G4 is responsible for coordinating the supply chain. The planning capacity in the C2 of the supply chain is not sufficient. Responsibilities have not been clear in the past. The expectation is that the establishment of a G4 army level will improve this, combined with a clearer distribution of discretion. Although this remains to be seen. One of the biggest challenges is that there has never been an exercise where supply has been put to the test. So, the size of the supply chain and the functioning of the C2 in crisis situations are based on assumptions.	Automated ordering by weapon systems or platforms seems the most promising new technology. It will improve the ordering system in the supply chain. But first of all, the current ERP system (SAP) has to be used right. Furthermore, Data solutions as a basis for decision making (predictive analytics / forecasting) Location based material handling / fleet tracking.	The demands on operational security make a lot of available data solutions unavailable for use in the military sector. As of now, logistics in the Army are depending on manual registration, communication and analysis as a result of these restrictions. The army/armed forces is/are a hierarchical and bureaucratic organisation. Modern ways of sharing information/and data without passing it through all levels of command first may not fit the culture of the organisation. A change towards an organisation based on mutual trust is necessary, but will take time. The use of sophisticated and (partly) automated systems will take human involvement out of processes. This may result in losing control.
C	Either by own subunits or civil suppliers, the NLC delivers supply goods to any location or unit the Army wants them to be delivered. It is not prescribed where the supplies shall be delivered. In some cases, delivery can be done directly to the end user. It is expected that from 2018 the LBL will become the entry point for deliveries to the army. LBL will be the interface	The brigade G4 orders supplies based on prognosis at the NLC. The NLC, as the operational part of the NDLO has all the civil contracts in place to order goods and have them delivered to the armed forces. It is the director of the NDLO who designs the supply chain. During operations NJHQ J4 plans logistics, while NLC	First of all, the right use of the current ERP system. Lett the software do its work and use the ERP system to collect information needed for planning instead of redundancy in reporting. Secondly Track and Trace systems to get insight in the whereabouts of supplies. Thirdly additive manufacturing / 3D printing.	With new technologies, the focus can sometimes shift from the purpose of the military organisation to the technology itself. One must be aware of the reason for having armed forces: crises and conflicts. The technology should support this task, if not there is no need for it.

Respondent	(3a) How is today's supply chain organised?	(3b) How is today's C2 of the supply chain organised?	(4) Which emerging technologies are most promising for the Army's supply chain?	(5) What are the disadvantages of implementing modern technology?
	between the civil and the army part of the supply chain. From the LBL the goods will be delivered to the CSS battalion, which will deliver them to the end users.	executes and coordinates the execution of these plans. Since the concept for supply in the army not has been approved yet, there are differences in how people/units perceive their role and responsibility. The fact that the supply chain has not been trained / putt to the test worseness this. The chief of the Army should have responsibility over the army part of the supply chain.		Implementing new technology takes its time due to: - Training and education of the personnel involved; - The time needed to convince people of the positive side of the change. Modern technology can make the armed forces vulnerable. If the focus is to become more LEAN with the use of technology, redundancy will disappear and the supply chain will become less robust. This might in fact be one of the reasons for opposing implementation.
D	Civil suppliers deliver goods to the units of the NLC/RLC. These transport or route them further to the army LBL. From the LBL, the supplies are delivered to the CSS battalion in the Brigade Support Area. The CSS battalion delivers the goods to the end user.	Conceptually the supply chain is designed by the director of the NDLO, in operations it is leaded by NJHQ. Within its organisation, the NLC has the executing task. Commander NLC leads supply / coordinates logistical operations on the tactical level up till the delivery points within the army. The chief of the army is the custodian for land operations. Since the supply chain in a way is part of the land operations there is a large area of coordination between the director NDLO and the chief of the Army. This gives room for disagreement as well. The division of roles and responsibilities, especially on the interfaces between the NLC and Army need clarification. The biggest challenges for the C2 of the supply chain are related to sharing information and the flow of information. A lot of military information is not cleared for use by civilian suppliers. Given a functioning communication system, the army might not need a role in the C2 of the supply chain, other than a customer role (knowing what and how to order).	The introduction of autonomous vehicles will remove a large part of today's challenges and ethical issues related to the use of civil contractors in dangerous/war environments. As well as they will simplify the (information)security aspect of this. Additive manufacturing Alternative energy sources (solar energy)	The increasing dependence on the availability of a networks makes the supply chain vulnerable for counter network operations

Respondent	(3a) How is today's supply chain organised?	(3b) How is today's C2 of the supply chain organised?	(4) Which emerging technologies are most promising for the Army's supply chain?	(5) What are the disadvantages of implementing modern technology?
E	NLC delivers supplies to the National Support Element of LBL. At the LBL, civil transport is transferred to military transport. LBL delivers the supplies to the CSS battalion in addition to this, LBL holds a part of the buffer capacity to the army. The CSS battalion executes the delivery of goods to the end users. It concentrates on the tactics of delivering the supplies and has no active role in C2 of the supply chain.	At the moment, it is not clear who is leading the supply chain for land operations. The plan and ordering level (G4/J4) orders supplies with the NLC based on operational plans and the units demands. NLC orders the supplies at civil suppliers based on framework agreements for both peace time and war. The supply chain has never been trained or tested. Only during some table top exercises, the real extent of the supply chain has been shown (on paper). Establishing a G4 branch at the army level will be a golden opportunity for the Army to establish C2 of the supply chain.	Improved communication systems (wireless) in order to establish the bandwidth necessary to use the ERP system. Autonomous vehicles or drones to supply units in extremely hostile or non-permissive environments. Systems to simulate logistics in (table top) exercises.	The army is like a dinosaur. The people deciding on (new) technology are the most experienced and thus oldest ones. They are used to do things like they "always" have been done. Introducing new technology will call for younger generations to get responsibility and discretion. This might ask for a culture change. The demands on secure communication and sharing information might hamper the implementation of new technology. Even if this is not a problem for a certain technology, army officers might choose not to implement it since they conceive security issues.

Translated citations:

"The Armed Forces have a special need for classifying and shielding information. In practice, many of the available and network-based logistics solutions are not approved by the Norwegian National Security Authority (NSM) and/or the Defence Security Department (FMA)."

"Implementing new technologies requires often retraining of employees, which is a time-consuming process"

"The organisation's institutional memory will hamper the implementations of new technology"

"We are used to sticking to our old habits, like dinosaurs. Perhaps it's time to bring our younger colleagues into play, without staying too hierarchical. The dinosaurs do not realise yet they are going extinct"

"In the [Norwegian] Armed Forces we have had a tradition to modify every acquired system to a 'Norwegian' model. This increases the products costs and delays the delivery, since the adjustments often require a lot of time. The result of this often is delivery of (near) obsolete systems by the time they are ready developed."

"We should buy of the shelf and only make small reasonable adjustments. As a result, we might have to, and must adjust routines, regulations, etc."

"The system should be based on 'push' information. That implies among other things a reform from a bureaucratic system towards a system based on trust, combined with risk acceptance and a common understanding of responsibilities and authority."

"The CSS battalion concentrates on the tactics of delivering the supplies and has no active role in C2 of the supply chain"