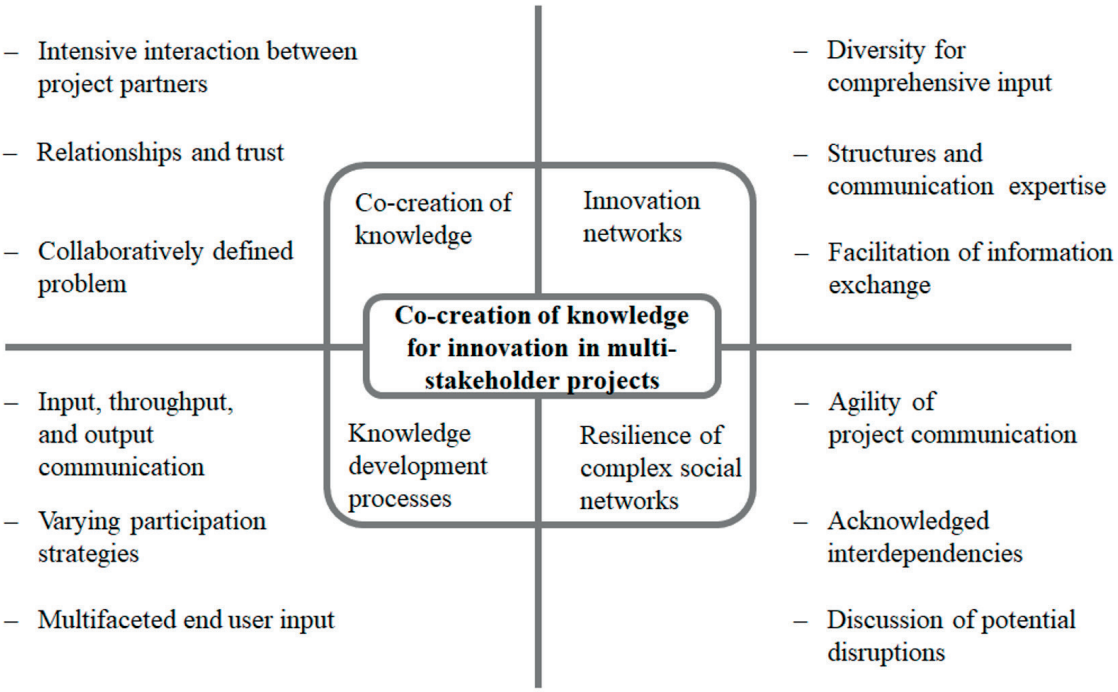
JYU DISSERTATIONS 138

Harri Ruoslahti

Co-creation of knowledge for innovation in multi-stakeholder projects



UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF HUMANITIES AND SOCIAL SCIENCES

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Esitetään Jyväskylän yliopiston humanistis-yhteiskuntatieteellisen tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston Agora-rakennuksen Gamma-salissa
marraskuun 22. päivänä 2019 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Humanities and Social Sciences of the University of Jyväskylä,
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JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2019

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Permanent link to this publication: http://urn.fi/URN:ISBN:978-951-39-7867-9

ISBN 978-951-39-7867-9 (PDF)
URN:ISBN:978-951-39-7867-9
ISSN 2489-9003

Jyväskylä University Printing House, Jyväskylä 2019

ABSTRACT

Ruoslahti, Harri
Co-creation of knowledge for innovation in multi-stakeholder projects
Jyväskylä: University of Jyväskylä, 2019, 91 p.
(JYU Dissertations
ISSN 2489-9003; 138)
ISBN 978-951-39-7867-9

The European Union (EU) promotes innovation through its research funding programmes that offer opportunities for the co-creation of knowledge involving diverse groups of academics, businesses and public organisations in project consortia. Although participants may have conflicting interests, during a project, the focus is sharing insights and experiences. Accordingly, this thesis aims to gain an understanding of knowledge co-creation for innovation in funded projects from the viewpoint of multi-stakeholder communication, focusing particularly on communication with and the participation of end-users. It does so by studying the topic from four theoretical perspectives: *the co-creation of knowledge*, *innovation networks*, *knowledge development processes* and *the resilience of complex social networks*. These function as a framework for the six studies and seven published papers of this thesis. The context of the studies delivering case data consists of eight EU-funded projects aimed at research and innovation.

The findings show that common development goals serve as the basis for partners to engage in sharing insights and experiences while developing knowledge for innovation. The perspective of the *co-creation of knowledge* highlights the intensive interaction among the many diverse actors who engage in building relationships and trust to enable joint work on a common problem. The perspective of *innovation networks* highlights that comprehensive solutions may require different roles from actors facilitated by structures and communication expertise. The perspective of *knowledge development processes* points to evolving input, throughput and output communication when engaging various stakeholders, especially end-users, adapting participation strategies over time. The perspective of *resilience of complex social networks* emphasises agile project communication to address vulnerabilities through interdependencies.

Research and innovation projects bring about complex processes that call for close attention to interactions among a diverse group of stakeholders and the ways that end-user participation takes form in various project phases. This thesis adds to the overall body of knowledge on co-creation in innovation networks and, in particular, collaboration within EU-funded research and innovation project consortia.

Keywords: co-creation of knowledge, innovation networks, multi-stakeholder projects

TIIVISTELMÄ

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Euroopan Unioni (EU) edistää innovaatioita tutkimusohjelmilla, jotka tarjoavat projektikonsortioiden erilaisille toimijoille (tutkimuslaitoksille, yrityksille, julkisille organisaatioille) tilaisuuksia tiedon yhteiskehittämiseen. Hankkeen aikana painopisteenä ovat näkemysten ja kokemusten jakaminen, vaikka osallistujien intressit voivatkin olla ristiriidassa. Tämä väitöskirja pyrkii ymmärtämään innovaatioon tähtäävän tiedon yhteiskehittämistä rahoitetuissa projekteissa monitoimijaisen viestinnän näkökulmasta, painottaen erityisesti loppukäyttäjäviestintää ja -osallistamista. Aihetta tarkastellaan neljän teoriasuuntauksen kautta: *tiedon yhteiskehittäminen, innovaatioverkostot, tiedon kehittämisen prosessit ja kompleksisten sosiaalisten verkostojen resilienssi*, jotka toimivat viitekehyksinä väitöskirjan kuudelle tutkimukselle ja seitsemälle julkaistulle paperille. Kontekstina ja tiedonlähteinä toimivat kuusi EU:n rahoittamaa innovaatio- ja tutkimusprojektia.

Tulokset osoittavat, että yhteiset kehittämistavoitteet toimivat perustana osallistaa partnereita näkemysten ja kokemusten vaihtoon, kun kehitetään innovaatioihin johtavaa tietoa. Tiedon yhteiskehittämisen näkökulma korostaa monien erilaisten toimijoiden välistä intensiivistä vuorovaikutusta heidän rakentaessaan keskinäisiä suhteita ja luottamusta mahdollistaen työskentelyn yhteisen ongelman ratkaisemiseksi. *Innovaatioverkostojen* näkökulma korostaa, että kokonaisvaltaiset ratkaisut voivat vaatia toimijoilta eri rooleja, viestintäosaamista ja fasilitointia. *Tiedon kehittämisen prosesseissa* näkyvät kehittyvät syöte- (input), läpisyöttö- (throughput) ja tuotosviestintä (output) kun monia toimijoita, erityisesti loppukäyttäjiä osallistetaan ajan kuluessa eri osallistumisstrategioiden käyttöönottoon. Lähestymistapa *kompleksisten sosiaalisten verkostojen resilienssi* painottaa ketterää projektiviestintää riippuvuuksien ja haavoittuvuuksien käsittelyyn.

Tutkimus- ja innovaatioprojektit käsittävät kompleksisia prosesseja ja nämä vaativat tarkkaa huomiota erilaisten sidosryhmien väliseen vuorovaikutukseen ja tapoihin osallistaa loppukäyttäjiä projektien eri vaiheissa. Näin tämä väitöskirja lisää tietämystä yhteiskehittämisestä innovaatioverkostoissa ja erityisesti yhteistyöstä EU:n rahoittamien hankkeiden projektikonsortioissa.

Avainsanat: tiedon yhteiskehittäminen, innovaatioverkostot, monitoimijaiset projektit

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PREFACE

The European Union (EU) promotes research and innovation with several funding programmes in its member states. Through my current work, I have had the pleasure to be involved in various EU-funded projects concerning security management. Therefore, I experienced collaboration between consortium partners that could sometimes be open and straightforward, but at other times, complex and challenging. Consequently, this thesis stems from an interest to better understand how multiple partners co-create knowledge for innovation.

Similarly, conducting this research has been a co-creative effort, as I could not have accomplished this work without collaborating and sharing insights with many people, for which I am grateful. To acknowledge all the support I received, I want to thank several people and organisations.

To start, I want to commemorate the warm memory of my deceased ex-colleague and friend Juha Knuuttila. He inspired me to move forward with my research. I published my first papers with Juha, and on several occasions, he encouraged me to begin my doctoral studies and recommended the University of Jyväskylä, which turned out to be an excellent choice for me.

Throughout my studies and while writing this thesis, Professor Marita Vos has given me positive support and guidance. Thank you! I also wish to express my appreciation to my second supervisor, Professor Vilma Luoma-aho, and the preliminary readers of this thesis for their constructive comments.

I would like to recognise my employer, Laurea University of Applied Sciences, for providing me the opportunity to combine teaching with participation in security management projects. I also wish to fully acknowledge the role of the research projects mentioned in Table 4 later in this work for providing a context for this thesis and the European Commission for funding these projects that drive co-created European innovation.

Many scholars at conferences (BledCom, EUPRERA and KMIS) and peers at Laurea and the University of Jyväskylä have shared their insights and offered useful comments to further my research work, and I warmly thank them for this. I also thank my co-authors, Kirsi, Kristina, Ilkka and Jyri, for collaborating and exchanging views to create results greater than the sum of individual parts. Because my main topic has been co-creation, I find it appropriate to have shared the work actively with co-authors, and I hope to continue to co-create knowledge with them in the future. Moreover, I would like to extend my gratitude to adjunct professor Rauno Pirinen for giving me a chance to share my ideas at the National Defence University, an opportunity that arrived at a good time to advance my research.

Finally, many, many thanks to my family! They patiently supported and tolerated my writing on the home sofa, even during summer boat trips and other travels.

Jyväskylä, 1.10.2019
Harri Ruoslahti

FIGURES

TABLES

ORIGINAL PAPERS

I. Co-creation of knowledge for innovation requires multi-stakeholder public relations
II. A co-created network community for knowledge and innovations – Promoting safety and security in the Arctic
III. End-users co-create shared information for a more complete real-time maritime picture
IV. Attributes of resilient collaboration in multi-stakeholder innovation networks
Va Complexity in project co-creation of knowledge for innovation
Vb Complex authority network interactions in the common information sharing environment
VI. Opportunities for strategic public relations – Evaluation of international research and innovation project dissemination

CONTENTS

1 INTRODUCTION

The European Commission calls for innovation by funding schemes, such as Horizon 2020 (Commission of the European Union, 2014b), which support collaborative knowledge development as an opportunity for innovation. The European Union (EU) aims to promote innovation throughout its member states by involving diverse groups of actors, such as academia and public sector and business organisations, which may have conflicting interests. Public organisations are seeking new technologies and service innovations to perform their duties more efficiently. Business organisations aim to market their products and develop products and services to sell. Academia actors are searching for funding and new knowledge to pass on to students and strengthen their institutions' innovation track record. All can use and exploit the results that research and innovation projects produce.

This thesis seeks to gain an understanding of the process of knowledge co-creation for innovation in funded projects from the viewpoint of multi-stakeholder communication, focusing particularly on communication with and the participation of end-users. A better understanding of the challenges involved will add to the body of knowledge on co-creation in innovation networks and ameliorate the functioning of future research and innovation projects. The author became interested in this topic when participating in EU funded projects and discussing co-creation with stakeholders.

This research links to previous studies targeting communication by organisations, but it does so by focusing on knowledge co-creation in research and innovation projects. "Understanding knowledge co-creation is of particular importance in this age where innovation and creativity have become a source of competitive advantage" (Bagayogo et al. 2014, p. 632). The involvement of end-user organisations is emphasised by the European Commission (Commission of the European Union, 2016). Mapping end-user processes and practices helps create innovation value (Payne, Storbacka & Frow 2008). However, there is scarce research to provide strategies enhancing co-creation involving multiple stakeholders (Frow et al. 2015). Within research and innovation projects, multiple stakeholders collaborate. "Multi-stakeholder networks are an organisational

structure that allows collective action beyond national boundaries, since the participation is voluntary, and objectives and actions are negotiated among participants" (Roloff 2008, p. 237).

Collaboration in projects requires communication among stakeholders. More-over, active, ongoing end-user communication ensures that the work in consortium projects fulfils end-user needs. It is important to collaborate with various types of end-users to gain a complete overview of their needs (Ruoslahti & Knuuttila 2011). Products and services can best be co-created with end-users (Miettinen & Koivisto 2009). Such co-production supports organisational innovativeness, state Luoma-aho et al. (2012). Similarly, Tikanmäki, Tuohimaa and Ruoslahti (2012) note that networking is important in developing services and processes.

1.1 A drive for knowledge and innovation

Knowledge is a form of value. Vargo, Maglio and Akaka (2008) argue that service systems are highly interdependent and co-create value, because in service-to-service exchange their survival depends on it. Ruoslahti et al. (2010), who write about cooperation in technical development projects, note that developers need to collaborate closely with end-users. However, Saarinen (2012) adds that the design of services cannot be completely user-based, because development processes aim to include the goals, actions and problems of several actors whose preferences most likely differ.

When a need arises to access others' resources, value-in-exchange also occurs. Frow et al. (2015) find that managers predominantly look at co-creation to generate ideas for new products and services. However, involving a broader range of stakeholders and multiple forms of co-creation further enables the co-creation of innovation.

The EU Commission 7th framework and Horizon 2020 funding schemes require that EU-funded projects include consortium partners from several member states and varying types of organisations: end-users, industry and research. The resulting connections can be seen to form multi-stakeholder networks. The broad range of stakeholders involved can co-create innovation by using multiple forms of working to support the co-creation process. Multi-stakeholder arenas call for systematic approaches to stakeholder management to organise relationships between organisations and stakeholders (Luoma-aho & Vos 2010).

EU-funded projects promote inter-organisational collaboration with the aim to promote knowledge for innovation, enhanced by a strong context for collaboration and renewal, such as within innovation ecosystems (Hautamäki 2010). The EU deems it important for society that knowledge is co-created and utilised for innovation. However, there are problems relating to collaboration and communication in inter-organisational project consortia. Besides communication with stakeholders that promotes innovation, there are challenges preventing the

sharing of insights and experiences needed for knowledge co-creation. For example, communication with end-users may be lacking, while it is imperative to listen to the various kinds of end-users to get a complete picture of their needs (Ruoslahti and Knuuttila (2011). Moreover, the current project environment is characterised by fast developments, necessitating resilient project cooperation.

This study is based on the project work done on eight EU-funded projects (presented in Table 4). These projects developed security-related knowledge, for example, concepts for information acquisition for crisis recovery, increased flexibility of passenger movement and information sharing between authorities.

This thesis focuses on the communication supporting knowledge co-creation in EU-funded projects among the project participants of the consortium and other stakeholders. Moreover, it attempts to understand forms of adding depth and regularity to communication with end-users. This may include activities such as scenario building, forming expert panels, creating end-user communities and disseminating project results. However, because it is still unclear how the actual process of co-creation is supported by communication, the studies in this thesis focus on the co-creation of knowledge for innovation in multi-stakeholder arenas. The concept of communication in multi-stakeholder arenas (e.g. Luomaaho & Vos 2010) emphasises perspectives according to the interests of the actors that have a stake in the project. This line of investigation is important to gain a better understanding regarding the mechanisms of collaboration and communication in these inter-organisational consortium projects.

1.2 Aims of the research

The purpose of this thesis is:

> to gain an understanding of knowledge co-creation for innovation in funded projects from the viewpoint of multi-stakeholder communication, focusing particularly on communication with and the participation of end-users.

This thesis aims to achieve this by scrutinising how multi-actor communication takes place, considering participant roles and project interaction throughout the co-creation process. Project consortia consist of multiple actors that have a stake in the research and innovation work, while stakeholders outside the consortium are also involved, for example, in end-user panels and communities. Given that the various stakeholders have different backgrounds and interests, it can be challenging to engage them for project aims and facilitate the sharing of insights and experiences.

The topic was narrowed down to guide the work by examining its keywords, making it more concrete in every step: co-creation, of knowledge, for innovation, in multi-stakeholder arenas, focusing on participation of end-users, through communication, in EU funded projects (see Figure 1).

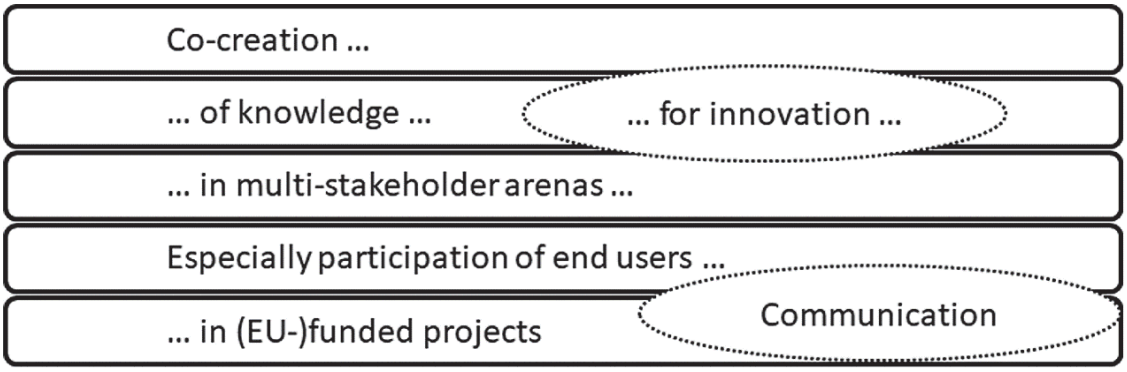


FIGURE 1 Narrowing down the topic to guide the work

The focus is on project communication enhancing end-user participation and resilience of collaboration in complex EU-funded projects aiming at innovation. How can the characteristics and challenges of multi-actor (and in particular end-user) project communication be understood, taking into account the complexity and resilience of knowledge co-creation in such projects?
This is further detailed in several detailed research questions in the six studies undertaken for this thesis, as will be explained in the research design (see Table 2 in section 3.1). Gaining insight into communication in multi-stakeholder consortium projects can be relevant to future funded research and innovation projects and may, thus, benefit both science and society.

The structure of this thesis's theoretical framework is based on four theoretical perspectives using insights from the existing literature on the co-creation of knowledge, innovation networks, knowledge development processes and resilience of complex social networks (related insights will be explored in Chapter 2.) These theoretical perspectives support the research design and provide angles to look at the findings (as further explained in Table 3 in section 3.1.) For example, structure is taken from the communication process phases (input, throughput and output, as further explained in section 2.3). A systems perspective applied to organisational communication allows to study interdependencies important to co-creation of knowledge in complex projects (further explained in section 2.3).

1.3 Components of this research

Myers (2008) writes that it may be difficult for a qualitative researcher to write one's results all in one paper. Thus, one solution is that qualitative researchers write various papers and treat each one as part of the whole story clarifying a topic. This thesis comprises six studies and seven related papers (see Table 1).

The research process proceeded iteratively. Each phase influenced the next, as the work was elaborated on from phase to phase concerning the accumulated

knowledge presented in individual articles and summarised for relevance to the entire thesis, in this thesis's shell. Summaries that explain each study constituent the work of this thesis are provided below.

Study 1 is a structured literature review on the co-creation of knowledge for innovation that serves as a starting point for this research work. It synthesises how the co-creation of knowledge for innovation and the end-user participation in the process have been investigated in the scholarly literature. Studies 2 to 6 focus on elements of co-creation in research and innovation projects, taking various EU-funded projects as a context for this research.

Study 2 scrutinises a co-operation network of higher education and end-users. It assesses how end-users can be involved in the process of creating a co-creation network for knowledge and information sharing, showing the need to study this topic further.

The work continues with Study 3, which focuses on user requirements concerning how end-users co-create shared information by using a complex collaboration system. It studies how end-user needs guide the setting of requirements in the case of cyber-physical systems, a commonly used information system in the maritime domain.

Study 4 is on the resilience of co-creation. It investigates resilience and how to target and promote it in project collaboration networks and resilient collaboration. This study examines the attributes of resilience in collaborative social networks.

Study 5 focuses on the complexity of co-creation in collaboration networks by investigating project collaboration and authority interactions when collaborating on common information sharing with a complex information system. Hence, this research analyses how complexity affects innovation.

Study 6 investigates communication and dissemination of research results in funded projects. The focus is on the output phase of project communication and how external communication and dissemination can be arranged to efficiently address the requirements of the funding instrument and benefit the project.

Vos and Schoemaker (2004) offer a process model that differentiates three phases of organisational communication: input, throughput and output (further explained in section 2.3). In the context of a funded project, *input communication* relates to the setting of requirements, for example, by involving end-users. *Throughput communication* refers to the process of co-creating knowledge for innovation, facilitating intensive collaboration. For funded projects, *output communication* relates to external communication and dissemination activities, such as creating user communities. Study 1 covers all three of these phases, while studies 2 and 3 focus on input communication. Studies 4 and 5 mainly address the throughput phase, and Study 6, the output phase of communication in a project context, as presented in Table 1.

TABLE 1 The sequence of studies, their foci and the related papers

Study	Focus	Related paper
1 *Input, throughput and output communication:* Co-creation of knowledge for innovation	Co-creation of knowledge for innovation, roles of end-users and modes and challenges of end-user participation in innovation projects	I: Ruoslahti, H. 2018. Co-creation of knowledge for innovation requires multi-stakeholder public relations. In Bowman S., Crookes A., Romenti S., Ihlen, Ø. (Eds). Public Relations and the Power of Creativity, Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, 115–133. Early version presented at EUPRERA 2017, London, October 12, 2017.
2 *Input communication:* Co-creating a collaboration network	Involvement of end-users in creating a collaboration network of higher education for the co-creation of knowledge and information sharing	II: Ruoslahti, H. & Hyttinen, K. 2017. A co-created network community for knowledge and innovations – Promoting safety and security in the Arctic. In Proceedings of BledCom 2016, Engaging people in a disengaged world, 100–106. Early version presented at BledCom 2016, Bled, Slovenia, July 2, 2016.
3 *Input communication:* Involving end-users in setting requirements	End-user scenarios and end-user involvement in setting requirements for a complex common cyber-physical information sharing system (case maritime domain)	III: Ruoslahti, H. & Tikanmäki, I. 2017. End-users co-create shared information for a more complete real-time maritime picture. In Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, 3, Science and Technology Publications, 267–274. Early version presented at KMIS 2017, Funchal, Portugal, November 2, 2017.
4 *Throughput communication:* Resilient collaboration in multi-stakeholder innovation networks	Resilience of multi-stakeholder collaboration networks that co-create innovation	IV: Ruoslahti, H., Rajamäki, J. & Koski, E. 2018. Educational competences with regard to resilience of critical infrastructure. Journal of Information Warfare 17.3: 1–16. Early version presented at ECCWS 2018, Oslo, Norway, June 28, 2018.
5 *Throughput communication:*	Complexity affecting innovation in multi-stakeholder collaboration networks, and time-to-innovation	Va: Ruoslahti, H. 2019. Complexity in project co-creation of knowledge for innovation. Submitted to a peer-reviewed journal.

Complexity and innovation in multi-stakeholder networks	Two sub-studies on complexity and related papers Va and Vb	Vb: Ruoslahti, H. & Tikanmäki, I. 2019. Complex Authority Network Interactions in the Common Information Sharing Environment. In Proceedings of the 11th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management. Edited by Jorge Bernardino, Ana Salgado and Joaquim Filipe. SCITEPRESS – Science and Technology Publications, 159–166.
6 *Output communication:* Dissemination by multi-stakeholder project consortia	Dissemination supporting the functioning of a project while addressing the requirements of the funding instrument	VI: Henriksson, K., Ruoslahti, H. & Hyttinen, K. 2018. Opportunities for strategic public relations – Evaluation of international research and innovation project dissemination. In Bowman S., Crookes A., Romenti S., Ihlen, Ø. (Eds). Public Relations and the Power of Creativity, Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, 197–214. Early version presented at EUPRERA 2017, London, October 14, 2017.

Two of these seven papers were published in peer-reviewed scientific journals (recognised as Jufo 1), whereas two others were published as peer-reviewed book chapters. Three were in peer-reviewed scientific conference proceedings (of which two are recognised as Jufo 1).

In two papers, the writer of this thesis, Ruoslahti, was the sole author. Five papers were co-authored. This researcher was the first author in four of these and the second in one of them. As this thesis concerns co-creation, it seems fitting that the main body of research in the included studies was conducted and reported co-creatively. In the following, the responsibilities of each co-author of the papers are listed and described.

Paper I: The writer of this work also authored this paper and designed the study in contact with his supervisor, Vos. The author used the process of a structured literature review to collect and analyse the data. A data extraction table and continuum were used to conduct the final analysis. This author compiled and wrote the paper, and was the contact for correspondence with the editor and adaptation after reviews.

Paper II: This researcher and Hyttinen co-authored this paper. The researcher designed the study and collected and analysed the data. Hyttinen joined in to conduct the final analysis. This researcher mainly compiled and wrote the paper, while Hyttinen contributed parts of it. This author was the contact for correspondence with the editor and adaptations after reviews.

Paper III: This writer and Tikanmäki co-authored this paper. This author designed the study in cooperation with MARISA project manager Pirinen. This author collected and analysed the data using a data extraction table specifically designed for the study. Tikanmäki commented on the final analysis. This author mainly compiled and wrote the paper, while Tikanmäki contributed some parts. This author was the contact for correspondence with the editor and adaptations after reviews.

Paper IV: This writer, Rajamäki and Koski co-authored the paper. The research was designed jointly. Rajamäki guided and analysed the data gathered by the information technology master's students, while this writer worked with the security management master's and bachelor's students and the data they collected. The analysis of the data collected by doctoral students was divided between both researchers. The paper was mostly written jointly by this researcher and Rajamäki; Koski contributed some parts. This writer was the contact for correspondence with the editor; Rajamäki was the contact for adaptations after reviews.

Paper Va: This researcher was the author of this paper, and he designed the study, using the project case narratives of six EU-funded projects to collect data. This researcher analysed the data, using a data extraction table designed for this study. Moreover, this researcher compiled and wrote the paper and was the contact for correspondence with the editor and adaptations after reviews.

Paper Vb: This writer and Tikanmäki co-authored this paper. In addition, this writer designed the study in cooperation with Tikanmäki. This writer collected and analysed the data, and this writer and Tikanmäki jointly compiled and authored it. This writer also served as the contact for correspondence with the editor and adaptations after reviews.

Paper VI: This writer, Henriksson and Hyttinen co-authored this paper. This writer and Henriksson designed the study in close contact with GAP, IECEU and ABC4EU project managers, one of who was Hyttinen. This writer and Henriksson also collected and analysed the data. Henriksson and this writer jointly compiled and wrote most of the paper, and Hyttinen contributed some parts. This writer was the contact for correspondence with the editor and adaptations after reviews.

1.4 The structure of this thesis

The framework of this thesis is structured into five parts. Chapter 2 outlines the theoretical approaches on which the research of this thesis is based. Chapter 3 reveals the research's design, including six studies and their research questions, data collection and analysis, methods and ethics. The findings of the six studies are discussed in detail in Chapter 4. Chapter 5 evaluates research findings from the perspective of the four theoretical approaches and proposes a model showing the understanding gained from the complexity of multi-actor cooperation for innovation. Finally, Chapter 6 presents the conclusions, assessing this research as

a whole, presenting the main contribution of this thesis to both academics and project practitioners, and providing recommendations for future research. Figure 2 depicts an overview of this thesis's structure.

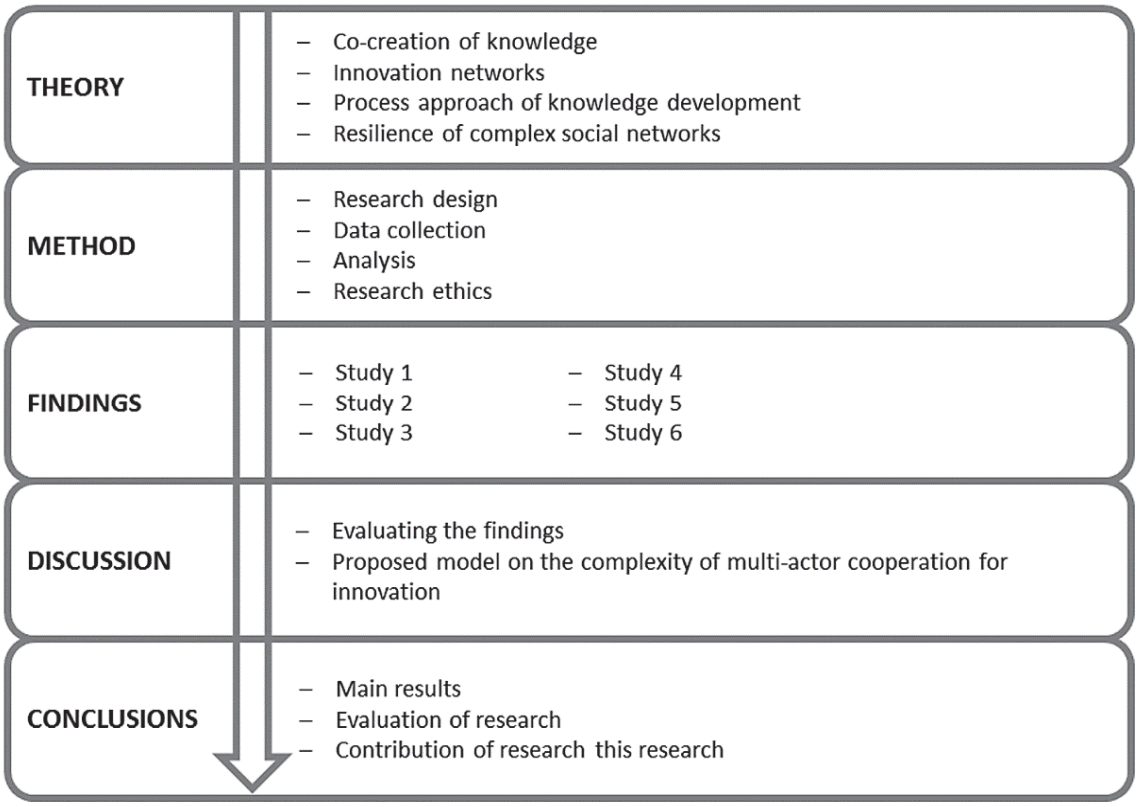


FIGURE 2 Overview of the thesis

This thesis's framework synthesises its studies, focusing on the central topic of knowledge co-creation for innovation in multi-stakeholder projects from the viewpoint of multi-stakeholder communication. The related seven original research papers are included in this thesis as appendices.

2 THEORETICAL FRAMEWORK

This chapter presents an overview of the relevant literature to synthesise what is already known about the topic, exploring various perspectives and related insights derived from the literature that act as a frame of reference for the empirical studies presented in this thesis: the co-creation of knowledge, innovation networks, knowledge development processes and the resilience of complex social networks. The co-creation of knowledge relates to the collaboration of various actors, discussed as joining resources in multi-actor communication, based on engagement, trust and learning. Innovation networks refers to the interconnectedness of the networks involved, discussed as network roles, innovation and interdependence. The process approach of knowledge development invites one to examine developments over time, discussed as a life cycle, communication phases and boundary spanning. The resilience of complex social networks concerns disturbances that may occur, discussed as complexity, vulnerabilities and agile communication.

In this chapter, first, the theoretical framework is discussed. Based on this theory-driven framework, the research approach is outlined in the last section of this chapter.

2.1 Co-creation of knowledge

The approach of co-creation of knowledge relates to the collaboration of multiple actors, which is relevant here because funded projects often require large project consortia. Knowledge development is currently being approached from the perspective of co-creation, whereby collaboration requires communication among various actors involved (e.g. Bhalla 2014, Galvagno & Dalli 2014, Pirinen 2015). Co-creation involves communication and interaction (Gustafsson, Kristensson & Witell 2012), and knowledge can be conceptualised as a form of value. Vargo, Maglio and Akaka (2008) argue that service systems co-create value because, to survive, they depend on each other's resources in service-for-service exchange

and resource integration. These result in the need to access resources from others and drive value-in-exchange. As Pirinen states, "knowledge itself is an increasingly important source to competitive advantage" (Pirinen 2015, p. 315).

Spaces for co-creation can be physical, digital or both (Bhalla 2014), as communication is suggested to take place in what Vos, Schoemaker and Luoma-aho (2014) call issue arenas, where actors meet in a physical place or join in a digital space to discuss issues relevant to them. To explain multi-stakeholder communication in funded projects this thesis expands on the use of a model offered by Vos, Schoemaker and Luoma-aho (2014) concerning communication for organisations. The model stresses dynamic interactions among multiple actors with diverse interests in issue arenas, focusing on issue-related aspects such as content characteristics, actor roles in the debate, features of the places of interaction and communication strategies during the course of the debate. This attention for multi-actor interplay contrasts with the customary emphasis on bilateral relations in the fields of organisational and marketing communication. Luoma-aho and Vos (2010) highlight that the participants involved in the debate and the issues they have a stake in change over time. Thus, "The concept of the issue arena has been suggested to lead to a more dynamic stakeholder model" (Vos 2017 p. 17). Therefore, project partners (according to Luoma-aho and Vos: organisations) must monitor what constitutes suitable media for interaction to communicate with people in these volatile times (Vos 2017). Moreover, the term arena suggests a competitive space where, next to problem solving, influencing strategies may be used, as the actors may have common agendas and interests beside their own (Saarinen 2012, Vos 2018). The acknowledgement and acceptance of competition and interest conflicts is very different from the former aim to increase goodwill mentioned in older communication literature.

Co-creation may enhance innovation and unlock sources of competitive advantage. Processes of resource integration can offer new resources to all the actors actively participating, whereas innovative ideas become formed when interactions between multiple stakeholders create cumulative knowledge (Frow et al. 2015). This is accomplished by central persons whom Taatila et al. (2006) call innovators. Bagayogo et al. (2014) point out that collaboration and group dynamics occur when co-creating knowledge. Thus, understanding the communication among those involved in knowledge co-creation is important today, as co-creation for innovation and creativity provides competitive advantages. Bhalla (2014, p. 19) notes that leading organisations enhance the creativity of their stakeholders "by establishing projects and systems for marrying their collaborators' interests with corporate knowledge and resources", as they have developed processes that enhance value co-creation.

According to DeFillippi and Roser (2014), co-creation of knowledge for innovation requires deep engagement of the actors involved. Johnston (2018) defines engagement as "a dynamic multidimensional relational concept featuring psychological and behavioural attributes of connection, interaction, participation,

and involvement, designed to achieve or elicit an outcome at individual, organisation, or social levels" (p. 53). Engagement evolves over time (O'Brien & McKay, 2018) through interaction and exchange (Johnston & Taylor 2018).

Especially engagement of end-users, and communication supporting this engagement, is currently aimed it in funded projects. Mapping end-user processes and practices provides insights in end-user engagement and, thereby, strengthen the co-creation of value (Payne, Storbacka & Frow 2008). One of the ways used to clarify end-user experiences and learn from them, is collecting stories and examples. Weick (2002) argues that paying attention to forgotten and avoided facts through stories and examples is a way to "discipline imaginations around the topic of organisational learning" (p. 7). However, duly paying attention may be a particular challenge considering the competitiveness of issue arenas (Vos 2018). Network actors must, based on their respective goals, both compete for attention for their perspectives and simultaneously choose how to interact within the arena – as must their audiences.

The co-creation of knowledge is an activity (Cook & Brown 1999) during which stakeholders constantly learn from their interactions. This must be learned, as collaborative relationships become constantly negotiated and re-negotiated and rules and structures developed (Engeström 2004). Cook and Brown (1999) also envision action as integral to knowledge acquisition. Engeström (2004) explains that learning is no small matter, as it involves "major transformations, upheavals, innovations, implementations and movements" (p. 16) that form "heterogeneous patchworks and textures of small and large, unnoticeable and spectacular actions, objectifications, trajectories and trails" (p. 16).

Engeström and Kerosuo (2007) consider the notion of 'objective' crucial for any collaborative activity, as it "embodies the meaning, the motive and the purpose of a collective activity system" (p. 337). Engeström (2004) notes that multiple collaborating producers work in networks, both within and between involved stakeholders, to produce learning from their interactions. This requires flexibility, in which authority is not fixed to any individual actor. Engeström (2004) calls this co-configuration.

Learning requires trust (Pirinen 2015). When various actors together co-creating knowledge, this assumes sharing of insights and experiences. This functions when the exchange is reciprocal, there is a common objective, and all actors more or less gain from it. "When developing trust, a process of cooperation needs to be developed, not just the sharing of information. Cooperation should be based on common objectives and emphasise the benefits of cooperation" (Tikanmäki & Ruoslahti 2017, p. 398). Thus, as Pirinen (2015) states, "new types of action, integration, trust and collaboration are required for the stimulation of creative innovation in services, technology, economy and society" (p. 316).

The work of Pirinen (2015) provides one of few studies focused on funded projects, finding that trust-based interactions are crucial in knowledge co-creation processes. Other important elements are confidence and participation by work and social communities, common information sharing environments, collective responsibility, and facilitation of the collective research and development.

Therefore, Pirinen (2015) concludes that "building of useful knowledge and innovation processes has become increasingly complex, multidisciplinary, trust-based, co-created, path-depended, and globalized" (p. 323).

Research and development projects funded by the European Commission "represent a unique form of a knowledge community" (Norvanto 2017, p. 78), where integrating research, work life and higher education can support the life-long learning aim of the European Union (Hyttinen, Ruoslahti & Jokela 2017). This thesis targets EU-funded projects which aim at knowledge creation for innovation to benefit the consortium, its individual stakeholders and others in the European Union. Thus, their work can be investigated through the lens of co-creation in multi-actor interaction, as in the above-cited scholarly literature. Similarly, the consortia can be perceived as innovation networks, a perspective taken in other scholarly sources, as will be discussed in the next section on innovation networks.

2.2 Innovation networks

The approach of innovation networks refers to the interconnectedness of the networks involved, which here relates to the project participants and other actors involved. Collaboration between multiple actors in innovation networks demonstrates different types of input and roles. According to Roloff (2008, p. 238), in multi-stakeholder networks, various actors participate "to find a common approach to an issue that affects them all". The author considers these networks issue-driven, bringing together various stakeholders, influencing or being influenced by "the approach to the issue addressed by the network" (2008, p. 328). Within the value chain, organisations (according to Roloff: companies) may share goals but perform disparate roles, and it may be difficult to balance common goals with the aims of individual network contributors (Roloff 2008).

Engeström and Kerosuo (2007) state that the notion of network underscores the importance of collaborative constellations, such as alliances and partnerships between organisations, as an important way to achieve inter-organisational learning, in which trust is central for exchanging information resources and collaborative problem solving across organisational boundaries. Network theory explains the roles and power relationships that occur in a network, the network being described as "a set of interconnected nodes" (Castells 2000). Rowley (1997) conceptualises the organisational environment as a combination of social actors with complex interrelationships among stakeholders because, according to Vos (2018, p. 4), stakeholders may have "conflicting stakes and interests". Networks strive to maintain relative stability (Vos et al. 2014). However, actors' actions or changes to external circumstances may cause imbalances (Vos 2017). The interconnectivity of system elements leads to complex actions concerning the individuals and organisations involved that, in turn, affect other related individuals and organisations (Mitleton-Kelly 2003).

Bhalla (2014, p.19) defines innovation as new ideas, refined prior ideas or new products and services. Burdon, Mooney and Al-Kilidar (2015) emphasise the importance of re-tuning business models towards innovation, while Dandonoli (2013) perceives ideas and their implementation as a way to achieve advancement in processes or technologies. The co-creation of value requires resource integration that is realised in complex interactions among the network actors (Pinho et al. 2014).

With today's increasing reliance on network collaboration technology, the nature of many modern networks is approaching cyber-physical systems, which have social, cognitive, information and physical characteristics (Linkov et al. 2013). Systems increasingly involve both people and technologies, so they are both social and technical simultaneously. Amir and Kant (2018) call these sociotechnical systems, as they have "complex interactions between people, organisations, institutions, and technologies" (p. 9). People and technologies in sociotechnical systems are social constructs themselves, as they are hybrid entities that comprehend the "complexity of meanings, contextual activity, and situated decision making" (p. 10). Accordingly, one should also consider sociotechnical interactions when investigating interactions in social networks. Mitleton-Kelly (2003) stresses that sociotechnical systems are networked and interdependent. Similarly, consortia and processes of value creation, including innovation, are characterised by being networked and interdependent.

Multi-stakeholder networks involve partnerships; most of these networks can be seen as tri-partite, involving business, civil society and state actors, often from many nations, all participating in the network process to deal with an issue deemed important to all, even coming from different parts of society (Roloff 2008). The European Union, for example, expects that end-users from different member states be involved in all large-scale projects (Commission of the European Union 2011, p. 43).

Taatila et al. (2006) note that one important role of social networks lies in verification processes, in which an idea receives feedback and becomes further developed. Dealing with other stakeholders in the multi-stakeholder network on a common problem will urge these actors to non-hierarchical interactions (Roloff 2008). Thus, innovation networks promote organisational learning (Kallio & Lappalainen 2015), in which open and honest communication between participants helps develop the level of trust needed for this process (Roloff 2008).

EU-funded research and innovation projects can be "recognised as important vehicles for cross-sectoral and multidisciplinary collaboration and knowledge exchange" (Norvanto 2017, p. 71). The network approach highlights various aspects relevant for collaboration and communication in EU-funded projects. To function, the consortia need interaction to build strong connections that enable the sharing of experiences and collective learning among all actors in the network. The next section of this work investigates yet another approach.

2.3 Knowledge development processes

The process approach of knowledge development invites one to examine developments over time, which in this context brings the project duration to mind. The co-creation of knowledge to develop innovations requires growing insights over time. This is seen as a process requiring competences from actors (organisations, according to Taatila et al. 2016), focusing on the social aspects of the innovation process to develop innovation. These social aspects include structural competence attributes, such as organisational culture, communication processes and shared knowledge, all of which are needed in the process to create innovation (Taatila et al. 2006).

Moreover, Pichyangkul, Nuttavuthisit and Israsena (2012) note that a rigorous process is needed to deliver radical innovations. The authors state that multi-stakeholder partnerships require resources in "continuous investment in project management, processes, and people" (p. 158). Over time, multi-stakeholder networks go through a process life cycle, including (1) initiation, (2) acquaintance, (3) first agreement, (4) second agreement, (4) implementation, (5) consolidation and (6) institutionalisation or extinction (Roloff 2008). During this phased process, creative problem solving requires management (Buijs, Smulders & Van der Meer 2009), and cooperation requires time for relationships to develop (Schertzer, Schertzer & Dwyer 2013), as "co-creation has to be organised, managed and facilitated" (Bhalla 2014, p. 22).

Taatila et al. (2006) state that the innovation process develops over time in four phases: (1) the situation before the actual innovation, (2) idea development and (3) implementation, and (4) the situation afterward, when the innovation no longer is an innovation, but has become a normal part of the functioning of an organisation. More simply, the process can be described as turning inputs through transformation into outputs (Katz & Kahn 1978). Inputs are resources, while outputs of knowledge creation processes can be ideas for products, for example (Mitchell & Boyle 2010). Throughput concerns value co-creation interactions among the different actors of a network which require active support and enabling (Pinho et al. 2014). Rantapuska and Ihanainen (2008, p. 236) propose that projects can benefit from "a set of tasks to be done in each phase by interpreting their nature as learning intensive activities of change, instead of pre-specified process tasks".

Vos and Schoemaker (2004) examine organisational communication through a process approach lens when distinguishing how communication contributes to all three phases of value creation (1) input, (2) throughput and (3) output in an organisational context, in which the phases relate to a process cycle of interrelated activities rather than the formation of simple linear steps. Thinking in linear steps would give an incorrect picture of an often more chaotic reality. However, the type of activities related to input communication, are different than those of throughput or output communication, and making this distinction in types of activities helps understanding the process of value creation, ever though

they may not follow in a well-organised chronological order and often rather exist in parallel. This thesis applies the process approach to project communication contributing to all phases of knowledge development by project consortia. As follows, dissemination as part of output communication, is not restricted to the last project phase but happens throughout the project duration whenever results are discussed with, for example, end users. Similarly, gaining input of end-users on requirements is usually done at the beginning of the project life cycle, but can also re-occur later in time for new points of attention that occur later in the knowledge co-creation process.

Burdon, Mooney and Al-Kilidar (2015) emphasise that innovation processes, for example in the service sector, need joint strategic engagement and intensive collaboration. The resource integration that is needed for this process requires intensive communication between the multiple stakeholders involved (Pinho et al. 2014). For this purpose, Draheim and Pirinen (2011) promote social software as a tool to support the intensive interaction needed in knowledge development.

Crossan, Lane and White (1999) argue that organisations operate in open systems. A systems approach conceptualises organisations or, in this case, projects as systems that have interrelated parts and that are open to influences from outside the system (Grunig, Grunig & Ehling 1992). They interact with each other and the environment, whereas communication, being an interface function, spans the boundaries between system parts, sub-systems and the environment (Vos 2017). In funded projects communication helps span the boundaries between the different organisations involved in the joint process of knowledge development. Senge et al. (2008) add that organisational learning involves recognising the larger systems that an organisation is part of and a process of building trusting relationships to create commitment among the stakeholders. In this way, organisational learning, over time, enables innovation and the gaining of sustainable competitive advantages.

Projects are a way to gather teams of diverse expertise to realise a common objective, preferably in a cheap and fast way (Canonico et al. 2013). They demonstrate the need to actively manage communication in all phases of knowledge development. Understanding the process of knowledge development by consortia can help clarify communication needs throughout the project lifecycle. As projects are complex and need resilient collaboration, the next section discusses the resilience of complex social networks.

2.4 Resilience of complex social networks

The resilience of complex social networks concerns disturbances that may affect networks and is relevant for the resilience of the innovation networks formed by funded projects. The organisational environments of today are changing. They have become complex and filled with interrelated risks (Linkov et al. 2013, Mitleton-Kelly 2003, Vos 2017). Like organisational environments consisting of diverse interdependent actors, organisations themselves can be understood as complex

social systems (Mitleton-Kelly 2003). The term complexity relates to "the deeply connected and interdependent nature of some systems" (Poutanen, Siira, & Aula, 2016, p. 6). Mitleton-Kelly (2003) identifies several elements of complexity, among which are the level of connectivity and interdependence, processes of self-organisation, the related history, previous decisions influencing later ones etc. (Mitleton-Kelly 2003). "Nowadays, there is a tight coupling of systems and processes, and there are many interdependencies between these systems and processes" (Vos 2017, p. 23). Complex systems are open and evolving and coevolving with other systems and their environments, and generating change in them (Poutanen, Siira, & Aula, 2016).

With increasingly complex interactions between people, technologies and processes, many systems can be considered cyber-physical (Linkov et al. 2013, Rajamäki & Ruoslahti 2018) or socio-technical (Amir & Kant 2018). Such interdependencies come with vulnerabilities. Therefore, many organisations aim to increase their resilience. Vos (2017, p. 23) states that the concept of resilience is about "coping with change and managing the unexpected" when functioning in turbulent environments. Organisational resilience is a framework that creates tools and conditions that help reduce risks, understand issues and mitigate crises. "Resilience requires cooperation and adaptive capacities" (Vos 2017, p. 20), which can be used to create tools or conditions to help organisations co-evolve with their constantly changing environments (Mitleton-Kelly 2003).

Understanding an integral system's view of an organisation in its environment emphasises relationships and interdependencies (Grunig, Grunig & Ehling 1992). This enables the recognition of complexities and increasing resilience on various interrelated levels, and it shows the importance of resilience across boundaries. Societal resilience is formed by different sectors in society together (Vos 2017), including both the risks and opportunities of cross-sector collaboration. Risks are formed by vulnerabilities spreading within a system because of interdependencies, while opportunities to enhance resilience are created in joint knowledge development. A systems approach may assess various levels, such as innovation processes within an organisation, as well as wider innovation ecosystems in which assorted types of actors build a facilitating context for innovation (Hautamäki 2010, Oksanen & Hautamäki 2014).

Stanciugelu et al. (2013) emphasise sharing information on threats and vulnerabilities, as this can "help identify trends, better understand the risk faced, and determine what preventive measures should be implemented" (p. 194). In volatile organisational environments, innovation may be required to deal with unforeseen disruptive changes. For such purposes, Pichyangkul, Nuttavuthisit and Israsena (2012) propose an approach built on open innovation, where "outsiders are invited to co-create innovations", which requires attention for the communication with them. Thus, innovation is considered a solution to enhance organisational resilience, but the collaboration itself should also function in a resilient way. Agility is needed in developing knowledge to be able to flexibly adapt the process to changing contexts. This also means agile communication, listening well and picking up trends. Existing knowledge can be used to create new

knowledge, whereas gaps and complexity in communicating existing knowledge can be reduced by exchanging knowledge among network actors (do Nascimento Souto 2013). The process of knowledge creation needs to consider flexibility, building resilience into its network and guiding its multiple actors individually to do the same.

The vulnerability of many socio-technical systems that combine human and technical aspects has increased. Understanding the mutual entanglement of human organisations and material structures helps develop practices to anticipate possible future incidents and gain the feedback needed for learning (Amir & Kant 2018). Linkov et al. (2014) emphasise the importance of communication with stakeholders for resilience. Risk cannot be excluded, only reduced and dealt with, utilising communication and considering that communication in the turbulent times of today is "co-constructed by multiple stakeholders characterised by different interests and various interdependencies" (Vos 2017, p. 13).

Windahl (2015) notes that complexity increased following "the extent of business and technological interdependencies between firms" (p. 388). These interdependencies result in complex evolving systems, where "learning and the generation and sharing of knowledge need to be facilitated" (Mitleton-Kelly 2003, p. 42). This includes bringing up resilience early to embed it into system design and management while enhancing communication. For example, learning how other network members view a common problem helps them understand interdependencies (Linkov et al. 2014).

Promoting resilience requires "awareness, leadership, resource allocation, and planning" (O'Rourke 2007, p. 26). Based on their system resilience model, Linkov et al. (2014) clarify that risks occur when threat, vulnerability and consequences for critical functionalities coincide. Thus, during planning phases, when preparing for possible disruptions, related organisations interact to jointly identify these elements in their risk assessments (Savage 2002).

Pirinen (2017) perceives the need for shared responsibility and situational intelligence to improve resilience. Moreover, resilient networks can be promoted through awareness and communication (O'Rourke 2007), while education needs to include all types of stakeholders, including industry, industry associations and policymakers. Savage (2002) stresses preparation, whereby organisations require a process, including the related communication, to keep recovery plans updated. This highlights "care for the robustness of their business processes" (Draheim & Pirinen 2011). Therefore, the plans to prepare for the next possible disturbance should constantly be kept updated, based on testing them and on exchanging what can be learned from actual experience. There is also a need for the broad acceptance of resilience concepts by maintaining a transparent dialogue on resilience management (Linkov et al. 2014), continued engagement, knowledge of potential risks, energetic leadership, thorough planning and a long-term commitment to allocate needed resources (O'Rourke 2007).

Furthermore, collaboration itself also should function in a resilient way. Moreover, agility is needed in developing the project communication to be able to flexibly adapt to changing contexts. This way of thinking fits projects, as they

are temporary and allow adaptations (Canonico et al. 2013) if supported by a flexible attitude and developed partnering skills. "Co-creation clearly requires alignment of vision and supporting processes, and the development of advanced inter-organisational collaboration skills" (Burdon, Mooney & Al-Kilidar 2015, p. 296).

Project consortia can be seen through the lens of resilient complex social systems to understand how they seek to reduce risks, stay in touch with their surroundings and mitigate crises on the level of social network collaboration and how they adapt the process of joint knowledge creation in a changing environment.

The next section of this work discusses how the four theoretical approaches described in this chapter have influenced the overall research approach of this thesis. In the next chapter's section 3.1, this will lead to a description of the research design.

2.5 Research approach

In the previous sections, divergent perspectives on knowledge development have been clarified. In this thesis, these represent four approaches that are considered to complement each other (see Figure 3):

- Co-creation of knowledge by multiple actors
- Innovation networks
- Knowledge development processes
- Resilience of complex social networks.

The four approaches mentioned have guided and acted as a framework for the research work in the individual studies presented in this thesis. The framework was constructed based on earlier literature to provide a common basis and focus for the research questions and the analysis of the findings of the studies. The context of these studies are EU-funded projects that aim to develop knowledge for innovation, benefitting more than just the directly involved stakeholders.

The project consortia use co-created knowledge to further innovation. The project partners interact with each other and their environment in complex ways. They are also open to outside influences during this collaboration. The consortia, thus, need resilient collaboration and organisational resilience to reduce risks and mitigate crises.

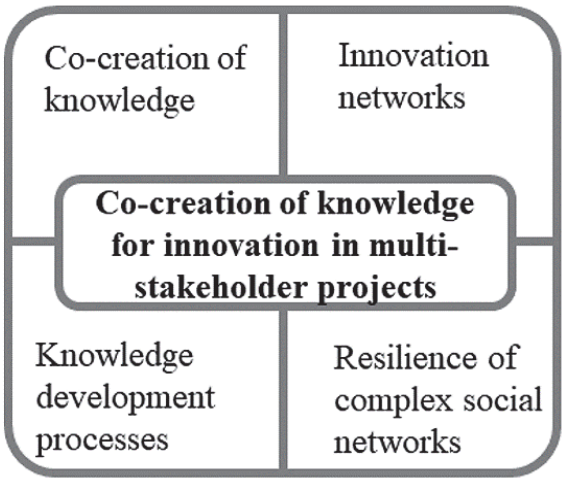


FIGURE 3 The research approach departs from four perspectives

The four approaches can be briefly outlined as follows.

- The approach of knowledge co-creation highlights multi-actor interactions and invites the investigation of how the interactions of multiple actors (as discussed by, for example, Bhalla) with diverse backgrounds and interests occur in a project.
- The network approach of multi-stakeholder interaction (as discussed by, say, Roloff) suggests examining the roles and interrelations of the actors involved in the network. Project partners contribute in different ways and are strongly interconnected to share insights and experiences.
- The process approach of knowledge development (as discussed by, for example, Taatila et al.) brings development over time into focus and invites a look at the requirements for the process of co-creation in various project phases and the development of knowledge throughout the duration of a project.
- The resilience approach (as discussed by Linkov et al., among others) adds a focus on change and turbulence when investigating complex network collaboration, noting the flexibility with which project participants work and how diverse current views are included. It also points to the evolving wider context of the project and other actors than those directly involved as project participants.

In this thesis, the four approaches complement each other. The varied foci help balance the research and evaluate its outcomes. The research problem is the lack of understanding of the co-creation of knowledge for innovation in multi-stakeholder projects and, in particular, communication with and the participation of end-users in funded projects. End-users have particular interests and are given different roles in funded projects. The European Commission considers their contributions crucial for the functioning and results of research and innovation projects and for taking up project results, not only by end-users, but also policymakers, industry and the academic community (Commission of the European Union

2014a). Thus, consortia are encouraged to promote their project and its results to multiple audiences and even engage them in a two-way exchange of views (Commission of the European Union 2016).

How the above four approaches relate to each individual study of this thesis is presented in Table 3 in the next chapter. The pattern shows that all approaches are addressed in more studies and that the approach of innovation networks occurs most often. This is not surprising, considering that network roles are central to investigating end-user participation.

The overall approach of this thesis also takes its structure from communication process phases (Vos & Schoemaker 2004). Thus, Table 1 describes how the individual studies link to the three project phases of input, throughput and output. One study gives an overview. Two studies focus on input communication, two on throughput communication and one on output communication.

A current systems perspective is taken which does not conflict with any of the four approaches and emphasises interdependencies important to innovation. In the resilience literature, a systems approach is common (e.g. Linkov et al. 2013 and 2014). Systems are perceived as complex, networked (e.g. Mitleton-Kelly 2003) and dynamic (e.g. Ahrweiler & Keane 2013). They may be combined with actor networks (e.g. Piperca & Floricel 2012, Steins & Edwards 1999). A systems approach has also been applied to organisational communication (e.g. Grunig, Grunig & Ehling 1994). Furthermore, according to Boje, Gephart and Thatchenkery (1995), organisation can be considered "a concept of social actors that is produced in contextually embedded social discourse and used to interpret the social world" (p. 2).

Although a systems perspective is taken here, it is acknowledged that there are also critical views on systems theory following Montuori and Purser (1995), who note that postmodernists seem to have a distaste for systems theory. As a solution, the authors identify a shift towards complex thinking, recognising that "system and environment can be said to exist in a dialogic, interretroactive relationship" (Montuori & Purser 1995, p. 182). This type of thinking offers scenario building and participative design as ways to promote "a systemic, collaborative, and creative set of discourse/practices" (p. 182). Hassard (1996) remarks that postmodern theory on organisational power suggests that people become empowered through the actions of others and that "power is a matter of social interdependence" (p. 58).

Of the four approaches guiding the studies of this thesis, the first two mostly inspire a social constructivist stance of trying to understand project communication, while it is also acknowledged that the latter two approaches and the related literature also bring functionalist elements discussing opportunities to strengthen the knowledge creation process. Together, the approaches provide a lens through which one can study collaborative interactions that aim at the co-creation of knowledge for innovation in multi-stakeholder projects. This chapter clarified the research approach leading to the methods and data described in Chapter 3.

3 METHODS AND DATA

The focus of this thesis is the co-creation of knowledge for innovation in funded projects from the viewpoint of multi-stakeholder communication, focusing particularly on communication with and the participation of end-users. The empirical work consists of six interrelated studies (as was presented in Table 1). This chapter describes the methods used to gather and make sense of the data in the studies to support the objectives of this thesis. To begin, the research design is clarified. This includes the research questions, approaches and context of each study. The various studies conducted for this thesis use case examples of EU-funded innovation projects, as will be further addressed in the next section. Subsequently, data collection, analysis, methods and research ethics are addressed.

The main research attributes of the studies in this thesis can briefly be outlined as follows (briefly, following Dubé and Paré 2003, and to be further explained below):

- Research target: Understanding co-creation for innovation in multi-stakeholder projects.
- Importance of this research work: It contributes to research on co-creation in innovation networks.
- Research questions: The research is structured in several individual studies with their own research questions (which follow in Table 2).
- Methodological focus: The research design, strategy and methods and strategies of inquiry are of a qualitative nature.
- Analysis form: Mainly qualitative analyses using data extraction tables.
- Unit of analysis: Instances of co-creation or participator experiences.
- Context: Funded research and innovation projects, as presented in Table 4.

3.1 Research design

The research comprises six studies that each have their own focus and were reported in seven papers targeting the co-creation of knowledge for innovation in

funded projects. Study 5 is split in two parts and reported in two related papers. Table 2 gives an overview of the main research questions.

Not all the content of the corresponding papers is included in the reporting in this thesis's framework, as the focus is on those research questions (RQs) that contribute to the aim depicted in this thesis's shell. Some RQs were rephrased to better connect to the central aim of this thesis. The table also mentions the context of the study, referring to the kind of data utilised. Here, project abbreviations are used that will be further explained in Table 4.

TABLE 2 The main research questions of the studies

Study	Main research questions	Context
1 Co-creation of knowledge for innovation	RQ 1: How has the co-creation of knowledge for innovation been investigated in the scholarly literature? RQ 2: What end-user roles are discussed in the literature? RQ 3: What characteristics and challenges of end-user participation are mentioned in the literature?	Literature on co-creation
2 Co-creating a collaboration network	RQ 1: What diversity of actors was engaged in the co-creation network for knowledge and information sharing in the case project on safety and security in the Arctic?	UARCTIC, Thematic Network of Safety and Security
3 Involving end-users in setting requirements	RQ 1: What are the views on involving end-users in setting requirements for a complex maritime collaboration system in the case projects? RQ 2: How are scenarios used to identify end-user needs in innovation projects?	MARISA EUCISE2020 CoopP AIRBEAM
4 Resilient collaboration in multi-stakeholder innovation networks	RQ 1: What are the views on resilience in a collaboration network of the case project on complex integrated cyber-physical systems? RQ 2: According to the project partners, how can the resilience of collaboration networks be strengthened?	MARISA EUCISE2020
5 Complexity and innovation in multi-stakeholder networks	RQ 1: How does complexity affect the co-creation of knowledge in innovation projects, according to project participants? (Study 5a) RQ 2: How is the time needed to achieve innovation affected by the level of complexity of collaboration networks, according to project participants? (Study 5b)	MARISA EUCISE2020 IECEU ABC4EU GAP AIRBEAM
6 Dissemination by multi-stakeholder project consortia	RQ 1: How are external communication and dissemination conducted in case projects? RQ 2: How do the external communication and dissemination of the case projects support the functioning of these projects, while addressing the requirements of the funding instrument?	GAP ABC4EU IECEU

Together, the six studies of this thesis contribute to understanding the co-creation of knowledge for innovation in multi-stakeholder projects. Table 3 (below) shows how the four theoretical approaches described in the previous chapter influence each study and how their results are reported. These four theoretical approaches are considered complementary. Each approach appears in more than one paper, and each study is influenced by more than one approach. Thus, not all of the studies are based on all four approaches, but they vary in focus. The approach of Innovation networks was guiding factor in five individual studies (Study 1, 2, 4, 5, and 6), while the other approaches were each most visible in four studies: Co-creation of knowledge in 1, 2, 3, and 5, Knowledge development processes in 1, 3, 4, 5, and 6, and Resilience of complex social networks in 3, 4, 5, and 6.

TABLE 3 The main theoretical research approaches influencing the studies

Approach:	Co-creation of knowledge	Innovation networks	Knowledge development processes	Resilience of complex social networks
Study 1: Co-creation of knowledge for innovation				
Study 2: Co-creating a collaboration network				
Study 3: Involving end-users in setting requirements				
Study 4: Resilient collaboration in multi-stakeholder innovation networks				
Study 5: Complexity and innovation in multi-stakeholder networks				
Study 6: Dissemination by multi-stakeholder project consortia				

Table 3 illustrates how each of the six studies relate to the four theoretical approaches. Study 1, Co-creation of knowledge for innovation, investigates the scholarly literature and draws on three approaches. The co-creation of knowledge approach is demonstrated through its focus on multi-actor projects. The network approach of innovation has the most articles in the sample networks creating innovation value. The process approach is visible whereby the study examines end-user roles in the project process.

Study 2, Co-creating a collaboration network for innovation, relies on a multi-actor approach in analysing co-creation and addressing a common problem that fits the diverse aims of each project partner. The network approach of innovation is revealed in the study when building a network for co-created innovation.

Study 3, Involving end-users in setting requirements, utilises two of the approaches. The focus on the engagement of many diverse actors relates to the co-creation of knowledge approach. Here, the process approach of knowledge development is used to understand the requirement phase of the process.

Study 4, Resilient collaboration in multi-stakeholder innovation networks, is the focus of the resilience approach of complex social networks. The study also is based on the network approach of innovation in focusing on collaborative networks and on the process approach of knowledge development in investigating resilience as a process with the phases of prepare for, absorb, recover from and adapt in case of disruptions.

Study 5, Complexity and innovation in multi-stakeholder networks, resonates with the co-creation of knowledge approach in evaluating multi-actor interaction. The study also appraises the complexity of networks, thus relating to the network approach of innovation.

The case projects (CoopP, EUCISE 2020 and MARISA) examined in studies 3 and 5 use risk and threat scenarios that call for continuous evaluation and revision as maritime activities evolve and end-user requirements change. In that sense, these case projects also relate to the approach of resilient, complex networks.

Study 6, Dissemination by multi-stakeholder projects, is partly based on the network approach of innovation, as it provides a broad picture of innovation networks. As it also judges evaluation as a process, it connects to the process approach of knowledge development. The resilience approach of complex social networks can be witnessed where it discusses learning and adaption for resilience.

This research is an individual's doctoral thesis. Hence, no other research groups are directly involved. However, the research made use of project documents and involved project participants whereas, in turn, the content of papers (III, Vb and VI, for instance) contributed to these projects. The participants were from end-user, industry or research and development organisations. The eight main projects are listed in Table 4, below.

TABLE 4 Contexts of the studies of this thesis

Project abbreviation	Main aim of the project and webpage	Opportunity for this research
ABC4EU	*Automated Border Control Gates for Europe* aims to make border control more flexible by enhancing workflows and harmonising automation functionalities. www.abc4eu.com	Studies 5 and 6
AIRBEAM	*AIRBorne information for Emergency situation Awareness and Monitoring* developed a toolbox for the management of crises over wide areas, benefitting from an optimised set of aerial (unmanned) platforms, including satellites. https://cordis.europa.eu/project/rcn/101536/factsheet/en	Studies 3 and 5
CoopP	*Cooperation Project* aims to support information sharing and cross-sectoral and cross-border operational cooperation between public authorities that execute defined maritime functionalities in European sea basins. http://coopp.eu/	Study 3
EUCISE2020	*EUropean test bed for the maritime Common Information Sharing Environment in the 2020 perspective* aims to achieve pre-operational information sharing between European maritime authorities. http://www.eucise2020.eu/	Studies 3, 4 and 5
GAP	*GAming for Peace* has as its objective a gaming environment for conflict prevention and peace building in which personnel can experience role-playing scenarios to increase their understanding, creativity and ability to communicate and collaborate with the people and organisations in the network. https://gap-project.eu/	Studies 5 and 6
IECEU	*Improving the Effectiveness of Capabilities in EU Conflict Prevention* attempts to enhance conflict prevention capabilities, analysing best practices and lessons learned to augment civilian conflict prevention and peace-building capabilities. www.ieceu-project.com	Studies 5 and 6
MARISA	*MARitime Integrated Surveillance Awareness, improving maritime surveillance knowledge & capabilities through the MARISA toolkit,* aims for collaboration between European agencies to improve situational awareness at sea with an ecosystem of users and providers for the integration of a wide range of data and sensors in the maritime domain. http://www.marisaproject.eu	Studies 3, 4 and 5
UARCTIC Safety and Security Network	*Thematic Network on Arctic Safety and Security within the University of the Arctic* aims at preventing incidents that threaten humans, the environment, values or communities in the Arctic by addressing the risks of operating in the Arctic and ways to cooperate across borders and the optimal use of preparedness resources. https://www.uarctic.org/organization/thematic-networks/arctic-safety-and-security/	Study 2

The projects mentioned in Table 4, with the exception of UARCTIC, have been EU-funded, partly under the funding programme Horizon 2020 (as coordination and support action or innovation action projects) and partly within the previous funding programme FP7 (as a collaborative project, large-scale integration project, combined collaborative project or coordination and support action).

3.2 Data collection

This research combines qualitative data collection methods in its six studies. Qualitative data can, for instance, be collected by observing interactions, conducting interviews or scrutinising materials (Denzin & Lincoln 1994). The way data are collected relates to the chosen strategy of inquiry (Denzin & Lincoln 1994, Myers 2013). The choice to use qualitative methods was based on the possibility of collecting rich data (Denzin & Lincoln 1994). The projects that form the context of this research had produced interesting written materials, project events provided data collection opportunities, and other input came from project stakeholder representatives. The number of projects selected was eight. The use of broader quantitative data could have provided a stronger basis to generalise the results. However, in the context of this explorative thesis and its individual studies, the qualitative methods were seen to be adequate in finding the answers to the research questions. The main focus was to remain methodologically interpretivist, as Green (1994) states, "with the human inquirer as the primary gatherer and interpreter of meaning" (p. 536).

For Study 1, the strategy of inquiry was a structured literature review. Instrumental case study research (following, for example, Stake 1994, Yin 2003) was chosen for studies 2, 3, 4, 5 and 6. An instrumental case study attempts to "provide insight into an issue of refinement of theory" (Stake 1994, p. 237). The issue for this research is the co-creation of knowledge for innovation in multi-stakeholder projects. The context of this research consists of research and innovation projects funded by the EU (see Table 4, above). The main bases of the methods used in the individual studies are case research strategy (Benbasat, Goldstein & Mead 1987, Yin 2003) and qualitative data analysis (Miles & Huberman 1994).

The data for the case studies have been collected by active participation and expert interviews with subjects (studies 2 and 6) and by reading their texts to understand them (studies 2 and 5). The qualitative content analysis of project reports has been used to identify how collaboration is present in them (studies 3, 4, 5 & 6).

Denzin and Lincoln (1994) argue that a researcher works to gain "some conceptual understanding of the processes being studied" (p. 356). Indeed, observation can become participation. Some elements of co-configuration are present in studies 2 and 6 because the researcher not only observed but also actively participated by directing workshops, thus facilitating end-user community discussions in these projects.

An overview of the data collection methods is given in Table 5, below.

TABLE 5 Data collection of each study

	Study 1	Study 2	Study 3	Study 4	Study 5	Study 6
Participation					5a	
Interviews					5a	
Materials					5b	

As recommended by Yin (2003), multiple sources of evidence were used to study the cases, utilising qualitative triangulation.

The structured literature review in Study 1 assesses a sample of 33 scientific articles. Study 2 draws on 16 encounters between multiple stakeholders on different levels of collaboration networks concerning Arctic safety and security. Sub-study 5a draws on project participants' views on complexity. Studies 3 and 5b are based on a total of 94 use cases and scenarios produced during four EU-funded innovation projects, of which five have been selected to serve as the basis for the MARISA project. Study 4 uses multiple cases produced by students of higher education in identifying attributes for resilience in social networks for critical infrastructure. Study 6 examines data on external communication and dissemination collected from three EU-funded projects.

The data collection techniques used for each study are further explained in section 3.4. The following section describes the forms of analysis, utilised in the studies, that this thesis builds on.

3.3 Data analysis

Table 6 shows that, for a thorough analysis of the data gathered, data extraction tables (DET) were used, as well as a data extraction on continuum (DEC).

TABLE 6 Data analysis methods for each study

Study 1	Study 2	Study 3	Study 4	Study 5	Study 6
Data extraction table (DET)	Content analysis	Data Extraction Table (DET)	Content analysis	Data Extraction Table (DET) for 5a	Evaluation matrix
Data extraction continuum (DEC)			Risk assessment matrix	Data Extraction Table (DET) for 5b	

Studies 1, 3 and 5 used data extraction tables (DET) that were individually designed for each of these studies. In Study 1, a data extraction continuum (DEC)

also was created to determine how the 33 sample articles relate to each other considering how complexity, type of co-creation collaboration and stakeholder involvement were discussed (see Figure 4 in section 3.4). The analysis of Study 2 and partly Study 4 was based on content analysis, in which the researcher "analyses the narrative, temporal, and dramatic structures of a text, forsaking the rigor of counting, for a close, interpretive reading of the subject matter at hand" (Denzin & Lincoln 1994, p. 358). Study 4 also used a risk identification framework (from the Risk Management Association of Finland), a risk assessment matrix and a participatory workshop process to identify the attributes relevant for resilience in social networks. Study 5 used DETs to identify the views on complexity and how this may affect innovation in the collaboration network of the case network. In Study 5a, the elements of Mitleton-Kelly (2003) are used to structure the analysis. In Study 5b, narratives on how complexity influenced project work are analysed by focusing on time-to-innovation. The method of analysis for Study 6 was placing units of analysis in an evaluation matrix of 25 indicators developed to serve as a framework for this study.

The units of analysis were instances of co-creation and participator views or experiences for all individual studies. Study 1 investigates how the co-creation of knowledge for innovation has been investigated in the scholarly literature by extracting both instances of co-creation and participator experiences in the DET. Its columns are based on the research questions. Study 2, which examines the diversity of actors involved in the process of creating a co-creation network, mainly focuses on participator views and experiences. Studies 3 and 5 also mainly draw on participator experiences, using co-created scenarios to gain data. In studies 3 and 5, instances of co-creation were placed in a DET. In Study 3, this happened in the form of objects and phenomena categorising findings under the framework of European Coast Guard functions, and in Study 5, this occurred through the lens of complexity and innovation in multi-stakeholder networks. Study 4 identifies instances of co-creation and participator experiences to identify resilient collaboration in multi-stakeholder innovation networks of infrastructure critical to society. Study 5 identifies participator experiences and instances of co-creation from scenarios that are based on co-creative end-user participation and complex authority interactions. This study examines views on complexity and how it may affect innovation in a collaboration network. The context is innovation projects and a complex maritime collaboration system that is being developed through the case projects that are under study. In Study 6, both instances of co-creation and participator experiences are evaluated regarding external communication and dissemination activities and materials.

The analysis methods used in each study are explained in further detail below in section 3.4.

3.4 Overview of methods used in the studies

Table 7 describes the main data collection and analysis methods employed in the six studies of this thesis.

TABLE 7 Overview of methods used in the studies

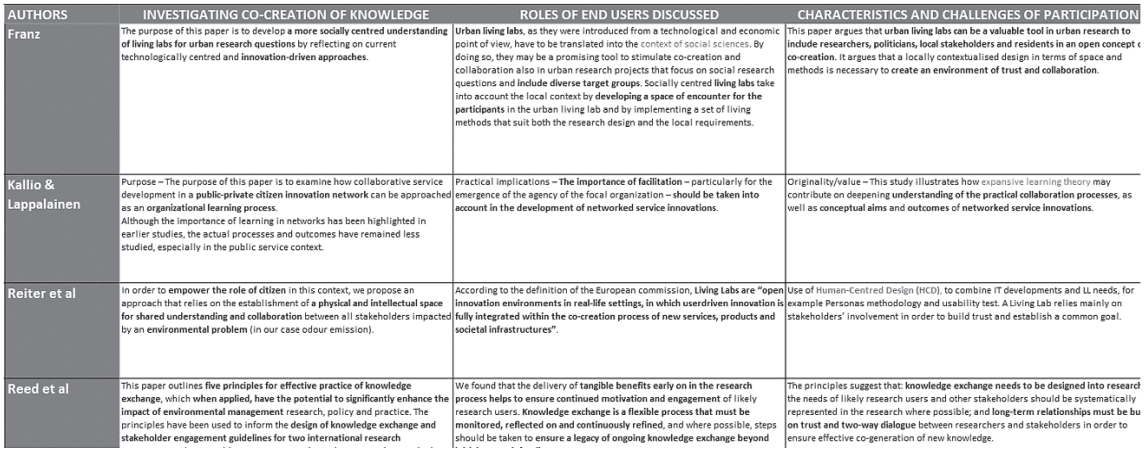
Study	Methods
Study 1: Co-creation of knowledge for innovation	Data collection by reading materials: – Structured literature review including a search of databases of peer-reviewed literature published in the past 10 years. Key words were limited to the abstract. – Decisions to include articles were based on inclusion criteria which ensured that irrelevant articles were omitted from the sample. – 52 articles were found, of which 33 met the inclusion criteria and, thus, were included in the sample. Analysis, by placing the units of analysis in a data extraction table (DET) and a data extraction continuum (DEC): – Sample articles were analysed with relevant content summarised in a DET, where the rows were based on the articles and the columns on the research questions. – Sample articles were also placed on a continuum in relation to each other (by complexity, type of co-creation collaboration and stakeholder involvement). – The DEC created for this study serves as a visualisation of four categories of co-creation (example provided in the paper).
Study 2: Co-creating a collaboration network	Data collection by participation in and the analysis of workshop materials: – Participatory observation focusing on the third phase of the expansive learning cycle, modelling a new solution (Engeström 2007). – Data were drawn from 16 encounters between multiple stakeholders on four levels of collaboration networks concerning Arctic safety and security. – The data were collected from researcher notes and collaboration workshop minutes and memos. Analysis by qualitative content analysis: – The analysis was accomplished by reading the materials and highlighting relevant views that model new solutions.
Study 3: Involving end-users in setting requirements	Data collection by reading materials: – Data were collected from use case and scenario narratives, and scenario analytics that were primarily developed in projects CoopP, EUCISE 2020, or MARISA.

	Analysis by placing units of analysis in a DET: – The collected data were subjected to a structured desktop analysis in which identified objects and phenomena formed columns in the DET, which was specifically developed as the analysis tool for this study. – The 10 European Coast Guard functions framework was used in the DEC as the basis to classify results.
Study 4: Resilient collaboration in multi-stakeholder innovation networks	Data collection by participation and reading materials: – This study utilises sample data from case studies on the resilience of cyber-physical systems. – Case study materials were produced by 53 IT and 22 security management master's students, one bachelor's student and five doctoral students. – To collect data on attributes that can improve the resilience of collaboration networks, the Risk Management Association of Finland risk identification framework was used. Further analysis by a content analysis and risk assessment matrix: – The researchers performed cross-case analyses of 16 individual studies on reliance, five risk identification and assessment matrixes, and other material. – To collect and identify the attributes improving the resilience of collaboration networks, the units of analysis were placed in a risk assessment matrix, followed by a participatory workshop process.
Study 5: Complexity and innovation in multi-stakeholder networks Study 5 consists of sub-studies 5a and 5b	Data collection by narratives and detailed use case descriptions: – Data collected from a total of nine narratives of participant views on how complexity and time-to-innovation affect innovation projects (5a). – Data collected from detailed use case descriptions for five MARISA use cases (5b). Analysis by placing units of analysis in a DET and a table identifying differences and similarities: – The collected data were subjected to a structured desktop analysis, whereby the elements of complexity by Mitleton-Kelly (2003) were identified as columns in the DET. It was specifically developed as the analysis tool for this study, marking citations that clearly illustrated what elements of complexity meant in the context of innovation projects, using the marked citations to summarise findings per element (5a). – MARISA use cases were analysed by a DET that compared their respective elements to identify differences and similarities, focusing on time-to-innovation (5b).
Study 6:	Data collection by participation and reading materials: – Dissemination and communication plans of three international projects: ABC4EU, IECEU and GAP.

Dissemination by multi-stakeholder project consortia	– External communication and dissemination activity reports by project partners in case project GAP. – External communication and dissemination activity evaluations by the projects IECEU and ABC4EU. – Co-creation is considered based on the pedagogical model Learning by Developing (Raij, 2011). Analysis by placing the units of analysis in an evaluation matrix of 25 indicators, developed by this study: – The evaluation model of Vos and Schoemaker (2004), combining elements of balanced scorecard and quality management, was applied to evaluate external project communication and dissemination. – The measurement processes follow the quality cycle by Juholin (2010). – The study adopted the dimensions of communication quality (following Palttala & Vos, 2012). – Quality dimensions were applied to five communication domains, based on the project grant agreement, which provided a matrix of 25 indicators to serve as a framework. – The framework was tested against the analysis of the dissemination and communication plans of three EU-funded innovation projects: ABC4EU, IECEU and GAP.

As Table 7 demonstrates, the research and data collection methods of this thesis vary depending on the research questions of each study. Below, these are discussed study by study.

For Study 1, a structured literature review was used. A literature search was conducted by using the databases ProQuest Central and EBSCOhost to identify peer-reviewed literature from the last 10 years, where the key words appeared in the abstract. The Boolean search paired the following key words: innovation* OR knowledge AND project OR end-user*. This search rendered 52 articles. The abstracts of these articles were read thoroughly and matched against inclusion criteria to ensure they were really scientific papers about the topic. This limited the final sample to 33 articles that were then read and analysed in detail. The sample articles of Study 1 were analysed with a DET, in which relevant article content was summarised in the rows, and research questions, in the columns. Figure 4 depicts an example portion of a DET that was utilised.



AUTHORS	INVESTIGATING CO-CREATION OF KNOWLEDGE	ROLES OF END USERS DISCUSSED	CHARACTERISTICS AND CHALLENGES OF PARTICIPATION
Franz	The purpose of this paper is to develop **a more socially centred understanding of living labs for urban research questions** by reflecting on current technologically centred and **innovation-driven approaches**.	**Urban living labs**, as they were introduced from a technological and economic point of view, have to be translated into the context of social sciences. By doing so, they may be a promising tool to stimulate co-creation and collaboration also in urban research projects that focus on social research questions and **include diverse target groups**. Socially centred **living labs** take into account the local context by **developing a space of encounter for the participants** in the urban living lab and by implementing a set of living methods that suit both the research design and the local requirements.	This paper argues that **urban living labs can be a valuable tool in urban research to include researchers, politicians, local stakeholders and residents in an open concept c co-creation**. It argues that a locally contextualised design in terms of space and methods is necessary to **create an environment of trust and collaboration**.
Kallio & Lappalainen	Purpose – The purpose of this paper is to examine how collaborative service development in a **public-private citizen innovation network** can be approached as an **organizational learning process**. Although the importance of learning in networks has been highlighted in earlier studies, the actual processes and outcomes have remained less studied, especially in the public service context.	Practical implications – **The importance of facilitation** – particularly for the emergence of the agency of the focal organization – **should be taken into account in the development of networked service innovations**.	Originality/value – This study illustrates how expansive learning theory may contribute on deepening **understanding of the practical collaboration processes**, as well as **conceptual aims** and **outcomes** of **networked service innovations**.
Reiter et al	In order to **empower the role of citizen** in this context, we propose an approach that relies on the establishment of **a physical and intellectual space for shared understanding and collaboration** between all stakeholders impacted by an **environmental problem** (in our case odour emission).	According to the definition of the European commission, **Living Labs are "open innovation environments in real-life settings, in which userdriven innovation is fully integrated within the co-creation process of new services, products and societal infrastructures"**.	Use of Human-Centred Design (HCD), to combine IT developments and LL needs, for example Personas methodology and usability test. A Living Lab relies mainly on stakeholders' involvement in order to build trust and establish a common goal.
Reed et al	This paper outlines **five principles for effective practice of knowledge exchange**, which **when applied, have the potential to significantly enhance the impact of environmental management** research, policy and practice. The principles have been used to inform the **design of knowledge exchange and stakeholder engagement guidelines for two international research**	We found that the delivery of **tangible benefits early on in the research process helps to ensure continued motivation and engagement** of likely research users. **Knowledge exchange is a flexible process that must be monitored, reflected on and continuously refined**, and where possible, steps should be taken to **ensure a legacy of ongoing knowledge exchange beyond**	The principles suggest that: **knowledge exchange needs to be designed into research** the needs of likely research users and other stakeholders should be systematically represented in the research where possible; and **long-term relationships must be bu on trust and two-way dialogue** between researchers and stakeholders in order to ensure effective co-generation of new knowledge.

FIGURE 4 Example part of a data extraction table that was utilised

Further analysis was accomplished by placing the sample articles on a continuum in relation to each other based on the type of collaboration discussed. The DEC was created as a visualisation to understand how the sample articles related to one another. (A sample part of the DEC is given in paper I.)

Study 2 is based on Engeström's (2007) expansive learning cycle, which includes several steps: questioning existing practices, analysis of existing practices, modelling a new solution, exploring the new solution, adopting the new solution, evaluating the process and solidifying and expanding new practices. This also considers the Nonaka and Takeuchi (1995) Knowledge Creation model to support innovations. The aim was to help understand a complex co-creation network collaboration to promote safety and security in the Arctic. The research activities of Study 2 focused on the third phase of this expansive learning process, analysing the modelling of a new solution. The data were collected from documents, minutes, notes and memos, as well as by observing meetings, discussions, events and collaboration workshops held between potential co-creation network partners (under the Chatham House Rule) between 2010 and 2015. The data were analysed by reading the collected materials and highlighting views pointing at new solutions to promote safety and security in the Arctic. In this way, the results of the study were based on an analysis of collaboration discussions and the related documents.

Study 3 assesses scenarios as input communication by identifying objects and phenomena that users of modern common-use maritime information systems need for a more complete real-time maritime picture. The study draws data from case and scenario narratives and scenario analytics primarily from three EU-funded projects, being CoopP, EUCISE2020 and MARISA. The collected data were subjected to a structured desktop analysis using a DET, where objects and phenomena, which formed the columns of the DET, were classified under 10 European Coast Guard functions, which formed the rows of the DET. Study 3 also lists the main category of risk for each Coast Guard function in the DET. In addition, the DET differentiated between observations, which are produced by out-

side agents, and actions, as the assets and resources that authorities use to respond to objects and phenomena that are produced by outside agents. Another class, general common to all, was added for issues that were found to appear in all categories. This study also served project MARISA to better understand what level of information (objects, phenomena, observations, actions, main risks) end-users need for a shared and more complete maritime picture.

Study 4 uses sample data from case studies on the resilience of cyber-physical systems collected from materials produced by 53 IT and 22 security management master's students, one bachelor's student and five doctoral students. For these students, the main motive was to advance their learning. They were guided by the researchers, who subsequently performed a cross-case analysis. The IT-related data for Study 4 were gained from 16 authentic research and development projects conducted in three Finnish universities. The security management-related data were collected using a risk identification and assessment matrix (from the Risk Management Association of Finland). Attributes to improve the resilience of collaboration networks were identified and prioritised based on a further cross-analysis by the researchers of the risk identification and assessment matrixes that had been produced by the student groups.

Study 5 is divided into sub-studies 5a and 5b. Sub-study 5a collects data from a total of eight written narratives and one interview of innovation project experts' views on how complexity had been visible and in their view had affected their innovation projects. The primary project context is six innovation projects in which the author had also participated. The analysis was conducted by placing the units of analysis in a DET, where the columns represented 10 elements of complexity. The DET is specifically developed as the analysis tool for this study. Sub-study 5b collects and analyses use cases from one case project and scenarios from another case project to understand the time needed to achieve innovation regarding the level of complexity of collaboration networks in these case projects. The use cases were analysed by comparing their respective elements in use case descriptions and placing them in a DET that was re-structured based on similarity and difference, with a focus on time-to-innovation.

Study 6 draws on various frameworks, including elements of the model of co-creation, a pedagogical model called 'Learning by Developing' (Raij 2014), the communication balanced scorecard (Vos & Schoemaker 2004), the quality cycle (Juholin 2010) and dimensions for communication domains (Palttala & Vos 2012). These frameworks are adapted to the domain of externally funded projects to offer an evaluation framework to examine project communication and dissemination of the project context and its results. The framework combines quality dimensions and communication dimensions, which provide a matrix with indicators.

In overview, Table 8 provides the data collection and analysis methods of each study.

TABLE 8 Data collection and analysis methods of each study

Study 1 Literature overview	Study 2 Input end users	Study 3 Input end users	Study 4 Throughput resilience	Study 5 Throughput complexity	Study 6 Output dissemination
Materials: Data extraction table & continuum	Participation, interviews: Content analysis	Materials: Data extraction table	Participation, materials: Content analysis & risk assessment matrix	Participation, interviews, materials: Data extraction tables	Participation, materials: Evaluation matrix

Study 1 was a literature review that provided insights for all communication phases, for this review articles were collected and analysed using a data extraction table. Study 2 and 3 aimed at providing insights on input of end users, based on interviews, resp. collected materials; here the methods were complementary. Study 4 and 5 scrutinised the throughput phase, with a different focus being resilience vs. complexity, and using various data collected to capture these multifaceted phenomena. Finally, Study 6 investigated output communication and, particularly, dissemination, using various data collected and analysed in an evaluation matrix. As different projects provided the context for the studies, the ways to collect the data also had to suit the projects involved. The related research ethics are explained in the next section.

3.5 Research ethics

Care was taken to protect the anonymity of all participants. The subjects of the studies typically either worked as high-level experts in security authorities or in related industries. The proceedings and workshops in which material was collected were held under the Chatham House Rule (Royal Institute of International Affairs 2015): "When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed." Therefore, when reporting results, this researcher mentioned the names of consortium organisations and discussed issues related to these, but he did not point out individual participants or their organisations regarding the issues addressed.

The structured literature review in Study 1 and the scenarios in studies 3 and 5 are based on public data sources that were free to be used as research data. Study 2 included participatory observation and analyses of discussion notes from 16 encounters, which were all conducted under the Chatham House Rule. This was made clear to the respondents at the beginning of each encounter. Study 4 used data collected by students of higher education and, therefore, their consent was asked to use the data in further research. Studies 5 and 6 contain data collected during workshops as part of activities in the case projects. The participants

were informed previously that the data collected would be used for research purposes, as one aim of EU-funded projects is to publish academic papers based on the work and results of these projects. This was explicitly agreed on and recorded in the project consortium's agreements. All data were stored on a computer system at Laurea University of Applied Sciences. The databases were protected by password and accessible only by the researcher. Now that the methods and data used have been described, the findings will be presented in the next chapter.

4 FINDINGS

This thesis consists of six studies, which contribute in different ways to understanding the co-creation of knowledge for innovation in funded projects from the viewpoint of multi-stakeholder communication, particularly, honing in on communication with and the participation of end-users. This section describes the main findings that answer the research questions presented earlier in section 3.1, Table 2. As explained before, not all the content of the papers is included in the reporting in the thesis's framework, as here, the aim is contributing to the central objective of this thesis.

4.1 Study 1

Study 1 utilises a structured literature review to provide an overview of scholarly insights on the topic that serves as a basis for the other studies included in this thesis.

The related paper is "Co-creation of knowledge for innovation requires multi-stakeholder public relations". For this paper, the publisher required the use of the term public relations, while in the reporting of this thesis, the term communication is used with a focus on project communication. Most of the content of this paper is relevant to the overarching structure, as the research questions reported in the paper all centre on the co-creation of knowledge for innovation. Table 9 gives a brief overview of the main findings per each research question. Next, the findings will be further explained.

TABLE 9 Overview of the main findings of Study 1 per research question

Study 1: Co-creation of knowledge for innovation
RQ 1: How has the co-creation of knowledge for innovation been investigated in the scholarly literature? – There are relatively few articles (52 after the search, from which 33 were included in the final sample) that match the search and sample criteria. – Most articles investigate the topic from a business angle. – Most of the literature found examines collaboration networks and learning as constructed through interaction. – The main perspectives presented in the literature are open innovation, living labs, new service development, the project context and the process context. – In the body of literature, four categories of co-creation networks were identified. RQ 2: What end-user roles are discussed in the literature? – The four categories of co-creation networks that were discussed relate to the types of stakeholders involved. – Scholars emphasised that end-user participation needs to be strategically structured and facilitated. – The roles fulfilled by stakeholders are contemplated as fluid and open to change. – In networks, value is created through stakeholder participation. RQ3: What characteristics and challenges of end-user participation are mentioned in the literature? – Co-creative development is a complex and interactive organisational learning process. – Co-creation is a process over time by which longer relationships are considered to enhance more interaction and trust building and, thus, more innovative outcomes. – Change and development need new thinking from the actors involved to understand multiple perspectives, different values and possibly conflicting individual aims. – One challenge noted is to have appropriate open innovation and cooperation tools to support the network. – Based on the findings, there seems to be related elements in the process of value co-creation in networks.

A total of 52 articles were found to match the search criteria, and the final sample was further narrowed down for relevance to include 33 articles. Many of these reported from a business viewpoint.

The perspectives presented in the literature are, for example, open innovation, living labs, new service development, the project context and the process context. In the literature, various kinds of co-creation networks are discussed. According to the study, these can be grouped into the following four categories.

– *Co-creation benefitting a single company:*
  Twelve articles discussed projects that only benefit one company. These articles examine service, next to marketing and consumer development for the benefit of that one particular organisation, often with a limited number

of stakeholders, without aiming at a wider societal impact. Because this thesis focuses on projects in which partners share resources for a collaborative goal, these articles were not analysed further and were just used for background information.

- *Co-creation benefitting business-to-business value chain networks:*
  Six articles dealt with innovation networks that include multiple stakeholders who are part of the same value chain. The discussed projects are often initiated and led by a focal company seeking business opportunities.
- *Co-creation benefitting public entities:*
  Eleven articles discuss innovation networks that have multiple stakeholders, but the projects discussed often mainly function for one focal public lead entity, such as a municipality.
- *Co-creation benefitting innovation network stakeholders:*
  Four articles were found to deal with innovation networks, in which a project is used by a diverse group of stakeholders that aim at a common development goal.

The terms used in the sample articles varied. This research uses the term network when there are communication and input exchange between more than two actors and the term project when a there is decision to share resources for a collaborative aim. Thus, the innovation projects that form the context of the research include planned tasks and given periods of duration, while other co-creation networks may not.

Moreover, the results indicate that co-creation initiatives may evolve and move between the above categories, depending on the nature and outcomes of the collaboration process. The literature envisions co-creative development in an innovation network as a complex (inter-)organisational learning process requiring intensive interaction. Thus, change and development benefit from new thinking, such as understanding multiple perspectives, values and individual aims. This study also showed that, in the literature, end-user participation is considered an activity which needs to be strategically structured by the organisation driving the innovation project. Both collaboration and learning in the innovation networks are construed as constructed in interaction, while exchanging insights and experiences. Scholars depict the roles of stakeholders as fluid and constantly changing. End-users may participate in various ways, including also being active in research.

Co-creation is further conceptualised as an evolving process. When relationships mature for a longer time, this enables more interaction and building of trust which, in turn, supports more innovative outcomes. A challenge that was noted is having appropriate open innovation and cooperation tools to facilitate the exchange of insights and experiences.

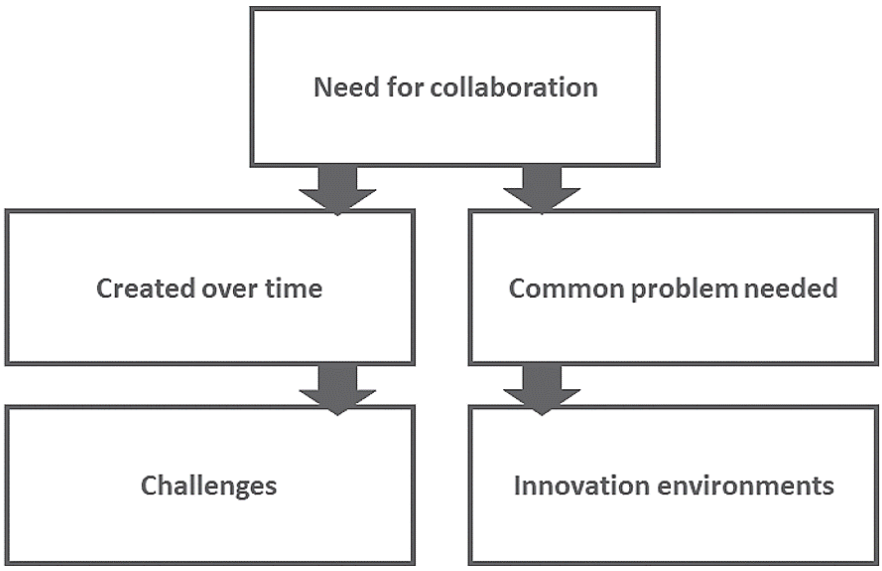


FIGURE 5 Related elements of co-creation networks

As Figure 5 demonstrates (further explained in paper I), the instigating element for networks aiming at innovation through the co-creation of knowledge is the mutual need for collaboration. When the need for collaboration is in place, the multiple stakeholders in the network are more likely to engage in open interaction and trust building. Partners need to collaborate to define a common problem and guide their efforts. Open innovation environments facilitate user-driven innovation based on this common objective. Cooperation platforms facilitate active stakeholder participation fostering knowledge sharing and co-creative innovation. Active stakeholder participation, thus, stems from common goals that promise benefits for all actors, driving the co-creation of knowledge, innovation and change. Therefore, the sample literature revealed that the co-creation of knowledge for innovation begins with an awareness of the need for collaboration by various stakeholders and an acknowledgement of a common problem.

Moreover, there are challenges to manage in an innovation network, as the stakeholders need to be actively engaged throughout the project, and this requires an investment in resources on three levels: project management, common processes and people. Furthermore, the co-creation process takes place over a period of time, and stakeholder roles are constantly changing during the collaboration period.

4.2 Study 2

Study 2 investigates the involvement of actors in creating a co-creation network for knowledge and information sharing. This study shows the need to delve deeper into the participation of end-users and other actors in collaboration networks, aiming for the co-creation of knowledge and innovation.

The paper included in this study, "A co-created network community for knowledge and innovations – Promoting safety and security in the Arctic", is written more as a position paper than a research paper, although it is precise in its description of the complex collaboration involved. Its argumentation is based on data collected in meetings, discussions and workshops, where the need was discussed to create an active network of academic collaboration to fill the existing void in co-creating innovations to benefit the safety and security of the Arctic domain. Here, the attention is placed on the research question, clarifying the diversity of the collaboration involved and, in this way, contributing to the thesis's framework.

TABLE 10 Overview of the main findings of Study 2 per research question

Study 2: Co-creating a collaboration network
RQ 1: What diversity of actors was engaged in the co-creation network for knowledge and information sharing in the case project on safety and security in the Arctic? – In the case project, a large group of diverse actors was engaged, which resulted in the demonstrated need for more elaborate structures of coordination. – During the project, four types of collaboration networks (policymakers, research and development institutions, authorities and practitioners operating in the Arctic) were engaged in complex mutual collaboration. – The demonstrated complexity is revealed in the need for more communication and new forms of cooperation for cross-sectoral and cross-regional research and development (in this case, concerning situational awareness, risk pictures and capacity pooling). – Results demonstrate that end-user participation is hampered if there is a lack of cross-sectoral communication.

In the case project on safety and security in the Arctic, a group consisting of many diverse actors was engaged in modelling new solutions for Arctic collaboration. This illustrated a lack of and need for more elaborate coordination structures. Thus, a proposal was made for a co-created network community aiming at knowledge and innovations for Arctic safety and security. The case project involved 16 encounters with representatives of multiple organisations with very diverse backgrounds. In fact, all of these organisations comprised various layers of collaboration networks engaged in complex collaboration to promote safety and security in the Arctic:

– Arctic Policy for Safety and Security
– Research and Development for Safety and Security in the Arctic
– Cooperation between Authorities for Safety and Security in the Arctic
– Safety and Security Preparedness of those operating in the Arctic.

Thus, the project engaged four levels of collaboration networks. On the first level, policymaker guidelines and representatives of the Arctic Council and International Maritime Organisation were consulted. On the second level, research and development community representatives were engaged. On the third level, end-user authorities were included in the co-creation process to contribute to a safer,

more secure Arctic domain. Finally, on the fourth level, practitioners operating in the Arctic also were engaged.

Representatives from all these levels of collaboration networks were engaged in complex mutual collaboration to develop insights on sustainable economic growth and best practices for increased situational awareness to support decision making for the benefit of the Arctic. These stakeholder organisations were asked to co-creatively model new solutions for a co-created network community for knowledge and innovations, while probing their interest in its practical development and their active participation in it.

On the highest political level, the Arctic nations agree on policies and practices, based on which actors on the level of the research and development community can innovate solutions. Simultaneously, on the authority level, actors can design and model cooperation for information sharing and joint activities. Finally, on the practitioner level, each operator present in the Arctic region should be prepared to help themselves, as assistance is always far away.

The existing coordination structures, such as the Arctic Council, networks of researchers and the Coast Guard cooperation network on Arctic research and development actions were not considered sufficiently comprehensive. The project attempted to model a new solution for creating wider knowledge exchange through an Arctic co-creation network community comprising all sectors involved in working towards a safe and secure Arctic domain. This cross-sectoral network would complement the existing forms of cooperation between coast guards and other authorities in the Arctic maritime domain. The network would include educational institutes with programmes on coast guard activities and related safety, security or maritime issues. Also included would be a multidisciplinary platform for information exchange by indivi-dual students and researchers interested in the security and safety of transport or human and economic activity in the Arctic environment. This could enhance long-term information and knowledge sharing, unlike the many currently existing scattered and unlinked programmes and systems.

The results demonstrate a need for cross-sectoral and cross-regional communication to support new forms of cooperation for increased situational awareness, more accurate risk pictures and more efficient resource pooling. End-user collaboration in these areas, aimed at preparing for disaster mitigation, actually can be greatly hampered by a lack of cross-sectoral and cross-regional communication.

This study's results provide insight into the challenges of projects that include several participants from various sectors and the complexity of the related innovation network to solve the heightened need for communication between many stakeholders on four levels of collaboration, all wanting to make the Arctic safer and more secure.

4.3 Study 3

Study 3 targets end-user scenarios and the involvement of end-users in setting the requirements for a complex common cyber-physical information-sharing system. In this case, it is a common information-sharing system in the maritime domain. The study relates to the input phase of project communication, in particular, communication to clarify the project's requirements. The study draws data from case and scenario narratives from four EU-funded projects: PERSEUS, CoopP, EUCISE2020 and MARISA.

The published paper, "End-users co-create shared information for a more complete real-time maritime picture", examines a case of a cooperation platform and its facilitation, namely, the European Common Information Sharing Environment (CISE). Here, the focus is those research questions that contribute to the thesis's shell. For each research question Table 11 provides an overview of the findings that are relevant to this thesis.

TABLE 11 Overview of the main findings of Study 3 per research question

Study 3: Involving end-users in setting requirements
RQ 1: What are the views on involving end-users in setting requirements for a complex maritime collaboration system in the case projects? – The four interconnected project consortia (PERSEUS, CoopP, EUCISE 2020 and MARISA) considered end-user involvement indispensable for setting requirements. They actively involved their end-user community stakeholders in the co-creation of the maritime collaboration system CISE. – A total of 94 scenarios have been developed with end-users to identify requirements. Five of these have been selected for closer study. – End-user requirements can be categorised based on the type of end-user activity; in this study, five categories are based on the EU Coast Guard Functions framework. – End-user involvement through complex collaboration has the potential to reach a deeper form of co-creation, enabling the network of collaboration actors to yield more value and faster innovation. RQ 2: How are scenarios used to identify end-user needs in innovation projects? – Requirements for the maritime collaboration system CISE are derived from scenarios that present practical use cases of information sharing between maritime surveillance and response authorities. – A total of 94 scenarios have been developed with end-users to set requirements for the CISE collaboration system. – Scenarios were used to identify and confirm end-user requirements related to the needs of end-users for a more accurate maritime picture, risk assessment, asset and operations planning and the sharing of resources. – Risk and threat scenarios should be constantly evaluated and updated with end-users, because end-user requirements change.

Study 3 finds that a continuum of four interconnected project consortia – PERSEUS, CoopP, EUCISE 2020 and MARISA – deemed end-user involvement necessary for setting requirements. They actively involved end-user organisations to clarify end-user needs for a Common Information Sharing Environment (CISE), an elaborate Europe-wide collaboration system for sharing maritime information. To identify such requirements and validate the work of the then-still ongoing two projects, EUCISE 2020 and MARISA, a total of 94 scenarios of use cases have been developed, and an end-user community was established. Study 3 demonstrates that the end-user requirements can be categorised based on the type of end-user activities. For example, in this study, the EU Coast Guard Functions framework was combined into five categories of similar end-user requirements for maritime information sharing.

This researcher also wanted to find how scenarios can be used to confirm end-user requirements in funded projects. The results depict how the requirements for the data fusion of the maritime collaboration system CISE were derived from the 94 scenarios, which were developed in collaboration with end-users. The data for Study 3 were collected from these scenarios. This study uses the data collected from these scenarios of practical use cases to identify and confirm the end-user requirements for the objects and phenomena that end-users need for a more accurate maritime picture, including risk assessment, asset and operations planning and the sharing of resources.

Moreover, Study 3 demonstrates that risk and threat scenarios must be constantly evaluated and revised, as activities in the maritime domain evolve and, consequently, end-user requirements change. This evaluation and revision process is, according to the results, best done in close co-creative collaboration with end-users. When collaboration becomes more complex, it has the potential to reach a deeper form of co-creation, enabling the network of collaboration actors to yield more value and innovation. Faster and widely shared information, in this case, can be seen as a driver of value and innovation. Identifying these very practical user needs can serve as the basis for the further technical development of CISE. The findings of Study 3 can serve the continuing work in EUCISE 2020 and MARISA on an EU-wide scale and, similarly, projects such as FINCISE on a national level.

Furthermore, the results indicate that using case and scenario narratives helped understand how the case project could promote the sharing of common information for a more accurate maritime picture. The results also showed how opportunities can be identified by mapping end-user processes and practices through co-creative encounters that allow the project and its end-users to create value through interactions. The scenarios in this study serve to bridge technical and human aspects of information sharing, and this depicts how co-creative collaboration end-user needs can be transferred to end-user requirements for innovation projects, ensuring that the innovation project targets end-user needs.

4.4 Study 4

Study 4 scrutinises the resilience of network collaboration, examining cases of the resilience of systems that operate as critical infrastructure for society, such as the Common Information Sharing Environment developed by MARISA, EUCISE 2020 and CoopP. It discusses the social level of communication and the organisational structures of these infrastructure systems.

The published paper "Educational competences with regard to resilience of critical infrastructure" offers a model for understanding the resilience of systems that operate as critical infrastructure to society and discusses the inclusion of related aspects of resilience in higher education programmes. Here, the attention is on those research questions that contribute to the thesis's framework.

TABLE 12 Overview of the main findings of Study 4 per research question

Study 4: Resilient collaboration in multi-stakeholder innovation networks
RQ 1: What are the views on resilience in a collaboration network of the case project on complex integrated cyber-physical systems? – The preparation phase is emphasised, as it creates a basis for the ability to absorb incidents and recover from them; the adaption phase provides feedback, making the process cyclical. – Collaborative crisis management can enable an organisation to sustain and resume operations, whereas increased collaboration is considered to provide faster detection, assessment, planning and response to increase system resilience. – Active leadership and facilitation enable the greater resiliency of social networks. – A clear situational picture enables the consideration of changes in the environment, whereas shared real-time information exchange adds to overall resilience. – Exercises were found useful to activate users to share information and stay active.
RQ 2: According to the project partners, how can the resilience of collaboration networks be strengthened? The following matters were mentioned: – A clear, co-created purpose for the network. – Actors' agreed roles. – A common culture and ways of working. – Clear leadership and facilitation of network collaboration and co-creation. – Trust building between stakeholders to enhance open communication. – A system to mitigate the effects of absenteeism and changes in stakeholder representatives. – Flexibility based on a common operational culture within a network. – Employment of crisis event management (such as prepare for, absorb, recover from and adapt to disruptions to become more resilient). – Sharing best practices and prior experiences.

The results of Study 4 indicate that a social network can use the preparation phase to create plans and make other preparations in case of possible disruptive incidents or crises. These activities serve as a basis for the network to be able to absorb the effects of a disruption and retain an adequate level of critical functionalities and activities. Preparations also enhance the network's ability to, as quickly as possible, recover and return to a normal level of collaboration and operation. Finally, the adaptation phase provides feedback that can be used to increase the level of collaborative functions in the network and to lay a basis for a new preparation phase, resulting in an improved plan in case of another incident. The process, hence, becomes cyclical, each time enhancing resilience for another possible disturbance.

This study also reveals that collaborative crisis management enables a network to sustain and resume its operations, as increased collaboration can provide faster detection, assessment, planning and response, all of which increases system resilience. Moreover, active leadership and the facilitation of the collaborative efforts of the social network were seen to enable increased network resilience. A clear situational picture enables the consideration of environmental changes, whereas real-time information exchange helps speed up relevant decision-making processes and adds to overall resilience. Exercises were found to be a useful tool to prepare for possible future events. The results indicate that exercises raise awareness and activate stakeholders to share information and be active within the network.

The results indicate that the resilience of social networks is based on a clear purpose and common aims. Working plans and shared insights gained in the planning phase guide the network in co-creating common ways to work. Resilience is also added by the network stakeholders in having clear roles and responsibilities, which becomes especially important when disruptions occur. Clear roles support a rapid response, if flexibility is also maintained. A common operational culture is considered to support flexibility when facing changing situations and disruptive events.

The results demonstrate that resilience can be better understood concerning the crisis event management phases, such as prepare, absorb, recover, adapt and learn, and self-modify (National Academy of Sciences 2012; Singapore-ETH Centre, 2015). For more depth, these phases can be combined with the domains of cyber-physical systems (CPS) (Alberts 2002). Best practices and prior experiences by critical infrastructure sectors can be used to design and maintain resilient CPS. The study shows that most CPS are considered complex and interconnected. Many industries critical to society, such as finance, energy, communications, transportation and food supply, are becoming increasingly CPS in nature.

The study reveals that open communication between the multiple innovation network stakeholders and the interconnections of other networks is considered to enhance resilience. This, for example, enables the building and maintaining of the shared situational awareness needed for an effective response to disturbances. During the project, partners rely on each other to reach innovation

outcomes. Accordingly, the participants emphasised that stakeholder representatives need a back-up system to cover for the absence of any individual representative. During the preparation phase, the project as a system creates the basis for a resilient process, that is, the ability to mitigate disruptions. In the adaptation phase, the system collects feedback and learns from its experience to further enhance its performance and resilience. Thus, a new preparation phase (forming a new cycle) begins.

Based on the results of this study, it seems that increasing collaboration between network stakeholders affects the depth and quality of planning, while the readiness to absorb disturbances may shorten the time to recover and increase the willingness of the network stakeholders to adapt and learn together.

4.5 Study 5

Study 5 of this thesis attempts to make sense of innovation project collaboration through 10 elements of complexity (Mitleton-Kelly 2003). This study was reported in two papers. Paper Va, "Complexity in project co-creation of knowledge for innovation", offers an understanding of how project participants view complexity and the co-creation of knowledge in innovation projects. In addition, paper Vb, "Complex authority network interactions in the common information sharing environment", also analyses complexity, but it focuses on how a project's level of complexity affects the time needed to achieve innovation. Here, the interest is in those research questions that contribute to the thesis's framework.

TABLE 13 Overview of the main findings of Study 5 per research question

Study 5: Complexity and innovation in multi-stakeholder networks
RQ 1: How does complexity affect the co-creation of knowledge in innovation projects, according to project participants? – All elements of complexity mentioned by Mitleton-Kelly (2003) are considered to affect the co-creation of knowledge in innovation projects and are to some extent present when innovation projects co-create knowledge. The following three elements were emphasised most. – Connectivity and interdependence: Project participants need close collaboration and joint activities to deliver the desired project output and create innovation value. – Self-organisation: Self-organisation processes are deemed important, and expert project partners are mostly intrinsically motivated for project work. – Co-evolution: It is considered important that project partners build trust and find ways of collaborating to deliver the desired results.

RQ 2: How is the time needed to achieve innovation affected by the level of complexity of collaboration networks, according to project participants?

- The time can be shortened from when the consortium partners come together to when the innovations resulting from the project are put to wider use.
- Attaining innovations can be sped up by having clear aims, roles and tasks for all consortium members and enabling parallel work.

The participants mentioned various ways in which complexity affects knowledge co-creation. The following is arranged according to the elements of complexity by Mitleton-Kelly 2003. *Connectivity & interdependence* concerns interrelations among the project participants. The participants stress that, to create innovation value, project participants need close collaboration in joint activities to deliver the desired project output, as planned in work packages and tasks. The results regarding *self-organisation* highlight processes of spontaneous order and that project partners as experts mostly are intrinsically motivated for the project work and, thus, bring expected as well as sometimes unexpected results. *Historicity* relates to the project consortium's partners and other stakeholders having different histories; each individual involved brings her/his own professional and educational background to the project interaction which, according to the participants, influences project consortia in many ways.

Exploration-of-the-space-of-possibilities refers to the flexibility of working and the space to explore and find solutions. The participants note that a project's ability to explore the space of possibilities increases productivity, which in all project consortia depends on the people, their attitudes and their approaches to the project work. *Path dependenc*e concerns prior decisions influencing later new opportunities. This is very visible in innovation projects, where new niches and opportunities are best achieved, according to a participant not just in one project but rather "via a continuum of innovation projects." The results indicate that how project partners work affects a project's ability to create paths for new opportunities.

Feedback helps identify changes needed in how a project is conducted. The participants perceive feedback as positive, even crucial. *Far-from-equilibrium* refers to projects needing major adaptations in fast-changing environments and situations. The participants note that, despite carefully planned project proposals that set specific goals and activities for EU-funded innovation projects, they are not in a state of equilibrium, as the diverse partners act in parallel and influence each other during the project. The project coordinator also affects how consortium partners perform.

Co-evolution is considered important and is seen as partners finding ways of working together, building relationships and trust to generate project results. The results emphasise that it is important for project partners to find ways to collaborate to deliver the innovations promised in the project proposal. According to participants, *emergence* refers to the new results in innovation projects emerging

from the workflow among active consortium partners, including ideas and innovative ways of working together. End-user experiences and using the potential of the extended networks of all consortium partners are seen as especially important to achieving project results. Innovation necessitates the active sharing of information between partners and being open to input both from within and from outside the project consortium.

The creation of new order becomes visible when an impact beyond the project is created. The participants note that the projects have resulted in new project continuums, networks, associations and businesses created based on project outcomes.

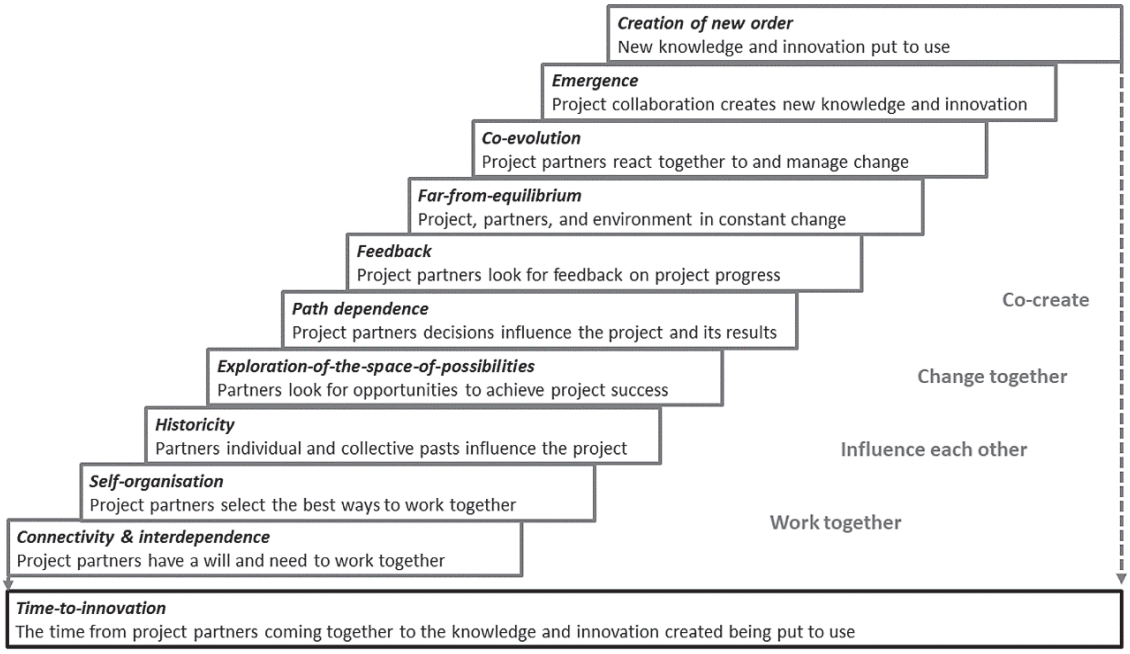


FIGURE 6 The elements of complexity (Mitleton-Kelly 2003) applied to funded projects

Based on the results of the study, Figure 6 depicts the elements of complexity (Mitleton-Kelly 2003) applied to funded projects and arranged according to time-to-innovation. Thus, the first collaboration will offer an opportunity to influence one another, promote change together and, finally, co-create new knowledge and innovation. The figure infers that there is an order in which a project could approach these elements, taking all elements into account to shorten the time needed to reach innovation.

For Study 5b, narratives were analysed focusing on time-to-innovation. The paper further illustrates what complexity means for projects. In the case, the use of case and scenario narratives supported the engagement of end-users in the co-creation process. These descriptions are a way to gain information from situations that end-users encounter. The MARISA user community provides an example of a shared forum for enhancing cross-sector, cross-border and cross-authority exchanges of information, even resources. The community also functions as an issue arena where practical, legal and ethical issues are discussed and actors

co-creatively define and refine relevant use cases. The results show that knowledge is developed collaboratively, requiring close interaction between the actors, which may even include resource integration and the usage of common capacities to reach common goals faster.

In the case of funded projects, time-to-innovation can be understood as the time from when the consortium partners come together to when the innovations resulting from the project are put to wider use. The idea behind the projects is that time-to-innovation can be shortened when multiple stakeholders work together to generate new knowledge for innovation and create new project ideas to pursue. The results highlight that time-to-innovation can be positively affected by complexity involving the engagement of diverse partners, whereas the time needed for innovation can be shortened considerably by having clear aims, roles and tasks for all consortium members and by enabling parallel work.

4.6 Study 6

Study 6 examines the output phase of projects, focusing on communication and dissemination in multi-stakeholder research projects. Three cases of EU-funded projects are studied, exploring the external communication and dissemination of project objectives, results and activities in ABC4EU, IECEU and GAP. The study targets the planning and evaluation of external communication.

The paper "Opportunities for Strategic Public Relations – Evaluation of International Research and Innovation Project Dissemination" addresses external communication and dissemination according to the requirements of the funding instrument. The publisher preferred the term public relations, while in this thesis, attention is placed on project communication. Here, the focus is on those research questions that contribute to the thesis's shell.

TABLE 14 Overview of the main findings of Study 6 per research question

Study 6: Dissemination by multi-stakeholder projects
RQ 1: How are external communication and dissemination conducted in case projects? – There is co-creative collaboration between communication practitioners, researchers and developers that supports the reaching of dissemination objectives. – External communication and dissemination take place through activities and the materials made. – Activities aim at project visibility and the application of its results. – The case projects attempt to create user networks that grow over time. These networks are urged to remain active after the project has ended. – Traditional means in case projects include press releases, newsletters, publications, workshops and conferences. – Feedback and learning from evaluations supported reaching dissemination objectives.

- An evaluation framework for external communication and dissemination activities was adopted.
- Results indicate that the practitioners involved were mainly security managers, with a noticeable lack of communication practitioners.

RQ 2: How do the external communication and dissemination of the case projects support the functioning of these projects, while addressing the requirements of the funding instrument?

- External communication and dissemination support the project with comprehensive visibility among key stakeholders (end-users, policymakers, academics and the wider public).
- Awareness of communication value and the availability of tools (such as a media-action matrix) help activate all project partners to engage in external communication and dissemination activities.
- Media evaluation indicators set early in the project can provide a tool for self-assessment and increased accountability.
- The active use of technology can promote interactive methods.

Notably, there was a lack of coordinating facilitators to support project members to jointly communicate with other partners and other stakeholders outside the project.

The results of Study 6 show that collaboration between communication practitioners, researchers and developers supports reaching the objectives set for external communication and dissemination. This relates to both the activities and materials that, with the activities, aim at increasing the visibility of the project and, more importantly, use of its results. Some traditional means that the case projects have used to reach their audiences include press releases, newsletters, publications, workshops and conferences. As a more current activity, all three case projects attempted to create user networks (called communities). The aim was to let these communities grow over time. Thus, they were urged to remain active even after the projects had ended.

Media evaluation indicators were set early in the project and provided a useful tool, not only for the project consortium, but also for its individual members to self-assess their communication activities and, by doing so, be accountable. The project GAP, for example, applied a framework to evaluate its external communication and dissemination activities. This supported reaching the dissemination objectives set by the project and, thus, promised to the European Commission.

Study 6 shows that external communication and dissemination can support the project with comprehensive visibility among key stakeholders, such as end-users, policymakers and academics, and similarly among publics. The results indicate that outlining the value of communication and creating tools, such as a media-action matrix that provides an overview of activities, helps activate project partners and stakeholders to engage in external communication and in the dissemination of project results by interactive methods and the active use of collaborative technology.

Based on the study's results, the planning and coordination of dissemination activities is challenging. The process benefits from actively using an evaluation framework. This study compiled a framework that combined elements of the

communication balanced scorecard by Vos and Schoemaker (2004), the quality cycle by Juholin (2010) and dimensions for communication domains by Palttala and Vos (2012).

Furthermore, the participants revealed that the practitioners involved in all three of these case projects were mainly security managers and that there is room to include more expertise provided by communication practitioners. For external communication and dissemination, the case projects used their respective project structures to involve the networks and expertise of all participants in producing content for press releases, newsletters, publications and social media feeds. According to the results of this study, coordinating facilitators in every partner organisation could further motivate and support the project members in communicating with other partners and actors outside the project. New knowledge on how to implement such ideas can be generated together, co-creatively combining the different skills and knowledge of individuals. The study suggests a process through which facilitators monitor the external communication and dissemination activities of their organisation and ensure that periodic reporting is timely, according to dissemination plans and guidelines. The facilitator team that they form together can then co-create further innovative ways to interact with and motivate communities of end-users to engage in project activities and gain feedback for the project.

All of the six studies contribute to the overall research problem, looking at multi-actor communication and end-user participation in complex innovation project contexts from the four theoretical perspectives that were discussed in section 2. Study 1 served as a basis, whereas Studies 2 to 6 provided empirical data concerning input, throughput, or output communication of funded projects. Where two studies addressed input communication, the first looked at multi-actor communication (primarily illustrating the large number of network participants), while the second focused on end-user participation, strongly contributing to the research. Where two studies addressed throughput communication, the first centred on resilience and the second on complexity, using a different project context. In the case of one study consisting of two sub studies (5a and 5b), the second added the aspect of time-to-innovation, also bringing a context of different projects. Some overlap in the studies was beneficial for the coherence of the thesis. The papers often had a wider content, as they also served different projects and other co-authors. Here, those elements of the papers have been utilised that served the central research problem and research questions as outlined in this thesis.

5 DISCUSSION

In this chapter, the findings of studies are discussed relating to one another. Section 5.1 evaluates the findings in light of the theoretical approaches described earlier in Chapter 2. Based on the findings of the six studies of this thesis, section 5.2 proposes a model for further understanding co-creation for innovation.

5.1 Evaluating results with viewpoints of theoretical approaches

This section first evaluates the results of the six studies of this thesis as they pertain to understanding knowledge co-creation for innovation in funded projects from the viewpoint of multi-stakeholder communication, focusing particularly on communication with and the participation of end-users.

The results show that the co-creation of knowledge forms the basis for innovation in multi-stakeholder projects. The investigated projects function as innovation networks co-creating knowledge in development processes. Simultaneously, they strive for resilience of the complex social networks.

The research utilised four complementary theoretical approaches, as described in section 2.5: the co-creation of knowledge, innovation networks, knowledge development processes and the resilience of complex social networks. Each of the six individual studies was conducted to gain understanding concerning the overall research problem, departing from its own research questions. The findings are now brought together by looking at project communication through the four theoretical approaches, that serve as lenses for the evaluation.

The theoretical approach of the *co-creation of knowledge* invited the investigation of interactions among multiple stakeholders that may have different interests. In studies 1, 2, 3 and 5, it was noted how the projects involved purposely aimed at co-creating knowledge. This included open communication and collaboration between various project partners and, to some extent, even more networks to which they belonged. This line of study is important, because knowledge, innovation and creativity are noted in the literature as a source of

competitive advantage (e.g. Bagayogo et al. 2014, Pirinen 2015). Collaboration and learning were constructed through interaction. Thus, the diverse actors involved became engaged in modelling the new solutions needed to achieve the development called for in all of the case projects studied. This is noted in the literature by, for example, Gustafsson, Kristensson and Witell (2012), who write that co-creation involves communication and interaction.

Study 1 discussed how the mutual need for collaboration sparked the co-creation of knowledge. Collaboration engages multiple networks' stakeholders in open interaction and trust building. Partners collaborate to define the common problem that guides their efforts. Most sample articles of Study 1 investigated the topic from a business perspective. Based on insights gained from the sample literature, new knowledge and learning in collaboration networks are constructed in interaction, and this principle can be extended to innovation projects.

Studies 1, 2 and 3 identified communication that actively involved end-users in setting requirements for issues such as achieving common awareness. For example, the case of Study 2 aimed at understanding how increased collaboration was intended to make the Arctic safer and more secure, whereas Study 3 highlighted how end-user scenarios were used to identify requirements. It suggested a categorisation of scenarios according to the type of end-user activity to classify the practical activities that end-users perform for engagement in the maritime domain (using the European Union Coast Guard Functions framework). End-users had an important contribution to the project collaboration and needed to be firmly included in project communication.

Studies 2 and 3 illustrated that real-time, faster information exchange enables the development of shared knowledge. This, in turn, opens the potential to reach deeper forms of knowledge co-creation for innovation. In Study 3, exercises were shown to provide a way to raise awareness and activate network stakeholders to engage in communication. This was similar to notions in the literature (e.g. Taatila et al. 2006) highlighting the importance of individuals serving as innovators.

The case projects in Study 3 indicated that end-user scenarios are useful in identifying end-user requirements for information-sharing processes that, in this case, helped build a more accurate maritime picture for the many European stakeholders involved both in cross-sector and cross-border interaction. In the case projects, end-user participation is shown as an activity benefitting from a strategic approach and structure. Similarly, the literature (e.g. Payne, Storbacka & Frow 2008, Miettinen & Koivisto 2009) suggests collaborating with end-users by mapping their processes and practices to find new ways to co-create value.

Together, the studies demonstrate that using innovation and collaboration tools for project communication with active process facilitation and stakeholder motivation helps achieve common goals faster. However, this can be challenging due to conflicting stakeholder interests. For user-driven innovation in open innovation environments, it is key to actively engage all stakeholders. The literature also notes that stakeholders learn from interactions with one another when co-

creating knowledge, which is a considered a learned activity that requires mutual trust (e.g. Engeström 2004, Cook & Brown 1999, Tikanmäki & Ruoslahti 2017).

The theoretical approach of *innovation networks* invited the study of the roles and interrelations of project actors. The results of studies 1, 2, 4, 5 and 6 of this thesis point at the strong interconnections between the actors in the project network. The collaboration between the actors involved in the various categories of co-creation networks can offer new thinking, leading to development and change. There are, however, multiple perspectives, even conflicting individual aims. Simultaneously, actors' roles are changing during the project. These studies show that many diverse actors are engaged in modelling new solutions and in co-creating value and innovations.

In the literature, related insights were discussed. Roloff (2008), for example, comments that a multi-stakeholder network can be considered an organisational structure of voluntary participation in which participants negotiate objectives and actions. Furthermore, Engeström and Kerosuo (2007) note that alliances and partnerships between organisations are important for exchanging information and networked inter-organisational learning. Study 1 shows that innovation networks take form through the active participation of multiple actors with roles constructed through interaction.

Networks serve to activate a wider knowledge exchange. In Study 2, this speaks to the need for more elaborate Arctic network structures for coordination. In the case project, this resulted in proposing a broad network community for knowledge and innovation, including active participation from different stakeholder networks of practitioners, authorities, academics and policymakers to collaborate on issues improving safety and security in the Arctic. Study 2 finds that existing Arctic coordination structures are scattered and unlinked, whereas new forms of interlinked Arctic cooperation systems and programmes help tackle this problem.

Mapping user processes and practices can be helpful in finding new ways to support threat assessment, asset planning and resource sharing. These can then be transferred to end-user requirements for further innovation goals and projects. This is similar to discussions in the literature (e.g. Bhalla 2014) on establishing ways to unify actor interests and harness creativity. Study 1 identified the need for facilitation by collaborative technology such as open innovation platforms, which help foster knowledge sharing and co-creative innovation.

Studies 1, 2, 3 and 5 demonstrate that value co-creation results from complex network interactions and resource integration between value network actors, as also noted in the literature (e.g. Pinho et al. 2014). Formal process frameworks, such as open innovation, living labs and new service design, can be useful to arrange end-user input and engage actors to actively participate in the throughput and output communication that is part of project activities.

Study 4 shows how innovation networks can benefit from a clear, shared innovation purpose for the network. This helps identify and agree on roles for the actors, views on network leadership and the facilitation of network collabo-

ration. The results indicate that engagement originates from acknowledged benefits for the project partners involved. This drives development and change within the innovation network.

The approach of *knowledge development processes* invited the investigation of developments over time in the various project phases. Studies 1, 3, 4 and 6 of this thesis revealed that development processes in a cross-sectoral network with a great many participants (e.g. EUCISE2020 and MARISA) need a clear structure to coordinate the exchange of insights and experiences on which the knowledge development for innovation is built. Multi-stakeholder projects can be considered knowledge development processes supported by input, throughput and output communication. Communication helps engage stakeholders and strengthen relationships, both of which is needed in collaboration processes. This was also discussed in the literature. For example, DeFillippi and Roser (2014) write that co-creation that includes the deep engagement of actors in innovation is a phased process.

Innovation projects especially benefit from collaboration with relevant end-users in all project phases when setting and validating user requirements (input communication), ensuring faster information exchange (throughput communication) and arranging efficient dissemination (output communication). In the projects investigated, co-creative collaboration with end-user communities was considered indispensable to identify user requirements and to validate the resulting innovation work to fulfil them. Increasing collaboration throughout the project duration and beyond is considered the goal of user community processes in all case projects studied. This entails continuously encouraging stakeholder involvement in the project, including arranging external communication targeted at various audiences, such as end-users, academia, industry and even the general public.

In Study 3, the case projects investigated assess input communication through five scenarios selected by project MARISA from 94 scenarios produced by case project CoopP. These were studied against the EUCGF framework. Taking the effort of identifying practical user needs served as the basis for the development of the case projects.

The throughput phase is most visible in all six studies, a notion in line with the literature (e.g. Bhalla 2014, Buijs, Smulders & van der Meer 2009, Pichyangkul, Nuttavuthisit & Israsena 2012, Schertzer, Schertzer & Dwyer 2013), noting the need for processes with investments in time, project management and people to deliver innovations. Organisational learning evolves as a complex process and includes collaborative functions and formal plans that are improved throughout projects' duration.

Study 6 demonstrates how evaluation and revision processes provide feedback to reshape the innovation process, potentially making collaboration more complex but also offering faster results. Monitoring activities can provide feedback to determine how investments in resources (e.g. for project management and common processes) are yielding a return according to the requirements and expectations of the funding instrument. Arranging feedback can be considered

output communication brought back to the process to serve as input for the future, quite like in the literature where, for example, Vos and Schoemaker (2004) write that communication process phases form interrelated activities.

Moreover, the results of Study 6 indicate that reaching objectives for external communication requires that, preferably, all partners participate in engaging stakeholders and, for example, produce relevant dissemination materials. The development of interactive methods, media evaluation indicators set at an early stage and tools like media action matrixes were shown to be useful in activating stakeholders to support the media values of case projects.

Furthermore, Study 6 depicts how actively engaging in output communication can increase the visibility of a project and its results. The study finds a lack of including communication practitioners of the project partners when engaging stakeholders in producing press releases, newsletters, publications, social media feeds etc.

The approach of *resilience of social networks* invited the study of complex collaboration, noting flexibility in a turbulent context, as was explored in studies 4 and 6. For this, Study 4 noted that crisis management is ideally a collaborative effort in which network stakeholders face a disruption together. Subsequently, they adapt and learn from their experiences together. This relates to working toward a more resilient innovation process. A clear situational picture notices changes that occur in the environment and helps form decision-making processes that add resilience. The project having a very clear purpose and clear stakeholder roles and responsibilities becomes very important when disruptions occur.

The results of studies 4 and 6 reveal that organisational environments are complex, changing and characterised by interrelated risks. Similar matters are discussed in the literature by authors such as Linkov et al. (2013), Mitleton-Kelly (2003) and Vos (2017). Study 4 reveals that, in the context of case projects, for example, exercises prepare for possible events. This study also confirms the importance of (re-)defining common aims for project partners throughout the project. These partners are all looking at the network to deliver some form of value or benefit to their organisations in a changing environment. This is a reason for them to participate in network activities and what motivates them to take active roles in shaping the network and its outcomes.

The attributes identified in Study 4 for resilience in network collaboration reveal that a good starting point is the co-creation of a clear purpose and common aims for the network. Network resilience is also affected by the level of organisation; that is, stakeholders and individuals acting as stakeholder representatives know their respective roles within the network. This is especially important if a disturbance or crisis occurs and timely decisions and responses are needed. Leadership and the facilitation of collaboration promote resilience, as do common ways of working. Open communication and information sharing help create a common culture and build trust among network stakeholders. Trust among stakeholders enhances flexibility when facing disturbances and promotes the sharing of experiences.

There are noted benefits of involving expertise from all stakeholders and, when possible, including those from multiple stakeholders' respective networks. When possible or needed, it is also beneficial to involve expertise from outside the network. The literature on a system's view of organisation emphasises such relationships and interdependencies (e.g. Grunig, Grunig & Ehling 1992, Linkov et al. 2013) and, thus, may help recognise the importance of resilience in subsystems and across system boundaries. The aim is to enable resilient knowledge development and innovation in these complex network settings. These findings seem to be in line with literature. Hautamäki (2010) and Pichyangkul, Nuttavuthisit and Israsena (2012) note that innovation ecosystems may need to deal with unforeseen disruptive changes, requiring agility when developing knowledge in a resilient way. This includes both organisational resilience and the resilience of collaboration and knowledge exchange between the network's actors (do Nascimento Souto 2013). The findings suggest that prior experiences can be collected and used to co-creatively design and maintain network resilience. The preparation for possibly disruptive events or crises affects a network's ability to absorb and recover from the effects of these events by retaining and re-establishing a level of critical functionalities. Thus, these crisis management cycles help better understand resilience and prepare for events that may test it, a notion also seen in the literature (e.g. Linkov et al. 2013).

Multi-stakeholder projects can be investigated from the context of complex social networks that strive to achieve common goals and gain resilience in a turbulent environment. Active stakeholder participation throughout the duration of a project can be a major asset – and difficult to achieve. Study 5 depicts that co-creative methods (such as project events, intensive workshops and digital platforms) are considered to enhance system resilience and provide an effective response to disturbances. Studies 4 and 6 show that project collaboration can go beyond the project horizon, as projects focus on the promotion of the common goals of the partners and others involved and that case projects, in making their work and results known, make active efforts to grow their user communities and maintain them even after case projects have terminated.

In summary, the following table (Table 15) lists insights on funded projects from the perspective of theoretical approaches, all gained based on the findings of all six studies that form the empirical work of this doctoral thesis.

TABLE 15 Overview of main findings per theoretical approach

Co-creation of knowledge:
– Co-creation occurs through intensive interaction between multiple project partners, resembling arena discourse where agendas are negotiated and insights shared.
– According to the partners, this requires actively enhancing relationships and building trust, whereas diverse backgrounds and interests should be acknowledged.
– The partners emphasise that project interaction needs to be geared toward a collaboratively defined common problem.
Innovation networks:
– A large number of diverse participants is beneficial to gain comprehensive input for faster innovation.
– Knowledge exchange is easily hampered by a lack of structures and expertise to arrange project communication.
– The necessity of facilitating information exchange for development is often underestimated.
Knowledge development processes:
– Multi-stakeholder projects can be seen as knowledge development processes, showing input, throughput and output communication.
– Projects need attention for varying participation strategies during project phases.
– End-user input is important in all project phases but takes other forms over time.
Resilience of complex social networks:
– Projects and project communication need agility to face changing circumstances.
– Vulnerabilities are acknowledged when addressing interdependencies and risks in complex projects.
– Project partners expect to discuss possible disruptions and changes that may affect their future functioning.

Many insights gained are in line with the earlier literature. However, now, they have been brought together and focus on funded projects. Moreover, the evolving partner roles and versatile contributions of end-users are emphasised. It is challenging to engage multiple stakeholders throughout projects, and it requires attention to communication in all project phases. Increased complexity with the broader participation of stakeholder groups can help to reach innovations faster. The innovation development process be-nefits from structures and facilitation by, for example, digital platforms for information exchange and virtual labs. As projects function in a changing context where disturbances occur, this requires attention to network resilience.

5.2 Proposed model for complex multi-actor cooperation for innovation

The findings of all six studies of this thesis highlight the need for collaboration and the role of communication when co-creating knowledge. Co-creation networks that engage in open communication and trust building foster knowledge sharing and co-creative innovation, for which common development goals serve as the basis. An overview of the insights gained can be seen below in Figure 7, compiled based on the literature consulted and the studies conducted for this thesis.

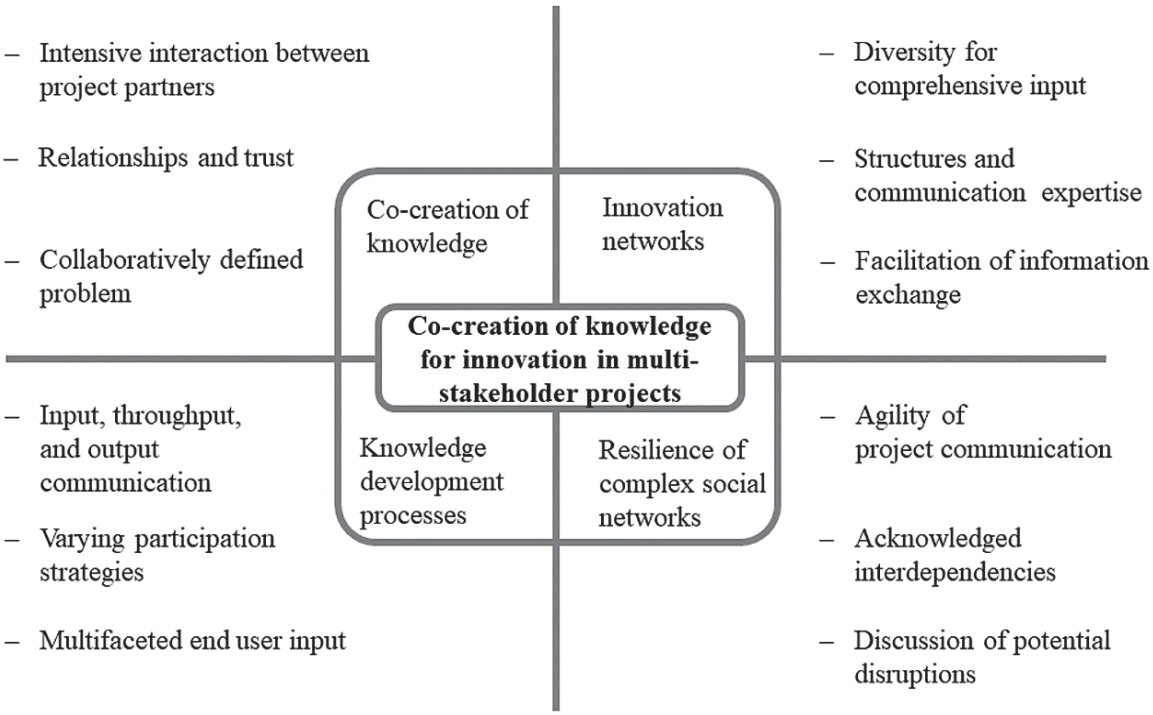


FIGURE 7 Model depicting the insights gained on the co-creation of knowledge for innovation in multi-stakeholder projects

The insights discussed in section 5.1 and summarised in Figure 7 above provide a framework for understanding the co-creation of knowledge for innovation in multi-stakeholder projects. From the perspective of the *co-creation of knowledge,* intensive interaction among many diverse actors is emphasised, enhancing relationships and trust to collaboratively define a common problem that will motivate all project partners to work towards it. *Innovation networks*, as a viewpoint, highlights the diversity needed to come to comprehensive solutions, structures and expertise for communication, as well as the robust facilitation of information exchange. The perspective of *knowledge development processes* highlights the importance of input, throughput and output communication, supporting end-user input with an eye for evolving objectives and changing participation strategies.

The *resilience of complex social networks*, as a perspective, acknowledges the need for agile project communication, taking vulnerabilities through interdependencies into account and addressing potential disruptions.

Innovation projects are structures of collaboration in which multiple viewpoints provide new thinking through disparate stakeholder roles and are geared toward a collaboratively defined common problem. This is a complex process identifying opportunities in various phases and end-user requirements through end-user participation, which necessitates strategy, structure and facilitation to promote the open sharing of information. Resilience thinking is being agile with a clear purpose and preparation to absorb and recover from changes and disruptions for a clear situational picture, on which decision making and future orientation can be based.

Input communication in a project context includes, for example, scenarios. They are one form of communicating end-user needs at the beginning of a project. In the projects AIRBEAM (AIRBEAM 2009) and MARISA (Pirinen 2017), scenarios functioned as a tool to communicate end-user situations demonstrating and visualising specific end-user needs.

Throughput communication in a project setting is demonstrated in the normal collaborative work of network stakeholders and the use of expert panels as a form of communication between project consortia and end-users. For example, throughout AIRBEAM, expert panels, called Wise Guys Panels, were periodic forums that included discussions on current topics. Panel participants believed the panels were fruitful, drawing on their collective knowledge. These panels dealt with issues relevant to diverse phases of the project by validating the premises of its main practical demonstrations.

Examples of output communication are forms of project dissemination in the projects ABC4EU, IECEU and MARISA (Study 6) to communicate the aims, progress, results and value of the project to end-users' organisations and wider audiences. One aim of ABC4EU (ABC4EU 2011) has been to closely include end-user opinions throughout the project lifetime and beyond, as well as to spread project knowledge among them. For this, the project dissemination plan included developing an active end-user community. However, security authorities were hesitant to participate in an end-user community, making it rather difficult to extend, focus and manage.

In addition, the resilience of complex social networks deserves more attention. This topic seems to be underrepresented in the scholarly literature. Study 4 finds that the education related to resilient critical infrastructure needs to be both multi-disciplinary and multi-sector. Insights from disciplines such as communication, engineering, resilience management and future scenarios underscore, especially in the field of critical infrastructure, the necessity of a focus on resilience and continuous operations. The study argues that learning to understand frameworks of collaboration and modes of co-creation helps future leaders build more resilient businesses, benefitting societal resilience. When stakeholders learn together, their speed and ability to adapt increase. Hence, the creation of innovations is facilitated more rapidly.

Study 4 notes that many modern industry and security-related networks are increasingly cyber-physical in nature. Through the lens of the system approach, they can be treated as cyber-physical systems. One finding, thus, is that resilience thinking can benefit from understanding the four domains of resilient cyber-physical systems, which are the physical components and environment, the information that is stored and used, the cognitive ways people use this information and the social settings and organisation to which these people belong.

Active, open interaction and collaboration between critical infrastructure stakeholders may result in deeper planning, enhancing the ability of a system (and even a system consisting of multiple sub systems) to absorb and recover. Therefore, to address resilience, higher education programmes may enhance the competencies of future leaders concerning multi-stakeholder communication and the interoperability between organisations. This can contribute to a shift from securing the data and knowledge of just one organisation to collaborating while sharing information and resources between the multiple stakeholders involved.

The case projects of Study 6 demonstrate a lack of facilitation to support the project coordinator responsible for project reporting, according to the funding instrument. The experiences in the three case projects of Study 6 support the notion "that it is important that partners agree to jointly cooperate on external communication and dissemination activities, and to understand how vital these activities are for the success of the project" (Henriksson, Ruoslahti & Hyttinen 2018, p. 211).

A resilience process is shown to be cyclical in that feedback from events serves as input for future planning and actions to absorb and recover from disruptions. The preparation phase provides plans to better cope with disruptions during the absorption and recovery phases, whereas the adaption phase provides the feedback and learning from experiences to be used during a subsequent preparation phase. At its best, the resilience process is also a co-creation process. Thus, it benefits from having active leadership and facilitation of the collaboration efforts that help co-create joint working plans, guidelines and standards, including clarity concerning stakeholder roles and a system to back up absentee stakeholder representatives. Study 6 reveals that many stakeholders tend to remain passive in the dissemination phase, which challenges the coordination of communication activities in this phase. The process benefits from having built-in evaluation and feedback facilitation to motivate and support stakeholders in remaining active throughout the project.

In summary, the model in Figure 7 provides a framework to understand the co-creation of knowledge for innovation in multi-stakeholder projects from a communication perspective. It illustrates that multiple actors join in an innovation project, together forming a network to create new knowledge through an evolving process, with an eye for changing circumstances. Thus, it highlights aspects characterising the process of knowledge development for innovation. By enhancing the understanding of the complexities faced by funded projects, it also

indicates areas with potential problems or opportunities for communication to strengthen collaboration.

By understanding the meaning of end-user input, it is recognised that end-user roles change over time, which mandates increased attention throughout the project. Similarly, by understanding the intensity of the collaboration needed between multiple actors, or even networks of actors, with various kinds of input, it becomes clear that there needs to be an eye for potential conflicts as well as opportunities, and strong facilitation of the sharing of insights and experiences to reach deep levels of co-creation. To have an impact beyond the project participants, addressing the social context of a project requires co-creative efforts that also go beyond its boundaries, not just after but during the project's duration. This research work hopes to have provided a better understanding of the challenges involved and their interrelatedness. The topic could not be captured by one approach alone, but a combination of four approaches was chosen to better understand the complexities of projects aiming at knowledge development for innovation. A systems perspective proved worthwhile, investigating a project as a system consisting of several other systems linked to participant organisations within a changing social context. Altogether, this showed, for example, that innovation projects form complex social networks that also placed the resilience of knowledge development on the research agenda. Besides this, investigating development processes over time also pointed at the evolving roles of network partners who need to bring different kinds of input and, consequently, come to the table with a range of backgrounds and interests. This adds project dynamics needing attention from a communication perspective, as stakeholders may see stakes as their own, which calls for relationship and trust building when sharing insights and experiences to co-create knowledge for innovation.

6 CONCLUSIONS

In this chapter, the findings of the six individual studies that are included in this thesis are drawn together to present the main results. Furthermore, the research is evaluated, and the contribution made by this research is discussed.

6.1 Main results

This research sought to gain an understanding of the co-creation of knowledge for innovation in funded projects from the viewpoint of multi-stakeholder communication, focusing particularly on communication with and the participation of end-users. It clarified participant roles and communication in research projects and how the participants perceived the co-creation in the case projects. Multi-stakeholder projects arrange collaborative processes in networked settings to develop knowledge and build resilience into their innovation work. The results showed that communication supports the co-creation of innovation in externally funded projects in various ways.

The findings of the six studies of this thesis highlight input, throughput and output communication in the process of co-creating knowledge in funded projects. Forms of input communication in the investigated projects include use cases and scenarios, which are used to communicate end-user needs during the early phases of the project. The scenarios show end-user situations that make specific end-user needs explicit. Throughput communication in a project context concerns the collaborative work among project partners, with outside stakeholders and among project partners and end-users. Output communication includes project dissemination by communicating about the aims, work and results of the project to both end-users and wider audiences. An end-user community can be actively utilised as a platform for input, throughput and output communication, depending on the needs and phase of the project.

Co-creation networks that engage in open communication need to foster trust among the partners involved to enable knowledge sharing and co-creative

innovation. Common development goals and collaborative functions can result in an improved organisational learning process. The studies of this thesis reveal that the co-creation of knowledge in innovation projects includes diverse stakeholders from disparate fields and countries. The participants have their own individual goals that explain how actively or passively they participate in discussing matters in the issue arena formed by the project and work toward common project goals. Thus, bringing together individual goals in common project goals and managing various expectations are an important task for the project coordinator, work package coordinators and task leaders. Projects are considered to benefit from strategic insights and prior experiences to enhance the resilience of the project network.

An insight gained by Study 1 is that co-creation has the potential to mature and deepen over time. Understanding that differences in levels of involvement among network stakeholders may affect the time it takes to reach innovation and can help project organisations structure collaborative efforts to match the level of co-creation for which they are striving. The four categories of co-creation projects found in Study 1 illustrated that the complexity of projects varies, and this can be used to find the level of structure that suits the achievement of an innovation goal of a particular project.

End-users help clarify the precise needs and problems sought for innovative solutions. Engaging end-users in collaboration requires communication so they feel that they contribute and directly benefit from partaking in collaboration, as their participation takes time and resources. Moreover, when security authorities are the concerned end-users, they must be able to retain their impartiality in the marketplace. This explains why it may be easier for authority end-users to participate in broad EU-funded research, innovation consortia or other project networks that involve various types of partners, multiple agencies, several companies (even competing ones), academia and multiple end-users in cross-border collaboration over one-on-one collaboration with an individual company.

It must be remembered, however, that various types of actors have various interests concerning co-creation. Companies are constantly seeking new opportunities in the marketplace, trying to build and strengthen their customer base, an objective that new innovative solutions for security management practitioners can help achieve. Academic institutions are, on the one hand, searching for knowledge and, on the other hand, need funding from participating in these projects.

Theoretically, a better understanding of the mechanisms behind co-creation helps focus future research. This research also contributes by introducing a model characterising the co-creation of knowledge for innovation in multi-stakeholder projects that shows the evolving process of co-creation as it relates to four categories of co-creation for innovation (as shown in Figure 7). This provides a framework to further analyse incidents of collaboration by identifying various phenomena as they appear in the process. Moreover, co-creative collaboration can be demonstrated in different layers of complexity. Understanding this may

help analyse networks of innovation and understand the rapidity, type or level of innovation of which a project network is capable.

Co-creation takes time and is a delicate process dependent on the trust among stakeholders needed for exchange of knowledge and experiences. Thus, project actors seek ways to ensure that the co-creation process continues and is resilient. Any major disruption in continuity may set back the willingness to continue the collaboration. It would be unfortunate if projects would fail or be discontinued because they lost key stakeholders. The time and effort put into the unfinished project then becomes a wasted effort for the stakeholders and the funders. Promoting resilient collaboration was considered a valuable asset in the case of disruptive events.

Collaboration networks can promote the co-creation of knowledge and innovation (as discussed in Study 2). Especially the networked collaboration between various innovation project networks seems to provide opportunities for fast and deep innovation potential. End-user involvement is key, as it provides the basis for identifying needs and possibilities (as discussed in Study 3). In the context of a funded project, input communication relates to the setting of requirements, for example, by involving end-users. Throughput communication refers to the process of co-creating knowledge for innovation, hence, facilitating intensive collaboration. For funded projects, output communication relates to external communication and dissemination activities, such as creating user communities.

Active end-user involvement begins in the input phase to identify requirements that pave the right path for the project. Ideally, end-users continue to be involved in validating preliminary and final project outcomes to ensure their adoptability. A main reason for external funding is that project results become adopted by the widest range of end-users possible. Therefore, project dissemination involves all project partners and engages a wide range of end-users.

Collaboration between networks of knowledge and innovation is complex and can be investigated both horizontally and vertically. Perceiving the issue horizontally includes collaboration between similar networks. The EU, for example, often funds topics that are close to one another, calling for collaboration rather than competition between ongoing projects. Vertical collaboration happens between networks that operate on different levels. As discussed in Study 2, the operative level includes, for example, networks of actors operating in the field who collaborate with authority networks (such as the Arctic Coast Guard Forum), academic networks (such as the University of the Arctic, a thematic network for security and safety in the Arctic) and networks of political guidance (such as the Arctic Council).

Any network collaboration may face disruptive events that must be dealt with to provide continuity of co-creation processes. As discussed in Study 4, resilience thinking begins with risk assessment and planning how to respond to events which may threaten the operations of the network. This thinking should encompass both the network and its individual stakeholders. The studies of this

thesis show that new knowledge concerning how to implement output communication also can be co-created, combining skills from all stakeholders to further motivate user community participants.

6.2 Evaluation of the research

A limitation to this research is that the case samples used in the individual studies are limited. Even though small samples are acceptable in qualitative studies, it would have benefitted this research to have had a larger number of case samples for analysis. Altogether, this thesis used data from various funded projects.

Qualitative research can be perceived as trustworthy when it is deemed credible, transferable, confirmable and dependable. Credibility refers to the evaluation of the truthfulness of the research results; transferability means that these research results are also valid in other contexts; confirmability conveys that the results are based on the research data collected, and dependability means that the research and its results are repeatable by other researchers (Tuomi 2002). To ensure credibility, the truthfulness of research results has been evaluated both by the researcher and the peer-review processes of the published papers. This research does not claim the transferability of research results to contexts other than funded projects. However, its results can be deemed transferrable to funded projects other than just the ones which have served as cases in this study that aim at innovation. The projects investigated were part of the security field. This raised attention to resilience, not just as a project focus but also concerning the resilience of the co-creation process itself. An eye for this matter also benefits projects in other fields. Care has been taken to achieve confirmability by basing all reported results on the research data collected and to attain dependability by describing the research process in detail so other researchers can repeat its results. Thus, care has been be taken to gather evidence that provides both validity and reliability, which has been improved by describing the research design and how each individual study of this research was conducted.

Research ethics, as it relates to the studies of this thesis, were discussed in section 3.5. Ethics has been an increasingly important issue in EU-funded projects. The European Commission has set tighter requirements for the ethical treatment of subjects and related materials. Research processes must be ethical, and the innovations that are created must be perceived to treat people ethically and respect their rights to privacy.

This research was guided by the ethical principles of the European Union Horizon 2020 Programme (Commission of the European Union 2016) and the Guidelines of the Finnish Advisory Board on Research Integrity (Finnish Advisory Board on Research Integrity 2012), which both highlight the importance of research ethics. Ethical issues such as privacy, data protection, informed consent and data protection safeguard the privacy of research subjects.

Ethical practices were followed, and the related research process (data collection and analysis, presentation of research results) was conducted meticulously. Care has been taken to appropriately archive and access data throughout the research. All data were handled with systematic care for privacy and data protection. Paperwork and digital materials were stored for a limited time in the Laurea University of Applied Sciences premises and its password-protected digital environment. The anonymity of participants in this research was ensured in all reports. All subjects consented to the data being used for research purposes, and all interactions took place under the Chatham House rule, where the content of the interactions is usable, but the sources or their respective organisations are not tied to any specific content. The research methods were evaluated in the course of the peer-review process of the related publications. The author took care to appropriately cite the previous work of researchers to acknowledge their prior achievements.

6.3 Contribution of this research

This research provides insight into the co-creation of knowledge for innovation in funded projects from the viewpoint of multi-stakeholder communication, which is relevant to future EU-funded research projects benefitting science and society. The findings of this study contribute to both theory and practice. There is little previous research that focuses on multi-actor communication in projects. Most previous research on communication by organisations addresses relations with customers or other stakeholders.

As a contribution to theory, the model highlights those aspects that characterise knowledge co-creation in projects, making it easier to understand the complexity of funded projects that aim to effect innovation. It shows how insights from the literature can be applied in the context of funded projects, illustrating their complex nature (as shown in Study 1). In turn, such insights add to the body of knowledge on co-creation processes and innovation networks, be they in a project context. It shows how, by combining approaches, a deep understanding of complexities is gained in this context, recognising the difficulties of the diversity of the often multiple partners involved, with how the project process evolves over time, changing network roles and resilience aspects of research and innovation projects. The insights gained and future research this invites will be further explained below.

This researcher clearly perceives the need for close attention to the intensive *multi-stakeholder collaboration* needed for innovation, and this is visible in all six of its studies. Just this finding alone motivates organisations to aim at deeper- and longer-lasting collaborative activities and include new stakeholders (industry, authority, academic, even individual persons) who join in and bring their contributions to the creation of collective knowledge (in line with e.g. Bhalla 2014, Galvagno & Dalli 2014). Such collaboration is fostered by relationships and trust building, as was also noted by Pirinen (2015). Assessing project interaction as a

multi-stakeholder arena helps keep an eye out for the backgrounds and interests of the project stakeholders involved who need to negotiate agendas to focus on common goals to yield innovation value (now detailed for projects, but in line with e.g. Luoma-aho & Vos 2010, Vos, Schoemaker & Luoma-aho 2014).

In funded projects, the partners form an *innovation network* or even interlink innovation networks. Involving more actors is often expected to slow down the development process, but this thesis found that complex problems call for diverse input and may even yield innovation faster (which was investigated based on organisational literature such as Roloff 2008, Engeström & Kerosuo 2007). More study is recommended on how the elements of complexity can deepen co-creation to provide faster innovation (as suggested based on Study 5).

Accordingly, many projects call for the collaboration of public- and private-sector actors. While the main focus for public authorities lies in the fulfilment of their tasks as defined in legislation, most private actors seek profit by providing products and services to customers in the marketplace. In this thesis, the positive example of MARISA has been investigated, but future research could more specifically investigate highly complex projects that show collaboration among different networks of actors and how this affects the co-creation process (e.g. based on Mitleton-Kelly 2003, Poutanen et al. 2016).

Through a *process* approach, this thesis pointed at the phases that characterise the development of knowledge for innovation, emphasising end-user participation not just to clarify requirements as a starting point, but also to provide a stimulus for the actual development process and validate results. The research supports the notions discussed by the process approach literature that, to achieve creative problem solving, there is the need for rigorous processes, project management and skilled people, with joint strategic engagement and intensive communication within the network of stakeholders (e.g. Taatila et al. 2016, Pichyangkul, Nuttavuthisit & Israsena 2012). For example, Study 3 discussed how end-user requirements can be categorised according to the type of end-user activity, using a framework to classify the practical activities performed by end-users in the maritime domain. It became evident that user requirements are best set in collaboration with the actual end-users. Over time, the roles and input provided by the end-users will vary, and the network of engaged end-users may be extended and continue beyond the project horizon. Various forms to include end-users were utilised in the investigated project, from advice panels to research roles, interactive workshops and platforms, as well as broad end-user communities. Future research could look at a higher number of projects in various fields to investigate which forms contribute most.

Further research is needed to better understand the aspects of the *resilience* of complex social networks. Much research has scrutinised the resilience of physical and information (software and data) domains, mainly by systems scientists (e.g. Amir & Kant 2018, Linkov et al. 2013). Social and communication scientists (e.g. Vos 2017) can fill this gap by elaborating on resilient collaboration and agile communication, bearing in mind the complexity of co-creation of knowledge for innovation (as addressed in Study 5). This thesis discussed safety and security

systems that are increasingly cyber-physical in nature and, thus, require increasingly complex collaboration spanning various networks (as investigated in studies 3 and 5). Further study is needed to better understand cyber-physical networked collaboration in the future.

This thesis scrutinised how the investigated projects deal with challenges related to project participation, for example, ways to include end-users and facilitate the exchange of insights and experiences throughout the project (as inspired by e.g. Engeström & Kerosuo 2007, Hautamäki 2010). The main practical implication of the research is that an awareness of such aspects facilitates participation in co-creation. To the people and organisations involved in the collaboration it can be emphasised, that the various aspects of the work they do greatly matter to how their innovation network functions.

For project management, the importance for communication cannot be underestimated. Project collaboration can be strongly enhanced if communication is well taken care of, but it can also be much hindered if the role of communication in projects is not understood. This relates equally to input communication referring to the collaborative setting of requirements, throughput communication concerning the core process of co-creation by multiple actors involved, as well as output communication including dissemination, for example, through user communities.

As another practical note, innovation is best shared. For this reason, the European Commission emphasises the dissemination and exploitation of EU-funded projects' results (Commission of the European Union 2016). Thus, it is recommended to rigorously evaluate dissemination activities, including the communication of the project with its various stakeholders (as addressed in Study 6). Increasingly, the attention to dissemination at the end of a project turns to involving a broad group of stakeholders outside the project partners, as well as in earlier stages of the project. This research underlines the awareness that the involvement of many diverse stakeholders is needed to solve complex problems that need innovations. Consequently, this leads to the inclusion of more stakeholders as partners in the project, creating large innovation networks in which communication needs evermore attention. Meanwhile, the involvement of other stakeholders outside the group of partners is sought, also in early phases of the project, again requiring communication to support the process of collaboration.

Communication with partners and other stakeholders was addressed by the participants of the conducted studies by stressing the facilitation of the exchange of insights and experiences, the engagement of those involved and the building of relationships and trust as a pre-condition for the sharing of information and experiences. Such communication aspects were often mentioned as either important or challenging. This thesis suggested involving communication experts of the project partners, not just at the dissemination stage, but throughout the whole project duration.

This research brings more understanding of the process of knowledge co-creation as it takes place in complex funded projects, and it advances the need

for attention for communication supporting the collaboration by the multiple actors that together form an innovation network. The work may benefit researchers engaged in related topics, as well as those who plan and implement co-creation collaboration networks for innovation. Knowing the results of this thesis can help understand the co-creation of knowledge by innovation networks and recognise the need for these networks to collaborate.

The main contribution of this thesis is that it adds to the overall body of knowledge on the co-creation of knowledge for innovation and the functioning of funded projects. The EU aims to promote innovation through collaborative research and innovation projects. This thesis brings more understanding to the theory behind complex project collaboration and the practical challenges and facilitation of such collaboration in funded projects that aim at the co-creation of knowledge for innovation.

FINNISH SUMMARY

Tämä väitöskirjatutkimus käsittelee yhteiskehittämistä Euroopan Unionin rahoittamissa innovaatiohankkeissa. EU:n komissio pyrkii aktiivisesti edistämään eurooppalaisia innovaatioita ja harmonisointia rahoittamalla monialaisia ja monikansallisia hankkeita.

Tutkimuksen tarkoituksena on lisätä ymmärrystä yhteiskehittämisestä ja sen innovaatioprosesseista. Ymmärrys monitoimijaisten innovaatioverkostojen tiedon tuottamiseen liittyvän viestinnän tärkeimmistä mahdollistajista ja haasteista edistää sekä viestinnän teoriaa, että tulevien yhteiskehittämishankkeiden yhteistyöverkostojen toimintaa. Syntyvät innovaatiot hyödyttävät yhteiskuntaa. Tämä tutkimus linkittyy aiempaan tutkimukseen, joka pyrkii ymmärtämään organisaatioiden välistä viestintää laajentamalla näkökulmaa innovaatioprojekteihin. Väitöskirjan tutkimuskysymys on: Miten voimme ymmärtää uuden tiedon luomiseen tähtäävän yhteiskehittämisen ilmiöitä (mahdollistajia ja haasteita) monitoimijaisissa hankkeissa? Tutkimus tarkastelee osallistujien rooleja ja viestintää tutkimus- ja kehittämisprojekteissa pyrkimällä tapaustutkimuksen keinoin ymmärtämään, miten osallistujat hahmottavat vuorovaikutusta projekteissa ja miten monitoimijaviestintä vaikuttaa innovaatioiden yhteiskehittämiseen ulkoisesti rahoitetuissa hankkeissa.

Teoriataustana on neljä viitekehystä: 1) tiedon yhteiskehittäminen, 2) innovaatioverkostot, 3) tiedon kehittämisen prosessit ja 4) kompleksisten sosiaalisten verkostojen resilienssi. Nykyisin uuden tiedon kehittämistä lähestytään paljolti yhteiskehittämisen perspektiivistä. Yhteiskehittämisen katsotaan vaativan viestintää ja vuorovaikutusta eri toimijoiden kesken, jotka osallistuvat verkostoihin löytääkseen yhteisiä lähestymistapoja heitä kaikkia koskeviin kysymyksiin. Näille verkostotoimijoille voidaan tunnistaa eri rooleja. Yhteiskehittäminen voidaan nähdä aikaa ja resursseja vaativana prosessina, jossa toimijoiden erilaiset osaamiset korostuvat. Verkostojen kompleksiset ympäristöt ovat jatkuvassa muutoksessa ja sisältävät riskejä, joiden vaikutuksia voidaan vähentää lisäämällä resilienssiä.

Väitöskirja sisältää kuusi osatutkimusta sekä niihin liittyvät tieteelliset julkaisut ja tämän kokoavan osan, jossa kootaan synteesiä tutkimustulosten ja teoriakirjallisuudessa esitettyjen neljän viitekehyksen näkemysten välille. Tutkimus perustuu laadulliseen tutkimusotteeseen. Osatutkimukset perustuvat aineistoihin, jotka on kerätty yhteensä seitsemästä EU:n rahoittamasta innovaatiohankkeesta sekä yhdestä innovaatioverkoston perustamisesta. Keruumenetelminä on käytetty havainnointia, haastatteluita ja aineistojen luentaa.

Osatutkimus 1 pyrkii strukturoidun kirjallisuuskatsauksen keinoin ymmärtämään uuden tiedon ja innovaatioiden yhteiskehittämistä, loppukäyttäjien rooleja ja osallistumisen muotoja ja haasteita innovaatioprojekteissa. Avoin tiedon yhteiskehittämiseen tähtäävä viestintä yhteistoimintaverkostoissa on haasteellista. Yhteisten prosessien koordinointi ja partnereiden aktivointi osallistumaan vaativat resursseja. Yhteiskehittäminen vaatii aikaa ja osallistujien roolit ovat jatkuvassa muutoksessa.

Osatutkimus 2 keskittyy loppukäyttäjien osallistamiseen tiedonvaihtoa, uutta tietoa ja innovaatioita edistävän yhteiskehittämisverkoston luomiseen. Tulokset osoittavat, että kompleksiselle uutta tietoa tuottavalle monialaiselle ja ylikansalliselle tutkimusyhteistyölle on tarvetta. Tarkempi tilannekuva, riskianalyysit sekä kapasiteettiyhteistyö voivat kärsiä monialaisen viestinnän puutteesta.

Osatutkimus 3 tutkii loppukäyttäjäskenaarioita keinoina sekä osallistaa loppukäyttäjien että muodostaa käyttäjävaatimuksia kompleksisessa kyber-fyysisen tiedonvaihtojärjestelmän kehittämiseksi. Tulosten perusteella skenaarioiden avulla toteutettu yhteiskehittäminen antaa toimijoille mahdollisuuden luoda arvoa vuorovaikutuksella. Tutkimus osoittaa esimerkkitapauksen kautta, miten skenaarioita voidaan käyttää käyttäjätarpeiden tunnistamiseen innovaatioprojekteissa.

Osatutkimus 4 keskittyy innovaatioita yhteiskehittävien monitoimijaisten yhteistyöverkostojen resilienssiin. Tulokset osoittavat, että yhteiskehittämisellä voidaan parantaa suunnitelmallisuutta, jolla voidaan vaikuttaa valmiuteen kohdata mahdollisia keskeytyksiä ja toipua niistä sekä lisätä verkoston jäsenten halukkuutta adaptoitua ja oppia yhdessä.

Osatutkimus 5 tutkii kompleksisuuden elementtien vaikutusta innovaatioihin yhteiskehittävissä monitoimijaisissa yhteistyöverkostoissa. Tulokset viittaavat siihen, että lisäämällä verkoston toimintaan kompleksisuutta voidaan innovaatioiden yhteiskehittämiseen tarvittavaa aikaa lyhentää.

Osatutkimus 6 pyrkii ymmärtämään, miten disseminaatio tukee hankkeen toimintaa ja rahoitusinstrumenttien vaatimuksia. Tapausprojektit käyttivät projektirakenteita ulkoisen viestinnän toteuttamiseen. Tutkimuksen tulosten perusteella koordinoiva fasilitaattori jokaisessa verkoston organisaatiossa voisi motivoida ja tukea jäseniä aktiivisempaan viestinnän toteutukseen.

Kun näitä kuutta osatutkimusta tarkastellaan neljän teoreettisen viitekehyksen kautta, voidaan todeta, että tiedon yhteiskehittäminen on intensiivistä vuorovaikutusta eri projektipartnereiden kesken. Tämä vaatii suhteiden aktiivista vaalimista ja luottamuksen rakentamista. Projektiviestintää voidaan tarkastella aiheiden areenana, näkökulmasta jossa osallistujilla voi olla omia agendoja, joiden puolelle he hakevat liittolaisia. Innovaatioverkostojen näkökulmasta puuttuvat projektiviestinnän rakenteet haittaavat tiedon vaihtoa ja siten tiedonvaihtoa edistävien rakenteiden ja toimien merkittävyyttä helposti aliarvioidaan. Projektit hyötyvät sen eri vaiheissa osallistavista strategioista.

Prosessinäkökulmasta suuri määrä erilaisia osallistujia voi hyödyttää laajaalaisen näkemyksen muodostumista innovaatioiden pohjaksi. Partnereiden sekä taustojen että intressien erilaisuus on hyvä huomioida. Partnerit korostavat yhdessä tunnistetun yhteisen ongelman ohjaavan vuorovaikutusta. Resilienssin näkökulmasta tarkasteltuna projektit ovat joustavia kohtaamaan muutoksia. Haavoittuvuuksia tunnistetaan kompleksisten projektien keskinäisten riippuvuuksien niitä uhkaavien riskien kautta. Projektikumppanit odottavat keskustelua mahdollisista keskeytyksistä ja projektin yhteistoimintaan kohdistuvista uhista.

Tämän väitöskirjan tulokset korostavat vuorovaikutuksen tärkeyttä projekteissa tapahtuvan uuden tiedon yhteiskehittelyn pohjana. Tämä tutkimus tarjoaa

näkemyksiä monitoimijaisissa innovaatioita tavoittelevissa projektikonsortioissa tapahtuvaan viestintään, mikä on tärkeää yhteiskuntaa ja tiedettä palveleville EU-rahoitetuille projekteille. Jatkotutkimusta ehdotetaan tunnistamaan menestyksekkään yhteiskehittämisen elementtejä ja niiden vaikutuksia innovaatioille sekä ymmärtämään paremmin sosiaalisten verkostojen resilienssin muodostumista. Tämän tutkimuksen pääanti on, että se lisää osaltaan sekä teoreettista että käytännön tietämystä yhdestä EU:n panostusalueista, yhteiskehittelystä innovaatioprojekteissa.

REFERENCES

ABC4EU 2011. Automated Border Control Gates for Europe, Proposal (2011). Framework Programme 7, Topic SEC-2012.3.4-6 Enhancing the workflow and functionalities of automated border control gates, Integration Project.

Ahrweiler, P. & Keane, M. T. 2013. Innovation networks. Mind & Society, 12(1), 73-90.

AIRBEAM 2009. AIRBorne information for Emergency situation Awareness and Monitoring Proposal (2009), Framework Programme 7, Topic SEC 2010.4.2.3: Information acquisition using dedicated platforms, including UAV, aerostatic platforms (balloons) and satellites, Collaborative Project (2009).

Alberts, D. 2002. Information age transformation; getting to a 21st century military. Defense Technical Information Center, Fort Belvoir.

Bagayogo, F., Lapointe, L., Ramaprasad, J. & Vedel, I. 2014,. Co-creation of knowledge in healthcare: A study of social media usage. Piscataway: The Institute of Electrical and Electronics Engineers, Inc. (IEEE), 2014, January, 626-635.

Benbasat, I., Goldstein, D. K. & Mead, M. 1987. The case research strategy in studies of information systems, MIS Quarterly, 11(3), 369-86.

Bhalla, G. 2014. How to plan and manage a project to co-create value with stakeholders, Strategy & Leadership, 42(2), 19-25.

Boje, D., Gephart, R. P. J. & Thatchenkery, T. J. (Eds) 1995. Postmodern Management and Organization Theory. SAGE Publications

Buijs, J., Smulders, F. & Van der Meer, H. 2009. Towards a more realistic creative problem solving approach. Creativity and Innovation Management 18(4), 286-298.

Burdon, S., Mooney, G. R. & Al-Kilidar, H. 2015. Navigating service sector innovation using co-creation partnerships. Journal of Service Theory and Practice, 25(3), 285-303.

Canonico, P., Söderlund, J., De Nito, E. & Mangia, G. 2013. Special issue on organizational mechanisms for effective knowledge creation in projects: Guest editorial. International Journal of Managing Projects in Business, 6(2), 223-235.

Castells, M. 2000. Materials for an exploratory theory of the network society. The British Journal of Sociology, 51(1), 5-24.

Commission of the European Union. 2011. Cooperation, Work Programme 2012, Theme 10, Security, European Commission C(2011)5068, 19 July 2011.

Commission of the European Union. 2014a. Horizon 2020, Communicating EU Research and Innovation Guidance for Project Participants, Version 1.0, 25 September 2014.

Commission of the European Union. 2014b. Horizon 2020, Open to the World! How to Participate? (2014). European Union, Belgium, doi:10.2777/84647 (accessed 2 June 2015).

Commission of the European Union 2016. Webpage: What is the difference between dissemination, exploitation and communication? Research and Innovation. Participant Portal. https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-933.html (accessed 25 May 2016).

Commission of the European Union 2017. Webpage: Participant portal H2020 On-line manual Ethics. http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/ethics_en.htm (accessed 20 November 2017).

Cook, S. D. N. & Brown, J. S. 1999. Bridging Epistemologies: The Generative Dance Between Organizational Knowledge and Organizational Knowing. Organization Science, 10(4), 381-400.

Crossan, M. M., Lane, H. W. & White, R. E. 1999. An organizational learning framework: from intuition to institution. Academy of Management Review, 24 (3), 522-537.

Dandonoli, P. 2013. Open innovation as a new paradigm for global collaborations in health. Globalization and Health, 9 (1), 1-5.

DeFillippi, R. & Roser, T. 2014. Aligning the co-creation project portfolio with company strategy. Strategy & Leadership, 42(1), Emerald Group Publishing Limited, 30-36.

Denzin, N. K., & Lincoln, Y. S. 1994. Handbook of Qualitative Research. Sage Publications, Thousand Oaks, USA.

do Nascimento Souto, P. C. 2013. Beyond knowledge, towards knowing: The practice-based approach to support knowledge creation, communication, and use for innovation. Revista de Administ ração e Inovação, São Paulo, 10(1), 51-78.

Draheim, D. & Pirinen, R. 2011. Towards exploiting social software for business continuity management. Proceedings of Database and Expert Systems Applications (DEXA), 29–30 August, Toulouse, 279-283.

Dubé, L., Paré, G. 2003. Rigor in information systems positivist case research: Current practices, trends, and recommendations. MIS Quarterly, 27(4), 597-635.

Engeström, Y. 2004. New forms of learning in co-configuration work. Journal of Workplace Learning, 16(½), Emerald Group Publishing Limited, 11-21.

Engeström, Y. & Kerosuo, H. 2007. From workplace learning to inter-organizational learning and back: The contribution of activity theory. Journal of Workplace Learning, 19(6), Emerald Group Publishing Limited, 336-342.

European Court of Auditors, Special Report #2 2013. Has the Commission Ensured Efficient Implementation of the Seventh Framework Programme for Research? European Union, Luxembourg.

Finnish Advisory Board on Research Integrity. 2012. Responsible Conduct of Research and Procedures for Handling Allegations of Misconduct in Finland. Helsinki: Finnish Advisory Board on Research Integrity.

Frow, P., Nenonen, S., Payne, A. & Storbacka, K. 2015. Managing co-creation design: A strategic approach to innovation. British Journal of Management, online 22 Jan 2015.

Galvagno, M. & Dalli, D. 2014. Theory of value co-creation: A systematic literature review, Managing Service Quality, 24(6), 643-683.

Greene, J.C. 1994. Qualitative program evaluation: Practice and promise. In N. K. Denzin & Y. S. Lincoln (Eds.), Handbook of Qualitative Research, Sage Publications, Thousand Oaks, USA, 530-544.

Grunig, L. A., Grunig, J. E. & Ehling, W. P. 1992. What is an effective organization. Excellence in Public Relations and Communication Management, 65-90.

Gustafsson, A., Kristensson, P. & Witell, L. 2012. Customer co-creation in service innovation: A matter of communication? Journal of Service Management 23(3), 311-327.

Hassard, J. 1996. Exploring the terrain of modernism and postmodernism in organization theory. In D. Boje et al. (Ed.), Postmodern Management and Organization Theory, SAGE Publications, 1995, 45 – 59.

Hautamäki, A. 2010. Sustainable innovation: A new age of innovation and Finland's innovation policy. Sitra, No. 87.

Hyttinen K., Ruoslahti H. & Jokela J. 2017. Model for effective integration of research, work life and higher education in international security studies. In Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (KMIS 2017), 299-306.

Johnston, K. A. 2018. Toward a theory of social engagement. In M. Taylor & K. A. Johnston (Eds.), The Handbook of Communication Engagement, Wiley & Sons Incorporated, Hoboken, NJ, USA, 53-70.

Johnston, K. A. & Taylor, M. 2018. Engagement as communication: Pathways, possibilities, and future directions. In M. Taylor & K.A. Johnston (Eds.), The Handbook of Communication Engagement, Wiley & Sons Incorporated, Hoboken, NJ, USA, 33-51.

Juholin, E. 2010. Arvioi ja paranna. Viestinnän mittaamisen opas. Vantaa, Infor Oy.

Kallio, K. & Lappalainen, I. 2015. Organizational learning in an innovation network. Journal of Service Theory and Practice, 25(2), 140-161.

Katz, D. & Kahn, R. L. 1978. The social psychology of organizations, Vol. 2, 528, Wiley, New York.

Linkov, I., Creutzig, F., Decker, J., Fox-Lent, C., Kröger, W., Lambert, J. H. & Thiel-Clemen, T. 2014. Changing the resilience paradigm. Nature Climate Change, 4, 407-409.

Linkov, I., Eisenberg, D. A., Plourde, K., Seager, T. P., Allen, J. & Kott, A. 2013. Resilience metrics for cyber systems. Environment Systems and Decisions, 33(4), 471-476.

Luoma-aho, V. & Vos, M. 2010. Towards a more dynamic stakeholder model: acknowledging multiple issue arenas. Corporate Communications: An

International Journal, Vol. 15 No. 3, 2010, Emerald Group Publishing Limited, 315-33.

Luoma-aho, V., Vos, M., Lappalainen, R., Lämsä, A. M., Uusitalo, O., Maaranen, P. & Koski, A. 2012. Added value of intangibles for organizational innovation. Human Technology, 8(1), 7-23.

Miettinen, S. & Koivisto, M. 2009. Designing Services with Innovative Methods. University of Art and Design Helsinki.

Miles, M. & Huberman, A. 1994. Qualitative data analysis: An expanded sourcebook, Sage Publications, Thousand Oaks, CA, US.

Mitchell, R. & Boyle, B. 2010. Knowledge creation measurement methods. Journal of Knowledge Management, 14(1), 67-82.

Mitleton-Kelly, E. 2003. Ten principles of complexity and enabling infrastructures. In E. Mitleton-Kelly (Ed.), Complex Systems and Evolutionary Perspectives on Organisations: The Application of Complexity Theory to Organisations. Pergamon, Amsterdam, 23-50.

Montuori, A. & Purser, R. E. 1995. Ecological futures: Systems theory, postmodernism, and participative learning in an age of uncertainty. In D. Boje et al. (Ed.)., Postmodern Management and Organization Theory, SAGE Publications, 181-201.

Myers, M. D. 2013. Qualitative Research in Business Management (2nd ed.). London, UK, Sage Publications.

Myers, M. D. 2008. Qualitative research in information systems. MIS Quarterly 21(2), 241-242. MISQ Discovery, archival version, June 1997, http://www.misq.org/discovery/MISQD_isworld/. MISQ Discovery, updated version, last modified: January 4, 2008, retrieved from: https://www.researchgate.net/publication/220260372_Qualitative_Research_in_Information_Systems. (accessed 2 June 2015).

Nonaka, I. & Takeuchi, H. 1995. The Knowledge-Creating Company: How Japanese Companies create the dynamics of Innovation. Oxford University Press. New York 1995.

Norvanto E. 2017. Knowledge creation in cross-border and cross-sectoral collaborations: Exploring EU externally funded security research and innovation projects as communities of practice. In Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (KMIS 2017), 70-82.

O'Brien H. L. & McKay, J. 2018. Modeling antecedents of user engagement. In M. Taylor & K.A. Johnston (Eds.), The Handbook of Communication Engagement. Wiley & Sons Incorporated, Hoboken, NJ, USA, 122-143.

Oksanen, K. & Hautamäki, A. 2014. Transforming regions into innovation ecosystems: A model for renewing local industrial structures. The Innovation Journal, 19(2), 1.

O'Rourke, T. D. 2007. Critical Infrastructure, Interdependencies, and Resilience. In The Bridge, Spring 2007, 22-29.

Palttala, P. & Vos, M. 2012. Quality indicators for crisis communication to support emergency management by public authorities. Journal of Contingencies and Crisis Management, 20(1), 39–51.

Payne, A. F., Storbacka, K. & Frow, P. 2008. Managing the co-creation of value. Journal of the Academy of Marketing Science, 36(1), 83–96.

Pichyangkul, C., Nuttavuthisit, K., & Israsena, P. 2012. Co-creation at the front-end: A systematic process for radical innovation. International Journal of Innovation, Management and Technology, 3(2), 121-127.

Pinho, N., Beirão, G., Patrício, L. & P. Fisk, R. 2014. Understanding value co-creation in complex services with many actors. Journal of Service Management, 25(4), 470-493.

Piperca, S. & Floricel, S. 2012. A typology of unexpected events in complex projects. International Journal of Managing Projects in Business, 5(2), 248-265.

Pirinen, R. 2015. Studies of externally funded research and development projects in higher education: Knowledge sources and transfers. Creative Education, 6(3), 315-330.

Pirinen, R. 2017. Towards common information systems maturity validation: Resilience readiness levels. In Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Volume 3, ISE, 259-266.

Poutanen, P., Siira, K., & Aula, P., 2016. Complexity and organizational communication: A quest for common ground. Human Resource Development Review, 15(2), 182-207.

Raij, K. 2014. Learning by developing in higher education. Journal of Education Sciences, Issue II, 6-21. Eötvös Loránd University, Faculty of Education and Psychology.

Rajamäki, J. & Ruoslahti, H. 2018. Educational Competences with regard to Critical Infrastructure Protection. Presented at 17th European Conference on Cyber Warfare and Security (ECCWS), 28-29 June 2018, Oslo, Norway.

Rantapuska, T. & Ihanainen, O. 2008. Acquiring information systems through organisational learning. In Proceedings of the European Conference on Information Management and Evaluation (ECIME 2008), London, UK.

Roloff, J. 2008. Learning from multi-stakeholder networks: Issue-focused stakeholder management. Journal of Business Ethics, 82, 233-250.

Rowley, T. J. 1997. Moving beyond dyadic ties: A network theory of stakeholder influences. Academy of management Review, 22(4), 887-910.

Royal Institute of International Affairs 2015. Chatham House Rule, from http://www.chathamhouse.org/about/chatham-house-rule (accessesed 21 April 2015).

Ruoslahti, H., Guinness, R., Viitanen, J. & Knuuttila, J. 2010. Airborne security information acquisition using micro air vehicles: Helping public safety professionals build real-time situational awareness. In Credibility Assessment and Screening Technologies at the 44th Hawaii International Conference of Systems Sciences 2010.

Ruoslahti, H. & Knuuttila, J. 2011. Listen to three types of border guard: Adopting technology into the process of border checks. In Credibility Assessment and Screening Technologies at the 45th Hawaii International Conference of Systems Sciences 2011.

Saarinen, L. 2012. Enhancing ICT Supported Distributed Learning through Action Design Research. Aalto University publication series, Doctoral Thesis 92 7 2012, Helsinki.

Savage, M. 2002. Business continuity planning. Work Study, 51(5), 254-261.

Schertzer, M. B., Schertzer, C. B. & Dwyer, F. R. 2013. Value in professional service relationships. Journal of Business & Industrial Marketing, 28(8), 607-619.

Singapore-ETH Centre. 2015. Future Resilient Systems https://www.ethz.ch/content/dam/ethz/special-interest/dual/frs-dam/documents/FRS-Booklet.pdf (accessed 1 November 2015)

Stake, R. E. 1994. Case Studies, In N. K. Denzin, & Y. S. Lincoln (Eds.), Handbook of Qualitative Research, Sage Publications, Thousand Oaks, USA, 236-247.

Stanciugelu, I., Alpas, H., Stanescu, D., Bozoglu, F. & Stan, S. 2013. Perception and communication of terrorism risk on food supply chain: A case study (Romania and Turkey), Applied Social Sciences: Communication Studies, Cambridge University Press, 189-196.

Steins, N. A. & Edwards, V. M. 1999. Collective action in common-pool resource management: The contribution of a social constructivist perspective to existing theory. Society & Natural Resources, 12(6), 539-557.

Taatila V. P., Suomala J., Siltala R. & Keskinen S. 2006. Framework to study the social innovation networks. European Journal of Innovation Management, 9(3), 312-326.

Tikanmäki I. 2017. Common information sharing on the maritime domain: A qualitative study on European maritime authorities cooperation. In Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (KMIS 2017), 283-290.

Tikanmäki, I. & Ruoslahti, H. 2017. Increasing cooperation between the European maritime domain authorities. International Journal of Environmental Science, 2, 392-399.

Tikanmäki, I., Tuohimaa, T. & Ruoslahti, H. 2012. Developing a service innovation utilizing remotely piloted aircraft system (RPAS). International Journal of Systems Applications, Engineering & Development, 6(4).

Tuomi, J. Sarajärvi, A. 2002. Laadullinen tutkimus ja sisällönanalyysi. Vantaa. Hansaprint Oy.

Vargo, S. L., Maglio, P. P. & Akaka, M. A. 2008. On Value and Value Co-Creation: a Service Systems and Service Logic Perspective. European Management Journal, 26(3), 145– 152.

Vos, M. 2018. Issue Arenas. In R. Heath & W. Johansen (Eds.), The International Encyclopedia of Strategic Communication (IESC). Whiley Blackwell, Malden MA.

Vos, M. 2017. Communication in Turbulent Times: Exploring Issue Arenas and Crisis Communication to Enhance Organisational Resilience. Jyväskylä University School of Business and Economics, N:o 40.

Vos, M., Schoemaker, H. & Luoma-aho, V. L. 2014. Setting the agenda for research on issue arenas. Corporate Communications: An International Journal, 19(2), 200-215.

Vos M. & Schoemaker H. 2004. Accountability of Communication Management: A Balanced Scorecard for Communication Quality. Lemma Publishers, Utrecht.

Weick, K. E. 2002. Puzzles in organizational learning: An exercise in disciplined imagination. British Journal of Management, suppl. Special Issue; London 13 September 2002: S7-S15.

Windahl, C. 2015. Understanding solutions as technology-driven business innovations. Journal of Business & Industrial Marketing 30 (3/4), 378–393.

Yin, R. K., 2003. Case Study Research, Design and Methods. Sage, Thousand Oaks, USA.

ORIGINAL PAPERS

I

CO-CREATION OF KNOWLEDGE FOR INNOVATION REQUIRES MULTI-STAKEHOLDER PUBLIC RELATIONS

by

Ruoslahti, H. 2018

In Bowman S., Crookes A., Romenti S., Ihlen, Ø. (Eds).
Public Relations and the Power of Creativity, Advances in Public Relations and Communication Management, Volume 3, 115–133.

in Sarah Bowman, Adrian Crookes, Stefania Romenti, Øyvind Ihlen (ed.) Public Relations and the Power of Creativity (Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, pp.115 - 133

Co-creation of Knowledge for Innovation requires Multi-Stakeholder Public Relations.

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Abstract

Co-creation of knowledge offers significant opportunities for innovation. This chapter seeks to gain understanding of the process of co-creation of knowledge for innovation and Public Relations in multi-stakeholder projects by exploring current insights in academic literature. The research questions look at how co-creation of knowledge for innovation has been investigated in the scholarly literature; the roles of end-users; and the modes and challenges of end user participation and in collaboration relating to communication.

The method of this chapter is a structured literature review, following a series of rigorous steps: a search of databases, analysis of 33 articles found, summarizing relevant content using a data extraction table and a data extraction continuum as analysis tools to show the range of projects discussed in the literature to create a comprehensive overview.

The findings indicate that multi-stakeholder networks can be structured for different aims. In the articles found different types of projects were investigated. Four categories of projects were found: (1) Co-creation projects benefiting one company; (2) Co-creation projects benefiting business-to-business value chain networks; (3) Co-creation projects benefiting public entities; and (4) Co-creation projects benefiting innovation network stakeholders.

Complexity is highest for multiple-stakeholder co-creation projects benefiting innovation network stakeholders, where the roles between stakeholders are fluid and changing constantly. Solving common issues motivates the stakeholders to collaborate and build trust. Open innovation environments may facilitate communication and interaction.

Co-creation of knowledge requires intensive collaboration. Knowing the main challenges to address this, will help the functioning of co-creation collaboration networks and their Public Relations.

Key Words: co-creation, innovation, knowledge, project, end-user, public relations

1. Introduction

Increasingly, creation of knowledge for innovation requires collaboration between research and business partners. Traditionally participation of end users, which in this chapter are considered authority partners and stakeholders of EU funded projects, has been initiated to validate research results. Now, the roles of end user organizations have become broader. For example, listening to different types of end user

representatives can clarify the range of end user opinions and needs (Ruoslahti and Knuuttila, 2011).

This chapter looks at relevant literature with a focus on co-creative communication and Public Relations between end users and research project partners. There are many innovation ecosystems, on different levels, the European Union, Member State, and Municipality that stimulate innovation through collaboration. A recent comprehensive literature overview of publications on co-creation research Galvagno and Dalli (2014) identify three streams of co-creation research: Service science; Marketing and consumer research; and Innovation and technology management. This research focuses on the latter of the research streams: innovation and technology management.

Co-creation is a collaborative activity involving objectives, arenas, collaborators, tools and processes, and contracts (Bhalla, 2014), and it can include three layers: co-creation of futures; policies; and the involvement of agents (Accordino, 2013). Innovation is based on new knowledge, and drives growth and success (Dandonoli, 2013; Burdon *et al.*, 2015).

Within the literature on projects for co-creation of innovation and technology management, this chapter identifies end user roles, communication enablers, and challenges, related to end user participation. The aim is to clarify current insights in academic literature on co-creation of knowledge in research projects from the perspective of inter-organizational communication and multi-stakeholder collaboration. It seeks to answer the following research questions:

RQ1: How has co-creation of knowledge for innovation been investigated in the scholarly literature?
This clarifies the main topics discussed, methods used, and trends over time.
RQ2: What roles of end-users are discussed in the literature?
This relates to the aims of participation for different kinds of end users.
RQ3: What modes and challenges of end user participation are mentioned in the literature?
This concerns different forms of collaboration and related communication problems.

2. Method

The structured literature review (Jesson, Lacey, & Matheson, 2011) followed a series of steps. This section continues first describing the Search, followed by the Criteria of selection, and analysis with a Data Extraction Table and a Data Extraction Continuum, before moving to Results.

2.1 Search

A search was conducted in May, and repeated in November 2017, by using the databases ProQuest Central, and EBSCOhost. It included peer-reviewed literature of the past 10 years. To ensure relevance to the article in question, key words of the search covered abstracts, titles and keywords.

For example, the key word *co-creation* alone rendered over 5.000 search hits. Therefore, Boolean search was conducted, pairing the key word with *innovation* OR knowledge AND project OR end-user** which limited the number of hits to 52 articles that met the search criteria.

The included article references were stored and organized with the online literature review tool RefWorks. In the next phase the abstracts of the found articles were read against the selection criteria.

2.2 Selection Criteria

Decisions to include an article, identified in the key word search, in to the sample of this chapter was based on inclusion criteria of articles. Using the selection criteria (see Table 1) ensured that non-relevant articles were not part of the sample. The initial 52 articles were narrowed down to a sample of 33 articles that met the inclusion criteria.

Key Word Search in ProQuest Central & EBSCO	Initial result	Sample after selection criteria
co-creation AND (innovation* OR knowledge) AND (project OR end-user)	52	33
Selection Criteria; articles include all four elements below:		
– Co-creation of innovation knowledge (knowledge is to create new innovations and innovative product or service applications)		
– Multi-stakeholder involvement (public, private, research organizations share tasks)		
– Participation of end users		
– Project(s) (finite end and funding)		

Table 1: Key Word Search and Selection Criteria

2.3 Data Extraction Table

The articles that met the inclusion criteria were further analysed. For this purpose, a Data Extraction Table **(**DET) was formed; rows were based on the articles, and relevant content was summarized, using columns based on the research questions.

- Co-creation of innovation: used to identify what topics the authors have discussed on co-creation of innovation (RQ1).
- Research Methods: used to identify what methods were used in the studies that were included in this literature review (RQ1).
- End-user roles: used to identify what the authors discussed on end-user roles and aims of their participation (RQ2).
- Modes and challenges of end-user participation: used to identify what modes and challenges of end-user participation the authors have identified and discussed (RQ3).
- Title, Author(s), and Source (as in reference list)
- Publication year: used to easily order articles by publication year to identify trends.

The sample articles were downloaded and fully read. Elaborating notes and additions were made to the DET. Table 2 (above) summarizes how using the DET narrowed the final sample to 33 articles from an initial result of 52 articles. These 33 articles were then included in the thorough investigation, during which the DET was continuously used as a tool of analysis.

To analyse this further, the sample articles were placed on a continuum in relation to each other. Criteria for the placement were the complexity and type of co-creation collaboration discussed. These were examined by looking at stakeholder involvement. Levels and complexity of end-user roles, and levels of power balance between consortium partners were looked at. To visualise this analysis, a Data Extraction Continuum (DEC) was created for this study (Figure 1, below).

Customer projects / one-company	One-company driven innovation network	Public service / Multi-stakeholder networks	Innovation projects with multiple stakeholders
Fosstenlökken	Tokman & Beitelspacher	Kallio & Lappalainen	Pinho et al
Sjödin & Kristensson	Dawe & Sankar	Reiter et al	
Gustafsson et al	Kazadi et al	Chang et al	
Bhalla	Burdon et al	Reed et al	
Constatinides et al	Edvardsson	Franz	Accordino
DeFillippi & Roser	Halonen et al	Powell	Pino et al
Guillart	Katzy et al	Diaz-Diaz & Perez-Gonzales	
Mele	Schertzer et al	Harmokivi-Saloranta & Parjanen	Doyle
Quero & Ventura	Dandonoli		
Windahl			
Livari			
Pichyangkul et al			

Table 2: The Data Extraction Continuum (DEC)

Analysis with the DEC, showed a classification into four types of articles. Headings for these four types of articles emerged from the data. Based on these findings, besides adding additional notes and remarks to the DET, its rows were re-structured, based on these four classes of innovation projects from the DEC. These four types of innovation collaborations are described below in the findings section of this study.

3. Findings

This section is structured based on the research questions RQ1, RQ2, and RQ3. Subsection (3.1) Co-creation of knowledge for innovation in the scholarly literature describes four classes of articles that were are identified in the DEC analysis; and subsections (3.2) Roles of end-users; aims of participation; and (3.3) Modes and challenges of end user participation; and (3.4) Table of Main Topics Discussed in the Literature elaborate further findings from the DEC and DET analysis.

3.1 Co-creation of knowledge for innovation in the scholarly literature

Pinho *et al.* (2014) note that, what they call many-to-many perspectives, where interaction between customer networks and supplier networks are studied from a multi-actor viewpoint, are little discussed in literature. The relatively small number of articles found by this study, supports this view.

The 33 articles that meet the selection criteria range from the year 2010 to 2016. The articles range from a focus on less complex innovations, e.g. from one company involving their customers to innovate a product or service for themselves, to much more complex innovation projects where multiple stakeholders co-created innovation in a more equal power structure with a common goal.

Analysis with the DEC, showed this classification, based on the types of project focus that the article in question discussed:

1) Co-creation projects benefiting one company
   Twelve (n = 12) articles discuss co-creation projects benefiting one company (the first group). These articles were omitted from this study, because these articles look at service, and marketing and consumer development for the benefit of that one company or organization. They were deemed less relevant for this study, and are not listed individually or included in the reference list.

2) Co-creation projects benefiting business-to-business value chain networks
   Seven (n = 7) articles deal with innovation projects that include multiple stakeholders, which are part of the same value chain. These projects are typically initiated and led by a single actor looking for better business.

3) Co-creation projects benefiting public entities
   Eleven (n = 11) articles discuss projects that have multiple-stakeholders, but mainly work for one lead entity, such as a public municipality, or other.

4) Co-creation projects benefiting innovation network
   Three (n = 4) articles deal with knowledge and innovation projects where multiple stakeholders share common benefits and goals of development.

Further results of this study are structured according to three of these four categories of innovation projects. Twelve articles dealing with Co-creation projects benefiting one company were only used as background information for this study. The following results section looks at what literature sees as important for co-creation in each of these innovation project categories.

Complexity increases, beginning from Co-creation projects benefiting one company (group 1), and moving on to the most complex type of Co-creation projects benefiting innovation network (group 4). These seem to have potential for the most rapid innovation, as the multiple actors may openly expand on the knowledge provided by other innovation project stakeholders.

3.1.1 Co-creation projects benefiting an innovation network

Three (n = 3) articles, ranging from 2010 to 2014, were classified as 'Co-creation projects benefiting an innovation network':

Pinho, Beirão, Patrício, & Fisk (2014)	Complex value networks with many actors
Accordino (2013)	IT-tool to engage stakeholders in the co-creation of the futures
Doyle (2010)	Mixed teams involved in improving universities' regional engagement

Table 3: Articles on Co-creation projects benefiting an innovation network

These articles deal with knowledge and innovation projects where multiple stakeholders share common benefits and goals of development. The networks that they discuss are complex value networks. They raise the importance of common frameworks, platforms, and services to co-create value, which are noted in all three articles. Also, the importance of stakeholder participation comes forth from these four articles, as an element needed to drive the co-creation of knowledge and innovation.

Complex value networks with many actors to design and manage services benefit from a common framework to select methods and guide the processes. Pinho et al., (2014) use grounded theory to understand value co-creation from multiple perspectives of multiple actors, noting that "grounded theory allows deriving further general, abstract theory that is grounded in data" (p. 474).

Accordino (2013) promotes, on behalf of the European Union, an IT-tool that combines the informal nature of social networks with a methodological approach of foresights to engage stakeholders in the co-creation of the futures that they all want. Doyle (2010) reports on a large international project, where mixed teams of academics and regional administrators are involved in improving universities' regional engagement.

A common note for these four articles is that change and development require new thinking from businesses and universities, alike. Common tools, approaches, and frameworks make it easier to guide the multiple perspectives of multiple actors to understand co-creation of knowledge and value in the same way.

3.1.2 Co-creation projects benefiting public entities

Eleven (n = 11) articles, ranging from 2010 to 2016, were classified as 'Co-creation projects benefiting public entities'. These articles discuss projects that have multiple-stakeholders, but mainly working for one lead entity, such as a public municipality, or other:

Dawe & Sankar (2016)	Project success factors leading to effective value co-creation
Diaz-Diaz & Perez-Gonzales (2016)	Social media as a value co-creation and participation tool
Franz (2015)	Possibilities and limitations of Living Lab in social urban research.
Kallio & Lappalainen (2015)	Collaborative service development as organizational learning
Reiter, Gronier, & Valoggia (2014)	Involve citizens, authorities, industry and non-governmental organizations

Reed, Stringer, Fazey, Evely, & Kruijsen, J. (2014)	Principles for effective practice of knowledge exchange
Chang, Chih, Chew, & Pisarski (2013)	Projects conceptualized as a value creation process for stakeholders
Dandonoli (2013)	Open innovation as a way to structure collaborations
Powell (2012)	Best practice projects; partners have powerful and collective co-creation
Halonen, Kallio, & Saari (2010)	Multiple points of view for research and innovation projects
Harmokivi-Saloranta & Parjanen (2010)	Users take active part in development and innovation

Table 4: Articles on Co-creation projects benefiting public entities

Several of these articles also note the importance of having the right tools and framework to drive forth co-creation. As new elements, active facilitation and key success factors, are noted as a basis for effective value creation. The key success factors should be tied to common aims, promising stakeholder benefits, so that they come across as the basis for active stakeholder involvement.

Collaborative service development is an organizational learning process for an innovation network. Kallio & Lappalainen, (2015) divide it into five phases: (1) The need for change – evaluating earlier practice; (2) Planning and ideating by scenario building; (3) Experimenting by prototyping; (4) Implementation – applying in daily practice; and (5) Generalizing – evaluating the lessons learned. Driving innovation can greatly benefit from future-oriented and interdisciplinary approaches that combine behavioural, social, and design sciences with technological knowledge. Research and innovation projects should be seen from multiple points of view: management, customers and research collaborators (Halonen *et al.*, 2010).

Open innovation, is a paradigm that offers a way to structure collaborations between entities and people; to combine internal and external ideas and paths to market to achieve advances in processes or technologies (Dandonoli, 2013). Dawe & Sankar (2016) look at key success factors in a service-learning project leading to effective value co-creation for both students and a community; value was co-created through partnership between a university and a municipality.

Powell (2012) examines best practice projects. Partners co-produce real world solutions, pass innovative skills to others for "powerful and collective co-creation" (p. 396), Powell calls this a "virtuous knowledge sharing cycle" (p. 402). Projects should be conceptualized as a value creation process for disparate stakeholders, where stakeholder values are identified at the project commencement stage and captured at the end, as is argued by Chang *et al.* (2013). They criticize traditional project management in focusing too much on efficient delivery of outputs (on time and on budget). Diaz-Diaz and Perez-Gonzales (2016) look at social media as a value co-creation and participation tool. New technologies allow citizens take a more active role in public management and consumers to interact with organizations, to co-creating value.

A way how citizens can be involved in local governance is establishing both physical and intellectual spaces for collaboration between stakeholders. Using a Living Lab approach to involve citizens, authorities, industry and non-governmental organizations (Reiter *et al.*, 2014). Franz (2015) examines possibilities and limitations of Living Lab in social urban research, and note that: methods of social living labs

must be interactive and engaging; participants should be a representative sample, not just the active ones; Living labs are an applicable method for interactive approaches of social and urban research that results in long-term involvement; local stakeholders provide early stage support, are a translating institution and, are valuable actors, and shift research strategy towards long-term engagement.

Harmokivi-Saloranta and Parjanen (2010, p. 75) write: "In the Living Lab development projects, the users take active part in development and innovation. The user not only supplies information to the developers but also is part of the development team".

Innovation networks need common aims. Aims that promise benefits for all concerned. An active co-creation process requires cooperation tools and environments, easily accessible by all, to foster the development of long-term relationships and sharing knowledge. The cooperation processes need facilitation and monitoring. This monitoring process is facilitated by key success factors. Co-creative cooperation should be an on-going cyclical endeavour.

In summary, the literature notes that to create common aims, it is first important to understand the multiple points of view, different values and individual aims that the multiple stakeholders in the innovation network may have. Identified key success factors can aid in both the selection of cooperation tools, and in guiding the facilitation toward structured collaborations. Co-creation may be achieved by finding best practices.

3.1.3 Co-creation projects benefiting business-to-business value chain networks

Seven (n = 7) articles, ranging from 2011 to 2016, were classified as one-company driven innovation co-creation networks. These articles deal with innovation projects with multiple stakeholders that are initiated and lead by a single actor looking for better business:

Kazadi, K., Lievens, A. & Mahr (2016)	Stakeholder co-creation capabilities in generating valuable knowledge
Burdon, Mooney, & Al-Kilidar (2015)	Identify requisites needed in building high value co-creation alliances
Edvardsson, Meiren, Schäfer, & Witell (2013)	Strategy for interacting with the customer
Katzy, Turgut, Holzmann, & Sailer (2013)	Strategy of exchange across stakeholder boundaries
Schertzer, Schertzer, & Dwyer (2013)	High-performance relationships over
Pino, M., Plichart, M., Kerherve, H., Bouilly, C. & Rigaud (2012)	Multi-stakeholder partnerships for the co-production of innovations
Tokman & Beitelspacher, (2011)	Supply chains as value co-creation networks

Table 5: Articles on Co-creation projects benefiting business-to-business value chain networks

These articles focus on needs based aims, facilitation and practical cooperation tools and methods. Facilitation is ideally guided by facilitation strategy. Focus should be put on the competences of project managers, who are the active facilitators of the co-creation process. Burdon *et. al.* (2015) have analysed engineering services

partnerships, and summarize nicely the need to identify and understand "requisites needed in building high value co-creation alliances – especially where innovation is the strategic goal." (, p. 285).

Co-creation of service offerings and value proposals for end-users derive from an exchange of knowledge and use of operant resources among the network members (Tokman & Beitelspacher, 2011). In their perspective they combine service-dominant (S-D), which views supply chains as value co-creation networks, with supply chain management (SCM), which creates competitively compelling value propositions, for the transformation of end-user experiences to perceptions of superior value-in-use. Edvardsson *et al.* (2013) argue for a service development strategy, including a formalized, stage-gate model based, development process, and a strategy for interacting with the customer during the different stages of the development process. They use a sample of service development projects to test a conceptual model for key strategic factors in new service development (NSD), which they see as a formalised development process, with integrated development teams and customer co-creation.

Strategies of exchange across stakeholder boundaries can increase returns from innovation (Katzy *et al.*, 2013). They offer open innovation as an example of a strategy for innovation intermediaries, who as process coordinators benefit from three strategic innovation capabilities: (1) Innovation process management capability; (2) Matchmaking capability; and (3) Valuation and portfolio management capability. Pino *et al.* (2012) discuss a Living Lab (LL) approach encouraging multi-stakeholder partnerships for the co-production of innovations in the fields of innovation and entrepreneurship. The approach is a way to go "beyond traditional user-centered design practices" (p. 150).

High-performance relationships take time to develop, and supplier firms need to recognize that "the needs of newly acquired and longer-term customers differ, and to accommodate these differences" (Schertzer *et al.*, 2013, p 610). Longitudinal customer data was used to classify customers based on relationship tenure, which showed that inter-firm business-to-business cooperation for the co-creation of value requires time for these inter-firm relationships to develop.

The literature on this type of projects emphasized an active need for collaboration. Based on these articles, relationships need time to develop and co-creation requires a strategy for it to have an innovative outcome. A working and long lasting co-creative relationship requires active management, which the internal structures of the organization must also support. A structured development process calls for active and open exchange of knowledge. First key strategic factors, and strategies for interaction and exchange of innovation, are identified, then the process coordinators. They serve as the intermediaries for innovation, as they coordinate the exchange use of operative resources and exchange of knowledge, over the time that the inter-stakeholder relationships require to develop into open value co-creation.

3.2 Roles of end-users; aims of participation

According to Dandonoli (2013, p. 1), "open innovation collaborations can be designed to foster true co-creation among partners in rich and poor settings, thereby breaking down hierarchies and creating greater impact and value for each partner".

Including both customers and employees in development projects will improve the performance of the development of new services (Edvardsson *et al*., 2013); as activities, requirements, information, and value co-created among actors are all highly interconnected (Pinho *et al.*, 2014). Three types of interdependencies between actors in value co-creation are identified: (1) dynamic role interdependency, where actors' roles may change between provider to consumer; (2) temporal interdependency, where interactions occur sequentially through time; and (3) self-interdependency, where value creation depends on the own actions of the actors. This notion of roles shifting through time and depending on the actions of the actors is important and interesting. These dynamic roles can be facilitated, but not controlled.

Collaborative service development, as an organizational learning process in an innovation network, involves a "complex and interactive learning process requiring both creative problem solving and systematic, conceptual co-construction" (Kallio & Lappalainen, 2015, p. 154). This calls for open interaction and mutual trust building among the actors in the network; and a common object of development to, during the entire complex shared networked learning process, phase by phase, guide the construction of shared tools, knowledge, social structures, and practices.

Broader and better engagement in knowledge sharing and co-creation for universities that develop socially inclusive projects with their surrounding business and community partners is suggested by Doyle (2010), so that universities become drivers of creative change. For engagement in knowledge sharing Halonen *et al.* (2010) offer a workshop process, combining foresight and organizational learning methods, for cross-discipline co-creation in a service research network. They explain (p. 128) that "this method worked as a concrete way for managing future-oriented networking across organizational borders as a basis for continuous learning and innovation."

Information is, according to Pinho *et al*. (2014, p. 489), a key resource underling value co-creating factors: "companies can enhance their offering by facilitating value co-creation through resource integration among other actors in the value network". Open innovation environments integrate user driven innovation (Reiter *et al*., 2014), build trust and establish a common goal to co-create new products, services, and societal infrastructures. Thus, Reiter *et al*. (2014) propose to add a human-centred design approach, to take into account people's interactions in a Living Lab IT-system; this combined approach makes both citizens and the IT system real actors in governance. Stakeholders should actively be engaged by project management throughout the project life (Chang, *et al*., 2013). Along these lines Harmonkivi-Saloranta, & Paajanen (2010, p. 75) state that the, "Living Lab is a system for building a future in which real-life user-driven development and innovation will be a normal co-creation technique for new products, services and societal infrastructure". This is critical not only in identifying and solving problems but also in managing expectations. Joint teams build a sense of community and shared purpose, as partnering relationships progress may include phases, such as (1) traditional service outsourcing, (2) trusted collaboration partnering, and (3) strategic joint engagement (Burdon et al., 2015).

According to Edvardsson, *et al*. (2013, p. 35), "co-creation stands out as the key to succeed with NSD, while the formalisation of the development process is of least concern for managers". New service development (NSD) is defined as a process to

develop new services together with practitioners, and with frameworks. Project management should focus on individual competencies within the development team and on their interaction with customers throughout the development process. Katzy *et al*. (2013, p. 296) note that: "The systemic setting for innovation, much like all markets, only runs with the necessary intermediaries in place that make interactions and matching of partners possible." Partnering with other organizations to progress innovative ideas is important for organisations that seek better commercial success and higher competitive advantage (Burdon *et al*., 2015).

Most business-to-business customer-partners look for radical and transformational innovation opportunities, thus co-creation is a collective experience (Burdon et al., 2015). Longer relationships render more innovative outcomes in co-creation, as customers are classified into three tenure related groups: (1) transactional; (2) emergent; and (3) mature relationships (Schertzer *et al*., 2013). The service development strategy and activities in a new service development process should take into account that services are activities and interactions, which are carried out by not only by service providers, but also by customers, and other network actors (Edvardsson, *et al*., 2013).

In the literature it is underlined, that there are strong interdependencies between stakeholders. True co-creation is a complex and interactive learning process, with trust as a key component and information as a key resource. Thus, joint teams, including customers and employees, with open innovation environments integrate stakeholder participation and build the necessary trust and engagement in knowledge sharing. It is noted that it is important to partner, to progress innovative ideas, engage in knowledge sharing and co-creation, where information is a key resource. Open innovation collaborations are a complex and interactive learning process, where actors are interconnected, and systemic conceptual co-construction and strategical approach are needed, as well as are tools for interactions and time to increase innovative outcomes.

3.3 Modes and challenges of end user participation

Both the innovation network, and its learning process are constructed simultaneously by interaction. It is essential to take into account the objectives of all parties to find a common object to co-construct (Kallio & Lappalainen, 2015). To develop cost-effective highly interactive learning, partners must collaborate to (1) define a problem that is worth their combined efforts, (2) develop dialogues with strategic partners, (3) improve knowledge sharing, and (4) develop collaborative processes. Searching for opportunities for mutual benefit of the partners unlocks the talents of the diverse groups working together in co-creation (Powell, 2012).

There is a lack of awareness of the advantages of open innovation. Many projects are isolated and based primarily on either research objectives, or on business goals (Pino *et al*., 2012). Doyle (2012) raises similar issues related to universities' engagement with their regions. It is complex and pervasive cooperation, and occasioned by other policies or agendas, mostly promoting economic, social inclusion, or community development. There is a need to facilitate the development of mutual understanding, calling for a common language and mutual expectations. Additionally, Pinho *et al*. (2014) note, that potential conflicts between stakeholders

should be considered, and communication and reconciliatory strategies be anticipated on.

Multi-stakeholder partnerships demand a continuous investment in project management, processes, and people. Careful stakeholder mapping can help identify all stakeholders concerned and enable having a holistic view of the entire innovation process (Pinho et al., 2014). Kallio and Lappalainen (2015) make the observation that collaboratively developed and co-created structures or processes cannot be controlled by a one single party.

Innovation is "not easy, either to foster or to achieve" says Dandonoli (2013, p. 1). Moreover, navigating the partnering dynamic can be harder than expected, as it is "potentially hindered by misunderstandings and differing expectations between enterprises" (Burdon et al., 2015, p. 285). Thus, maintaining any virtual community requires adequate resources for active follow up (Diaz-Diaz & Perez-Gonzales, 2016). This explains that many large organizations struggle to re-tune their business model towards innovation, even though they are aware it can lead to corporate success (Burdon et al., 2015).

Management practices should move towards enabling and supporting radical, collective learning (Kallio & Lappalainen, 2015), as multi-stakeholder partnerships are resource demanding and require continuous investment in project management, processes, and people (Pino, et al. 2012). Customer co-creation can use very different methods and practices to involve customers, and to actively gain information and knowledge about the customer (Edvardsson *et al*., 2013). Diaz-Diaz and Perez-Gonzales (2016) find that the usability of co-creation technology is important, and Doyle (2010) identifies the need for awareness to clarify meanings between partners.

A strategy helps align "a service development strategy has to do with the internal strategic alignment of resources, capabilities and organisational units, including value capture in a service system that enables and facilitates customers in their context-specific, value-creation situations and efforts" (Edvardsson, *et al*., 2013, p 38).

End-user participation was seen as an activity which should be strategically structured by the organization driving the innovation project. Networks and learning become constructed through interaction, where open innovation, facilitation, and cooperation tools can bring advantages. We should enable collective learning. Co-creation of knowledge, value, and innovation are constructed only through interaction. So it is, first of all, important to partner and have a strategy for cooperative interactions. The objectives of all parties involved should be taken into account, as active resources from all are needed, and clear management practices are to facilitate mutual understanding between the various innovation network partners.

3.4 Table of Main Topics Discussed in the Literature

The table below summarizes the main topics discussed in the articles related to co-creation.

Co-creation projects benefiting innovation network	Co-creation projects benefiting public entities	Co-creation projects benefiting business-to-business value chain networks
Need for collaboration:	**Need for collaboration:**	**Need for collaboration:**

– Value is co-created in the network when actors integrate resources through their actions and interactions with each other (Pinho *et. al*., 2014) – Value co-creating factors (Pinho *et. al*., 2014): quality of information, and facilitation of different actor's activities – Broader and better engagement in knowledge sharing and co-creation (with surrounding business and community partners) (Doyle, 2010) **It takes time:** – Value is co-created in a flow over time; actors constantly change their roles (Pinho *et. al*., 2014). – Engage stakeholders (in the co-creation of the futures that they all want) (Accordino, 2013) – Develop of mutual understanding (through a common language and mutual expectations) (Doyle, 2010) **Challenges:** – Multi-stakeholder partnerships are resource demanding and require continuous investment in project management, processes, and people (Pino *et. al*. 2012) – Lack of awareness of the advantages of open innovation among organizations (Pino *et. al*. 2012) – A need for awareness to clarify meanings between partners (Doyle, 2010) – Activities, requirements, information, and value co-created among actors are all highly interconnected (Pinho *et. al*., 2014). – The benefit an actor gets today is dependent on what he or she and others	– Open interaction and mutual trust building among the actors in the network (Kallio & Lappalainen, 2015) – Value was co-created through partnership (Dawe & Sankar, 2016) – Partners "worked extremely closely together to co-produce 'real world' solutions (Powell, 2012) **A common problem needed:** – Active engagement of stakeholders throughout the project life to identify and solve problems, manage stakeholder expectations, and co-create value (Chang *et. al*., 2013) – Partners have to collaborate to define a problem that is wort their combined effort (Powell, 2012) – Innovation, networks, and the learning processes result from interaction and become constructed simultaneously (Kallio & Lappalainen, 2015) **Innovation Environments:** – Collaboration between stakeholders in physical and intellectual spaces (Reiter *et. al*., 2014) – Open innovation environments integrate user driven innovation, build trust and establish a common goal to co-create (Reiter *et. al*., 2014) – New technologies allow citizens take a more active role …, to co-creating value (Diaz-Diaz & Perez-Gonzales, 2016) **Challenges:** – Innovation is not easy, either to foster or to achieve (Dandonoli, 2013) – Co-created structures or processes can no longer be controlled by any single	– Joint teams build a sense of community and shared purpose (Burdon *et al.*, 2015) – Focus on: individual competencies in development team, and interaction with customers (Edvardsson *et. al*., 2013) – Open innovation as a strategy of exchange across firm boundaries can benefit from innovation intermediaries (Katzy *et. al*., 2013) – Inter-firm relationships and cooperation for the co-creation of value require time to develop (Schertzer *et. al.*, 2013) **Challenges:** – Misunderstandings and differing expectations (Burdon *et al*., 2015) – Businesses struggle to re-tune their business model towards innovation (Burdon *et al*., 2015) – Contrary to management belief: a service development strategy is needed to improve new service development performance (Edvardsson *et. al*., 2013) – Firms need to recognize , and to accommodate to the differing needs of newly acquired and longer-term customers (Schertzer *et. al*., 2013)

have done before (Pinho *et. al*., 2014).	party (Kallio & Lappalainen, 2015) – Usability of co-creation technology is very important (Diaz-Diaz & Perez-Gonzales, 2016) – Maintaining virtual communities require resources for follow up (Diaz-Diaz & Perez-Gonzales, 2016)	

Table 6: Main focus concerning co-creation in innovation networks

4. Discussion, Conclusions, and Further Study

Roles between stakeholders are found to be fluid and in constant change. One common point in the co-creation literature examined is that end users participate actively – also in research.

The findings (see Figure 1) show that co-creation of knowledge for innovation and active multi-stakeholder participation of end users calls for: (1) collaboration; and (2) a common problem. The results also show that to ensure open communication toward co-creation of knowledge, there are the three main challenges to manage in an innovation network: (3) stakeholders need to be actively engaged of throughout the project, and this; (4) takes time; and (5) effort.

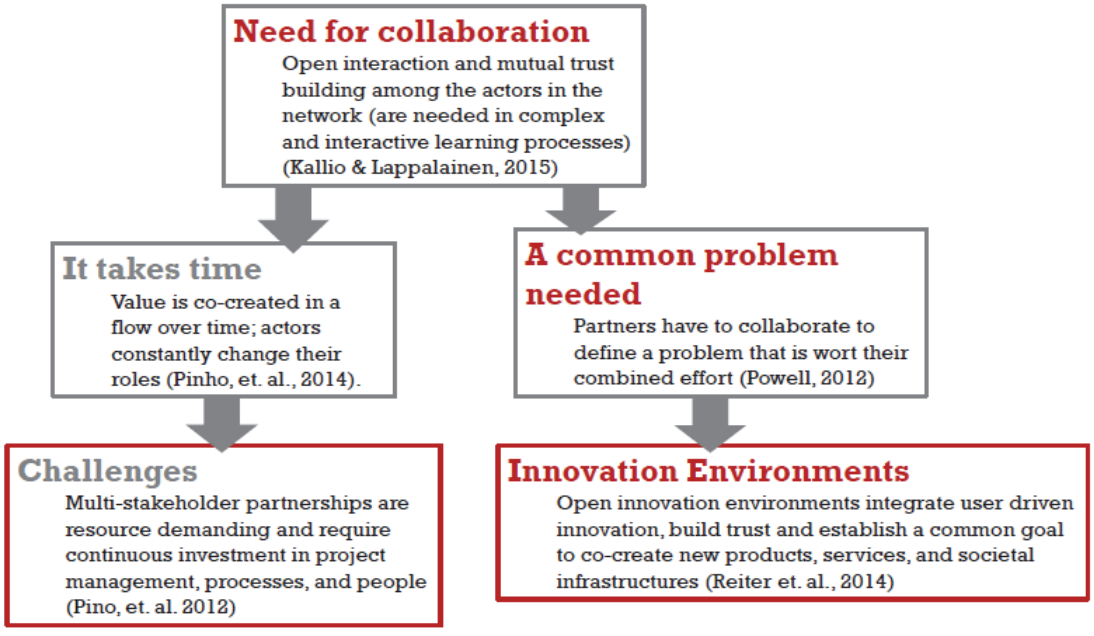

Figure 1: Elements of co-creation of knowledge for innovation identified from the sample literature.

Innovation environments and collaboration technology are widely discussed ways to tackle these challenges. Active and open collaboration is the key to successful co-creation. Collaboration is jointly constructed and lead. Any one organization cannot

be in charge alone, but all must feel that they will benefit from the process and its outcomes.

A common goal or benefit guides the innovation process. Finding a common problem may already be a co-creation process in its self. Innovation ecosystems may publicly (by the European Union, Member States, or Municipalities) stimulate innovation, and reward collaboration. Work that could otherwise be left undone may get done by the scale of different actors.

The literature studied suggests that there be a cyclical connection between value co-creation networks (see Figure 2); the cooperation platforms, tools, and active facilitation needed to foster co-creative innovation and knowledge sharing; active stakeholder participation stemming from common aims, which promise benefits for all; and an active drive for co-creation of knowledge, innovation, and change. Besides being cyclical, this connection can move both forward and backward. These cyclical connections, the cooperation efforts between project stakeholders, can either evolve and move forward to the next, higher level of the four categories of innovation projects with multiple stakeholders, identified in this study, or recede backward to the previous, lower level category: (1) Co-creation projects benefiting one company; (2) Co-creation projects benefiting business-to-business value chain networks; (3) Co-creation projects benefiting public entities; (4) Co-creation projects benefiting innovation network.

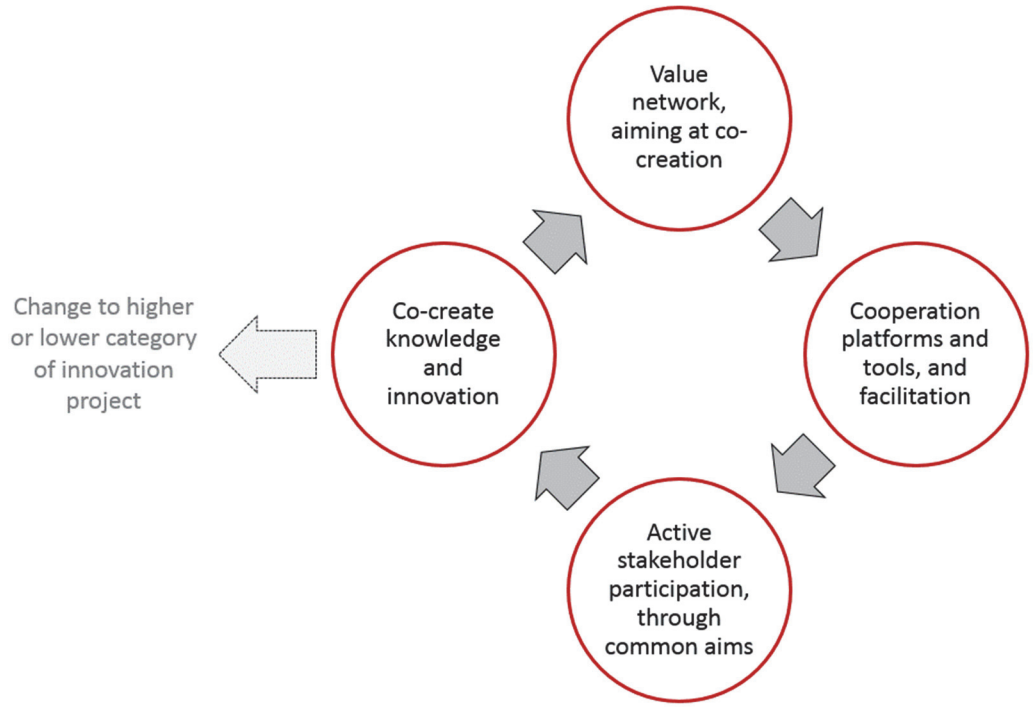

Figure 2: The cyclical connections in co-creation projects.

A limitation of this study is the somewhat limited number of 33 chosen articles from a comprehensive total of over 5.000 search hits for key word *co-creation*. On the other hand this gives the study specific focus, needed to identify the most relevant articles.

More study is recommended to further deepen the study on modes of collaboration and related Public Relations.

Further study is planned to look at scenario building and the use of expert panels as forms of input and throughput communication in innovation projects. This may involve the study of end user scenarios and end user involvement in setting requirements for network performance.

Another interesting question for further research stemming from this study is, if more complex value networks can lead to faster and deeper co-creating innovation. This may be the involvement of end users in creating collaboration network cases for the co-creation of knowledge and information sharing to look at how attributes of complexity affect innovation in these cases of collaboration networks,

Further interesting topics are resilience in collaboration networks, and how Public Relations, external communication and dissemination by a project, matches requirements set by funding instruments.

References

Accordino, F. (2013). The Futurium – a Foresight Platform for Evidence-Based and Participatory Policymaking, Philosophy & Technology, vol. 26, no. 3, 321-332.

Bhalla, G. (2014). How to plan and manage a project to co-create value with stakeholders, Strategy & Leadership, Vol. 42 No. 2 2014, pp. 19-25.

Burdon, S., Mooney, G.R. & Al-Kilidar, H. (2015). Navigating service sector innovation using co-creation partnerships, Journal of Service Theory and Practice, vol. 25, no. 3, 285-303.

Chang, A., Chih, Y., Chew, E. & Pisarski, A. (2013). Reconceptualising mega project success in Australian Defence: Recognising the importance of value co-creation, International Journal of Project Management, vol. 31, no. 8, 1139.

Dandonoli, P. (2013). Open innovation as a new paradigm for global collaborations in health, Globalization and Health, vol. 9, no. 1, n/a.

Dawe, S. & Sankar, C.S. (2016). Research note for "Developing a smart city by operationalizing the co-creation of value model, Journal of Information Technology Case and Application Research, vol. 18, no. 1, 50-52.

Díaz-Díaz, R. & Pérez-González, D. (2016). Implementation of Social Media Concepts for e-Government: a Study of a Social Media Tool for Value Co-Creation and Citizen Participation, Journal of Organizational and End User Computing, vol. 28, no. 3, 104.

Doyle, L. (2010). The Role of Universities in the 'Cultural Health' of their Regions: universities' and regions' understandings of cultural engagement, European Journal of Education, vol. 45, no. 3, 466.

Edvardsson, B., Meiren, T., Schäfer, A. & Witell, L. (2013). Having a strategy for new service development - does it really matter? Journal of Service Management, vol. 24, no. 1, 25-44.

Franz, Y. (2015). Designing social living labs in urban research, Info: the Journal of Policy, Regulation and Strategy for Telecommunications, Information and Media, vol. 17, no. 4, 53-66.

Galvagno, M. & Dalli, D. (2014). Theory of value co-creation: a systematic literature review, Managing Service Quality, vol. 24, no. 6, 643.

Halonen, M., Kallio, K. & Saari, E. (2010). Towards co-creation of service research projects: a method or learning in networks, International Journal of Quality and Service Sciences, vol. 2, no. 1, 128-145.

Harmokivi-Saloranta, P.M.J. & Parjanen, S. (2010). Promoting health related sport by using living lab, British journal of sports medicine, vol. 44, i75.

Jesson, J.K., Matheson, L. and Lacey, F.M. (2011). Doing Your Literature Review. Traditional and Systematic Techniques, Sage, London.

Kallio, K. & Lappalainen, I. (2015). Organizational learning in an innovation network, Journal of Service Theory and Practice, vol. 25, no. 2, 140-161.

Katzy, B., Turgut, E., Holzmann, T. & Sailer, K. (2013). Innovation intermediaries: a process view on open innovation coordination, Technology Analysis & Strategic Management, vol. 25, no. 3, 295-309.

Kazadi, K., Lievens, A. & Mahr, D. (2016). Stakeholder co-creation during the innovation process: Identifying capabilities for knowledge creation among multiple stakeholders, Journal of Business Research, vol. 69, no. 2, 525.

Pinho, N., Beirão, G., Patrício, L. & P. Fisk, R. (2014). Understanding value co-creation in complex services with many actors, Journal of Service Management, vol. 25, no. 4, 470-493.

Pino, M., Plichart, M., Kerherve, H., Bouilly, C. & Rigaud, A. (2012). Multi-stakeholder partnerships for the development and implementation of assistive technology interventions for older adults with cognitive impairment, Non-Pharmacological Therapies in Dementia, vol. 3, no. 2, 149-161.

Powell, J. (2012). The university role in the innovative leadership of small to medium sized enterprises, International Journal of Entrepreneurial Behaviour & Research, vol. 18, no. 4, 396-416.

Reed, M., Stringer, L., Fazey, I., Evely, A. & Kruijsen, J. (2014). Five principles for the practice of knowledge exchange in environmental management, Journal of environmental management, vol. 146, 337.

Reiter, S., Gronier, G. & Valoggia, P. (2014). Citizen Involvement in Local Environmental Governance: A Methodology Combining Human-Centred Design and Living Lab Approaches, Electronic Journal of E-Government, vol. 12, no. 2, 108-116.

Ruoslahti, H., & Knuuttila, J. (2011). Listen to three types of border guard – adopting technology into the process of border checks, Credibility Assessment and Screening Technologies at the 45th Hawaii International Conference of Systems Sciences 2011, pp. n/a.

Schertzer. M.B., Schertzer, C.B., Dwyer, F.R. (2013). Value in professional service relationships, Journal of Business & Industrial Marketing 28/8 (2013) 607–619.

Tokman, M. & Beitelspacher, L.S. (2011). Supply chain networks and service-dominant logic: suggestions for future research, International Journal of Physical Distribution & Logistics Management, vol. 41, no. 7, 717-726.

II

A CO-CREATED NETWORK COMMUNITY FOR KNOWLEDGE AND INNOVATIONS – PROMOTING SAFETY AND SECURITY IN THE ARCTIC

by

Ruoslahti, H. & Hyttinen, K. 2017

Proceedings of BledCom 2016
Engaging people in a disengaged world

5

A Co-created Network Community for Knowledge and Innovations – Promoting Safety and Security in the Arctic

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Abstract

The cooperation between Arctic states – Russia, the United States, Canada, Denmark, Iceland, Norway, Sweden, and Finland – has been particularly peaceful while geopolitical tensions have risen elsewhere (Pezard et al., 2017). Discussions on prospecting Arctic natural resources (Haftendorn, 2016., p. 133) have raised new challenges also to knowledge and information management. Therefore, this paper argues that there is a need to develop a co-creation network among higher education and key end users, for knowledge and information sharing and promoting innovation, which will contribute on safety and security in the Arctic domain. The research question for this paper is: How can end users be involved in the process of creating a co-creation network for knowledge and information sharing to contribute on innovations to Arctic safety and security?

The method focuses mostly on the third phase of the Engeström's (2007) expansive learning process, *modeling a new solution*. This is a participatory work in progress. Beyond the desk review, the notes from co-creation network partner communication and meeting discussions have been and are gathered under the Chatham House rule (Chatham House, 2016) to ensure anonymity of all people participating in the process. Creating a new long-term co-operation program of higher education and end users, a co-creation network will attempt to engage a still disengaged field by affecting change to currently scattered and unlinked programs and systems, and build alignment of best practices. This co-creation network needs to be multi-disciplinary and multi-institutional to bring disparate security and safety management and other researchers and experts together with both one another, and with end-users. Online platforms can facilitate the information and knowledge sharing, as well as enable the co-creation of innovations among the network community. This paper provides a suggestion of the process for co-creation and knowledge exchange between the network members.

The enhanced Arctic research and study community aims to contribute to a safer, more secure and cleaner domain. Developing insights on sustainable economic growth, international processes and best practices, may lead to increased situational awareness as well as supports decision-making – for the benefit of the Arctic.

Key Words: Co-creation of knowledge, Innovation, Co-creation Network, Knowledge, Arctic Security

Introduction

The Arctic is the northern circumpolar region and its ice covered ocean (Heikkilä & Laukkanen, 2013). Economic and human activity is increasing there, partly because the climate of the Arctic is warming. The Arctic Ocean is projected to become nearly ice-free during the summer times within the next 30 to 40 years. Thus, global climate change is opening new Arctic possibilities, such as drilling for natural resources and new sea routes that cut distances between the Pacific and Atlantic oceans. But, these also present new challenges. "*Regardless of the risks involved, these Arctic routes and possibilities are a hot topic and shipping in the Arctic will most likely increase in the future*" (Salokannel, Knuuttila & Ruoslahti, 2015: p. 2).

The Northeast Passage between Europe and Asia is 30 – 40 % shorter than the route through the Suez Canal (Guy & Lasserre, 2016). There is still little traffic on the Northeast Passage, but it is constantly increasing. There is a growing need to cooperate and share information that benefits the security and safety of living, transport, and economic use in the Arctic environment (Ruoslahti & Knuuttila, 2016). "*The regulations concerning the safety of shipping, Arctic navigation services, and the readiness to prevent various accidents and to act in accident situations are badly inadequate… Surveillance arrangements in the Arctic sea area and cooperation between the authorities can be seen as an area of development …*" (Finland's strategy for the Arctic region, 2010, p. 28).
Also beyond the national strategies the necessitated additional multilateral strategies have been argued to ensure stable and harmonized priorities (Haftendorn, 2016. p. 134). European Maritime development, for example, seeks to respond to challenges facing the entire European maritime domain in an integrated and cross-sectorial way (European Coast Guard Functions Forum, 2014), which can serve as a working example also for the Arctic regions. The agreement of the Arctic Council on Cooperation in Aeronautical and Maritime Search and Rescue in the Arctic (Arctic Council, 2011) and the International Maritime Organization's (IMO) Guidelines for Ships Operating in Polar Waters (IMO, 2010) are important indicators of development towards proactive safety and security and coordinated coast guard functions related activities in the Arctic domain.

End users in this context are the affected communities living in the region, key political decision makers, private sector companies, shipping and drilling industries, with a presence on the Arctic seas; as well as the coast guard functions, who oversee security and safety in the region. Denmark, Norway, Russia, United States, and Canada have Arctic coastline. Also Sweden and Finland have Baltic Sea coast-line that becomes ice covered during winter months.

The focus of this paper is to investigate the process of involving public and private institutions, and, in particular of end users, in creating an enhanced Arctic research and study community. A network for knowledge and innovation contributing to Arctic safety and security that will involve the actors in active communication. A network of co-creation to promote safety and security on the Arctic domain (later: co-creation network) can add communication and new forms of cooperation through cross-sectorial and regional research and development in issues such as: common awareness, risk pictures, preparation against disaster, joint capacity building, resource pooling and innovations. Built network cooperation will benefit and add value to all sectors working towards a safer and more secure Arctic maritime domain.

This research question for this paper is: How can end users be involved in the process of creating a co-creation network for knowledge and information sharing to contribute on innovations to Arctic safety and security?

2. Literature review

2.1 A Safety and Security Gap in the Arctic

For a long time, the Arctic has been seen as an exceptional space, "an apolitical space of regional governance, functional co-operation, and peaceful co-existence" (Käpylä & Mikkola, 2015, p. 5).

The last decade has seen the Arctic re-emerge as a political component, due to the exceptionally rapid warming and reduction in the Arctic sea ice cover, which is especially noticeable during the summer months. The Arctic is opening up "and substantial natural resource bases as well as new maritime routes in the area were becoming more easily exploitable" (Käpylä & Mikkola, 2015, p. 6).

The Arctic includes the Northern fringes of Europe, Asia, and North-America. Besides the increasing economic and human activity in the Arctic regions, about 4 million people live there permanently. Research shows that the climate of the Arctic is warming (Heikkilä & Laukkanen, 2013). Between 2005 and 2010 was the warmest period ever measured in the Arctic and the extent of Arctic sea ice has never been recorded as low as it was in 2012 (European Commission, 2012).

The rate of the warming of the Arctic, and the decrease of the ice-cover have been surprisingly rapid. There is a great deal of pressure and increased strategic, political, and economic interest to the area. A future, where the Arctic Ocean could, much like the Baltic Sea around Finland today, freeze in winter and melt in summer is easily imaginable (Heikkilä & Laukkanen, 2013; Gascard, 2014).
Russia, for example is building an Arctic gateway of its sea route, the Northeast Passage. Its traffic is increasing and is expected to continue increasing (Zalyvsky & Eduardovna, 2015; Guy & Lassarde, 2016). Vessels are aided by nearly two dozen Russian icebreakers and protected by a string of 10 up-to-date search-and-rescue centres along the route. Continued increase in the near future on this Arctic gateway that the Russians are building between European and Asian ports is predicted. "…*to reduce risks, Russia imposed a mandatory piloting scheme along the northern sea route (NSR)*" (Guy & Lasserre, 2016; Gascarde, 2014).

Over 200 transit traffic vessels have passed through the Northeast Passage on Russia's Northern Sea Route between 2010 and 2014, with 71 in 2013 alone (Guy & Lasserre, 2016). Besides transit traffic, there are additional traffic, within the Arctic that load or unload cargo to and from the region, and transport of supplies to local communities or industry.

"*For the first time ever, an ice class 1A bulk carrier "Nordic Orion" 225 m long from the Nordic Bulk Carriers A/S Danish company, is using the North West Passage in September 2013 as a transit trade lane when transporting 75000 tons of coal from Vancouver, Canada to the port of Pori in Finland*" (Gascard, 2014, p. 13).

As activity in the Artic is increasing, the discussion on the safe use of Arctic resources is a very contemporary topic. This paper argues that there is a need to develop a co-creation network to increase knowledge and innovation, and to promote and ensure safety and security in the Arctic domain.

Fees paid by shippers, help cover costs of improvements to the sea route. This busier maritime transportation corridors are also starting to stimulate inland development; a railroad is planned to connect Russia's mineral-rich interior to its Arctic coast and liquid natural gas facilities on the coast are scheduled (Heininen, et. al., 2014; Lipponen, 2015).

The US Geological Survey (2011) estimates that the Arctic holds 30 % of undiscovered oil and 30% of undiscovered gas supplies, offshore and in depths of under 500 meters. This creates an increasing presence and development possesses specific safety and security challenges for maritime safety and security and Coast Guard functions (Guy & Lasserre, 2016; Salokannel, Knuuttila & Ruoslahti, 2015): Increasing economic activity and Arctic sea traffic may cause safety and environmental impacts. Arctic tourism, involving cruise ships in particular is increasing; and yet there are very limited monitoring and surveillance capabilities (Gascard, 2014).

Possible rescue operations will be extremely difficult in case of accidents and emergencies, as the northern coast of Russia, Alaska, and Canada are largely uninhabited and have few harbours. Possible oil discharges could inflict large areas while there is no real oil destruction response capacity available. Due to the lack of a regulatory framework, uncontrolled fishing may occur. There is a lack of international navigation aids and of common Risk analysis in Cost Guard Functions (Salokannel, Knuuttila & Ruoslahti, 2015; Ruoslahti & Knuuttila, 2016).

2.2 Knowledge and Innovations

Knowledge is an important source to competitive advantage and "*a key to the success of modern organizations and creative higher education*" (Pirinen, 2015, p. 1). The capability to create organizational knowledge is a key to innovate. The dynamic interactions among all level roles lead to creation of new

knowledge instead of individuals. Knowledge creation leads to continuous innovation and finally to competitive advantage. (Nonaka, I. & Takeuchi, H. 1995. p.6).

Co-created knowledge, knowledge from sharing experiences and knowledge with reflection, is a process of participation in work and social communities. These networks use common information sharing environments and build trust and confidence in one another through interactions between them. A collective responsibility to facilitate a collective R&D progress results in investigations; inventions and innovations (Pirinen, 2015). Co-creation feeds from common objectives and it can occur in both physical and digital arenas. (Bhalla, 2014), where the collaborators can share tools and collaborative processes. There should also be a structure of formal contracts between the collaborators. Valkokari et. al. (2012, p. 27), note that: "… *a strategic approach to knowledge management is a key element of success within networked innovation, both in the theory and in the practices*…".

The issue arenas model for organizational communication (Vos, Schoemaker, & Luoma-aho, 2014; Luoma-aho & Vos, 2010) explains multi-stakeholder communication, while Galvagno & Dalli (2014) note that co-creation is useful in promoting innovation, as is a strategic approach to knowledge management. A strategic approach is a key element of success in networked innovation, according to Valkokari, et. al. (2012).

Online platforms provide secured online possibilities for needed common information sharing environments, co-creative knowledge creation, and for sharing information and finally research results (Bhalla, 2014; Saarinen, 2012; Hosie, et. al., 2003). The computers made the delivery of education possible and the material were able to deliver both print and electronical media (Moore, 1990). The critical components of successful integration of technology innovations within education and training settings and influences the adoption rate of such technologies are transparency in user interface design and Human Computer Interaction (HCI) (Charalambos, 2004.). Shared information are needed in externally funded projects and innovation networks; participation in which is an important channel of knowledge transfer (Pirinen, 2015; Di Cagno, et. al., 2014); and where combining management of projects, networking, and learning is challenging (Ruoslahti, et. al., 2011).

3. Methodology

To build a basis for the creation of the co-creation network this study uses Engeström's (2007) expansive learning process together with the understanding of Nonaka & Takeuchi (1995) Knowledge Creation model to support innovations. The expansive learning process consists of the following phases: (1) Questioning existing practices, (2) Analysis of existing practices, (3) Modeling a new solution, (4) Exploring the new solution, (5) Adopting the new solution, (6) Evaluating the process, and (7) Solidifying and expanding new practices.
This paper focuses on the third phase of the expansive learning cycle, modeling a new solution. The method is participatory and a work in progress. Conclusions from co-creation network partner communication (meetings, discussions, workshops, events) are gathered under the Chatham House rule (Chatham House, 2016) to ensure anonymity of all people participating in the study. The data is collected from public sources, and from work completed 2011 – 2016. The data consists of the conclusions from discussions with policy maker representatives, and from the Laurea UAS internal documentation (documentation of European CISE (Common Information Sharing Environment roadmap and CISE Education Network). It also includes the notes from a cooperation workshop with World Maritime University in August 2014 and European Maritime Day 2015, and from Center for Island, Maritime, and Extreme Security – CIMES meetings 2011 - 2014. The data includes also the work conducted in ShipArc 2015.

4. Results

The results of this paper focus on the possible actors needed to a co-creation network in Arctic domain with its main aim. As this is still a work in progress, this paper is limited to the current situation and knowledge.

5.1 Coordination Structures on the Arctic Research and Development Actions

5.1.1 The Arctic Council

The Arctic Council is the most important international forum for cooperation in the region. The Artic Council is formally established in Ottawa Declaration of 1996 as high level intergovernmental forum which aims to provide a means for promoting cooperation, coordination and interaction among the Artic States (Arctic Council, 1996). The particular issues concentrate on sustainable development and environmental protection in the Artic. Canada, United States, Russia, Denmark (Greenland and the Faroe Islands), Iceland, Norway, Sweden, and Finland are member states of the Arctic Council together with permanent participants of six councils representing indigenous peoples of the Arctic. The Arctic Council promotes various forms of collaboration in the Arctic Region (Arctic Council, 1996).

The Arctic Council has a very broad scope, but the Agreement on Cooperation in Aeronautical and Maritime Search and Rescue (Arctic Council, 2011) demonstrates that safety and security in the Arctic domain are an important part of it. The co-creation network will be able to raise topics to the attention of the Arctic Council decision making and, thus increase awareness of safety and security related issues and solutions, and cooperation among its member states. The decision making may benefit from the work of co-created network community.

4.2 Networks of Researchers and University of the Arctic

An important form of collaboration are scientific research networks on Arctic issues; notable networks of Arctic research and education are the International Arctic Science Committee (IASC), providing guidelines for international science policy and research cooperation on the Arctic; the Association of Polar Early Career Scientists (APECS), promoting cooperation between students and researchers in

the early phase of their careers; and University of the Arctic, a network of close to 140 institutions from Arctic countries, enhancing research and student exchange, training between participating universities (University of the Arctic, 2013).
"*The University of the Arctic (UArctic) is a cooperative network of universities, colleges, and other organizations committed to higher education and research in the North. Our members share resources, facilities, and expertise to build post-secondary education programs that are relevant and accessible to northern students*" (University of the Arctic, 2013). To promote focus the UArctic has thematic networks. An alternative is, that the co-creation network be structured into a thematic network under the University of the Arctic.

5.3 Safety and Security on the Maritime Domain and Coast Guard Functions in Europe
European Maritime Policy seeks to respond to challenges facing the European maritime domain in an integrated and cross sectorial manner. Issues, named Coast Guard Functional activities, have been defined by the European Coast Guard Functions Forum (ECGFF) (European Coast Guard Functions Forum, 2014): The European coast guard functions are maritime safety and vessel traffic management; fisheries control; maritime border control, surveillance, security, customs activities, and law enforcement; also maritime environmental protection and response; accident and disaster response; and search and rescue at sea; plus other related activities (Figure 1).

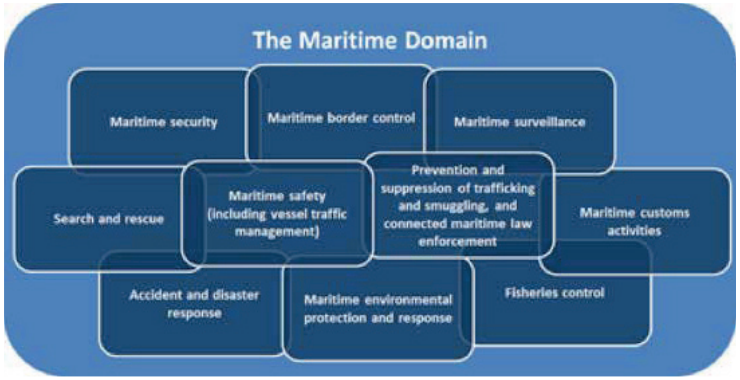

Figure-1: The Constructive Manner of the Terms of Reference (TORs) of Coast Guard Functions (European Coast Guard Functions Forum, 2014)

The European Union and its Member States are working towards a future of integrated non-military maritime surveillance and deeper Coast guard functions related coordination. This development will improve coordination and the wider implementation of platforms, such as EUROSUR (Frontex, 2015) and CISE – Common Information Sharing Environment, for example (European Commission, 2015).
Present national Coast Guard education systems mainly serve operational targets and are regulated by professional and organizational purposes; thus post-graduate, and post-doctoral, levels of education are not included.
A Co-creation Network could promote more unified requirements to educational institutions in the field (coast guard and other actors on the maritime domain). National authorities use, their own educational resources, and also those of other public and relevant private actors. To fully exploit the potential of an integrated maritime policy, the Coast Guard Functions approach could be extended to the academic and educational sectors (WMU Workshop, 2014).

Coast Guard Cooperation Networks
Coast Guard Cooperation Networks include: the Baltic Sea Region Border Control Cooperation (BSRBCC), the Northern Atlantic Coast Guard Forum (NACGF), the Black Sea Littoral States Border/Coast Guard Cooperation Forum (BSCF), the Mediterranean Coast Guard Services Forum (MEDFORUM), and the North Pacific Coast Guard Forum (NPCGF). They all have a regional maritime focus in maritime safety and security, environmental protection, combat of cross-border crime, and enhancement of information exchange (PERSEUS, FP-7 Project, 2013).

These networks represent the different authorities in charge of Coast Guard functions in each country. Thus each of these member organizations will also have educational and research structures and institutions such as mentioned above. The relevant coast guard cooperation networks for the arctic are the Atlantic, Baltic, and Pacific Coast Guard Forums (Figure 2), which cover the entire Arctic domain.

Figure-2: Relevant Northern coast guard cooperation networks for the co-creation network on the Arctic Domain

Today national Coast Guard educational institutions form bodies of knowledge through their interaction with practitioners on the field. Professional best practices are transferred from generation to generation both inside and outside of existing formal curricula. A coordinated, genuinely open and coast guard functions focused post graduate study environment for authority officers is now missing. For example, active coast guard personnel are not always as free, to address and discuss professional problems and lacking solutions in an open academic manner, as retired officers are (Third European Maritime Domain Security Planning Meeting, 2013).

5.5 The Added Value of an Arctic Co-creation Network Community
The Arctic co-created network community would benefit and add value to all sectors aiming towards a safer and more secure Arctic domain. As stated earlier current coast guard education systems lack post-graduate, and post-doctoral, levels of education, as well as matching levels of basic and applied

research and study. The co-creation network aims to be a multi-disciplinary cooperation body, bringing now disparate researchers and institutions together with other security and safety management, and coast guard functions oriented researchers and institutions. Thus, the co-creation network would have a clearly broader focus than existing coast guard institutions; but also a much more defined scope and focus than the University of the Arctic (Second European Maritime Domain Security Planning Meeting, 2012).

The purpose of this co-created arctic network community could add communication and new forms of cooperation through cross sectorial and regional research and development in issues such as common awareness, risk pictures, preparation against disaster, joint capacity building, resource pooling. All these developments will require open study and common mechanisms, such as the co-creation network would provide. One purpose is to complement existing coast guard forms of cooperation, one of the main ones being the European Coast Guard Academies Network Project initiative (Third ECGFF Secretariat Meeting, 2013).

The co-created arctic network community can broaden the focus of today's defined training oriented National Coast Guard Institution educational programs; while bringing focus to very broadly defined academic basic research and study networks, such as the University of the Arctic. Most added value will come from a cooperation and study platform for individual students and researchers interested in a multi-disciplinary approach toward security and safety of transport, and human and economic activity in the Arctic environment. The co-creation network will enhance information exchange and participation possibilities in EU and Government Agency funded research and development projects.

5.6 Participation and involvement

The co-created Arctic Network Community key participants will be institutes that either educate coast guard personnel or participate in research and development in topics, which are (loosely) under coast guard activities and processes topics as discussed above. Many educational and research institutions will not be official coast guard authority institutions, but have related programs to safety and security, maritime domain, and coast guard development and education issues. Potential institutions are those which focus on IMO based maritime safety aspects, security management focused institutions, relevant technological institutions, environmental research institutions, and those of customs authorities, etc. (WMU Workshop, 2014).

The co-creation network can help create long term involvements such as information and knowledge sharing which affect change into the current status quo of scattered and unlinked programs and systems. It can demonstrate new knowledge on how a cooperation should work in the future (e.g. in SAR) – not only technically, but also as a process to change the current mind-sets to cooperate more and share information to benefit the security and safety of living, transport, and economic use in the Arctic environment.

One working group of Arctic network community may focus on building the networks around research and studies that aim to lead to safer, more secure and cleaner seas, through sustainable economic growth. Better information and knowledge sharing will lead to better situational awareness and sound to decision-making – for the benefit of the Arctic seafarer. If the route of R&D related learning can be extended and generalized, higher education institutions will face new opportunities from their networked expertise (Pirinen, 2015): "… higher education institutions can increase their contribution to the innovation system; higher education institutions can keep co-creation and innovation processes alive at the regional, national and global levels;…"

Arctic network community development should also lead toward Artic security related online education. Education programs, which provide learning possibilities that are not tied to time or place. An as flexible of an approach as possible will empower students "to choose their own learning curriculum according their own interest. That is the benefit having so many universities and institutes on board" (Heinonen, 2016).

Artic safety and security education can be facilitated as online basis among and between network members. The platform can provide secured online possibilities for sharing the information and research results and related to the issued topics as well as facilitate the online learning. To integrate the social dimension into the pedagogy of online learning environments, Felix (2005) has proposed the synthesis of the cognitive constructivist and social constructivist approaches. This online learning will follow constructivist understanding and the constructivism can be manifested in online settings; e.g. as defined above (Hosie, Clifton, & Joe, 2003).

In a role of an individual expert (researcher, student, other expert), the expert will have the wide selection offering the various participating institutions sharing research results, created knowledge and information and finally study curriculum based on individual and professional preferences to result in a PhD or a multi-disciplinary Master's or Doctorate of Business Administration. Authority officials will have a broader venue of advancing their knowledge and education (Third European Maritime Domain Security Planning Meeting, 2013; Gröndahl, et. al., 2014).

The research of co-creation range between the smallest collaborative innovation in new product development processes to a wider theory of co-creation research stream (Galvagno & Dalli, 2014), and a co-creation network can be active throughout this spectrum. A co-creation network will need common objectives to work towards, it will exist and operate in both digital and physical arenas, share cooperation tools and collaborative processes, and we shouldn't forget contracts between the collaborators (Bhalla, 2014).

Conclusions

Creating a new long-term co-operation among Arctic experts, a co-creation network community can engage a still disengaged field by affecting change to currently scattered and unlinked programs and systems, and build alignment of best practices. New knowledge and more effective future cooperation, technically and as a process, may bring about a change of current mind-sets and provide further innovations to meet with the set objectives. This research aims to provide insights on ways to involve end users in the co-creation process. This could help other collaborative problem solving processes that need input of end users.

This co-created Arctic network community needs to be multi-disciplinary and multi-institutional, bringing disparate security and safety management and communication researchers together with both one another, and with end-users. An online platform will serve learning online and sharing research results and co-creation information between the network members and experts.

The co-creation network aims to broaden the focus of today's defined training oriented national coast guard institution educational programs, and create broadly defined academic basic research networks and larger community bringing all end users to the same network. This should provide an opportunity to experience a multi-disciplinary approach toward security and safety of activities in the Arctic. The enhanced Arctic research and study society aims to contribute to a safer, more secure and cleaner domain, and develop insights on sustainable economic growth, international processes and best practices, leading to increased situational awareness and decision making – for the benefit of the Arctic.

Also, the education programs in this context can provide learning possibilities that are not tied to time or place. A flexible approach may enable students across the network to choose a learning curriculum based on content and interest. This paper suggests that the co-created Arctic network community should also award higher levels of post post-graduate and post-doctoral education. The network can be a UArctic thematic network, having a much more defined scope and focus on coast guard functions, security, and safety on the Arctic maritime domain than the University of the Arctic itself; while also having a clearly broader higher education focus than any coast guard institution or their cooperation networks.

Further work will focus on the process of co-creation and knowledge exchange between the network members to identify ideal modes of cooperation.

Acknowledgements

With warm memories we acknowledge the influence to this idea of our dear friend and colleague Juha Knuuttila, who unfortunately passed away last in the fall of 2016. We miss you!

References

- Arctic Council (1996). Declaration of the Establishment of the Arctic Council – Joint Communique of the Governments of the Arctic Countries on the Establishment of the Arctic Council, 19th of September 1996, Arctic Council, Ottawa, Canada.
- Arctic Council, 2011. Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic. Arctic Council Secretariat, Tromsø: Norway.
- Artic Council (2014). About the Artic Council. From: www.artic-council.org.
- Artic Portal. 2014. http://www.arcticportal.org/, Accessed 25th April 2016.
- Bhalla,G. (2014). How to plan and manage a project to co-create value with stakeholders, Strategy & Leadership, 2014, 42, 2, 19-25, Emerald Group Publishing, Limited, Chicago, United Kingdom, Chicago.
- Charalambos, V., Michalinos, Z. Chamberlain, R. 2004. The Design of Online Learning Communities: Critical Issues. Educational Media International. ISSN 1469-5790 online © 2004 International Council for Educational Media.
- Chatham House, Royal Institute of International Affairs (2016). Chatham House Rule, Retrieved April 21, 2015, from http://www.chathamhouse.org/about/chatham-house-rule, Accessed 4th April 2016.
- Di Cagno,D., Fabrizi,A., & Meliciani,V. (2014). The impact of participation in European joint research projects on knowledge creation and economic growth, Journal of Technology Transfer, 2014, 39, 6, 836-858, Springer Science & Business Media, Indianapolis, Netherlands.
- Engeström,Y., Kerosuo, H., & Kajamaa, A. (2007). Beyond Discontinuity: Expansive Organizational Learning Remembered, Management Learning, 2007, 38, 3, 319-336, Sage Publications Ltd., Thousand Oaks, United Kingdom.
- European Coast Guard Functions Forum (2014). Non Paper - July 8th 2014. Unpublished.
- Felix, U. (2005). E-learning pedagogy in the third millennium: The need for combining social and cognitive constructivist approaches. ReCALL, 17(1), 85-100.
- Gascard, J-C. (2014). ACCESS – Arctic Climate Change, Economy and Society. Arctic research funded by the European Union. Research and Innovation, edited by Immler F., European Commission
- Guy, E., & Lasserre, F. (2016). Commercial shipping in the arctic: New perspectives, challenges and regulations. The Polar Record, 52(3), 294-304.
- European Commission DG-MARE (2015). From: http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/cise/index_en.htm, Accessed 16th April 2016.
- European Commission, Education & Training (2013). From: http://ec.europa.eu/education/higher-education/bologna_en.htm, Accessed 16th April 2016.
- Finland's Strategy for the Arctic Region (2010). Prime Minister's Office Publications 8/2010, 5 July 2010 Helsinki, Finland.
- Frontex (2015). From: http://frontex.europa.eu/intelligence/eurosur, Accessed 3rd March 2016.

- Galvagno,M., & Dalli,D. (2014). Theory of value co-creation: a systematic literature review, Managing Service Quality, 2014, 24, 6, 643, Emerald Group Publishing, Limited, Bedford, United Kingdom.
- Gröndahl, M., Hookana, R., & Rajamäki, J. (2014). Emergency Management Module UArctic Network Online Course, Interactive Collaborative Learning (ICL) International Conference on 3rd – 6th of Dec. 2014, Dubai.
- Haftendorn, H. (2016). Arctic Security – new challenges in a diverse region. In Krause, J. & Bruns, S. (2016). Routledge Handbook of Naval Strategy and Security. Routledge, 2016.
- Heikkilä, M. & Laukkanen, M. (2013), the Arctic Calls, Arctic University of Lapland & Ministry of Foreign Affairs, Finland.
- Heininen, L., Sergunin, A., & Yarovoy, G. (2014). Russian Strategies in the Arctic: Avoiding a New Cold War. Valdai Discussion Club, Moscow, September 2014.
- Heinonen, J. (2016). International Security MBA – Tailored Safety and Security. UArctic Shared Voices Magazine 2016.
- Hosie, P., Clifton, L. Joe, L. (2003). Security Management Education Online. http://www.ascilite.org.au/conferences/adelaide03/docs/pdf/244.pdf, Accessed 25th April 2016.
- International Maritime Organization (IMO) (2010). Guidelines for Ships Operating in Polar Waters. Resolution A.1024(26).
- Käpylä, J., & Mikkola, H. (2015). On Arctic Exceptionalism, Critical Reflections in the Light of the Arctic Sunrise Case and the Crisis In Ukraine. 85 FIIA Working paper, The Finnish Institute of International Affairs.
- Lipponen, P. (2015). A Strategic Vision for the North – Finland's prospects for economic growth in the Arctic región. Confederation of Finnish Industries EK, March 2015
- Luoma-aho, V., Vos, M. (2010). Towards a more dynamic stakeholder model: acknowledging multiple issue arenas. Corporate Communications: An International Journal, Vol. 15 No. 3, 2010, pp. 315-33, Emerald Group Publishing Limited.
- Moore, M. G. (1990). Background and overview of contemporary American distance education.
- Nonaka, I. & Takeuchi, H. 1995. The Knowledge-Creating Company – How Japanese Companies create the dynamics of Innovation. Oxford University Press. New York 1995.
- PERSEUS, FP-7 Project (2013). Baltic Sea Region Maritime Border Surveillance Cooperation, Laurea University of Applied Sciences.
- Pezard, S., Tingstad, A., Van Abel, K., Stephenson, S. (2017). Maintaining Arctic Cooperation with Russia: Planning for Regional Change in the Far North. Rand Corporation, 2017.
- Pirinen,R. (2015). Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers, Creative Education, 2015, 6, 3, 315-330, Scientific Research Publishing, Irvine, United States.
- Ruoslahti, H., & Knuuttila, J.S. (2016). Remotely Piloted Aircraft Systems (RPAS) for Extreme Missions in the Arctic and the monitoring of the Ukraine crisis by the Organization for Security and Co-operation in Europe (OSCE), Hawaii International Conference on System Sciences, HICSS-49, Grand Hyatt, Kauai, Hawaii, USA, 5-8 January 2016.
- Ruoslahti, H., Tiainen, S., Kortelainen, M., & Vesterinen, O. (2011), How Networking and Projects Can Best Promote Learning in Higher Education? Campus Encounters – Bridging Learners Conference "Developing Competences for Next Generation Service Sectors" April 13–14, 2011, Porvoo, Finland
- Saarinen, L. (2012). Enhancing ICT Supported Distributed Learning through Action Design Research. Aalto University publication series, Doctoral Dissertations 92 7 2012, Helsinki.
- Salokannel, J., Knuuttila, J., & Ruoslahti, H. (2015). Arctic Maritime Safety and Security– the Human Element seen from the Captain´s Table, International Conference on "Safe and Sustainable Shipping in a Changing Arctic Environment" ShipArc 2015, AUGUST 25-27, 2015, Malmö Sweden.
- Second European Maritime Domain Security Planning Meeting (2012). Hosted 10th – 11th of August 2012 by Laurea University of Applied Sciences, Meri-Teijo, Finland.
- Third ECGFF Secretariat Meeting (2013). Held in Athens, 04th of July 2013. Unpublished.
- Third European Maritime Domain Security Planning Meeting (2013). Hosted 2nd – 3rd of August 2012 by Laurea University of Applied Sciences, Meri-Teijo, Finland.
- University of the Arctic (2013). From: http://www.uarctic.org/Frontpage.aspx?m=3, Accessed 25th April 2016.
- US Geological Survey (2011). U.S. Geological Survey circum-arctic resource appraisal. Society of Petroleum Engineers - Arctic Technology Conference 2011 proceedings, pp. 219 – 222, February 2011, Houston, TX.
- Valkokari, K., Paasi, J., Rantala, T. (2012). Managing knowledge within networked innovation, Knowledge Management Research & Practice, 2012, 10, 1, 27-40, Palgrave Macmillan, Basingstoke, United Kingdom.
- Vos, M., Shoemaker, H., Luoma-aho, V., L. (2014). Setting the agenda for research on issue arenas. Corporate Communications: An International Journal, Vol. 19 No. 2, 2014, pp. 200-215. Emerald Group Publishing Limited.
- WMU Workshop (2014). Workshop between World Maritime University – Laurea University of Applied Sciences on European University of Coast Guard Functions, Hosted 29th of September 2014 by the World Maritime University, in Malmö, Sweden.
- Zalyvsky, N. P., & Eduardovna, T. V. (2015). The Northern Sea Route: the potential of expectations and the real functioning problems. Arctic & North, (20), 32-50.

III

END-USERS CO-CREATE SHARED INFORMATION FOR A MORE COMPLETE REAL-TIME MARITIME PICTURE

by

Ruoslahti, H. & Tikanmäki, I. 2017

Proceedings of the 9th International Joint Conference on Knowledge Discovery Knowledge Engineering and Knowledge Management, 3

End-users Co-create Shared Information for a More Complete Real-time Maritime Picture

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Keywords: Co-creation, Cooperation, Maritime Domain, Information Sharing.

Abstract: European Union Member States are working towards an integrated maritime surveillance and deeper information sharing and implementation of Common Information Sharing Environment. Value networks aiming at co-creation, need active facilitation, and relevant platforms for open cooperation. This study analysed scenario analytics, and narrative documents from projects CoopP, CISE, and MARISA by using a Data Extraction Table to classify both objects and phenomenon relevant to European maritime information sharing systems. The object and phenomenon rows are grouped under a European Coast Guard Functions, CGFs framework, to better understand their occurrence and interdependencies. This paper finds that objects and phenomena need to be continuously evaluated against evolving risk and treat scenarios and end-user needs. Shared maritime information systems need to include tools for continuous self-revaluation. Added complexity may greatly reduce the time to value creation and innovation, which in this context is the ability to create greater common knowledge, learning, and value. Thus, faster and more widely shared information on objects and phenomena result in an accurate Recognized Maritime Picture, which supports threat assessment, asset and operations planning, and sharing of resources for added safety and security on the European maritime domain.

1 INTRODUCTION

"The overall objective of the Cooperation Project is to support further cross-border and cross-sectoral operational cooperation between public authorities (including EU Agencies) in the execution of the defined maritime functionalities, with a focus on information sharing across sea-basins. The project is one step towards the Common Information Sharing Environment, or CISE" (HELCOM, 2017).

The European Union with its Member States work towards an integrated non-military maritime surveillance and deeper coordination in information sharing. This development is demonstrated in putting wide European resources in the development and implementation of wider cooperation processes and platforms and a Common Information Sharing Environment – CISE (PERSEUS, 2017; EUCISE2020, 2017; European Commission, 2015). EUCISE2020 aims to achieve pre-operational information sharing between maritime authorities in different European States (EUCISE2020, 2017); the Cooperation Project, CoopP, is an integral part of this development; as is project MARISA, which seeks to strengthen the information exchange needed to optimize the surveillance of the EU maritime area and borders (Laurea, 2017). Together these EU-wide projects show that European authorities on the maritime domain can and need to cooperate.

The main contribution of this paper is that it raises the issue that technical systems, such as CISE, require shared, frameworks of content, on which human processes of operation can be based on. This practical case study aims to serve its part in filling some of this research gap. This study contributes, as a relevant part of project MARISA, by, in a rigorous way, identifying what objects and phenomena information systems and platforms used to share data between authorities on the maritime domain should contain.

Theoretically this paper draws from co-creation theory and the collaboration framework by Ruoslahti, (2017). Active stakeholder participation can be achieved through defining common aims, and the foundation of cooperation is openly shared

Ruoslahti H. and TikanmÃďki I.
End-users Co-create Shared Information for a More Complete Real-time Maritime Picture.
DOI: 10.5220/0006559702670274
In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (KMIS 2017)*, pages 267-274
ISBN: 978-989-758-273-8

information. This will require both open cooperative and co-creative processes, and tools, such as information systems to share the needed data. Any value network that aims at co-creation, needs not only active facilitation, but also relevant platforms and tools for open cooperation (Figure 1) (Ruoslahti, 2017, p. 15). This paper sees that CISE is a cooperation platform for open cooperation between and active participation by authorities as in figure 1.

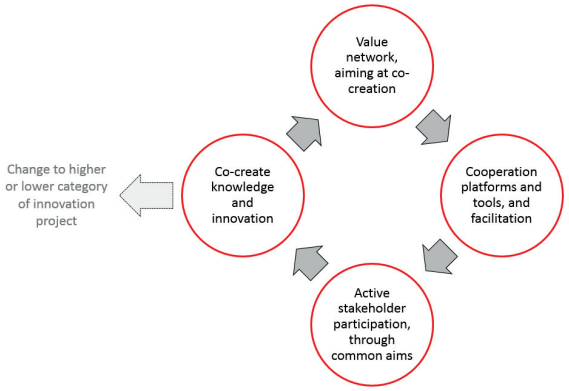

Figure 1: Cyclical connections in co-creation projects (Ruoslahti, 2017, p. 15).

This cycle of co-creation is completed when knowledge and innovation becomes co-created. Depending on the outcome and evolution of the co-creative cooperation, the network may continue on the level of a similar co-creation cycle, regress, or evolve to a more complex level of cooperation.

Based on defined use cases the EUCISE2020 based CoopP project identified and classified, in its WP3 (Scaroni, 2014), seven main groups of risk: (1) Illegal, unreported and unregulated fishing; (2) Illegal oil discharges or Environmental destruction and degradation; (3) Counterfeit goods; (4) Irregular immigration; (5) Trafficking in human beings; (6) Trafficking of drugs; and (7) Piracy. This paper combines this classification with that of a framework of European Coast Guard Functions, CGFs, as its basis of analysis to answer the research question of this study:

RQ: What objects and phenomenon should modern common use maritime information systems produce for its users to gain a more complete real-time maritime picture?

The structure of this paper is (2) Authorities on the Maritime Domain, (3) Method, (4) Results, (5) Discussion and Conclusions.

2 AUTHORITIES ON THE MARITIME DOMAIN

"Situational awareness is one of the starting points for feeling safe and secure. Maritime surveillance is the cornerstone of situational awareness at sea. It is also written in integrated Maritime Policy in EU which aims among other objectives to ensure the safe and secure use of European maritime area and protection of European Sea Borders" (de Arruda Camara, et. al., 2012, p. 5).

European Maritime Policy has adopted an integrated and cross sectorial approach to respond to the various challenges that the authorities serving the European maritime domain face. These authorities, which are responsible for safety and security at sea are many, and member states are organized very differently in their ways of organizing the responsible authorities covering the various tasks needed on the maritime domain.

Frontex, which recently became the European Border and Coast Guard Agency, facilitates cooperation between national law enforcement, customs and other authorities operating in the maritime domain. (Frontex, 2017). Joint multi-purpose operations, may include personnel, vessels and aircraft from different authorities from various Member States.

To ensure continuous improvement in safety and security on the maritime domain, the European Union has classified the activities promoting safety and security on European waters as European Coast Guard Functions, CGFs, which aid coordinate the work of the different authorities. The European Coast Guard Functions Forum, ECGFF (2014) categorized ten CGFs (Ruoslahti & Hyttinen, 2017), and the results of this study are structured be these CGFs.

On the European level there are four more major Coast Guard Cooperation Networks as frameworks for sharing best practices and relevant information between coast guard authorities. They all have a similar regional maritime focus in maritime safety and security, environmental protection, combat of cross-border crime, and enhancement of information exchange (de Arruda Camara, et. al., 2012; Ruoslahti, 2013).

The Baltic Sea Region Border Control Cooperation, BSRBCC, for example, is "a flexible regional tool for daily inter-agency interaction in the field of environmental protection and to combat cross-border crime in the Baltic Sea region, with a maritime focus. Cooperation Partners are Police, Border Guards, Coast Guards and Customs Authorities." (BSRBCC, 2013).

There are also other frameworks that bring together the dispersed authorities on other European maritime fields, and they all exchange information directly within each other. Multinational military maritime surveillance cooperation began between Sweden and Finland as the Sea Surveillance Co-Operation Finland Sweden cooperation, and has broadened to include eight Baltic Sea countries as Sea Surveillance Cooperation Baltic Sea. "Today Maritime Situational Awareness is continuously shared between the participating parties benefitting at the same time maritime safety, maritime rescue, maritime assistance, VTS, maritime environmental protection, maritime security and law enforcement in the Baltic Sea region" (SUCBAS, 2013). Other cooperation networks on the Baltic maritime domain include the European Maritime Safety Agency, EMSA (EMSA, 2013); the Baltic Sea Task Force on Organised Crime (CBSS, 2017), and the Helsinki Commission – HELCOM (HELCOM, 2017). These examples of various frameworks show the complexity of cooperation regarding safety and security on the maritime domain – across Europe.

2.1 Authorities and Co-creation

Ruoslahti and Knuuttila (2011) note that listening to different types of end user representatives is important to successfully communicate the total range of end user opinions and needs. Networks of co-creation "can demonstrate new knowledge on how a cooperation should work in the future (e.g. in SAR) – not only technically, but also as a process to change the current mind-sets to cooperate more and share information to benefit the security and safety…" (Ruoslahti & Hyttinen, 2017, p. 104).

Safety and security on the maritime domain begins from the vessel level. Empowering a ship's crew is important in creating a self-regulating culture, as managing safety on board is "leadership and management of the people living and working in the ship. The execution of safety measures lies within the seafarers and their masters working at sea" (Salokannel, et. al., 2015, p. 12). Managing crisis on board prevents harm and damage, and the goals in managing communication in crisis are: (1) empowerment, (2) understanding, and (3) cooperation.

Ruoslahti and Knuuttila (2016) apply the concept of issue arenas (Luoma-aho and Vos, 2010) to the interaction between stakeholders in cooperation networks. Through the life-cycle of a project, the number of stakeholders – end users, industry, NGOs, authorities, and academia – that participate in the communication should grow, as the project progresses. (Henriksson, Ruoslahti, & Hyttinen, 2017, p. 11).

Ruoslahti (2017) notes that as networks become structured based on different aims. Complexity is greatest in multiple-stakeholder co-creation projects that benefit innovation network stakeholders, where roles between stakeholders are in fluid and constant change, and open innovation environments – such as a CISE –facilitates communication and interaction.

2.2 Applying a Business Point of View on Co-creation on Authority Networks

From a business point of view, mapping end-user processes and practices can identify opportunities for encounters to support the co-creation of value (Payne, Storbacka & Frow, 2008). Co-creation allows companies, communities, and customers to create value through interaction (Dawe & Sankar 2016). Multi-stakeholder networks, as an organizational structure, allow collective actions over national boundaries, participation is voluntary and both objectives and actions can be negotiated among participants (Roloff, 2008). Value networks that aim at co-creation require active stakeholder participation, and this is best achieved through common aims. Innovation networks need these to promise benefits for every concerned stakeholder (Ruoslahti, 2017).

Saarinen (2012) points out that developing services cannot be totally user-based, but that a design process includes several actors' problems, goals, and actions, which may differ in preference. Co-production with customers supports organizational innovativeness (Luoma-aho, et.al., 2012), knowledge is value, and stakeholder services and systems depend on the resources of others to survive, and to co-create this value (Pirinen, 2015; Ruoslahti, et. al, 2011). True co-creation is an interactive and complex learning process, where information as a key resource and trust a key component (Ruoslahti, 2017).

2.3 Co-creation of Knowledge through a Common Information Sharing Environment

Change and development require new thinking from organizations, and end-user participation is an activity, strategically structured by the organization coordinating the innovation project. Networks and learning within them only become constructed by interaction. Tools that promote information sharing,

cooperation, and open innovation can bring advantages (Ruoslahti, 2017), and networking is very important in developing services (Tikanmäki, Tuohimaa, & Ruoslahti, 2012), as well as for smooth cooperation in technical development projects, where it is important that developers and potential end users work closely together (Ruoslahti, et. al., 2010).

Project MARISA is working towards the common use of existing and future on-line platforms to serve as a cooperation tool for European-wide maritime authorities. The project "seeks to address the need to strengthen the information exchange to optimize the surveillance of the EU maritime area and its maritime borders" (Laurea, 2017).

Active co-creation processes require tools and environments for cooperation to foster knowledge sharing and long-term relationships (Ruoslahti, 2017), as truly co-creative cooperation is cyclical and on-going. To achieve innovative outcomes, co-creation requires a strategy, and relationships require time and active management to develop, supported by the internal structures of all stakeholder organizations (Figure 1). Identifying key success factors helps facilitate and monitor these cooperation processes. In creating common aims, it is important "to understand the multiple points of view, different values and individual aims that the multiple stakeholders in the innovation network may have" (Ruoslahti, 2017, p. 7).

3 METHOD

The aim of this study is to identify the objects and phenomenon that modern common use maritime information systems should produce for a more complete real-time maritime picture. Users of the system can make better informed decisions when they have a comprehensive picture of what objects and phenomenon are out there, how they might evolve in time, and what effects these developments may have. This paper identifies relevant objects and phenomena needed in common information sharing. A European wide CISE, will support this desired development, which this paper is in part promoting.

This study draws from use case and scenario narratives, and scenario analytics gathered and developed in projects CoopP, CISE, and MARISA. The data collected, was submitted to a structured desktop analysis, where objects and phenomena were first identified, then placed as rows on a Data Extraction Table, DET, which was developed in Excel as an analysis tool for this study. The objects and phenomena were further classified under one of the ten CGFs that this paper uses as part of its analysis framework (ECGFF, 2014; Ruoslahti & Hyttinen, 2017): (1) Maritime safety and vessel traffic management; (2) Fisheries control; (3) Maritime border control; (4) Maritime surveillance; (5) Maritime security; (6) Maritime customs activities; (7) Prevention of trafficking and smuggling; (8) Maritime environmental response; (9) Accident and disaster response; and (10) Search and rescue at sea.

The DET is structured so that each individual object or phenomenon is classified under a CGF (rows), and as an object or phenomenon (columns). Also the main category of risk (Scaroni, 2014) were listed under each CGF on the title row in red. Columns in the DET are *Category of Coast Guard Function*, *Object*, and *Phenomenon*. Also the DET makes a difference between *Observations* and *Actions*. Under Observations are listed all objects and phenomena that are produced by outside agents, and under Actions all objects and phenomena that pertain to the assets and resources that the authorities have to respond to the objects and phenomena produced by these outside agents.

Issues that were clearly common to all categories of CGFs appeared, and to avoid repeating them under each category, one additional class *General common to all* was added. The issues that are shared by all CGF classifications were listed here. Besides serving this study the DET is intended to serve as an individual tool in project MARISA to better understand what objects and phenomena level information end-users need shared for a more complete real-time maritime picture.

In the results section of this paper is structured by grouping the ten CGFs under five subtitles: 4.1 Maritime Safety and Vessel Traffic Management; and Maritime Surveillance; 4.2 Accident and Disaster Response; and Search and Rescue at Sea; 4.3 Maritime Border Control; Maritime Customs Activities and Prevention of Trafficking and Smuggling; 4.4 Maritime Security; and 4.5 Maritime Environmental Response; and Fisheries Control.

4 RESULTS

There are six issues identified that are common to all categories and functions of EU-CGF. (1) Anomaly detection, classification and threat assessment; (2) Prediction of the operational maritime picture; (3) Threat assessment; (4) Intervention plans; (5) Address underlying problem that stimulated the threat; and (6) Mission Planning and Decision Support. All these six topics generate needs to

identify objects and phenomenon on the maritime domain.

Anomaly detection, classification, threat assessment, and alert operators is key. To gain a Common Operational Picture from different contributors will aid to classify the threats, evaluate their seriousness, and predict possible impacts. All this information are needed to protect potential victims of any potential incident. Accurate real-time information will help support rapid decision making, planning operations, and operations asset planning for the most accurate and rapid response possible.

4.1 Maritime Safety and Vessel Traffic Management; and Maritime Surveillance

Maritime accidents are the main risks in maritime safety and vessel traffic management (Scaroni, 2014). Objects that are needed to know are vessel, its type, characteristics, identification, and preferably its port history, travel plan, crew and when applicable passenger list, and cargo manifest. Thus accuracy and validation of the automated vessel identification system AIS-signals is also very important.

Maritime safety and vessel traffic management are concerned with a wide variety of issues ranging from commercial shipping to leisure boats, and from vessel safety inspections, through personnel qualification issues, to active traffic control and VTS-monitoring. Thus the objects and phenomenon that it is interested in are concerned with information related vessels, their seaworthiness, manning, and movements. Predicting maritime traffic evolution is important. It calls for predictions of vessel trajectories, understanding of the evolution of events and circumstances over a potential areas of interest, potential threats, aided by density and risk maps that picture maritime activities over areas of interest, heavily used traffic routes and points of cross traffic, potentially risky routes, and deeper understanding of seasonal trends.

Anomaly detection, classification and threat assessment should include observing change of speed, direction, or vessel interactions, and possible vessels approaching the coast suspiciously far from ports or unauthorized access to areas of interest, prohibited anchoring.

Also metrological information, such as clouds, winds, waves, and storms, and oceanographic information such as currents and topography are of interest. Sea metrological conditions information and evolution predictions aid in the assessment of abnormal weather conditions and support route and asset planning and when needed in Search and Rescue, SAR operations.

4.2 Accident and Disaster Response; and Search and Rescue at Sea

When maritime accidents occur, the main alerts are SOS / Mayday calls, or vessels or aircraft disappearing from maritime surveillance and traffic control radar screens. The operational IT-systems should be capable of aiding to identify which vessels are concerned, and where. Also, where are potential places of refuge and what accident response capabilities are at disposal, and how quickly. The main focus is in the prevention of accidents and their impacts. Knowing what operational assets and search and rescue teams are available guide rational decision making.

If vessels and people are lost at sea, must the SAR operations begin swiftly after receiving an SOS or Mayday call, and with enough resources. The last known location, intended port or travel route, persons on board (at least number of), and if possible their nationalities and names are needed information. Also if persons are in vessel, lifeboat, or in water (overboard)? In case of accident response, to make the right decisions on the spot, an on-scene coordinator (OSC) will need information that is as accurate and real-time as possible.

4.3 Maritime Border Control; Maritime Customs Activities and Prevention of Trafficking and Smuggling

The main risks for maritime border control are irregular immigration and trafficking in human beings (Scaroni, 2014). Objects that need to be recognized are vessels and persons of interest, both EU residents and non-residents, their travel documents, and biometric information. Suspect travel patterns, detections of illegal border-crossing between BCPs, illegal or clandestine entries between BCPs, as well as persons using false identities or fraudulent documents are of high interest. Abnormal behaviour recognition, facilitator information, applications for asylum, refusals of entry, illegal stay, and return decisions issued should be included in the system for easy information sharing.

Victims and suspected traffickers of forced sexual exploitation, forced labour exploitation are important information in preventing trafficking. Knowing the common countries of origin and countries of destination of detected victims are also needed.

The main focus for maritime customs activities and prevention of trafficking and smuggling is in detecting and preventing the smuggling of goods and the export and import of counterfeit goods, narcotics, alcohol, tobacco, firearms, explosives, and stolen property (e.g. vehicles), as well as people. Following estimated worldwide production sites and main logistics sea routes to Europe, worldwide hot-spots of users, consumption patterns per drug category, and the modus operandi of traffickers aid in planning effective measures against trafficking. Some of the main tasks, to fight against the main risks counterfeit goods and trafficking of drugs, are sharing of intelligence information, ship inspections, and detected contraband modus operandi. Drugs, alcohol, cigarettes, and other goods, where customs or tax are unpaid are of interest.

Knowledge of available assets for interception and capacities of prevention are needed for effective response. The main risks, trafficking of firearms and explosives, and smuggling and counterfeit goods is closely tied to maritime customs activities, and trafficking of human beings to maritime border control.

4.4 Maritime Security

The main identified risks for maritime security are piracy and terrorist threats (Scaroni, 2014). The focus is in understanding phenomena, such as vessels transiting the area concerned and goods transported through these hot-spots of piracy (such as the Gulf of Aden), suspicious activity, pirate attacks, fishing vessels seized, possible seafarers and fishermen abducted, taken hostage, or killed by pirates.

Understanding one's assets is key in preventing and countering risks for maritime security. Knowledge of which military and other authority vessels are operating in the area concerned, which are protected, and which are not, also what re-routing possibilities are there and what could be achieved with increased speed.

Also information on ransoms and recovery, protection and counter (military) operations, counter-piracy organizations, and both security equipment and guards are needed to coordinate counter-piracy measures. All in all, detection of anomalies, firearms, possible bomb building, or vessel highjack, be it piracy or terrorism, may alert operators to successfully enforce criminal law on the maritime domain.

4.5 Maritime Environmental Response; and Fisheries Control

Some main risks are illegal oil discharges, formerly known as environmental destruction and degradation (Scaroni, 2014). The main task for authorities is to detect and prevent waste at sea. The main object to identify is pollution (of any kind). Oil unfortunately is still deliberately dumped into the sea in quantities. Detecting oil and chemical spills, illegal or accidental bilge, grey, and black water discharges and seepages are in the focus. Also ships' emissions are monitored. Polluters should be identified.

Oil transport routes by sea, the volumes transported, and potential risk areas help prioritize how to place assets. Aircraft observation, capacities of prevention, drift calculations, estimated volume of possible oil discharges (m^3), and assets of pollution response guide the planning of resources and possible operations.

For fisheries control the main risks (Scaroni, 2014) are illegal, unreported and unregulated fishing. The large problem are the commercial fishing groups that overfish and do not comply with EU fishing regulations and quota. The main problem is with third country vessels, so checking fishing vessels is an important deterrent against wrongdoings. Risk and blacklisted vessels are important to identify. Important objects to identify are vessel identification and position, amount and type of catch, as well as the fishing equipment used.

The phenomenon that fisheries control authorities need are knowledge of fishery resources and fish populations, applicable quotas, allowed fishing areas and detection of illegal fishing activity. Information on equipment allowed or disallowed, and licenses and permits needed by vessel or captain can also guide fisheries control authorities in their work – to control fishing, be it commercial or leisure fishing.

5 DISCUSSION AND CONCLUSIONS

The work that EU-wide projects such as PERSEUS, CoopP, EUCISE2020, and MARISA, or FINCISE on a national level, have begun, should be continued and elaborated. These projects have shown that it is important to share information cross-sector (a) nationally between different authorities; and cross-border (b) between responsible authorities from different EU member states; (c) and with cooperative third countries.

The objects and phenomena, relevant to CISE, need to be continuously evaluated and redefined. This should be done together with end-users and against changing risk and treat scenarios and evolving end-

user needs, and national and EU-wide strategies, and also taking into account the assets, which cooperative third country nations may bring. Shared maritime information systems should inherently include both tools and processes for continuous re-evaluation of both the objects and phenomena, which it should be able to provide its users.

The cooperation between these different authorities has the potential to evolve into a deeper and more encompassing mode of co-creation, where the added complexity may greatly reduce the time to value creation and innovation. In this context the ability to create greater common knowledge, learning, and value can be seen as innovation. The value in this innovation to EU and national authorities are the in faster recognition, assessment, planning, and reaction capabilities, which lead to a safer, more secure European maritime domain.

Seemingly adding complexity to the common information sharing systems and processes is the way to substantially faster innovation: detection, assessment, planning, and response. In becoming more complex, mere cooperation has the potential of reaching deeper forms of co-creation. This enables the network to yield more value and innovation. In this case the innovation potential is in the faster and widely shared information. It demonstrates as confirmed objects and phenomena resulting in an accurate Recognized Maritime Picture.This in turn supports threat assessment, asset and operations planning, and sharing of resources. This is innovation and value.

The work in project MARISA, as also this paper, is just the beginning. Identifying these practical user needs can serve as a basis for further technical development of CISE, and these results directly serve further work in projects MARISA and FINCISE.

The framework of objects and phenomena identified in the DET analysis of this study is seemingly complex, but only by this adding of complexity can we shorten the time to innovation and value. Further research should amend and validate the results of this study, and continue to identify new objects and phenomena, while evaluating and redefining the existing ones. This research facilitates the study aiming to create the technical elements of CISE and bridge between the technical and human aspects of information sharing, and co-creative collaboration.

REFERENCES

BSRBCC, 2013. Baltic Sea Region Border Control Cooperation, BSRBCC Webpage: http://bsrbcc.org/home/, Accessed 16th February 2013.

CBSS, 2017. Council of the Baltic Sea States, CBSS Webpage: http://www.cbss.org/safe-secure-region/baltic-sea-task-force-organized-crime/, Accessed 26th July 2017.

Dawe, S. & Sankar, C.S., 2016. *Research note for developing a smart city by operationalizing the co-creation of value model*, Journal of Information Technology Case and Application Research, vol. 18, no. 1, pp. 50-52.

de Arruda Camara, A., Helanto, P., Kuusela, A., Tyni, J., 2012. *Deliverable 2012-03-09, Project PERSEUS*, Protection of European Seas and Borders through the Intelligent Use of Surveillance.

EMSA, 2013. European Maritime Safety Agency, EMSA Website: www.emsa.europa.eu/, Accessed 16th February 2013.

EUCISE2020, 2017. FP-7 project European test bed for the maritime Common Information Sharing Environment in the 2020 perspective, EUCISE2020 Website: http://www.eucise2020.eu/, Accessed 28th July 2017.

European Coast Guard Functions Forum, 2014. *Non Paper - July 8th 2014*, Unpublished.

European Commission, 2015. European Commission DG-MARE Webpage: http://ec.europa.eu/dgs/maritime affairs_fisheries/consultations/cise/index_en.htm, Accessed 16th April 2016.

FRONTEX, 2017. European Cooperation on Coast Guard Functions, European Border and Coast Guard Agency, FRONTEX Website: http://frontex.europa.eu/press room/hot-topics/european-cooperation-on-coast-guard-functions-8phwLF, Accessed 26th July 2017.

Frow, P., Nenonen, S., Payne, A., & Storbacka, K., 2015. *Managing Co-creation Design: A Strategic Approach to Innovation*, British Journal of Management, Accessed 22nd January 2015.

HELCOM, 2017. Helsinki Commission, HELCOM Web-page: http://www.helcom.fi/, Accessed 26th July 2017

Henriksson, K., Ruoslahti, H., & Hyttinen, K., 2017. *A Co-Creative Model for Modern Communication and Dissemination in Multi-Stakeholder Research Projects*, unpublished paper, submitted to EUPRERA 2017, 12th – 14th October 2017.

Laurea, 2017. *Engaging user community to build European Maritime Security solutions, Horizon2020 project Maritime Integrated Surveillance Awareness*, Laurea University of Applied Sciences, MARISA, https://www.laurea.fi/en/news/Pages/Engaging-user-community-to-build-European-Maritime-Security-solutions.aspx, Accessed 28th July 2017.

Luoma-aho, V., Vos, M., 2010. *Towards a more dynamic stakeholder model: acknowledging multiple issue arenas*, Corporate Communications: An International Journal, Vol. 15 No. 3, 2010, pp. 315-33, Emerald Group Publishing Limited.

Luoma-aho, V., Vos, M., Lappalainen, R., Lämsä, A-M., Uusitalo, O., Maaranen, P., & Koski, A., 2012. *Added Value of Intangibles for Organizational Innovation*, Human Technology, Volume 8 (1), 7 – 23.

Payne, A., F., Storbacka, K. & Frow, P., 2008. *Managing the co-creation of value*, Academy of Marketing

Science. Journal, March 2008, Vol. 36(1), pp.83-96.

PERSEUS, 2017. FP-7 Project Policy-oriented Marine Environmental Research in the Southern European Seas, PERSEUS, http://www.perseus-net.eu/site/content.php?locale=1&locale_j=en&sel=1, Accessed 27th July 2017.

Pirinen,R., 2015. *Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers*, Creative Education, 2015, 6, 3, 315-330, Scientific Research Publishing, Irvine, United States.

Roloff, J., 2007. *Learning from Multi-Stakeholder Networks: Issue-Focused Stakeholder Management*, Journal of Business Ethics, 2008, 82, pp. 233–250.

Ruoslahti, H., 2013. *Baltic Sea Region Maritime Border Surveillance cooperation*, unpublished Laurea University of Applied Sciences contribution draft-5 for FP-7 Project Policy-oriented Marine Environmental Research in the Southern European Seas, PERSEUS, 4th April 2013.

Ruoslahti, H., 2017. *Co-creation of Knowledge for Innovation and Multi-Stakeholder Participation of End Users: A Structured Literature Review*, unpublished paper, submitted to EUPRERA 2017, 12th – 14th October 2017.

Ruoslahti, H., Guinness, R., Viitanen, J., & Knuuttila, J., 2010. *Airborne Security Information Acquisition Using Micro Air Vehicles: Helping Public Safety Professionals Build Real-Time Situational Awareness*, Credibility Assessment and Screening Technologies at the 44th Hawaii International Conference of Systems Sciences 2010.

Ruoslahti, H., & Hyttinen, K., 2017. *A Co-created Network Community for Knowledge and Innovations – Promoting Safety and Security in the Arctic*, Proceedings of BledCom 2016, Engaging people in a disengaged world, BledCom 2016 23rd International Public Relations Research Symposium, 1st – 2nd July 2016, Bled, Slovenia, www.bledcom.com/knowledge.

Ruoslahti, H., & Knuuttila, J., 2011. *Listen to Three Types of Border Guard – Adopting Technology into the Process of Border Checks*, Credibility Assessment and Screening Technologies at the 45th Hawaii International Conference of Systems Sciences 2011.

Ruoslahti, H., & Knuuttila, J., 2016. *Remotely Piloted Aircraft Systems (RPAS) for Extreme Missions in the Arctic and the monitoring of the Ukraine crisis by the Organization for Security and Co-operation in Europe (OSCE)*, Track: Collaboration Systems and Technologies, Emerging Issues in Distributed Group Decision-Making: Opportunities and Challenges, 49th Hawaii International Conference of Systems Sciences 2016.

Ruoslahti, H., Tiainen, S., Kortelainen, M., & Vesterinen, O., 2011. *How Networking and Projects can Promote Learning in Higher Education?*, Campus Encounters – Bridging Learners Conference, Developing Competences for Next Generation Service Sectors, 13th – 14th April 2011, Porvoo, Finland.

Saarinen, L., 2012. *Enhancing ICT Supported Distributed Learning through Action Design Research*, Aalto University publication series, Doctoral Dissertations 92 7 2012, Helsinki.

Salokannel, J., Knuuttila, J., & Ruoslahti, H., 2015. *Arctic Maritime Safety and Security – the Human Element seen from the Captain´s Table*, International Conference on Safe and Sustainable Shipping in a Changing Arctic Environment, ShipArc 2015, 25th – 27th August 2015, Malmö Sweden.

Scaroni, E., 2014. *EU CISE Project Annex 6 WP3 Annex III Final Statistical Report*, 22nd January 2014.

SUCBAS, 2013. Sea Surveillance Cooperation Baltic Sea, SUCBAS Webpage: http://www.sucbas.org/objectives.php, Accessed 8th February 2013.

Tikanmäki, I., Tuohimaa, T., & Ruoslahti, H., 2012. *Developing a Service Innovation Utilizing Remotely Piloted Aircraft System (RPAS)*, International Journal of Systems Applications, Engineering & Development, Issue 4, Volume 6, 2012.

IV

EDUCATIONAL COMPETENCES WITH REGARD TO RESILIENCE OF CRITICAL INFRASTRUCTURE

by

Ruoslahti, H. & Rajamäki, J. 2018

Journal of Information Warfare 17.3

Educational Competences with regard to Resilience of Critical Infrastructure

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Abstract*: Current critical infrastructures can be considered Cyber Physical Systems (CPS), which seamlessly integrate human, physical, and computational elements. Data for this case study is collected from 16 R&D projects from three Finnish universities. Results indicate that future CPS competences are multidisciplinary, and include many industrial sectors, academic disciplines, and theories. In this paper, the writers argue that such multi-stakeholder collaboration is needed to control complex integrated Cyber Physical Systems of critical infrastructure, and that CPS education should cover all CPS domains (physical, informational, cognitive, and social) and event-management cycles (plan/prepare, absorb, recover, and adapt), and should focus on cooperation and information-sharing between the different stakeholders involved.*

Keywords: *Education, Competences, Resilience, Cyber Physical Systems, Case Study, Learning by Research and Development*

Introduction

Universities should teach what they research, and vice versa. The research and educational field of critical infrastructures, including the Internet of Things and other Cyber Physical Systems (CPS), as well as new innovations concerning smart cities, are multidisciplinary; and resilience is needed in the multi-stakeholder collaboration networks that constitute the social elements of the field. Existing empirical research is characterised by a considerable degree of fragmentation among different research programs and different geographic regions in Europe. For example, the topic of resilient smart cities, related to critical infrastructure, offers tremendous potential for innovation and development of new technologies and services. At the same time, the increasing 'smartness' of urban environments introduces both threats and opportunities, which are related to societal security, safety, and resilience. Thus, the authors regard this topic to be of high societal importance and worthy of further development and stronger focus in higher education. Additionally, the topic of resilient Cyber Physical Systems, also related to critical infrastructure, can still be said to be in its infancy. Both topics require the development of new concepts, approaches, and multidisciplinary collaboration between research groups and stakeholders who, at present, rarely collaborate

with each other. This lack of collaboration underlines the need to establish multidisciplinary networks to pave the way for future research efforts on resilient CPS, as well as an educational approach, including new and improved programs with tools that support learning the corresponding technological and business skills in higher education.

In this case study, the main research question looks at resilience in the social domains of networks*;* RQ 1: What attributes are considered to improve the resilience of collaboration networks? The auxiliary research question is related to future educational competences with regard to resilience in CPS; RQ 2: What are the views on competences needed with regard to resilient Cyber Physical Systems?

The data for the case study is collected from authentic research and development projects, and the paper is structured as follows. After the introduction, the literature review deals with resilient CPS. The following section covers the major methodologies applied in the study modules as well as the applied research data. Section four presents CPS-related research and development projects carried out by higher education students. Section five states cross-case conclusions about the work made by students and discusses results. Also, section five proposes a framework and an overall picture of the future educational competences with regard to CPS. Section six discusses conclusions.

Literature Review

Cyber Physical Systems (CPS), subsets of sociotechnical systems, demonstrate seamless integration between computational, human, and physical elements (Broy & Geisberger 2011). Interconnections between social and technical subsystems that encompass a variety of linear and non-linear relationships are referred to as 'sociotechnical' (Singapore-ETH Centre 2015). CPS are transforming the ways in which people live and interact with things in the physical world, and the rate of this transformation is faster than ever. The technological impacts of CPS and their resilience are evident in many fields, including healthcare (Rajamäki & Pirinen 2017), disaster management (Dahlberg *et al*. 2015), engineering resilience (Park *et al*. 2013), and platforms of authority collaboration (Ruoslahti & Tikanmäki2017).

According to Murakami (2012), cyber-physical social systems include inputs and outputs between cyber, physical, and social worlds; thus, computational elements interact with technical and ecological elements for the benefit and by the design of society and organisational and human elements, as well as by the use of cyber networks and the Internet.

Many critical infrastructures in society, such as transportation, communications, finance, energy, food and water supply, and cyber communication, typically lack resilience. They may easily lose essential functionality when hit by adverse events (Linkov *et al*. 2014). The National Research Council (2012) and the Singapore-ETH Centre (2015) identify event-management cycles, which a system needs to maintain to be resilient in the case of disruptive events such as a malfunction or attack. First, the system needs to prepare to keep its services available; second, when a disruption occurs, the system needs to isolate and maintain its most critical assets, functions, and services while repelling the disruption; third, it needs to restore the availability of all services; and finally, it must learn from what happened and modify its operations to become more resilient against future events (National Research Council 2012). The Singapore-ETH Centre (2015) event-management cycles begin with the shock point and are labelled 1) absorb, 2) recover, 3) adapt & learn, and 4) self-modify, as shown in **Figure 1**, below.

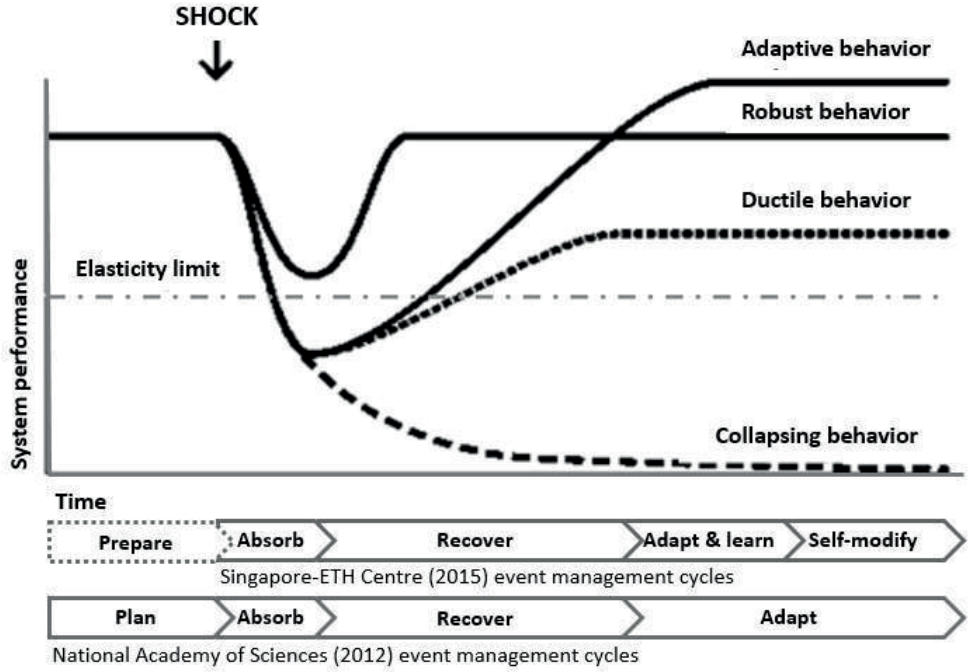

Figure 1: Resilience as response behaviour of a self-organising system to endogenous or exogenous shocks (adapted from Singapore-ETH Centre 2015 and National Research Council 2012)

Figure 1, above, shows the two examples of event-management cycles (Singapore-ETH Centre 2015; National Research Council 2012) in relation to time and system performance and also includes four curves demonstrating differences in effects to system performance after a shock of disruption. The behaviour of a system may be adaptive, robust, ductile, or collapsing in nature. Both event-management examples have four stages. The main difference is that Singapore-ETH Centre (2015) event-management cycles begin at the disruptive shock, while the National Research Council (2012) begins its cycle earlier with planning. Thus, in **Figure 1**, a prepare phase has been added prior to the absorb phase. Self-organising systems can use such event-management cycles to better structure their plans and response strategies.

The Network-Centric Warfare (NCW) doctrine (Alberts 2002) identifies four domains 1) physical, 2) informational, 3) cognitive, and 4) social, all of which create shared situational awareness and act as a basis for decentralised decision-making. Systems possess both physical resources and information; and the cognitive decisions by the system or its stakeholders are based on not only the information and the physical, but also on the social level of communication and on organisational structures.

Management strategies for networks of critical infrastructure (for instance, telecommunications, electricity, or transportation) may also rely on the functionality of other interrelated networks. These networks could be considered part of an overall system of constituting systems. Thus, resilience can be enhanced by studying and improving the interconnectivity of these relevant networks (Linkov *et al*. 2014). Enhancing the surrounding social networks is also an important component of societal resilience (O'Rourke 2007). According to Amir and Kant (2018), sociotechnical systems are intentional hybrids of people and technologies that involve complex interactions between people, organisations, and technologies. The complexity of such hybrid systems complicates their resilience.

Vos (2017) sees that risks in collaboration in and among networks can be reduced, not avoided. Thus, organisational resilience provides tools and conditions to both understand and to reduce risks, as well as to mitigate crises. As resilience requires cooperation by and between social networks, communication becomes co-constructed by its multiple stakeholders, although they most likely have different interests and various interdependencies (Vos 2017). According to Gustafsson, Kristensson, and Witell (2012) co-creation requires interaction among various actors who need knowledge-creation processes to build resilience into their networks and to guide connected stakeholder networks to do the same. Pirinen (2017b) adds that situational intelligence is needed to build resilience, and that the roles, engagement, and responsibility of the actors, as well as their mutual interactions and impacts, become key factors in network collaboration.

Continuity of operations becomes enhanced when different actors, such as authorities, have interoperability along with the capability to supplement and, when needed, to fill in for each other (Tikanmäki & Ruoslahti 2017; Ruoslahti & Hyttinen 2016). Co-creation results from complex interactions that may bring about resource integration among the many actors in the network (Pinho *et al*. 2014), while non-hierarchical interaction helps solve a common problem with other stakeholders (Roloff 2008). Network operations benefit from a common aim (Ruoslahti 2018), but network actors also need to be aware of their different interests (Vos 2018).

Methodology and Research Data

In this study, the research is guided by information from each of the following sources: 'The case research strategy in studies of information systems' (Benbasat, Goldstein & Mead 1987); 'Building theories from case study research' (Eisenhardt 1989); 'Case studies and theory development in the social sciences' (George & Bennett 2005); 'Qualitative data analysis' (Miles & Huberman 1994); 'Real world research' (Robson 2001); and 'Case study research design and methods' (Yin 2009).

Figure 2, below, presents an overview of the research methodology applied in this paper. The research data is collected from authentic research and development projects (n=16), which were conducted at three Finnish universities.

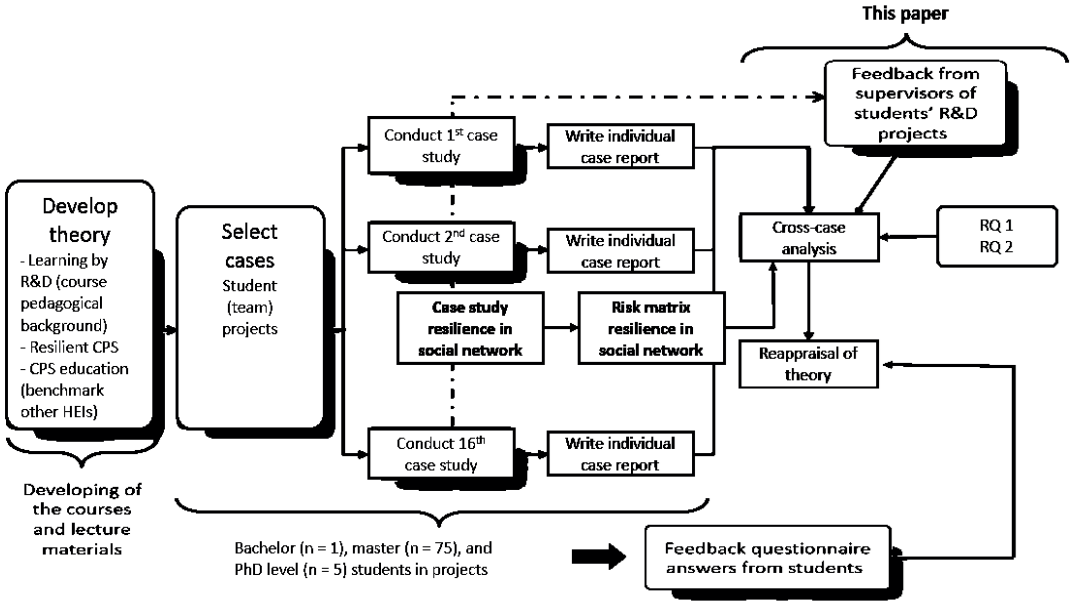

Figure 2: Research methodology applied within this paper (modified from Yin 2009)

Students contributed a large part of the practical research work, and the sample data of this study is collected mainly from materials produced by the students, as seen in **Figure 2**, above. The cross-case analysis for this research included the independent studies of IT (n=53) and security management (n=22) master's students, one bachelor's thesis (n=1), and individual studies by five (n=5) PhD-level students. The focus has been for the students to advance their learning according to the learning requirements of the classes and assignments. The lecturers have, thus, developed courses, assignments, and respective lecture materials with these requirements in mind. The students have, in the spirit of learning by R&D, completed, alone or in teams, separate studies in resilient CPS within seven fields (see **Table 1**, below), and have written corresponding case reports. These have been the main source of data for the cross-case analysis, which has been guided by the research questions of this paper.

Critical infrastructure	**Reference**
1. Energysupply: - Regional electricity generation company - Finnish electricity grid system - Smart grid	(Pöyhönen *et al*. 2018)
2. Communication and information-sharing environments: - Finnish telecommunications system - TUVE - State security communications network - CISE - Information-sharing systems on the Maritime Domain - KRIVAT - Information-sharing network between critical-infrastructure companies	See section **CISE - Resilience in a Cyber Physical System on the maritime domain**, below; (Ruoslahti & Tikanmäki 2017) See section **KRIVAT - Information-sharing network between critical-infrastructure companies**, below; (Koski 2015)
3. Airtransportation: - Smart airport - Airplane - Aviation cybersecurity - Air-traffic control	
4. Roadtransportation: - Smart cars - Tesla pilot	
5. Finance: - Verifone sales connector	(Rajamäki 2018)
6. Food supply: - Finnish food-supply system as a CPS	See section **Finnish food-supply system as a resilient CPS**, below
7. Living: - Smart homes	

Table 1: Relevant fields of critical-infrastructure industry

IT students looked at protection of critical infrastructure through 16 related project examples, which were all on resilience of Cyber Physical Systems functions vital to society. These 16 R&D projects cover seven types of Cyber Physical Systems as shown above in **Table 1**, above, which also refers to later sections of this paper as well as to sources that discuss an earlier-published study. The students in the security-management master's program are enrolled in a part-time curriculum, and most of them are also employed as security-management professionals. They performed risk- assessment matrices for social networks, where attributes were identified

and prioritised. These are discussed in further detail in the section entitled 'Attributes to improve the resilience of collaboration networks' and **Table 2**, below.

Descriptions and Lessons Learned from the R&D Projects

This section describes four examples of the student-performed studies and is based on the cross-case analysis of these student R&D projects. It also describes the major findings of this study, with special emphases on what attributes are considered to improve the resilience of collaboration networks and on lessons learned from the perspective of what competences are needed to provide meaningful education about resilient Cyber Physical Systems.

CISE—Resilience in a Cyber Physical System on the maritime domain

While the preparation phase creates a basis for the ability to absorb and to recover from a disruptive incident, the adaptation phase creates a feedback loop to enhance futurepreparation phases. In this way, the process becomes cyclical. This principle is also seen in literature on business continuity planning (Savage 2002; Woodman 2007). Ruoslahti and Tikanmäki (2017) raise the issue that technical systems, such as the Common Information Sharing Environment (CISE) initiative by the European Union, need structured and shared frameworks of content on which to base their human processes of operation. In this example, the physical level is formed by the information and communications system components; the information level by objects and phenomena, which are shared; the cognitive level by the common principles according to which these are shared; and the social level by the organisational structures of the CISE network and its participating authorities, as well as the shared communication among them.

CISE can, thus, serve as a platform of active participation and open collaboration between authorities (Ruoslahti & Tikanmäki 2017). Active stakeholder participation requires common aims. An important foundation for open cooperation is openly shared information, which in turn requires collaborative co-creative processes and information-sharing. Thus, value networks which aim at co-creation need stakeholder participation, which in turn needs active facilitation, including tools and platforms to foster open collaboration and information-sharing (Ruoslahti 2018).

There are many frameworks of collaboration that bring together various dispersed authorities on the different European maritime fields. They need to exchange information directly within their own networks and with each other. Maritime situational awareness is constantly shared between these participating parties. This benefits maritime safety, rescue, assistance, environmental protection, security, and law enforcement, while providing resilience in shared actions.

Work has been done by several EU-wide (PERSEUS, CoopP, EUCISE2020, and MARISA) and national projects (such as FINCISE) on information-sharing in the maritime domain. These projects show the importance of sharing information both cross-sector and -nationally between different authorities; cross-border between authorities from different EU member states and also with cooperative third-country authorities. Alerting operators to anomaly detection, classification, and threat assessment is key to classifying the threats, evaluating their seriousness, predicting possible impacts, and gaining a Common Operational Picture between all these different contributors (Ruoslahti & Tikanmäki 2017; Tikanmäki & Ruoslahti 2017).

Allowing complexity in network collaboration to increase by adding such elements to what is now only network collaboration creates potential for reaching deeper forms of co-creation (Ruoslahti & Tikanmäki 2017), which may provide faster innovation. In the case of CISE, this

means that substantially faster detection, assessment, planning, and response are reached for increased system resilience on all four levels: physical, informational, cognitive, and social. It can be argued that increased collaboration will affect the depth of planning, the abilities to absorb and recover, as well as the abilities to adapt or learn together.

KRIVAT—Information-sharing network between critical-infrastructure companies

The KRIVAT service of the State Security Networks Group Finland is an example of an information-sharing and cooperation framework, which is specifically designed for the management of disturbances and continuity of critical-infrastructure operations. It, thus, exists to specifically enhance the preparedness of critical infrastructure. KRIVAT is a framework for action, and its main purpose is to supplement the existing preparedness and disturbance-management activities of critical-infrastructure operators during major disturbances. It responds to a recognised need for clearer communications structures and better situational awareness between organisations for disturbance management (Koski 2015).

Once any one threat meets vulnerability and has the capability to cause a consequence, it may be considered a risk (Linkov *et al*. 2014). Crisis management enables an organisation to sustain and resume operations, thus minimising financial losses to stakeholders and enabling learning about how to better manage future incidents (Pearson & Clair 1998). The KRIVAT concept involves organisations from various sectors who, when encountering disturbances or crises, take needed actions together. Thus, critical-infrastructure operators and their support organisations have a shared system for real-time information exchange between these organisations when incidents occur.

KRIVAT works to reduce damage caused by major disturbances, first, by aiding in the planning and preparation for disturbances and, second, by speeding up recovery processes when these disturbances do occur. KRIVAT also brings enhanced coordination of resources between organisations, increases information-sharing, and provides better situational awareness. Shared situational awareness, interoperability, open communication, and shared crisis management add to preparedness and, thus, to the overall resilience of participating critical-infrastructure operators.

Under normal conditions, critical-infrastructure organisations may compete with one another in the marketplace. Therefore, it is not natural for them to exchange operational information. However, Finland is one of a few countries in which critical-infrastructure companies are, in case of disruptions, required to cooperate with one another; and facilitating open information-sharing is key to the KRIVAT community. Thus, all KRIVAT member organisations sign an agreement of mutual aid. This agreement has rules for both information exchange among the organisations and for the treatment of information. To make information exchange as clear as possible, a traffic light protocol is used to classify non-public information. This is to identify optimal levels of interoperability between organisations, because unclear communication responsibilities are known to cause problems.

Successful crisis-management efforts enable an organisation to first sustain and then resume its operations, to minimise losses, and to adapt to manage future incidents (Linkov *et al*. 2013). Effective response to disturbances and collaboration during those disturbances depend heavily on shared situational awareness. Exercises were found to be useful in activating users to share, train, and keep active. KRIVAT and its systems remain mostly unused between periods of disturbances. Thus, training exercises help users remember KRIVAT as their preferred option

to respond to a live crisis. When time is of the essence, falling back on possibly old routines may not be as efficient as a timely and innovative response.

Finnish food-supply system as a resilient CPS

The food-supply chain ranges from agriculture and other primary production, through refining, to distributing foods; and it is one of the most important basic functions of society, as it secures food for all its citizens. Its aim is to ensure that the entire population can, in all conditions, get sufficient nourishment. The national agricultural production is the central foundation of the food supply. Attempts to increase crop farming are made, for instance, by increasing production of high-energy crops such as corn, while refocusing domestic animal production, such as pig, poultry, and fur farming, which use food suitable for humans, such as corn, potatoes, and fish.

Legislation and national regulations instruct general principles for preparedness; and alterations to normal operations and irregular actions are based on government decisions, which in turn are based on objectives for the security of supply. These decisions ensure that adequate food supplies are being secured under all circumstances, since maintaining an adequate food supply is a vital function of society.

During unusual conditions, the production equipment capacity of standard times is supplemented by different reserve supplies of foods and by available production equipment. There are also intervention warehouses, which are controlled by the European Union.

The food-supply chain is vulnerable and dependent on other critical infrastructures, such as energy, transportation, finance, and communications. To nourish the population during unusual conditions, the entire food supply must be examined to prepare the logistic chains that are needed during disturbances. Two main objectives are, first, to secure adequate agricultural production and, second, to make sure that the food industry has sufficient capacity to refine this raw production to food products that are usable in both consumer and industrial kitchens. Functional distribution systems for food from industry, through trade, and up to the consumer must be examined and the operations of retail and group eating food distribution networks secured.

Information systems direct the physical devices on which food production is based. These can be challenging to keep operational in all conditions, especially with the growing amount of advanced technology involved. One example is how the tractor manufacturing company John Deere attempted to channel all maintenance of the farm machines they manufactured to their official dealer for after-market maintenance and service by closing the software that controlled their machines. This, however, was counteracted by hacking tools being developed for farmers, which enabled them to access the software and perform independent on-site maintenance to their farm machines (Koebler 2017). These events show how conflicting interests of actors may increase dependencies and, thus, conflict with network resilience.

The food-safety system in Finland, for example, is systematically prepared against different threats, and is considered to be at a high level internationally. Both the safety of foods and the informing of consumers are regulated and supervised by national authorities and by the actors responsible for the production. Some challenges in the future will be climate change and risks brought by population developments. Possible shortcomings may be, among other things, the loss of clean drinking water and any intentional endangering of food safety.

Attributes to improve the resilience of collaboration networks

Security-management master's students performed risk-assessment workshops from mainly an authority's perspective. They first produced a list of attributes toward greater resilience of multi-stakeholder collaboration networks; these attributes were then prioritised and placed in risk matrices. The main attributes are summarised in **Table 2**,below.

As seen in **Table 2**, clear attributes that a network can address to gain resilience on its social domain were identified. A clear purpose is the starting point at which to agree upon roles and create common ways of working. Leadership and facilitation are needed; these also are roles that the network stakeholders must agree upon. Developing a back-up system for representatives is important for both having an open flow of communication and building trust among the stakeholders.

Attributes of resilience in collaboration networks
Clear co-created purpose and common aims for the network
Agreed organisation and roles within the network
Common culture and common ways of working among network stakeholders
Leadership within the network
Facilitation of collaboration and co-creation in the network
System to back-up (or exchange) network stakeholder representatives
Trust-building among the stakeholders of the network
Open communication and information-sharing between all network stakeholders

Table 2: Attributes that can improve resilience in collaboration networks

Resilience in a social network is based upon the network's having a clear purpose and common aims. The preparation phase is dependent upon strategy work resulting in common aims and common ways of working. Stakeholders should work toward plans, guidelines, and standards, and they should agree upon clear roles and responsibilities; they should also identify and align individual and common user requirements. If the need to absorb the effects of possible negative incidents arise, the level of acceptance of roles and responsibilities for each stakeholder comes into play.

Also, a common operational culture can ensure needed flexibility to successfully face changing situations. Recovery toward jointly-set and jointly-accepted targets are needed to act as steps toward full normalisation of services and operations. The adapt phase should include an open analysis of performed actions, as well as the usefulness of planned guidelines and actions. Knowledge of and a situational picture of the operating environment are needed to make educated decisions.

Furthermore, a resilient social network has leadership, and it benefits from process facilitation. The planning phase should be based on a thorough risk-management process, which includes the opinions of each stakeholder. After an incident, crisis management becomes crucial. A clear situational picture enables consideration of possible further changes in the environment. Leadership should focus on the most important element needed to recover from the incident and should prioritise network activities. Follow up and reporting aid in collecting the needed data to learn from the experiences of both one's own organisation, as well as other network organisations. Network leadership and coordination must be neither too vague nor too controlling.

Security of information exchange (cyber and physical) is also needed. Aspects of this are documentation and stand-in procedures in case a representative is absent or in case other personnel issues arise. A clear system to mitigate the effects of possible absenteeism and changes in stakeholder representatives should be in place. Timely and effective communication and information exchange help build trust between stakeholders. There must be trust between stakeholder representatives and organisations.

Moreover, participants indicated that large changes in the operational environment, such as rapid technical developments, difficulties in scheduling, and unexpected costs, may challenge network resilience and cooperation processes. Open communication during the preparation phase relates to managing pre-crisis communication (Vos, Schoemaker & Luoma-aho 2014); after an incident has occurred, the interaction turns into crisis communication (Palttala & Vos 2012). During the recovery phase, the focus shifts back to communication on issues' management.

Cross-Case Analysis and Discussion

This section discusses implications of the results of this study for resilience in the social domains of networks, identifies how to improve resilience in collaboration networks, and offers views on competences needed with regard to resilient Cyber Physical Systems and the strong connection between research and higher education. The section is structured in three sub-sections: Resilience in CPS – environment and industrial sectors, Knowledge base and academic disciplines, and Pedagogy and future educational competences.

Resilience in CPS – environment and industrial sectors

Event-management cycles (plan or prepare, absorb, recover, adapt and learn, and self-modify) should be considered in relation to CPS, which are composed of cyber, technical, social, and ecological systems. Known best practices of CPS and earlier experiences from critical-infrastructure sectors are utilised in the design and maintenance of resilient CPS. According to the research, most CPS are complex and interconnected. Thus, the characteristics and experiences from many different industry sectors should be considered simultaneously.

Complexity within networks may be greatest in multi-stakeholder co-creation, where stakeholder roles need to be fluid because they are constantly changing. Co-creation networks aiming at value, knowledge, and innovation require active stakeholder participation, which is best achieved through common aims that promise benefits for every concerned stakeholder. Open collaboration benefits the aims of each innovation network stakeholder. Innovation projects and open innovation environments, such as CISE and KRIVAT, are examples of CPS frameworks that actively facilitate interaction between network stakeholders. CPS in critical infrastructure and vital functions, and related education, should take into account the fluidity of stakeholder roles and the need for common goals in designing facilitation activities (Ruoslahti 2018).

One example is that, so far, there are no scientific methods available that could precisely predict major weather phenomena (such as the long-term evolution and spatial distribution of tropical cyclones, atmospheric blockages, or extra-tropical storm surges), nor are the impacts on society's infrastructure in any way quantified (Linkov *et al*. 2014). Because of these unknowns, building resilience becomes the optimal course of action for large Cyber Physical Systems that manage society's critical infrastructure and vital functions.

Knowledge base and academic disciplines

The theoretical perspectives of critical-infrastructure-related CPS are based on sociotechnical systems' theory. The concept of sociotechnical resilience employs an interdisciplinary perspective derived from the fields of science and technology studies, human factors, safety science, organisational studies, and systems engineering (Amir & Kant 2018). Resilience domains (physical, informational, cognitive, and social), as well as all event-management cycles (plan or prepare, absorb, recover, adapt and learn, and self- modify) can be used to make sense of resilience on the four domains (physical, informational, cognitive, social) of CPS in technology-focused social-ecologicalsystems.

The theoretical background of the cyber domain of CPS can be derived from the science of design for software-intensive systems (Hevner & Chatterjee 2010), including software design theories (building artefacts, evaluating artefacts, artefact behaviours, artefact qualities, representations, utility theories), dynamic system theories (control theories, emergent behaviours, emergent qualities, adaptive design theories, real-time systems), socio-economic theories (human cognitive abilities, social and group behaviours, human-computer interaction, economic theories, market forces), and domain theories (laws, rules and constraints of the application domain), as well as a multi-actor communication approach (engagement of many very diverse actors, who may have very diverse aims), and co-creation of knowledge and innovation (see **Figure 3**, below).

In order to integrate learning into Research and Development, three roles were identified: 1) the responsible teacher, who integrates learning development objectives with research and development activities; 2) the teacher preparing lecture materials, who integrates teaching with research and development activities; and 3) the student, who integrates learning with research and development activities.

Pedagogy and future educational competences

CPS covers nearly all industrial sectors and academic disciplines. Thus, the history and focus of the discipline in question, together with the best practices of relevant industrial sectors, should be taken into account when designing new curricula and educational needs with regard to CPS in critical infrastructure. Learning together increases the speed and ability to adapt, and it may even facilitate the creation of innovations. Increased interaction and collaboration between the stakeholders of critical infrastructure can result in deeper, more encompassing planning. This, in turn, can enhance a system's and a system of system's ability to absorb and to recover. Thus, learning to understand collaboration frameworks and modes of co-creation, such as the co-creation cycle (Ruoslahti 2018), helps leaders of tomorrow add resilience to their businesses and to society in general.

The research results indicate that future competences with regard to CPS are multidisciplinary. Many industrial sectors and theories from multiple academic disciplines can be included in academic research, applied development, and education. The Design Science Research (DSR) framework (Hevner & Chatterjee 2010) can be applied to designing new curricula and educational needs with regard to CPS. **Figure 3**, below, summarises the research findings of this paper. It demonstrates how the DSR framework was applied to map future CPS-related educational needs. These were demonstrated in the research projects of this case study.

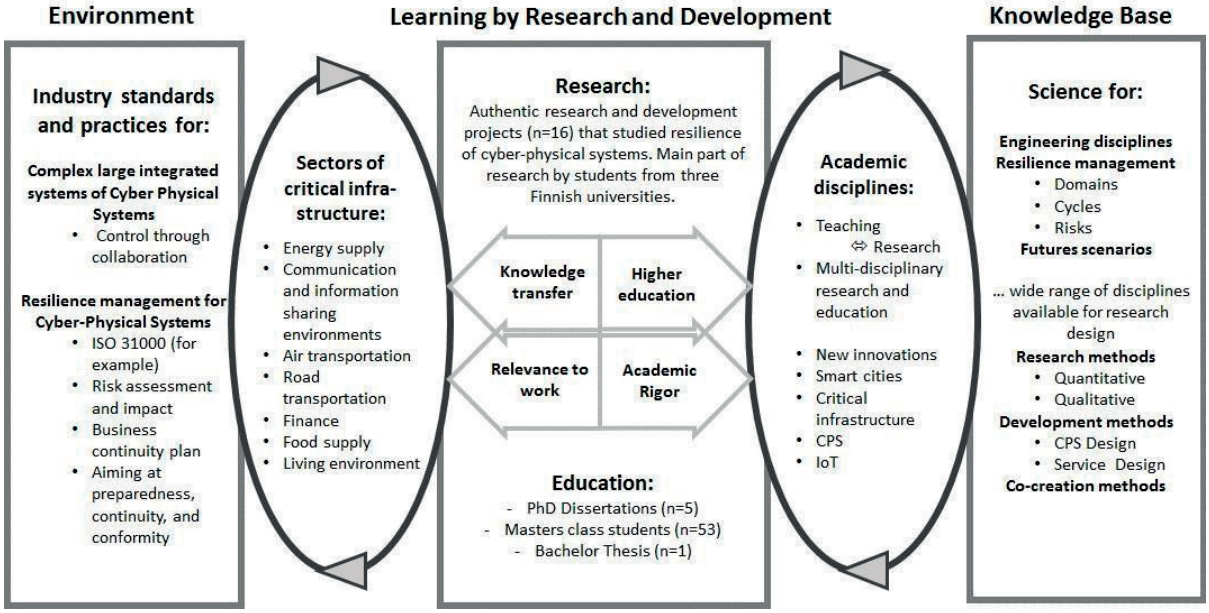

Figure 3: Future educational competencies applied from case studies on Cyber Physical Systems

Future educational competencies, as shown in **Figure 3**, show that knowledge of communication theory and practical skills and modes of promoting interoperability between organisations should be a focus in the higher-education programs that aim to address resilience. In addition, understanding how to build and maintain shared situational awareness is also important to include. It is needed both to respond to disturbances and to collaborate more effectively. Open and clear information exchange between the network of organisations responsible for critical infrastructure with CPS is key in handling crises and in recovering from disturbances.

Models such as Learning by R&D (Pirinen 2011; Pirinen 2017a) or Learning by Developing (Raij 2014; Hyttinen, Ruoslahti & Jokela 2017) can be adopted to integrate learning and R&D related to critical infrastructure and Cyber Physical Systems. The structure of the model Learning by R&D, for example, is easy to adapt and to renew when change or turbulence occurs. It can be further developed from within a network to produce interactions, adaptions, resilience, and innovations.

Conclusions

To design CPS education, relevant industrial sectors and academic disciplines can be selected and focused on so that they complement each other (see **Figure 3**, above). In any case, CPS education needs to cover all resilience domains (physical, informational, cognitive, and social) as well as all event-management cycles (plan or prepare, absorb, recover, adapt and learn, and self-modify).

Academic knowledge bases are a place to begin when designing research or education related to resilience of critical infrastructure. Many academic disciplines can be applied. Some important disciplines are engineering, resilience management, and future scenarios. The field of critical infrastructure is one that needs to focus especially on resilience and continuity of operations. Disruptions in operations affect many and, in some cases, the entire society. Thus, securing the operations of critical-infrastructure operators—be they public or private—may be crucial for the functioning of society.

Some industrial fields that are critical to society are energy supply, communication and information-sharing environments, air transportation, road transportation, finance, food supply, and living environment. All these fields of industry are increasingly CPS in nature. The fields of critical infrastructure use resilience-practices and business-continuity-planning (such as ISO 31000:2018) standards that guide their planning and preparedness. Risk assessment, business impact analysis, and business continuity planning are commonly used by these industries.

Teaching and research need a tie between knowledge base and R&D needs. Knowledge base provides the theory and methods on which to ground applied R&D activities. These activities serve to provide a context for practical learning. Including stakeholders from the environment using co-creative methods provides genuine user input and relevance to work.

Compliance with the requirements set by the different sectors of critical-infrastructure industry provide a baseline for resilience of CPS, and the related systems of systems. The focus of security actions has traditionally been to control one's own system (improving its protection, staying inside a circle of protection) because safety and security thinking has been based on the supposition that risks and 'bad touch' can be prevented. However, no one alone is able to fully control complex, large, integrated Cyber Physical Systems. To do so, coordination and cooperation are needed, and these approaches need to be taught in higher education.

The focus of CPS education needs a shift from controlling and securing one's own data to collaboration and information-sharing between the different stakeholders. This way, more resilient, complex systems of systems can be promoted. Existing safety and risk-management knowledge bases may be complemented by developing frameworks and models that enable network-wide resilience management to maintain and to improve critical functionalities.

Acknowledgements

Acknowledgement is paid to the Maritime Integrated Surveillance Awareness project (MARISA). This project is funded by the European Commission through the Horizon 2020 Framework under the grant agreement number 740698. The sole responsibility for the content of this paper lies with the authors. It does not necessarily reflect the opinion of the European Commission or of the full project. The European Commission is not responsible for any use that may be made of the information contained therein.

References

Alberts, D 2002, *Information age transformation: Getting to a 21st century military*, Command and Control Research Program (CCRP) publication series, Department of Defense, Washington, DC, US.

Amir, S & Kant 2018, 'Sociotechnical resilience: A preliminary concept', *Risk Analysis,* vol. 38, no. 1, pp. 8-16.

Benbasat, I, Goldstein, DK & Mead, M 1987, 'The case research strategy in studies of information systems', *MIS Quarterly*, vol. 11, no. 3, pp. 369-86.

Broy, M & Geisberger, E 2011, *Cyber-physical systems: Driving force for innovation in mobility, health, energy and production*, Acatech: The National Academy of Science and Engineering, Munich, DE.

Dahlberg, R, Johannessen-Henry, C, Raju, E & Tulsiani, S 2015, 'Resilience in disaster research: Three versions', *Civil Engineering and Environmental Systems*, vol. 32, no. 1-2, pp. 44-54.

Eisenhardt, K 1989, 'Building theories from case study research', *Academy of Management Review*, vol. 14, pp. 532-50.

George, L & Bennett, A 2005, *Case studies and theory development in the social sciences*, MIT Press, Cambridge, MA, US.

Gustafsson, A, Kristensson, P, & Witell, L 2012, 'Customer co-creation in service innovation: A matter of communication?', *Journal of Service Management,* vol. 23, no. 3, pp. 311-27.

Hevner, A & Chatterjee, S 2010, *Design research in information systems: Theory and practice,* Springer Science and Business Media, New York, NY, US.

Hyttinen, K, Ruoslahti, H & Jokela, J 2017, 'Model for effective integration between research, work life and higher education in international security studies', *Proceedings of the 9th international joint conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, vol. 3, pp. 299-306.

Koebler, J 2017, 'Why American farmers are hacking their tractors with Ukrainian firmware', *Motherboard*, 21 March, viewed 25 September 2018, <https://motherboard.vice.com/en_us/article/xykkkd/why-american-farmers-are-hacking-their-tractors-with-ukrainian-firmware>.

Koski, E 2015, 'Building organisational interoperability and situation awareness for crisis management: The KRIVAT framework', Bachelor's thesis, Laurea University of Applied Sciences, November, viewed 24 September 2018, <https://www.theseus.fi/handle/10024/101656>.

Linkov, I, Bridges, T, Creutzig, F, Decker, J, Fox-Lent, C, Kröger, W, Lambert, JH, Levermann, A, Montreuil, B, Nathwani, J, Nyer, R, Renn, O, Scharte, B, Scheffler, A, Schreurs, M & Thiel-Clemenet, T 2014, 'Changing the resilience paradigm', *Nature Climate Change*, vol. 4, pp. 407-9.

Linkov, I, Eisenberg, DA, Plourde, K, Seager, TP, Allen, J & Kott, A 2013, 'Resilience metrics for cyber systems', *Environment Systems and Decisions*, vol. 33, no. 4, pp. 471-6.

Miles, M & Huberman, A 1994, *Qualitative data analysis: An expanded sourcebook*, Sage Publications, Thousand Oaks, CA, US.

Murakami, K J 2012, *CPSS (Cyber-Physical-Social Systems) initiative - Beyond CPS (Cyber-Physical Systems) for a better future*, 13 March, viewed 20 September 2018, <http://www.jpgrid.org/event/2011/ws34_murakami.pdf>.

National Research Council 2012, *Disaster resilience: A national imperative,* The National Academies Press, Washington, DC, US.

O'Rourke, TD 2007, 'Critical infrastructure, interdependencies, and resilience', *The Bridge*, vol. 37, no. 1, March 1, viewed 23 September 2018, <https://www.nae.edu/Publications/Bridge/EngineeringfortheThreatofNaturalDisasters/CriticalInfrastructureInterdependenciesandResilience.aspx>.

Palttala, P & Vos, M 2012, 'Quality indicators for crisis communication to support emergency management by public authorities', *Journal of Contingencies and Crisis Management*, vol. 20, no. 1, pp. 39-51.

Park, J, Seager, TP, Rao, PSC, Convertino, M & Linkov, I 2013, 'Integrating risk and resilience approaches to catastrophe management in engineering systems', *Risk Analysis*, vol. 33, no. 3, pp. 356-67.

Pearson, C & Clair, J 1998, 'Reframing crisis management', *Academy of Management Review*, vol. 23, no. 1, pp 59-76.

Pinho, N, Beirão, G, Patrício, L & Fisk, R 2014, 'Understanding value co-creation in complex services with many actors', *Journal of Service Management*, vol. 25, no. 4, pp. 470-93.

Pirinen R 2011, 'Externally funded research and development projects in perspective of learning', *International Journal of Engineering Pedagogy*, vol. 1, no. 3, pp. 27-36.

——2017a, 'Resilient learning: Towards integration of strategic research programmes', *International Journal of Engineering Pedagogy*, vol. 7, no. 2, pp. 94-108.

——2017b, 'Towards common information systems maturity validation – Resilience Readiness Levels (ResRL)', *Proceedings of the 9th international joint conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, vol. 3, pp. 259-66.

Pöyhönen, J, Nuojua, V, Lehto, M and Rajamäki, J (in press) 2018, 'Application of cyber resilience review to an electricity company', *ECCWS 2018*, Academic Conferences and Publishing International Limited, Sonning Common, UK.

Rajamäki, J (in press) 2018, 'Industry-University collaboration on IoT cyber security education. academic course: Resilience of Internet of Things and Cyber-Physical Systems', *IEEE Global Engineering Education Conference (EDUCON)*, Santa Cruz de Tenerife, Canary Islands, ES, 18-20 April.

Rajamäki, J & Pirinen, R 2017, 'Design science research towards resilient cyber-physical eHealth systems', *Finnish Journal of eHealth and eWelfare*, vol. 9, no. 2-3, pp. 203-16.

Raij, K. (2014). 'Learning by Developing in Higher Education', *Journal of Education Sciences*, no. II, pp. 6-21, Eötvös Loránd University, Faculty of Education and Psychology.

Robson, C 2001, *Real world research*, Blackwell Publishing, Oxford, UK.

Roloff, J, 2008, 'Learning from multi-stakeholder networks: Issue-Focused stakeholder management', *Journal of Business Ethics*, vol. 82, pp. 233-50.

Ruoslahti, H. 2018. 'Co-creation of knowledge for innovation requires multi-stakeholder public relations', *Public Relations and the Power of Creativity, Advances in Public Relations and Communication Management*, vol. 3, S Bowman, A Crookes, S Romenti & Ø Ihlen (eds), Emerald Publishing Limited, pp. 115-33.

Ruoslahti, H & Hyttinen, K 2016, 'A co-created network community for knowledge and innovations – Promoting safety and security in the Arctic', *Proceedings of the 23rd international Public Relations Research Symposium, BledCom,* Faculty of Social Sciences, Ljubljana, SL, pp. 100-6.

Ruoslahti, H and Tikanmäki, I 2017, 'End-Users co-create shared information for a more complete real-time maritime picture', *Proceedings of the 9th international joint conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, vol. 3, pp. 267-74.

Savage, M 2002, 'Business continuity planning', *Work Study*, vol. 51, no. 5, pp. 254-61.

Singapore-ETH Centre 2015, *Future resilient systems*, viewed 20 September 2018, <https://www.ethz.ch/content/dam/ethz/special-interest/dual/frs-dam/documents/FRS-Booklet.pdf>.

Tikanmäki, I & Ruoslahti, H 2017, 'Increasing cooperation between the European maritime domain authorities', *International Journal of Environmental Science*, vol. 2, pp. 392-9.

Vos, M 2017, *Communication in turbulent times: Exploring issue arenas and crisis communication to enhance organisational resilience*, Jyväskylä University School of Business and Economics, no. 40.

——(in press) 2018, 'Issue arenas', *The International Encyclopedia of Strategic Communication (IESC),* R Heath & W Johansen (eds), Whiley Blackwell, Malden, MA, US.

Vos, M, Shoemaker, H, Luoma-aho, V, 2014, 'Setting the agenda for research on issue arenas', *Corporate Communications: An International Journal*, vol. 19, no. 2, pp. 200-15.

Woodman, P 2007, *Business continuity management,* Chartered Management Institute, London, UK.

Yin, R 2009, *Case study research design and methods*, Sage Publications, Thousand Oaks, CA, US.

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COMPLEXITY IN PROJECT CO-CREATION OF KNOWLEDGE FOR INNOVATION

by

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Submitted to a peer-reviewed journal

Complexity in Project Co-creation of Knowledge for Innovation

Abstract

The European Union (EU) promotes collaboration across functions and borders in its funded innovation projects, which are seen as complex collaboration to co-create knowledge. This requires the engagement of multiple stakeholders throughout the duration of the project. To probe complexity in EU-funded innovation projects the research question is: How does complexity affect the co-creation of knowledge in innovation projects, according to project participants? The data for this study was collected from project experts in the form of short narratives, using a questionnaire based on the elements of complexity of Mitleton-Kelly (2003). The results indicate that complexity characterises the co-creation of knowledge in innovation projects in various ways. Most emphasis was put on the elements Self-organisation, Connectivity and interdependence, Co-evolution, and Creation of new order. Thus, although this study demonstrates that the elements of complexity can be used to gain insight into innovation projects, the results show that not all elements of complexity are equally important in this context and that they appear in a certain order. Moreover, understanding the complexity of collaboration for innovation in relation to the input-throughput-output model of organisational communication is a contribution to theory that may help future projects achieve faster innovation.

Keywords: Co-creation, Innovation projects, Complexity, Time-to-innovation

JEL Codes: H8, L0, M0, O3

Introduction

The European Union (EU) promotes collaboration across functions and borders, and involving

multiple authorities, academics, practitioners, and industry. The aim is to enhance innovation and thus, increase the competitive advantage of Europe (European Commission, 2016). For example, the Horizon 2020 program calls for European research and development initiatives that are expected to strengthen European collaboration for innovation (European Commission, 2019).

These EU-funded innovation projects can be seen as complex forms of cooperation aimed at the co-creation of knowledge, a process in which multiple stakeholders with diverse backgrounds participate (Ruoslahti, 2018). Aaltonen and Saunders (2005) note that complexity can be used as a framework of sense making. Systems emerge through interaction between its agents, the people, processes, technology, governance, etc. (Aaltonen & Sanders, 2005), however these emergent systems cannot be led by just one agent. This principle can be applied to innovation projects, which operate through collaboration "facilitating reciprocal learning and co-evolution between the partners" (Mitleton-Kelly, 2005, p. 38). In projects, various partners try to make sense of challenges, including diverse input to co-create innovations. Diverse input can facilitate knowledge creation and innovation in complex problem-solving (Valkokari, Paasi & Rantala, 2012).

EU-funded innovation projects often involve a high number of participants with very different backgrounds from industry, universities, governments, and civil society. They have, therefore, been characterized as complex. This may lead to a bureaucratic burden, but complexity can also be seen as a positive characteristic. Bassett-Jones (2005) for example, concludes that, diversity can enhance creativity and innovation, although when managed poorly, it can also be "a cause of misunderstanding, suspicion and conflict" (p. 169). Creativity, the source of new ideas and creative processes, "is a complex and diffuse construct", write Alves, Marques, Saur and Marques (2007, p. 28), and continue to note that "multidisciplinary and multisectoral networks can play important roles in members' competitiveness" (p. 32), as diverse input helps facilitate innovation and complex problem-solving. Based on experiences of several EU-funded projects, this study aims to further

clarify how complexity affects the functioning of innovation projects and, in particular, time to innovation.

Innovation Projects

This section looks at innovation networks, complex co-creation, innovation projects, and organisational communication in the context of EU-funded innovation.

Multi-stakeholder projects

EU-funded innovation projects are multi-stakeholder projects. Franco and Pinho (2019) note that innovation needs research that creates technological advancements and new and improved products. These projects are required to include multiple actors representing e.g. end-user, industry, and academic organisations in their consortia (European Commission, 2019). When organisations come together, "there should be emphasis on post-merger relationships, and the development of an emergent culture to support the new organisational form" (Mitleton-Kelly, 2005, p. 39). Although her study focuses on mergers and acquisitions, the principle could be useful to apply also to forming project consortia. Thus, the innovation network stakeholders need to put enough emphasis on discussing what expectations they have for their relationships and the emergent culture during the innovation project. Projects may come with internal crises and, therefore, form a turbulent environment for several years in time, and "as many crises combine different kinds of threats, cooperation with other actors is needed for their mitigation" (Vos, 2017). Networks of relationships are sustained through communication, feedback, and inter-dependence. "When they meet a constraint they are able to explore the space of possibilities and find a different way of doing things, i.e. they are creative and innovative" (Mitleton-Kelly, 2005, p. 45).

Stakeholder management offers some systematic approaches to organise the relationship between organisations and the stakeholders involved (Roloff, 2008). Innovation projects can also be studied as systems; and systems cannot be understood by analysing their parts separately, write Aaltonen and Sanders (2005), their global features should be seen as a whole. Understanding knowledge co-creation is important, as innovation and creativity are sources of competitive advantage (Bagayogo et al., 2014). Organisations explore alternative ways of working toward their tasks (Mitleton-Kelly, 2005), and can identify opportunities for encounters that support the co-creation of value in business by mapping end-user processes and practices (Payne, Storbacka & Frow, 2008). Consequently, managing creative knowledge capital is about "providing the conditions and circumstances for creativity and innovativeness" (Wilenius, 2008, p. 66). To create new knowledge Nonaka and Takeuchi (1995) advocate dynamic interactions between stakeholders.

Multi-stakeholder networks are organisational structures, which allow collective innovation over organisational and national boundaries. Objectives and actions in multi-stakeholder networks become negotiated by the participants, as their participation is voluntary (Roloff, 2008). Collaboration for co-creation of knowledge and innovation calls for a common problem, and ideally, also end-users are engaged to participate actively (Ruoslahti, 2018). The roles of the stakeholders may change over time. For example, end-users are often active in the beginning when project requirements are set, and they may also be involved in the development and testing of solutions. Managers predominantly see co-creation as a way to generate ideas for new products and services (Frow et al., 2015). Organisations (e.g. projects) that aim at innovation benefit from networked environments that encourage and facilitate exploration of the space of possibilities

(Mitleton-Kelly, 2005, p. 50). To ensure open communication enabling co-creation of knowledge, an innovation network needs to manage engaging its stakeholders throughout the project, and be aware that this takes both time and effort.

Complexity of Funded Projects

Innovation projects are networks that aim at co-creative collaboration. They need facilitation and cooperation tools. When network stakeholders agree on common aims which also permit each stakeholder to reach individual goals, they are already co-creating. These common aims promote active stakeholder participation. This helps co-create knowledge and innovation. In turn, and collaboration is strengthened by bonds of trust within the value network (Ruoslahti, 2018).

Open innovation is based on voluntary collaboration and is, thus, self-organising (Leminen, Westerlund & Nyström, 2012). EU-funded project consortia include collaboration between different types of partners: businesses, public authorities, universities, and end-users (Valkokari et al., 2012). While co-creation results from complex interactions between the various network actors, and even resource integration (Pinho et al., 2014), communication becomes co-constructed by multiple stakeholders, who have different interests and often many interdependencies (Vos, 2017). As knowledge co-creation is a main source of innovation and creativity in organisations (Bagayogo et al., 2014), co-creation to develop innovation can be promoted by organisational cultures that favour innovativeness and participation of end-users (Santos-Vijande & Gonzalez- Mieres, 2013). Responding to and influencing emerging events allows an organisation to influence its future (Aaltonen & Sanders, 2005), while Pirinen (2015) notes that knowledge is important for the competitive advantage of modern organisations. Knowledge strengthens the collective expertise needed in today's competitive global economy.

Criteria for innovation projects by the European Commission (2012) include the involvement if user communities, evidence of reduced time or costs to meet innovation purposes, and intensity of technology and information exchanges. Understanding the different ways of working and the motivation of the different partners is needed to understand collaboration between multiple actors in innovation networks (Valkokari et al., 2012). According to Mitleton-Kelly (2005) distributed leadership means that every participant feels responsibility to explore possibilities and take initiatives that fit the overall strategic direction. According to Aaltonen & Sanders (2005), in the currently fast changing environments organisations must understand their history and make sense of both future developments and how to influence these. Organisations make use of knowledge to anticipate future needs (Wilenius, 2008) and, similarly, innovation projects could act in a future-oriented way.

According Poutanen, Siira and Aula (2016) communication theories and complexity theory have common roots. Communication can be considered a central means to coordinate organisational activities, to achieve organisational goals, and support a process of organizing. Innovation projects as human systems are self-organising entities. This begins already at the project idea and proposal phases. People exchange ideas, ways of working and relating. Projects, as human systems, can co-evolve and co-create something that could possibly not have be predicted at the outset (Mitleton-Kelly, 2005).

Poutanen et al. (2016) find that many of the complexity-based studies that they examined, emphasize communication as information exchange that supports knowledge creation by networks of actors. Co-creative social interaction and knowledge sharing raise the need for new competencies for those experts and professionals sharing competences in networks (Pirinen, 2015). End-users should be active participants in value co-creation when designing products or services (Allen, Bailetti & Tanev, 2009). The processes to build knowledge and innovation are “increasingly

complex, multidisciplinary, trust-based, co-created, path-depended, and globalized" (Pirinen, 2015, p. 323). Co-creation of knowledge calls for group dynamics in collaboration. Understanding this is "of particular importance in this age where innovation and creativity have become a source of competitive advantage" (Bagayogo et al., 2014, p. 632). This also relates to having a clear purpose, roles and common ways of working in the project. Building trust among the stakeholders, with leadership, facilitation, and a back-up system for representatives enhance an open flow of communication (Ruoslahti & Rajamäki, 2018).

Project organisations need to be resilient for continuity also in case of disturbances (Ruoslahti & Rajamäki, 2018). Similar to a resilient organisation, the project organisation needs the ability "to accommodate several heterogeneous cultures, provided that there is overall coherence that provides unity of purpose and/or values" (Mitleton-Kelly, 2005, p. 47). Polyphony and diversity in organisations are highlighted in the complexity perspective. Continuous balancing of opposing tendencies and preservation of diversity require skills, write Poutanen et al. (2016). Mitleton-Kelly (2005) brings up the notion of co-evolutionary integration to explain that where organisations cooperate the new organisation inherits characteristics from each constituting entity. In innovation projects multiple stakeholders together try to make sense of challenges in business and society, sharing experiences to bring about innovations. These projects can be seen as complex evolving systems, a concept used by Mitleton-Kelly (2003) to describe organisations characterized by various elements of complexity including, for example, the level of interconnectedness of the parts of the system. Altogether, she mentions ten elements of complexity, discussed also by Aaltonen (2005).

In this paper, the elements of complexity by Mitleton-Kelly (2003) are used to make sense of the complexity of innovation projects, where partners come together (*Connectivity and interdependence*), to agree on roles, goals, and ways of working (*Self-organisation*). All project

partners bring their individual and common histories into the collaboration (*Historicity*), and together they explore possibilities to reach innovative results and create new knowledge (*Exploration-of-the-Space-of-Possibilities*). The project consortium makes decisions on which path to take, presented in the project proposal and further plans (*Path dependence*). Interaction is used to re-focus the project plans (*Feedback*), as the project will encounter changes, both, in its environment and among the partners (*Far-from-equilibrium*). The project partners continue working together and influencing each other (*Co-evolution*) and, consequently, new innovations can emerge from the workflow among the consortium partners (*Emergence*), while the knowledge gained is disseminated and new collaborative structures are created (*Creation of new order*). In this study the focus is on innovation projects with EU-funding.

Projects Create Knowledge for Innovation

Research and development collaborations ultimately aim at creating knowledge (Matt, Robin & Wolff, 2012). “Innovation is as an idea, practice, behaviour, or artefact that is perceived as being new by the adopting unit” (Eservel, 2014, 806). It is a competitive advantage (Bagayogo et al, 2014) that is increasingly important for researchers and practitioners (Eservel, 2014), as the EU calls for Europe-wide innovation by its current Horizon 2020 funding programme (European Commission, 2019). New opportunities for change are constantly emerging (Aaltonen & Sanders, 2005) for organisations and projects alike. “In turbulent, surprising, continuously evolving marketplace environments only flexible, agile, and relentlessly dynamic organisations will thrive” (Lengnick-Hall et al., 2011, p. 243), as risks in network collaboration cannot be avoided, only reduced. (Vos, 2017), while knowledge creation processes can be significantly impacted by disseminating knowledge through collaboration (Abubakar et al., 2019).

EU-funded projects are co-creation networks formed by research and development consortia, and

knowledge management in networked innovation calls for a strategic approach (Valkokari et al., 2012). However, "EU-funded projects are likely to involve a higher bureaucratic burden than spontaneous collaborations" (Matt et al., 2012, p. 900). Organisational innovativeness is supported by co-creation with customers (Luoma-aho et al., 2012), and, when developing services and processes networking is considered especially important (Tikanmäki, Tuohimaa & Ruoslahti, 2012), as in co-creation "designers and users engage in mutual enabling roles" (Kummitha, 2019, p. 108). Similarly, in EU-projects the role of end-users is emphasised. Thus, ensuring that the consortium project fulfils end-user needs calls for active on-going end-user communication, co-creating products and services with end-users (Miettinen & Koivisto, 2009).

Major problems occur when organisations are put together, ignoring the diversity of people and cultures, for example, by a lack of communication with stakeholders, unclear roles and, responsibilities (Mitleton-Kelly, 2005). As diversity is also, according to Bassett-Jones (2005), "a recognizable source of creativity and innovation that can provide a basis for competitive advantage", such issues need to be taken into account when creating innovation projects. To increase the impact of the project commitment and active participation, already in the early stage of the project implementation, by partners and end-users are key (Henriksson, Ruoslahti & Hyttinen, 2018). EU-funded innovation projects bring together organisations and professionals who usually do not work together. In this way, they are according to Norvanto (2017, p. 78) a unique form of a knowledge community enabling the participants "to enter completely new domains while expanding their social networks and learning new practices". Pirinen (2015) says that shared expertise is created, taking the form of a "body of knowledge in action" (p. 327).

Co-creating innovation requires dialogue for active learning processes in which the actors mutually affect each other (Santos-Vijande et al., 2013). Collaboration in EU-funded innovation projects may add to the competencies of organisations (Matt et al., 2012). Ruoslahti and Tikanmäki (2017) note a

connection between the elements of complexity (Mitleton-Kelly, 2003) and the time that it takes to achieve co-created innovation: “Added complexity may greatly reduce the time to value creation and innovation” (p. 267). This may be a crucial success factor in funded innovation projects, as they have pre-determined periods in, which to achieve their results.

Vos and Schoemaker (2004) offer a process model that divides organisational communication into three phases: input, throughput and output. In the context of innovation projects, Input communication, for example, helps involve end-users to set requirements, Throughput communication facilitates close collaboration and knowledge co-creation for innovation, whereas Output communication includes disseminating project results to external stakeholders and user communities. Vos and Schoemaker (2004) note that communication contributes to value creation in an organisational context in ways, where these phases are not linear steps but rather cyclically interrelated activities in often chaotic environments. Distinguishing between these three types of communication phases can help understand collaboration within innovation projects Most EU-funded projects can be understood as co-creation projects benefiting innovation networks, and as such are relatively complex and can be more or less diverse (Ruoslahti, 2018).

Method

Based on experiences of several EU-funded projects, this study aims to further clarify what complexity means for innovation in EU-funded projects. Consequently, the research question of this study is: How does complexity affect the co-creation of knowledge in innovation projects, according to project participants?

The research focused on recent EU-funded innovation projects in the security area. The six projects that served as the context of this study are:

1. Airborne Information for Emergency Situation Awareness, AIRBEAM, 2012 – 2015

2. Automated Border Control Gates for Europe, ABC4EU, 2014 – 2018
3. European Test Bed for the Maritime Common Information Sharing, EUCISE2020, 2014 – 2019
4. Improving the Effectiveness of Capabilities in EU Conflict Prevention, IECEU, 2015 – 2018
5. Gaming for Achieving Peace, GAP, 2016 – 2019
6. Maritime Integrated Surveillance Awareness, MARISA, 2017 – 2019.

The data for this study was collected by expert consultation, as such a qualitative approach can provide richness and depth (Poutanen et al., 2016). Nine experts were selected, who all agreed to participate in this study. All had extensive project experience, including being work package and task coordinator in one or more of the EU-funded projects that provided the context for this study and are listed in Table 1. All project consortia consisted of various partners. The project experts were approached with direct requests to participate as respondents in this study. Eight respondents agreed to write short narratives while one of the experts preferred to be interviewed instead. In the latter case the researcher reported the answers in a similar way.

Informed consent was collected from each participant to meet with the principles of research ethics. To ensure the anonymity of the respondents, their comments are presented in a way that they cannot be attributed to or be interconnected for a particular respondent, not to reveal their identity and affiliation. The respondents were provided with a questionnaire consisting of 11 open questions. For each question they were asked to write a short narrative on their views related to the EU-funded innovation project they were part of. The questions were based on the ten elements of complexity by Mitleton-Kelly (2003).

The data was collected during the spring of 2019. The narratives were nicely on point, per question up to 230 words in length, and provided the insight to address the research questions. A first reading of the material showed that satisfaction level was reached. Next, the material was read again to arrange for analysis it in a Data Extraction Table (DET). This was an Excel sheet, where the rows

were formed by the respondents and the columns addressed the elements of complexity as explained in section 2.2. The units of analysis were phenomena of cooperation that were identified from the narratives data. The analysis focused on identifying those phenomena that occurred more often in the data, marking citations that clearly illustrated what the elements of complexity meant in the context of innovation projects.

Results

The structure of this Results section follows the elements of complexity (Mitleton- Kelly, 2003; Aaltonen, 2005), including Connectivity and interdependence, Self-organisation, Historicity, Exploration-of-the-space-of-possibilities, Path dependence, Feedback, Far-from-equilibrium, Co-evolution, Emergence, and Creation of new order. For each element, a short description is given based on the author's explanation but in this case applied to innovation projects, after which the findings are presented.

Connectivity & interdependence

One of the elements of complexity concerns interrelations, in this case, among the project participants. The respondents stress that in order to create innovation value, project participants need to collaborate closely in the project to deliver output through joint activities for the planned work packages and tasks. Thus, partners share and combine their different areas of expertise when solving real case problems.

Project participants stimulate each other toward broader views. When working in parallel, partners depend on each other and their work is affected if they have to wait for results by others. The respondents, however, also note that some innovation project partners may compete within these projects. This may serve to blur the overall innovation goal, and even prevent the consortium proceeding towards it. Thus, some respondents noted that reaching innovations becomes difficult if

the consortium includes companies that are direct competitors in the market, as they are unwilling to openly share with one another.

The respondents strongly feel that partners in innovation projects are connected and interdependent. One's performance has a direct effect on the ability of others to perform their tasks, as project output is compiled by combining the work of all consortium participants. Thus, the project performance of one partner may positively, but also negatively, influence other partners.

Self-organisation

Self-organisation relates to spontaneous order. The results show that expert project partners are often intrinsically motivated to conduct well in the project, and by doing so also bring expected – and sometimes unexpected – results. "Well planned is almost done", notes one respondent. A project can gain high-level results, when the project proposal is well planned in advance. In addition, partner motivation and expertise are important in gaining good results. Workshops, seminars, and questionnaires are proven ways of working together to identify how to solve issues, note the respondents. It shows self-organisation when partners come together to address issues at hand.

The project consortium has freedom in organising project work packages, tasks, and activities. When these are well described in the project proposal, the consortium has a better chance to deliver what has been agreed, once the project becomes funded. Respondents note that the level of self-organisation varies from project to project. One respondent commented that most projects have been "really well organized". However, also, some have been organised poorly, one comment, for example notes that participant commitment may greatly differ: "Having worked in many international projects, there is the tendency that some partners in consortia can follow the general idea and plan quite well, then there are partners who need constant reminding of their duties, and there are partners who ignore any kind of reminding".

The results emphasise that project work cannot be left to a few active partners, but that active collaboration is needed by all consortium partners to achieve optimal levels of self-organisation within project consortia. The ability for self-organisation thus, differs from consortium to consortium. It was noted that normally, a core group will develop the main idea and goals, and then also drive the work for innovation. Furthermore, “the coordinator is in a very crucial position”, as one respondent wrote, and the funder may have strict guidance.

Historicity

Complexity also relates to the different histories of the project consortium partners and other related stakeholders involved. Moreover, each individual involved brings one’s own professional and educational background to the project while interacting with others. The respondents, thus, point out that these individual and organisational histories influence project consortia in many ways. On the one hand, partners who share a positive history often work well together, which may then cause that “some partners might feel left out”, as stated by a respondent. On the other hand, the fact that some partners have a bad shared history can exert a negative influence on the project as a whole. A related point of view brought up by a respondent was, that when partners do not know each other’s histories, the lack of established reputations may lead to “unnecessary highlighting of what partners have done in the past”.

Respondents note that it is beneficial to include partners who know each other and have common experiences of earlier project work, but not to exclude partners who bring other beneficial knowledge and experience to the project consortium. Cultural backgrounds also influence the way in which partners work together, as this influences ways of working and communicating.

According to the respondents, motivated expert consortium partners help deliver the best results. However, expertise usually is needed in many different fields and, thus, all project partners are expected to bring in their specific expertise. Partnerships are then continued, in consequent projects, with those who are seen to be the most motivated experts. As stated by a respondent: “A member that has managed well in a previous project is a desired partner for new projects”.

Exploration-of-the-Space-of-Possibilities

The space of possibilities relates to flexibility of working and, thus, space to find different solutions. A project’s ability to explore the space of possibilities depends, as one respondent notes, on “the time available, meaning the extent of funding and people in the project”. The productivity and success of any project consortium are based on its people, their attitudes, and on how they approach the project work. One problem that was addressed by a respondent is, that after the proposal has been submitted and accepted, there “is little possibility to change the content of work packages”. Project proposals are often made years in advance and require a high level of detail. Work in projects is expected to follow the planning upon which the decision to allocate funding was based. Adaptations have to be communicated or even negotiated with the funder, which may hinder the exploration of possibilities.

The respondents acknowledge that exploring possibilities must already be addressed during the project preparation phase, so it depends heavily on project planning and how it is documented. One responded notes, about addressing a specific issue: “if this is embedded to the project then the result will be achieved at least in some level”. The funding instrument also affects the ability of a project to explore the space of possibilities. However, it was noted that an innovative group can, also during the project, think flexibly to find ways to arrange the content and events of the project.

Path dependence

Path dependence concerns new opportunities being influenced by prior decisions. This path dependence is also visible in innovation projects. Filling niches that create new niches and opportunities are best achieved "via continuum of innovation projects", as one respondent said. How project partners work and cooperate, their nationalities, and prior backgrounds impact the project's ability to identify opportunities. Results indicate that filling niches can create paths toward new opportunities. One respondent noted that: "All of the projects I have been involved in over last two years have created new opportunities – some of them are already implemented", and another that "new partnerships are always built in consortiums."

According to the respondents, partners often perform at different levels, which is also demonstrated in the relations between them. Some partners are active with their project tasks and their responsibilities, duly reacting to communication from work package and task coordinators. On the other hand, some partners perform slowly, only when reminded. Such partners who do not conform to the general flow of work disrupt the common working spirit: "Then there are partners who really annoy the rest of partners because they do not even pretend to be working", according to a respondent. The level of activity will affect future project opportunities.

Feedback

Feedback is a way to identify what changes should be made to how a project is conducted. In most cases, feedback was looked at in a positive way, and considered even "crucial", as one respondent saw it, positive feedback "gives joy and builds trust", while critique should be given "in a way that is no too harsh".

When there are more partners, feedback can however, become a difficult issue. Some comments show that the role and effects of feedback can be twofold: "I have not experienced any 'artificial'

need-to-be feedback in the recent projects" quoted one respondent, while another quote on the effects of feedback states: "Actually the role is big but the effects have been zero", and a third wrote that: "Constructive feedback of end users help the development and innovation project".

Results show that on-going analysis of project results are needed to engage expert partners and core stakeholders. Feedback whom e.g. the Commission of the European Union, stakeholders, coordinator, industry, and others is essential to an innovation project. However, project feedback processes are often seen as being too slow. Therefore, projects need to focus enough on collecting and responding to feedback, which is seen as a main way to engage partners and accomplish when needed a re-focus in project tasks.

Far-from-equilibrium

In fast changing or extreme situations projects will need to make major adaptations. Even though carefully planned project proposals set the goals and direction for EU-funded innovation projects, they are often far from a state of equilibrium. As one of the respondents says: "Good projects follow the outside world continuously". Even daily politics can affect a project. For example, changes in global politics can set back a lot of work, which happened in a regionally funded innovation project with Russian partners who could not proceed their work in the project, when Russia was sanctioned.

The many partners that act in parallel influence each other during an innovation project. Moreover, the project coordinator has a definite effect on how the consortium performs. If the project coordinator is weak, it is difficult to find consensus which can be problematic, according to a respondent, especially if the preparation phase involves too many partners to be effective. This would require coordination intervention. Some respondents experienced that a small core team can best plan the project proposal, making a project idea into a project proposal.

Co-evolution

Co-evolution of partners is seen in partners finding mutual ways of working together, having

positive relationships where they trust and appreciate each other to generate good results and new ideas. It was noted that disseminating project results can be challenging, despite advances in social media and other mediums of communication.

“When a project comes to an end, core members create a new project”, notes one respondent. Thus, a project continuum that builds on the success and results of earlier projects become possible. These partners co-evolve together, which promotes the emergence of new ideas and innovations.

The results indicate that projects identify new problems, find new important research questions, and even evolve to form new projects or even businesses. As, discussed earlier, the time available, the histories, attitudes and expertise of partners, and role of the coordinator are issues that can promote success of failure. Thus, it is important that project partners find ways to build trust and collaborative ways of working together toward the innovations promised in the project proposal.

Emergence

The respondents view that new results in innovation projects emergence from a good workflow among active consortium partners. One project example was quoted, where they were able to create an analysis to crosscheck project results with the existing operational capabilities and legislation. Many that influence each other can at times cause confusion and at other times develop something totally new.

When all consortium members have clear tasks, parallel work can considerably shorten the time needed for innovation. However, it was also noted that a very high number of partners in the consortium, may make it longer to reach innovations. Project consortia were perceived to undertake project activities quite well. Common ways of working strengthen trust between the actors, noted one respondent, and new persons bring new insights to projects.

End-user experiences are seen as especially important to project results, as is utilizing the extended networks that consortium partners each have of their own. Innovation partly depends on how active and how much partners want to share information, and how open they are to input from within and outside the consortium. Means for this may be e.g. public events, webinars, social media campaigns, communications and disseminations for large audiences.

In most projects, next to solving problems, one desired result is also to find new problems to further solve. One respondent even notes that university partners could help companies also in other innovation processes than the project.

Creation of new order

Innovation projects aim at creating impact useful outside the project and thus, need input from outside the group of project partners involved. A consortium is influenced by the information that flows into the project consortium from the external environment. Information that is related to the ongoing project and its tasks is likely to influence project work, depending on the type of information and how it is related. In addition, it is crucial who are the project people that first receive the information and if they actively use it or pass it on.

Seminars, workshops, questionnaires, interviews, and conferences on project issues and its goals are, according to the respondents, useful ways of creating new order innovation. Thus, dissemination of project results aims to affect technologies and processes by taking project recommendations into wider use. Therefore, new ways of disseminating project results, such as during the project creating and expanding end user communities, and organising intensive and digital workshops with them, have been utilized in the projects.

The respondents remind that many currently active pan-European networks and associations have

been created in the course of funded projects. In addition, new businesses have been created based on project innovations. These examples demonstrate how EU-funded projects are intended to provide not only results in the form of new knowledge but also new order innovations.

Diverse enough input is needed for out of the box thinking and to push boundaries. Linking different sectors to solve very complex problems can help shorten the time needed to reach solutions and shorten time-to-innovation, which refers to the time from when the consortium partners come together to when the innovations resulting from the project are put to wider use. The respondents suggest that multi-stakeholder innovation projects can shorten the time needed to reach to innovations when multiple partners add insights, working closely together to generate new knowledge. Working together, face-to-face, in intensive workshops helps generate innovations, while working at a distance does not seem to provide the same results in the same time. One respondent said that "partners who work together generate new knowledge in addition to finished project tasks". Partners may also come up with new project ideas to pursue.

The ability for projects to create new ways of organising, working and thinking, depends on the organisations, groups and individuals involved. "If the people have the drive, the flow, and can get other people into this flow, the results have been great concerning the new organising, working and thinking", comments one respondent. The partners involved explore new opportunities, for which the respondents promote using co-creative methods, collaboration technologies, shared documents, and feedback systems to ensure smooth collaboration towards solutions. Turbulent environments call for such dissipative structures and commitment to faster create innovations and new order.

Discussion and Conclusions

The views of project participants demonstrate how complexity characterizes co-creation of

knowledge in innovation projects. The results show that all ten elements are visible but some more than others. Respondents clearly elaborated on the practical issue of how project partners work together, emphasising the element of *Self-organisation* as problems in this area directly affect everyone working in the project. There is a clear awareness of strong interrelations and a need for collaboration among project consortium partners, which concerns the elements of *Connectivity and interdependence* and *Co-evolution*. Moreover, projects have limited periods. For a project to be deemed successful, new knowledge and innovations must be reached fast. Similarly, new insights need to be disseminated timely to new groups of users and shared with wider audiences involved. Time-to-innovation is emphasised by the respondents, which relates to *Creation of new order*.

This study showed that the elements of complexity by Mitleton-Kelly (2003) can be used to gain understanding of communication and collaboration in innovation projects, and that some elements of complexity may be more important than others. How many and which elements of complexity dominate may be different for the various types of innovation projects, and more research on this is recommended. As there is yet little empirical evidence on organisational communication in the literature on complexity (e.g. Poutanen et al., 2016), this study contributes some empirical evidence on organisational communication to the literature on complexity.

The results demonstrate that complexity in innovation projects is often experienced as challenging. The high level of *Connectivity and interdependence* characterizes the innovation projects, and this may form a burden when some partners are not willing to share information, for example, because of being competitors in the market. However, complexity can also be seen as a positive characteristic, when considering *Creation of new order*, as time-to-innovation can be faster if projects that aim at solving complex problems draw on multiple stakeholders that provide different types of input. This supports the way in which the EU promotes diversity in the project consortia that get funding for their project proposals, but also puts pressure on the consortia to select diverse partners that yet work well together.

Moreover, the results indicate that these ten elements, in the context of projects, show a certain order of appearance. *Creation-of-new-order*, for example, does not come first but rather appears among the last of these elements, etc. Project partners first come together and in close collaboration share their combined areas of expertise (*Connectivity & interdependence*) and are engaged in active collaboration to address issues (*Self-organisation*). These expert partners each bring their organisational and personal backgrounds, and experiences of good prior collaboration, into the project (*Historicity*) to find different solutions and explore opportunities (*Exploration-of-the-space-of-possibilities*), while co-creating a project plan or proposal. Choices made together (*Path dependence*) and feedback (*Feedback*) influence what adaptions are made to the work and which direction that project takes (*Far-from-equilibrium*), as well as how well the project partners work together and how much they trust each other (*Co-evolution*) to provide project results, new knowledge and innovation (*Emergence*) to create a meaningful impact that lasts even beyond the project life-cycle (*Creation-of-new-order*). This flow of relationships between the ten elements of complexity is visible below in Figure 1.

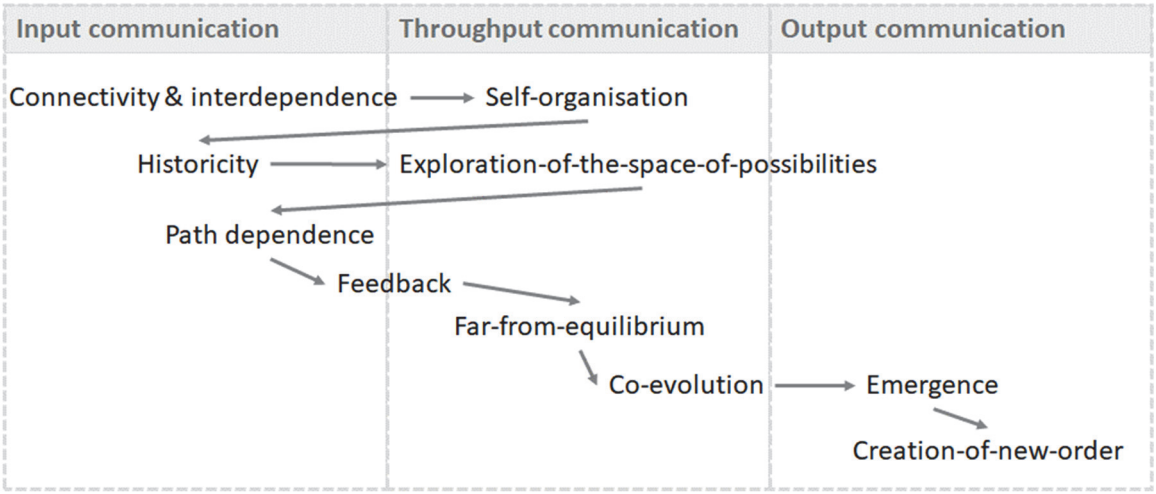

Figure 1: Elements of complexity in relation to input, throughput and output communication in innovation projects

The above Figure 1 also shows how the flow of the elements of complexity, as mentioned by

Mitleton-Kelly (2003) but now shown in the context of innovation projects, can be related to the earlier discussed input-throughput-output model of organisational communication (Vos & Schoemaker, 2004). The project partners are seen to first interact through two cycles of input-throughput communication, before focusing on throughput, and lastly moving towards output communication. This helps understand how the cyclicality of the communication activities and the order of the elements of complexity combine in the context of funded projects. This notion can form a basis for further research to clarify the process, and as such, is the main theoretical contribution of this study.

This approach can also provide a sort of guide map of facilitation (as suggested by e.g. Mitleton-Kelly, 2005; Valkokari et al., 2012) for co-creation processes and, thus, serve as a useful framework for innovation project practitioners (e.g. Norvanto, 2017; Pirinen, 2015) to focus on during the different stages of the project life-cycle, helping future projects achieve faster innovation. . Understanding the complexity of collaboration for innovation and the challenges posed by this collaboration can help future projects to function better and gain added flexibility to face the unexpected. The added knowledge may also benefit the EU when evaluating its funding models.

References

Aaltonen, M., & Sanders, T. I. (2005). Complexity as a sensemaking framework for methodology. Aaltonen, M., Barth, T., Casti, J. L., Mitleton-Kelly, E., & Sanders, T. I. (Eds.) Complexity as a sensemaking framework. FFRC-publications, 4(2005), 21-37.

Abubakar, A. M., Elrehail, H., Alatailat, M. A., & Elçi, A. (2017). Knowledge management, decision-making style and organizational performance. Journal of Innovation & Knowledge, 4(2), 104-114.

Allen, S., Bailetti, T., & Tanev, S. (2009). Components of co-creation. Open Source Business Resource, (November 2009).

Alves, J., Marques, M. J., Saur, I., & Marques, P. (2007). Creativity and innovation through multidisciplinary and multisectoral cooperation. Creativity and innovation management, 16(1), 27-34. doi: http://dx.doi.org.nelli.laurea.fi/10.1111/j.1467-8691.2007.00417.x

Bagayogo, F., Lapointe, L., Ramaprasad, J., & Vedel, I. (2014, January). Co-creation of knowledge in healthcare: A study of social media usage. Piscataway: The Institute of Electrical and Electronics Engineers, Inc. (IEEE), 626-635.

Bassett-Jones, N. (2005). The paradox of diversity management, creativity and innovation. Creativity and innovation management, 14(2), 169-175.

Eservel, U. Y. (2014). IT-enabled knowledge creation for open innovation. Journal of the Association for Information Systems, 15(11), 805-834.

European Commission (2016). Webpage: "What is the difference between dissemination, exploitation and communication?" Research and Innovation. Participant Portal, available at: https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-933.html (accessed 25 May 2017).

European Commission (2019). Webpage: Funding & tender opportunities, Find calls for proposals in Horizon 2020, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/h2020 (accessed 18th February 2019).

Franco, M., & Pinho, C. (2019). A case study about cooperation between University Research Centres: Knowledge transfer perspective. Journal of Innovation & Knowledge, 4(1), 62-69.

Frow, P., Nenonen, S., Payne, A., & Storbacka, K. (2015). Managing co-creation design: A strategic approach to innovation. British Journal of Management, 26(3), 463-483.

Henriksson, K., Harri, R., & Hyttinen, K. (2018). Opportunities for Strategic Public Relations–Evaluation of International Research and Innovation Project Dissemination, in Public Relations and the Power of Creativity: Strategic Opportunities, Innovation and Critical Challenges. Emerald Publishing Limited, 197-214

Kummitha, R. K. R. (2019). Design thinking in social organizations: Understanding the role of user engagement. Creativity and Innovation Management, 28(1), 101-112. doi: 10.1111/caim.12300

Leminen, S., Westerlund, M., & Nyström, A. G. (2012). Living Labs as open-innovation networks. Technology Innovation Management Review. September 2012, 6-11.

Lengnick-Hall, C. A., Beck, T. E., & Lengnick-Hall, M. L. (2011). Developing a capacity for organizational resilience through strategic human resource management. Human Resource Management Review, 21(3), 243-255.

Luoma-aho, V., Vos, M., Lappalainen, R., Lämsä, A-M., Uusitalo, O., Maaranen, P., & Koski, A. (2012). Added value of intangibles for organizational innovation. Human Technology: An Interdisciplinary Journal on Humans in ICT Environments, Volume 8 (1), 7-23.

Matt, M., Robin, S., & Wolff, S. (2012). The influence of public programs on inter-firm R&D collaboration strategies: project-level evidence from EU FP5 and FP6. The Journal of Technology

Transfer, 37(6), 885-916. doi: http://dx.doi.org.nelli.laurea.fi/10.1007/s10961-011-9232-9

Miettinen, S., & Koivisto, M., (2009). Designing Services with Innovative Methods. University of Art and Design Helsinki.

Mitleton-Kelly, E. (2003). Ten Principles of Complexity and Enabling Infrastructures, in Mitleton-Kelly, E. (Ed.), Complex Systems and Evolutionary Perspectives on Organisations: The Application of Complexity Theory to Organisations. Pergamon. Amsterdam, 23 - 50.

Mitleton-Kelly, E. (2005). Co-evolutionary Integration – the Co-creation of a New Organisational Form Following a Merger or Acquisition, in Aaltonen, M., Barth, T., Casti, J. L., Mitleton-Kelly, E., & Sanders, T. I. (2005). Complexity as a Sensemaking Framework. FFRC, 4, 2005, 39 - 66.

Nonaka, I. and Takeuchi, H. 1995. The Knowledge-Creating Company – How Japanese Companies create the dynamics of Innovation. Oxford University Press. New York 1995.

Norvanto E. 2017. Knowledge Creation in Cross-Border and Cross-Sectoral Collaborations - Exploring EU Externally Funded Security Research and Innovation Projects as Communities of Practice. In Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - Volume 3: KMIS, ISBN 978-989-758-273-8, pages 70-82.

Payne, A. F., Storbacka, K., & Frow, P. (2008). Managing the co-creation of value. Journal of the academy of marketing science, 36(1), 83-96. doi: http://dx.doi.org.nelli.laurea.fi/10.1007/s11747-007-0070-0

Pinho, N., Beirão, G., Patrício, L., & P. Fisk, R. (2014). Understanding value co-creation in

complex services with many actors. Journal of Service Management, 25(4), 470-493. doi: http://dx.doi.org.nelli.laurea.fi/10.1108/JOSM-02-2014-0055

Pirinen, R. (2015). Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers. Creative Education, 6(03), 315-330.

Poutanen, P., Siira, K., & Aula, P. (2016). Complexity and organizational communication: A quest for common ground. Human Resource Development Review, 15(2), 182-207.

Roloff, J. (2008). Learning from multi-stakeholder networks: Issue-focussed stakeholder management. Journal of business ethics, 82(1), 233-250. doi: http://dx.doi.org.nelli.laurea.fi/10.1007/s10551-007-9573-3

Ruoslahti, H. (2018). Co-creation of Knowledge for Innovation Requires Multi-Stakeholder Public Relations. In Public Relations and the Power of Creativity: Strategic Opportunities, Innovation and Critical Challenges. Emerald Publishing Limited, 115-133.

Ruoslahti, H., & Tikanmäki, I. (2017). End-Users Co-create Shared Information for a More Complete Real-time Maritime Picture. Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - (Volume 3), 267-274.

Rajamäki, J., & Ruoslahti, H. (2018, June). Educational Competences With Regard to Critical Infrastructure Protection. In ECCWS 2018 17th European Conference on Cyber Warfare and Security (p. 415). Academic Conferences and publishing limited.

Tikanmäki, I., Tuohimaa, T., & Ruoslahti, H. (2012). Developing a Service Innovation Utilizing

Remotely Piloted Aircraft System (RPAS). International Journal of Systems Applications, Engineering & Development, (4).

Santos-Vijande, M., González-Mieres, C., & Jose Ángel López-Sánchez. (2013). An assessment of innovativeness in KIBS: Implications on KIBS' co-creation culture, innovation capability, and performance. The Journal of Business & Industrial Marketing, 28(2), 86-102. doi: http://dx.doi.org.nelli.laurea.fi/10.1108/08858621311295236

Valkokari, K., Paasi, J., & Rantala, T. (2012). Managing knowledge within networked innovation. Knowledge Management Research & Practice, 10(1), 27-40. doi: http://dx.doi.org.nelli.laurea.fi/10.1057/kmrp.2011.39

Vos, M. (2017). Communication in turbulent times: exploring issue arenas and crisis communication to enhance organisational resilience. Reports from the School of Business and Economics, (40/2017).

Vos, M. (2018). 'Issue Arenas', in Heath, R. L., Johansen, W., Falkheimer, J., Hallahan, K., Raupp, J. J., & Steyn, B. (Eds.) (2018). The International Encyclopedia of Strategic Communication: A-E. Wiley.

Vos, M., & Schoemaker, H. 2004. Accountability of Communication Management: A Balanced Scorecard for Communication Quality. Lemma, Utrecht.

Wilenius, M. (2008). Taming the dragon: How to tackle the challenge of future foresight. Business Strategy Series, 9(2), 65-77. doi: http://dx.doi.org.nelli.laurea.fi/10.1108/17515630810865671

FIGURE:

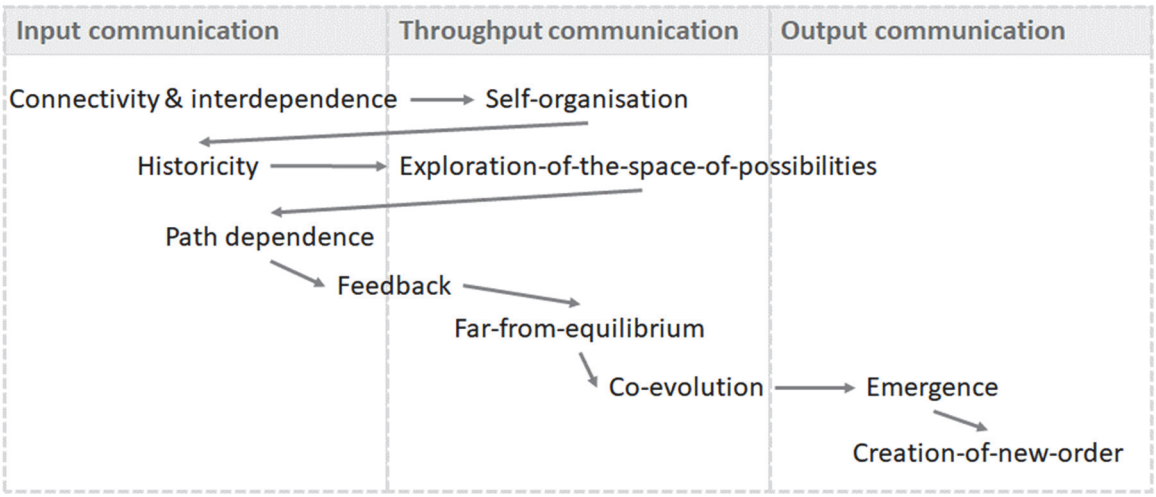

Figure 1: Elements of complexity in relation to input, throughput and output communication in innovation projects

V b

COMPLEX AUTHORITY NETWORK INTERACTIONS IN THE COMMON INFORMATION SHARING ENVIRONMENT

by

Ruoslahti, H. & Tikanmäki, I. 2019.

In Proceedings of the 11th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management. Edited by Jorge Bernardino, Ana Salgado and Joaquim Filipe. SCITEPRESS – Science and Technology Publications, 159 -166.

Complex Authority Network Interactions in the Common Information Sharing Environment

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Keywords: Complexity, Multi-stakeholder Collaboration, Information Sharing, Situational Picture.

Abstract: European authorities collaborate as a community toward a coherent approach of situational understanding and open trust base information sharing. Innovation in multi-stakeholder collaboration networks involve complex collaboration between user community members, providing cross-sector, cross-border and cross-authority interaction and information sharing for collaborative situation awareness, and cooperation to increase safety and security. This study analyses data consisting of elements of use cases, collected from EU funded innovation projects. These were placed in a table based on similarity, difference and relevance to produce a classification. The results of this study indicate that use cases and scenarios engage end-users to co-create very practical descriptions providing input communication for innovation projects; also multi-actor projects are complex networks thus, this study contributes to the network approach of innovation. The implications of this study are that reaching faster innovation can be facilitated by leading and organising projects well, providing appropriate feedback to ensure project plans and results stay connected with project goals, fostering project continuums, and having e.g. higher education institutions bring problems as project ideas. The results, innovations, and feedback from research and innovation projects can benefit the European society.

1 INTRODUCTION

European maritime authorities, as a community, have collaborated aiming at a coherent approach of situational awareness based on open trust base information sharing. Project MARISA (Maritime Integrated Surveillance Awareness, 2017-2019), which develops clean data based solutions, data refining tools and expanded data fusion functionalities is one example of such collaboration (MARISA, 2019). MARISA is based on prior collective maritime development projects from 2009 to 2019 (e.g. BLUEMASSMED, Perseus, CoopP, and EUCISE 2020). The MARISA user community acts as a forum that steers the project. Similar examples of end user engagement have been used in earlier FP7 funded projects (e.g. AIRBEAM) to built user communities and provide information sharing, and involve them in cross sector, cross border and cross authority exchange and co-creation. In MARISA, these exchanges have proven to be valuable in defining user requirements and identifying possible legal and ethical barriers.

MARISA has selected five use cases that serve as the basis for the project work (MARISA, 2018) to define cooperation mechanisms, trust-based data sets, and trust building mechanisms between the users of the Common Information Sharing Environment (MARISA, 2019). Earlier studies point towards complexity of collaboration having an effect on innovation in multi-stakeholder collaboration networks (Ruoslahti, 2018; Ruoslahti and Hyttinen; Ruoslahti and Tikanmäki, 2017). To further understand this issue, the research questions for this paper are:

RQ 1: How are use case narratives used to engage end-users in complex innovation projects?

RQ 2: Is the time needed to achieve innovation affected by the level of complexity of collaboration networks in the case project?

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Ruoslahti, H. and Tikanmäki, I.
Complex Authority Network Interactions in the Common Information Sharing Environment.
DOI: 10.5220/0007946501590166
In *Proceedings of the 11th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2019)*, pages 159-166
ISBN: 978-989-758-382-7

2 LITERATURE

2.1 European-wide Collaborative Situational Picture

Interaction and information sharing between authorities is important in building collaborative situational awareness and promoting cooperation to increase maritime safety and security. European maritime cooperation aims at increasing situational awareness, sharing best practices, improving interoperability, removing overlapping activities, and promoting cross-border and cross-sector cooperation (Tikanmäki and Ruoslahti, 2017).

Project MARISA, divides its users under seven user community sectors. The EU also, in some other instances, uses a classification of ten EU Coast Guard Functions (ECGFF, 2014; Ruoslahti and Hyttinen, 2017). These mostly correspond to each other, and Table 1 below makes a comparison of the two classifications. One main difference is that the Coast Guard Functions do not include defence, and they make a finer division of Maritime safety into Maritime safety and vessel traffic management, Accident and disaster response, and Search and rescue at sea. The Coast Guard Function Maritime surveillance has not been included under any MARISA sector, as it is elementary to each sector and how Maritime surveillance relates to the MARISA use cases and end-user sectors is discussed below in the Methods and Results sections.

Table 1: MARISA user community sectors in relation to the Coast Guard Functions of the European Union.

Seven user community sectors of Project MARISA	Ten EU Coast Guard Functions (EUGCF)
	Maritime surveillance
Border control	Maritime border control Prevention of trafficking and smuggling
Customs	Maritime customs activities Prevention of trafficking and smuggling
Defence	
General Law Enforcement	Maritime security
Marine Environment	Maritime environmental response
Fisheries Control	Fisheries control
Maritime Safety	Maritime safety and vessel traffic management Accident and disaster response Search and rescue at sea

Project MARISA has an expansive approach, as data from various authority sensors and sources, and open access big data are used to build a situational picture for maritime surveillance and response. (MARISA, 2018).

The innovation action process of MARISA is co-creative. Maritime integration and development activities are structured as a relatively novel cross-border socially constructed user community (MARISA, 2018). The different sectors (Coast Guard Functions) have different user needs and, therefore, require different operational approaches and respective technical solutions. The European authorities are beginning to understand that sharing information cross-border and cross-sector is important and a benefit to all stakeholders concerned (Tikanmäki and Ruoslahti, 2017).

2.2 End User Community

Maritime awareness and safety can be improved through collaboration between partners. Inter-agency collaboration can broaden the knowledge of the multiple stakeholders on each other's concepts, measures, resources and plans (Tikanmäki, 2017). Eicken et al. (2016) note that it is a challenge to ensure that information is shared with all relevant entities and agencies from the regional or local to international level. According to the Ministry of Foreign Affairs of Finland (2018) individuals, organizations, businesses, and communities will most likely take larger roles in negotiating future international norms.

The Common Information Sharing Environment (CISE) is based on trust between the authorities on the maritime domain. This includes sharing operational information and procedures, and developing a culture and technology that enables also sharing confidential information. MARISA's user community involvements, together with other MARISA meetings aim to co-create value, such as a revised methodology, key performance indicators, readiness level metrics, a maturity matrix to assess resilience, and privacy impact assessments, all validated by the user community (Pirinen, 2017; Ruoslahti and Tikanmäki, 2017).

EU-wide projects such as PERSEUS, CoopP, EUCISE2020, and MARISA have shown that there is a need share information cross-sector and cross-border. Collaboration is needed between different national authorities; nationally, between the different EU member states, as well as with cooperative (non-EU) third countries (Ruoslahti and Tikanmäki, 2017).

Engeström,Kerosuo and Kajamaa (2007) argue that inter-organizational learning highlights networks that have trust, exchange information and resources, and solve problems collaboratively and across organizational boundaries. Ruoslahti and Tikanmäki (2017) highlight that the objects and phenomena, relevant to CISE, need to be continuously evaluated and redefined together with end-users; against changing risk and treat scenarios, evolving end-user needs, national and EU-wide strategies, and "taking

into account the assets, which cooperative third country nations may bring." (Ruoslahti and Tikanmäki, 2017, p. 273). Collaborative information sharing, situational awareness and open innovation opportunities support the building of organizational resilience (Rajamäki and Ruoslahti, 2018).

Communication helps engage stakeholders and innovation projects benefit from collaboration with relevant end-users. Setting and validating user requirements can be considered input communication, ensuring smooth information exchange throughput communication, and efficient dissemination output communication (Vos and Schoemaker, 2004).

Ruoslahti and Tikanmäki (2017) propose that cooperation between different authorities may have the potential to evolve into deeper modes of co-creation, and that added complexity may reduce the time to value creation and innovation. In the context of their study, they see innovation as the ability to create common knowledge, learning, and innovation value (Ruoslahti and Tikanmäki, 2017). Knuuttila (2017) points out difficulties in collaboratively improving practical resilience, because it may be seen as a risk to one's autonomy or a possible loss of power and, thus, the starting point to reach targets is the division of power between the different actors.

2.3 Complexity of Systems

Sociotechnical systems (Amir and Kant, 2018) are hybrids of people and technologies involving complex interactions between people, organisations, and technologies. Cyber-physical systems (Murakami, 2012) include cyber, physical, and social inputs and outputs that are designed by society organisations, and humans for their benefit. Domains that create shared situational awareness and a basis for decentralised decision-making are 1) physical; 2) informational; 3) cognitive; and 4) social (Alberts, 2002).

Mitleton-Kelly (2003) sees that complex systems, such as innovation and information sharing networks (such as CISE), have connectivity and interdependence. They co-evolve together and form dissipative structures to explore the space-of-possibilities, and generate variety. These systems self-organise to create new order, as groups within and between systems come together spontaneously to perform tasks, to share knowledge, and to generate new learning and knowledge. As their environments and social ecosystems are changing fast, these systems also face turbulence, chaos and complexity. This makes ensuring the survival of systems challenging, which calls for the ability to collect and react to feedback (positive, reinforcing feedback drives change, while negative feedback balances and maintains system stability).

2.4 Complexity of Collaboration

Collaboration within the MARISA user community is complex in nature. The use cases in the project MARISA include multiple actors from several sectors and often from many countries, and complexity is further increased with some EU Member States having multiple authorities under the same sector (e.g. police and gendarmerie perform general law enforcement) (MARISA, 2018).

Knowledge becomes developed by collaboration (Pirinen, 2017; Ruoslahti, 2018), even interdependence and resource integration (Ruoslahti and Tikanmäki, 2017). These result in the need to access resources from others and drive value-in-exchange: "knowledge itself is an increasingly important source to competitive advantage and a key to the success of modern organizations and creative higher education, strengthening the collective expertise, industry-service clusters, employees and competitiveness in the global economy" (Pirinen, 2015, p. 315).

Multi-stakeholder communication in organisations (also publicly funded innovation project consortia or CISE network) needs to stress dynamic interaction among multiple actors with diverse interests (Vos, Schoemaker and Luoma-aho, 2014). Issues central to people are the ones that matter to them most (Luoma-aho and Vos, 2010). Authority communities function as issue arenas for exchange of practical, legal and ethical issues and where actors co-creatively define and refine relevant use cases. Thus, these arenas also are competitive spaces for problem solving and influencing based on actors aligning behind common agendas, but also having their own (Vos 2018).

When innovation projects are understood as complex systems, collaboration across boundaries, and creating desired futures are their core organizational learning capabilities (Senge, et al., 2008). "EU Funded R&I projects represent a unique form of a knowledge community" (Norvanto, 2017, p. 78). The ways in which authorities work together (Frey et al., 2006) and elements of complexity (Mitleton-Kelly,2003) can be looked at in relation to each other. Elements of complexity are least visible in the simplest form of working together, Networking, and increase through Cooperation and Collaboration, to be the highest in Co-creation (Frey

et al., 2006). This seems to be supported by the notion that collaboration between authorities can evolve into deeper modes of co-creation. Thus, authority collaboration and interoperability become increasingly important (Ruoslahti and Tikanmäki, 2017).

2.5 Co-creation

Co-creation requires communication and interaction between multiple actors. Ruoslahti (2017) identifies that co-creation networks have cyclical connections in value. Networks require active facilitation and cooperation tools or platforms to actively and efficiently share co-creative innovation and knowledge. Active stakeholder participation can be motivated and guided through having common aims that promise benefits for all individual collaborators, and can result in an active drive to co-create of knowledge and change.

Sankowska (2013) notes that there are simultaneous relationships between trust, knowledge creation and transfer, and innovativeness. These strong links between them explains differences in competitiveness and innovativeness of organizations. Trust fosters knowledge creation. Climates of trust can create what the author calls virtuous circles of knowledge transfer, creation and innovativeness. Organizational trust must be built first, so it can foster innovativeness through knowledge practices.

Co-creation of knowledge can offer significant opportunities for innovation (Ruoslahti, 2017). Multiple-stakeholder co-creation projects benefiting innovation network stakeholders are highest in complexity, as roles between stakeholders are constantly changing. Common aims and issues to solve motivates stakeholders to collaborate, and open innovation environments may facilitate communication and interaction, and co-creation of knowledge requires intensive collaboration. Active stakeholder participation stems from common aims, and they should promise benefits for each stakeholder. All resulting in an active drive for co-creation of knowledge, innovation, and change. (Ruoslahti, 2018)

Learning, knowing, and becoming are the basis of evolution and change, a dynamic and iterative process of "continuous experiencing, learning and sense making" (Jakubik, 2011, p. 392). "The logic of complexity suggests that learning and the generation and sharing of knowledge need to be facilitated by providing the appropriate socio-cultural and technical conditions to support connectivity and interdependence and to facilitate emergence and self-organisation" (Mitleton-Kelly, 2003, p. 59).

3 METHOD

The main case project of this study, MARISA, is based on five selected use cases on authority information sharing on the maritime domain. Data for this study was collected from detailed descriptions and narratives of its five use cases. Six scenario descriptions of authority collaboration in recovery from disaster from project AIRBEAM were used as comparative background information for this study. These eleven use case and scenario descriptions were produced to identify requirements for systems demonstrations, which were the concrete and usable deliverables of these two projects – the innovations that they produced.

Project MARISA focuses on five of use cases (Table 2 below) and the results of this paper are structured accordingly. The use case descriptions that the data of study was collected from, are based on a total 94 use cases that were produced in the Cooperation Project, CoopP and narrowed to five in EUropean test bed for the maritime Common Information Sharing Environment in the 2020 perspective, project EUCISE2020 (MARISA, 2018).

The European Commission (2012) has set criteria for business value in the context of innovation projects, and these have been used in the case of project MARISA developing a European-wide CISE to address: 1) the number of user communities that benefit by the use case; 2) the number of user communities needed to fulfil purpose; 3) evidence that CISE helps reduce time or cost to meet the purpose;4) criteria for technical complexity (sensitiveness of data used, standardization of data models); and 5) the complexity of information exchanges between information systems (MARISA, 2019). The use cases selected for project MARISA involve seven end-user communities (Table 2).

Table 2: MARISA Use Cases in Relation to the User Community Sectors.

Potential number of user communities interested in the use cases	**13b**	**37**	**44**	**70**	**93**
Border Control	X	X	X		
Customs	X	X	X	X	
Defense	X	X	X	X	
General Law Enforcement	X	X	X	X	
Marine Environment	X	X	X		X
Fisheries Control		X	X	X	X
Maritime Safety		X	X	X	

Use Case 13b is the inquiry on a specific suspicious cargo vessel. The use case may include authorities from the five different sectors border control, customs, defence, law enforcement, and marine environment.

Use Case 37 covers the monitoring of all events at sea in order to create conditions for decision making on interventions, including authorities from all seven sectors border control, customs, defence, law enforcement, marine environment, fisheries control, and maritime safety.

Use Case 44 is about requesting any information to confirm the identification, position and activity of a vessel of interest, and it may include authorities from all seven sectors border control, customs, defence, law enforcement, marine environment, fisheries control, and maritime safety.

Use Case 70 looks at a suspect fishing vessel or small boat, which is cooperating with other vessels (such as a container vessel). This may include authorities from five sectors, which are customs, defence, law enforcement, fisheries control, and maritime safety.

Use Case 93 on detection and behaviour monitoring of vessels listed as IUU (Illegal, Unreported and Unregulated fishing). This use case may involve authorities from two sectors marine environment and fisheries control.

As MARISA is part of a project continuum, projects such as BLUEMASSMED (Cross-Border and Cross-Sectoral Maritime Information Sharing for a better knowledge and control of activities at sea), PERSEUS (Protection of European seas and borders through the intelligent use of surveillance), CoopP, and EUCISE2020 during a time span of 10 years have combined European efforts to build a Common Information Sharing Environment for integrated maritime surveillance. Thus, co-created end user narratives, both written, spoken, and collaborated, were collected to first produce 94 use cases, and then select the five, which serve as the basis to identify data fusion requirements for the collaborative information exchange in the Common Information Sharing Environment by project MARISA, and as the data for this study. The next project in this continuum is already in the funding pipeline and will commence 2019.

This study further analysed the five MARISA use cases, by comparing their respective elements, detailed in use case descriptions produced by project CoopP. The use case elements extracted from the use case descriptions and data was placed in a data extraction table (DET) based on their similarity, difference and relevance. The DET-table was then subjected to a series of three rounds of iteration among the researchers to restructure the data. Use case element were reordered according to similarity, difference and relevance in regard to the two research questions. As a result the final classification, which is presented in the Results section and the use case hierarchy that is visualized in Figure 1 below, were produced to answer RQ1 and RQ2.

4 RESULTS

The results of this study serve to motivate the use of use case narratives and scenarios as a practical way to engage end users in co-creation. These very concrete descriptions are shown to be a way to gain and share information on situations, circumstances, and efforts, which end users encounter or perform in fulfilling their tasks. The method of first co-creating end user narratives was used in the case projects to develop use cases or scenarios. These in turn served to define system requirements, which are needed to design and implement systems, both technical and social. Most modern systems are cyber-physical in nature and include technical, information, and human elements. The case system, the European-wide CISE system is an excellent example of a cyber-physical system involving physical technologies, shared information and human issue arena operations. Based on the results, the use of CISE use case narratives can also be regarded as one form issue arena, where relevant authorities exchange information, innovations and best practices regarding their respective operations and can identify more and better ways to collaborate with one another. This study finds that multi-actor networks are complex in nature and is thus within the multi-actor approach of research arenas, and also contributing to the network approach of innovation.

One further result of this study is the way in which MARISA use cases became hierarchically structured to show their occurrence in respect to each other (see Figure 1). Use case 37, Monitoring all events at sea, is common to all sectors, and it precedes all these other use cases. It is equivalent to the Coast Guard Function Maritime surveillance, which is a base function, where the seas are monitored, without anything out of the ordinary or dangerous having detected to have happened yet. All maritime authority sectors structure their daily operations to ensure adequate monitoring and detection of events at sea. The ways in which this is done differs from sector to sector. However, this function is addressed in one way or other by all maritime authorities. Thus, use case 37 can be classified as being a base function that

all other use cases and authority interaction are based upon, including adequate resources and information.

Once some possible anomaly is detected use case 44 Request information to confirm identification, position and activity of a vessel of interest becomes activated. The information that is relevant to each sector differs depending on their mission and tasks. This information may also be, as can other possible information may be gained relevant to other sectors that is relevant to some other sector. The case project use case narratives show what information can and should be shared, even though it might not have been directly relevant to the responding authority in question.

Use case 44 may then revert back to use case 37, or alternatively, it may escalate to one of the three remaining use cases: use case 13b Inquiry on a specific suspicious cargo vessel, use case 70 Suspect fishing vessel or small boat cooperating with other vessel, or use case 93 Detection and behaviour monitoring of vessels listed as IUU (Illegal, Unreported and Unregulated fishing).

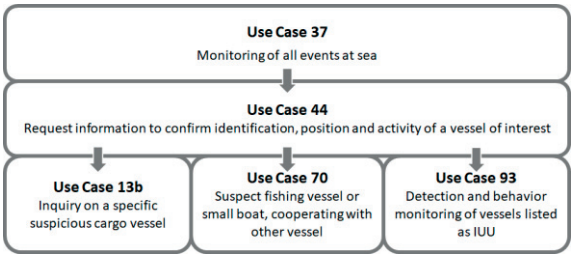

Figure 1: The five MARISA use cases in relation one another.

The results indicate that the MARISA user community provides a shared forum to enhance cross sector, cross border and cross authority exchange, while also taking into account legal and ethical issues. It has co-creatively defined these above five use cases, on which the user requirements for the MARISA data fusion services have been based on. Maritime authorities and stakeholders work together on different levels, ranging from networking to co-creation. On an authority level, some ethical issues to consider are authorized usage of data, distribution of interoperability resources, and basis of register listings. Some privacy issues may include usage and fusion of open source data, identity of vessel crew or passengers, authorized usage of registers, and basis of register listings.

All these use cases may include authorities from various nations, and contain privacy and related ethical issues, such as identity information of crew or passengers. Thus, the more authority sectors, member states, and other stakeholders involved, the greater is the complexity of their interactions, but also the opportunity to share information, and experiences to induce learning and faster reach innovation.

In summary, using use case narratives provides a process and arena to engage end-users in discussing complex issues in a practical ways, and serves as concrete input communication for innovation projects. The hierarchy between use cases further facilitates this, and serves to shorten the time needed to achieve innovation, as levels of complexity become added within the collaboration network.

5 DISCUSSION AND CONCLUSIONS

One implication of this study is that practical use case narratives are a useful way to engage end-users in complex project innovation. Use cases provide them with concrete situations, where end users can see commonalities and identify new needs. Results show that knowledge becomes developed collaboratively and as seen in literature this requires close, even co-creative interaction between actors (Pirinen, 2015; Ruoslahti, 2018). Collaboration may even deepen and provide resource integration and usage of common capacities to reach common goals (Ruoslahti and Tikanmäki, 2017). However, accessing the resources of other actors presents an ethical consideration of the ownership of data and information, and the distribution of resources, which most likely are scarce, and this is also one issue that is recommended to be co-creatively addressed by all project stakeholders.

A second implication is that care should be placed on how projects are led and organized. They form complex social networks, where each partner has its own interests and agenda. These many, sometimes even conflicting, interests need to be aligned in a way, which produces benefit for all stakeholders involved. The collaborative efforts of these networks require active coordination and facilitation that motivates the consortium members and other stakeholders to actively participate, both, in co-creating the consortium goals and the activities through which these goals become realized. One recommendation is, thus, that the use of use cases is led and organized in ways that stimulate the creation of new knowledge.

A third implication is that there is a tie between projects and education. Higher education institutions have a responsibility to bring problems and ideas that evolve from their classrooms as well as practical

contacts with their environments forth as project ideas and proposals. In addition, they have a responsibility to include the innovations and knowledge gained in projects in their study curricula. This is a way to further develop innovations, and to bring them to wider use in society. Moreover, industry and end user organizations will also benefit when they build ties between innovation projects and their in-house training programs. This speeds up the implementation of innovations, and builds a readiness in the organization to reach further innovations, faster and in more depth. Thus, results from the case project indicate, that the time needed to achieve innovation can indeed be affected by the level of complexity in respective collaboration networks. Stakeholders can share use cases and learn from one another, and it was pointed out in literature (e.g. Engeström and Kerosuo, 2007; Sankowska, 2013) that this is a useful way to create knowledge and innovation.

A fourth implication is that society may gain from promoting project continuums, where later projects build on the success and innovation of earlier projects to develop a path toward faster and deeper further innovation. The PERSEUS – CoopP – EUCISE 2020 – MARISA –continuum serves as a good practical example of this. This type of continuum thinking permits use cases to evolve, trust to build and collaboration to deepen, as these both take time to evolve. In addition, the connected projects may permit eco-systems to evolve and spread, as project efforts over time engage more and more stakeholders from all wakes of society.

Fifth, the results of this study also imply that creating and selecting appropriate measures provide the feedback needed to ensure that project plans and preliminary results stay connected with the goals of the project, and possibly changing or evolving end user needs. It is recommended that use case narratives become evaluated and re-written every so often to keep them up-to-date, and to identify changes and new opportunities, with the emergence of further innovation.

One further implication is that a European-wide policy can greatly benefit from the results, innovations, and feedback from research and innovation projects. Research takes time from idea to capability and this speaks in favour of linking projects in continuums, to deepen innovation and to take advantage of possible spin-off effects and innovations provided by these projects. This type of policy will enable EU-funded projects to create new knowledge and, by doing so, change society.

There seems to be positive a relationship between complexity within the innovation network and the time in which it could create new knowledge and innovation. When containing more elements of complexity, networks can work together in deeper forms of co-creation and provide faster innovation. Networks aiming at innovation must dare to become more complex in nature. Adding complexity can result in reaching networks innovation goals faster than in less complex networks. The results of this study indicate that more complexity of collaboration within a cyber-physical system, such as a Common Information Sharing System, can shorten the time to innovation leading to faster recognition, assessment, planning, and capability reaction. All these help realize a safer, more integrated European maritime surveillance.

All of the above results inductively point toward a relationship between complexity and the time needed to co-create knowledge and innovation. More study is recommended on this issue, as understanding collaboration for innovation and its challenges can help future co-creation collaboration networks to function better and gain added resilience to face the unexpected. This added knowledge may benefit future innovation networks.

REFERENCES

Ahrweiler, P., Keane, M. T., 2013. Innovation networks. *Mind & Society, 12(1)*, 73-90. doi:http://dx.doi.org.nelli.laurea.fi/10.1007/s11299-013-0123-7

Alberts, D., 2002, Information age transformation: Getting to a 21st century military, *Command and Control Research Program (CCRP) publication series*, Department of Defense, Washington, DC, US.

Amir, S., Kant V., 2018, 'Sociotechnical resilience: A preliminary concept', *Risk Analysis*, vol. 38, no. 1, 8-16.

Bueger, C., 2015. What is maritime security? *Marine Policy Volume 53, March 2015*, 159-164. https://doi.org/10.1016/j.marpol.2014.12.005

Commission of the European Communities, 2009. Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain, *Communication from the Commission to the Council the European Parliament, the European Economic and Social Committee and the Committee of the Regions*. COM (2009)538 final, Brussels. (2009)

Eicken, H. Mahoney, A. Jones, J. Heinrichs, T. Broderson, D. Statscewich, H. Weingartner, T. Stuefer, T. Ravens, T. Ivey, M. Merten, A., Zhang, J., 2017. Sustained Observations of Changing Arctic Coastal and Marine Environments and Their Potential Contribution to Arctic Maritime Domain Awareness: A Case Study in Northern Alaska. *Arctic Vol. 71*, Suppl. 1 (2018). 1 – 15.

Engeström,Y., Kerosuo, H., Kajamaa, A., 2007. Beyond Discontinuity: Expansive Organizational Learning Remembered, *Management Learning*, 2007, 38, 3, 319-336, Sage Publications Ltd., Thousand Oaks, United Kingdom.

European Coast Guard Functions Forum, 2014. *Non Paper - July 8 2014*. Unpublished (authors have copy).

European Union, 2014. European Union maritime security strategy. *Council of the European Union Doc. 11205/14* European Union, Brussels (2014).

Frey, B.B., Lohmeier, J.H., Lee, S.W., Tollefson, N., 2006. Measuring collaboration among grant partners. *American Journal of Evaluation, 27(3)*, 383-392.

Jakubik , M., 2011. Becoming to know. Shifting the knowledge creation paradigm. *Journal of Knowledge Management, VOL. 15 NO. 3* 2011, 374-402.

Knuuttila, J. S., 2017. Orchestrating Without Partiture. In *Proceedings of the 50th Hawaii International Conference on System Sciences, January, 2017*.

Luoma-aho, V., Vos, M., 2010. Towards a more dynamic stakeholder model: acknowledging multiple issue arenas. *Corporate Communications: An International Journal, Vol. 15 No. 3, 2010*, Emerald Group Publishing Limited , 315-33.

MARISA, 2018. Project MARISA Deliverable 2.1 User Community Report (In progress).

MARISA, 2019. *Project MARISA Web-page*, https://www.marisaproject.eu/, Accessed 18 Feb 2019.

Ministry of Foreign Affairs, 2018. Finland acts in a changing world. *Futures Review of the Ministry of Foreign Affairs*. Finnish government publication series 26/2018, Helsinki.

Mitleton-Kelly, 2003. *Complex systems and Evolutionary Perspectives on Organisations*, The application of complexity Theory to organisations. Elsevier Science ltd, Oxford.

Murakami, K. J., 2012. *CPSS (Cyber-Physical-Social Systems) initiative - Beyond CPS (Cyber-Physical Systems) for a better future*, 13 March.

Norvanto E., 2017. Knowledge Creation in Cross-Border and Cross-Sectoral Collaborations - Exploring EU Externally Funded Security Research and Innovation Projects as Communities of Practice. In *Proceedings of the 9th International Joint Conference on Knowledge Discovery,* Knowledge Engineering and Knowledge Management - Volume 3: KMIS, ISBN 978-989-758-273-8, 70-82.

Piperca, S., Floricel, S., 2012. A typology of unexpected events in complex projects. *International Journal of Managing Projects in Business, 5(2)*, 248-265.

Pirinen, R., 2015. Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers. *Creative Education, 2015, 6*, 315-330.

Rajamäki, J., Ruoslahti, H., 2018. Educational competences with regard to critical infrastructure protection. In A. Jųsang (Ed.), *ECCWS 2018: Proceedings of the 17th' European Conference on Cyber Warfare and Security*, 415-423. Academic Conferences International.

Ruoslahti, H., 2018. Co-creation of Knowledge for Innovation Requires Multi-Stakeholder Public Relations, in Bowman, S., Crookes, A., Romenti, S., Ihlen, Ø. (ed.) *Public Relations and the Power of Creativity, Advances in Public Relations and Communication Management, Volume 3*, Emerald Publishing Limited, 115-133.

Ruoslahti, H., Hyttinen, K., 2019. Comprehensive approaches to collaboration networks for organisational resilience in the Arctic, *presented June 27th at EURAM 2019.*

Ruoslahti, H., Tikanmäki, I., 2017, 'End-Users Co-create Shared Information for a More Complete Real-time Maritime Picture'. *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Vol 3*, 267–274.

Tikanmäki I., 2017. Common Information Sharing on Maritime Domain - A Qualitative Study on European Maritime Authorities' Cooperation. In *Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - Volume 3*: ISE, ISBN 978-989-758-273-8, 283-290.

Tikanmäki I., Ruoslahti, H., (2017) Increasing Cooperation between the European Maritime Domain Authorities. *International Journal of Environmental Science, 2*, ISSN: 2367-8941.392-399. IARAS, Nicosia, Cyprus.

Sankowska, A., 2013. Relationships between organizational trust, knowledge transfer, knowledge creation, and firm's innovativeness. *The Learning Organization, Vol. 20 No. 1*, 2013, 85-100.

Senge, P. Smith B. Kruschewitz N. Laur J. Schley S., 2008. *The Necessary Revolution – How Individuals and Organizations Are Working Together to Create a Sustainable World*. Doubleday, New York, USA.

Steins, N. A., Edwards, V. M., 1999. Synthesis: Platforms for collective action in multiple-use common-pool resources. *Agriculture and Human Values, 16(3)*, 309-315.

Vos, M., 2018. Issue Arenas. In Heath, R. and Johansen, W. (Eds), *The International Encyclopedia of Strategic Communication (IESC)*. Whiley Blackwell, Malden MA.

Vos, M., Schoemaker, H., 2004. *Accountability of Communication Management, A Balanced Scorecard for Communication Quality*, Lemma Publishers, Utrecht, 2004.

Vos, M., Shoemaker, H., Luoma-aho, V., L., 2014. Setting the agenda for research on issue arenas. *Corporate Communications: An International Journal, Vol. 19 No. 2, 2014*. Emerald Group Publishing Limited, 200-215.

VI

OPPORTUNITIES FOR STRATEGIC PUBLIC RELATIONS – EVALUATION OF INTERNATIONAL RESEARCH AND INNOVATION PROJECT DISSEMINATION

by

Henriksson, K., Ruoslahti R. & Hyttinen, K. 2018

Public Relations and the Power of Creativity,
Advances in Public Relations and Communication Management

Henriksson, K., Ruoslahti, H., & Hyttinen, K.

in Sarah Bowman, Adrian Crookes, Stefania Romenti, Øyvind Ihlen (ed.) Public Relations and the Power of Creativity (Advances in Public Relations and Communication Management, Volume 3, Emerald Publishing Limited, pp.197 - 214.

Opportunities for Strategic Public Relations – Evaluation of International Research and Innovation Project Dissemination

Abstract

European industry, academia, and potential end users for future solutions are widely involved in applying for European Union (EU) funding of research and innovation and implementation of the projects. Funding instrument requirements emphasize the influence of skills and knowhow of these project consortia professionals. This chapter proposes a co-creative model for communication and dissemination, or project PR, based on the experiences of both planning and coordinating dissemination activities of three EU funded projects. Multidisciplinary international project PR offers strategic opportunities for PR professionals.

The model employs the co-creation methods based on the pedagogical model called Learning by Developing (Laurea, 2011). In addition to the pedagogical model, the proposed conceptualization of co-creation for public relations and dissemination utilizes a media evaluation framework, which is adapted from Vos & Schoemaker's model (2004), combining elements of both balanced scorecard and quality management.

The findings demonstrate that commitment and active participation of end user groups in the early stage of the project are needed for successful dissemination, which should be supported by each partner's PR actions and networks. The dissemination process should start when the project begins, be ongoing, even extending to beyond the project. Dissemination is an expanding process, and it requires facilitation that supports PR and the engagement of key stakeholders. The European Commission can gain from modernized PR and dissemination activities, and from as many end users as possible adopting new innovations, which generate more business possibilities for the industry, and further research projects for the academia.

Key words: Public relations, strategic communication, dissemination, communication, co-creation, Learning by Developing, evaluation

1. Introduction

European industry, academia, and potential end users for future solutions are widely involved in applying for EU funding for research and innovation projects. The requirements for efficient dissemination and exploitation set by the funding instruments, such as the European Commission's Horizon 2020, are increasing. Requirements emphasize the influence of the projects and the skills and knowhow of the project consortia, as Di Cagno et al. (2014, p. 853) write: "given the large and increasing amount of European resources devoted to promote scientific co-operations among countries, it is important trying to assess their actual technological and economic impact." One objective of funded projects is to expand the benefit of results in the European Union. The dissemination of Horizon 2020 projects is defined as public disclosure of results by all appropriate means (European IPR Helpdesk, 2014), and the overall purpose of dissemination includes achieving scientific excellence. Project dissemination can be looked upon as Public Relations (PR), and its actors as PR practitioners.

One example is the FP7 project topic SEC-2012.3.4-6 Enhancing the workflow and functionalities of Automated Border Control (ABC) gates - Integration Project (European Commission, 2011). This

project is expected to contribute towards a more harmonized common European approach in its field, automated border control. Funding instruments often require the active participation of end users in both research by project consortia and as targets for dissemination. In the case of the Automated Border Control (ABC) gates project, "Institutions of several Member States are expected to be involved in the case of large-scale pilot project involving different border crossing points and all types of borders" (European Commission, 2011, p. 43). Another example is the H2020 call BES-2014-12 on border and external security for improvement of conflict prevention and peacebuilding capabilities of the EU. This call looked for a project that can deliver enhanced activities of coordination and support with strong engagement of key stakeholders and end users. The resulting project, Improving the Effectiveness of Capabilities in EU Conflict Prevention (IECEU), was funded under this call and aimed to meet the requirements through active dissemination methodology and PR activities.

Funded projects are joint ventures built on trust and common goals. Basically, partners form a consortium with a joint interest for development and / or research which they carry out together. In light of this common interest, it is important to identify sufficient ways of communication and dissemination to satisfy the requirements of the funding instrument, and to meet the aims and agendas of the various stakeholders. The ways to plan and implement dissemination activities are many, so it is important that project consortia have clear plans, which are in line with the project objectives, carry them out actively, and react to any feedback that they receive.

There are clear duties set for partners regarding external communication and dissemination activities by the funding instruments. Project partner actors, who are not used to working with actual external communication and dissemination duties, can find these duties unnecessary or unfamiliar. Some partners outsource these PR activities, and some even end up avoiding the activities as much as possible.

Then there are partners who actively promote the project, disseminate and communicate externally to the general public, the academia, and various stakeholders. Projects, where every partner does not actively participate in PR activities throughout the whole project lifecycle, do not necessarily meet the criteria for funding. Although the projects are based on trust and partners' mutual agreement on joint ventures, the case of not participating in daily communication and dissemination makes the project and its results weaker than in those projects where there are shared ways of working.

This chapter proposes a modern co-creative model for PR activities and dissemination based on theoretical approaches on communication quality, and practical experiences gained in planning and coordinating communication and dissemination activities of three EU funded projects. The results section discusses some strategic opportunities for the creative use of Public Relations to mitigate critical challenges in innovation projects. The research question is: how can external communication and dissemination, i.e. project PR, be carried out to efficiently address the requirements of the funding instrument and benefit the project?

2. Project Communication and Dissemination

The European Commission (2014) outlines that communication about European research projects should aim at demonstrating the ways in, which "European collaboration has achieved more than have otherwise been possible" (p. 1) and how its outcomes are both relevant to the lives of us Europeans. Creative people best achieve desired outcomes, when objectives are clearly defined. For efficient strategic communication it is key to clarify messages and choose the appropriate media according to the target audience.

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Efficient and timely communication of project activities ensures the success of a project and is a core interest of projects (GAP D7.1, 2016), both during, and even beyond, the lifespan of the project. A dissemination plan will provide an overall framework to coordinate and manage communication during the implementation of a project. Dissemination in projects can be divided into two different key groups; dissemination material and dissemination activities. (Hyttinen, 2017). Different communication platforms and tools are developed to ensure a wide reach of various stakeholders and end users (IECEU, 2015). EU research and innovation funding and project dissemination should pay special attention to showing how collaboration has achieved more than would otherwise have been possible, showing how the outcomes are relevant, and making better use of the results among decision-makers, industry or academia (Hyttinen, 2017).

To make best use of project results, they should be taken up by the end users, policy-makers, industry, and the scientific community (European Commission, 2014). A project itself functions as an organization with an action plan, vision and mission, as well as a clear budget and time plan. The project's main actor organizations are partners by contract. Partners who work together in teams generate new knowledge and skills, resulting in innovations. In the action model Learning by Developing (LbD), projects function as a learning environment, while they also create new knowledge for innovations. LbD has five dimensions, which form the learning / working environment: authenticity, experiential nature, partnership, creativity, and research orientation (Laurea, 2011). A project is an authentic environment; the case is real. Partners operate in partnership with the stakeholders and end users, and they employ an experiential approach and are creative, while they carry out research and develop new joint products to meet their aims. The value that is created in a joint activity is generated by their shared experiences and the partnership with stakeholders, in an authentic manner.

In projects, partners co-create with stakeholders, and their shared experiences are vital for dissemination activities. With active co-creation, new competencies arise from social interaction and knowledge sharing, as shared competence of communities and organized groups of experts and professionals (Pirinen, 2015). The value of this shared competence is key to receiving funding for joint projects. Customers and users are active participants in value co-creation to design personalised experiences, services, and products (Allen et al., 2009). Pirinen (2015) concludes that building useful knowledge and innovation processes is "increasingly complex, multidisciplinary, trust-based, co-created, path-depended, and globalized" (p. 323). Frow et al. (2015) seek to provide an understanding on how co-creation can improve resource integration in complex settings and offer a framework for organizations to design and manage co-creation processes.

Project experts sometimes find themselves in uncomfortable positions when facing the need to communicate and disseminate in a professional way in projects. These experts might have a basic understanding of strategic communication. Wilson et al. (2010) find that the identified theoretical research dissemination frameworks are converging and still overly focus on "linear messenger-receiver models and do not draw upon other aspects of communication theory" (p. 14); they note that the key to successful dissemination is dependent on the need to interact with end users. Some traditional ways of sharing knowledge and interacting with end users have been press releases, seminars and conferences. At present, modern electronic platforms provide secure possibilities for co-creative knowledge sharing and learning online (Davis Cross, 2015).

Public relations is strategic communication, and different organizations use it to establish and maintain symbiotic relationships with relevant and increasingly culturally diverse publics (Sriramesh et al., 2017). Falkenheimer & Heide (2014) see PR as one of three fields under strategic communication, the other two being organizational communication, and marketing communication. They note that PR concentrates on activities and communication where stakeholders or publics can

be treated as segments. This also applies to innovation projects, as dissemination is described as the public disclosure of the results of the project in any medium.

According to the European Commission (2017), the key aim for dissemination is to make research results known to different stakeholder groups, such as academia, industry, professional end user organizations, and policymakers in a planned and targeted way. The Commission (European Commission, 2016) makes a clear difference between dissemination, exploitation, and communication, the concepts of which are defined as follows.

The Commission likens dissemination activities to a shopkeeper attracting customers. Therefore, one should always consider a funded project as a fixed-duration business with all the duties, aims, objectives and tasks. A process of promotion and awareness-raising from the beginning of a project can make its research results known to research peers, industrial and other commercial actors, and policymakers, in targeted ways, enabling them to exploit the results in their own work.

The Commission describes exploitation as "the use of the results during and after the project's implementation. It can be for commercial purposes but also for improving policies, and for tackling economic and societal problems" (European Commission, 2016). Exploitation, thus, spreads the findings and utilizes them for the benefit of a larger geographical area. Furthermore, if the benefits can be employed in a variety of fields of interest, in addition to the field of the project, it makes the results of exploitation activities more valuable.

Communication refers to the project

> taking strategic and targeted measures for promoting the action itself and its results to a multitude of audiences, including the media and the public, and possibly engaging in a two-way exchange. The aim is to reach out to society as a whole and in particular to some specific audiences while demonstrating how EU funding contributes to tackling societal challenges. European Commission, 2016

It is interesting to note that one-way communication still seems to be the main direction and scope for projects funded by the European Union. The option of engaging in a two-way exchange is voluntary. However, to make an impact, two-way communication has the potential of being more efficient than one-way. To ensure improved quality, research is needed to develop professionalism in the management of communication, and best practices should be actively shared (Vos & Schoemaker, 2004). This can be extended to external communication and dissemination in funded projects. Communication in a project will initially start when collaborators start working towards common goals, and information is input to serve as a basis for the project, and the development and innovation work within. A project can, for example, interview stakeholders and create scenarios that input information to the project and guide the co-creation of knowledge and innovation (Ruoslahti, 2017).

To guide the practical work of a project network, information is shared and communicated between project members, partners and other stakeholders. In many funded projects, work packages are distributed between partners, and solitude work by one partner at a time is carried out, making shared work activities sometimes difficult. Communication takes place all the time, whenever one acts or does something. If partners work as a team on different tasks and work packages, it would make all the duties of communication, dissemination and exploitation much easier for all. Vos (2015) notes that "communication can contribute to a company's economic and social goals by seeking to enhance its corporate reputation, positioning of products and services, and internal consistency" (p.64). Key processes in doing this include monitoring stakeholder perceptions, arranging interaction with them and facilitating network exchange within the organization (Vos and Schoemaker, 2011).

These same principles can be applied to projects as well as established organizations. Communication plays a role in a project's economic and social goals by seeking to enhance the reputation of the project in question, positioning of its outcomes and deliverables, and internal consistency. In their strategy map for communication, Vos & Schoemaker (2011) look at communication on four different levels: organizational goals, communication goals, key processes, and learning and growth.

On the first level, organizational goals, or in this case common goals for a project network, are added value and social acceptance. On the second level, communication goals, are reputation and being rooted in the social environment; project outcomes are positioned as products or services, and coherence as the organization of the project network. On the third level, key processes include monitoring stakeholder perception, examining communication via news, social media, etc., and facilitation of network exchange. These key processes are identifiable in the dissemination and communication plans for all three projects ABC4EU, IECEU, and GAP. On the fourth level, learning and growth, one can find communication planning and research, and knowledge management and training. The focus of this chapter is on this level.

Projects are required by the EU funding instruments to openly disseminate the results of the project for efficient exploitation. In past experiences this has been done towards the end of the project, which poses a serious problem both to the consortium and the funding instrument. Criteria for funding may not be met in those cases. This should change. One can keep in mind the Commission's simile of a shopkeeper and the need to attract the shop's customers. End users and other stakeholders should become involved in the dissemination process already from the start of the project. The dissemination process, and its evaluation, which are proposed in this chapter, are designed around this principle.

3. Three Projects Examined

This chapter explores the planning and evaluation of external communication and dissemination in three funded project cases. Project ABC4EU will have run its course during the year 2018, whereas IECEU and Gaming for Peace started their activities in the fall of 2015 and 2016, respectively. This chapter suggests that a framework with strengthened co-creation as a method can intensify external communication and dissemination in funded projects. The experiences of the three funded projects partially present the co-creation concept of this chapter; the authors have developed the idea further to conceptualize the planning, process, and evaluation of the activities. As an example, the dissemination process for ABC4EU is illustrated in Figure 1 (ABC4EU, 2012). The main aim of this process is to engage a community of potential users from the very start of the project to ensure not only efficient dissemination, but also the continuous and active input of end user experts. This model of co-creation can create opportunities to link stakeholder collaboration for creativity and innovation. PR skills and active facilitation become emphasized in this approach.

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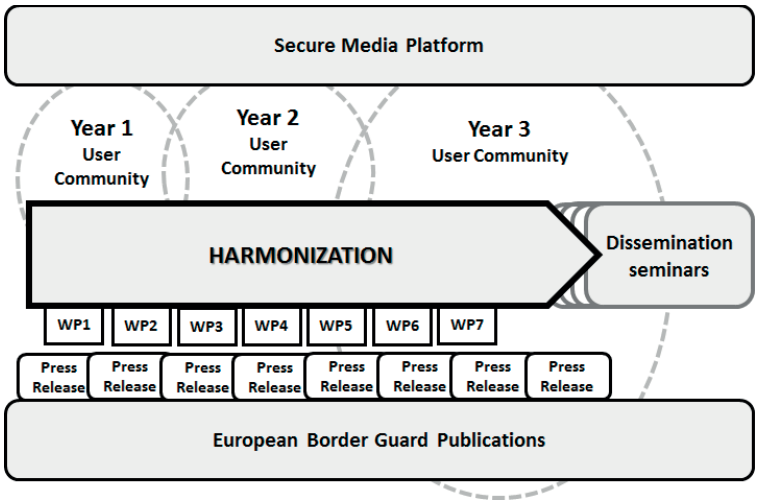

Figure 1: Communication and dissemination model for project ABC4EU

ABC Gates for Europe – ABC4EU is a project with 17 partners. The main objective of the project is to "focus in the need for harmonisation in the design and operational features of ABC Gates, considering specially the full exploitation of the EU second generation passports and other accepted travel documents" (ABC4EU, 2012, p.4). There are nine work packages, with WP7 Dissemination & Exploitation focusing on external communication and dissemination. In the Framework Programme FP7 project ABC4EU, dissemination, as seen in figure 1, was planned to begin from the very start of year one (Y1) of the project (ABC4EU, 2014). The aim has been to grow the User Community in number and keep end users, industry, and academia actively involved with interactive participation on a secure social media platform. The key to get end users involved in ongoing communication activities in a project where the end users receive no funding for their efforts is to find their ultimate benefit and smaller benefits during the project lifecycle. Interactive participation can enable the creation and growth of an end user community, and this community can in turn serve as a basis for two-way communication with end user organizations and professionals. In addition, press releases, publications and articles have been used.

The second examined project IECEU (Improving the Effectiveness of Capabilities in EU conflict prevention) was implemented from 2015 to 2018. The dissemination methodology was a combination of defined end user groups and the use of different dissemination tools and activities. The overall comprehensive dissemination methodology included the involvement of both EU and other international organizations, respective countries, universities, as well as other projects and partners, and the use of a secured internal website and external online tools for dissemination, discussion, and media-based learning (IECEU D8.1, 2015). The aim of the dissemination focused on making better use of the results among key stakeholders. (Hyttinen, 2017). The use of technology in dissemination and communication was strongly addressed in this project implementation.

The third funded project which this chapter discusses is the Horizon 2020 project Gaming for Peace, GAP, which is based on the notion that operationally critical soft skills, communication, cooperation, and negotiation, are often not emphasized enough. The Project GAP proposes to fill this training gap, by embedding, into a gaming environment, a "base curriculum of soft skills that facilitates coordination and relationship building in an environment of organisational, gender and cultural diversity" (GAP D7.2, 2016, p. 5). The project has fourteen partners. "The communication and dissemination activities are fundamental in order to create project visibility and to reach various target groups" (GAP D7.2, 2016, p. 3). Efficient communication is key to a successful GAP project.

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4. Adapted Methodology for Project PR

This chapter presents a model of co-creation based on the pedagogical model, Learning by Developing (Laurea, 2011). LbD is a way of learning and developing, created for university studies and utilized in project work. A project, in itself, is a learning environment, involving partners, stakeholders, possible clients and end users cooperating with each other in partnership, employing an experiential nature when researching and co-creating something new in an authentic project, all participants learning from each other at the same time. The LbD Guide (2011, p.12) also notes that

> A learning environment is also a psychological state. It enables encounters among different participants and interaction that leads to genuine cooperation. The atmosphere is open and respects equality. The working culture is inspiring, supporting creative and finding new ideas. Shortcomings and sidetracks are turned into positive learning experiences. The communication culture is open and respectful. Diversity is a resource for innovation. Partnership fosters responsible collaboration. Learning environments enable joint activities, evaluation and development of personal ways of action based on experiences.

The description above meets the ways of working in a multi-actor cross-border project. The criteria set by the funding instruments are crucial for the planning of external communication and dissemination of funded projects. The consortium needs to include a plan for communication and dissemination with their funding application. This emphasizes the importance of the role of PR, in this case communication and dissemination, for the project. Furthermore, in the planning stage of external communication and dissemination, one needs to look at the whole cycle of external communication and dissemination: plan, act, evaluate, re-plan, act, evaluate, etc. Projects should make sure that PR skills are developed, and that PR professionals jointly facilitate collaboration in co-creation activities. Communication and dissemination technologies require the competences of the people related to a project's knowledge and information sharing. The dissemination technologies which support project collaboration within a consortium as well as among key stakeholders and public audience are: the Web, secured access websites, video conferences, social media, document management and so forth. The selection of the dissemination technology depends on the target group (Juan, 2012. p. 220). The technology and information sharing increase additional competence and professional requirements for experts working with project dissemination.

The proposed framework employs the model of Vos and Schoemaker (2004) that combines elements of both balanced scorecard and quality management to evaluate communication. The evaluation of external communication and dissemination is done by measuring the effectiveness of its activities. The measurement process follows the quality cycle by Juholin, (2010). The first step is to define evaluation aims, the second step is the method and data sets, third, data is collected and analyzed, fourth, results reported, and the final step is re-evaluation and choosing the next steps, so that the cycle may start again. The main aim is to continuously improve the quality of the communication and its value for the organization (Vos, 2015). According to Verčič et al. (2015), finding internationally socialized people to "… work in a cross-cultural setting, and capable of taking international and global public relations practice to a new level …" (p. 791) is a major challenge. This is also demonstrated in the three projects examined.

4.1. Quality Dimensions

This section discusses the dimensions of communication quality by Palttala & Vos (2012, p. 39) and illustrates how these dimensions were linked to the externally funded project domain. These dimensions are A) clarity, B) environment orientation and linkages, C) consistency, D) responsiveness, and E) effectiveness and efficiency. They are summarized in Table 1 below.

Evaluation targets focus		
Dimensions of communication quality	A. Clarity	Clarity refers to communicating a clear profile and with messages that are distinctive, accessible, and in clear language
	A. Environment orientation and linkages	Taking into account the internal and external environment, networking and media contacts
	B. Consistency, effectiveness and efficiency	The communication is coherent, has a thread that connects the activities over time and fits the project
	C. Responsiveness	Detect changes through monitoring and use feedback for improvement
	D. Effectiveness and efficiency	A result- and goal-oriented communication effort, defining priorities by using planning, research and cost-efficient operations

Table 1: The dimensions of communication quality (adapted from Vos & Schoemaker, 2004; Vos 2009)

Palttala and Vos (2012) emphasize that these five dimensions are “the pillars of communication quality” (p. 39), and that they cannot be isolated from each other. They are all linked to and support each other.

4.2 Domains of Project Communication and Dissemination

The quality dimensions presented above are applied to various domains in evaluating dissemination activities. For this, the model of Vos and Schoemaker (2004) on organizational communication are adapted to meet the criteria of funded project dissemination. Figure 2 shows the different domains of project communication and dissemination, which are included in the evaluation framework proposed in this chapter. The five domains refer to the areas of project communication and dissemination.

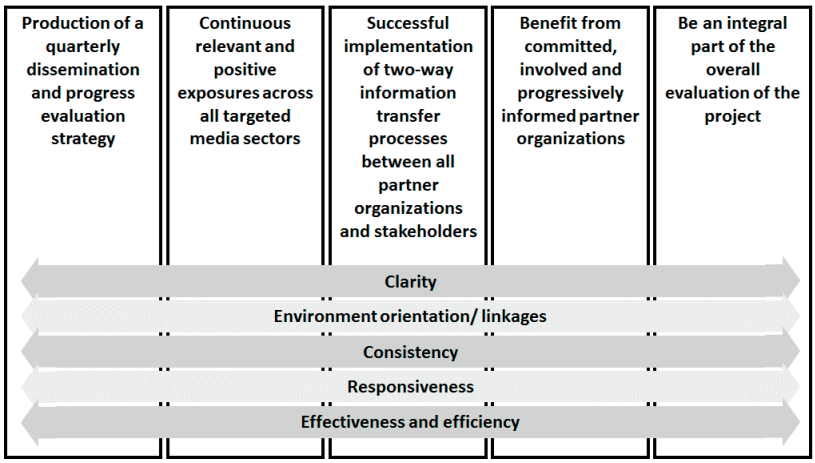

Figure 2: Communication and dissemination evaluation model (partly based on Vos & Schoemaker, 2004)

The domains are based on the grant agreement (unpublished document) for the project GAP and are thus expected to have a wider bearing. In the project GAP, they were used as a basis for the communications plan of the project (GAP D7.1, 2016). The grant agreements of EU funded projects specify important communication that, consequently, should be reported to the funder. In externally funded projects, dissemination and communication activities should be reported regularly both within the consortium, and to the funding agency. This is done as part of periodic technical reviews, as well as summarized for the duration of the project as part of the final report. Dissemination reporting is due between monthly and every four months' time, throughout the duration of the project implementation.

Some key features of reporting are the dissemination/communication action (e.g. event), date and place, target group, number of people/participants that dissemination was done towards, objective and description, and communication channels/tools used. Dissemination reporting is typically aided by templates, which are prepared based on these key features, and support the data collection from the various consortium partners.

If not paid close attention to, in the planning phase, these templates that gather information from dissemination activities may gather information that is dispersed into different tables, resulting in unlinked incoherent details. Also, it is advisable to remember to include an easy access system to attach written messages and texts to the report template as records of communication and dissemination activities carried out. All partners should report their external communication and dissemination activities regularly, even if there have not been any activities or only a few. Motivating each partner to do their reporting in a timely fashion and generating a routine to examine and document one's own dissemination activities are a way to develop one's own work and find common ground to cooperate with partners.

4.3 The Evaluation Framework

For evaluation of project communication and dissemination, the quality dimensions are applied to the communication dimensions. This provides a matrix with various indicators, as shown in Table 2.

Quality dimensions	Quarterly dissemination and progress evaluation	Relevant and positive exposures across all targeted media sectors	Successful two-way information transfer processes between project partners and stakeholders	Committed, involved and progressively informed partner organizations	Adoption of project processes across the EU
Clarity	Clear positioning of the project	Clear positioning across targeted media sectors	Information to stakeholders is clear	External communication vision is clearly defined	Clear positioning of project processes across the EU
Environment orientation/ linkages	Maintain networks for the project's reputation	Maintain networks across targeted media sectors	Communication reinforces commitment and supports two way information transfer between partner organizations and stakeholders	Internal and external communication function is well embedded in all project work	Communication supports two way information transfer of project processes across the EU
Consistency	Consistency with other communication	Consistency in message across targeted media sectors	Consistency with other communication	Common starting points for internal and external communication, with room for project partners	Consistency with other communication
Responsiveness	Monitoring and action based on managing issues	Monitoring and action based on feedback from targeted media sectors	Communication contributes to internal views on external changes and communication skills encourage internal responsiveness	Feedback is used to develop communication planning and activities	Monitoring and action based on feedback from professional sectors across the EU
Effectiveness and efficiency	Assessment of project reputation, cost efficient methods	Assessment of cost efficient methods	Internal communication audits, cost-efficient methods	Assessment of internal and external communication quality, time management	Assessment of project processes adoption across the EU, cost efficient methods

Table 2: GAP media evaluation tool; as an example of the proposed evaluation framework.

Measurement with the tool presented in Table 2 above is carried out as part of a quality cycle, the aim being to continuously improve the quality of the communication and its value for the organization (Vos, 2015; Juholin, 2010). Evaluation, according to Juholin (2010, p. 29), is an assessment of the value communication in its different forms produces, and how single actions benefit the organization. This chapter views projects as organizations created for a limited timeframe, and evaluation as a process, which aims at developing the activities of the project. Evaluation needs to be continuous and holistic, and based on the aims set for the project. Evaluations target planned activities, results achieved with these activities, objects for development, and needs for immediate action. The evaluation method and the measurements used must be defined, case-by-case, for the organization (Juholin, 2010, p. 30), or in this case, the project.

Section 5 discusses the experiences in the three projects ABC4EU, IECEU, and GAP, based on an analysis of the dissemination and communication plans of these three international projects. This chapter proposes an evaluation framework based on these experiences and illustrates the relevance of the framework by arguing that it fits the experiences gained in planning and coordinating dissemination activities in three EU funded projects.

5. Results from the Three Projects

The project ABC4EU Dissemination Plan (ABC4EU, 2014) stresses that all external communication and dissemination activities begin as soon as the project begins, and run throughout the project duration, with the aim of gaining project visibility. The plan outlines what will be communicated, who will do it, to whom, how, and why. Besides traditional methods for dissemination, such as press releases, newsletters, electronic publications, workshops, and conferences, the project aims at creating and growing its user network (end user community) in numbers, by using a secure online platform, an active end user community to disseminate relevant information of the project. "To ensure

continuation for the work done in the project" (p. 9), this end user community is urged to live on and continue its active existence and cooperation even after the project has ended. The means of dissemination in project ABC4EU are divided in: dissemination materials (the products created), and dissemination activities (the actions taken), and these are outlined in the ABC4EU Dissemination Plan (2014). Because the Framework Programme 7 did not have a requirement for media evaluation, the ABC4EU project did not evaluate its communication impacts in any other way than by listing and calculating its dissemination activities. For this purpose, there was a template and system of periodic reporting, and end user community reports.

The monitoring and evaluation indicators for IECEU were set early in the project, and later adapted, as the IECEU dissemination was evaluated to reach comprehensive visibility among its key stakeholders by use of different dissemination means, tools and activities (IECEU D8.1, 2015). The project was acknowledged by policymakers, academic and public audiences. The approach provided positive lessons for future projects in the external European safety and security domain. The engaging of key stakeholders in policy dialogues in various EU Member States was seen as a successful method of PR in terms of raising impact. The active use of technology selected in project dissemination activities by the partner organizations enhanced the information sharing towards end users and the general public. Moreover, social media polls and online meetings ensured the use of interactive methods when employing technology. In the final reporting phase, this was seen as key in terms of successful dissemination. IECEU engaged over 1,000 participants to actively follow only two social media channels, Twitter and Facebook.

The external communication and dissemination plan for GAP, Gaming for Peace (GAP D7.1, 2016) also looks for ways to "ensure efficient and sustainable information sharing in GAP even beyond the lifespan of the project" (p. 4). The GAP plan focuses on asking the questions: to whom to disseminate; where to disseminate? The plan is in line with the European Commission stressing the importance on clarifying messages based on the target audiences. These questions in the GAP plan guide all GAP dissemination actors to clearly focus their dissemination activities on the potential audiences for the results and products of the GAP project. Knowing how to identify these audiences can bring sustainability to the project. The Communications Plan for GAP lists key stakeholders for dissemination (GAP D7.1, 2016, pp.15-9).

GAP has a communication action matrix, which is built around milestones, work packages with partner responsibilities to communicate relevant actions, and deliverables that are related to each milestone. This is to ensure that all the partners of GAP are in a timely manner actively and fully carrying out the information sharing responsibilities that are expected of them. Building the relationships between the actors of the project's operational work packages and its external partners are based on these communication activities. It is important that all actors understand the values, which underline the communication practices of the GAP project. To create a GAP brand, the project partners need to share a clear vision. Thus, it is easier to form clear messages that communicate what GAP is, who its actors are, and why this project is important to society (GAP D7.2, 2016).

GAP's project documentation indicates that the division of work between internal and external communication is clear, with the coordinator being responsible for internal communication, and Laurea UAS for external communication, although external communication activities require approval by the coordinator before communication can take place. External communication and dissemination activities are also the responsibility of each beneficiary in addition to a work division table of responsibilities.

The media evaluation framework adapted for GAP takes the GAP Communications Plan, Grant Agreement and template for reporting of dissemination activities into consideration. The Communications Plan includes a table of both quantitative and qualitative questions to be used for

the scientific analysis of external communication and dissemination in the project. The required scientific analysis has so far not been possible to carry out because not all the partners have delivered their periodic reporting of external communication and dissemination activities.

The evaluation tool adapted for the media evaluation can, in the future, be utilized as a self-assessment tool, thus, including the qualitative approach to evaluation by the active actors and communicators themselves. This enables the emphasis of accountability and the generating of self-development of the communication and dissemination activities of each project partner (beneficiary). Accountability for communication refers to taking responsibility for the communication strategy and the choices that are made, and how these contribute to the objectives of the project (Vos, 2015). Accountability is examined here on the level of the communication work package and the communication performance of the project as a whole.

All three projects implemented their dissemination and communication activities with people who mainly had knowledge and competence of the substance areas of research and development (e.g. security). Only few communication and PR professionals participated in project dissemination. This result was unexpected, since the dissemination objectives in EU funded projects are strongly related to deep competences and experiences of management of dissemination and PR. It was, however, recognized that the co-creative collaboration between professionals, researchers and developers, as well as the feedback and learning provided by evaluation, supported the reach of dissemination objectives.

6. Tentative Conclusions and Implications

The experiences in the three projects suggest that it is important that partners agree to jointly cooperate on external communication and dissemination activities, and to understand how vital these activities are for the success of the project. These actions are PR for the project, and thus the project should include PR professionals to develop PR skills of its actors. Next, commitment and active participation of partners and end user groups in the early stage of the project implementation is key to increase the impact of the project results and finally, meet with the project's dissemination goals. Moreover, dissemination in international research and development projects should be an ongoing process. The process should start when the project begins, and last until the end of the project. Ideally, the dissemination process begins with the project proposal and extends to the sustainability of the project stakeholder community, even after the project has terminated or not received funding. The benefit of networks may bring added value for partners in the future.

Additionally, it can be noted that dissemination is an expanding process. Figure 1 shows this expansion of the User Community from year one (Y1) to year three (Y3), a growing number of stakeholders (end users, industry, NGOs, authorities, academia, etc.) participating in the communication within the community. A small nucleus in the beginning of the project leads to growing numbers of stakeholders actively being targeted and participating in the co-creation of the dissemination process. Also, key target audiences should be clarified, followed, and updated throughout the project lifespan. The selection of communication channels should be amended based on this clarification process. The target audience will most likely expand in not only number, but also to include a wider range of stakeholders by the end of the project, and after.

In the project IECEU, easily measurable indicators (IECEU D8.1, 2015) were set at an early stage to monitor the success of dissemination by IECEU. The monitoring process includes quantitative monitoring and evaluation indicators. Measuring the objectives throughout the project identified both gaps and trends to make sure that the project was going to a desired direction and provided valuable information to further improve the communication activities. Results from the first media evaluation

in GAP indicate that not all partners have yet realized the potential and benefits of actions promoting strategic communication of the project. Furthermore, there is little cooperation between partners as the cooperation is regulated by the contract and enacted by the project coordinator. However, as the project has only recently started, there are many options to develop the activities even together. The key to such co-creative work lies in the will to work as a team. Therefore, PR skills become more and more important for projects to meet requirements set by the EU for the external communication and dissemination of research and innovation projects. The use of selected technology for PR, dissemination and communication, presents a new type of competence challenges and opportunities for professionals and experts.

Instruments for public funding of research and innovation projects call for open dissemination of project results. However, the EU does not demand two-way communication in these activities, which clearly would be the way to generate better results and engage different audiences. Perhaps the EU could develop their visions of external communication and dissemination in the era of digital communication and community-based cooperation. When communication and dissemination activities begin early enough, for example right at the start of the project, and expand the stakeholder community, the project and its results become wider known. It is in the interest of the European Commission that as many end users as possible adopt new innovations, which in turn will generate more business possibilities for the industry, and further research projects for the academia.

Ideally the project's end user communities may find sustainability that outlasts the project. Project partners could engage end user communities in collaborative PR activities to engage the end users during the project. This creates opportunities for spontaneous cooperation and further the co-creation of innovations, products, and services, not to mention new development projects. PR professionals have a strategic opportunity in facilitating activities within the proposed model of co-creation in the EU funded projects context. The potentials in using technology in dissemination and communication of international research and innovation projects are highly recommended to be further studied while enhancing professionalism.

Acknowledgements:

The research leading to these results has received funding from the European Community's Framework 7 Programme for ABC4EU – ABC Gates for Europe, and the European Community's Horizon 2020 Programme for IECEU – Improving the Effectiveness of Capabilities in EU conflict prevention and GAP – Gaming for Peace.

References:

ABC4EU – ABC Gates for Europe (2012). ABC gates for Europe Proposal, SEC-2012.3.4-6 Enhancing the workflow and functionalities of Automated Border Control (ABC) gates –Integration Project

ABC4EU – ABC Gates for Europe (2014). Dissemination Plan, Project deliverable D 7.7 M3, 9.4.2014.

Allen, S., Bailetti, T., and Tanev, S. (2009). Components of Co-Creation, The Open Source Business Resource, November 2009.

Davis Cross, M.K., (2015). The Limits of Epistemic Communities: EU Security Agencies, Politics and Governance, Volume 3, Number 1.

Di Cagno, D., Fabrizi, A., and Meliciani, V. (2014). The impact of participation in European joint research projects on knowledge creation and economic growth, Journal of Technology Transfer, Vol. 39, 6, 836-858.

Falkheimer, J. & Heide, M. (2014). From Public Relations to Strategic Communication in Sweden: The Emergence of a Transboundary Field of Knowledge, Nordicom Review, 35(2), 123-138.

European Commission (2011). Cooperation, Work Programme 2012, Theme 10, Security, European Commission C(2011)5068, 19 July 2011.

European Commission (2014). Horizon 2020, Communicating EU research and innovation guidance for project participants, Version 1.0, 25 September 2014.

European Commission (2016). Webpage: What is the difference between dissemination, exploitation and communication? Research and Innovation. Participant Portal, available at: https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-933.html (accessed 25 May 2017).

European Commission (2017). Webpage: European Commission, Research & Innovation, Participant Portal, support, available at: https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-933.html (accessed 25 May 2017)

European IPR Fact Sheet (2014). The Plan for the Exploitation and Dissemination of Results in Horizon 2020, European IPR Helpdesk, available at: https://www.iprhelpdesk.eu/.

Falkheimer, J. & Heide, M. (2014). From Public Relations to Strategic Communication in Sweden: The Emergence of a Transboundary Field of Knowledge, Nordicom Review, 35(2), 123-138.

Frow, P., Nenonen, S., Payne, A., and Storbacka, K. (2015). Managing Co-creation Design: A Strategic Approach to Innovation, British Journal of Management, Vol. 26(3), 463.

GAP – Gaming for Peace (2016). D7.1 Communications Plan, available at: 1.9.2016. http://gap-project.eu/publications/deliverables/ (accessed 25 May 2017)

GAP – Gaming for Peace (2016). D7.2 Communications Package, available at: 1.9.2016. http://gap-project.eu/publications/deliverables/ (accessed 25 May 2017)

Hyttinen, K. (2017). Project Management Handbook. Laurea Publications 76, Laurea University of Applied Sciences. ISBN: 978-951-799-452-1.

IECEU – Improving the Effectiveness of Capabilities (IEC) in EU conflict prevention (2015). 8.1 Dissemination Plan PU IECEU CSA project: 653371 Start date: 01/05/2015, available at: http://www.ieceu-project.com/wp-content/uploads/2016/12/D8.1-Dissemination-Plan-PU.pdf (accessed 5 July 2017)

Juan, A et al. 2012. Collaborative and Distributed E-Research: Innovations in Technologies, Strategies and Applications: Innovations in Technologies, Strategies and Applications. IGI Global. ISBN13: 9781466601253.

Juholin, Elisa. Arvioi ja paranna. Viestinnän mittaamisen opas. Vantaa: Infor Oy, 2010.

Laurea University of Applied Sciences (2011). Learning by Developing. LbD Guide, available at: https://www.laurea.fi/en/document/Documents/LbD_Guide_04102011_ENG.pdf#search=lbd%20guide (accessed 5 July 2017).

Palttala, P., & Vos, M. (2012). Quality Indicators for Crisis Communication to Support Emergency Management by Public Authorities. Journal of Contingencies and Crisis Management, 20(1), 39–51.

Pirinen,R. (2015). Studies of Externally Funded Research and Development Projects in Higher Education: Knowledge Sources and Transfers, Creative Education, 2015, 6, 3, 315-330.

Ruoslahti, H. (2017). Co-creation of Knowledge for Innovation and Multi-Stakeholder Participation of End Users: A Structured Literature Review, paper submitted to EUPRERA 2017, London, October 12 – 14.2017.

Sriramesh, K. Štumberger, N. (2017). Globalization and Public Relations, In: Global Encyclopedia of Public Administration, Public Policy, and Governance, A. Farazmand (ed.), Springer International Publishing AG 2017.

Verčič, D, Zerfass, A, Wiesenberg, M (2015). Global public relations and communication management: a European perspective. Public Relations Review 41(5): 785–793.

Vos M. (2015). Communication Health Check – Measuring Corporate Communication Performance, Journal of Business Studies Quarterly 2015, Volume 7, Number 1.

Vos & Schoemaker (2004). Accountability of Communication Management, A Balanced Scorecard for Communication Quality, Lemma Publishers, Utrecht, 2004.

Vos, M., & Schoemaker, H. (2011). Integrated Communication: Concern, Internal and Marketing communication. Amsterdam: Eleven Publishing.

Wilson, P. M., Petticrew, M., Calnan, M. W., & Nazareth, I. (2010). Disseminating research findings: What should researchers do? A systematic scoping review of conceptual frameworks. Implementation Science, 5, 91.