National Defence University
Department of Military Technology
Series 1: Publication No. 33

MPKK 1993–2013

Enhancing the Development of Military Capabilities by a Systems Approach

Jukka Anteroinen

JUKKA ANTEROINEN

ENHANCING THE DEVELOPMENT OF MILITARY CAPABILITIES BY A SYSTEMS APPROACH

Doctoral dissertation for the degree of Doctor of Military Sciences
to be presented, with due permission of the National Defence University,
for public examination in the Maneesi of Kruununhaka
at the National Defence University
on 8th of August 2013 at 12 o'clock.

NATIONAL DEFENCE UNIVERSITY
HELSINKI 2013

NATIONAL DEFENCE UNIVERSITY
DEPARTMENT OF MILITARY TECHNOLOGY
SERIES 1: PUBLICATION NO. 33

MAANPUOLUSTUSKORKEAKOULU
SOTATEKNIIKAN LAITOS
JULKAISUSARJA 1: JULKAISU NO. 33

ENHANCING THE DEVELOPMENT OF MILITARY CAPABILITIES BY A SYSTEMS APPROACH

JUKKA ANTEROINEN

NATIONAL DEFENCE UNIVERSITY
Department of Military Technology
HELSINKI 2013

JUKKA ANTEROINEN: *ENHANCING THE DEVELOPMENT OF MILITARY CAPABILITIES BY A SYSTEMS APPROACH*

NATIONAL DEFENCE UNIVERSITY
DEPARTMENT OF MILITARY TECHNOLOGY
SERIES 1: PUBLICATION NO. 33
DOCTORAL DISSERTATION

Author:	Commander, G.S., M.Sc. (SED) Jukka Anteroinen
Supervising professor:	Professor Juha-Matti Lehtonen, National Defence University
Preliminary examiners:	Professor Mika Hannula, Tampere University of Technology, Finland
	Professor Gunnar Hult National Defence College, Sweden
Official opponents:	Professor Gunnar Hult National Defence College, Sweden
	Professor Lauri Ojala University of Turku, Finland

Cover design: Annele Palonen

The dissertation can be read at: http://www.doria.fi

ISBN 978-951-25-2483-9 (pbk.)
ISBN 978-951-25-2484-6 (PDF)
ISSN 1796-4059

Maanpuolustuskorkeakoulu – National Defence University
Sotatekniikan laitos – Department of Military Technology

Juvenes Print
Tampere 2013

I am like Leonardo, I want to know everything.
Creating relations between things is my constant preoccupation
– Salvador Dali

ABSTRACT

The political environment of security and defence has changed radically in the Western industrialised world since the Cold War. As a response to these changes, since the beginning of the twenty-first century, most Western countries have adopted a ‘capabilities-based approach’ to developing and operating their armed forces. More responsive and versatile military capabilities must be developed to meet the contemporary challenges. The systems approach is seen as a beneficial means of overcoming traps in resolving complex real-world issues by conventional thinking.

The main objectives of this dissertation are to explore and assess the means to enhance the development of military capabilities both in concept development and experimentation (CD&E) and in national defence materiel collaboration issues. This research provides a unique perspective, a systems approach, to the development areas of concern in resolving complex real-world issues. This dissertation seeks to increase the understanding of the military capability concept both as a whole and within its life cycle.

The dissertation follows the generic functionalist systems methodology by Jackson. The methodology applies a comprehensive set of constitutive rules to examine the research objectives.

This dissertation makes contribution to current studies about military capability. It presents two interdependent conceptual capability models: the comprehensive capability meta-model (CCMM) and the holistic capability life cycle model (HCLCM). These models holistically and systematically complement the existing, but still evolving, understanding of military capability and its life cycle.

In addition, this dissertation contributes to the scientific discussion of defence procurement in its broad meaning by introducing the holistic model about the national defence materiel collaboration between the defence forces, defence industry and academia. The model connects the key collaborative mechanisms, which currently work in isolation from each other, and take into consideration the unique needs of each partner. This dissertation contributes empirical evidence regarding the benefits of enterprise architectures (EA) to CD&E. The EA approach may add value to traditional concept development by increasing the clarity, consistency and completeness of the concept. The most important use considered for EA in CD&E is that it enables further utilisation of the concept created in the case project.

Keywords: military capability, systems approach, development, concept development and experimentation, enterprise architecture, collaboration, defence materiel, centre of excellence

TIIVISTELMÄ

Turvallisuus- ja puolustuspoliittinen ympäristö on muuttunut läntisissä teollisuusmaissa merkittävästi Kylmän sodan jälkeen. Muutoksen seurauksena useimmat läntiset maat ovat 2000-luvun alusta lähtien siirtyneet asevoimiensa kehittämisessä ja käytössä suorituskykyperustaisuuteen. Asevoimien toimintaan kohdistuu myös taloudellisia paineita. Muutostekijät edellyttävät, että asevoimista kehitetään aiempaa mukautuvampia ja muutoskykyisempiä vastaamaan nykyisiin ja tuleviin haasteisiin. Systeeminäkökulma on koettu hyödylliseksi keinoksi tällaisten monimutkaisten ongelmien ja haasteiden ratkaisemisessa.

Tämän väitöskirjan tavoitteena on kartoittaa ja arvioida keinoja ja tapoja tehostaa sotilaallisten suorituskykyjen kehittämistä sekä konseptien kokeellisessa kehittämistoiminnassa (CD&E) että kansallisessa puolustusmateriaaliyhteistyössä. Tutkimus lähestyy tutkimuskohteita systeeminäkökulmasta. Tutkimus pyrkii myös lisäämään ymmärrystä sotilaallisesta suorituskyvystä kokonaisvaltaisesti.

Työn tutkimusstrategiana (research design) on erityinen systeemimenetelmä, Yleinen funktionaalinen systeemimenetelmä. Menetelmän soveltamista tukevat yksityiskohtaiset säännöt, jotka ottavat kantaa tutkimuskohteen määrittämiseen, analysointiin ja tuloksiin.

Tutkimus tuottaa hyödyllistä ja uutta tietoa sotilaallisesta suorituskyvystä. Tutkimuksen tuloksina esitetään kaksi toisiinsa liittyvää käsitteellistä suorituskykymallia. Ne täydentävät nykyistä ymmärrystä sotilaallisesta suorituskyvystä ja sen elinjaksosta kokonaisvaltaisella tavalla, ja siten ne edistävät kommunikaatiota suorituskyvyn kehittämiseen ja käyttöön liittyvien sidosryhmien kesken.

Tutkimuksessa esitetään myös systeemiperustainen kokonaismalli kansallisen puolustusmateriaaliyhteistyön tehostamisesta vaihtoehtona nykyiselle, osina toteutettavalle mallille. Malli liittää keskeiset yhteistyömekanismit toisiinsa osoittamalla mekanismien väliset vuorovaikutussuhteet ja sen, miten mekanismit voivat tukea toisiaan. Tutkimus lisää myös empiiristä tietoa yritysarkkitehtuurien hyödyistä konseptien kokeellisessa kehittämistoiminnassa. Yritysarkkitehtuurit ja niiden avulla tehdyt mallit voivat lisätä konseptien selkeyttä, yhdenmukaisuutta ja kokonaisvaltaisuutta. Tällaiset mallit tukevat erityisesti konseptien jatkohyödyntämistä suorituskykyjen kehittämistyössä.

Avainsanat: Sotilaallinen suorituskyky, systeemilähestymistapa, kehittäminen, konseptien kokeellinen kehittäminen, yritysarkkitehtuuri, yhteistyö, puolustusmateriaali, osaamiskeskus

ACKNOWLEDGEMENTS

My interest in military capabilities dates back to the late 1980s when I began my military career at the Finnish Navy. At that time, I looked at capabilities from the perspective of an end user through the portholes of the minelayer *Pohjanmaa*. In practice, I engaged with the procurement of military capabilities while acting as a project manager in naval procurement programmes in the early 21st century. However, to gain an understanding of the weaknesses of my knowledge about the capabilities from a theoretical perspective, I was sent to the United Kingdom to take a master's course in systems engineering for defence. In 2007, after that mind-opening experience, I was assigned to capability development related research and technology duties. Interesting assignments from across the military capability life cycle awoke my desire to further understand and explore the concept of military capability and related issues. In realising that desire, in the autumn of 2009, I was lucky enough to be chosen to hold a researcher position at the National Defence University.

My journey in this field, conducted since 2009, is now compiled into this article-based doctoral dissertation. This would not have been possible without the help and support of a number of people and organisations. Consequently, I want to convey my gratitude in several directions.

I would like to thank Professor Juha-Matti Lehtonen, the supervisor of my dissertation, for his constant support with a judicious balance of freedom and guidance. Because he was engaged with the supervision of my work in the middle of the process, his own work has not been the easiest. However, it had no negative effects on the supervision of/or the progress of the research. It has been a joy to work with you. I sincerely hope a fruitful collaboration can continue with you in the future.

I also owe gratitude to Professor Josu Takala, for his time for discussions, for guidance in conducting research, and the kindness he consistently showed me during my research. I would additionally like to thank Juha-Matti and Josu for co-authoring three papers of the dissertation.

Professor Jorma Jormakka supervised my work at the beginning of the process. I truly admire his straight-forwardness and his passion towards research and miss the thought-provoking discussions with him. I also owe gratitude to Doctor of Philosophy Antti Rissanen for his voluntary support and valuable help. Whenever I had doubts and questions in conducting research, he always had time for discussions.

I have had the honour of having professors Mika Hannula from Tampere University of Technology and Gunnar Hult from the National Defence College of Sweden as my pre-examiners. I would like to thank them for their constructive critique of the dissertation.

The library staff of the National Defence University exceeded all of my expectations of friendly and professional service. I would like to express my special thanks to Mr. Joonas Parviainen for his overwhelming willingness to solve even my strangest requests concerning information searches and management.

I would also like to thank the Finnish Defence Forces for giving me this unique and magnificent opportunity. I certainly hope that my research has relevance to the forces and that I can take advantage of the knowledge I have gained in my future assignments.

I would like to express my gratitude to the following foundations and associations: Kauppaneuvos Werner Hacklinin säätiö, Suomen Marsalkka Mannerheimin sotatieteellinen rahasto, and Maanpuolustuskurssiyhdistys, whose support enabled me to procure numerous books and state-of-the-art tools to facilitate the research.

I want to express my deepest gratitude to my family, my mother, father and my sisters Anne, Outi and Eve, along with their families, for all their support.

Äiti ja isä ja rakkaat siskot, kiitos teille kaikesta tuesta ja huolenpidosta kaikkina hetkinä. Teidän uskonne ei horju koskaan.

Last, but definitely not least, my wife Kaisa and my children, Akseli and Lumi, truly deserve their share of the credit for the completion of this work. They have tolerated my absences and distraction more than anyone should be expected to do. I hope that I can repay them one day.

Rakkaimpani, kiitos jaksamisestanne ja siitä, että olette olemassaolollanne muistuttaneet tärkeistä ja vieläkin tärkeimmistä asioista elämässä. Toivon sieluni pohjasta, että voin hyvittää teille työni aiheuttaman vaivan jonakin päivänä.

Santahamina, 6th June 2013,

Jukka Anteroinen

PUBLICATIONS OF THE DISSERTATION

This doctoral dissertation of Jukka Anteroinen consists of a summary and the following seven publications (papers):

[I] Anteroinen, Jukka. 2012. Integration of Existing Military Capability Models into the Comprehensive Capability Meta-model. *Proceedings of the 2012 IEEE Systems Conference*. Vancouver, Canada. 19–22 March 2012, pp. 156–162. © 2012 Institute of Electrical and Electronics Engineers (IEEE). Reprinted, with permission.

[II] Anteroinen, Jukka. 2012. The Holistic Military Capability Life Cycle Model. *Proceedings of the 7th IEEE System of Systems Conference 2012*. Genoa, Italy. 16–19 July 2012, pp. 167–172. © 2012 Institute of Electrical and Electronics Engineers (IEEE). Reprinted, with permission.

[III] Anteroinen, Jukka. 2011. The Application of Enterprise Architecture Approach to Military Concept Development – Case Study. *Proceedings of the 2011 Military Communications and Information Systems (MilCIS) Conference 2011*. Canberra, Australia, 8–10 November 2011. © 2012 Institute of Electrical and Electronics Engineers (IEEE). Reprinted, with permission.

[IV] Anteroinen, Jukka and Lehtonen, Juha-Matti. 2012. The Enterprise Architecture Approach to Support Concept Development in a Military Context: A Case Study Evaluation of EA's Benefits. *Journal of Enterprise Architecture*, 8(1), pp. 63–75. © 2012 The Association of Enterprise Architects. Reprinted, with permission.

[V] Anteroinen, Jukka, Lehtonen, Juha-Matti, and Takala, Josu. 2012. Sustainable Cross-Sector Collaboration by the Centre of Excellence – An Evaluation of the Expectations by Case Study. *International Journal of Sustainable Economy*, 4(4). pp. 410–428. © 2012 Inderscience Publishers. Reprinted, with permission.

[VI] Anteroinen, Jukka, and Takala, Josu. 2013. A Performance Evaluation of Cross-Sector Collaboration. *International Journal of Performance Measurement*, ISSN: 2165-6371. Accepted, forthcoming.

[VII] Anteroinen, Jukka. 2010. Enhancement of National Collaboration between Defence Establishment and Industry by Systems Approach. *Journal of Military Studies*, 1(1), pp. 79–103. Open access journal.

CONTRIBUTIONS OF THE AUTHOR

The author was the sole author of papers [I], [II], [III] and [VII] and the primary author in papers [IV], [V] and [VI]. Professor Juha-Matti Lehtonen conducted the statistical analysis in papers [IV] and [V]. Professor Josu Takala provided invaluable insights and comments for papers [V] and [VI].

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AF	Architecture framework
CADMID	Concept, assessment, demonstration, manufacture, in-service and disposal
CCMM	Comprehensive capability meta-model
CD&E	Concept development and experimentation
CDP	Capability development plan
CFI	Critical factor index
CoE	Centre of excellence
CONOPS	Concept of operations
D&M IS	Delone and Mclean information system success model
DCoE	Defence centre of excellence
DLoD	Defence Lines of Development
DoD	Department of Defence (Australia)
DoD	Department of Defense (USA)
DODAF	Department of Defense of the United States Architecture Framework
DOTMPLFI	Doctrine, organization, training, materiel, personnel, leadership and education, facilities and integration
DTIB	Defence technological and industrial base
EA	Enterprise architecture
EAC	European armaments cooperation
EBAO	Effects based approach to operations
EC	European Commission
EDA	European Defence Agency
EDRT	European defence research and technology
EDTIB	European defence technological and industrial base
EM	Enterprise modelling
EU	European Union
FIC	Fundamental inputs to capability
HCLCM	Holistic capability life cycle model
IP	Industrial participation
ISO	International Organization for Standardization
IT	Information technology
MNC	Multinational corporation
MNE	Multinational experiment
MODAF	The United Kingdom Ministry of Defence Architecture Framework
MoE	Measures of effectiveness
MSc	Master of science
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organization

NCW	Network-centric warfare
NEPRO	Network of excellence for protection
NNEC	NATO network enabled capabilities
NORDEFCO	Nordic Defence Cooperation
NOV	NATO operational view
O	Objective
P&S	Pooling and sharing
PANDA	Participatory appraisal of needs and the development of action
R&D	Research and development
S&RL	Sense and respond logistics
SE	Systems engineering
SiME	Situational method engineering
SOD	Systemic operational design
SoS	Systems of systems
TEPIDOIL	Training, equipment, personnel, information, concepts and doctrine, organisation and infrastructure
TFEU	Treaty on the functioning of the European Union
TLCM	Through-life capability management
TOGAF	The Open Group Architecture Framework
UK	United Kingdom
ZFEA	Zachman Framework for Enterprise Architecture

LIST OF FIGURES AND TABLES

FIGURES

TABLES

CHAPTER 1 – INTRODUCTION

1.1 Context of the research

The political environment of security and defence has changed radically in the Western industrialised world since the Cold War. Traditional boundaries between states' external and internal security have blurred (Lutterbeck, 2005). The focus of military threats has changed from symmetric to asymmetric threats (Neuneck, 2008). Western military forces are increasingly drawn into highly complex and lethal campaigns in urbanised terrain against irregular enemies invulnerable to many advanced technologies (Kilcullen, 2005). As a response to these changes, since the beginning of the twenty-first century, most Western countries have adopted a 'capabilities-based approach' of developing and operating their armed forces. This is considered an evolutionary advancement from the Cold War paradigm of threat-based approach and planning (Davis, 2002; Defence Research and Development Canada, 2005; National Research Council, 2005). The capabilities-based approach places more emphasis on how an opponent may fight rather than on who the opponent may be or where a war may occur (US DoD, 2001). In practice, the transformation from Cold War capability requirements to meet the current needs has, among other, led to the development of organisation-wide transformational concepts in various armed forces, such as NATO's network enabled capabilities (NNEC) and the United States' network-centric warfare (NCW) (Terriff, 2010).

In addition to changes in the security environment, the armed forces currently face financial challenges. The economic crisis in the developed world has forced countries to reduce their defence budgets (Military Balance, 2012), which has further constrained their financial possibilities and military capabilities to respond to complex challenges (Bates, 2012). The economic pressures have profoundly influenced the initiation of cooperation programmes both in the North Atlantic Treaty Organization (NATO) and in the European Union (EU). In NATO, the programme is known as 'Smart Defence' (NATO, 2012) and in EU as 'Pooling & Sharing' (P&S) (EDA, 2011b). The goal of the programmes is to increase the cost-effectiveness of military capabilities by pooling and sharing capabilities, setting priorities and improving the coordination of efforts among the nations of NATO and the EU. Moreover, the new directives in defence materiel procurement by the European Commission, which opens up the majority of defence materiel procurement contracts for public competition among EU countries, attempts to attain better military capabilities and defence industrial competitiveness more cost-effectively (EC, 2013).

Armed forces are required to develop more responsive and versatile military capabilities to meet these contemporary challenges (Bach, 2003; Hoffman, 2006; National Research Council, 2005). The capabilities to be developed should also be critical, specifically, they should be the most needed, deployable and sustainable (NATO, 2012). However, a number of factors complicate the development of the required capabilities. The time needed to transform a new war-winning idea into a tangible military capability is relatively long—usually

10 to 20 years (Reynolds, 2006; Setter and Tishler, 2006). Moreover, shrinking defence budgets combined with defence materiel costs that rise faster than inflation (Hartley, 2003; Kirkpatrick, 1997; Smith, 2009) necessitates that appropriate capabilities be developed immediately. Concept development and experimentation (CD&E) plays an important role in this process by enabling the structured development of creative and innovative ideas into viable solutions for capability development (North Atlantic Military Committee, 2009).

Despite the international collaboration initiatives and new European-level defence materiel procurement directives, national collaboration among the armed forces, local defence industry and academia is still considered an important enabler of military capability sustainment. National, defence-related research and development (R&D) capabilities are needed to develop and maintain the knowledge base that supports industrial-military self-sufficiency during peacetime and that enhances the security of supply in wartime (Wylie et al., 2006).

Modern capability systems are becoming more complicated due to an increased number of interacting components. In addition, they frequently include the notion of systems of systems (SoS) in which many distinct systems are linked together through a common data network (Drezner, 2009). This SoS ideology also underpins NATO's NNEC and the United States' NCW concepts (Terriff, 2010). The goal of the NCW concept, for instance, is to achieve shared awareness, an increased speed of command, higher tempo of operations and greater lethality by networking sensors, decision makers and shooters to each other (Moffat, 2010).

All of the above requirements and factors manifest an increased complexity for the development and sustainment of military capabilities. Complexity can be divided into environmental, organisational and technical dimensions. Environmental complexity deals with the political and economic context of the development and sustainment of capabilities, the threat environment and the operational environment. Organisational complexity addresses the structures and interactions of the government and industry organisations responsible for design, development, production and support of capabilities. Technical complexity means weapon system functionality and capability, including that related to the use of embedded information technology (Drezner, 2009).

Therefore, it can be assumed that those who understand complex systems can better execute modern warfare than those who focus on simple linear, transparent and classically logical constructs (Bar-Yam, 2003). The systems approach is seen as an advantageous means to overcome traps in resolving complex real-world issues by conventional thinking (Checkland, 1981). These traps of non-systems thinking occur in two areas: 1) in avoiding the inevitable interconnectivity between variables—the trap of reductionism and 2) in working on the basis of a single unquestioning perspective—the trap of dogmatism (Reynolds and Holwell, 2010). In contrast, the systems approach is a method of tackling a problem, which takes a broad view, attempts to consider all perspectives and concentrates on the interactions between the constituent parts of the problem (Checkland, 1999).

1.2 Research purpose, question and objectives

From a practical perspective, this dissertation attempts to explore and find the means to enhance the development of military capabilities. The enhancements seek to improve the evolution and employment of military capabilities. From a scientific perspective, this research attempts to provide a unique perspective, a systems approach, to the development areas in concern in order to overcome challenges in resolving complex real-world issues, as described above, by conventional thinking. Additionally, this dissertation attempts to increase understanding of the military capability concept as a whole and within its life cycle.

Therefore, the research question of the dissertation is as follows:

In what ways can the development of military capabilities be supported by a systems approach?

The contextual (area of application) part of the research question ‘development of military capabilities’, demands that the term ‘military capability’ is understood as widely as possible, including its life cycle. This knowledge is requisite to the ability to position the areas of study within the capability life cycle and in relation to other systems concepts that already exist in various stages of the capability life cycle. The methodological part of the research question, ‘by systems approach’, requires that the systems approach is understood and defined properly, and that it is applied in the dissertation in the defined way. The problem part of the question, ‘in what ways’, dictates to seek and propose tangible proposals that also take into account the methodological choices.

Correspondingly, the implied research objectives, defined as operationalised and explicit questions in relation to the three central themes of the dissertation are:

Objective 1 (O1): How do military capability views form a hierarchical and temporal whole?

- O1.1 How do current views of military capability relate with each other hierarchically?
- O1.2 How do various capability views relate with the overall capability life cycle?

Objective 2 (O2): What benefits do enterprise architectures (EA) bring to concept development and experimentation (CD&E)?

- O2.1 How can the military architecture framework be tailored to meet the needs of CD&E?
- O2.2 What benefits does the EA approach bring to the conventional CD&E method?

Objective 3 (O3): How does the systems approach enhance defence materiel collaboration between the defence forces, defence industry and academia during capability planning and procurement?

- O3.1 How does current collaboration between the parties perform in the form of the centre of excellence (CoE)?
- O3.2 How can the functioning of CoE and other collaboration mechanisms be enhanced by the systems approach?

The research objectives represent the three main themes of the dissertation. Each paper of the dissertation answers to one sub-objective (excluding O3.1, which is answered by papers [V] and [VI]). Therefore, the papers represent the contributions of the dissertation and the research objectives act as compilations of those contributions.

1.3 Research process

This dissertation presents seven papers, ordered logically (not chronologically) to follow the order of the research objectives, illustrated in Figure 1. The response to the first research objective presents comprehensive views of military capability with regard to the existing capability models and the capability life cycle in papers [I] and [II]. These comprehensive capability views lay the foundation to reply to the second and third research objectives by enabling the ability to position those objectives and related issues into the capability life cycle. Papers [III] and [IV] answer the second research objective by assessing the applicability of the enterprise architecture approach to support the concept life cycle stage of military capability. Papers [V], [VI] and [VII] concern the third research question. Papers [V] and [VI] study a centre of excellence (CoE) as a manifestation of national defence materiel collaboration among armed forces, the defence industry and academia to primarily support capability planning and procurement life cycle stages. Paper [VII] proposes a systems model to enhance this collaboration by incorporating related collaboration mechanisms to the work of the centre of excellence.

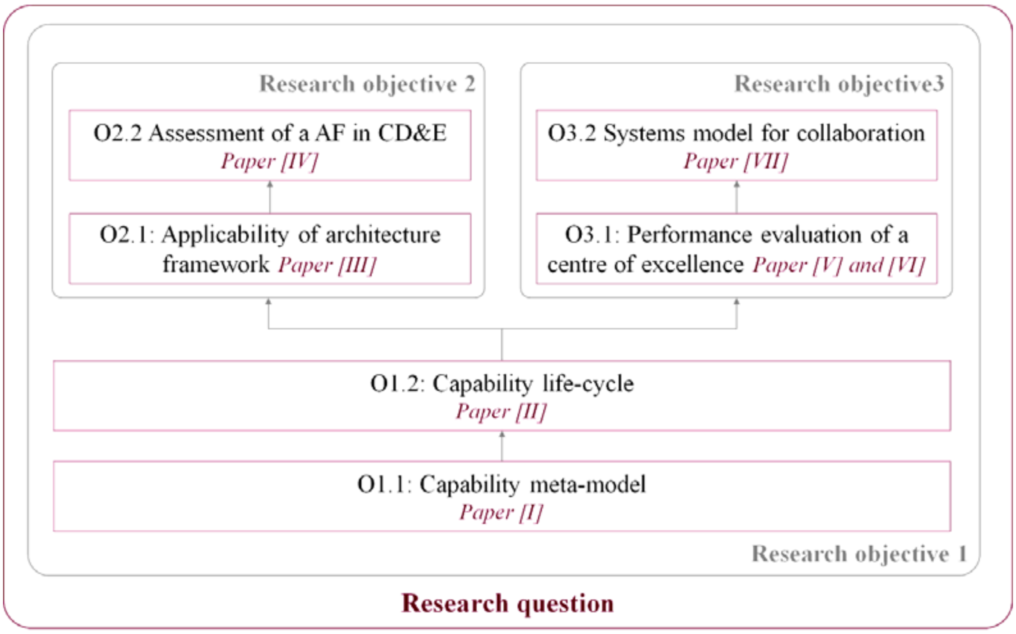


Figure 1. *Research process of the dissertation.*

1.4 Scope of the dissertation, assumptions and limitations

A life cycle model is a conceptual segmentation of the definition of any man-made system's—conceptual or physical—purpose, its realisation as a product or service, and its utilisation, evolution and disposal. The life cycle model is typically segmented into stages to facilitate planning, provisioning, operation and support of the system (ISO 15288, 2008). The ISO 15288 (International Organization for Standardization) standard presents a life cycle stage model with six stages: concept, development, production, utilisation, support and disposal.

Methods, models and techniques based on the systems approach have successfully been applied to many of the military capability life cycle stages, as illustrated in Figure 2. Hard systems methodologies, systems engineering and systems analysis have gained an established status to support production, for instance, in the procurement of military capabilities, such as weapon systems (INCOSE, 2006; Jackson, 2000; US DoD, 2008b). The use of these systems practices to foster military procurement is briefly exemplified as follows: the needs of users are transformed into system requirements and the design of a system using requirements engineering (Sommerville, 2005) and the help of systems engineering life cycle models (Engel and Barad, 2003), for example, the Vee model. Manifesting the systems thinking principle of 'wholeness', capability systems to be procured are thought of in terms of interlocking and interdependent components, such as doctrine, materiel and personnel. Similarly, the costs or concepts of capabilities are considered within the whole capability life cycle to embody the understanding of wholeness of a capability over time (UK MoD, 2005b).

In the operations (i.e. in-use or utilisation) stage of the military capability life cycle, the foundation of doctrinal concepts to use military capabilities, such as systemic operational design (SOD) in Israel and the effects based approach to operations (EBAO) in NATO, lean heavily on systems thinking (Anteroinen, 2013). The EBAO concept additionally employs systems analysis to build a comprehensive understanding of the operating environment (ACT, 2010).

During the utilisation and the support stages of the military capability life cycle, the recent logistics concepts in the United States Air Force (Tripp et al., 2006) and Army (Hammond, 2009) are called sense and respond logistics (S&RL). The core of this concept derives from Haeckel's book, *Adaptive Enterprise*, which builds upon the notion of a 'purposeful adaptive system' (Haeckel, 1999).

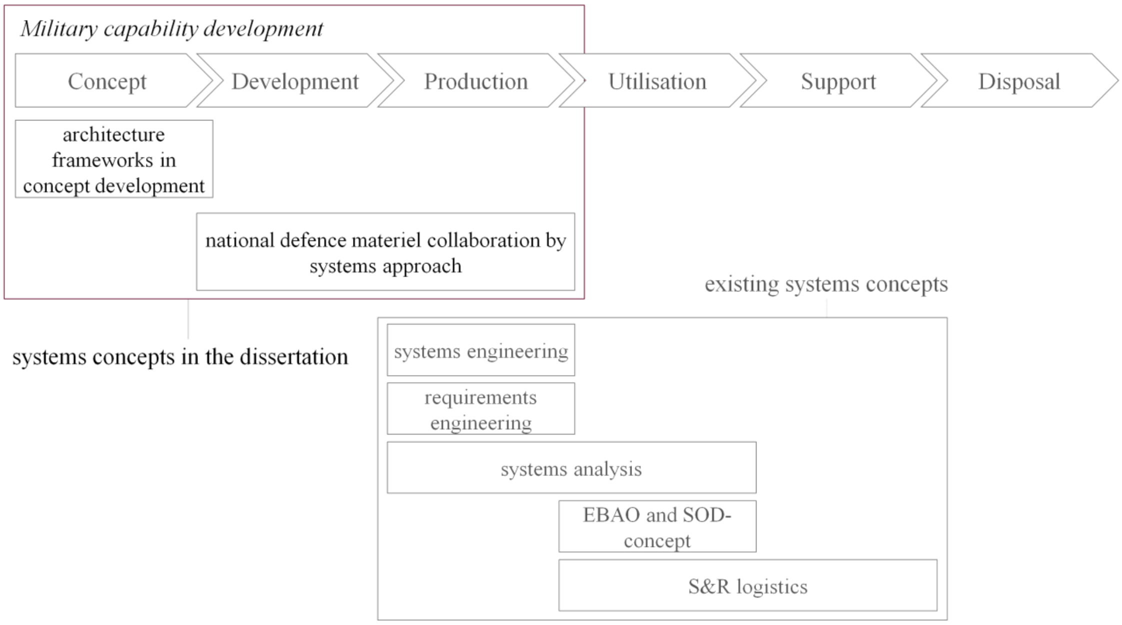


Figure 2. *The systems concepts under study in the dissertation and other: the existing systems concepts across the military capability life cycle.*

This dissertation recognises that various strands of systems approach have been widely applied to support the evolution and employment of military capabilities. The current broad use of systems concepts in the armed forces indicates also that the systems approach is capable of fulfilling its promises to provide an effective problem solving methodology to complex real-world issues such as production, use and support of military capabilities.

Therefore, this dissertation does not attempt to propose alternative systems concepts to those life cycle stages of military capability in which established systems practices and concepts already exist. Instead, this research deals with the life cycle stages and issues of military capability in which the systems approach is not known to have been applied. Concept development and experimentation represents the concept life cycle stage in the military community (Joint Chiefs of Staff, 2006). It enables the structured development of creative and innovative ideas into viable solutions for capability development (North Atlantic Military Committee, 2009). Military sources recognise that enterprise architecture frameworks serve as an excellent means to provide a precise description of military problems and potential candidate solutions (The Technical Cooperation Program, 2006; UK MoD, 2009). High-level CD&E guidance (The Technical Cooperation Program, 2006) and code of best practice (Command & Control Research Program, 2002) recommend using the enterprise architecture (EA) approach to enhance the products and processes of CD&E. Nonetheless, the detailed guidance for the concept development process does not recognise the EA approach as an organic element of CD&E, but instead characterises the development as 'writing the concept' (Joint Chiefs of Staff, 2006). This implies that concept development is considered more a simple writing process than a comprehensive innovation process in which various methods, such as comprehensive modelling, would be used.

Despite the international collaboration initiatives, such as EU's pooling and sharing and EC's defence procurement directives, in the development and production life cycle stages, known in the military community as capability planning and procurement, national defence materiel collaboration among the armed forces, local defence industry and academia is considered an important issue. The security of supply perspective is considered a crucial element of this collaboration, and is emphasised especially in militarily non-aligned countries, such as Finland (EDA, 2011a). The perspective of the contemporary literature about defence materiel collaboration between the armed forces, industry and academia is usually industry focused or economic-driven. There also appears to be a tendency to view issues on a multinational, such as EU level, instead of with a national focus (Hartley, 2008; James, 2006; Struys, 2004). The capability aspect (e.g., security of supply) is not dealt with substantially. Furthermore, issues are usually viewed from the perspective of large defence industrial countries (Bellais and Guichard, 2006; Dunne et al., 2007; Struys, 2004), rather than smaller countries such as Finland.

The first research objective of this dissertation deals with the systems models of military capability. The models derive from the practices and concepts followed not just in Finland, but also in other countries, such as Australia and the United Kingdom. The second research objective concerns the concept of the life cycle stage of military capability. Findings about the applicability of enterprise architectures to support this life cycle stage are utilisable in similar cases in any branch of the armed forces. Concentrating on the centre of excellence, a key collaboration mechanism, the third research objective concerns national collaboration during the capability planning and procurement stages. The papers related to that research objective have a Finnish focus and delineate the challenges as identified with a Finnish example. Nonetheless, the systems model it represents is of universal application, especially for countries that do not have a comprehensive defence industry but import the major part of their materiel from abroad.

1.5 Research design

1.5.1 Generic foundation

Research design is referred to as the plan to conduct research (Creswell, 2009) or, more specifically, as the plan to answer the research questions (Saunders et al., 2012). The Creswell framework for research design involves the intersection of worldviews (paradigms), strategies of inquiry and research methods. In comparison, Saunders et al. (2012) consider the research design as a layered construct, in which the layers are from the outside to the inside as follows: philosophy, approach, methodology, strategy, time horizon and techniques, as depicted in Figure 3. The terms 'research design' and 'research strategy' have also been used in reverse order (Bryman, 2008) to the way Creswell and Saunders et al. use them. In this case, research strategy is a general orientation towards conducting research and research design is a framework solely for the collection and analysis of data (Bryman, 2008; Walliman, 2006).

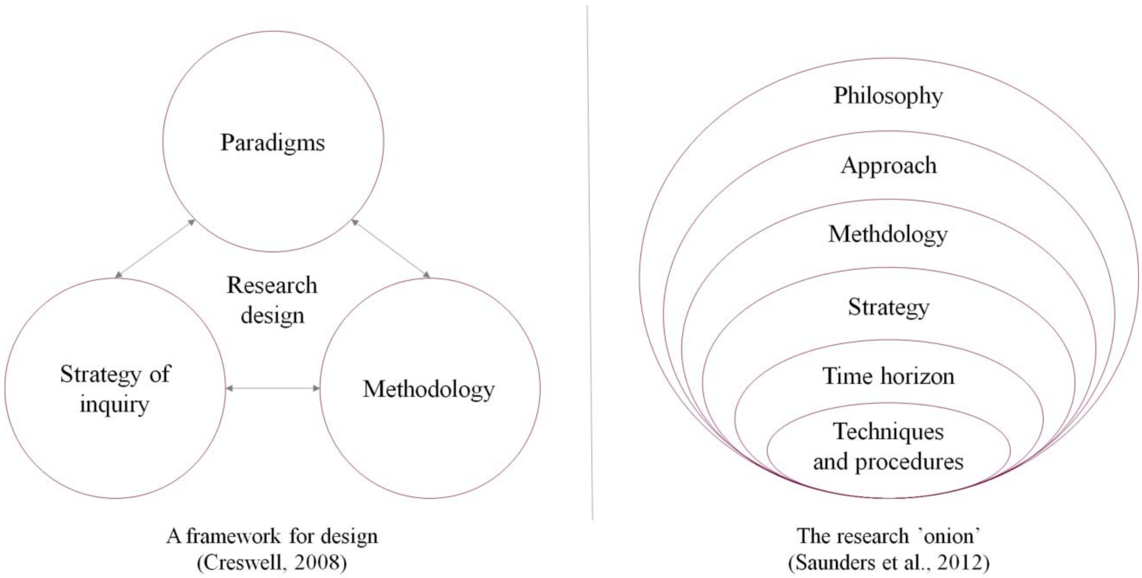
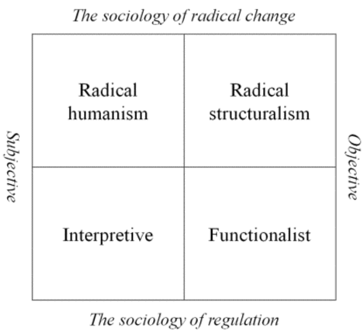


Figure 3. *Research design models of Creswell (2008) and Saunders et al. (2012).*

The first element of research design, ‘research philosophy’, refers to how a researcher sees the world around him/her, and his/her view about what constitutes facts, evidence, truth or science (Kelemen and Rumens, 2008). Philosophical ideas influence the practice of research (Guba and Lincoln, 1994) and help to explain and defend the selection of the methodological approach for the research (Creswell, 2009; Saunders et al., 2012). These ideas are known as epistemologies or ontologies (Bryman, 2008), paradigms (Guba, 1990) or worldviews (Creswell, 2009). There are a number of research paradigm typologies of which two well-known examples (Kelemen and Rumens, 2008), Burrell and Morgan (1979), and Guba and Lincoln (1994), illustrated in Figure 4, are briefly introduced. The introduction lays the foundation for the application of the research design and philosophy in this dissertation.



Typology of sociological paradigms
(Burrell and Morgan, 1979)

Item	Positivsm	Postpositivism	Critical theory	Constructivism
Ontology	Naive realism	Critical realism	Historical realism	Relativism
Epistemology	Dualist / objectivist	Modified dualist	Transactional, value mediated	Transactional, created findings
Methodology	Experimental	Modified experimental	Dialogic	Hermeneutical

Typology of alternative inquiry paradigms
(Guba and Lincoln, 1994)

Figure 4. *Research paradigm typologies of Burrell and Morgan (1979) and Guba and Lincoln (1994).*

The framework of Burrell and Morgan builds on the idea that ‘all theories of organisations are based upon a philosophy of science and a theory of society’. Consequently, they present a two-by-two matrix with two classification dimensions: nature of science and nature of society, resulting in four types of sociological paradigms: radical humanism, radical structuralism, interpretive and functionalist paradigms. The assumptions about the nature of science can be considered in terms of the subjective-objective dimension, whereas the nature of society deals with a stability dimension, represented by the terms ‘radical change’ and ‘regulation’ at opposite ends of the dimension. The functionalist paradigm perceives the world from regulatory and objectivist points of view and approaches the sociological concerns from a realist, positivist standpoint. This paradigm is considered problem-oriented in approach and thus concerned with providing practical solutions to practical problems. The interpretive paradigm can be characterised as regulatory, subjectivist and nominalist in nature. It attempts to understand the nature of the social world at the level of subjective experience. The radical humanist paradigm can be defined as being a radical change, subjectivist and emancipatory in nature. Researchers adopting a radical change perspective hold the view that emancipation is only possible if an entire ideology regime, which dominates the consciousness of man and inhibits his true consciousness (Burrell and Morgan, 1979), is overthrown (Kelemen and Rumens, 2008). The fourth paradigm, ‘radical structuralism’ advocates a sociology of radical change from an objectivist perspective. Whereas radical humanists concentrate upon consciousness as the basis for a radical change of society, radical structuralists focus on structural relationships within a realist social world. (Burrell and Morgan, 1979)

Guba and Lincoln present a typology with four paradigms: positivism, postpositivism, critical theory and constructivism. They state that each paradigm represents a worldview (i.e., a set of beliefs that defines for its holder the nature of the world, man’s place in it and the range of possible relationships to that world and its parts). Each paradigm differs from the others in its assumptions regarding three fundamental questions related to the conceptualisation of science: ontology, epistemology and methodology. The paradigm of positivism views reality as driven by natural laws and mechanisms and its basic posture is reductionist. The investigator and the object to be investigated are assumed independent entities. Methodologically, the research conducted in accordance with positivism should be validated empirically and the conditions be carefully controlled (manipulated). Postpositivism can be entitled ‘critical realism’. It differs from positivism in the sense that, because of flawed human intellectual mechanisms, it sees reality as only imperfectly understandable. Although objectivity remains a regulatory ideal, the independence of the investigator and the investigated object is abandoned. The methodology emphasis is placed on critical multiplism (i.e., a refurbished triangulation as a means to falsify rather than verify hypotheses). The critical theory paradigm can be labelled as ‘ideologically oriented inquiry’. It rejects the claim of value freedom made by positivists (Guba, 1990). The investigator and the object are interactively linked and the values of the investigator influence the inquiry. The inquiry in critical theory requires a dialogue between the investigator and the subjects of the inquiry. The dialogue must be dialectic to remove misapprehensions. Constructivism sees reality as multiple intangible mental constructions, which are local and specific in nature. The investigator and the object are interlinked as in the critical theory paradigm, but the findings are literally the creation of the process of interaction between the two. Individual constructions are refined hermeneutically (interpretative manner) and compared dialectically. (Guba and Lincoln, 1994)

The previously mentioned typologies are considered on the one hand as parallel constructs (Kelemen and Rumens, 2008). On the other hand, Burrell and Morgan's typology is seen as a complementary construct to the research philosophies, such as the typology of Guba and Lincoln. In this case, the paradigm of Burrell and Morgan is considered helpful in clarifying and summarising the epistemologies and ontologies of research philosophies (Saunders et al., 2012). Similarly, a paradigmatic framework is introduced for organisation studies (Alvesson and Deetz, 2000). The shifting research directions (i.e., the paradigms named in this framework) include normative, interpretive, critical and dialogic. In contrast to the views of Kelemen and Rumens, and Saunders et al., Alvesson and Deetz criticise the typology of Burrell and Morgan for favouring dominant traditions of the past and discouraging the investigation of similarities and collaborative possibilities among the paradigms. Despite criticisms, Burrell and Morgan's framework is considered extremely influential for contemporary organisational analysis (Kelemen and Rumens, 2008).

The common denominator for the typologies of Burrell and Morgan, Guba and Lincoln, Alvesson and Deetz, and Saunders et al., is that they all distinguish between the different paradigms based on the ontological, epistemological and methodological differences of those views. Ontologically, the views differ because of their assumptions about the nature of reality: is social reality given or is it constructed through people's meanings and interactions. Epistemologically, which considers the nature of the knowledge, the question is about the relation between the subject and the object. Objectivist knowledge views the scientist, i.e. the subject, as being removed from the social world under study, i.e., the object. The scientist acts as a mirror, which reflects reality and expresses it within a neutral language. Subjectivist knowledge is deeply embedded in the social and cultural context in which it is produced. Methodologically, the different typology perspectives refer to the variety of actual processes by which we can go about finding out what we believe to be 'true', such as specific quantitative or qualitative methodologies (Kelemen and Rumens, 2008).

This second element of research design, the 'strategies of inquiry' (methodologies), is defined as quantitative, qualitative or mixed methods designs or models, such as ethnography or experimental research that provides specific direction for procedures in a research design (Creswell, 2009). Methodological guidelines, which may be derived from philosophical deliberations, are stressed as being needed to guarantee valuable and defencible practice (Midgley, 2000). The third element, 'methods', involves the forms of data collection, analysis and interpretation, for example, statistical or text analysis (Creswell, 2009).

1.5.2 The research design of the dissertation

This dissertation approaches the research question from the perspective of a 'systems approach'. Writers and researchers have expressed diverse views about the systems approach by introducing various concepts, methodologies, methods, techniques and typologies of the approach (Reynolds and Holwell, 2010). These diverse views will be elaborated in Chapter 3, the methodology chapter of the dissertation. A specific systems approach, ‘the generic functionalist systems methodology’, which belongs to the functionalist systems approach by Jackson (2000), will be applied as the overall research design of this dissertation. The use of this approach in relation to the objectives of the dissertation will be explained in the methodology chapter. However, the suitability of the generic functionalist systems methodology to be used as a research design and to cover all the necessary elements of this design is explained in the next paragraphs. The rationalisation includes how the functionalist systems methodology builds on the philosophical foundation of the research, which was presented earlier in this chapter.

An approach is regarded as a way to go about tackling a problem. Science provides a ‘scientific approach’, just as systems provides a ‘systems approach’. Both of those approaches are meta-disciplines and both manifest a particular way of regarding the world. Those who apply a systems approach suppose that it will contribute usefully to our knowledge of the world. Although the systems outlook is a part of scientific tradition and it accepts the basic propositions of science, it assumes that the world contains structured wholes. In contrast, the traditional scientific approach considers that the world is featured by natural phenomena, which are ordered and regular, and this has led to an effective way of discovering those regularities (i.e., the ‘laws of nature’). (Checkland, 1999) The systems approach is seen by Checkland as a meta-discipline, ‘a subject which can talk about the other subjects’ (Checkland, 1999), meaning that the systems approach can be applied very widely and is adoptable to any area of human inquiry (Checkland, 1989).

From the philosophical perspective of the research, Burrell and Morgan’s framework is tremendously popular in the systems community and has been employed by systems thinkers such as Checkland (1981) and Jackson (1982). However, although various strands of systems approaches can be rationalised using ideas from the social sciences, systems approaches are not the same type of social theory as those found in Burrell and Morgan’s paradigms. Seldom providing an explanation of what the ‘real-world’ is like, they focus instead on methodologies, methods and models, which can be used to intervene in that world. Nonetheless, those who perceive the world through a ‘systems lens’ also incorporate assumptions about the nature of systems thinking, or social science, and the nature of social systems, or society. Correspondingly, Burrell and Morgan’s typology helps systems thinkers relate different systems approaches to different sociological paradigms, what each of those paradigms takes for granted and how each of those paradigms perceives the world. In addition, another significant difference between the traditions of systems thinking and social science is that the focus of systems thinking is usually in practice, whereas social sciences tend to be strong in theory. (Jackson, 2000) Jackson divides systems approaches into four types: functionalist, interpretive, emancipatory and postmodern (Jackson, 2000). His classification of the systems approaches stems not just from Burrell and Morgan’s typology, but also from various social and organisational theories and typologies of research philosophies. Jackson states, for instance that his division of systems approaches neatly corresponds to the earlier introduced typology of Alvesson and Deetz (2000), who call the approaches research directions and name them normative, interpretive, critical and dialogic. The differences in the names of Alvesson and Deetz's and Jackson's typologies reflect the different purposes for which those approaches are used (Jackson, 2000).

Jackson (2000) presents 13 constitutive rules. Those rules, presented in Table 6, represent the selected research design of the dissertation, which is the generic functionalist systems methodology. The rules place constraints and demands on all elements of the research design: the research philosophy, strategies of inquiry and research methods. From the perspective of research philosophy, Rule 1 states that functionalist systems methodology should be 'a structured way of thinking, with an attachment to the functionalist theoretical rationale that is focused on improving real-world problem situations'. As Jackson explains, the functionalist systems approach derived from Burrell and Morgan's functionalist paradigm is rooted in the tradition of sociological positivism (Burrell and Morgan, 1979). The functionalist systems approach represents the hard systems methodologies, such as systems analysis. When systems are viewed from within the functionalist paradigm (i.e., the objective, sociology of regulation), they appear to have an easily identifiable existence independent of the observers. If regularities in the interactions among the sub-systems and the whole are found, the understanding of such systems' functioning is increased. It is also possible to build a model of the system and the humans in the system do not cause any more problems than any other component in that system. The purpose of studying such systems is typically to improve the control and prediction of the systems. (Jackson, 2000)

This dissertation complies with the above mentioned rule as follows; the research question of this dissertation is approached from a systems perspective and applied in accordance with a specific research philosophical tradition, functionalism. It deals with tackling a real-world problem and seeks ways to enhance and improve the development of military capabilities in armed forces. Improvement is pursued primarily to increase the possibilities to achieve goals related to military capabilities. The components of military capabilities under examination are queried as external entities in relation to the researcher and thought of as socio-technical issues. Socio-technical systems thinking sees organisations as pursuing their primary tasks, which can best be realised if they are treated as open systems and fitted into their environment. Moreover, their social, technological and economic dimensions should be jointly managed (Jackson, 2000).

From the methodological perspective, Rule 2 dictates that the generic functionalist systems methodology should 'use systems ideas as the basis for its intervention strategy and will frequently employ methods, models, tools and techniques, which also draw upon systems ideas'. In this dissertation, all three research objectives are investigated and answers for them are sought using various systems methods, models and techniques. In addition, the military capability, which contextually provides the theoretical grounds for the dissertation, is modelled as systems from both whole system and whole time perspectives (i.e., intervened by using systems ideas).

To summarise, this dissertation specifically follows Jackson's functionalist systems approach, 'the generic functionalist systems methodology', as a research design. By presenting a comprehensive set of constitutive rules, which embrace all the elements of research design, it enables the interconnection of research philosophy, methodology and research methods, model, techniques and the area of concern in the study.

1.6 Terms and definitions

The key terms are briefly presented and explained below. They are discussed in a broader context later in the dissertation.

Military capability means different things in different contexts (Biddle, 2006; Kerr et al., 2006; Neaga et al., 2009; Touchin and Dickerson, 2008); therefore, it is only meaningful when it is defined within a context (Yue and Henshaw, 2009). Despite the context-dependent definition of the term 'capability', the generally recognised objective of military capability is the ability or power to achieve a desired operational effect in a selected environment and to sustain this effect for a designated period (New Zealand Defence Force, 2008; US DoD, 2008a).

Capability systems models, such as US DOTMPLFI (doctrine, organization, training, materiel, personnel, leadership and education, facilities and integration) (US DoD, 2008a) and the Australian FIC (fundamental inputs to capability), view capability as a system of interlocking and interdependent components (Director, Capability Operations and Plans, 2006). Therefore, these capability models shift attention away from traditional platforms and technical-systems-focused approaches, which usually refer capability as weapon system to the non-materiel aspects of capabilities (Fitzsimmons, 2007).

The systems approach is a problem solving concept, an attitude or an ability to look at wholes, different levels and interrelationships (De Greene, 1972). It is also a meta-discipline, which enables the combination of framework of ideas, methodologies and real-world entities into one conceptual framework; the systems framework of ideas is applied in accordance with some systems methodology in many areas of application, such as real world systems (Checkland, 1989).

Concept development is a process (North Atlantic Military Committee, 2009) or life cycle phase (ISO 19439, 2006) directed toward identifying conceptual solutions to capability challenges.

A life cycle model is a conceptual segmentation of the definition of a system's purpose, its realisation as a product or service and its utilisation, evolution and disposal. The life cycle model is typically segmented into stages to facilitate planning, provisioning, operation and support of the system. These segments ensure that a system progresses through established checkpoints to ensure satisfactory progress (ISO 15288, 2008).

Capability development is a part of the overall capability life cycle. It consists of concept, development, and production life cycle stages. In military community, these stages are usually known as concept development and experimentation, capability planning and procurement life cycle stages.

An enabling system enables a part (e.g., a stage of the life cycle) of a system-of-interest. Therefore, enabling systems facilitate the progression of the system-of-interest through its life cycle. As with any system, each enabling system has its own life cycle. Each life cycle could be linked to and synchronised with that of the system of interest. During any particular stage in the system's life cycle, the relevant enabling systems and the system-of-interest should be considered together. Since they are interdependent, they can also be viewed as a system (ISO TR 24748, 2010).

The centre of excellence in cross-sector collaboration is a physical or virtual centre or a network of centres, typically in research and development (R&D). They enable personnel to collaborate across disciplines and institutions on programmes, either long-term or short-term, that are locally relevant and/or internationally significant (Lawrence and Bodger, 2006).

From a broader perspective, security of supply is defined as 'the safeguarding of economic functions vital to the livelihood of the population, the national economy and national defence in exceptional circumstances' (Prime Minister's Office, 2004). The European Commission provides a more defence focused definition: 'a guarantee of supply of goods and services sufficient for a member state to discharge its defence and security commitments in accordance with its foreign and security policy requirements' (EC, 2009e).

1.7 Structure of the dissertation

This dissertation consists of four chapters and an introduction. Chapter 2 deals with the theoretical foundation of the dissertation. It describes and discusses the key concepts and terms related to the research objectives. First, the concept of 'military capability' is presented. Various capability models are introduced and the military capability life cycle is described. Second, the enterprise architectures (EA) in general and in the concept development stage of the military capability life cycle are discussed. Third, focusing on national collaboration defence materiel mechanisms, a review is provided of the collaboration to develop and sustain military capabilities. Chapter 3 explains the methodology of the dissertation by first reviewing the systems approach as a concept and second by describing the application of the specific systems methodology this dissertation follows. Chapter 4 summarises the published papers of the dissertation and presents the contributions of each paper in relation to the research objectives. The contributions of the author to each paper are displayed, and the application of the chosen methodology is explained. Finally, Chapter 5 concludes the summary of the dissertation by discussing the contributions of the dissertation both from theoretical and practical perspectives. The validity and reliability of the research are also assessed. Last, the directions for future research are proposed.

CHAPTER 2 – THEORETICAL FOUNDATIONS

In this chapter, key concepts and terms related to research objectives are described and discussed as the theoretical foundation of the dissertation. First, the concept of 'military capability' is presented. Various capability models are introduced and the military capability life cycle is described. Academic studies about military capability frameworks are discussed. Second, the enterprise architectures (EA) in general and in the concept development stage of the military capability life cycle are examined. Third, focusing on national defence materiel collaboration mechanisms, a review is provided of the collaboration to develop and sustain military capabilities.

2.1 Military capability and its perspectives

Military capability means different things in different contexts (Biddle, 2006; Kerr et al., 2006; Neaga et al., 2009; Touchin and Dickerson, 2008); therefore, it is only meaningful when it is defined within a context (Yue and Henshaw, 2009). Capability is also used interchangeably to refer to objectives, tasks that need to be accomplished in support of these objectives, and the means of conducting these tasks (Fitzsimmons, 2007). Despite the context-dependent definition of the term 'capability', the generally recognised objective of military capability is 'the ability or power to achieve a desired operational effect in a selected environment and to sustain this effect for a designated period' (Director, Capability Operations and Plans, 2006; New Zealand Defence Force, 2008; US DoD, 2008a). This objective is only achieved when real-life military units are engaged in an operation (Touchin and Dickerson, 2008).

A number of military capability models, such as joint capability areas in the United States (US DoD, 2008a) and the TEPIDOIL (training, equipment, personnel, information, concepts and doctrine, organisation and infrastructure) systems model in the United Kingdom (UK MoD, 2005b), have been developed to help manage and understand capabilities. Presentations of these models can be seen both in academic literature and in official government documentation, as described in the following sub-chapters.

2.1.1 Military capability as an instrument of foreign policy

Capability is one element of the concept of power in international relations (Holsti, 1964), which itself is a branch of political science that deals with relations between countries. The military component of international relations refers to the hard power of capabilities (Biddle, 2006; Nye, 1990). Although 'power' is a nebulous concept that does not tangibly address military capability and is often treated as both a resource and an outcome (Newsome, 2003), the term 'military capability', in this context, is used interchangeably with the term 'military power' (Biddle, 2006). Military power is carried out by armed forces, which exist to defend the state against real or potential external threats and to act as a coercive tool to protect national interests abroad (Edmunds, 2006).

The main views of the nature and determinants of military power in the existing literature are a) materialist, in which military power is a direct function of material resources and b) a conception that takes into account not only the quantity of a state's material resources but also how well it uses those resources in combat (Beckley, 2010).

This high-level military capability concept has also been identified in strategic-level government documentation. In Australia's Defence White Paper (Australian DoD 2009), defence is characterised as an element of national security, which provides options when the government contemplates the use of force. In the United Kingdom, the armed forces are seen, among other things, as an instrument of the legal use of force in support of the United Kingdom's vital interests overseas (HM Government, 2010).

2.1.2 Capability as an effect or a function to execute tasks

Since the end of the Cold War, functional capability models have become a popular framework for developing transformational concepts (Fasana, 2011). One of the key concepts of the functional capability approach is that required capabilities are considered first as effects or functions of armed forces, rather than as specific solutions to avoid potential bias towards particular developmental solutions (Cochrane, 2011). Another key feature of this capability approach is that it attempts to provide capabilities suitable for a wide range of challenges while working within an economic framework that necessitates choice. Hence, it contrasts with developing forces based on a specific threat and scenario (Davis, 2002).

The functional capability models of four countries are shown in Table 1. In the United Kingdom, high-level operational concepts provide an effects-based framework for future military operations and a depiction of seven interdependent capability components (Joint Doctrine and Concepts Centre, 2004), also known as functions of the Defence Capability Framework. In the United States, joint capability areas are defined as functionally grouped capabilities to support future force development and operational planning. Capabilities are abilities to achieve desired effects to perform a set of tasks (US DoD, 2008a). The Finnish functional capability areas (Välivehmas, 2010) are, in practice, similar to those of the United States. Australian capability areas usually include effects or functions, although they could also be technology or some other capability input (Director, Capability Operations and Plans, 2006).

USA Joint capability areas	UK Functions of defence capability framework	Australia Capability areas	Finland Capability areas
Command and control	Command	Command and control (EC)	Command and control
Battlespace awareness	Infrom	Information superiority (CP)	Situational awareness
Net centric		Networked capability (CDP)	Net centric
Logistics	Sustain	Logistics (EC)	Logistics
Building partnerships			Partenrships
Force support	Protect	Repair and maintenance elements (EC)	Protection
Force application	Project Operate	Transport and movement (EC) Precise Force Application (CDP)	Generation of force Force application
Corporate management and support			Corporate management and support

Legend: EC = enabling capability, CDP = capability development principle, CP = capability priority

Table 1. *The functional capability models in various countries.*

2.1.3 Capability as systems

Capability systems models, such as US DOTMPLFI (doctrine, organization, training, materiel, personnel, leadership and education, facilities and integration) (US DoD, 2008a) and the Australian FIC (fundamental inputs to capability), view capability as a system of interlocking and interdependent components (Director, Capability Operations and Plans, 2006). Therefore, these systems capability models shift attention away from traditional platforms and technical-systems-focused approaches to the non-materiel aspects of capabilities (Fitzsimmons, 2007). The UK's systems capability model (UK MoD, 2005b) has virtually the same components as the US DOTMPLFI. In Finland, the capability systems model is defined in a more basic manner (Defence Staff, 2007) than the three other systems models shown in Table 2.

USA (DOTMPLF(I))	UK DLoD (TEPIDOIL)	Australia FIC	Finland
D = doctrine	D = concepts and doctrine I = information	Command and management	Doctrine Will for defence
O = organisation	O = organisation	Organisation	
T = training	T = training	Collective training	
M = materiel	E = equipment L = logistiscs	Major systems Supplies	Materiel
L = leadership and education P = personnel	P = personnel	Personnel	Personnel
F = facilities	I = infrastrcuture	Facilities Support	Infrastrcture, Support
Legend: DLoD = Defence lines of development, FIC = Fundamental inputs to capability			

***Table 2.** The systems capability models in various countries.*

2.1.4 Capability as weapons system or a platform

Traditionally, military capability has been thought of primarily in terms of materiel (De Spiegeleire, 2011), as a function of a specific weapons system or as a military platform and its performance. A physical system perceived to exhibit capability is often compared with a system that is viewed as its opponent. For example, the protection capabilities of a main battle tank are compared with the penetration capabilities of an anti-tank missile, either for future system requirements or to assess existing performance. Physical systems are also viewed as a type of building block, such as resources (Davis, 2002) or solutions (James, 2005) for capabilities, rather than capabilities themselves. The weapons system capability model has also been criticised as a flawed approach to rationalising wider capability issues because it focuses on inputs rather than outputs or ends, for instance, the effects that the defence policy is trying to create (Cornish and Dorman, 2009). In the academic literature, the platform-level capability approach is used, for example, to assess military operations (Johnson, 2010) or consider threat evaluation and weapons allocations (Paradis et al., 2005).

2.1.5 Capability as fighting power through military units

The most obvious elements of national military power are represented by combat arms; specifically, the force elements that bring military power directly to bear, including special forces, infantry, and naval and air units (Whitehall Papers, 2000). These force elements—military units—manifest real-life fighting power, the ability to fight and operate; thus, it is the ultimate performance measure of the military units. Fighting power comprises a conceptual component (how to fight), a morale component (the ability to get people to fight), and a physical component (the means to fight) (Development, Concepts and Doctrine Centre, 2010). Real-life military units view themselves as having the military capability to achieve a desired operational effect in a selected environment and to sustain this effect for a designated period (New Zealand Defence Force, 2008).

2.2 Capability frameworks

As a consequence of many different capability models, all related stakeholder groups, such as political decision makers, military planners, the acquisition community, field commanders, and the defence industry, discuss and use models and concepts of capabilities. However, each of these stakeholders focuses on certain capability concerns and considers these concerns with a certain level of detail and at particular stages in the capability life cycle. Therefore, each stakeholder may perceive capability in a different way from other stakeholders. The number of and variation in capability models may create misunderstandings between stakeholder groups. These misunderstandings may impede the ideal evolution and employment of military capabilities.

Nonetheless, some studies provide a comprehensive and systematic perspective of military capability models. These models are frequently referred to as capability frameworks. A capability model in which systems capability model components are seen as resources in a unit that fulfils responsibilities has been presented by Russell et al. (2008). In the model, the resources are transformed into capabilities when they are integrated with each other to fulfil operational responsibilities. The upper-level ontology in Suzic and Svenson's (2006) capability-based plan resembles the model by Russell et al., but ignores the responsibility component, which exists between the capability and resource components. An alternative capability model based on the interaction between effects, time and space has been presented by Fasana (2011). These three models do not build on the existing capability models, presented above, but represent analytical constructs created by the authors.

A framework for military capability, consisting of building blocks, a function layer, an effects layer and an influencers layer, has also been proposed (Kerr et al., 2006). The paper provides a multi-layered capability model, but approaches the issue primarily from the bottom-up, specifically, in how military systems, such as materiel, create functions and effects, rather than viewing issues from the top-down, as the actual capability development process does. A holistic view of the UK's military capability development is presented by Yue and Henshaw (2009) articulating what through-life capability management (TLCM) means for defence capability planning, development and delivery. This paper focuses on systems and military unit capability models and the challenges related to capability development in a specific country. Capability architecting, which links the customer's needs with the structure of the capability solution to be implemented, has been presented by Touchin and Dickerson (2008). This article compares various architecting approaches and proposes a definition of the term 'architecting for capability', but does not propose a capability architecting or life cycle model. The summary of the capability framework studies, along with their characteristics, is presented in Table 3.

Author	Year	Generic	Top-down direction	Life-cycle included	Based on	
					existing models	known framework
Suzic and Svenson	2006	x	N/A			
Kerr et al.	2006	x		P	P	
Russell et al.	2008	x	N/A			
Touchin and Dickerson	2008	x	N/A		P	x
Yue and Henshaw	2009		x	P	P	
Fasana	2011	x	N/A			

Legend: N/A = not available, P = partly

***Table* 3.** Studies of military capability frameworks and their characteristics.

2.3 Capability life cycle

2.3.1 Life cycle concept

The term 'system life cycle' is traditionally used to refer to the step-wise evolution of a system from concept through development, and on to production, operation, and finally disposal (Buede, 2000; Kossiakoff and Sweet, 2003). This system life cycle concept is applicable to any man-made system that provides services in defined environments for the benefit of users and other stakeholders (ISO 15288, 2008). A life cycle model is a conceptual segmentation of the definition of a system's purpose, its realisation as a product or service, and its utilisation, evolution and disposal. The life cycle model is typically segmented into stages to facilitate planning, provisioning, operation and support of the system. These segments ensure that a system progresses through established checkpoints to ensure satisfactory progress. A life cycle model can help an organisation to think of its work and its processes within a larger framework (ISO TR 24748, 2010).

The ISO 24748 technical report approaches life cycles from the systems perspective. It identifies two systems terms: system-of interest and enabling system. System-of-interest refers to a particular system that is of interest to an observer. Each enabling system enables a part, for example, a stage of the life cycle, of a system-of-interest. Therefore, enabling systems facilitate the progression of the system-of-interest through its life cycle. As with any system, each enabling system also has its own life cycle. Each life cycle could be linked to and synchronised with that of the system-of-interest, as illustrated in Figure 5. During any particular stage in the system's life cycle, the relevant enabling systems and the system-of-interest should be considered together. Since they are interdependent, they can also be viewed as a system (ISO TR 24748, 2010).

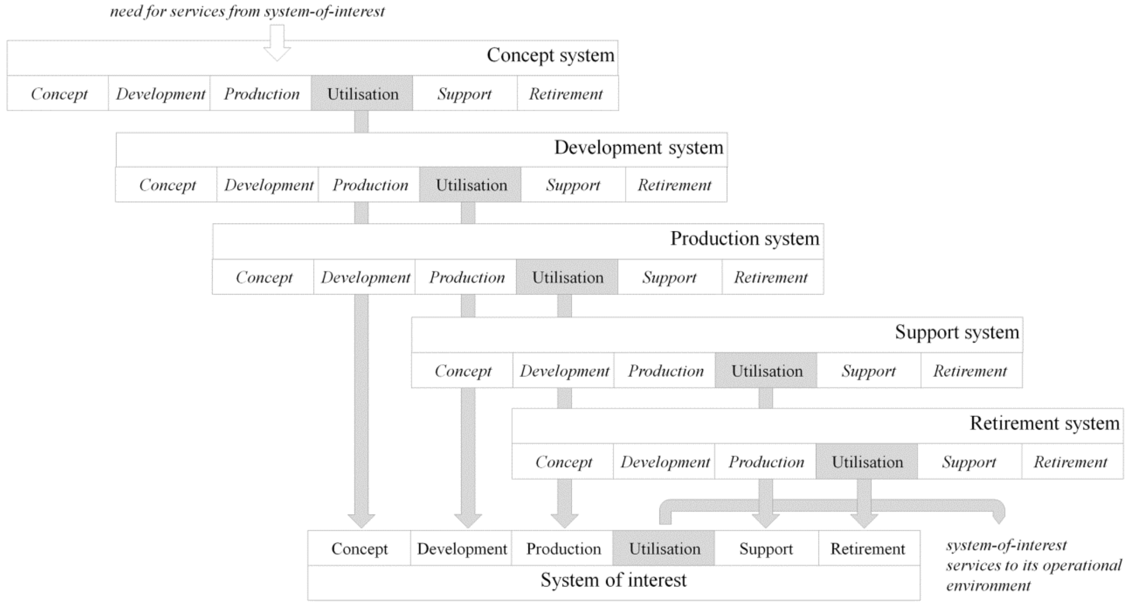


Figure 5. *Interaction between system-of-interest and enabling systems (adapted from ISO TR 24748).*

2.3.2 Concept development, capability planning and procurement life cycle stages

Taken as a whole, in this dissertation, military capability life cycle is understood to consist of concept development and experimentation, capability planning, procurement, in-field operation and disposal life cycle stages. The capability development, in turn, is a part of the overall military capability life cycle and it includes concept development and experimentation, capability planning and procurement life cycle stages.

The purpose of the concept stage in accordance with the ISO 24748 report is to identify stakeholder needs, explore concepts and propose viable solutions. In the military organisation, this stage corresponds to the concept development and experimentation (CD&E) stage as well as the related CD&E system that enables the conduct of that particular life cycle stage.

Military concepts can be seen as a visualisation of future operations. They describe how a military commander, using military art and science, might employ the requisite capabilities to meet future military challenges (Joint Chiefs of Staff, 2006). Concept development is a process (North Atlantic Military Committee, 2009) or life cycle phase (ISO 19439, 2006) directed towards identifying conceptual solutions to capability. Experimentation is seen as a controlled investigation to discover information, confirm or disprove a hypothesis, or formally validate a concept based on a conceptual rationale (North Atlantic Military Committee, 2009).

The CD&E stage plays an important role in driving strategic transformation in the military community. Concepts connect strategic guidance to the development and employment of future military force capabilities (Joint Chiefs of Staff, 2006) by enabling the structured development of creative and innovative ideas into viable solutions for capability development (North Atlantic Military Committee, 2009), and therefore can be seen as an 'engine for transformation'. Transformation could eventually lead military organisations to changes in doctrine, organisation, training, materiel, leadership and education, personnel and facilities, and policy (Oxenham, 2010).

The second life cycle stage in the ISO 24748 is development. Its activities include refining system requirements and creating solution descriptions. The corresponding enabling capability stage and system in the military organisation is frequently called capability planning. The capability planners refine the functional capability requirements initially identified in the CD&E stage into viable functional capability goals (Director, Capability Operations and Plans, 2006) and systems solutions.

The capability procurement system enables the conduct of production life cycle stage, with the purpose of producing the system of interest, for example, military units (ISO TR 24748, 2010). The capability solutions are procured as capability systems by taking into account the defence lines of development such as the TEPIDOIL capability systems model.

2.3.3 Military capability life cycle models

Military capability life cycle models, such as the DoD 5000 series in the United States (US DoD, 2008b), CADMID (Concept, assessment, demonstration, manufacture, in-service, and disposal) in the UK (UK MoD, 2005b) and the life cycle stage model in Finland (Defence Staff, 2007), focus heavily on the procurement stage of the capability life cycle and systems capability model. This is just one of the many capability models used to facilitate the evolution of military capability from cradle to grave. Moreover, only two (Kerr et al., 2006; Yue and Henshaw, 2009) of the above mentioned capability framework studies incorporate life cycle considerations into the discussion on military capabilities. In addition to the US DoD, CADMID life cycle model and the Finnish military capability life cycle model, the United Kingdom's through life capability management (TLCM) concept is similarly focused on specific stages—the acquisition and in-service—of the life cycle and leans primarily on the systems capability model (Oxenham, 2010). TLCM is defined as 'an approach to the acquisition and in-service management of military capability in which every aspect of new and existing military capability is planned and managed coherently across all Defence Lines of Development (DLoD) from cradle to grave' (Tetlay, 2010).

Specifically, the known capability life cycle models tend to deal with capability as a system-level issue rather than addressing it on the enterprise-level. On the system-level, capability life cycle refers, for example, to how a functional need of air supremacy is transformed to an operational fighter aircraft with requisite enabling systems such as maintenance or personnel. On the enterprise-level, the analogous example would refer to a future defence concept of a country, transformed to a real-world military capability by a development programme, which includes all capability systems produced in the next 10 to 12 years.

2.4 Enterprise architectures

2.4.1 Enterprise architecture as concept

An enterprise is one or more organisations sharing a definite mission, goals and objectives to offer an output, such as a product or service (ISO 15704, 2005). Enterprise integration is the process of ensuring the interaction between enterprise entities necessary to achieve domain objectives (ISO 19439, 2006; McGinnis, 2007) and is applicable to any enterprise, regardless of its size and mission (ISO 15704, 2005). One way of approaching the enterprise integration is through enterprise modelling, for example, by using a consistent modelling framework (Chen et al., 2008). Enterprise modelling (EM) is an abstraction of an enterprise domain that represents enterprise entities, their interrelationships, their decomposition and detailing to the extent necessary to convey what it intends to accomplish and how it operates (ISO 19439, 2006). Therefore, the enterprise model is a representation of those intentions (ISO 15704, 2005). Enterprise modelling is also seen as how the enterprise architecture (EA) is visualised and expressed and how this visualisation serves and increases the enterprise integration (Lankhorst, 2009). The architecture at the level of an entire organisation is commonly referred to as EA. It is a coherent whole of principles, methods and models used in the design and realisation of the enterprise's organisational structure, business processes, information systems and infrastructure (Jonkers et al., 2006). Architecture framework (AF) provides an organising structure for the information contained in EA. Although AF is not architecture, it specifies the guidance, rules and product descriptions for developing and presenting architecture information (Lim et al., 2009; NATO Consultation, Command and Control Board, 2007). AFs can also be built to contain a domain, for example, capability that is a subset of the whole enterprise (O'Rourke et al., 2003). However, based on the information in ISO 15704 (2005) and the IFIP–IFAC Task Force (1999), AFs are also seen as architectures that pursue the structuring concepts and activities necessary to design and build a system (Chen et al., 2008). Architecture products are graphical, textual, and tabular items developed in the course of creating a given architecture description; they describe characteristics relevant to the purpose of the architecture (Handley and Smillie, 2008).

As previously noted, the definitions of EM and EA are similar. However, researchers have identified differences between these notions. While EM describes the EA from various viewpoints in detail to allow the specification and implementation of the systems (Chen et al., 2008), EA is a framework for practicing EM (McGinnis, 2007). Furthermore, the concept of EM is also considered less developed than that of EA, and thus unable to achieve the effectiveness of EA (Kamogawa and Okada, 2005).

The importance of EAs in supporting strategic change and execution is identified by an increasing number of both commercial companies (Ross et al., 2006; Schekkerman, 2004; Yu et al., 2006) and public sector actors (Government Accountability Office, 2010; NATO Consultation, Command and Control Board, 2007). Therefore, it is not surprising to realise that enterprise architectures are also considered one of the key elements (Carlock and Fenton, 2001; Panetto and Molina, 2008) or even the foundation (Chen et al., 2008) in enterprise engineering or enterprise systems engineering, which build, among other disciplines, upon general systems theory and are closely related to systems engineering (Giachetti, 2010).

Nonetheless, there is little evidence of how expectations toward EAs and their frameworks are met. Several academic papers (Aier et al., 2009; Chen et al., 2008; Kaisler et al., 2005; Kamogawa and Okada, 2005; Niemi and Pekkola, 2009) have identified the lack of research evidence on the benefits of EAs, including governmental organizations (Hjort-Madsen, 2006; Liimatainen, 2008). While EA application studies in military contexts deal with capability testing (Dryer et al., 2007) and mapping the Department of Defense of the United States Architecture Framework (DODAF) tools against military outcome (Saulson, 2006), no research evidence for EA application in CD&E has been found.

2.4.2 Evaluation of the benefits of the EA

Current studies about the evaluation of EA focus on presenting frameworks and methodology. However, the potential benefits based on empirical evidence have received less study (Niemi and Pekkola, 2009).

Furthermore, the notion of 'benefit' or 'value' has been defined in various ways, and no single comprehensive view of the ways EA might add value to an organization exists. A systematic literature review of EA contributions to organisations found the potential benefits of EA in 29 unique contexts within which EA has been found to deliver 100 unique benefits through three value-generative mechanisms (Boucharas et al., 2010). In the context of this dissertation, 'benefit' is defined as a helpful and useful effect that something has (Oxford University Press, 2005).

The current research about the frameworks and methodologies of EA benefits can be divided into two main categories. The first comprises research that perceives benefits mainly as qualitative outcomes, for example, the quality of information and potential use of EA. The DeLone and McLean model of information systems success (Delone and McLean, 2003) has been adapted to the EA benefit realisation process (Kluge et al., 2006; Niemi and Pekkola, 2009). These models provide a framework for assessing EA benefits, such as assessment criteria, but do not describe in detail the measures of effectiveness, which define in detail the evaluation parameters. EA value has also been divided into three dimensions: the architect, process to build the EA, and its products (Boster et al., 2000). Although this paper introduces several EA products, they are too generic to be applied to the current study. Benefit analysis is considered as well as a complementary element for cost analysis, among many analyses, that EA could support for the mission accomplishment of an enterprise (Bucher et al., 2006). That paper lists and presents a comprehensive set of analyses rather than describing individual analysis in detail.

The second category comprises research that includes both quantitative and qualitative dimensions in the study of benefits. A multi-perspective framework based on the concept of Balanced scorecard has been proposed to identify the value of EA (Schelp and Stutz, 2007). Although the framework includes assets, processes, services and financial aspects, it is too generic to provide an adequate foundation for this work. An analytical framework for assessing EA effectiveness has also been proposed (Kamogawa and Okada, 2005). This paper concentrates on the e-business domain—business conducted by utilising methods brought about by advances in information technology (IT). A set of EA metrics to measure inter-related IT goals, particularly those related to EA, has also been proposed (Velitchkov, 2009).

2.4.3 Architecture frameworks

Numerous enterprise architectures are in use today to guide and provide the rules for enterprise architecture development. Thirteen different architecture frameworks, which are used in either private or public sectors, have been listed in a book, called 'How to survive in the jungle of enterprise architecture frameworks: creating or choosing an enterprise architecture framework' about the AFs (Schekkerman, 2004). The Zachman Framework for Enterprise Architecture (ZFEA) is considered a pioneer in the enterprise architecture domain (Urbaczewski and Mrdalj, 2006). The original Zachman framework was published in 1987 (Zachman) and was extended and formalised in 1992 (Sowa and Zachman). The ZFEA provides a comprehensive, logical and technology-neutral structure for descriptive representations (i.e., models) of any complex object (Zachman, 1996). The focus of the ZFEA is on ensuring that all aspects of an object are well organised and exhibit clear relationships in describing the entire information structure of the object (Schekkerman, 2004). It describes systems in two dimensions: perspective and aspect. Perspectives capture all of the critical models required for systems development; a complete system (on each perspective) can be modelled by answering the questions (aspects) of why, what, who, how, where and when. The framework does not provide guidance on sequence, process or implementation (Schekkerman, 2004) and it does not have explicit compliance rules (Urbaczewski and Mrdalj, 2006). The ZFEA is identified to provide at least three distinctive benefits: 1) it helps in conceiving of and communicating complex concepts precisely with few, non-technical words, 2) it enables working with abstractions and simplifying issues without losing the sense of complexity of the issue as whole, and 3) it helps in positioning the issue in the larger context (Zachman, 1996). Hence, the ZFEA is considered a suitable framework for a multi-level and technology-neutral meta-model for military capability, and it is capable of incorporating existing military capability models.

In addition to generic AFs, such as ZFEA and specific business and industrial domain built AFs, such as The Open Group Architecture Framework (TOGAF) (Schekkerman, 2004), several architecture frameworks have been developed particularly for defence sector needs and purposes. The most mature and widely adopted architectural frameworks in the defence sector (Alghamdi, 2009; NATO Consultation, Command and Control Board, 2007) are the Department of Defense of the United States Architecture Framework (DODAF) (US DoD, 2009) and the United Kingdom Ministry of Defence Architecture Framework (MODAF) (UK MoD, 2009). NATO uses its own NATO Architecture

Framework (NAF) (NATO Consultation, Command and Control Board, 2007). Military sources recognise that enterprise architecture frameworks not only support conventional system planning and implementation activities, but also play an increasing role in prototyping and experimental work, because they are an excellent way to describe military problems and potential candidate solutions with high precision, including CD&E activities (The Technical Cooperation Program, 2006; UK MoD, 2009). In military CD&E, AFs are seen primarily as a modelling support to capture and describe the processes, information nodes, data flows and the range of different interrelationships being experimented with (The Technical Cooperation Program, 2006) and identified as one sort of static model among all potential modelling support (Command & Control Research Program, 2002).

A limited amount of research compares defence architecture frameworks. The characteristics of DODAF have been compared with various non-defence related AFs, based on quality attributes of EAs (Lim et al., 2009), or using the goals, inputs, and outcomes of AFs as fundamental elements in the analysis (Tang, 2004) or comparing it against the earliest EA framework (Lim et al., 2009), the Zachman framework (Urbaczewski and Mrdalj, 2006). Earlier versions of DODAF have been evaluated using the International Organization for Standardization (ISO) Standard 15704 (Noran, 2005). No evidence of similar comparisons of NAF has been found. There is also a comparative analysis of the three aforementioned defence AFs by the analytical hierarchy process: the study ranked MODAF as first, DODAF as second, and NAF as third in its assessment (Alghamdi, 2009). However, the data source used for weighing the assessment criteria (Tang, 2004) in that paper refers to out-dated versions of the AFs. Consequently, the ranking results are likewise out-dated.

Two of these well-known defence AFs, namely DODAF and NAF, are described briefly below, as they were considered the most suitable candidates for application to the case project in papers [III] and [IV] of this dissertation. DODAF version 2.02 was approved for use in 2010. DODAF serves as the overarching framework and conceptual model used to facilitate the ability of managers to make decisions more effectively through organised information sharing. DODAF focuses on architectural data as information required by decision makers, rather than on developing individual products (US DoD, 2009). Therefore, DODAF does not have products; it has DODAF-described views. Architecture views are subsequently organized into viewpoints (DoD Deputy Chief Inormation Officer, 2010). DODAF consists of eight viewpoints: capability, operational, services, systems, standards, data and information, project and all viewpoints. The current version of NAF, version 3, was implemented in 2007. NAF provides mechanisms that enable communication about the essential elements of the NATO enterprise and its environment, including its partners. It enables architectures to contribute to acquiring and fielding cost-effective and interoperable military capabilities. NAF includes seven views: capability, operational, service-oriented, system, technical, programme and all views (NATO Consultation, Command and Control Board, 2007).

DODAF is a department-level AF developed primarily for national purposes. In contrast, NAF is a multinational framework. Currently, there are 28 NATO member nations and 21 partner nations, including Russia (NATO, 2010). Consequently, NAF emphasises the interoperability requirements among the large number of multinational users. While DODAF also seeks interoperability, it is primarily across the Department of Defense. Based on the amount of AF documentation, the level of detail is considered substantial both in NAF and in DODAF: the NAF document has 882 pages and DODAF's documentation totals 390 pages. The large volume of documentation indicates AF's attempt to both serve a broad audience and provide concrete support for the various functions of those organisations. These AFs emphasise a 'fit-for-purpose' approach (US DoD, 2009); specifically, architectures and their products should be designed for a purpose, such as to address a particular set of problems. One should model only the required elements of the system of concern on the appropriate level of AF, based on needs and situational constraints. The fit-for-purpose approach means that the AFs do not guide which parts and what levels of the framework should be used (Baumgarten and Silverman, 2007; US DoD, 2009) in specific situations, such as CD&E.

2.5 Collaboration as a vehicle to innovation and new knowledge

Various forms of inter-organisational collaborative arrangements, such as partnerships, networks and alliances, have become a common part of institutional life (Huxham and Vangen, 2000; Thomson and Perry, 2006) and widely adopted vehicles for organisations to work together (Googins and Rochlin, 2002). The common denominator of the collaboration arrangements is that they are directed toward obtaining a collaborative advantage, such as achieving outcomes that could not be attained by any of the organisations acting alone (Gazley, 2008; Huxham, 1996; Lasker et al., 2001). In practice, collaborative activities are initiated, for instance, as a response to a lack of competencies (Selsky and Parker, 2005) or environmental or funding uncertainty (Gazley, 2010). Collaboration may take place within one sector, such as inter-firm, or it may expand across many sectors (Babiak and Thibault, 2009). The term 'cross-sector' refers to partnerships that involve governments, businesses, non-profits and philanthropies, communities and/or the public as a whole (Bryson et al., 2006). Cross-sector collaboration suggests an orientation toward the public good and some measure of public or non-profit actor involvement (Simo and Bies, 2007).

Aspirations and scientific evidence variously show collaboration as a critical new source of competitive advantage for enterprises (Escribano et al., 2009; Rigby and Zook, 2002) and/or a valuable mechanism for organisations to acquire knowledge and promote their innovativeness (Becheikh et al., 2006; Caloghirou et al., 2004; Souitaris, 2001). Nonetheless, there is also substantial evidence showing that collaboration often fails to meet the expectations of those involved (Anderson and Jap, 2005; Babiak and Thibault, 2009; Huxham, 1996; Medcof, 1997), thus endangering the advantages that the collaboration seeks to achieve. Moreover, the academic literature addressing collaboration has focused on defining the characteristics of various forms of cross-sector partnerships or their processes rather than assessing the implications or outcomes of actual examples

(Boase, 2000; Donahue, 2004; Dowling et al., 2004). As one method of preventing collaboration failures, the systematic documentation of the progress of collaboration partnerships is recommended to assess progress and redirect efforts (Roussos and Fawcett, 2000). To measure whether collaboration meets its goals, scholars have paid increasing attention to the functioning of partnerships. This is because achieving goals depends on how well the partnerships function. One approach to conceptualising the functioning of partnerships is to examine the actions carried out in the various phases or stages of the partnerships (Lasker et al., 2001).

2.5.1 Collaboration-related terms and concepts

Although collaboration-related terms, such as 'collaboration', 'partnerships', 'collaborative partnerships' and 'strategic alliances', are used interchangeably in academic papers, various definitions have been given for each of them, as shown in Table 4.

Collaboration	
Gray (1989)	a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited visions of what is possible
Mattessich et al. (2001)	a mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals
Partnerships	
Mohr and Spekman (1994)	purposive strategic relationships between independent firms who share compatible goals, strive for mutual benefit, and acknowledge a high level of mutual interdependence
Collaborative partnership	
Roussos and Fawcett (2000)	an alliance between people and organisations from multiple sectors working together to achieve a common purpose
Strategic alliance	
Das and Teng (2000)	inter-firm cooperative arrangements aimed at the pursuit of mutually strategic objectives

Table 4. *Collaboration terms.*

Mohr and Spekman's (1994) definition is close to Gray's (1989), although Gray's does not identify the need for a high level of mutual interdependence in collaboration. While Gray's definition stresses the process of gaining a collaborative advantage, Mattessich et al. (2001), Roussos and Fawcett (2000), and Das and Teng (2000) emphasise common goals in their definitions. Das and Teng limit the use of the term 'strategic alliances' just to inter-firm cooperative arrangements. Mattessich et al. and Czajkowski (2007) also note that collaboration is commonly used synonymously with cooperation and coordination, although each word exhibits a different level of formality and structure, cooperation being the least formal and collaboration being the most formal inter-organisational relationship.

2.5.2 Defence materiel related collaboration

2.5.2.1 Role of defence procurement in the provision of military capabilities

The government is ultimately responsible for the provision of national security. The task of defence organisations, such as the armed or defence forces, is to produce and operate military capabilities to participate in the provision of that security. The forces acquire the non-human, physical elements of military capability from industry at home and abroad. The acquisition of defence materiel is usually regarded as defence procurement (Markowski et al., 2010), such as when looking at the issue from the defence forces perspective or alternatively arms trade, when considering the topic primarily as an economic issue or reviewing it from the perspective of the supplier, the industry. However, defence procurement often has a variety of contradictory security and economic objectives (Garcia-Alonso and Levine, 2007). From the national economic perspective, in-country production would be beneficial to national employment and the potential export of the produced materiel would cover the development costs of that materiel. From the perspective of defence forces capabilities and budget, the most cost-effective system supplied either by national or foreign industry would yield the best value for the money. From the wider perspective of national security, the security of supply and the capability advantage achieved by a domestically produced state-of-the-art system would be important factors in the decision making of defence procurement.

For those reasons, both producer countries (Garcia-Alonso and Levine, 2007), and buyer countries use various instruments to regulate defence procurement. The regulative mechanisms include export controls, defence industrial and technological strategies and related organisational instruments, such as centres of excellence, and export and import subsidies. Export controls are used to stabilise the arms race and reduce tensions (Levine and Ron, 2000) by regulating, for instance, the export of defence materiels to defined customers or of certain technologies (Garcia-Alonso and Levine, 2007). Defence industrial strategies attempt to establish and maintain required indigenous supply and support options (Hall et al., 2010), while defence technology strategies attempt to create and maintain a sufficient technological base at home (Australian DoD, 2010; UK MoD, 2005a). The centre of excellence concept is one way to implement the defence industrial and technology strategies or parts of them and related activities. Export subsidies refer to state support of national industry to promote their export potential and thus increase their market share (Garcia-Alonso and Levine, 2007). National defence industrial import subsidies, such as offsets, may be justified by a number of motives, including strategic, such as security and economic reasons (Dumas, 2004; Markowski et al., 2010). The strategic reason could be the desired indigenous security of supply, while the economic reason could be, for example, fostering the competitiveness of local industry.

Although the previously mentioned mechanisms relate to defence procurement, as their descriptions indicate, their sphere of influence extends from the early stages of capability development to the operations stage of the developed and procured defence systems. Technology related activities create the necessary knowledge and preparedness for the defence industrial activities that can be in place both during the production and operations stages of the defence materiel. Furthermore, those mechanisms may be inter- or intra-national. In spite of the form of realisation of those mechanisms (inter- or intra-national), especially defence industrial policy related activities, there are justifications both for and against each of those forms (Hartley, 2007). In either case, the regulations naturally have a substantial impact on the relations between the national defence industry, related academic institutions and the defence forces. Therefore, they also define the degree and practical forms of defence materiel collaboration carried out nationally and internationally.

2.5.2.2 Trends in European Union in defence procurement collaboration

The EU defence manufacturing sector can be best described as a set of independent national markets, each with a distinctive set of supply and demand arrangements (Edwards, 2011). Therefore, it is easy to understand that the academic literature (Braddon, 2004; Hartley, 2008; Struys, 2004) and the governmental documentation (EDA, 2006; European Parliament, 2007) have both identified a need for European countries to consolidate their national defence technological and industrial efforts to a common European defence technological and industrial base (EDTIB) to attain better military capabilities and industrial competitiveness more cost-effectively.

As a response to those aspirations, both the European Defence Agency (EDA) and the European Commission have issued various policies, initiatives and legal instruments to promote EDTIB and related activities. EDA has published a strategic framework to support its work, organically linked to the increased European defence cooperation. The framework consists of four strategies: the capability development plan (CDP) from 2011, the European defence research and technology strategy (EDRT) from 2008, the European EDTIB strategy from 2007 (EDA, 2007) and the European armaments cooperation strategy (EAC) from 2008. The European Commission introduced the ‘defence package’—two directives—as a legislative framework. The defence package attempts to simplify the transfers of defence-related products within the EU by Directive 2009/43/EC and coordinate procedures for contract awards in the fields of defence and security by Directive 2009/81/EC (EC, 2013). Directive 2009/81/EC (EC, 2009a) is the more influential of those two regulations. It introduces, at the European level, fair and transparent rules to help companies’ access defence and security markets in other EU countries, and the option for member states to require safeguards from suppliers to ensure the protection of classified information and security of supply (EC, 2010). In theory, the directive opens up the majority of defence materiel procurement contracts for public competition among EU countries and places constraints on nationally conducted R&D, security of supply and offsets. The difference between the direction and guidance by the European Commission and EDA is, however, that the directives by EC are legally binding instruments (Article 288 TFEU) for implementing European policies (EU, 2010), whereas EDA’s strategies and codes of conduct are recommended ways of acting. For instance, the EDA's code of conduct for offsets comes into play only in cases where Directive 2009/81/EC does not apply (EC, 2010).

New international collaboration programmes have also emerged, which include cooperation both in defence procurement and in the use of existing military capabilities. In NATO, the programme is known as 'Smart Defence' (NATO, 2012) and in EU as 'Pooling & Sharing' (P&S) (EDA, 2011b). The programmes are directed toward increasing the cost-effectiveness of military capabilities by pooling and sharing capabilities, setting priorities and coordinating efforts better among the nations of NATO and EU. The NORDEFCO (Nordic Defence Cooperation) cooperation programme is similarly directed toward collaboration across the entire military capability life cycle among the Nordic countries (NORDEFCO, 2013).

2.5.2.3 National collaboration

It is recognised that defence markets often deviate from the theoretical models of competition partially because of government behaviour as a major buyer. They can use their buying power to determine the size, structure, conduct, performance and ownership of national defence industries (Hartley, 2008). Even the legally binding Directive 2009/81/EC identifies and accepts the importance of the national security of the supply in defence procurement. Security of supply is crucial, particularly in times of crisis, when reliable and in-time delivery can be critical. Countries may consider it an essential security interest to have key industrial capabilities in certain strategic areas on their own territory, in certain strategic areas or sectors, and not to depend on non-national suppliers. Therefore, in the defence domain, national industry, which develops, produces or supports vital defence materiel has not only economic, but also strategic and political implications (EC, 2009e). As the adjective, 'vital' in the previous sentence hints, the real degree of self-sufficiency, cannot be calculated on the basis of the apparent fraction of domestic defence materiel production, but the on the basis of the criticality of that production to the desired military capabilities (Markowski et al., 2010). Specifically, the local expertise to build and/or sustain key capabilities, such as command and control systems is more meaningful to the real security of supply, for instance, than the capability to manufacture large amounts of combat suits domestically.

The security of supply perspective is considered a crucial element of national collaboration between the defence forces and local industry, and is emphasised especially in militarily non-aligned countries, such as Finland (EDA, 2011a; Finnish MoD, 2011). In this respect, its goals differ from the policy objectives of larger countries, such as the United Kingdom, whose defence technology strategy emphasises military advantage (i.e., the capability to do things better than the adversary) as an aim to be pursued (UK MoD, 2006). Furthermore, the defence industrial (UK MoD, 2005a) and technology strategies of the United Kingdom stress that there are some critical technology areas, which shall be retained in the UK to safeguard the state and consequently are considered assets for strategic assurance. Likewise, national, defence-related research and development (R&D) capabilities are needed for development and maintaining the knowledge base that supports industrial-military self-sufficiency during peacetime and that enhances the security of supply in wartime (Wylie et al., 2006).

It has been recognised that the main challenges in national defence industrial policy are not the lack of domestic collaboration programme mechanisms between the forces and industry, but the lack of clearly communicated goals, frameworks and processes to implement those goals as effectively as possible (Australian DoD, 2010).

2.5.2.4 National defence technology build-up

Generally, a technology strategy is the part of the overall business strategy of an organisation that enables the organisation to be as competitive as possible (Ford and Saren, 1996). In military organisations, competitive advantage equals enhanced military capability. It is also identified that the performance of defence firms is dependent, among other, on R&D spending and government defence procurement policies. (Hartley, 2008)

Directive 2009/81/EC excludes from its scope certain research and development services, such as enabling R&D contracts to be conducted nationally or in a collaborative manner without a public competition. Because R&D is a key enabler for strengthening the EDTIB, the directive allows maximum flexibility to the award of R&D contracts. However, the nationally conducted R&D that is exempted from the directive covers only the R&D stages; fundamental research, applied research and experimental development of a product life cycle. (EC, 2009d)

In Finland, the defence technology strategy attempts to create preparedness for development and sustainment of defence materiel and procuring it cost-effectively and in a timely manner. One instrument for implementing the defence technology strategy is the defence technology programmes. They endeavour to demonstrate the feasibility of defined technologies in the military context in order to increase critical knowledge and decrease risks in the later development phases of products and services. From the armed forces perspective, the interest is to increase the knowledge to be able to act as an intelligent customer in oncoming materiel procurement projects. From the industry's perspective, the objective is, above all, to create or strengthen the knowledge of demonstrated technologies to create the basis for products and services needed to guarantee security of the supply in time of crisis. The required knowledge focuses on integration, verification, validation and reparation competencies. (Finnish MoD, 2011)

2.5.2.5 Industrial participation as a defence industrial mechanism

Offsets have been a part of normal trade relations between the defence materiel buyers and suppliers, involving tens of thousands of people around the globe and reaching far beyond the market for military-related goods and services (Brauer and Dunne, 2004). Offsets are defined as 'agreements in foreign trade to compensate importing countries for the loss of domestic economic activity and foreign currency occasioned by the import' (Sköns, 2004). In Finland and

Sweden, in the official terminology, offsets are called ‘industrial participation’ (IP) to emphasise the cooperative aspects of offsets and long-term business relations and activities (Sköns, 2004).

Numerous academic studies discuss offsets and evaluate their benefits. Scholars present widely diverse views on the effectiveness and desirability of offsets (Hagelin, 2004; Markusen, 2004; Sköns, 2004) and the empirical evidence on offset deliverables remains shallow (Matthews, 2004). However, the offset studies usually represent the views of defence economists; hence, they tend to perceive and evaluate the offsets primarily from the economic perspective. They mention that the claimed benefits, the arms importing countries seek by applying offsets are, for instance, preservation of foreign exchange, employment creation and technology creation (Brauer, 2004; Markowski and Hall, 2004). Thus, those studies neglect the military perspective of the offset, which can be the security of supply by creating the maintenance capability of the imported arms to the recipient country. The military rationale for the offsets can also be linked to strategic reasons, such as aspirations to produce better military defence materiel domestically, for example, a desire to have national encryption algorithms.

From the perspective of EU, a common European DTIB should ultimately be able to create market conditions where there is no need for offsets. Nevertheless, European countries have accepted that in the current situation there is still a need for offsets. Although Directive 2009/81/EC does not mention the offsets, its guidance note restricts the use of offsets to the cases where an EU country exempts defence contracts from the directive by applying Article 346 TFEU (Treaty on the functioning of the European Union) (EC, 2009c). This article refers to measures that a member state ‘considers necessary for the protection of the essential interests of its security’ or to ‘information the disclosure of which it considers contrary’ to those interests. The definition of a state’s essential security interests is the sole responsibility of the respective EU member state (EC, 2009b). The participating member states of the EDA have agreed to a code of conduct on offsets (EDA, 2008), and EDA still runs a portal of offsets in order to evolve towards more transparent use of industrial participation in Europe.

In Finland, the principal objective of IP is ‘to give Finnish defence related industry full opportunity to participate in the manufacturing of parts, the assembly, the testing etc. of the purchased equipment, as well as getting the necessary knowledge for maintenance and further development of said equipment’ (Ministry of Employment and the Economy of Finland, 2006). In Finland, since the establishment of formal policy guidelines in 1991, the trend in industrial participation has been to increase the military-technological content through technology transfers and to involve more participation of local industry in the development and manufacturing of the purchased defence materiel. All of this has targeted to increase the capabilities of the industry to maintain and support the materiel during its life cycle. Moreover, the promotion of competitiveness of small and medium sized enterprises through the offsets is an important objective in Finnish offset policy. (Hagelin, 2004) Currently, the IP mechanism is still in place in Finland. Finland applies the IP by taking into account the restrictions of Directive 2009/81/EC, and assessing its necessity on a case-by-case basis, such as Sweden does (EDA, 2013). However, the Finnish defence materiel strategy demands that adequate requirements for security of supply should be placed with the defence materiel quotations and contracts in which the directive is applied (Finnish MoD, 2011).

2.5.2.6 Centres of excellence in various contexts

One manifestation of collaborative arrangements is the centre of excellence (CoE) concept, which also has a wide variety of definitions, depending on the context in which it is applied. In studies of multinational corporations (MNC), the term 'centre of excellence' refers to corporate-wide subsidiaries with a distinct set of competencies intended be used by other corporate units (Frost et al., 2002; Holm et al., 2001; Reger and Zafrane-Bravo, 2002). CoEs may focus, for instance, on R&D (Guido, 2004) or knowledge management (Adenfelt and Lagerström, 2006). However, at least two distinct meanings of the term CoE have been identified in the research on MNCs. The first approach views CoEs as a form of high value-added subsidiary—one that has a strategic role in the corporation. The second approach views CoEs as a form of best practice, which is disseminated throughout the firm (Frost et al., 2002).

In public-private sector or cross-sector collaboration, since the 1980s, the need to optimise the use of R&D efforts between industry, government and universities has resulted in a number of national and regional CoE programs (Fisher et al., 2001; Lawrence and Bodger, 2006; Malkamäki et al., 2001; Roy and Mohapatra, 2002; Soon, 1995). In cross-sector collaboration, CoEs are defined as physical or virtual centres or networks of centres, typically in R&D. These enable personnel to collaborate across disciplines and institutions on programmes, either long-term or short-term, that are locally relevant and/or internationally significant (Lawrence and Bodger, 2006). However, by organisationally integrating research, development and commercialisation, the work of these centres often goes beyond the traditional boundaries among academia, industry and government (Beerkens, 2009; Garrett-Jones et al., 2005).

In the defence sector, for instance, the creation of poles (i.e centres) of excellence is seen as a key means of survival for the defence industries of small countries (Struys, 2004). A strategy for the European defence sector's technological and industrial base also calls for the development of European centres of excellence to facilitate the creation of competitiveness (EDA, 2007).

In Finland, in 2004, the Defence White Paper (Prime Minister's Office, 2004) demanded that the Defence Centres of Excellence (DCoE) should support the vital competence areas. In 2005, the supplementary report of the Defence Technology Strategy (Defence Staff, 2005) repeated the need for establishing technology strategy related DCoEs to provide an optimal environment to develop the critical technologies into appropriate competences, products and services. Likewise, in 2007, the Finnish Defence Industrial Strategy (Finnish MoD, 2007) directed that DCoEs should be built in the area of systems integration. The industrial strategy also imposed that the DCoEs should be implemented based on the needs of the Finnish Defence Forces and in co-operation with the defence industry and academia. The latest edition of the Finnish Defence Materiel Strategy, from 2011, states that both national and international networks of excellence should support defence technology related activities (Finnish MoD, 2011). Consequently, there are both defence technology and industry driven demands for the establishment and use of CoEs in the field of defence.

2.6 Summary

In this chapter, the theoretical foundation of the dissertation was laid by describing and discussing the key concepts and terms related to the research objectives, including the current research needs and gaps in the issues. First, introductions of the existing capability models and the military capability life cycle comprehensively described the concept of military capability. Academic studies about the military capability frameworks were also discussed. A comprehensive understanding of military capability can be built on this foundation. This understanding enables the ability to position various capability models to the capability life cycle. It also provides a conceptual framework for the CD&E and capability planning as both enabling life cycle stages and systems within the whole capability life cycle. Second, enterprise architectures (EA), both in general and in the concept development stage of the military capability life cycle, were discussed. This enables the evaluation of the applicability of an EA approach in the CD&E life cycle stage. Third, national collaboration to develop and sustain military capabilities was reviewed broadly and within the framework of the latest defence materiel related changes and trends in the European Union. It lays the foundation for the assessment of one of the national collaboration mechanisms, the centre of excellence, and the considerations of how this collaboration could be enhanced by also taking into account the other mechanisms, technology programmes, industrial participation and related issues, such as the various motives of the collaboration partners or financing the collaboration.

CHAPTER 3 – METHODOLOGY

In this chapter, to provide an understanding of the diversity of the concept and its meaning, the systems approach concept is first reviewed from a range of different perspectives. Second, the application of the specific systems methodology, the generic functionalist systems methodology, which this dissertation follows, is explained by showing how the constitutive rules of the methodology relate to the research question, the objectives and the papers of the dissertation.

The terms ‘method’ and ‘methodology’ are frequently used interchangeably, especially in management science and operational research communities. However, some of the systems literature has given those terms a distinctive meaning as have some of the writings on the philosophy of science (Midgley, 2000). By definition, a methodology is intermediate in status between a philosophy and a method. A philosophy provides a broad non-specific guideline for action, whereas a method or technique is a precise and specific programme of action (Checkland, 1981; Skyttner, 2005). Specifically, a methodology is the set of theoretical ideas that justify the use of a particular method or methods. A method is a set of techniques for achieving a given purpose (Midgley, 2000). Midgley’s definitions of the terms ‘method’ and ‘methodology’ correspond to those of Checkland. However, Midgley orders the terms ‘method’ and ‘technique’ hierarchically, whereas Checkland uses them in parallel.

3.1 Perspectives of the systems approach

The ‘meta’ nature of systems enables the structuring of systems research into three categories: framework of ideas, methodologies and real-world entities. The framework of ideas expresses the knowledge about the situation being researched, such as the theory related to the problem situation. Methodology consists of various methods, tools and techniques in a manner appropriate to the framework of ideas and uses them to study the area of application (Checkland, 1989). Nonetheless, this area can be a real world problem situation (Jackson, 2000). As a whole, the systems framework of ideas is applied in accordance with some systems methodology and in many areas of application, as illustrated in Figure 6. Thus, the systems approach can be seen as an initiative to combine theory, empiricism and pragmatics (Skyttner, 2001).

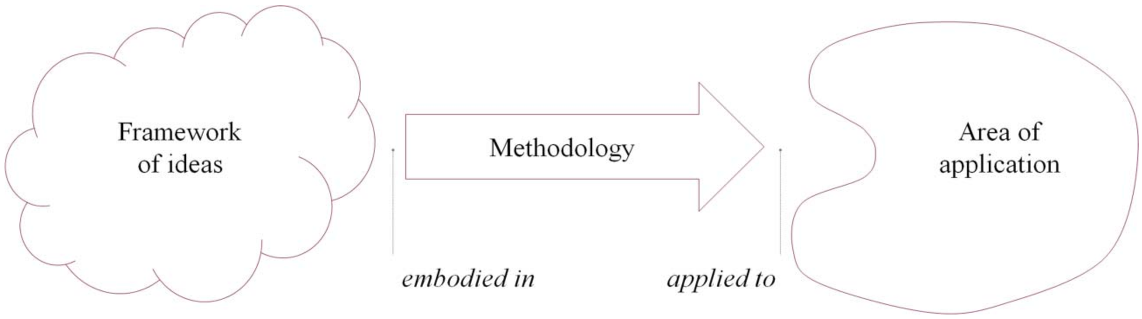


Figure 6. *Elements of systems research (Checkland, 1989; Checkland and Holwell, 1998).*

The various strands of systems approaches have been divided into the following perspectives, which are based on Checkland's systems research framework, to allow review of the systems approach concept:

- common features: characteristics, which are widely identified as being part of the systems approach,
- conceptual perspective: systems thinking perspective, which focuses on the systems approach as a conceptual framework of ideas,
- methodological perspective: emphasises the means to tackle problems from the systems perspective,
- practical and applied perspective: concerned with applying the systems approach into a specific area of applications, and
- taxonomy perspective: tries to embrace various systems approaches together with the help of research philosophies or changes in methods.

3.1.1 Common features

In general, most writers agree that the systems approach means that systems are considered holistically (De Greene, 1972; Jenkins, 1972; Kramer and Smit, 1977; Reynolds and Holwell, 2010) and explored top-down (Churchman, 1968; Hitchins, 1992; Skyttner, 2001). Similarly, there is a common understanding that looking at the relationships between things (Jackson, 2000; Reynolds and Holwell, 2010) and viewing and studying systems as a part of larger systems are elemental characteristics of the systems approach (Blanchard and Fabrycky, 2005; Skyttner, 2001).

The above mentioned features are naturally close to general systems fundamentals: emergence, hierarchy, communication and control (Reynolds and Holwell, 2010). These systems elements are usually embedded in all of the systems approach perspectives studied in this chapter.

3.1.2 Conceptual perspective

Rather than focusing on applying it specifically to a certain problem area, the conceptual perspective emphasises the systems approach as a concept, a way of seeing the world and of thinking about the systems in question and their components (Churchman, 1968). Because it will dictate how the systems are described later, it is extremely important to consider how to think about the systems (Churchman, 1968). Churchman is identified as the describer of the characteristics of the systems approach to problem solving (Sage and Armstrong, 2000). His work is a conceptual framework about the systems approach rather than a 'recipe book' for how to implement the approach.

Many other writers define the systems approach as a conceptual method or methodology, which should not be understood as a rigorously defined problem solving methodology, method or technique (e.g. hard systems methodology). The systems approach is defined as a problem solving concept, an attitude or an ability to look at wholes, different levels and interrelationships rather than a formal method (De Greene, 1972). Similarly, it is considered that a systems approach is the synthetic mode of thought, when applied to systems problems (Blanchard and Fabrycky, 2005). The terms 'systems approach' and 'systems thinking' are used interchangeably as a means of tackling a problem (i.e., a methodology) (Kramer and Smit, 1977). The systems approach is seen also as an application of systems theory and to be considered a method. The fundamental principle of the approach is that all facets of human problems should be managed together in a rational manner (Skyttner, 2001).

3.1.3 Methodological perspective

Some researchers see the systems approach primarily as a framework for systems engineering, systems analysis or some other practical methodology, which are indeed practical ways to apply the systems approach to man-made systems. Specifically, they concentrate on expressing the systems approach through the way it is applied (i.e., the methodology). The systems approach, in this context, refers to methodologies under the systems thinking concept. Different systems approaches, methodologies such as soft systems methodology, are embraced by the systems thinking, which is seen as a discipline (Jackson, 1989). Systems engineering is further defined as 'the application of the systems approach' (Checkland, 1972). This means that system concepts are used to analyse complex problem situations, for instance, to see a structure in them. The systems approach is typically regarded as pursuing the following path: requirement description—requirements functional decomposition—physical architecture—physical system integration (Hitchins, 1992). This path is analogous to the systems system engineering life cycle model, the Vee model, postulated by Forsberg et al. (2000). Soft systems methodology and viable systems models are also mentioned as examples of methodologies drawn on the systems approach (Avison, 1989).

De Greene was considered as representing the conceptual thinking of the systems approach in the previous sub-chapter. However, De Greene (1972) also states that systems analysis is an appreciable engineering and management methodology in systems development by the systems approach. The stages in a systems approach to problems are considered to consist of systems analysis, systems design, implementation and operation (Jenkins, 1972). Although Jenkins uses the word analysis instead of requirements, as the waterfall model uses, these stages are consistent with the classical systems engineering waterfall model (Buede, 2000).

3.1.4 Practical, applied perspective

The systems approach is said to be applicable to a wide area of applications (Checkland, 1989). Among other areas, the systems approach has been widely applied to organisations, such as the armed forces, as explained in the introduction (p. 5), and related organisation theory (Hatch, 1997). The systems approach has also been seen to provide a collective framework for organisation theory and management practice (Kast and Rosenzweig, 1972). First, it is directly related to organisation theory, which has started to consider the organisation as an open system interacting with its environment. Second, the systems approach helps to view the organisation as a structured socio-technical system. Nonetheless, it is noteworthy that Kast and Rosenzweig wrote their work at the beginning of 1970s, when the systems approach was a relatively new concept in organisation theory (Silverman, 1970). Since the 1970s, organisations have been regarded variously as a socio-technical system and as a human activity system (Pugh, 1989). The fundamental difference between human activity and socio-technical organisational systems approaches is that the former sees (i.e., assumes ontologically) the reality as problematic, while the latter sees it in reality as a system (Wood-Harper, 1989).

Recent systems development calls for multi-view development, which attempts to expand the systems approach further by combining many methodologies and aspects to the development, including human activities, information and socio-technical aspects (Avison and Fitzgerald, 2003). The approaches all attempt to look at systems holistically (their viewpoints follow systems theoretical principles) and therefore are representations of the systems approach in real world situations and problem solving.

3.1.5 Taxonomies of a systems approach

In addition to studies that focus on a certain aspect or area of systems approach, other academic research attempts to build a comprehensive picture of various systems approaches, concepts and methodologies. These studies could be classified as taxonomies of systems approaches (Cabrera et al., 2008). Three systems taxonomies are presented and mapped with each other in Table 5. Jackson's taxonomy (2000) is by far the most comprehensive of the taxonomies under review. Jackson lists 23 different systems concepts under four approaches, which were discussed in the introduction (p. 11). In addition, he mentions numerous explicit systems practices under the 23 listed system concepts. For instance, hard systems thinking in the functionalist approach consists of operational research, systems analysis and systems engineering as explicit systems practices. Concentrating on management systems, in his taxonomy, Midgley (2000) presents a partial history of the development of intervention methodologies and methods during the 20th century. Each of his three waves of systems thinking relates to a particular focus of the systems field, which brought with it a new set of methods (Reynolds and Holwell, 2010). Midgley uses his taxonomy to advocate a methodological pluralism by explaining that there are numerous ways to synthesise those methodologies. Reynolds and Holwell (2010) recognise three traditions of systems thinking; including hard, soft and critical systems approaches with 19 different systems concepts. However, because they each demonstrate a rich interplay between the situation, the practitioner community and the methodology itself, they just chose five systems concepts to their own taxonomy. Those five systems concepts address the three motivations, which differ from the others, for the use of a systems concept in any systems intervention. Those three motivations include understanding interrelationships, dealing with different perspectives and addressing power relations.

Jackson, 2000	Midgley, 2000	Reynolds and Holwell, 2010
Functionalist approach • *Organizations as systems, incl. socio-technical systems theory* • *Hard systems thinking, incl. operational resarch* • *System Dynamics (SD)* • *Organizational cybernetics, incl. VSM* • *Living systems theory* • *Autopoiesis* • *Complexity theory* • *Generic functionalist systems methodology*	The first wave of systems thinking • *Socio-technical systems thinking* • *Systemic family therapy* • *Systemic operational research*	System dynamics (SD) Viable systems model (VSM)
Interpretive approach • *Interactive management* • *Social systems design* • *Strategic assumption surfacing and testing (SAST)* • *Social systems sciences, i.e. interactive planning* • *Soft systems methodology (SSM)* • *Soft systems thinking* • *Soft operational research,incl. SODA, soft SD, soft cybernetics* • *Generic interpretive systems methodology*	The second wave of systems thinking • *Interactive planning* • *SAST* • *SSM*	Strategic Options Development and Analysis (SODA) Soft Systems Methodology (SSM)
Emancipatory approach • *Emancipation as liberation* • *Emancipation through discursive rationality, incl. CSH* • *Emancipation through the oblique use of systems methods* • *A generic emancipatory systems methodology*	The third wave of systems thinking • *Critical systems thinking*	Critical Systems Heuristics (CSH)
Postmodern (PM) approach • *Intervention in the spirit of PM* • *PM systems methods* • *A generic framework for the application of the PM systems approach*		
Legend: SD = system dynamics, VSM = viable systems model, SAST = strategic assumption surfacing and testing, SSM = soft systems methodology, SODA = strategic options development and analysis, CSH = critical systems heuristics, PM = postmodern		

Table 5. *Various taxonomies of the systems approach.*

While Jackson's taxonomy attempts to create a comprehensive understanding of various systems approaches in general, Midgley's taxonomy serves a specific purpose, and Reynolds and Holwell's taxonomy attempts to create an understanding of various systems traditions by well-known representative examples. It is also noteworthy that neither Midgley and Reynolds nor Holwell mention any post-modern systems approaches as Jackson does. The reason for this may be that post-modernism emphasises novelty and disorder and it refuses meaning. This is an extremely radical perspective compared to other systems approaches, which all seek order or understanding by various means and have more established status as methodologies or practices than, for instance, Taket and White's post-modern, pragmatic pluralistic PANDA (participatory appraisal of needs and the development of action) concept. (Jackson, 2000)

3.2 Application of the systems approach in this dissertation

The taxonomies of systems approach provide a comprehensive picture of various systems approaches, concepts and methodologies. In contrast, three other perspectives of the systems approach including framework of ideas, methodology and area of application are focused on just one of the three elements of systems research. Therefore, the taxonomy perspective provided the basis for the selection of a comprehensive systems approach in this study. The taxonomy of Jackson is the most comprehensive of the presented taxonomies. He presents generic systems methodologies to each of four systems approaches, drawn upon explicit systems methods within each of these approaches. To facilitate the use of the methodologies in actual practice, Jackson also provides a set of constitutive rules to each of those generic systems methodologies. For the purposes of this dissertation, the suitability of the functionalist worldview was justified in the introduction. Consequently, the generic functionalist systems methodology was considered a well-suited research design for this dissertation; it is capable of effectively guiding the practical application of the methodology with its constitutive rules.

The constitutive rules of the generic functionalist systems methodology are presented in Table 6. Those rules form an explicit method of applying the chosen methodology and should be followed to ascertain that the study is conducted in accordance with the generic functionalist systems methodology.

1. A functionalist systems methodology is a structured way of thinking, with an attachment to the functionalist theoretical rationale, that is focused on improving real-world problem situations.

2. A functionalist methodology uses systems ideas as the basis for its intervention strategy and will frequently employ methods, models, tools and techniques which also draw upon systems ideas.

3. The claim to have used a systems methodology according to the functionalist rationale must be justified according to the following guidelines.

a. an assumption is made that the real-world is systemic;

b. analysis of the problem is conducted in systems terms;

c. models aiming to capture the nature of the situation are constructed enabling us to gain knowledge of the real-world;

d. models are used to learn how best to improve the real-world and for the purposes of design;

e. quantitative analysis is presumed to be useful since systems obey mathematical laws;

f. the process of intervention is systematic and is aimed at discovering the best way to achieve a goal;

g. the intervention is conducted on the basis of expert knowledge;

h. solutions are tested primarily in terms of their efficiency (do the means use minimum resources?) and efficacy (do the means work?).

4. Since a functionalist systems methodology can be used in different ways in different situations, and interpreted differently by different users, each use should exhibit conscious thought about how to adapt to the particular circumstances.

5. Each use of functionalist systems methodology should yield research findings as well as changing the real-world problem. These research findings may relate to the theoretical rationale underlying the methodology, to the methodology itself and how to use it, to the methods, models, tools and techniques employed, to the real-world problem situation investigated, or all of these.

Table 6. *Constitutive rules for a generic functionalist systems methodology (Jackson, 2000: 203).*

Rule 4 states that the methodology follows a ‘fit-for-purpose’ approach. Although there is no one right way to apply the methodology, each use should exhibit conscious thought. The whole set of rules can understandably not be used in each individual paper of the dissertation, but they can be used in the dissertation as whole. The rules will not be applied to the papers randomly. Rules 1, 2, 4 and 5 are applicable on the dissertation level, whereas Rule 3, with its in-detail requirements, will be applied in each of the three research objectives. Various systems methods, models and techniques are used in the individual papers.

Rule 1 was explained in the introduction to justify the application of the methodology as an overall research design of the dissertation. Rule 1 deals with the world-view part of the research design, whereas Rule 2 concerns the general methodological choices. It requires that the core content of the dissertation, the military capability and its life cycle should be perceived as a system and an attempt should be made to answer the related research objectives by using systems methods. Rule 3 elaborates on Rule 2 by presenting a set of explicit requirements for how to perceive the research question and the objectives (i.e., the real-word problem) and in which way to analyse the problem and assess the solutions. The application of rules 2 and 3 will be justified in detail in Chapter 5, the discussion and conclusions chapter.

Finally, Rule 5 asks that the use of the methodology should yield both practical and scientific findings. Generally, the requirements of doctoral dissertations call for the same objectives. In this dissertation, the research purpose, question and related objectives with both practical and scientific aims were presented in Chapter 1.2. The contributions of the dissertation to those purposes will be presented in Chapter 5.1.1 for the theoretical contributions and Chapter 5.1.2 for the practical contributions.

3.3 Summary

This chapter reviewed the various understandings and concepts of the systems approach to shed light on the diversity of those concepts. The chapter also described the use of the generic functionalist systems methodology in the dissertation by presenting its constitutive rules and explaining how those rules will be applied in the dissertation.

CHAPTER 4 – RESULTS

In this chapter, the seven published papers of the dissertation are summarised and the contributions of each paper in relation to the research objectives are presented. The author's contributions to each paper are also presented. The application of the chosen methodology is explained fully. The contributions to theory and practice will be discussed in Chapter 5, the discussion and conclusions chapter.

4.1 Results of the papers and their correspondence to the research objectives

The summary of all the papers, along with their type, context and main contributions, are depicted in Table 7. The results and contributions of each paper to the research objectives are elaborated as follows.

RO	ROs	P	Type of paper	Context	Contribution
O1	O1.1	[I]	Conceptual	Study of military capability models	The comprehensive capability meta-model that compiles existing capability models into a hierarchical whole
	O1.2	[II]	Conceptual	Study of military capability life cycle and related capability models	The holistic capability life cycle model, which provides a holistic view of military capability throughout its life cycle and shows how existing capability models fit into this life cycle
O2	O2.1	[III]	Empirical, case study	Tailoring enterprise architecture framework to military concept development	The adaptation of the NATO architecture framework to fulfil the needs and situational constraints of the military concept development case project
	O2.2	[IV]	Empirical, case study	Study of benefits of enterprise architecture approach in military concept development	The benefits of enterprise architecture approach to the traditional way of developing concepts
O3	O3.1	[V]	Empirical, case study	Evaluation of expectations of centre of excellence as means to contribute defence materiel collaboration	Success factors, motives, strengths and weaknesses of a defence centre of excellence supporting military capability development
		[VI]	Empirical, case study	Evaluation of centre of excellence as means to contribute defence materiel collaboration	Performance assessment of a defence centre of excellence to support prevention of collaboration failure
	O3.2	[VII]	Conceptual	Study of enhancing national defence materiel collaboration between defence forces, defence industry and academia	The systems collaboration model, which links all collaboration mechanisms , including centres of excellence, between the parties into one framework.

Legend: RO = research objective, ROs = sub-objective, P = paper

Table 7. *Summary of the papers.*

4.1.1 Research objective 1 (O1) – How do military capability views form a hierarchical and temporal whole?

O1.1 – How do current views of military capability relate with each other hierarchically? This research objective was studied in paper [I].

The paper presents and discusses established military capability models, their characteristics and primary areas of application. It also reviews existing capability frameworks. The paper compiles the presented capability models into an integrated whole using a well-known framework, the Zachman Framework of Enterprise Architecture, as the structure of the model. The resulting conceptual model, the comprehensive capability meta-model (CCMM), presented as a 6 x 6 textual matrix, is the main contribution of the paper. It provides a comprehensive understanding of military capability, both vertically and horizontally. It presents the existing capability models in hierarchical order (vertical comprehensiveness) and describes basic features, such as the primary area of application, stakeholders, intrinsic process, and the life cycle considerations of each capability perspective, constituting a complete model on each capability row as well (horizontal comprehensiveness). The validity of the model was demonstrated through the verification results. The majority of the respondents (71% of 39 respondents) felt that the CCMM is complete (i.e., it includes all necessary capability layers). Of the remaining respondents, 64% would have liked the morale aspects of capability, such as unit cohesion, to be addressed more in the CCMM than is done currently. Over 90% of the respondents (91%) perceived the perspectives of the CCMM to be in the correct hierarchical order.

O1.2 – How do various capability views relate to the overall capability life cycle? This research objective was studied in paper [II].

This paper examines the military capability life cycle and related capability models. It builds on paper [I] and its CCMM capability model, but expands the CCMM by connecting and combining existing capability models and capability systems into a single military capability life cycle model. The paper applies the ISO 15288 standard's life cycle concept, which is based on the system-of-interest and enabling system concepts, to the military capability life cycle. This enables differentiating the real-life military capability, manifested in operational military units, from enabling systems, such as CD&E, which facilitate the progression of the system-of-interest through its life cycle. The holistic capability life cycle model (HCLCM), which is the key contribution of the paper, provides a holistic view of military capability throughout its life cycle and shows how existing capability models fit into this life cycle.

4.1.2 Research objective 2 (O2) – What benefits do enterprise architectures (EA) bring to concept development and experimentation (CD&E)?

O2.1 – How can the military architecture framework be tailored to meet the needs of CD&E? This research objective was examined in paper [III].

This paper deals with tailoring enterprise architecture framework to military concept development. It first describes and discusses enterprise architectures and architecture frameworks. Second, the paper studies how a well-known military enterprise architecture framework, the NATO architecture framework (NAF), can be adapted to meet the needs of the CD&E case project. Situational method engineering (SiME) is used as an adaptation framework and method. Findings of the case study show that the NAF was perceived to be both applicable and adaptable to military CD&E. The adaptation of the NAF to fulfil the needs and situational constraints of the CD&E case project were considered to be satisfactory based on further utilisation of the EA model in the case project. Despite the positive results, the study also showed that NAF could not fully capture the elements of the original concept. The full spectrum of human aspects of the concept could not be incorporated in the EA model. Although the organisational elements of the human aspects could be included in the EA model of NAF, more vague concepts of human activities, such as social aspects, could not be embedded in it. SiME provided a more analytical approach for the adaptation of NAF than, for instance, the standard architecture development and tailoring process of DODAF.

O2.2 – What benefits does the EA approach bring to the conventional CD&E method? This research objective was examined in paper [IV].

In this paper, an empirical study on the benefits of the EA approach to military CD&E is presented. Building on paper [III], it expands the discussion of EAs and their benefits. It uses the DeLone and McLean information system success model as an evaluation framework. The results suggest that the EA approach can bring value to traditional concept development by increasing the clarity, consistency, and completeness of the concept. In addition, the survey showed that as a methodology and product, EA was comprehensible for concept developers who were not subject matter experts in the modelling or visualisations of EA. The most important use considered for EA was that it enables the further utilisation of the concept created in the case project. CD&E is the predecessor of the capability planning life cycle stage where the NAF or similar military sector architecture framework (e.g., DODAF) plays a vital role. It would be extremely beneficial in subsequent capability development work to have the CD&E products already in the form of EA diagrams and views to support the transition from one life cycle stage to another. A common model base could provide greater consistency and traceability among different development stages, which would also reduce redundant work.

4.1.3 Research objective 3 (O3) – How does the systems approach enhance defence materiel collaboration between the defence forces, defence industry and academia during capability planning and procurement?

O3.1 – How does current collaboration between the parties perform in the form of the centre of excellence (CoE)? This research objective was studied in papers [V] and [VI].

Paper [V] evaluates the expectations regarding the network of protection (NEPRO) CoE as an example of the national defence materiel collaboration mechanism between the defence forces, the defence industry and academia. The paper discusses the current scientific literature about collaboration, its motives, and the success factors, as well as evaluation of the collaboration to lay the foundation for the case study in the paper. The case study revealed the most important motives as well as the success factors among the earlier agreed aims for the CoE. The study also identified risks and strengths in the CoE, based on the current academic literature about the motives and success factors of collaboration. The potential risks regarding the success of the CoE are seen first in the lack of funding, which CoE stakeholders considered one of its key success factors. Second, seeing the CoE as a panacea, where there are no clear priorities among goals, but rather a wide variety of goals are expected to be achieved with high marks, poses a threat to the success of the CoE. Scaling back expectations to a realistic level may offer more opportunities for accountability because it will then be easier for all participants to fulfil their mutually agreed-upon obligations (Kreuter et al., 2000). The strengths of the CoE stem from the findings that the stakeholders see a clear need for collaboration in the area of protection. The identified self-interest motives of the stakeholders to participate in the CoE are similarly encouraging signs for its potential success. Organisations believe that the CoE can facilitate better performance for them in the future. The expectations focus on concrete results, such as new innovations, which, while being a good sign, also increase the ambition level of the collaboration and, simultaneously, increase the risk of failure. The assessment of the CoE projected the future expectations of the respondents. Therefore, the findings provided timely evidence for the CoE decision makers to consider how real expectations meet the original aims of the CoE and how current activities meet the measured and evaluated expectations.

Paper [VI] assesses the performance of the centre of excellence, the NEPRO, whose earlier state of functioning was evaluated in paper [V]. The assessment of this paper forms the second phase in the evaluation of the CoE. The assessment takes into account the data collected in the first phase of the survey, reported in paper [V]. The evaluation method, CFI, identified the six most important development and risk factors for the CoE, the validity of which was demonstrated by the feedback of the key informants of the CoE. Half of those identified development and risk factors have a common feature. They all recognise the unsatisfactory status of tangible results. The CoE stakeholders had identified concrete, achievable goals as the most important success factor in the first phase of the survey. Therefore, focusing on actions that improve the performance of those factors would be an effective method of increasing the likelihood of meeting the objectives of the CoE. CFI-based findings of the evaluation provide timely evidence and awareness for the CoE decision makers regarding the following: 1) how the current situation meets expectations overall, 2) the critical factors in which the stakeholders are least satisfied, and 3) the factors in which the level of satisfaction is mixed and hence pose risks for the CoE. The findings lay the groundwork for the decision makers to focus their efforts and readjust the operations of the NEPRO to maximise the possibilities of collaboration success.

O3.2 – How can the functioning of CoE and other collaboration mechanisms be enhanced by a systems approach? This research objective was examined in paper [VII].

Paper [VII] examines how to enhance national defence materiel collaboration between defence forces, defence industry and academia. It discusses the challenges related to the current isolated way of managing defence technology and industrial mechanisms: centres of excellence, technology programmes, industrial participation and immaterial property rights. The paper additionally analyses the relationships between those mechanisms and lists the main purposes of each mechanism from four different perspectives: capability, competitiveness, economic and management. The key contribution of the paper is the holistic, conceptual co-operation model of the previously mentioned mechanisms of the systems approach, to enhance the current cooperation. The model attempts to manage cooperation activities and mechanisms comprehensively by taking into account the capability, competitiveness, management and economic views to fulfil the expectations placed for the collaboration by both defence forces and industry. The role of the centre of excellence in the model is to work as an organisational hub to link activities in technology programmes and industrial participation (IP). Connecting the activities to each other requires that both technology programmes and IP activities focus on the same strategic competence areas. Although those areas should be military capability driven, they should also take into consideration the existing industrial base and its aspirations. National competitiveness is a foundation for international collaboration in Europe, which is anticipated, will eventually lead to a common European defence technological and industrial base (EDTIB). Consequently, national collaboration mechanisms should not be used for increasing protectionism. Instead, they should be used as a means to enhance local competitiveness to facilitate internationalisation of the defence industry. This holistic manner of understanding and managing the collaboration would further support the national industry in becoming more capable to deliver direct IP work (i.e. directly related the defence materiel under the contract). Increased competitiveness of industry would also contribute to the security of supply. This model enables the return of the invested funds back to the importing country to contribute to the development of her military capabilities and national industry. Therefore, financially, this model helps to justify, for both military personnel and the public, the financial investment in technology programmes and IP activities. From a management perspective, a single source interface, such as CoE, instead of multiple business counterparts, makes the management of technology programmes and IP activities more effective.

4.2 Contributions of the author

The author was the sole author in papers [I], [II], [III] and [VII] and the primary author in papers [IV], [V] and [VI]. Professor Juha-Matti Lehtonen conducted the statistical analysis in papers [IV] and [V]. Professor Josu Takala, the co-founder of CFI method used in paper [VI], provided invaluable insights and comments for papers [V] and [VI]. The in-detail description of the author’s role in each paper is presented in Table 8. It shows the author’s involvement in the different parts of the paper preparation process: conceptualisation and design, model and questionnaire development, data collection and analysis, and the interpretation and concluding the results.

P	Conceptualisation and design	Building model	Building questionnaire	Collecting data	Analysing data	Interpretation and conclusions	Paper writing	Overall role
[I]	x	x	x	x	x	x	x	S
[II]	x	x	N/A	x	x	x	x	S
[III]	x	x	N/A	x	x	x	x	S
[IV]	x	x	x	x		x	x	Pr
[V]	x	N/A	x	x		x	x	Pr
[VI]	x	N/A	x	x	x	x	x	Pr
[VII]	x	x	N/A	x	x	x	x	S

Legend: P = paper, N/A = not applicable, S = sole author, Pr = primary author

Table 8. *The contribution of the author in the papers of the dissertation.*

4.3 The application of the methodology

In this sub-chapter, the application of the chosen methodology, introduced in Chapter 3.2 is justified with the help of its constitutive rules. The whole set of rules could understandably not be used in each individual paper of the dissertation, but in the dissertation as whole. The application of the rules to the research question, objectives and individual papers is shown in Table 9. Rules 1, 2, 4 and 5 are applicable on the dissertation level, whereas Rule 3, with its in-detail requirements, was applied to each of the three research objectives as follows.

					R3									
RO	ROs	P	R1	R2	a	b	c	d	e	f	g	h	R4	R5
RQ			x	x	x	x	x	x	x	x	x	x	x	x
O1	O1.1	[I]			x	x	x	x		x	x	x		
	O1.2	[II]			x	x	x	x		x	x			
O2	O2.1	[III]						x		x	x			
	O2.2	[IV]			x	x	x	x	x	x	x	x		
O3	O3.1	[V]							x	x	x			
		[VI]							x	x	x	x		
	O3.2	[VII]			x	x	x	x		x	x	x		

Legend: RQ= research question, RO = research objective, ROs = sub-objective, P = paper, R=rule

Table 9. *The application of the selected methodology in the dissertation.*

Rule 4 – Since functionalist systems methodology can be used in different ways in different situations, and interpreted differently by different users, each use should exhibit conscious thought about how to adapt to the particular circumstances.

Rule 4 essentially means that the methodology follows the ‘fit-for-purpose’ approach. There is not one right way to apply the methodology, but each use should cautiously be considered. In this dissertation, the justification of the generic functionalist systems methodology and its rules in relation to the dissertation objectives and papers are as follows.

Rule 1 – A functionalist systems methodology is a structured way of thinking, with an attachment to the functionalist theoretical rationale that is focused on improving real-world problem situations.

The first rule was discussed and justified, along with the research design of the dissertation in Chapter 1 (p. 11). This rule applies on the dissertation level.

Rule 2 – A functionalist methodology uses systems ideas as the basis for its intervention strategy and will frequently employ methods, models, tools and techniques, which also draw upon systems ideas.

The military capability, its models and life cycle form the theoretical foundation of this dissertation. This foundation has been modelled using specific systems models to intervene, such as to act purposefully to create change (Midgley, 2003), thus the research topic. In paper [I], the Zachman Framework for Enterprise Architecture (ZFEA) was used to integrate various capability models into one comprehensive capability meta-model. In paper [II], the capability models were attached to the life cycle model by taking advantage of ISO 15288 standard's and ISO 24748 technical report's systems ideas. This enabled the ability to link the CD&E (objective 2) and the national collaboration (objective 3) to both the capability models and the life cycle. A comprehensive presentation of the methods, models and techniques used in the papers of the dissertation are presented in Table 10. The table also demonstrates how various explicit systems methods, models and techniques have been applied in each of the objectives. The systems methods are the ones with a grey background colour. These will be elaborated during discussion of the details of Rule 3 below.

RO	ROs	P	Method	Model	Technique
O1	O1.1	[I]	CM, SA	Zachman EA	
	O1.2	[II]	CM	ISO 15288 / 24748	E-R
O2	O2.1	[III]	SiME		
	O2.2	[IV]	CM	NATO AF	Multi-technique
			SA	D&M ISS	
O3	O3.1	[V]	SA		
		[VI]	CFI		
	O3.2	[VII]	CM	Checkland GSRF	ID, E-R

Legend: RO = research objective, ROs = sub-objective, P = paper, CM = conceptual modelling, EA = enterprise architecture, SiME = situational method engineering, AF = architecture framework, SA =statistical analysis, D&M ISS =Delone and Mclean information system success model, CFI=critical factor index, GSFR = general systems research framework, E-R=entity-relationship, ID=influence diagram

Table 10. *The methods, models and techniques of the dissertation. Systems derived methods, models and techniques are indicated with a grey background colour.*

Rule 3a – An assumption is made that the real-world is systemic. Rule 3b – Analysis of the problem is conducted in systems terms.

As explained above, military capability was modelled as a system in papers [I] and [II]. This means that the military capability is understood to be systemic both in its nature as well as in being analysed as systems. The CD&E project in paper [IV] of objective 2 was modelled as a system by using the NATO architecture framework. The enhanced collaboration model in paper [VII] of objective 3 was similarly presented as a system using Checkland's general systems research framework. The analysis of the paper was partially supported by an influence diagram, which is a systems diagramming technique (Waring, 1996). However, the analyses in papers [V] and [VI] of objective 3 were not conducted specifically in systems terms, but as normal quantitative studies.

Rule 3c – Models, aiming to capture the nature of the situation, are constructed enabling us to gain knowledge of the real-world.

Both papers [I] and [II] in objective 1, which sought to understand military capability comprehensively, consisted of conceptual modelling. Conceptual models are defined as being mostly graphical models, used to present both static (e.g., things) and dynamic (e.g., processes) phenomena. They are directed toward increasing the understanding of the domain, providing input for the design process, supporting communication between the developers and users and at documenting the requirements for further use (Wand and Weber, 2002). The enterprise architecture frameworks used in papers [I] and [IV] represent the established form of graphical modelling. In enterprise architectures, there is a tendency to see diagrams and pictures as models and as a form of structure, which helps in understanding and visualising the system of concern (Lankhorst, 2009). In paper [II], a specific graphical modelling technique, entity-relationship diagram (Stevens et al., 1998), was used to capture the topics and their relations comprehensively. Likewise, the basis for the evaluation in paper [IV] of objective 2 was an EA model of the case project. Paper [VII] of objective 3 presented a holistic systems model to combine various collaboration mechanisms between the armed forces, the local defence industry and academia. The model's information and the relationships between them were elaborated by an entity-relationship diagram.

Rule 3d – Models are used to learn how best to improve the real-world and for the purposes of design.

From the problem improvement perspective, this dissertation attempts to improve the real-world issue by exploring and proposing enhancements to the development of military capabilities by the systems approach, as mentioned in Chapter 1. In paper [III], a specific method, Situational method engineering (SiME) was used to tailor, i.e. build a fit-for-purpose model of the NATO architecture framework to meet the needs of the CD&E case project, presented in paper [IV]. In addition to the interest in knowing how to take best advantage of the model, the EA model in paper [IV] of objective 2 sought to increase clarity, consistency and completeness of the concept in the CD&E project of concern. The collaboration systems model in paper [VII] of objective 3 attempted to understand the relationships of different collaboration mechanisms to enhance how to more effectively bring add-on value for the different stakeholders. Armed forces seek increased security of supply and knowledge to be able to make smart acquisition decisions in the future, whereas industry is interested in competitiveness and economic success. From a design perspective, all of the systems models in papers [I], [II], [IV] and [VII] were directed toward presenting a conceptual design of the topics they confronted. For example, paper [IV] presented the original concept of operations (i.e., design how to create and sustain the multinational, inter-agency situational awareness in an extended maritime environment) in the form of a multi-perspective, graphical EA model.

Rule 3e – Quantitative analysis is presumed to be useful since systems obey mathematical law.

Traditionally, modelling a system in accordance with a functionalist perspective consists of constructing a mathematical model, because they, among other things, allow predictions about the real-world systems without the risk and costs of intervening in the actual systems in question. However, the use of mathematical modelling is criticised as being too limited to capture all the aspects of a complex situation. Building quantitative models is a highly selective process and reflects the limitations of vision and the biases of the builder (Jackson, 2000). In this dissertation, mathematical models have not been used in the sense that the rule dictates, but instead used multi-perspective and multi-aspect conceptual modelling (i.e., graphical modelling) to create as comprehensive an understanding of the topics as possible. As explained above, it is a common practice that visualisations replace mathematical models in enterprise modelling (Lankhorst, 2009). The use of non-mathematical descriptions that arise from conceptual modelling activities are also rationalised by the fact that they are intended to be used by humans, not machines (Mylopoulos, 2008). This means that enterprise modelling should offer reconstructions of language concepts characteristic of cognitive perspectives of relevant stakeholder groups, meaning, and among other things, using domain-specific modelling languages (Frank, 2012). As an example, the NATO architecture framework consists of an operational view-1 (NOV-1), which depicts the ‘big picture’ view of the military operations in an operational context and acts as a facilitator of human communication. It is intended for presentation to high-level decision makers. Therefore, tailored representations, such as traditional concept of operations (CONOPS) pictures along with their characteristic elements, such as geographic maps, types of forces and their connectivity, are used to fulfil the goals of the model (NATO Consultation, Command and Control Board, 2007), as done in paper [IV].

Nonetheless, despite the focus to conceptual modelling, this dissertation also uses quantitative methods to support answering the research question. In doing so, it perceives the armed forces, the organisations that deal with military capabilities, as socio-technical systems. This means that the exploration of the capability development issues additionally involve the people and their opinions about the issues and the solutions to improve the situation. However, the functionalist research tradition stresses objectivity. It seeks to find regularities in the social world and quantitative analyses are preferred techniques for acquiring detailed knowledge (Jackson, 2000). Therefore, this dissertation attempts to build an objective perspective of those opinions using quantitative methods. Whether to gain an understanding of the problems or to verify the results, either the issues or the proposed solutions in all three research objectives have been subjected to the quantitative evaluation of stakeholders. In paper [I], the value of the comprehensive capability model was assessed through descriptive statistical analysis. In paper [IV] of objective 2, the benefits of the EA model were analysed through an inferential statistical analysis. In objective 3, the expectations towards the CoE were similarly analysed through an inferential statistical analysis in paper [V], and in paper [VI], the performance of the CoE was assessed using a quantitative method, CFI.

Rule 3f – The process of intervention is systematic and is aimed at discovering the best way to achieve a goal.

The systematic logic of the dissertation and exploration of its objectives from one to three were explained in Chapter 1 (p. 4). In this dissertation, systematic is defined as being done according to a system or plan, in a thorough, efficient or determined way (Oxford University Press, 2005). The second part of the requirement emphasises the general functionalist paradigm, which values the improved prediction and control of systems in concern, rather than just attempting to understand the situation better, such as with the interpretive systems tradition. In this sense, this dissertation complies with the requirement, which demands the improvement with regard to set goals, as explained in the discussion of Rule 1. Nonetheless, this dissertation does not attempt to propose alternative ways or competing systems models to improve the situation, as the requirement could be also interpreted. Instead, it is perceived that functional systems methodology, in general, is the correct systems method to improve the existing situation and achieve the purpose of the organisation it is designed primarily to serve. In this dissertation, this means improving the development of military capabilities in armed forces by practical proposals.

Rule 3g – The intervention is conducted on the basis of expert knowledge.

The author of the dissertation who built the systems models that this dissertation presents is a subject matter expert from both systems and the topic content perspectives. He has an MSc degree in systems engineering for defence and is the general staff officer, with more than 20 years of service background in the Finnish Defence Forces, including assignments in the operational, procurement and R&D communities of the forces.

Rule 3h – Solutions are tested primarily in terms of their efficiency (do the means use minimum resources?) and efficacy (do the means work?).

From the perspective of efficacy, the completeness, correctness and benefits of the comprehensive capability meta-model (CCMM) in paper [I] of objective 1 were verified with positive results. Likewise, in paper [IV] of objective 2, the original concept development team validated the value of the proposed EA model. The results showed that the EA approach can bring value to traditional concept development by increasing the clarity, consistency, and completeness of the concept. For practical reasons, the collaboration model in paper [VII] of objective 3 was not tested in the same way that the two other solutions mentioned above were validated. The collaboration model suggests seeing and jointly managing the three existing collaboration mechanisms: technology programmes, centres of excellence and industrial participation programmes. Currently, each of these programmes is run in isolation from each other, specifically, they are managed by separate timeframes and organisations. The implementation of the proposed model will take several years and is dependent on operational and administrative decisions both in the defence forces and in industry. Therefore, papers [V] and [VI] of objective 3 assessed the current implementation of the 'hub' collaboration mechanism, the centre of excellence. In paper [VI], the performance of the centre of excellence was measured on the basis of stakeholders' experiences and earlier expectations, which were measured in paper [V]. The weaknesses that the assessment revealed in the functioning of the CoE have been addressed in the proposed collaboration model in paper [VII]. In addition, the benefits of the collaboration model were assessed by an analytical risk assessment in the paper itself. The efficiency (i.e., 'do the means use minimum resources') testing was not fully conducted in the papers for the following reasons. In paper [I], which is a conceptual construct, a need for efficiency testing was not considered necessary. The use of a model is not resource dependent, thus there is no more efficient or less efficient way of applying it. In paper [IV], it was recognised that the evaluation of benefits included just the qualitative aspects of the benefits and excluded the cost dimension. The focus of the paper was to assess the functional value of the EA model to complement existing concept development methods. It was proposed that the return of investment aspects be included in future work. However, the collaboration model in paper [VII] takes into account the cost and resource dimensions as well as the qualitative improvements. The justification of the model's ability to increase efficiency both from management and from economic perspectives is done by analytical argumentation.

Rule 5 – Each use of the functionalist systems of methodology should yield research findings as well as changing a real-world problem. These research findings may relate to the theoretical rationale underlying the methodology, to the methodology itself and how to use it, to the methods, models, tools and techniques employed, to the real-world problem situation investigated, or all of these.

Generally, the requirements of doctoral dissertations call for the same objectives. In this dissertation, the research purpose, question and related objectives with both practical and scientific aims were presented in Chapter 1.2. The theoretical contributions of the dissertation to those purposes are presented in Chapter 5.1.1 and 5.1.2 presents the practical contributions.

4.4 Summary

This chapter presented the summaries of the papers in this dissertation in relation to the research objectives and explained the author's contributions in each paper. This chapter justified the use of the chosen methodology in relation to the whole dissertation, its research question, the objectives and its papers in detail by explaining how each of the constitutive rules of the methodology have been applied in the dissertation. The complete set of rules is applied at the dissertation level, whereas each research objective fulfils the in-detail requirements of Rule 3. It should be noted that the quantitative analyses (Rule 3e) and the testing of solutions (Rule 3h) have not fully been conducted in the dissertation as the rules dictate. However, the rationale for non-compliance of those rules has been explained in the justifications above. Despite those exceptions, it is considered that the dissertation complies with the selected methodology.

CHAPTER 5 – DISCUSSION AND CONCLUSIONS

This chapter concludes the summary of the dissertation by discussing the theoretical and practical contributions of the dissertation. In addition, the validity and reliability of the research are assessed. Last, the directions for future research are proposed.

5.1 Contributions of the dissertation

The idea of a contribution resides largely on the ability to provide *original insight* into a phenomenon by advancing knowledge in a way that is deemed to have *usefulness or utility* for some purpose. Originality means that the proposed conceptualisation offers either a critical redirection of existing views, such as an incremental insight or entirely new perspective on phenomena (i.e., revelatory insight). Utility simultaneously refers to scientific utility, which improves the current research practice, and practical usefulness, which can be directly applied to the problems faced by organisational practitioners. (Corley and Gioia, 2011)

The originality and scientific utility perspectives of the contribution have been elaborated by the introduction of four essential elements of a theory and its development: ‘what’, ‘how’, ‘why’ and ‘who, where, when’ (Whetten, 1989). However, theories are seldom generated from scratch. Therefore, those elements may additionally be used to consider whether a proposition constitutes enough of a theoretical contribution on improving something that already exists. Consequently, the constituent elements of Whetten are used as the criteria to justify that the conceptual models regarding military capability and national defence materiel collaboration between the defence forces, defence industry and academia, are sufficient. In accordance with Whetten, new conceptualisations are, as a rule, sufficient for contribution, if they focus on more than one of four theory elements.

5.1.1 Theoretical contribution

The term ‘theory’ is understood in this dissertation ‘as a set of concepts and the proposed relationships among these, a structure that is intended to represent or model something about the world’. This means that the theory does not denote a specific level of complexity, abstraction or generality of explanatory conceptualisations, but instead refers to the entire range of such conceptualisations (Maxwell, 2005). However, the range of theories was elaborated by presenting three theory categories: grand theories, such as Einstein’s theory of relativity, middle-range theories and substantive theories. The last, and most common category, is restricted to a particular time, research setting, group, population or problem (Saunders et al., 2012).

The theoretical contribution of this dissertation deals with the substantive level of theories, while the concept of military capability provides its theoretical foundation. The dissertation makes a valuable contribution to current studies about military capability, its frameworks and the capability life cycle models. It presents two interdependent conceptual capability models; the comprehensive capability meta-model (CCMM) and the holistic capability life cycle model (HCLCM). They holistically and systematically complement the existing, but still evolving understanding of military capability and its life cycle. They link widely used military capability models hierarchically and connect those models to the standard-based system life cycle model to show the relationships temporally. The holistic capability life cycle model shows, among other things, that a functional capability model relates primarily to the concept and development life cycle stages, the systems model to the production stage and the military unit model, in turn, to the in-use and disposal life cycle stages.

The in-detail justification of the theoretical contribution of these models is as follows: The first theory element of Whetten is ‘what’. A theory or its critique should contain a comprehensive set of factors in the phenomenon of interest. The CCMM consists of six widely known and utilised capability models. None of the known frameworks by scientists (Fasana, 2011; Kerr et al., 2006; Russell et al., 2008; Yue and Henshaw, 2009) includes all of those models. However, the parsimony principle, wherein insignificant factors are excluded from the factors, should also be considered when selecting the right factors. While the CCMM attempts to display the entire set of military capability views, the HCLCM, which builds on the CCMM and increases the understanding of how capability evolves in defence organisations over time, only uses the capability models that are needed in defence forces to manage the capability life cycle on the enterprise level. Therefore, the weapons model, which is not used directly to manage the capability life cycle, and the military power model, which is primarily utilised by political decision-makers, have both been excluded from the HCLCM.

Second, Whetten’s ‘how’ element seeks to determine how those factors relate with each other. This element adds order to the conceptualisation by showing patterns and typically introducing causality. The more complex the set of interdependencies under consideration, the more valuable it is to present them graphically. The CCMM presents the existing capability models in a hierarchical order. The hierarchy includes six perspectives of the capability, each of which represents a different role, a different set of constraints, and therefore different model structures of military capability. Figure 7, presented originally in paper [II], is included to illustrate how the HCLCM reveals the relationships between the capability life cycle stages, the capability models, the in-use and the enabling capability systems in a graphical entity-relationships model. The current capability models in the United States (US DoD, 2008b), in the UK (UK MoD, 2005b), and in Finland (Defence Staff, 2007) list the life cycle stages. However, rather than looking at capability as an enterprise-level model as the HCLCM does, they perceive the capability as a system-level issue. In other words, they look the life cycle primarily as an evolution of a capability system, such as an infantry battalion or as a technical system, such as fighter aircraft. In addition, the HCLCM expands the current application of ISO 15288 in military capabilities by incorporating the standard’s system concept to the capability life cycle. The organisational view of military capability (i.e. military unit model) is seen in the HCLCM as a system-of-interest. The generally recognised objective of military capability is the ability or power to achieve a desired operational effect in a selected environment and to sustain this effect for a designated period (US DoD, 2008a; New Zealand, 2008). This objective is only achieved when real-life military units are engaged in an operation (Touchin and Dickerson, 2008). Specifically, military units, such as force elements, represent the elements of military power that bring military capability directly to bear (Whitehall Papers, 2000) and manifest real-life fighting power, which is defined as the ability to fight and operate. The other capability models, the functional and systems models, act, in turn, as enabling systems facilitating the conduct of capability development life cycle stages, and thus supporting the progression of a military unit through its life cycle.

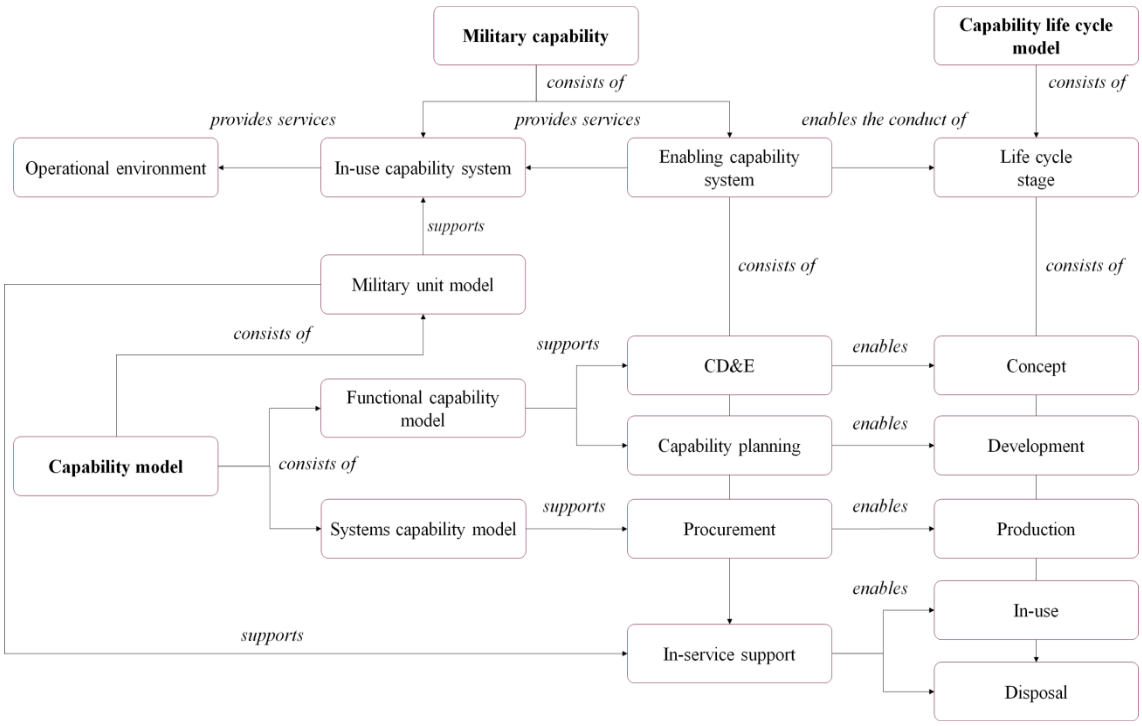


Figure 7. *The illustration of the relationships among the HCLCM factors as a graphical entity-relationship model.*

Third, Whetten's 'why' element deals with the underlying economic or social dynamic rationales of the 'what' and 'how' elements. The key question here is why colleagues should give credence to this specific representation of the phenomenon. During the theory-development process, logic takes the place of data as a basis of evaluation. The soundness of fundamental views of organisational or societal processes provides the basis of assessing the reasonableness of the suggested conceptualisation. The capability models seek to increase understanding of the phenomenon of military capabilities. An attempt has been made to guarantee the soundness of the proposed models by using well-known frameworks for model building, which are directed toward comprehensiveness. The CCMM uses the Zachman framework of enterprise architecture. In the HCLCM, the structure is ISO 15288, to which, for instance, the capability life cycle models of Finland and the UK are already based. In addition, the capability models included in the models are in use in many different countries. The verification results of the CCMM further indicate the value of the model to various groups of users, including doctorate-level teachers at the National Defence University. Five of the verification survey questions (questions 12–16) specifically addressed the scientific value of the model. They questioned how the model increases the general understanding of military capability, the relations between various capability models and their specific roles in relation to the other models. On average (median), the model was considered to yield strong benefit in increasing general understanding of the capability and specific roles of the various models. Understanding about the relationships of the models was perceived to produce moderate benefits.

Fourth, the 'who, where, when' element places limitations on the propositions of the theoretical model, and thus sets the boundaries of its generalisability. The proposed capability models are generic. They do not address any specific country. They are based on existing capability and capability life cycle models and widely used frameworks. Therefore, they could be applied widely in defence organisations. However, the concept of military capability is bounded—as the name indicates—to the defence domain. Consequently, the application of the models beyond the military sphere would not be directly possible.

This dissertation additionally contributes to the scientific discussion of defence materiel collaboration by introducing the holistic model about collaboration between the defence forces, the defence industry and academia. First, with respect to Whetten's 'what' element, the national collaboration model includes the key collaboration mechanisms: defence technology programmes, industrial participation and centres of excellence as well as immaterial property rights. It is noteworthy that those mechanisms are typically viewed in isolation, which is frequently the focus of current academic literature. For instance, there is a wide array of academic studies that only discuss the offsets and present widely disparate perspectives on the effectiveness and desirability of offsets (Hagelin, 2004; Markusen, 2004; Sköns, 2004; Matthews, 2004). Moreover, rather than focusing on only one or any subset of those views, which is usually the case in the offset literature, the model perceives the mechanisms from four different perspectives: capability, competitiveness, economic and management. Since the academic discussion about offsets usually represents the views of defence economists, they tend to perceive and evaluate the offsets primarily from an economic perspective (Brauer, 2004; Markowski and Hall, 2004). Consequently, those studies neglect the military perspective of the offset, which can be security of supply.

Second, concerning the 'how' element, the model shows how existing collaboration mechanisms form a synergistic whole. Despite the fact that the individual mechanisms are, in reality, implemented under separate programmes, schemes, and at different times, the model provides desired advantages both for the defence organisation and for the national industry. Figure 8, originating from paper [VII], exemplifies how those mechanisms interact with each other.

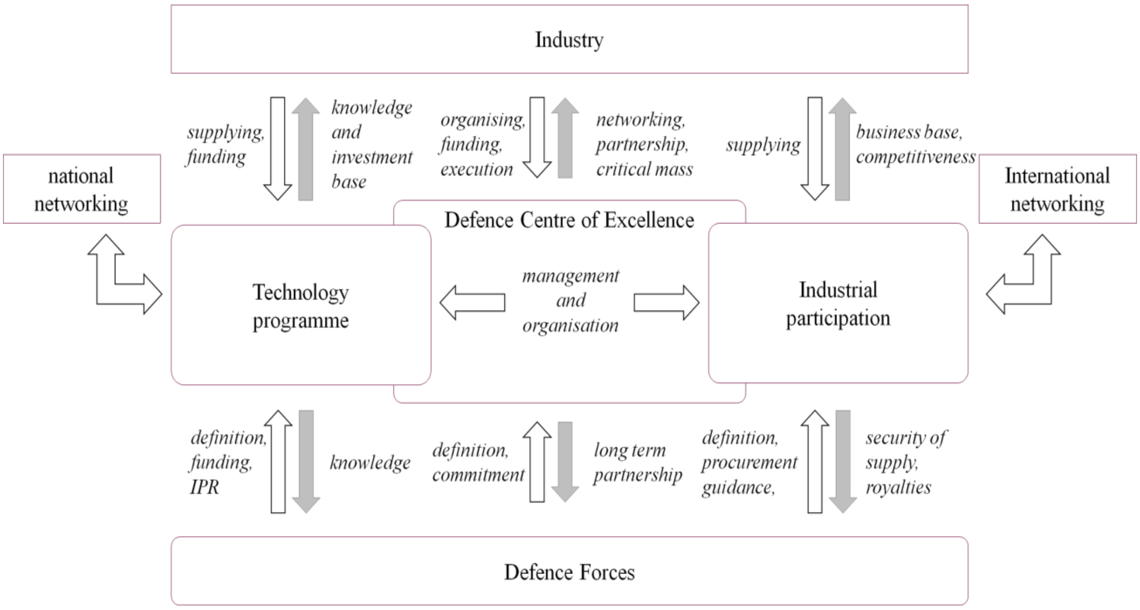


Figure 8. *The illustration of the interactions among the national defence materiel mechanisms and parties as a graphical systems diagram.*

Third, in terms of the 'why' element, the collaboration model rationalises both the need and the opportunities and provides a conceptual solution for a synergistic national defence materiel collaboration. This is despite the trends and guidance towards international defence cooperation in development and use of military capabilities. An attempt was made to increase the solidity of the model by considering the risks in the situation where each of the mechanisms is implemented in isolation from each other. The soundness of the model has also been investigated by exploring the influences among the involving mechanisms and views.

Fourth, with regard to the 'who, where, when' element, the model does not provide a generic collaboration model, but expands the current scientific discussion, which is often focused on international collaboration (Hartley, 2008; James, 2006; Struys, 2004) or big countries with substantial defence technological and industrial bases (Bellais and Guichard, 2006; Dunne et al., 2007; Struys, 2004), with a model that views the collaboration from the perspective of a small country with a moderate industrial base using Finland as an example country.

The empirical papers of the dissertation contribute to the scientific discussion about both the benefits of enterprise architectures and the collaboration. The dissertation adds empirical evidence about the benefits of EAs, which is a widely identified research gap in studies about EAs (Aier et al., 2009; Chen et al., 2008; Kaisler et al., 2005; Kamogawa and Okada, 2005; Niemi and Pekkola, 2009), including governmental organisations (Hjort-Madsen, 2006; Liimatainen, 2008).

The longitudinal study of the NEPRO assessed the performance of the centre of excellence as a manifestation of cross-sector collaboration. Thus, the evaluation addresses the research interest (Boase, 2000; Donahue, 2004; Dowling et al., 2004), which calls for the assessment of actual collaboration examples, rather than defining the characteristics of cross-sector collaboration or its processes, on which the research has typically focused. The evaluation sheds light on the factors that pose risks and even endanger the success (i.e., development factors) of the collaboration. Therefore, the evaluation contributes to the collaboration studies, which attempt to find reasons for collaboration failures or prevent them, as an answer to the research gap, which identifies that collaboration frequently fails to meet the expectations of those involved (Anderson and Jap, 2005; Babiak and Thibault, 2009; Huxham, 1996; Medcof, 1997). The results of the evaluation additionally showed, among other things, that the experiences regarding NEPRO were considered worse than the expectations among all the evaluation factors. This finding is supported by the earlier results of the collaboration research, which claimed that expectations regarding collaborative mechanisms tend to be broad and ambitious (Kreuter et al., 2000). Moreover, half of the identified development and risk factors had a common feature in that they, in turn, identify the unsatisfactory status of tangible results. The collaboration studies simultaneously recognise that the concrete results not only represent tangible outputs in themselves, but also as critical process outcomes, which are necessary for building the momentum that can lead to successful collaboration (Ansell and Gash, 2008). However, implementation of those actions could be tedious and there are no quick-fix solutions. Collaboration is a complex, potentially fragile process, it cannot be easily accelerated and the required investments of time and training will exceed the expectations of even the most well informed decision makers (Miles et al., 2006).

5.1.2 Practical contribution

Foremost, this dissertation tackles a real-world problem by exploring and finding the means to enhance the development of military capabilities. The enhancements seek to improve the evolution and employment of those capabilities in armed forces. This emphasis to practice is reflected both in the research question and the research design of the dissertation. The research question directly addresses the practical research interest by asking, ‘In what ways can the development of military capabilities be supported by a systems approach?’ Rule 1 of the chosen research methodology states, ‘A functionalist systems methodology is a structured way of thinking, with an attachment to the functionalist theoretical rationale that is focused on improving real-world problem situations.’ The key contributions of the dissertation to practice are as follows.

With regard to *the concept of military capability*, the military capability models: CCMM and HCLCM, increase understanding and facilitate communication among various military capability stakeholders. Each stakeholder group, such as concept developers, capability planners, procurement community, end-users and the defence industry, uses certain capability models, focuses on specific capability concerns and considers these concerns at particular stages in the capability life cycle and with a certain level of detail. Therefore, as the verification results of the CCMM indicate, each stakeholder may perceive capability in a different way from the other stakeholders. The military capability models of the dissertation help the stakeholders to see how the capability model, characteristic for them, relates with the capability models used by the other stakeholders. The models additionally enhance the overall understanding of how the others perceive the capability. The models help to align each capability model to a larger context and within the life cycle of military capability. Furthermore, the models simplify complex capability issues and relations in a meaningful way. The increased understanding of the military capability fosters communication among the stakeholders both inside the armed forces and between the armed forces and related communities outside the armed forces, such as the defence industry. Communication further facilitates the ideal evolution and employment of military capabilities. The previously mentioned benefits that the capability models provide are supported by the verification results of the CCMM.

Concerning *the concept life cycle stage of military capability*, the findings of the case studies about the application of EA to military concept development indicate that the EA approach could bring practical benefits to military CD&E. It plays an important role in driving strategic transformation in the military community by enabling the structured development of creative and innovative ideas for viable solutions to the challenges of capability development.

The findings of the study suggest that the EA approach adds value to traditional concept development by increasing the clarity, consistency and completeness of the concept. The graphical information of the EA model enables the ability to capture large amounts of the concept data to individual graphs, which in the original concept could be scattered across several text sections, and it simultaneously enables the presentation of the information in a compressed format that communicates effectively. Moreover, the EA model's ability to increase consistency suggests that it is easier to control and check the conformity of the used terms and their relationships in a limited number of graphs than in a large text document. The most important use considered for EA in CD&E was that it enables the further utilisation of the concept created in the case project. CD&E is the predecessor of the capability development life cycle stage, where the NAF or similar military sector architecture framework (e.g., DODAF) plays a vital role. It would be tremendously beneficial in subsequent capability development work to have the CD&E products already in the form of EA diagrams and views to support the transition from one life cycle stage to another. A common model base provides greater consistency and traceability among different development stages, which also reduces redundant work. From a broader, practical perspective, the identified benefits that the EA approach brings to CD&E may be used to motivate practitioners to change CD&E from a simple writing exercise to a comprehensive innovative process in which the EA approach would be an organic part of the CD&E, as best practice has already recommended.

The practical benefits of the EA model and its evaluation for further development work were demonstrated by the fact that the EA model of the dissertation was included in the final report of the case project (MNE 6, Multinational experiment) as a complementary work parallel to the original concept of the case project. Moreover, the parts of the case project EA model, such as individual graphs, were embedded in the final version of the concept to increase its consistency and clarity. Finally, further utilisation of an EA approach (i.e., NAF-based modelling for future CD&E work) was recommended in the final case project report (Viita-aho, 2011).

Regarding the *capability planning and procurement stages of military capability,* the findings of the dissertation, from one standpoint, directly support the management of national defence materiel collaboration focused on knowledge development and innovation related issues. The NEPRO CoE evaluation provided timely evidence and awareness regarding how the functioning of the NEPRO CoE generally meets the expectations of the stakeholders, the critical factors in which the stakeholders are least satisfied, and in which factors the level of satisfaction is mixed and hence poses risks for the NEPRO. Therefore, the longitudinal evaluation of the NEPRO lays the groundwork for the decision makers of the NEPRO to focus their efforts and readjust the operations of the CoE to maximise the possibilities of collaboration success.

From another perspective, the national defence materiel collaboration model adds value to defence forces, national defence industry and academia by proposing a systems approach as an alternative to the current method of implementing the collaboration. The model links key collaboration mechanisms, which currently work in isolation from each other, and takes into consideration the unique needs of each partner. Likewise, the model shows the interdependencies of/and how the mechanisms could contribute to each other.

The model additionally addresses factors identified as weaknesses, risks or dangers for the success of the NEPRO CoE during its evaluation. First, the model recognises that although the CoEs should be financed appropriately, a separate funding instrument for the CoEs should not be established. Instead, they should be funded through technology programmes, which already have funding in place. In the NEPRO CoE, the missing funding was found to be a risk factor for the success of the CoE. The lack of common funding may have contributed to the underachievement of tangible results in the CoE, which was another finding of the evaluation. Second, the model allows building the necessary competencies and capabilities incrementally over time by taking advantage of the existing collaboration mechanisms. During the technology programmes, networking should focus on national partners to enable them to first build critical mass and then develop the knowledge base. Industrial participation would naturally create opportunities for international networking during the times of defence materiel procurement and provide the business base for the firms, which have built necessary competencies with the help of technology programmes and the CoE. In contrast, the goals set for the NEPRO were very ambitious including knowledge development, innovating and international partnering. Furthermore, there were no priorities among the goals. The expectations of the stakeholders towards the goals were found to be very high at the beginning of the NEPRO operations. The CoE was also assumed to achieve those goals primarily as a parallel, not as a linking, mechanism with regard to the existing technology programme and industrial participation. The evaluation showed that none of the initial expectations of the stakeholders towards those goals were met.

The findings of the NEPRO performance evaluation as well as the requirements of the national defence materiel collaboration model are supported by the recommendations of the NEPRO advisory committee in its report about the NEPRO CoE project (Defence Forces Technical Research Centre, 2012). The committee makes several proposals, totally independent of the studies of this dissertation, for the future development of defence centres of excellence (DCoE). These suggestions include, among other, that DCoEs and their work should be organically linked to customer needs and the processes of the defence forces. This would guarantee that DCoEs contribute to the capability driven needs, including the security of supply. Linking DCoEs to customer needs would increase the willingness of industry to engage with the DCoEs. Furthermore, DCoEs should also be part of knowledge development, technology management and production, critical to military security of supply. DCoEs additionally need a business model that clearly shows what tangible benefits they produce to different stakeholders. These recommendations are compliant with the characteristics of the defence materiel collaboration model of the dissertation. The advisory committee of the NEPRO CoE further states that proper functioning of DCoEs requires that they have both adequate personnel and financial resources. Moreover, it should be accepted that the development of a CoE is a time consuming process and endeavour. These statements concur with the findings of the NEPRO evaluation.

5.2 Assessment of the dissertation

There are several types of criteria for judging the quality of research depending on the chosen methodology and/or the strategy of inquiry. The importance of validity has long been accepted in quantitative research (Onwuegbuzie and Johnson, 2006). However, validity has a range of definitions. In the narrow meaning, validity is the integrity of the conclusions (Bryman, 2004). From a broader perspective, validity means that 'a research study, its parts, the conclusions drawn, and the applications based on it can be of high or low quality, or somewhere in between'. Specifically, validity may be used as a synonym for quality (Onwuegbuzie and Johnson, 2006). In qualitative research, discussions of validity have been more contentious (Onwuegbuzie and Johnson, 2006). Consequently, an alternative set of quality criteria was introduced to the qualitative research, including the factors: credibility, transferability, dependability and confirmability (Guba and Lincoln, 1985). In mixed methodology research, it is recommended that validity be termed 'legitimation' (Onwuegbuzie and Johnson, 2006).

It is also recognised that it would be wrong to think that the validity and reliability in all research is submitted to rigours, or the characteristics of quantitative studies that are analysed statistically. In those cases, reliability, for instance, consists of measures, such as stability, internal reliability and inter-observer consistency, tested with explicit mathematical methods and techniques. In contrast, typically, measures are simply asserted (Bryman, 2004). Therefore, despite the established views of validity, it is not generally about singular (Onwuegbuzie and Johnson, 2006) or objective truths (Maxwell, 2005). This means that there is no need for a 'gold standard' to which the accounts of a researcher may be compared to ascertain whether those accounts are valid. Instead, it is essential to have the possibility of testing these accounts against the world, and thereby provide the phenomena that the researcher is attempting to understand the opportunity to prove it right or wrong. Therefore, a key concept for validity is the validity threat: a way that the researcher may be wrong. (Maxwell, 2005)

In this dissertation, as Table 7 (p. 45) shows, three of seven papers are conceptual in nature, and four are empirical case studies. The data in three of the case studies, in papers [IV], [V] and [VI], were analysed quantitatively. Paper [III] represents a qualitative analysis and papers [I], [II], and [VII] use conceptual modelling as an analysis method. The validity and reliability considerations of the papers vary in the basis of the nature and the type of the analysis of the paper. These considerations are discussed in detail in the individual papers. Consequently, the review of the validity and reliability focuses on the general principles and the avoidance of generally identified threats to the validity and reliability of the dissertation.

The validity of the conceptual papers is conceived in its broad meaning—the general quality of those papers. The rationale for this interpretation of the validity in those papers is that while they are conceptual constructs by the author, the rigorous validity tests, suitable to quantitative case studies, would be problematic if applied to them. However, the detailed justification of the sufficient quality of those papers against the criteria by Whetten (1989) was conducted in Chapter 5.1.1, theoretical contributions. The quality factors consisted of the comprehensiveness of the factors included in the models, the relationships between the factors, the logic and soundness of the reasoning, and the limitations to generalisability, such as external validity. Therefore, it is considered that the quality of the conceptual papers of the dissertation has already been reviewed and found to be sufficient.

Concepts of validity and reliability have been commonly used to establish the quality of any empirical social science. While case studies are one form of such empirical research, four different types of quality tests: construct validity, internal validity, external validity and reliability are relevant to case study research (Swanborn, 2010; Yin, 1994). Consequently, the general validity and reliability considerations of the empirical case studies of the dissertation are discussed below; this is in addition to the discussion of those features in the individual papers.

5.2.1 Validity

Construct validity, or measurement validity, refers to the question of whether a measure devised of a concept really does reflect the concept that it is supposed to be denoting (Bryman, 2004). This quality measure is frequently linked to the validity of questionnaires (Saunders et al., 2012). An attempt was made to strengthen the construct validity of the EA case study questionnaire by using a well-validated framework, the DeLone and McLean model of information system (D&M IS) success, as criteria for assessing the benefits of EA. In addition, the measures of effectiveness (MoE) within the criteria were derived from the academic EA literature and standards dealing with EA benefits. However, the lack of discriminant validity of the framework, observed in the survey, calls for further investigation of the applicability of the Delone and Mclean model to evaluate successfully the potential benefits of the EA approach in CD&E. Questions drawn from the operational goals laid out in the founding contract of the NEPRO, and operationalised in the assessment plan of the NEPRO, were used in an attempt to secure the construct validity of the NEPRO CoE evaluation. Additionally, the draft results and reports of both studies were reviewed by the key informants of the case projects. These are considered viable tactics for increasing construct validity (Yin, 1994). In the first phase of the NEPRO evaluation, the data was analysed statistically. In the second phase, a specific quantitative performance measurement method, the Critical Factor Index (CFI), was used for the analysis. This method used data collected in both phases of the assessment. The initial CFI evaluation results, of the paper, identified a development factor that was assessed to be non-critical in further analysis. This finding supports the earlier reported limitation of the CFI, which admits that the development factors identified during the initial CFI generation were not necessarily critical (Mäntynen and Takala, 2010). However, the manner by which this non-critical CFI parameter was identified by systematically studying the values of the individual parameters in the CFI formula was not found to have been used in the earlier CFI studies. A comparative analysis of the evaluation results by the CFI method, with inferential statistical analysis, would shed light to the statistical validity of the CFI, in addition to its earlier reported pragmatic validity.

Internal validity is the degree to which alternative explanations for the obtained results can be ruled out (Teddlie and Tashakkori, 2009). This type of validity test is only applied to causal or explanatory studies (Saunders et al., 2012; Yin, 1994). The case studies in the dissertation were primarily exploratory studies, in that they were directed towards learning the current opinions or situation in the issues they studied, rather than predicting or specifically pointing out causalities. Therefore, this measure of validity is not considered applicable to this dissertation.

External validity concerns the question of whether the results of the study can be generalised beyond the specific research context (Bryman, 2004). In the statistical generalisation, inferences are made about a population based on empirical data collected about a sample, for instance, by a survey (Yin, 1994). In this sense, the threats related to external validity include issues concerning the interaction of selection, such as the generalisability across people, the interaction of the setting, i.e. the generalisability across situations and the interaction of history, i.e. the generalisability over time (Creswell, 2009). Case studies are typically criticised for providing an account of a unique circumstance that it is not possible to generalise (Bryman, 2004; Drake and Heath, 2011; Swanborn, 2010; Yin, 1994) and hence prone to the above mentioned threats. Nonetheless, in the case studies, a sample-to-population logic should not be assumed, but each case, in the tradition of laboratory psychology, should be treated as a new experiment. Therefore, the external validity of case studies should be focused on how the cases can be generalised to theory (Swanborn, 2010). This means that a previously developed theory is used as a template with which to compare the empirical findings of the case study (Yin, 1994). Generalisations can be used both for theory development and testing purposes (Bryman, 2004). This generalisation-to-theory logic is termed as 'analytical generalisation' (Yin, 1994). In the dissertation, the case studies primarily exhibit theory testing features of analytical generalisation. The empirical findings of the NEPRO CoE were reflected with the earlier results of the collaboration studies to rationalise the findings and simultaneously provide empirical evidence to the existing understanding of collaboration and its success factors. The EA case studies provided empirical evidence to the scientific discussion regarding the benefits of EA to support strategic transformation. In addition, both in the NEPRO and the EA studies, the potential weaknesses of the chosen evaluation methodologies were discussed, which can be considered a part of analytical generalisation. Nonetheless, it should be noted that in the EA evaluation, a cautious recommendation for further use of the EA approach in the CD&E was suggested. It was proposed that, from a broader practical perspective, the findings of the case study could be used to motivate practitioners to include the EA approach as an organic part of the CD&E, as best practice has already recommended. This suggestion is justified by the similarity of dynamics and constraints of the case study to non-tested CD&E cases, vindicated by the identified practical implications that the case study yielded. Because no precise extrapolation of the results to the population is done, it is considered that the recommendation does not threaten the external validity of the dissertation. Moreover, similarity is one of the identified characteristics that may be used to rationalise the generalisation in case studies (Maxwell, 2005).

5.2.2 Reliability

Research reliability concerns the extent to which an experiment, test or any measuring procedure yields the same results on repeated trials (Carmines and Zeller, 1979; Saunders et al., 2012; Yin, 1994). Reliability is basically an empirical issue, focusing on the performance of empirical measures (Carmines and Zeller, 1979). The key aspect of reliability is that the research is reported in a fully transparent way to allow others to judge for themselves and repeat the research if one wishes to do so (Saunders et al., 2012; Yin, 1994). The emphasis of reliability is also on doing, for instance, the same case study over again, and not on replicating the results of one case study by doing another study (Yin, 1994). Issues that threaten reliability may derive from both the participants and the researchers. Participant error could be any factor, which adversely alters the way in which a participant performs. Participant bias is any factor, which induces a false response. Researcher error may be any factor, which alters the researcher's interpretation. Researcher bias is any factor, which induces bias in the researcher's recording of responses (Saunders et al., 2012).

In this dissertation, the likeliness of participant error was reduced by implementing two questionnaires through the Internet with detailed instructions as to what was expected from the respondents and how much time the survey was estimated to take. Consequently, the respondents could choose the best time for them to answer the survey.

The probability of participant bias was decreased by conducting all four questionnaires anonymously. All three case study questionnaires were pilot-tested with key informants. To reduce possibilities for misunderstandings, the scale used for answering was explained in all of the questionnaires by examples on the front page of the questionnaire. Additionally, in the two questionnaires conducted vis-à-vis, the researcher explained the models thoroughly before answering the questionnaire. After the presentations of the models, discussion followed to ensure that respondents understood the models and goals of the survey. The researcher was available to respond to potential questions by the respondents in the survey venue during the designated answer time. The EA model, of which the benefits to CD&E were evaluated, consisted of a substantial amount of data. To ensure that the respondents had enough time to get familiarised with the model, the model was sent to respondents well in advance of the actual time to answer. Nonetheless, despite preparations to avoid participant biases, it was observed that the potential benefits of the EA model varied considerably among the different respondents and this could not be explained by the background variables. One explanation for the variability in the respondents' answers could be that the EA model of the case project was not constructed by the original concept development team; nonetheless, it was consulted by three team members. For that reason, some respondents could have had a bias either for or against it. Some respondents could have seen the EA model as a competitor for the original concept, while some others may have taken the EA model as a welcome supplement for the case project by introducing an innovative approach to the existing CD&E.

Closed-ended questions were used in all questionnaires to decrease the possibility of researcher error. Researcher bias was decreased by analysing the data of the questionnaires quantitatively. Furthermore, more than one researcher was used in the analysis of the case study data. The preliminary results were discussed with the respondents in the EA evaluation case. In the CoE evaluation, the key informants reviewed the draft reports in both phases of the study.

To facilitate that the empirical studies of the dissertation can be carried out by another researcher, the collected data of the questionnaires are stored in a database (Webropol). In addition, to increase the transparency of the analysis of the data, the measurement frameworks, background variables and the results have been documented in the case study reports (i.e., the papers in-detail).

5.3 Recommendations for future research

This dissertation presented two holistic military capability models that facilitate communication among the capability stakeholders. Future research on military capability should address systems engineering (SE) issues related to the capability life cycle, such as requirements management or the systems engineering life cycle. These elements would enable further development of the models of this dissertation by demonstrating how stakeholders' needs are satisfied throughout the capability life cycle with the help of related capability models.

The findings about the applicability of the EAs to CD&E are based on a single CD&E project. Therefore, more empirical studies on EAs are required to increase the external validity of the findings. The evaluation of the EA benefits to CD&E included the qualitative aspects of the benefits and excluded the cost dimension. Likewise, the assessment focused on the EA products. Although the EA approach may bring benefit to CD&E or any business process it attempts to support, the benefits gained should be balanced with the effort needed to produce them. Therefore, adding both the return-on-investment and the process aspects to the empirical EA evaluation would be a relevant focus in future research.

The national defence materiel collaboration model of the dissertation links the key collaboration mechanisms together, and considers the unique needs of each partner, including the capability sustainment aspects. Nonetheless, the empirical evaluation of the mechanisms dealt only with the CoE. Consequently, empirical studies about the benefits of both technology programmes and offsets could bring new insights for scholars and practitioners about the reasonableness of those collaboration mechanisms. To enable holistic assessments, the studies should take into account not only the competitiveness or economic aspects, but also the military capability perspective. The focus of the collaboration is currently in the international programmes. Thus, the comparative studies about the advantages and disadvantages about international and national collaboration in defence technological, industrial and procurement issues would support the practitioners in their decision making. This type of research would enable scholars to test current theories about the necessary prerequisites for collaboration success in both environments.

REFERENCES

ACT – Allied Command Transformation, 2010. *Bi-Strategic Command knowledge development*. Norfolk: Allied Command Transformation.

Adenfelt, M. and Lagerström, K., 2006. Knowledge development and sharing in multinational corporations: the case of a centre of excellence and a transnational team. *International Business Review,* 15(4), pp. 381-400.

Aier, S., Kurpjuweit, S., Saat, J. and Winter, R., 2009. Enterprise architecture design as an engineering discipline. *AIS Transactions on Enterprise Systems,* 1(1), pp. 36-43.

Alghamdi, A. S., 2009. Evaluating defense architecture frameworks for C4I system using analytic hierarchy process. *Journal of Computer Science,* 5(12), pp. 1075-1081.

Alvesson, M. and Deetz, S. A., 2000. *Doing critical management research.* Thousand Oaks, California ; London: Sage.

Anderson, E. and Jap, S. D., 2005. The dark side of close collaboration. *MIT Sloan Management Review,* 46(3), pp. 75-82.

Ansell, C. and Gash, A., 2008. Collaborative governance in theory and practice. *Journal of public administration research and theory,* 18(4), pp.543-571.

Anteroinen, J., 2013. The systems concepts in military operations – discussion of critique. In *proceedings of the 2013 IEEE international systems conference.* Orlando, U.S.A. 15-18 April 2013. IEEE. *FORTHCOMING*

Australian DoD – Australian Government Department of Defence 2009. *Defending Australia in the Asia Pacific Century: Force 2030.* S.l.: Australian Government Department of Defence.

Australian DoD – Australian Government Department of Defence 2010. *Building defence capability: a policy for a smarter and more agile defence industry base.* S.l: Australian Government Department of Defence.

Avison, D. E. 1989. An overview of information systems development methodologies. In Flood, R. L., Jackson, M. C. and Keys, P., eds. 1989. *Systems prospects - The next ten years of systems research*. New York: Plenum Press, pp.189-193.

Avison, D. E. and Fitzgerald, G., 2003. *Information systems development: methodologies, techniques and tools.* 3rd ed. London: McGraw-Hill.

Babiak, K. and Thibault, L., 2009. Challenges in multiple cross-sector partnerships. *Nonprofit and Voluntary Sector Quarterly.* 38(1), pp.117-143.

Bach, W., 2003. European defence: Bridging the capabilities gap. *The RUSI Journal,* 148(6), pp.16-18.

Bar-Yam, Y., 2003. *Complexity of military conflict: multiscale complex systems analysis of littoral warfare, Report to Chief of Naval Operations*

Strategic Studies Group. (F30602-02-C-0158), s.l: New England Complex Systems Institute.

Bates, G., 2012. *Introduction. International security, armaments and disarmament, SIPRI Yearbook 2012.* Oxford: Oxford University Press: SIPRI.

Baumgarten, E. and Silverman, S. J., 2007. Dynamic DoDAF and executable architectures. In *proceedings of 2007 military communications conference*, MILCOM 2007. Orlando, U.S.A 29-31 October 2007. IEEE.

Becheikh, N., Landry, R. and Amara, N., 2006. Lessons from innovation empirical studies in the manufacturing sector: a systematic review of the literature from 1993–2003. *Technovation,* 26(5–6), pp.644-664.

Beckley, M., 2010. Economic development and military effectiveness. *Journal of Strategic Studies,* 33(1), pp.43-79.

Beerkens, E., 2009. Centres of excellence and relevance: the contextualisation of global models. *Science Technology & Society,* 14(1), pp.153-175.

Bellais, R. and Guichard, R., 2006. Defence innovation, technology transfer and public policy. *Defence & Peace Economics.* 17(3), pp.273-286.

Biddle, S., 2006. *Military power: Explaining victory and defeat in modern battle.* Princeton ; Oxford: Princeton University Press.

Blanchard, B. S. and Fabrycky, W. J., 2005. *Systems engineering and analysis.* 4th ed. Upper Saddle River, N.J. ; London: Prentice Hall.

Boase, J. P., 2000. Beyond government? The appeal of public-private partnerships. *Canadian Public Administration.* 43(1), pp.75-92.

Boster, M., Simon, L. and Thomas, R., 2000. Getting the most from your enterprise architecture. *IT Professional.* 2(4), pp.43-51.

Boucharas, V., Steenbergen, M., Jansen, S. and Brinkkemper, S., 2010. The contribution of enterprise architecture to the achievement of organizational goals: a review of the evidence. In Proper, E., Lankhorst, M. M., Schönherr, M., Barjis, J. and Overbeek, S., eds. 2010. *Trends in enterprise architecture research*. Berlin ; Heidelberg: Springer, pp.1-15.

Braddon, D., 2004. The matrix reloaded - what future for the defence firm?. *Defence & Peace Economics,* 15(6), pp.499-507.

Brauer, J., 2004. Economic aspects of arms trade offsets. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets*. Abingdon: Routledge, pp.54-65.

Brauer, J. and Dunne, J. P., 2004. Introduction. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets.* Abingdon: Routledge, pp.1-14.

Bryman, A., 2004. *Social research methods.* 2nd ed. Oxford: Oxford University Press.

Bryman, A., 2008. *Social research methods.* 3rd ed. Oxford: Oxford University Press.

Bryson, J. M., Crosby, B. C. and Stone, M. M., 2006. The design and implementation of cross sector collaborations: propositions from the literature. *Public Administration Review,* 66, pp.44-55.

Bucher, T., Fischer, R., Kurpjuweit, S. and Winter, R., 2006. Analysis and application scenarios of enterprise architecture: an exploratory study. In *proceedings of the 10th IEEE on international enterprise distributed object computing conference workshops*. Hong Kong, China 16-20 October 2006. IEEE Computer Society.

Buede, D. M., 2000. *The engineering design of systems: models and methods.* New York ; Chichester: Wiley.

Burrell, G. and Morgan, G., 1979. *Sociological paradigms and organisational analysis: elements of the sociology of corporate life.* Aldershot: Gower.

Cabrera, D., Colosi, L. and Lobdell, C., 2008. Systems thinking. *Evaluation and Program Planning,* 31(3), pp.299-310.

Caloghirou, Y., Kastelli, I. and Tsakanikas, A., 2004. Internal capabilities and external knowledge sources: complements or substitutes for innovative performance?. *Technovation,* 24(1), pp.29-39.

Carlock, P. G. and Fenton, R. E., 2001. System of Systems (SoS) enterprise systems engineering for information-intensive organizations. *Systems Engineering,* 4(4), pp.242-261.

Carmines, E. G. and Zeller, R. A., 1979. *Reliability and validity assessment.* Thousand Oaks, California: Sage Publications.

Checkland, P., 1981. *Systems thinking, systems practice.* Chichester: Wiley.

Checkland, P., 1989. Researching systems methodology: some future prospects. In Flood, R. L., Jackson, M. C. and Keys, P., eds. 1989. *Systems prospects - The next ten years of systems research*. New York: Plenum Press, pp.9-15.

Checkland, P., 1999. *Systems thinking, systems practice: includes a 30-year retrospective.* New ed. Chichester: John Wiley.

Checkland, P. B., 1972. A systems map of the universe. In Beishon, J. and Peters, G., eds. 1972. *Systems behaviour*. London: Harper & Row Ltd, pp.50 - 55.

Chen, D., Doumeingts, G. and Vernadat, F., 2008. Architectures for enterprise integration and interoperability: past, present and future. *Computers in Industry,* 59(7), pp.647-659.

Churchman, C. W., 1968. *The systems approach.* Rev ed. New York: Dell Publishing.

Cochrane, M. F., 2011. Capability disillusionment. *Defense AT&L,* 40(4), pp.22-26.

Command & Control Research Program, 2002. *Code of best practice experimentation.* Washington D.C.: DoD Command & Control Research Program.

Corley, K. G. and Gioia, D. A., 2011. Building theory about theory building: what constitutes a theoretical contribution?. *Academy of Management Review,* 36(1), pp.12-32.

Cornish, P. and Dorman, A., 2009. National defence in the age of austerity. *International Affairs,* 85(4), pp.733-753.

Creswell, J. W., 2009. *Research design : qualitative, quantitative, and mixed methods approaches.* 3rd ed. Los Angeles ; London: Sage.

Czajkowski, J. M., 2007. Leading successful interinstitutional collaborations using the collaboration success measurement model. In *the Chair Academys 16th annual international conference.* Jacksonville, Florida, U.S.A. 7-10 March 2007. Leadership Academy.

Das, T. K. and Teng, B.-S., 2000. Instabilities of strategic alliances: an internal tensions perspective. *Organization Science,* 11(1), pp.77-101.

Davis, P. K., 2002. *Analytic architecture for capabilities-based planning, mission-system analysis, and transformation.* Santa Monica, California: RAND Corporation.

De Greene, K. B., 1972. Systems and psychology. In Beishon, J. and Peters, G., eds. 1972. *Systems behaviour*. London: Harper & Row Ltd, pp. 92 -127.

De Spiegeleire, S., 2011. Ten trends in capability planning for defence and security. *The RUSI Journal,* 156(5), pp.20-28.

Defence Forces Technical Research Centre [Puolustusvoimien teknillinen tutkimuslaitos], 2012. *NEPRO CoE advisory committee: Minutes of the meeting 18.12.2012 [Suojan osaamisverkoston neuvottelukunnan kokouksen pöytäkirja 18.12.2012]*. Unpublished. Ylöjärvi: Finnish Defence Forces.

Defence Research and Development Canada, 2005. *Collaborative capability definition, engineering and management (CapDEM).* Ottawa: Defence Research and Development Canada.

Defence Staff – Finland, 2005. *Competences and competitiveness of the national defence industry in European networked environment 2025 [Kotimaisen teollisuuden osaaminen ja kilpailukyky vuonna 2025 verkottuneessa eurooppalaisessa toimintaympäristössä]*. Unpublished. Helsinki: Finnish Defence Forces.

Defence Staff – Finland, 2007. *General defence doctrine - The principles of the defence system [Kenttäohjesääntö, Yleinen osa - Puolustusjärjestelmän toiminnan perusteet]*. Helsinki: Edita Prima Oy.

Delone, W. H. and McLean, E. R., 2003. The DeLone and McLean model of information systems success: a ten-year update. *J. Manage. Inf. Syst.,* 19(4), pp.9-30.

Development, Concepts and Doctrine Centre – United Kingdom, 2010. *Army doctrine publication operations*. Swindon: Development, Concepts and Doctrine Centre – United Kingdom.

Director, Capability Operations and Plans, 2006. *Defence capability development manual*. Canberra: Director, Capability Operations and Plans.

DoD Deputy Chief Inormation Officer, 2010. *DODAF v2.0 relationships to other frameworks*. Washington D.C.: DoD Deputy Chief Inormation Officer.

Donahue, J. D., 2004. *On collaborative governance*. Corporate Social Responsibility Initiative Working Paper No.2. Cambridge, MA: Harvard University.

Dowling, B., Powell, M. and Glendinning, C., 2004. Conceptualising successful partnerships. *Health & Social Care in the Community,* 12(4), pp.309-317.

Drake, P. and Heath, L., 2011. *Practitioner research at doctoral level: developing coherent research methodologies.* London: Routledge.

Drezner, J. A., 2009. *Competition and innovation under complexity*. Santa Monica, California: RAND Corporation.

Dryer, D. A., Bock, T., Broschi, M. and Beach, T. D., 2007. DoDAF limitations and enhancements for the capability test methodology. In *proceedings of the 2007 spring simulation multiconference - Volume 3*. Norfolk, Virginia, U.S.A 25-29 March 2007. Society for Computer Simulation International, pp.170-176.

Dumas, L., J., 2004. Do offsets mitigate or magnify the military burden?. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets*. Abingdon: Routledge, pp.16-29.

Dunne, P., García-Alonso, M. D. C., Levine, P. and Smith, R., 2007. Determing the defence industrial base. *Defence & Peace Economics,* 18(3), pp.199-221.

EC – European Commission, 2009a. *Directive 2009/81/EC of 13 July 2009 on the award of contracts in the fields of defence and security*.

EC – European Commission, 2009b. *Guidance Note: Field of application for Directive 2009/81/EC on the award of contracts*.

EC – European Commission, 2009c. *Guidance Note: Offsets for Directive 2009/81/EC on the award of contracts*.

EC – European Commission, 2009d. *Guidance Note: Reserach and development for Directive 2009/81/EC on the award of contracts.*

EC – European Commission, 2009e. *Guidance note: Security of supply for Directive 2009/81/EC on the award of contracts*.

EC – European Commission, 2010. *EU law and defence procurement*.

EC – European Commission, 2013. *Defence industries - European defence industrial policy*. [online] Available at: <http://ec.europa.eu/enterprise/sectors/defence/defence-industrial-policy/index_en.htm> [Accessed 13 March 2013].

EDA – European Defence Agency, 2006. *Characteristics of a strong future European defence technological and industrial base (EDTIB)*. [online] Available at: <http://www.eda.europa.eu/docs/documents/eda-characteristics-edtib.pdf> [Accessed 15 January 2013].

EDA – European Defence Agency, 2007. *EDA : a strategy for the European defence technological and industrial base*.

EDA - European Defence Agency, 2008. *The code of conduct on offsets*.

EDA - European Defence Agency, 2011a. *EDA portal of security of supply – Finland*. [online] Available at: <http://eda.europa.eu/sosweb/Finland.aspx> [Accessed 15 January 2013].

EDA - European Defence Agency, 2011b. *EDAs pooling and sharing*. [online] Available at: <http://www.eda.europa.eu/docs/documents/factsheet_-_pooling_sharing_-_301111> [Accessed 15 january 2013].

EDA - European Defence Agency, 2013. *EDA portal for offsets*. [online] Available at: <http://www.eda.europa.eu/offsets/> [Accessed 17 February 2013].

Edmunds, T., 2006. What are armed forces for? The changing nature of military roles in Europe. *International Affairs,* 82(6), pp.1059-1075.

Edwards, J., 2011. *The EU defence and security procurement directive: a step towards affordability?*. International Security Programme Paper. ISP PP 2011/05. London: Chatham House.

Engel, A. and Barad, M., 2003. A methodology for modeling VVT risks and costs. *Systems Engineering,* 6(3), pp.135-151.

Escribano, A., Fosfuri, A. and Tribó, J. A., 2009. Managing external knowledge flows: the moderating role of absorptive capacity. *Research Policy,* 38(1), pp.96-105.

EU – European Union, 2010. *Consolidated version of the treaty on the functioning of the European Union 2007/C 306/01of 13 December 2007*.

European Parliament - Directorate general external policies of the Union, 2007. *The protection of the European defence technological and industrial base*.

Fasana, K. G., 2011. Using capabilities to drive military transformation: an alternative framework. *Armed Forces & Society,* 37(1), pp.141-162.

Finnish MoD – Ministry of Defence, Finland, 2007. *Defence industrial strategy [Puolustus- ja turvallisuusteollisuusstrategia]*. Helsinki: Puolustusministeriö.

Finnish MoD – Ministry of Defence, Finland, 2011. *Materiel policy strategy of the Ministry of Defence [Puolustushallinnon materiaalipolitiikka, osastrategia].* Helsinki: Puolustusministeriö.

Fisher, D., Atkinson-Grosjean, J. and House, D., 2001. Changes in academy/industry/state relations in Canada: the creation and development of the networks of centres of excellence. *Minerva,* 39(3), pp.299-325.

Fitzsimmons, M., 2007. *Whither capabilities-based planning?.* S.l.: DTIC Document.

Ford, D. and Saren, M., 1996. *Technology strategy for business, Management of technology and innovation series.* London: International Thomson Business Press.

Forsberg, K., Mooz, H. and Cotterman, H., 2000. *Visualizing project management : a model for business and technical success.* 2nd ed. New York ; Chichester: Wiley.

Frank, U., 2012. Multi-perspective enterprise modeling: foundational concepts, prospects and future research challenges. *Software & Systems Modeling*. pp.1-22.

Frost, T. S., Birkinshaw, J. M. and Ensign, P. C., 2002. Centers of excellence in multinational corporations. *Strategic Management Journal.* 23(11), pp.997-1018.

Garcia-Alonso, M. D. and Levine, P., 2007. Arms trade and arms races: a strategic analysis. In Sandler, T. and Hartley, K., eds. 2007. *Handbook of defense economics.* Amsterdam: North-Holland, pp.941-971.

Garrett-Jones, S., Turpin, T., Burns, P. and Diment, K., 2005. Common purpose and divided loyalties: the risks and rewards of cross-sector collaboration for academic and government researchers. *R&D Management,* 35(5), pp.535-544.

Gazley, B., 2008. Beyond the contract: the scope and nature of informal government–nonprofit partnerships. *Public Administration Review,* 68(1), pp.141-154.

Gazley, B., 2010. Linking collaborative capacity to performance measurement in government—nonprofit partnerships. *Nonprofit and Voluntary Sector Quarterly,* 39(4), pp.653-673.

Giachetti, R. E., 2010. *Design of enterprise systems: theory, architecture, and methods.* Boca Raton, Florida: CRC Press.

Googins, B. K. and Rochlin, S. A., 2002. Creating the partnership society: understanding the rhetoric and reality of cross□sectoral partnerships. Business and Society Review, 105(1), pp.127-144.

Government Accountability Office, 2010. *Organizational transformation: a framework for assessing and improving enterprise architecture management* *(version 2.0)*. GAO-10-846G, Washington D.C.: Government Accountability Office.

HM Government, 2010. *Securing Britain in an age of uncertainty: the strategic defence and security review*. London: The Stationery Office Limited on behalf of the Controller of Her Majestys Stationery Office.

Gray, B., 1989. *Collaborating: finding common ground for multiparty problems*. San Francisco: Jossey-Bass.

Guba, E. G., 1990. *The paradigm dialog: conference entitled "Alternative paradigms": papers.* Newbury Park, California: Sage Publications.

Guba, E. G. and Lincoln, Y. S., 1985. *Naturalistic inquiry.* Newbury Park, California: Sage Publications.

Guba, E. G. and Lincoln, Y. S., 1994. Competing paradigms in qualitative research. *Handbook of qualitative research,* 2, pp.163-194.

Guido, R., 2004. Coordinating globally dispersed research centres of excellence—the case of Philips Electronics. *Journal of International Management,* 10(1), pp.51-76.

Haeckel, S. H., 1999. *Adaptive enterprise: creating and leading sense-and-respond organizations.* Boston, Mass.: Harvard Business School Press.

Hagelin, B., 2004. Nordic offset policies: changes and challenges. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets*. Abingdon: Routledge, pp.137-148.

Hall, P., Markowski, S. and Wylie, R., 2010. Defence procurement and defence industry. In Markowski, S., Hall, P. and Wylie, R., eds. 2010. *Defence procurement and industry policy*. Abingdon: Routledge, pp.153-184.

Hammond, M. F., 2009. Sense and respond: logistics at the unit level. *Army Logistician*, 41(1), p.6.

Handley, H. A. H. and Smillie, R. J., 2008. Architecture framework human view: the NATO approach. *Systems Engineering,* 11(2), pp.156-164.

Hartley, K., 2003. The future of European defence policy: an economic perspective. *Defence and Peace Economics,* 14(2), pp.107-115.

Hartley, K., 2007. The arms industry, procurement and industrial policies. In Sandler, T. and Hartley, K., eds. 2007. *Handbook of defense economics.* Amsterdam: North-Holland, pp.1139-1176.

Hartley, K., 2008. Collaboration and European defence industrial policy. *Defence and Peace Economics.* 19(4), pp.303-315.

Hatch, M. J., 1997. *Organization theory: modern, symbolic, and postmodern perspectives.* Oxford: Oxford University Press.

Hitchins, D. K., 1992. *Putting systems to work.* Chichester: Wiley.

Hjort-Madsen, K., 2006. Enterprise architecture implementation and management: a case study on interoperability. In *proceedings of the 39th Annual Hawaii international conference on system sciences, 2006. HICSS'06.* Vol. 4. Kauai, Hawaii, U.S.A. 4-7 January 2006. IEEE, pp. 71c-71c.

Hoffman, F. G., 2006. Complex irregular warfare: the next revolution in military affairs. *Orbis,* 50(3), pp.395-411.

Holm, U., Pedersen, T. and Björkman, I., 2001. *The emergence and impact of MNC centres of excellence.* London: Macmillan Press.

Holsti, K. J., 1964. The concept of power in the study of international relations. *Background,* 7(4), pp.179-194.

Huxham, C. ed., 1996. *Creating collaborative advantage.* London: Sage Publications Ltd.

Huxham, C. and Vangen, S., 2000. Ambiguity, complexity and dynamics in the membership of collaboration. *Human Relations,* 53(6), pp.771-806.

IFIP-IFAC Task Force – on Architectures for Enterprise, 1999. *GERAM: the Generalised Enterprise Reference Architecture and Methodology*. Version 1.6.3.

INCOSE – International Council on Systems Engineering, 2006. *Systems engineering handbook.* Version 3 ed. INCOSE-TP-2003-002-03.

ISO 15704 - International Organization for Standardization, 2005. *ISO 15704:2005. Industrial automation systems - Requirements for enterprise - reference architectures and methodologies*. Geneva: ISO.

ISO 19439 - International Organization for Standardization, 2006. *ISO 19439:2006(E). Enterprise integration - Framework for enterprise modelling.* Geneva: ISO.

ISO 15288 - International Organization for Standardization, 2008. *ISO / IEC 15288:2008 - Systems and software engineering — System life cycle processes - Second Edition.* Geneva: ISO.

ISO TR 24748 - International Organization for Standardization, 2010. *ISO/IEC TR 24748: Guide to the application od ISO/IEC 15288 (System life cycle processes), part 1*. Geneva: ISO.

Jackson, M. C., 1989. Future prospects in systems thinking. In Flood, R. L., Jackson, M. C. and Keys, P., eds. 1989. *Systems prospects - The next ten years of systems research*. New York: Plenum Press, pp.73 - 80.

Jackson, M. C., 2000. *Systems approaches to management.* New York ; London: Kluwer Academic/Plenum.

James, A., 2005. European military capabilities, the defense industry and the future shape of armaments co-operation. *Defense & Security Analysis,* 21(1), pp.5-19.

James, A. D., 2006. The transatlantic defence R&D gap: causes, consequences and controversies. *Defence & Peace Economics,* 17(3), pp.223-238.

Jenkins, G. M., 1972. The systems approach. In Beishon, J. and Peters, G., eds. 1972. *Systems behaviour*. London: Harper & Row Ltd, pp.56 - 82.

Johnson, D. E., 2010. *Military capabilities for hybrid war: insights from the Israel Defense Forces in Lebanon and Gaza.* Santa Monica, California: RAND Corporation.

Joint Chiefs of Staff – United States, 2006. *Joint operations concept development process (JOpsC-DP).* Washington D.C.: Joint Chiefs of Staff.

Joint Doctrine and Concepts Centre, 2004. *The UK joint high level operational concept*. Shrivenham: Joint Doctrine and Concepts Centre.

Jonkers, H., Lankhorst, M., ter Doest, H., Arbab, F., Bosma, H. and Wieringa, R., 2006. Enterprise architecture: management tool and blueprint for the organisation. *Information Systems Frontiers,* 8(2), pp.63-66.

Kaisler, S. H., Armour, F. and Valivullah, M., 2005. Enterprise architecting: critical problems. In *proceedings of the 38th annual Hawaii international conference on system sciences, 2005. HICSS'05.* Hawaii, U.S.A. 3-6 January 2005. IEEE, pp.224b-224b.

Kamogawa, T. and Okada, H., 2005. A framework for enterprise architecture effectiveness. In *proceedings of the international conference on services systems and services management, 2005.* Chongqing, China 13-15 June 2005, pp.740-745 Vol. 1.

Kast, F. E. and Rosenzweig, J. E., 1972. The modern view: a systems approach. In Beishon, J. and Peters, G., eds. 1972. *Systems behaviour*. London: Harper & Row Ltd, pp.14-28.

Kelemen, M. L. and Rumens, N., 2008. *An introduction to critical management research in organisational paradigms and management research*. London: Sage Publications Ltd, pp.21-37.

Kerr, C., Phaal, R. and Probert, D., 2006. A framework for strategic military capabilities in defense transformation. In *proceedings of the 11th international command and control research and technology symposium.* Cambridge, United Kingdom 26-28 September 2006.

Kilcullen, D., 2005. Complex irregular warfare: the face of contemporary conflict. In t*he Military Balance 2005 – 2006*. London: Institute for Strategic Studies, pp.411 - 420.

Kirkpatrick, D., 1997. Rising costs, falling budgets and their implications for defence policy. *Economic Affairs,* 17(4), pp.10-14.

Kluge, C., Dietzsch, A. and Rosemann, M., 2006. How to realise corporate value from enterprise architecture. In Ljungberg, J. and Andersson, M., eds., *proceedings of the 14th European conference on information systems*. IT University of Goteborg, pp.1-12.

Kossiakoff, A. and Sweet, W. N., 2003. *Systems engineering : principles and practice*. Hoboken, N.J.: Wiley-Interscience.

Kramer, N. J. T. A. and Smit, J. D., 1977. *Systems thinking: concepts and notions*. Leiden: Martinus Nijhoff Social Sciences Division.

Kreuter, M. W., Lezin, N. A. and Young, L. A., 2000. Evaluating community-based collaborative mechanisms: implications for practitioners. *Health Promotion Practice,* 1(1), pp.49-63.

Lankhorst, M., 2009. *Enterprise architecture at work: modelling, communication and analysis*. New York: Springer.

Lasker, R. D., Weiss, E. S. and Miller, R., 2001. Partnership synergy: a practical framework for studying and strengthening the collaborative advantage. *Milbank Quarterly,* 79(2), pp.179-205.

Lawrence, J. D. and Bodger, P. S., 2006. Practices of successful organisations applied to centres of excellence in New Zealand. In *proceedings of 2006 IEEE international conference on management of innovation and technology*. Singapore 21-23 June 2006. IEEE, pp.146-150.

Levine, P. and Ron, S., 2000. Arms export controls and proliferation. *The Journal of Conflict Resolution,* 44(6), pp.885-895.

Liimatainen, K., 2008. Evaluating benefits of government enterprise architecture. In *proceedings of the 31st Information Systems Research Seminar in Scandinavia*. Åre, Sweden 10-13 August 2008.

Lim, N., Lee, T. and Park, S. G., 2009. A comparative analysis of enterprise architecture frameworks based on EA quality attributes. In *proceedings of the 10th ACIS international conference on software engineering, artificial intelligences, networking and parallel/distributed computing 2006*. Daegu, Korea 27-29 May 2009, pp.283-288.

Lutterbeck, D., 2005. Blurring the dividing line: the convergence of internal and external security in Western Europe. *European Security,* 14(2), pp.231-253.

Malkamäki, U., Aarnio, T., Lehvo, A. and Pauli, A., 2001. *Centre of excellence policies in research: aims and practices in 17 countries and regions*. Helsinki: Academy of Finland.

Markowski, S. and Hall, P., 2004. Mandatory defence offsets - conceptual foundations. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets*. Abingdon: Routledge, pp.44-53.

Markowski, S., Hall, P. and Wylie, R., 2010. Procurement and the chain of supply: a general framework. In Markowski, S., Hall, P. and Wylie, R., eds. 2010. *Defence procurement and industry policy*. Abingdon: Routledge, pp.11-44.

Markusen, A., 2004. Arms trade as illiberal trade. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets*. Abingdon: Routledge, pp.44-53.

Mattessich, P. W., Murray-Close, M. and Monsey, B. R., 2001. *Collaboration - what makes it work.* 2nd ed. Saint Paul: Amherst H. Wilder Foundation, Minnesota.

Matthews, R., 2004. Defense offsets: policy versus pragatism. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets*. Abingdon: Routledge, pp.89-102.

Maxwell, J. A., 2005. *Qualitative research design: an interactive approach.* 2nd ed. Thousand Oaks, California ; London: Sage Publications.

McGinnis, L. F., 2007. Enterprise modeling and enterprise transformation. *Information Knowledge Systems Management,* 6(1/2), pp.123-143.

Medcof, J. W., 1997. Why too many alliances end in divorce. *Long Range Planning.* 30(5), pp.718-732.

Midgley, G., 2000. *Systemic intervention: philosophy, methodology, and practice.* New York: Kluwer Academic/Plenum.

Midgley, G., 2003. Science as systemic intervention: some implications of systems thinking and complexity for the philosophy of science. *Systemic Practice and Action Research.* 16(2), pp.77-97.

Miles, R. E., Miles, G. and Snow, C. C., 2006. Collaborative entrepreneurship: a business model for continuous innovation. *Organizational Dynamics,* 35(1), pp.1-11.

Military Balance, 2012. Editors foreword. *The Military Balance,* 112(1), pp.5-7.

Ministry of Employment and the Economy of Finland [Työ- ja elinkeinoministeriö], 2006. *Rules on industrial participation.* Helsinki: Ministry of Employment and the Economy of Finland.

Moffat, J., 2010. *Complexity theory and network centric warfare.*Washington D.C.: DIANE Publishing.

Mohr, J. and Spekman, R., 1994. Characteristics of partnership success: partnership attributes, communication behavior, and conflict resolution techniques. *Strategic Management Journal,* 15(2), pp.135-152.

Mylopoulos, J., 2008. *Conceptual modelling and Telos 1.*S.l: s.n.

Mäntynen, M. and Takala, J., 2010. **C**reating supporting data for decision making by using a sense and response method. In *proceedings of technology innovation and industrial management (TIIM) 2010.* Pattya, Thailand 16-18 June 2010.

National Research Council, 2005. *Naval analytical capabilities: improving capabilities-based planning.* Washington D.C.: The National Academies Press.

NATO – North Atlantic Treaty Organization, 2010. *Official site of Nato.* [online] Available at: <http://www.nato.int/> [Accessed 15 January 2013].

NATO – North Atlantic Treaty Organization, 2012. *Smart defence.* [online] Available at: <http://www.nato.int/cps/en/natolive/topics_84268.htm> [Accessed 13 March 2013].

NATO Consultation, Command and Control Board, 2007. *Nato Architecture Framework.* Version 3. Brussles: NATO C3 Board.

Neaga, E. I., Henshaw, M. and Yue, Y., 2009. The influence of the concept of capability-based management on the development of the systems engineering discipline. In *proceedings of the 7th annual conference on systems engineering research*. Loughborough, United Kingdom 20- 23 April 2009. Loughborough University.

Neuneck, G., 2008. The revolution in military affairs: its driving forces, elements, and complexity. *Complexity,* 14(1), pp.50-61.

New Zealand Defence Force, 2008. *Statement of intent 2008 – 2011*. Wellington: New Zealand Defence Force.

Newsome, B., 2003. Don't get your mass kicked: a management theory of military capability. *Defense & Security Analysis,* 19(2), p.131.

Niemi, E. and Pekkola, S., 2009. Adapting the DeLone and McLean model for the enterprise architecture benefit realization process. In *proceedings of the 42nd Hawaii international conference on system sciences, 2009*. Hawaii, U.S.A. 5-8 January 2009, pp.1-10.

Noran, O., 2005. A systematic evaluation of the C4ISR AF using ISO15704 annex A (GERAM). *Computers in Industry,* 56(5), pp.407-427.

NORDEFCO - Nordic Defence Cooperation, 2013. *The official site of Nordefco – programme.* [online] Available at: <http://www.nordefco.org/> [Accessed 15 January 2013].

North Atlantic Military Committee, 2009. *MC Policy for Nato concept development and experimentation*. Brussels: North Atlantic Military Committee.

Nye, J. S., Jr., 1990. The changing nature of world power. *Political Science Quarterly,* 105(2), pp.177-192.

O'Rourke, C., Fishman, N. and Selkow, W., 2003. *Enterprise architecture: using the Zachman framework.* Boston, Mass.: Course Technology.

Onwuegbuzie, A. J. and Johnson, R. B., 2006. The validity issue in mixed research. *Research in the Schools,* 13(1), pp.48-63.

Oxenham, D., 2010. Agile approaches to meet complex system of system engineering challenges: a defence perspective. In *proceedings of the 5th international conference on system of systems engineering (SoSE), 2010.* Loughborough, United Kingdom 22-24 June 2010, pp.1-6.

Oxford University Press, 2005. *Oxford advanced learners dictionary of current English.* 7th ed. Oxford: Oxford University Press.

Panetto, H. and Molina, A., 2008. Enterprise integration and interoperability in manufacturing systems: trends and issues. *Computers in Industry,* 59(7), pp.641-646.

Paradis, S., Benaskeur, A., Oxenham, M. and Cutler, P., 2005. Threat evaluation and weapons allocation in network-centric warfare. In *proceedings of the 8th international conference on information fusion, 2005.* Philadelphia, U.S.A. 25-29 July 2005.

Prime Ministers Office – Finland, 2004. *Finnish security and defence policy 2004*. Helsinki: Prime Ministers Office Finland.

Pugh, D. S., 1989. Systems and organisations. In Flood, R. L., Jackson, M. C. and Keys, P., eds. 1989. *Systems prospects - The next ten years of systems research*. New York: Plenum Press, pp.127 - 131.

Reger, G. and Zafrane-Bravo, C. E., 2002. Managerial implications of the research on centers of excellence - a conceptual view. In *proceedings of the IEEE international engineering management conference 2002.* Cambridge, United Kingdom 18-20 August 2002, pp.178-183, vol.1.

Reynolds, K. P., 2006. Building the future force: challenges to getting military transformation right. *Contemporary Security Policy,* 27(3), pp.435 - 471.

Reynolds, M. and Holwell, S., 2010. *Systems approaches to managing change: a practical guide.* London: Springer.

Rigby, D. and Zook, C., 2002. Open-market innovation. *Harvard Business Review,* 80(10), pp.80-93.

Ross, J. W., Weill, P. and Robertson, D., 2006. *Enterprise architecture as strategy: creating a foundation for business execution.* Boston, Mass.: Harvard Business School Press.

Roussos, S. T. and Fawcett, S. B., 2000. A review of collaborative partnerships as a strategy for improving community health. *Annual Review of Public Health,* 21(1), pp.369-402.

Roy, S. and Mohapatra, P. K. J., 2002. Regional specialisation for technological innovation in R&D laboratories: a strategic perspective. *AI & Society,* 16(1), pp.100-111.

Russell, D., Looker, N., Lu, L. and Jie, X., 2008. Service-oriented integration of systems for military capability. In *proceedings of the 11th IEEE international symposium on object oriented real-time distributed computing.* Orlando, U.S.A. 5-7 May 2008, pp.33-41.

Sage, A. P. and Armstrong, J. E., 2000. *Introduction to systems engineering, Wiley series in systems engineering.* New York: Wiley.

Saulson, B., 2006. SEAS ISR architect: mapping department of defense architecture views to military outcome. *The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology,* 3(4), pp.217-225.

Saunders, M., Lewis, P. and Thornhill, A., 2012. *Research methods for business students.* 6th ed. Harlow ; New York: Pearson.

Schekkerman, J., 2004. *How to survive in the jungle of enterprise architecture frameworks : creating or choosing an enterprise architecture framework.* 2nd ed. Victoria, B.C.: Trafford.

Schelp, J. and Stutz, M., 2007. *A Balanced scorecard approach to measure the value of the enterprise architecture.* [online] Available at: <http://www.via-nova-architectura.org/files/TEAR2007/Schelp.pdf> [Accessed 10 May 2011].

Selsky, J. W. and Parker, B., 2005. Cross-Sector partnerships to address social issues: challenges to theory and practice. *Journal of Management,* 31(6), pp.849-873.

Setter, O. and Tishler, A., 2006. Introduction: defense research and development in the 21st century. *Defence & Peace Economics,* 17(3), pp.165-167.

Silverman, D., 1970. *The theory of organisations: a sociological framework, (Heinemann studies in sociology).* London: Heinemann Educational.

Simo, G. and Bies, A. L., 2007. The role of nonprofits in disaster response: an expanded model of cross-sector collaboration. *Public Administration Review,* 67, pp.125-142.

Skyttner, L., 2001. *General systems theory: ideas & applications.* Singapore ; River Edge, N.J.: World Scientific.

Skyttner, L., 2005. *General systems theory: problems, perspectives, practice.* 2nd rev. and updated. ed. Hackensack, N.J.: World Scientific.

Sköns, E., 2004. Evaluating defense offsets: the experience in Finland and Sweden. In Brauer, J. and Dunne, J. P., eds. 2004. *Arms trade and economic development: theory, policy, and cases in arms trade offsets*. Abingdon: Routledge, pp.149-163.

Smith, R. P. D., 2009. *Military economics: the interaction of power and money.* Basingstoke: Palgrave Macmillan.

Sommerville, I., 2005. Integrated requirements engineering: a tutorial. *Software, IEEE,* 22(1), pp.16-23.

Soon, I. I. A., 1995. A new program in cooperative research between academia and industry in Korea, involving centers of excellence. *Technovation,* 15(4), pp.241-257.

Souitaris, V., 2001. External communication determinants of innovation in the context of a newly industrialised country: a comparison of objective and perceptual results from Greece. *Technovation,* 21(1), pp.25-34.

Sowa, J. F. and Zachman, J. A., 1992. Extending and formalizing the framework for information systems architecture. *IBM Systems Journal,* 31(3), pp.590-616.

Stevens, R., Brook, P., Jackson, K. and Arnold, S., 1998. *Systems engineering : coping with complexity.* London: Prentice Hall Europe.

Struys, W., 2004. The future of the defence firm in small and medium countries. *Defence & Peace Economics,* 15(6), pp.551-564.

Suzic, R. and Svenson, P., 2006. Capabilities-based plan recognition. In *proceedings of the 9th international conference on information fusion.* Florence, Italy 10-13 July 2006, pp.1-7.

Swanborn, P. G., 2010. *Case study research: what, why and how?.* London: Sage.

Tang, A., 2004. A comparative analysis of architecture frameworks. In *proceedings of the 11th Asia-Pacific software engineering conference.* Busan, Korea 30 November - 3 December 2004, pp.640-647.

Teddlie, C. and Tashakkori, A., 2009. *Foundations of mixed methods research: integrating quantitative and qualitative techniques in the social and behavioral sciences.* London: Sage.

Terriff, T., 2010. NATO military transformation: challenges and opportunities for France. *European Security,* 19(1), pp.61-78.

Tetlay, A., 2010. Through life capability management perspective for framework development for assessing and measuring system maturity, system readiness and capability readiness using architecture frameworks. In *proceedings of the 5th international conference on system of systems engineering (SoSE), 2010.* Loughborough, United Kingdom 22-24 June 2010, pp.1-7.

The Technical Cooperation Program, 2006. *Guide for Understanding and Implementing Defense Experimentation (GUIDEx).* Ottawa: Canadian Forces Experimentation Centre.

Thomson, A. M. and Perry, J. L., 2006. Collaboration processes: Inside the black box. *Public Administration Review,* 66, pp. 20-32.

Touchin, M. and Dickerson, C., 2008. Architecting for capability. In *proceedings of the conference on realising network enabled capability (RNEC'08), 2008*. Leeds, United Kingdom 13-14 October 2008.

Tripp, R. S., Amouzegar, M. A. and McGarvey, R. G., 2006. *Sense and respond logistics: integrating prediction, responsiveness, and control capabilities.* Santa Monica, California: RAND Corporation.

UK MoD – Ministry of Defence, United Kingdom, 2005a. *Defence industrial strategy*. London: Ministry of Defence, United Kingdom.

UK MoD – Ministry of Defence, United Kingdom, 2005b. *The acquisition handbook*. Edition 6. London: Ministry of Defence, United Kingdom.

UK MoD – Ministry of Defence, United Kingdom, 2006. *Defence technology strategy for the demands of 21st century*. London: Ministry of Defence, United Kingdom.

UK MoD - Ministry of Defence, United Kingdom 2009. *The MODAF architecting process*. London: Ministry of Defence, United Kingdom.

Urbaczewski, L. and Mrdalj, S., 2006. A comparison of enterprise architecture frameworks. *Issues in Information Systems,* 7(2), pp.18-23.

US DoD - United States Department of Defense, 2001. *Quadrennial defense review.* Washington D.C.: United States Department of Defense

US DoD – United States Department of Defense, 2008a. *Capability portfolio management*. Washington D.C.: United States Department of Defense.

US DoD – United States Department of Defense, 2008b. *Operation of the defense acquisition system: instruction*. Washington D.C.: United States Department of Defense.

US DoD – United States Department of Defense, 2009. *DODAF v2.0, volume 1: introduction, overview, and concepts.* Washington D.C.: United States Department of Defense.

Velitchkov, I., 2009. *Enterprise architecture metrics in the Balanced Scorecard for IT*. [online] *JournalOnline,* Available at: <http://www.isaca.org/Journal/Past-Issues/2009/Volume-3/Documents/jpdf0903-online-enterprise.pdf> [Accessed 20 February 2013].

Whitehall Papers, 2000. Capabilities: what the UK brings to coalitions. Categories of capabilities. *Whitehall Papers.* 50(1), pp.44-64.

Viita-aho, A., auvo.viita-aho@mil.fi, 2011. *The role of the EA model in the MNE 6 final report.* [email] Email from the custodian of the MISA-EM case project, Commander Auvo Viita-aho to author of the dissertation (jukka.anteroinen@mil.fi). Sent 26 January 2011 at 14:41. Copy of the correspondence stored by the receipent of the email.

Välivehmas, H., 2010. *Development programme of Finnish Defence Forces [Pv:n kehittämisohjelma ja näkymiä suunnittelusta]*. [online] Available at: <http://www.finse.org/2010Spring/01_Finse_Valivehmas_PVn%20suorituskyvyn%20kehittamine.pdf> [Accessed 15 February 2013].

Walliman, N., 2006. *Social research methods.* London: Sage Publications Limited.

Wand, Y. and Weber, R., 2002. Research commentary: information systems and conceptual modeling - a research agenda. *Information Systems Research,* 13(4), pp.363-376.

Waring, A., 1996. *Practical systems thinking.* London: International Thomson Business Press.

Whetten, D. A., 1989. What constitutes a theoretical contribution?. *Academy of Management Review,* 14(4), pp.490-495.

Wood-Harper, A. T., 1989. Characteristics of information systems definition approaches. In Flood, R. L., Jackson, M. C. and Keys, P., eds. 1989. *Systems prospects - The next ten years of systems research*. New York: Plenum Press, pp.359 - 367.

Wylie, R., Markowski, S. and Hall, P., 2006. Big science, small country and the challenges of defence system development: an Australian case. *Defence & Peace Economics*, 17(3), pp.257-272.

Yin, R. K., 1994. *Case study research: design and methods.* 2 rev.ed. London: Sage Publications.

Yu, E., Strohmaier, M. and Deng, X., 2006. Exploring intentional modeling and analysis for enterprise architecture. In *proceedings of the 10th IEEE on international enterprise distributed object computing conference workshops.* Hong Kong, China 16-20 October 2006.

Yue, Y. and Henshaw, M., 2009. An holistic view of UK military capability development. *Defense & Security Analysis,* 25(1), pp.53-67.

Zachman, J. A., 1987. A framework for information systems architecture. *IBM Systems Journal,* 26(3), pp.276-292.

Zachman, J. A., 1996. The framework for enterprise architecture: background, description and utility, *Zachman International*.

ORIGINAL PUBLICATIONS

Reprinted with permission of the copyright holders. The below-named journals are the original sources of publication for the articles as follows.

Original publications are not included in the electronic version of the dissertation.

[I] Anteroinen, Jukka. 2012. Integration of Existing Military Capability Models into the Comprehensive Capability Meta-model. *Proceedings of the 2012 IEEE Systems Conference*. Vancouver, Canada. 19–22 March 2012, pp. 156–162. © 2012 Institute of Electrical and Electronics Engineers (IEEE). Reprinted, with permission.

[II] Anteroinen, Jukka. 2012. The Holistic Military Capability Life Cycle Model. *Proceedings of the 7th IEEE System of Systems Conference 2012*. Genoa, Italy. 16–19 July 2012, pp. 167–172. © 2012 Institute of Electrical and Electronics Engineers (IEEE). Reprinted, with permission.

[III] Anteroinen, Jukka. 2011. The Application of Enterprise Architecture Approach to Military Concept Development – Case Study. *Proceedings of the 2011 Military Communications and Information Systems (MilCIS) Conference 2011*. Canberra, Australia, 8–10 November 2011. © 2012 Institute of Electrical and Electronics Engineers (IEEE). Reprinted, with permission.

[IV] Anteroinen, Jukka and Lehtonen, Juha-Matti. 2012. The Enterprise Architecture Approach to Support Concept Development in a Military Context: A Case Study Evaluation of EA's Benefits. *Journal of Enterprise Architecture*, 8(1), pp. 63–75. © 2012 The Association of Enterprise Architects. Reprinted, with permission.

[V] Anteroinen, Jukka, Lehtonen, Juha-Matti, and Takala, Josu. 2012. Sustainable Cross-Sector Collaboration by the Centre of Excellence – An Evaluation of the Expectations by Case Study. *International Journal of Sustainable Economy*, 4(4). pp. 410–428. © 2012 Inderscience Publishers. Reprinted, with permission.

[VI] Anteroinen, Jukka, and Takala, Josu. 2013. A Performance Evaluation of Cross-Sector Collaboration. *International Journal of Performance Measurement*, ISSN: 2165-6371. Accepted, forthcoming.

[VII] Anteroinen, Jukka. 2010. Enhancement of National Collaboration between Defence Establishment and Industry by Systems Approach. *Journal of Military Studies*, 1(1), pp. 79–103. Open access journal.

NOTIFICATION

Due to copyright laws a compound dissertation (an article dissertation) is published on the web so that only the overview part is public.

Please contact the Library of the National Defence University for a full printed version of this dissertation!

Enhancing the Development of Military Capabilities by a Systems Approach

The political environment of security and defence has changed radically in the Western industrialised world since the Cold War. As a response to these changes, since the beginning of the twenty-first century, most Western countries have adopted a 'capabilities-based approach' to developing and operating their armed forces. More responsive and versatile military capabilities must be developed to meet the contemporary challenges. The systems approach is seen as a beneficial means of overcoming traps in resolving complex real-world issues by conventional thinking.

The doctoral dissertation of Commander G.S, M.Sc. (SED) Jukka Anteroinen explores and assesses the means to enhance the development of military capabilities both in concept development and experimentation (CD&E) and in national defence materiel collaboration issues. This research provides a unique perspective, a systems approach, to the development areas of concern in resolving complex real-world issues. Furthermore, this dissertation seeks to increase the understanding of the military capability concept both as a whole and within its life cycle.

This dissertation makes contribution to current studies about military capability. It presents two interdependent conceptual capability models: the comprehensive capability meta-model and the holistic capability life cycle model. These models holistically and systematically complement the existing, but still evolving, understanding of military capability and its life cycle. In addition, this dissertation contributes to the scientific discussion of defence procurement in its broad meaning by introducing the holistic model about the national defence materiel collaboration between the defence forces, defence industry and academia. This dissertation also contributes empirical evidence regarding the benefits of enterprise architectures (EA) to CD&E. The EA approach may add value to traditional concept development by increasing the clarity, consistency and completeness of the concept.

National Defence University
Department of Military Technology
P.O. BOX 7, FI-00861
Helsinki Finland

Tel. +358 299 800
www.mpkk.fi

ISSN 1796-4059
ISBN 978-951-25-2483-9 (pbk.)
ISBN 978-951-25-2484-6 (PDF)