SITUATIONAL AWARENESS CONCEPT IN A MULTINATIONAL COLLABORATION ENVIRONMENT

Challenges in the Information Sharing Framework

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DOCTORAL DISSERTATION

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Abstract

Technological capabilities are built to support different types of collaboration, and this gives the justification to widely observe, how activity environments are influenced by technology. Technology as an enabler can be addressed from different perspectives, other than merely technological. Dynamic, evolving environment is at the same time interesting but also challenging. As a multinational collaboration environment, the maritime surveillance is an good example of time critical and evolving environment, where technological solutions enable new ways of collaboration. Justification for the inspiration to use maritime environment as the baseline for understanding the challenges in creating and maintaining adequate level of situational awareness, derives from the complexity of the collaboration and information sharing environment elements, needed to be taken into account, when analyzing criticalities related to decision making.

Situational awareness is an important element supporting decision making, and challenges related to it can also be observed in the maritime environment. This dissertation describes the structures and factors involved in this complex setting, found from the case studies that should be taken into account when trying to understand, how these elements affect the activities. This dissertation focuses on the gray area that is between a life threatening situation and normal everyday activities. From the multinational experimentation series case studies, MNE5 and MNE6 it was possible to observe situations that were not life threatening for the participants themselves, but not also basic every day activities. These case studies provided a unique possibility to see situations, where gaining of situational awareness and decision making are challenged with time critical crisis situations.

Unfortunately organizations do not normally take the benefit from the everyday work to prepare themselves for possible emerging crisis situations. This dissertation focuses on creating a conceptual model and a concept that supports organizations – also outside the maritime community – to improve their ability to support gaining of situational awareness from the individual training level, all the way to changes in organizational structures in aiming for better support for decision making from the individual level to the highest decision making level. Quick

changes and unpredictability are reality in organizations and organizations do not have the possibility to control all the factors that affect their functioning. Since we cannot be prepared for everything, and predict every crisis, individual activities inside teams and as a part of organizations, need to be supported with guidance, tools and training in order to support acting in challenging situations. In fact the ideology of the conceptual model created, lies especially in the aim of not controlling everything in beforehand, but supporting organizations with concrete procedures to help individuals to react in different, unpredictable situations, instead of focusing on traditional risk prevention and management.

Technological capabilities are not automatically solutions for functional challenges; this is why it is justified to broaden the problem area observation from the technological perspective. This dissertation demonstrates that it is possible to support collaboration in a multinational environment with technological solutions, but it requires the recognition of technological limitations and accepting the possible restrictions related to technological innovations. Technology should not be considered value per se, the value of technology should be defined according to the support of activities, including strategic and operational environment evaluation, identification of organizational elements, and taking into account also the social factors and their challenges. Then we are one step closer to providing technological solutions that support the actual activities by taking into account the variables of the activity environment in question.

The multidisciplinary view to approach the information sharing and collaboration framework, is derived especially from the complexity of decision making and building of situational awareness, since they are not build or created in vacuity, but in the organizational framework by the people doing it with the technological capabilities, enabled by the organizational structures. Introduced case studies were related to maritime environment, but according to the research results, it is valid to argue, that based on the lessons learned it is possible to create and further develop conceptual model and to create a general concept to support a wider range of organizations in their attempt to gain better level of situational awareness (SA) and to support decision making. To proof the versatile usage of the developed concept, I have introduced the case study findings to the health care environment and reflected the identified elements from

the trauma center to the created concept.

The main contribution to complete this adventure is the presented situational awareness concept created in the respect to NATO concept structure. This has been done to tackle the challenge of collaboration by focusing on situational awareness in the information sharing context by providing a theoretical ground and understanding, of how these issues should be approached, and how these elements can be generalized and used to support activities in other environments as well. This dissertation research has been a several year evolving process reflecting and affecting presented case studies and this learning experience from the case studies has also affected the goals and research questions of this dissertation. This venture has been written from a retro perspective according to ideology of process modeling and design rationale to present to the reader how this entire journey took place and what where the critical milestones that affected the end result, conceptual model.

Support in a challenging information sharing framework can be provided with the right type of combination of tools, procedures and individual effort. This dissertation will provide insights to those with a new approach to war technology for the organizations to gain a better level of awareness and to improve the capabilities in decision making. This dissertation will present, from the war technology starting point, a new approach and possibility for the organizations to create a better level of awareness and support for decision making with the right combination of tools, procedures and individual effort.

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Abstrakti

Teknologisia suorituskykyjä rakennetaan tukemaan erilaisia yhteistyön muotoja ja tämä antaa perusteet laaja-alaiseen teknologian vaikutusten tarkasteluun. Teknologiaa toiminnan mahdollistajana on siis mahdollista tarkastella myös muista kuin teknologisista lähtökohdista. Dynaaminen, alati muuttuva ympäristö, on samaan aikaan mielenkiintoinen, mutta myös erittäin haasteellinen. Monikansallisena toimintaympäristönä meritilannevalvonta on hyvä esimerkki aikakriittisestä ja muuttuvasta ympäristöstä, jossa teknologiset ratkaisut mahdollistavat uusia yhteistyön muotoja. Inspiraatio merellisen ympäristön käyttämisestä tapaustutkimuksena tilannetietoisuuden ja päätöksenteon haasteiden ymmärtämiseen on perusteltua juuri merellisen yhteistyöympäristön haasteellisuuden ja siihen liittyvien päätöksentekoon vaikuttavien elementtien vuoksi. Tilannetietoisuus on merkittävässä roolissa päätöksenteon tukemisessa, ja haasteita, joita tähän yhdistelmään liittyy, voidaan löytää myös merellisen ympäristön tarkastelusta. Henkeä uhkaavien tilanteiden ja jokapäiväisen normaalin työskentelyn väliin jäävä ns. harmaa alue on tämän väitöskirjan keskipisteessä. Tapaustutkimukset monikansallisesta eksperimentaatio-sarjasta (MNE5 ja MNE6) mahdollistivat tilanteiden havainnoinnin, jotka eivät olleet toimijoiden omaa henkeä uhkaavia, mutta eivät myöskään jokapäiväisiä rutiineja. Nämä tapaustutkimukset mahdollistivat aikakriittisten kriisitilanteiden havainnoinnin, joissa tilannetietoisuuden ja päätöksenteon haasteita oli mahdollista tarkkailla.

Valitettavan harvoin organisaatiot näkevät normaalissa työarjessa potentiaalia hyödynnettäväksi varautumiseen yllättäviin tilanteisiin ja kriiseihin. Väitöskirjani keskittyy organisaatioita tukevan konseptin luomiseen – myös merellisen toiminnan ulkopuolella – parantamaan kykyä tukea tilannetietoisuuden luomista yksilöiden kouluttamistasolta aina organisaatioiden rakenteiden muokkaamiseen päätöksenteon tukemiseksi.

Väitöstyön työstäminen on ollut usean vuoden, jatkuvasti muuttuva prosessi, joka on vaikuttanut myös väitöskirjassa esitettävien tapaustutkimusten tutkimusasetelmiin ja toisaalta tapaustutkimukset ovat vaikuttaneet väitöstyön tavoitteiden ja tutkimuskysymysten muotoutumiseen. Olen dokumentoinut tämän mielenkiintoisen matkan

väitöskirjaksi prosessimallinnuksen ja design rationale -ajatusmallin mukaisesti mahdollistaakseni lukijalle käsityksen siitä, minkälaisesta tutkimusmatkasta olikaan kyse, ja minkälaisia kriittisiä päätöksentekopisteitä työn edistyessä esiintyi, jotka vaikuttivat väitöskirjani merkittävimmän kontribuution, tilannetietoisuuskonseptin luomiseen.

Nopeat muutokset ja ennakoimattomuus ovat nyky-yhteiskunnassa realiteetteja, jolloin organisaatioilla ei ole valmiuksia kontrolloida kaikkia muuttujia, joilla saattaa olla vaikutuksia organisaation toimintaan. Koska emme kykene varautumaan kaikkeen ja ennakoimaan jokaista kriisiä tai muutosta, yksilöiden toiminta osana ryhmiä ja osana organisaatiota tulee olla tuettua ohjeistusten, työkalujen ja koulutuksen kautta. Itse asiassa konseptuaalisen mallin ideologia perustuu juuri tavoitteeseen, jossa organisaatioiden ja niihin kuuluvien yksilöiden reagointivarmuus perustuu toimintoihin, joilla tuetaan yksilöiden kykyä reagoida ennakoimattomiin tilanteisiin perinteisen riskien ennaltaehkäisyn ja hallinnan sijaan.

Teknologiset suorituskyvyt eivät automaattisesti toimi ratkaisuina toiminnallisiin haasteisiin, siksi ongelmakentän tarkastelua on perusteltua laajentaa myös teknologian ulkopuolelle. Väitöskirja osoittaa, että teknologisilla ratkaisuilla on mahdollista tukea esimerkiksi kollaboraatiota monikansallisessa toimintaympäristössä, mutta se edellyttää teknologian reunaehtojen tunnistamista ja rajoitusten hyväksymistä. Teknologiaa ei tule käsitellä itseisarvona, vaan sen arvon tulisi määräytyä kokonaisuuden tukemisen kautta, johon kuuluvat niin strategisen ja operatiivisen ympäristön analysointi, organisatoristen elementtien tunnistaminen ja sosiaalisten tekijöiden asettamien haasteiden huomioonottaminen, jolloin ollaan askeleen lähempänä teknologisia ratkaisuja, jotka tukevat todellista toimintaa, toimintaympäristön variabiliteetit huomioonottaen.

Väitöskirjani monitieteellisyys juontaa juurensa nimenomaisesti päätöksentekoprosessien ja tilannetiedostamisen muodostamiseen vaikuttavien tekijöiden monimuotoisuudesta, sillä tilannetietoisuus eivätkä päätökset synny tyhjiössä, vaan siinä organisatorisessa viitekehyksessä, niiden henkilöiden toteuttamana ja niiden teknologisten ratkaisujen mahdollistamana, joita organisaatiolla on käytössä. Väitöskirjassa hyödynnetyt tapaustutkimukset sijoittuvat merelliseen

yhteistyö-ympäristöön, mutta tapaustutkimuksista saatujen tutkimustulosten perusteella on validia ja argumentoitua jalostaa tilannetietoisuusmallin sekä luodun konseptin generoimista myös laajemmin erilaisten kriisiorganisaatioiden toiminnan tukemiseen. Tämän todistaakseni, olen esitellyt merellisen toimintaympäristön havainnot myös sairaalaympäristössä ja reflektoinut sairaalaympäristöstä tunnistettuja elementtejä luotuun konseptiin.

Väitöstyöni keskeisin kontribuutio on tilannetietoisuuskonsepti, joka noudattaa NATOn konseptin rakennetta. Konseptissa keskitytään yhteistyön haasteisiin tiedonjakamisen kontekstissa, tarjoamalla ratkaisu siihen, miten tilannetietoisuuteen ja päätöksentekoon liittyvät haasteet ja mahdollisuudet voidaan hyödyntää erilaisissa organisaatioissa. Tämä väitöskirja esittelee sotatekniikan lähtökohdista uuden lähestymistavan ja mahdollisuuden organisaatioille parempaan tilannetietoisuuden luomiseen ja päätöksentekoon oikeanlaisilla työkalujen, toimintamallien sekä yksilöiden panostuksen yhdistelmällä. Tämä yhteensovitus kiteytyy väitöskirjan teoreettisena näkökulmana konseptuaalisessa mallissa sekä konkreettisella ohjeistuksella tilannetietoisuus-konseptissa.

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Anne

"Finding happiness in ourselves is not easy,
though it's impossible to find it elsewhere"
- Happy Joe

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Abbreviations

ACO	Allied Command Operations
ACT	Allied Command Transformation
AIS	Automatic Identification System
AOR	Area of Responsibility
AWC	Assistant Watch Captain
BRITE	The Baseline for Rapid Iterative Transformational Experimentation
C4IS	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CD&E	Concept Development & Experimentation
CFCA	The European Fisheries Control Agency
C2	Command and Control
C4IS	Command, Control, Communications, and Computers Information System
C4IR	Command Control Communication Computers Intelligence and Recognition
COI	Contact of Interest
CONOPS	Concept of Operations
COP	Common Operational Picture
DCAP	Data Collection and Analysis Plan
DoDAF	Department of Defense Architecture Framework (US)
DOTMLPFI	Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities and Interoperability
DSG2	Swedish Demo System Generation 2
ECSA	European Community Ship owners' Associations
EDD	Experimentation Design Document
EMSA	European Maritime Safety Agency
HELCOM	The Helsinki Commission
HHQ	Higher Headquarter
HQ	Headquarter

HQSACT	Headquarters of Allied Command Transformation
IFC	Information Fusion Centre
IMO	International Maritime Organization
IMSO	International Mobile Satellite Organization
JFCOM	Joint Forces Command (US)
JISR	Joint Intelligence, Surveillance and Reconnaissance
LL	Lessons Learned
LOE	Limited Objective Experiments
MEVAT	Merivalvonnan tietojärjestelmä (Maritime surveillance system)
MNE	Multinational Experimentation
MISA-EM	Multinational Interagency Situational Awareness of the Extended Maritime environment
MOC	Maritime Operation Centre
MoDAF	Ministry of Defense Architecture Framework (UK)
MOU	Memorandum of Understanding
MSA	Maritime Situational Awareness
MSSIS	Maritime Safety and Security Information System
NAF	NATO Architecture Framework
NASA TLX	NASA Task Load Index
NATO	The North Atlantic Treaty Organization
NATO MSA	NATO Maritime Situational Awareness
NGO	Non-governmental Organization
PfP	Partnership for Peace
POC	Point of Contact
PRQ	Performance Rating Questionnaire
PSAS	Process for Situational Awareness Support
PSP	Problem Solving Process
QoS	Quality of Service

UN	United Nations
RFI	Request For Information
RMP	Recognized Maritime Picture
SA	Situational Awareness
SABARS	Situation Awareness Behaviorally Anchored Rating Scale
SAGAT	Situation Awareness Global Assessment Technique
SMART	Singapore-MIT Alliance for Research and Technology
SME	Subject Matter Expert
SMTP	Simple Mail Transfer Protocol
SOA	Service Oriented Architecture
SOP	Standard Operating Procedure
STORS	Social-Technical-Organizational Rating Scale
SUCBAS	Sea Surveillance Co-operation Baltic Sea
TIDE	Technology for Information, Decision and Execution Superiority
WC	Watch Captain
VoIP	Voice over Internet Protocol
VTS	Vessel Traffic Service
XMPP	Extensible Messaging and Presence Protocol

1 INTRODUCTION

1.1 Justification and background of the study area

When you think of the Baltic Sea, the first thing that comes to you mind might not be that despite its small size, Baltic Sea is the worlds most operated traffic area. For example in May 2011, 11 887 vessels arrived to Finnish ports (Liikennevirasto, 2011). At this very moment couple thousand vessels are sailing in our Baltic Sea area. Oil and chemical transportation and passenger traffic have been increasing and the amount of traffic has been estimated to grow up to 50 percent of the current level before 2030 (Ulkoasianministeriö, 2010).

Actors in the maritime environment face a lot of challenges that are among others the intensity of traffic, weather conditions and geographical restrictions. With the respect to this, it is justified to say that the amount of traffic in the Baltic region is substantial and varying as demonstrated in Figure 1 about the traffic near our coast line. This is why maritime environment can be seen as a challenging environment for the actors involved. Unlike air traffic, traffic at sea is not controlled in the similar way that would allow us to be aware and control all the actors and actions related to maritime activities. Different maritime organizations in addition to military, such as coast guard, customs and port authorities are trying to secure everyone's safety in this multidimensional maritime environment. Surveillance is done in cooperation within national agencies. Maritime Operators, MO, (in Finnish Merelliset Toimijat, METO) is one good example of this cooperation where Finnish Boarder Guard, Finnish Navy and Finnish Maritime Authority work together for the joint goal. The reason for collaboration is indisputable: The sea line is crucial to Finland's trade; major part of the foreign trade is transported via sea. Therefore the awareness of the situations is important because of the dynamic and wide environment. Operators, individual actors in the Maritime Operations Centers, MOCs, are trying to gain adequate level of awareness of the activities at the sea in the area of their responsibility. Many nations, including Finland, do surveillance around their local areas, but cooperation among nations is becoming more and more relevant. As a result of this, it is a common interest to secure our waters even though

there may be cases where these interests do not match. This task in the demanding environment requires new, major investments for the nations involved. Collaboration is one of the key elements in achieving the goal of tackling the problems caused by the uncontrolled, increased traffic.

The maritime environment reflects common elements such as time criticality and possible crisis situations. This gives the justification for the inspiration to use maritime environment as the baseline for understanding elements that need to be taken into account when analyzing criticalities related to gain adequate situational awareness (SA), and to support decision making.
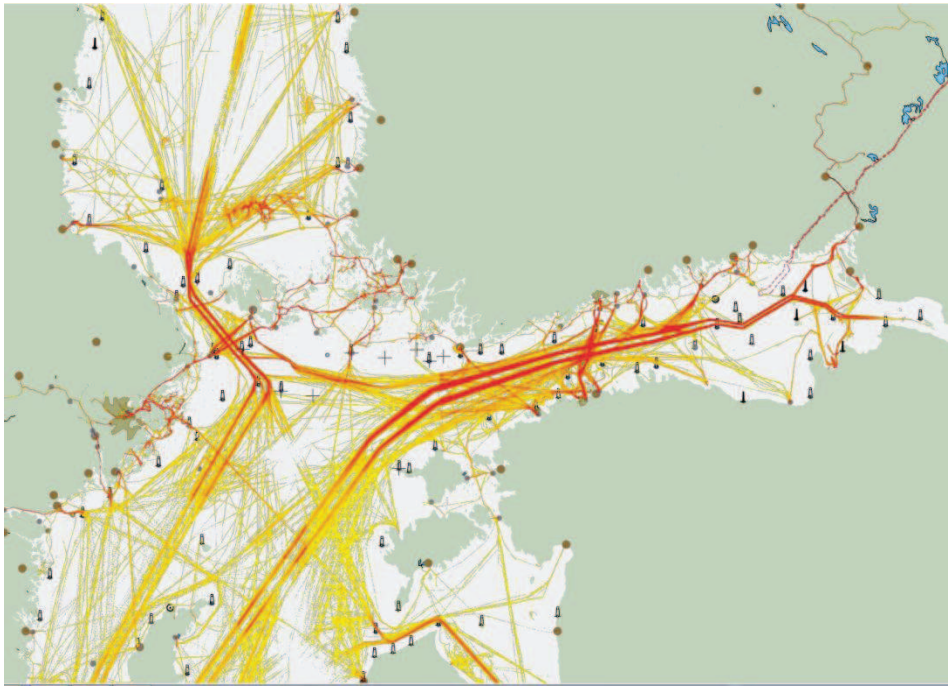
Figure 1:   An example of the traffic around Finnish coast line

1.2 Research area definition (multinational maritime collaboration)

There is a number of reasons, including security and economy, why co-operation is needed in the maritime environment. Terrorist attacks, illegal immigration in addition to drug and human trafficking are issues that concern many nations. When operating internationally, shared situational awareness plays a significant role in the maritime environment. Many issues from cultural differences to language barriers can influence the effectiveness of co-operation and basic working practices within a Maritime Operation Centre (MOC). The scope of this dissertation has been to observe *operators* in MOCs working in a multinational environment by collaborating with other nations MOCs in order to understand the context of the maritime activities and how situational awareness is gained; what are the challenges and supporting elements that can be found in this environment.

I have had difficulties in defining the theoretical angle, from which point of view this dissertation should be looked at. Figure 2 (original University of Jyväskylä, 2012) allows me to try to locate myself and this dissertation to somewhere between empiricism and hermeneutics. I justify this definition leaning to the basic definition of empiricism as viewing the situations as the bases of the formation of knowledge. The research process was guided by my perceptions of the studied phenomenon and the generalization of the knowledge acquired through my observations and experiences along this research journey. (University of Jyväskylä, 2012, see also Markie, 2012).

The reason why I want to locate this research closely also to hermeneutics, is because hermeneutics focuses in understanding and interoperating processes and phenomena by replacing individuals and their intentions to have various meanings. With the fundamental ideology that knowledge is formed through perceiving relationships between phenomena and their contexts, gives justification for the research strategy in this dissertation, since in hermeneutics knowledge is seen as a continuous process in which interpretations and knowledge are reformed (University of Jyväskylä, 2012, see also Demeterio III, 2010).
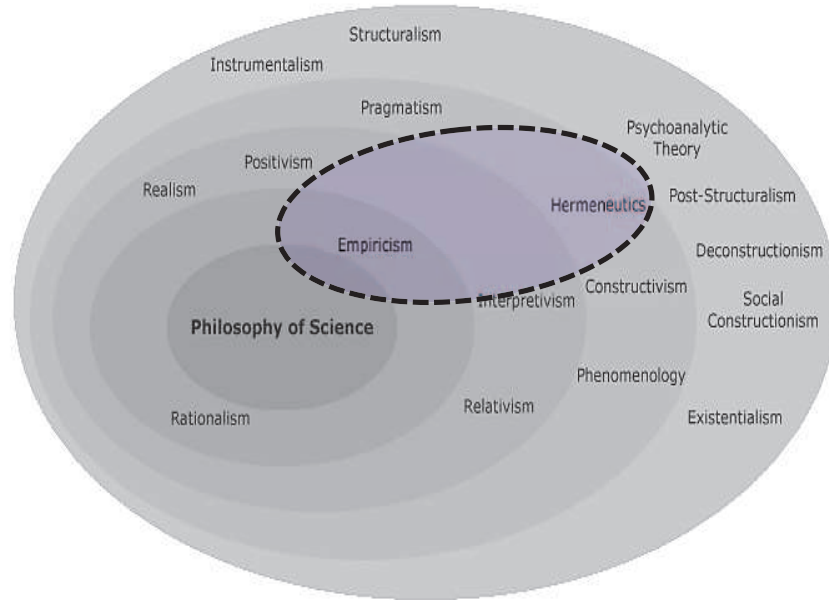
Figure 2:   Identifying the philosophy of science affecting this dissertation

As presented in Figure 3 (original University of Jyväskylä, 2012), this dissertation does not follow just one research strategy, but in fact it is a combination of multi-methods research (see for example Spratt, Walker & Robinson, 2004), qualitative and quantitative research from the used methods perspective, (see for example Walker, 2004; Woodley, 2004) case study and experimental research because of the case studies form the Multinational Experimentation series. One could argue that at some level this also fit the profile of ethnographic research (see for example Genzuk, 2003). Dotted oval in Figure 2 and Figure 3 indicate my research focus.

After locating this dissertation to the theoretical field and after introducing the combination of chosen research strategies, we can carry on with the context were the research was conducted: Since information sharing and situational awareness are the key definitions, before continuing further to explain the problem statement, we need to separate the situational awareness and information sharing from each other.

Situational awareness is needed by the individual him/herself alone or as a member in a team in order to perform the needed tasks. The individual needs to have adequate level of awareness of the processes and information requirements and after these the needed level of awareness of the devises that support the actual information sharing.
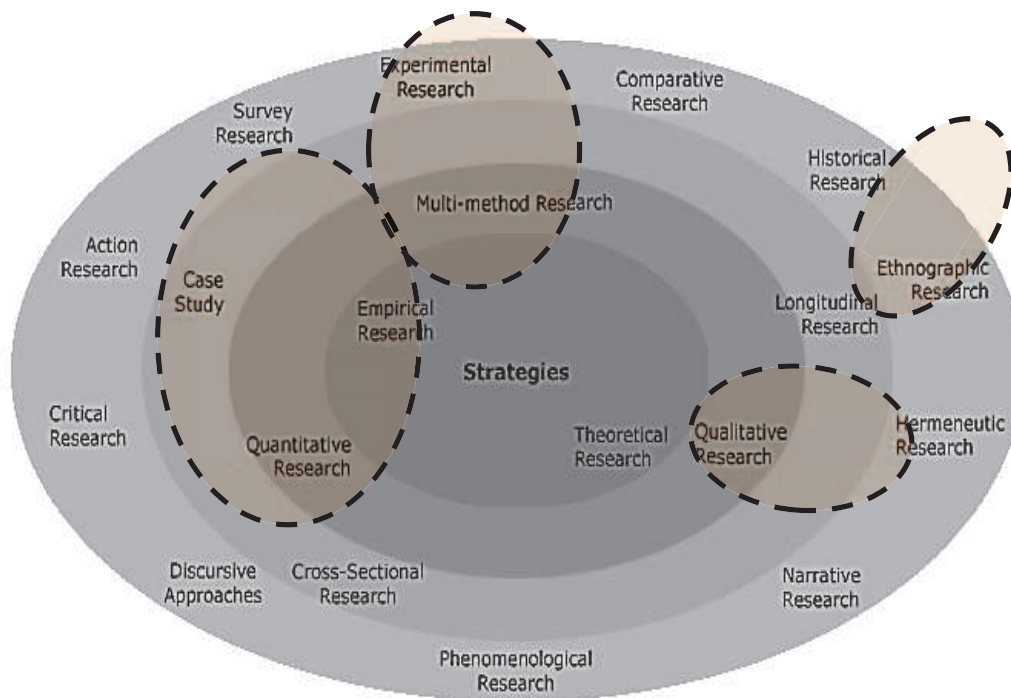
Figure 3: Here we are: Research strategies

From the information sharing perspective we can identify issues that affect the actual information sharing and those are categorized to social, technical and organizational issues explained in more detail when representing the case studies.

The purpose of this dissertation was to focus from the collaboration perspective in the maritime environment to information sharing framework that is affected by the level of SA of the operators.

The case studies introduced in Chapter 3 and 4 gave me the opportunity to observe these intriguing elements affecting situational awareness and decision making. My intention was to scale down to focus on individuals inside the MOC teams and interactions within and between the teams. Influences from and to the higher decision making level were left out of the scope since the amount of issues affecting even the chosen scope is quite large itself. Nevertheless, the findings and recommendations from this journey will support also the higher decision making level, since the findings will provide guidance for the higher level of the organization to allow proper adjustments to be made to procedures, technologies and training in order to support the team members in gaining the needed level of awareness in the information sharing framework.

The information sharing framework was identified to be time strained, not a regular day at the office, but not also a life threatening situation for the participants themselves. This is due to the fact that psychological differences in human behavior can vary a lot when we enter the level of individuals facing a life threatening situation (See for example Lambert & Hogan, 2010; Hoge, Auchterlonie & Milliken, 2006; Cooper, Dewe & O'Driscoll, 2001; Zapf, Dormann & Frese, 1996; Cooper & Cartwright, 1994; Quick, Murphy & Hurrell, 1992; Staw, Sandelands & Dutton, 1981). It would have been difficult with the used methods to capture the differences and influences of factors when the psychological element would have been too strong. The purpose was not to focus on individuals' mental model, but to seek for generalities and patterns that would help to create the conceptual model. Crisis situation without the fear of injury to the participants themselves was the scope of the intensity and effect.

The setting was challenging since it required considerable amount of knowledge and learning from different disciplines: understanding human behavior, information technology, organizational theories, sociology and so on. This is why this dissertation is a combination of several disciplines contributing to understand this multi-perspective research area. Even though this dissertation focuses on time critical and possible crisis situations leaving out normal day to day basis work, the findings and lessons learned may still be applied in organizations to support all the organizational levels in preparing for incidents such as described in the case studies.

These tools and processes are the means to share information, but it is always up to the individual to make the decision on whether or whether not to share information inside and outside the team. In another words, we need to support the individuals in gaining the adequate level of situational awareness so that the decision of sharing or not sharing is based on accurate facts. The developed conceptual model aims to support this dilemma. There are numerous different situations when the individuals are not aware that others might need the information one possesses or does not know who the relevant actors are, what tools could be used to inform others or that is the person allowed to do so etc.

The creation of this dissertation has been an amazing journey, a research process that consists of two separate case studies and this dissertation concludes this journey with lessons learned and developed from the research data given by the maritime case studies. I have had the honor of being Finnish lead analyst in these MNE5 MSA and MNE6 MISA-EM case studies that provided me the front seat to see all the possible elements that have an effect on individuals and teams while trying to create an adequate level of situational awareness in challenging situations.

Next, I will present the case studies, research structure and goals from both of the case studies. As a conclusion of the learning experience of these case studies, the created conceptual model focuses on revealing the social, technical and organizational factors that support the information sharing. Addition to this the conceptual model presents evidence based ways to support the individual in gaining situational awareness (SA) and this is done by the created concept. We need to cut back everything that might weaken the individuals' decision making to be based on facts and to reflect the actual situation at hand. This is why the level of awareness of the information requirements cannot be highlighted enough. Once the individual has gained the level of awareness the support for information sharing becomes crucial. This is why the list of guidelines will be provided for the higher decision making level to ensure that the individuals have the organizational support along with tools and ways of working. The influence of social factors is difficult to measure and to pin point but it is very closely present. This is why also the mental processes and social factors are closely related to the research focus.

1.3 Case studies

This dissertation is supported by two case studies from Multinational Experimentation 5, Maritime Situational Awareness (MNE5 MSA) and Multinational Experimentation 6, Multinational Interagency Situational Awareness of the Extended Maritime environment (MNE6 MISA-EM).

Case studies are part of a wider Multinational Experiment series led by US Joint Forces Command (JFCOM). MNE series started from MNE1 in 2001 to develop better ways to plan and conduct coalition operations. Over ten years the MNE community has developed structures, processes and tools that are designed to make future multinational engagements in crisis interventions more effective and efficient (MNE5 Final Report, 2008. For more information see USJFCOM, 2003; 2005; 2007; 2010; 2011).

Figure 4 demonstrates the dialect between case studies and my dissertation process. Both case studies addressed maritime related challenges from different agendas and perspectives but both of the case studies had the same elements, need for situational awareness and information sharing that created a strong linkage to this dissertation and supported the creation of the conceptual model. The challenging nature of the maritime environment requires understanding of crisis context, complexity and change as critical elements affecting the studied environment. These factors are addressed in more detail in Chapter 2. Both of the introduced case studies gave crucial information to create the developed conceptual model from different perspectives: The MNE5 MSA case study focused more on technical information sharing but allowed to collect also data related to individual decision making and gaining of situational awareness. MNE5 case study required understanding of technological artifact's influence and more understanding of individual psychological elements and military decision making. These types of aspects are introduced in Chapter 2 by presenting the social elements and activity theory as guidelines that supported in understanding the case study environment.

The dissertation process
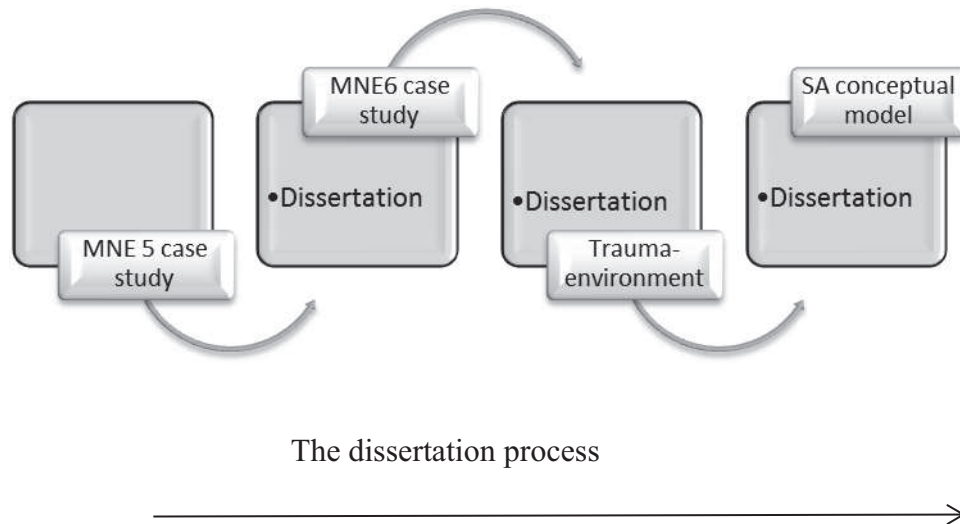
Figure 4:   Overview of the overall learning process

MNE6 case study focused more on team interaction, capturing and measuring situational awareness. This type of case study environment required understanding of the theoretical aspects of situational awareness but also organizational aspects that are discussed in more detail in Chapter 2. Since the created conceptual model is a creation of collective understanding along the process structured according to NATO Concept Development and Experimentation (CD&E) structure, the basic elements of the process are also introduced in Chapter 2.

Overall, the literature review is a collection of all the important aspects that I felt were important to recognize and understand while studying the case study environments, in forming research questions for the dissertation purposes, and in the process of creating the conceptual model.

This dissertation was done closely related to the case study research and the learning process itself has impacted the case studies and research questions that defined the framework for this dissertation. The findings and reflections to the presented conceptual model were also introduced to health care world to analyze whether the conceptual model could be

applicable also in other time critical organizations outside the military and/or maritime context. The findings from the comparison to the trauma center context are presented in Chapter 7. The overall conclusion of this journey I will present in Chapter 8.

Figure 5 demonstrates the overall learning process that started with the MNE 5 MSA case study, inspiring this dissertation, continuing with the MNE 6 MSA case study. With the lessons learned from these case studies the conceptual ideology was verified in another crisis environment, in health care context. From the overall results the situational awareness conceptual model was refined and is presented in this dissertation in Chapters 6 and 8.

This journey begun in April 2008, when I first time participated in a meeting with the MNE5 MSA community. I had the opportunity to influence to the factors that we would as an analyst team be interested in discovering. This first inspiring meeting gave me the courage to start drafting my dissertation research plan. Although the experimentation design had already been almost defined, we had the opportunity to implement our qualitative methods to the scenarios and get the needed data to analyze and understand the influences of the technological capabilities from the experimentations. The learning experience from the MNE5 MSA gave me good insight of the maritime context and with the learning experience from this case study I was able to support my new team in MNE6 MISA-EM with the lessons learned from the previous case study.

One major lesson learned was the importance of the experimentation and analysis documentation and following the agreed design. Also in the experimentation team it was important to understand the research goals and how all the elements from the scenario planning, experimentation design and analysis planning were important and needed to be linked to each other. For me it was important to highlight the theoretical framework and its importance to the research study we were aiming for in MNE6 MISA-EM. I had an amazing team and the entire MNE6 MISA-EM community understood the importance of the theoretical framework. I was honored to be the involved in the creation of the MISA-EM concept and contributing to the concept development with the theoretical aspects that gave the foundation to the conceptual work.

1.

Ede, Netherlands Apr 2008

First contact to the MNE community, creation of analysis plan

MNE 5 MSA

2.

Research interest to collect data for dissertation and focus on social interaction by widening the technical approach

Dissertation

3.

Lillehammer, Norway Jun 2008 experimentation and analysis plan refinement

Upinniemi, Finland Aug 2008, National event 1

MNE 5 MSA

4.

Enköping, Sweden Sep/Nov 2008

Event 2 experimentation and data collection

Dissertation

5.

Research question refinement, making of the interim report, preparations for Event 3 based on data from event 2

MNE 5 MSA

6.

December 2008 in Finland

Event 3 experimentation and data collection

Dissertation

7.

January-May 2008

Meetings in USA, Greece and Finland

Theoretical approach to campaign design planning

MNE 6 MSA-EM

8.

Widening the research focus to include also organizational elements and stronger linkage to SA

Dissertation

9.

May-September 2009

Meetings in Spain and Finland

SA theoretical framework as common language for concept development

MNE 6 MSA-EM

10.

Widening the theoretical aspects of social and organizational elements to include also CD&E ideology

Dissertation

11.

October 2009-January 2010

Meeting in Spain and Singapore

MNE 6 MSA-EM

12.

March, LOE 1 in Helsinki, Finland 2010

LOE results give guidance how what elements are crucial

Focus on team interaction

Dissertation

13.

April 2010
LOE 2 in Spain, Cartagena

LOE results supported the development of the SA concept creation for the Dissertation

MNE 6 MSA-EM

14.

May 2010 in Cartagena, Spain. Dissertation analysis supported also the analysis of the LOEs

Dissertation

15.

October 2010 in Helsinki

Finalization of the MISA-EM Concept

MNE 6 MSA-EM

16.

All the case study data was collected and data provided the opportunity to continue developing the SA Concept creation

Dissertation

Figure 5: Research process - linkage between case studies and dissertation

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As the MISA-EM work continued, it was easy to see how the theoretical framework gave the multinational team a common language and thinking structure. For me personally this has been my greatest award from the multinational cooperation to be able to contribute and influence the common interest and to support our team effort to succeed in our goals.

MNE6 MISA-EM allowed me to study the influences of SA from a team's perspective and the case study provided me vital information related to team processes. I was also able to observe closely team interactions in addition to the general goals of the experimentation related to the case study objectives. The lessons learned from the organizational perspective and seeing how SA affects the team's performance, it also guided me in my dissertation work to focus my research ambition.

1.3.1. MNE5 MSA

In MNE5 MSA the purpose was to improve situational awareness against maritime threats. Official statement for MNE5 MSA was: *"The understanding of military and non-military events, activities and circumstances within and associated with the maritime environment that are relevant for current and future operations and exercises". This description is based on NATO's working definition but without the restrictive interpretation of the term "maritime environment". In the context of MNE5 MSA, each partner is allowed to define a "maritime environment" most suitable to their roles, responsibilities and mission"* (MNE5 MSA final report 2008, 13-14). Different types of Multinational Experiments have been conducted from year 2001, in order to enhance coalition operations. First experimentation was executed in November 2001 and since then the MNE community has built up structures, processes and tools to improve future multinational co-operations. The Maritime Situational Awareness (MSA) track of Multinational Experiment 5 (MNE5) was launched to help develop processes and tools in a federated and distributed environment that increase information exchange and collaboration between MOC's.

The MNE5 MSA Area of Interest (AOI) was co-led by Finland and NATO (ACT) with participation from the US, Sweden. The research team

roles consisted of technical personnel, experimentation designers and controllers, scenario creators, and analysts. The MOC's consisted of one *intelligence* (intel) officer plus at least one operator. Each MOC was given an Area Of Responsibility (AOR) as designated in the Standard Operating Procedures (SOP). Operators were also given training on Memorandum of Understanding (MOU), Technical Agreement (TA), their own system, the SOPs, a brief overview of the other MOCs capabilities plus the problem planning process.

The experimental objective was to discover issues that affect the MOC team's performance, but also to observe the co-operation inside a MOC and between MOC teams. In international operations it is important to ensure that relevant information is shared among the participants to gain needed level of situational awareness. Operators from Finland, Sweden, NATO and Singapore were given the same settings and scenarios, and their MOC processes for information management and information sharing were observed as they attempted to solve scenario-based problems. Additionally, best practices were captured to assist nations in enhancing their own MOC processes. Also, at the same time the co-operation and interaction with the technical systems and other social actors were studied. For this dissertation case study provided the possibility to focus on especially gaining and supporting the individual situational awareness as presented in Figure 6, which demonstrates how the collaboration can be studied from inside the teams and between teams, especially focusing on to the individual level of awareness. Qualitative research methods observation, interviews, NASA task load index (TLX) and the Social technical organizational rating scale (STORS) and The Analyst Assessment Report Performance Rating Questionnaire (AAR PRQ) were used to gather the needed data from the experimentation to meet the following official MNE 5 MSA experimentation goals:

"*Improve information sharing and collaboration by developing a framework to share maritime information between international partners and coordinate global maritime security operations promoting transition from a "need-to-know" to a "need-to-share" culture.*
- *Identify IERs to support international maritime operations across multiple classification domains.*
- *Improve MSA processes by harmonizing human (functional and*

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cognitive) activities with emerging technologies resulting in improved concepts and streamlined procedures.

- *Develop technical standards which enhance shared maritime situational awareness and support decision-making among international partners compliant with relevant information security regulations.*
- *Develop and evaluate algorithms/tools to enhance maritime information collection, correlation, fusion, automatic anomaly detection, analysis, visualization, decision support, dissemination, and collaboration"* (MNE5 MSA final report 2008, 14-15).

The used methods and structure of the experimentation are introduced in more detail in Chapter 3, where the entire MNE5 MSA case study is presented with the results.
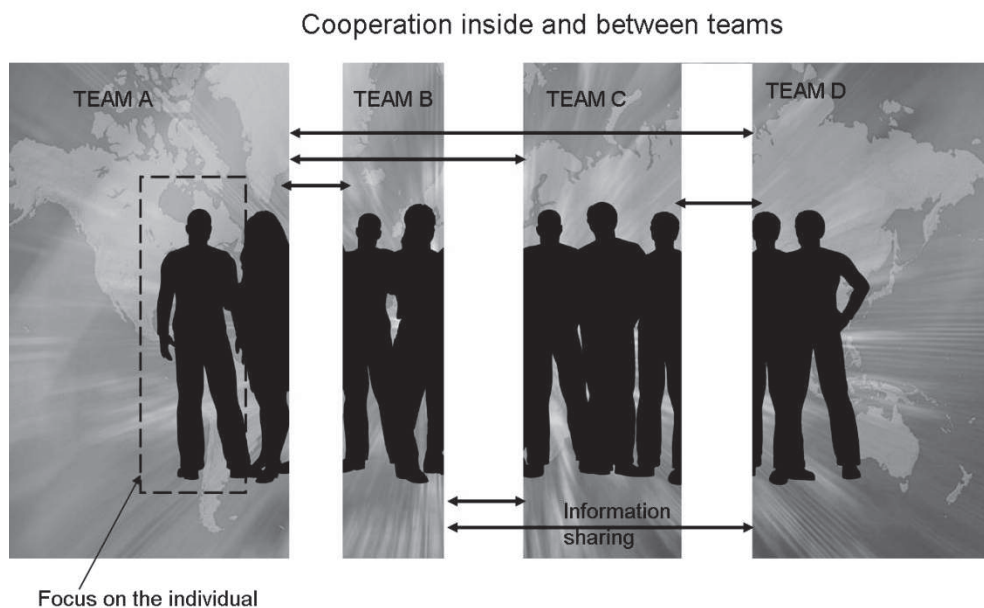
Figure 6:   The focus was to analyze MNE 5 MSA case study from the individual SA perspective

1.3.2 MNE6 MISA-EM

MNE5 MSA focused on situational awareness in domestic waters. MNE6 MISA-EM focused on remote or distant areas, where local capabilities hardly exist and the environment is not well understood. The case study provided the possibility to focus on the shared situational awareness (SSA) perspective as presented in Figure 7 that demonstrates the team interaction in a multinational collaboration.

Figure 7:   The focus was to analyze MNE6 MISA-EM from the shared SA perspective

The Multinational Experiment 6, Objective 4.2 consisted of two separate Limited Objective Experiments (LOEs). The aim of the LOE 1 was to prioritize the most important challenges in the maritime situational awareness in unprepared waters and analyze some of the solutions that the created MISA-EM conceptual framework proposed to address those challenges. New innovative solutions were also welcomed. The experiment was formed as expert panel, where both the facilitated discussions and the orchestrated assessments were captured through a

collaboration tool and analyst observations. The aim of the LOE 2 was to measure the level of situational awareness in the MISA-EM organization and compare the level of situational awareness with an organization that does not use the MISA-EM concept in distant theaters/unprepared areas. LOE 1 experiment team consisted of data collectors, analysts, experiment control and technical experts and SMEs. Main method in LOE was computer-assisted assessment (surveys). More details of the actual LOE and used methods are described in Chapter 4 in more detail. Based on the experimentation the MISA-EM conceptual framework was developed to create an accurate awareness of unprepared maritime environment, shared by the spectrum of involved stakeholders in a multinational framework, to facilitate safety, security and environmental protection. Used methods to discover the crucial elements from the LOE 2 were observation, structured interview, system logs and recordings, special tools designed to capture situational awareness elements. More details and information about the used methods are presented in Chapter 4.

The general goal of MNE6 MISA-EM allowed to observe similar elements as in the previous case study, MNE5 MSA, but also to add the multinational team perspective also to the research interest. With the opportunity provided by the MNE6 MISA-EM community, the focus for the dissertation purposes was to analyze MNE 6 MISA-EM case study from the both individual and shared SA perspective and again we have the same dilemma: We need to be able to separate the process of situational awareness and information sharing process from each other even though they are closely related. In order to the information sharing to be reasonable and effective, the participants in the information sharing process need to have certain level of SA.

1.4 Problem definition

The objective of this dissertation is to create a concept to support individuals in their attempt to gain situational awareness in crisis situations with a multinational collaboration in a complex environment. The overall goal is to present how an organization in changing situations can be supported by improving the level of situational awareness of the individuals

and teams to support decision making in all levels in the information sharing framework. Focus is mainly on how the roles and task division are done inside the team and how the tools and processes support their work and gaining situation awareness in the information sharing framework.

The presented different case studies provided the possibility to discover elements that support in developing the concept to support gaining of situational awareness. I had the opportunity as the Finnish lead analyst to be a part of the multinational experimentation team to the see all the interesting elements found in the case studies and to learn more about the context to create this dissertation.

The main product of this dissertation is the situational awareness concept to support gaining of adequate situational awareness in an information sharing framework from three different perspectives: 1) Technological solutions that include monitoring tool and guidance for the usage of technological tools, 2) organizational processes, implementation of the conceptual model and listing of critical functions and 3) social influences, all the elements that can be identified and supported in the information sharing framework. MNE5 MSA and MNE6 MISA-EM case studies gave the view of the maritime activities that provided a good example of the complex and time critical crisis environment.

From the organization perspective the focus has been limited to general view, modeling of the organizational functionalities and developing of the working processes and gaining support for the higher decision making level of all the crucial organizational elements that have an impact on the end results. The social aspect is supported by acknowledging possible challenges reflecting to the findings from the case studies. The problem formulation is focused on the Process of Situational Awareness Support for information sharing (PSAS) that guides individuals and supports their attempt to gain situational awareness. From the technological perspective a lot of things could be studied but due to limited resources I was forced to limit focus on to the usability and information sharing perspective that were the most critical views that guided the observation of technological challenges in the chosen framework.

As described above, the main objective of this dissertation is to model crisis situation support to gaining of situational awareness in a multinational collaboration. The presented case studies support modeling of the

maritime environment and gave a good starting point for understanding time critical crisis environments. This research answers the following questions:

- What are the elements that support or hinder information sharing in co-operations?
- What factors affect the individuals in gaining situational awareness in co-operations?
- How can we support individuals and teams in gaining situational awareness in co-operations?

How these objectives and research questions are met, is analyzed in an iterative process between the case studies and reflecting the created Concept to the case study findings. My goal and intention was not to create a list of facts and claim that by following these steps from the beginning to the end, you will avoid miscommunication in a crisis or there will be no system failures if these procedures are taken. On the contrary, my aim has been to develop the concept along with processes and guidelines to help individuals inside the organizations realize and familiarize themselves with factors that are – based on the evidence from the case studies – proven to be crucial elements that have huge impacts on the organizations tasks all the way from the individual and team level to the highest decision making level. This aim to connect the different pieces of the information sharing puzzle for the understandable framework that includes all the affecting and related elements that exist in cooperation is presented in Figure 8, explaining how collaboration can be examined also from inside a team, from individual perspective. The support is given to gain adequate level of SA for the individuals to make decisions related to information sharing based on facts relevant to the co-operation.
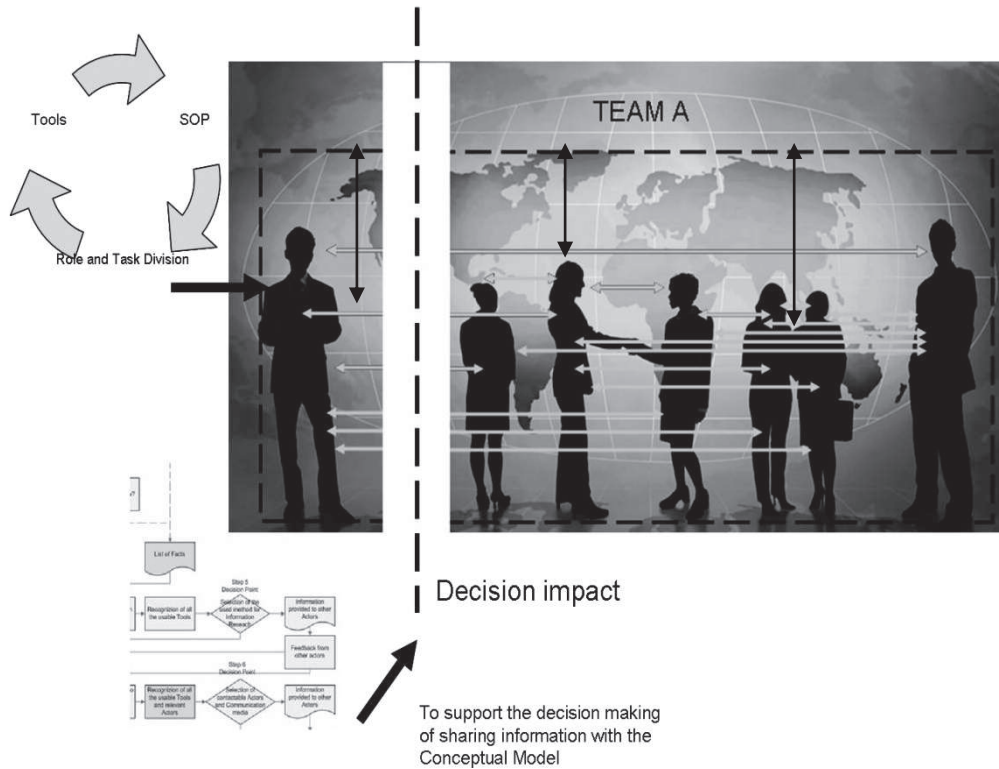
Figure 8: The support for decision making in the information sharing framework

1.5 Scientific contributions

This dissertation presents the concept, created with inspiration from the maritime environment, to be used as a general support for other challenging environments as well. To formulate the findings and support to the maritime environment as well to other environments, the concept is written to follow the ideology of NATO concept development and experimentation (CD&E) process. To begin this journey, along with me I had a set of data, theories and methods that provided me the framework for this research. I will draw a storyline all the way from the maritime operation center to the health care world. As a testimony of this journey I hereby claim the following contributions for my dissertation in the order of importance:

Contribution 1: **Development of the conceptual model to support gaining of SA in the spirit of Endsley's theoretical approach** is presented in Chapter 7. The Conceptual Model consists of three different separate products: 1) SA model to support the higher decision making level of the organization and 2) Supporting Process for the *operator*s in MOC teams for training purposes, 3) Monitoring tool that will provide for the information systems development an instrument to view SA criticalities. Second product was originally presented in Stockholm's contribution in Military Technology, No. II, 2010, p. 121-139. Third product was originally presented in Journal of Military Sciences, Vol. 1, No. 1, 2010, p. 55-77.

Contribution 2: **Modeling of the maritime environment and its elements related to situational awareness by introducing the case studies and comparing them from both national and multinational perspectives** are presented in Chapters 3-5. I will take you to the world of maritime environment, the setting where the data was collected. I will draw a picture of the fascinating maritime environment of the case studies that provided a lot of vital information from all the elements affecting the level of awareness and decision making in the information sharing framework. Insights from the experimentations are provided from both national and multinational perspective. I will also analyze how national organization (from the MNE5 MSA case study) versus multinational organization (from the MNE6 MISA-EM case study) functioned with a certain structure, discovery of the benefits and downfalls. Case study analysis is presented in User's view on battle space systems in Finnish National Defense University Department of Military Technology, Ser. 3, No. 9, 2009, p. 23-41, and in Tiede ja Ase, No. 67, 2009, p. 86-109.

Contribution 3: **Creation of the situational awareness concept** to support information sharing in a multinational collaboration presented according to the NATO CD&E process is presented in Chapter 2 and analyzed in Chapter 6.

Contribution 4: **Verifying the conceptual model in a health care environment**. I will present the developed conceptual model and SA concept applicable for different crisis organizations that have similar time-critical and emergent situations part of the organizational function, as demonstrated with the health care environment. Health care environment and maritime environments are not identical, but they share similarities due to the crisis environment where the need for supporting

situational awareness and decision making in time critical events is required. Health care environment was a good context to reflect the conceptual maturity. Discovered findings are presented in Chapter 7.

Contribution 5: **The dialogue between theoretical aspects of situational awareness and organizational theories**, their combination and output for the practice is presented in Chapter 2. This dissertation brings theoretical discussion and demand for practicality closer together. My goal has been to demonstrate how theoretical frameworks and methodologies can have important influence on real life development and how theoretical thinking can be used as a bridge builder for multinational collaboration. This dissertation focuses more on practical implementation than theoretical debate but the influence of the theoretical impact is indisputable: The dialect between supporting theories and real-life applications hopefully encourages other researchers also to take a stand for the practical implications of theories. I used process modeling and design rationale as supporting methods for capturing the essential phases of this learning experience. Lessons learned from this venture are presented in Chapter 8.

1.6 Structure of the dissertation

Chapter 2 presents an overview of the literature related to theoretical aspects to understand the information sharing framework and situational awareness (SA). Case study from MNE5 MSA, especially from the national perspective, focusing on individual aspects to situational awareness, is presented in Chapter 3. Chapter 4 presents case study from the MNE6 MISA-EM, especially from the multinational perspective focusing on team aspects to shared situational Awareness (SSA). The comparisons between the case studies from the national and multinational perspective, and from the individual and team level, are presented in Chapter 5. The created conceptual model and product related to the entire conceptual model is introduced in Chapter 6. Chapter 7 evaluates the usefulness of the conceptual model in other environments by comparing its functionality to the healthcare environment. Conclusions of the development process of the concept in the form of situational awareness concept and also guidelines for future research related to this field are presented in Chapter 8.

2 REVIEW OF THE LITERATURE

The complexity of the maritime environment required the contextual elements such as change and crisis need to be included in the theoretical discussion. Also military decision making in terms of the Observe, Orient, Decide and Act (OODA) model is introduced as one model to view the decision making process. Since the outcome of this dissertation, the conceptual model, is created according to NATO standards, also the Concept Development & Experimentation principles are introduced. The theoretical foundation of this dissertation underlies in organizational and social theories that give the basic ground to understand how organizations function in this particular framework. Situation Awareness (SA) theory gives the insights of the elements that as a combination affect the framework for sharing information. The literature review is a combination of an information asset that I needed in order to understand the case study environments. All the relevant basics are presented to the reader to demonstrate the wide variety of elements needed to be taken into account, when creating conceptual framework of this complex environment.

2.1 Information sharing frameworks

In the literature review focus is on the issues surrounding this fascinating field of situational awareness reflecting the organizational perspectives. The approach was from the beginning to learn about different organizational aspects that support in understanding the framework related to the conceptual model that has been created to support situational awareness in co-operations. This Chapter presents the findings related to the theoretical dialect and literature. While searching through potential theories it was possible to build up the level understanding of the organizational aspect, influence and contribution to the conceptual model. In this Chapter, reader will be walked through the interesting views and interpretations of from the field of organizational theories that supported understanding the information sharing framework and the process of creating and developing the conceptual model. The organizational and individual perspectives are also presented. Since actions and more

distinctively decision making is one of the main focus in this framework, it is only natural to include understanding of the activity theory to understand the elements related to activities in organizations. One of the elements in this context is also the technological tools that will be highlighted since technological capabilities play also an important role in information sharing as an enabler of communication. Since the case study environment and context are challenging because of rapidly changing situations, also the influence of crisis need to be studied. Let us start by focusing to crisis and change perspectives and their influence to the collaboration environment.

2.1.1 Crisis and change – understanding the environment

First it is important to focus on analyzing the meaning of crisis in organizational theories to get an understanding of its meaning in this context. We need to notify that small unusual events all the way to crisis have both individual and organizational level impacts. As Wang (2008) recognizes that even though effects of crisis have been recognized, still there has not been enough effort put to tackle this issue. As Wang (2008) highlights, the need is to realize the dynamics and interconnectedness of crisis management, organizational learning, and organizational change since current organizations function surrounded by uncertainty, risk, and turbulence. Despite of the scale, crisis events have impacts on both individuals and organizations. Wang (2008) talks about avoiding or reducing impacts, by practice of crisis management. It is evident that in order for organizations to survive, adaptability, competitiveness, and long-term viability are required (Reason, J., 2004; Barnett & Pratt, 2000; Clampitt, & Williams, 2000; Ulrich, Mitroff, 1993; Jick, & von Glinow, 1993). These requirements fit the profile of the maritime environment. This is why it is grounded to study organizational crises from different perspectives to get a better understanding of how crisis is been seen in the research community. Psychological perspective brings forth the essence of crisis as formation of uncertainty, complexness and emotional events in limited information processing capabilities. Irrational behavior and errors affect individual's decision making and this is why the role of individuals cannot be highlighted enough in organizational crisis management.

From the social perspective Weick (1993) and Habermas (1975) see problems in role structure, leadership and cultural norms, Turner (1976) describes crisis occurring as a breakdown in collective sense making. All of this emphasizes the individual's way of reasoning and acting in sudden and unpredictable situations where normal rules do not apply. Even though literature still treats crisis management as combination of planning, preparation and prevention as key issues, Pearson and Clair (1998) see crisis management efforts when sustaining and resuming operations, minimizing stakeholder losses and applying lessons learned for the future.

Albritton (2010) states that even though change management and used information systems fit the organization's needs, the next, implementation creates the challenge: The complexity of information technology and continuously changing environment appear often unexpectedly since the information systems enable these rapid changes. It is challenging that changes, even though how controlled and organized, create usually also unanticipated changes. This is why it would be preferable to focus on recognizing and accepting the changes and instead of focusing the energy to controlling and planning change management. As Albritton (2010) also highlights that the focus should be on flexibility, when the general goal and objectives drive the potential changes.

Information technology and technological changes make issues more complex and this is the reason why improvisation and sense making are factors that have a huge difference since organizations include different actors with different assumptions and expectations inside the organization. This view underlines also the need for the "map" to understand organizational needs related to change since the organizations are combination especially of the actors that with the given technological tools do the tasks that are related to the goals of the organization. Individuals act based on their interpretations of the world. This is why it is important to understand how individuals make sense also of technology. It is evident that in major technological changes misaligned expectations, contradictory actions, resistance, skepticism, and poor appropriation of IT may occur (Davidson 2006). But when we are focusing on organizational changes and emergent situations, it is not just about technological change but the focus should be, as Davidson (2006, 26) mentions, in frames related to information technology features and attributes, frames related to organizational applications of IT, and frames related to incorporating IT

into work practices.

McLoughlin et al. (2000) point out related to introduction of new technologies that we need to recognize and understand the processes by which the organizational outcomes of technological change are shaped. This is relevant also with the existing technologies when changes in situations and usage occur. We should not forget that not all changes are planned and expected. Crisis situations can have huge impact on the processes and performance of the organization. Weick (1988) characterizes crises by low probability/high consequence events that threaten the most primary goals of the organization. Since the low probability, these events challenge interpretations and impose severe demands on sense making (For more information related to sensemaking, see for example Hutton, Klein & Wiggins, 2008; Klein et al., 2007; Klein, Moon & Hoffman, 2006a; Klein, Moon, & Hoffman, 2006b Gioia & Mehra, 1996).

These issues related to crisis and change have briefly identified issues such as influences to organizational processes and primary goals, used technological tools and especially the influences on the individuals behavior inside organizations. (For more information, see for example Grant & Marshak, 2011; Smith, & Graetz, 2011; Choi & Ruona, 2010; Latta, 2009; Blokdijk., 2008; Kling & Lamb, 1999). It is important to understand the environment and how the emergent situations and changes affect the organization and the individuals working towards the common goal. After identifying these affecting elements, we can move on towards for the attempt to understand the context related to complexness and uncertainty: introducing the key elements and reflections to the organization.

2.1.2 Complexity and uncertainty – understanding the context

A refreshing view to crisis comes from Power's ideology and statement on how complexity and uncertainty are issues that should be taken into account. He emphasizes that this complex phenomenon in organizations do not follow the traditional forms of risk management (Power, 2007). From aspects mentioned, it is possible to learn and develop methods to avoid failures in emergent situations. According to these ideologies, learning is an important element to take into account (see for exam-

ple Senge, 1993). As Kuchinke (1995) mentions elements that crystallize organizational learning to use past experience as learning basis, collecting knowledge, organizational change, identifying, preventing and resolving problems and using the organization as the unit of analysis. Kuchinke refers learning as *"a fundamental mechanism by which organizations, as open systems, interact with their environment, process information, and adapt to changing external and internal conditions"* (Kuchinke 1995, 308). One major impact to the organizational change is the discussion about shifting to address change and recognition of the importance of context as Sturdy & Grey (2003) states. Kahneman et al., (1982, 508) define uncertainty as a

> *"…fact with which all forms of life must be prepared to contend. At all levels of biological complexity there is uncertainty about the significance of signs or stimuli and about the possible consequences of actions. At all levels, action must be taken before uncertainty is resolved, and a proper balance must be achieved between a high level of specific readiness for the events that are most likely to occur and a general ability to respond appropriately when the unexpected happens."*

It is challenging to understand and measure how individuals learn to operate in such uncertain situations. How to measure and identify the level of tolerance for uncertainty? Again, this aspect seems to be more related to individual ability and it is up to the organization to create the working environment to support individuals in situations where the complexity of tasks and uncertainty exist since certainty is defined by Campitt & Williams (2000) as something that is fixed or settled, with the notion that distinction between certainty and uncertainty is not an either/or proposition. In the end it is up to the individuals, how they embrace uncertainty and illustrate their tolerance level. Hofstede (1984) identifies societal rules, rituals, educational standards, religious orientations, and technologies to be recognized as cultural forces that shape an individual's responses to uncertainty. It is safe to say, that organizations differ from each other from the complexity perspective but every organization have their own challenges due to the complexity of the working environment and

uncertainty factors. Emergent and evolving situations create circumstances where the actors face situations that challenge their working context and performance. This is why complexity and uncertainty are elements that need also to be taken into account when trying to find ways to support the individuals and the entire organization to maintain the adequate level of performance despite the changing and challenging situations. The jump from complexity and uncertainty to the action level to understand the social element – actors – is the next logical step in trying to understand how these elements match and mismatch.

2.1.3 Actors and actions – understanding the social element

King, Felin & Whetten (2009) want to emphasize the distinctive qualities of organizations. They raise important question on how does the organizations differ from the social forms? Organizations consist of individuals interacting with each other and it would be natural to see organizations as network of social actors working together to reach a common goal, although the common goal can be argued to not be the same for all the individuals even though that would be the ideal state. Actors are identified according to King, Felin & Whetten (2009) the way they are perceived and interpreted by others. This is presented as actors capability for decision making and behaving of own volition, to make decisions. Actors are hold accountable for the made decisions also in the individual level. These factors distinguish actors from other entities. King, Felin & Whetten (2009) see organizations as actors since the society, legally, practically and also linguistically grant the status for organizations. As Bauman & May (2001) also identify organizational status deriving from others. All this comes down to action level and it can be agreed with the view that actors are seen through the ability to take action.

le Roux & le Roux (2010) discuss about the role of sense making as framework to study organizational contexts and roles in facilitating coordinated action. Sense making is individual's continuous effort to understand and act efficiently in an environment as a combination of people, places and events. We as individuals build up our frame of reference of tacit knowledge while trying to understand otherwise ambiguous social and situational information. With these frames we are able to position,

observe, identify and label signals that are produced by their contexts. These steps shape our individual interpretations of organizational events and guide us to make sense of the situations and to take actions. Even though individual sense making is something that only the individual possesses, le Roux & le Roux (2010) mention shared frames and collective cognition, that support the fact that sense making and support of individuals construction of their social reality can be supported by organizational structures and organizational ways of working. But this is not an easy task, as Weick (1995) warns that sense making as a social process should not be handled as equivalent with shared understanding since joint actions might not need shared frames. It has not been solved how these frames are sources of innovation, but more importantly it is critical to understand that individual interpretations and organizational context are relevant elements when trying to create structures and/or processes that support individuals in their attempt to gain the needed situational awareness to complete their tasks. (For more information see for example Freese, 2009).

After identifying elements related to sense making, it is time to move forward to explore more relevant elements that contribute to the individual's actions. Next the Activity theory is explained.

2.1.4 Activity theory – understanding the relevant elements contributing to the action

Activity theory gives insights to elements that focus to functions that are surrounded by the context. After understanding the activity theory, it is important to know how the community and its rules and division of labor are connected together from the organizational perspective. As Kuutti (1995) has stated that the action is focused on the target which means that actions are separated from other activities through objectives. When we change the target to result that we are aiming for, it motivated the existence of the action. Like in the maritime context, the target is the maritime traffic and when we transform the target to result, such as making sure that we have a the needed recognized maritime picture (RMP), where all the vessels and actions are identified, we are motivating the existence of the action. Or, like in health care, the patient's welfare is the

collective motivation and the driver for the action. In order to proceed with the object and action, the individual, actor, needs to have also all the other elements from the activity model, including rules to regulate activities, tools used by the actor, subjects that are the actor engaged in the activities, objects to be the targets of the activities, community providing the social context and division of labor giving the hierarchical structure of activities as presented in Figure 9. For more information, see Engeström, 1993; Engeström et al., 1999.
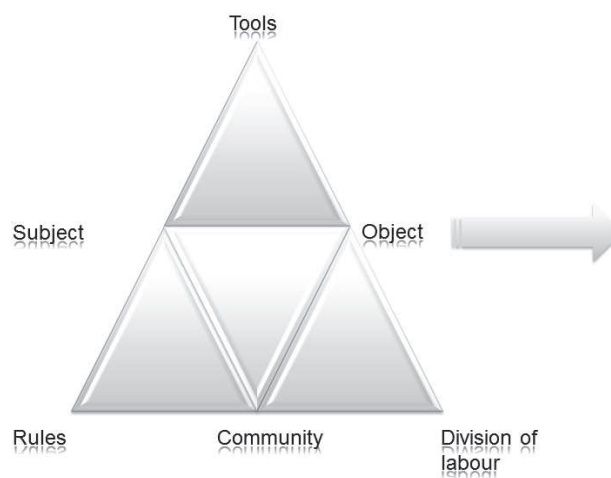
Figure 9: Activity theory elements

2.1.5 Tools, tools, tools and technology

Like demonstrated in the activity theory model, technological tools are seen as one crucial element. In the maritime environment, technological capabilities play an important role and this is why the technological perspective in action needs to be taken into account.

Orlikowski (1992) highlights structuration as a social process where rules and resources used by the individuals mediate human action. As she is referring to Giddens notes (1984. p. 22): *"All social actors, all human beings are highly 'learned' in respect of knowledge which they possess and apply, in the production and reproduction of day-to-day social encounters".*

According to Giddens (1979, 144) it is important to acknowledge that knowledge of individuals (Actors) is to an extent limited by the nature of action, the difficulty of articulating tacit knowledge, unconscious sources of motivation, and unintended consequences of action. Orlikowski (1992) has tried to seize the technological perspective to structuration by understanding how the technology can embody rules and resources constituting the organizational structure. Even though technologies are created and changed by humans, we use technology to accomplish some of our actions. The amount of actions related to technology is increasing every year. This is why the structuration and technological awareness needs to be raised, as Orlikowski (1992) refers to the duality of technology. This model consists of human agents that are defined to be designers, users and decision makes. Technology is identified as material artifacts and institutional properties of organizations, including organizational dimensions as presented in Figure 10 (Orlikowski, 1992; 410).
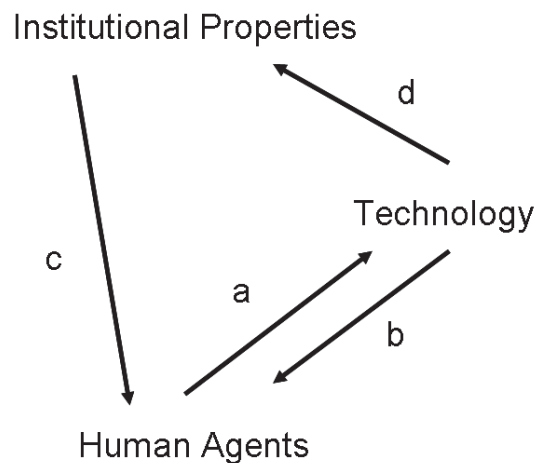
Figure 10: Orlikowskis Structurational Model of Technology

The explanation of the arrows and influences of the Orlikowskis Structurational Model of Technology are explained in Table 1 (Orlikowski, 1992; 410). Orlikowski & Barley (2001) raise a question how agency shapes the way technologies affect work practices and organizational structures.

Table 1.   Orlikowski's Structural Model of Technology

Arrow	Type of Influence	Nature of Influence
a	Technology as a Product of Human Action	Technology is an outcome of such human action as design, development, appropriation and modification
b	Technology as a medium of Human Action	Technology facilitates and constrains human action through the provision of interpretive schemes, facilities and norms
c	Institutional Conditions of Interaction with Technology	Institutional Properties influence humans in their interaction with technology
d	Institutional Consequences of Interaction with Technology	Interaction with technology influences the institutional properties of an organization, through reinforcing or transforming structures of signification, domination, and legitimation

While technologies are considered to be both social and physical objects, it is essential to understand that technologies reflect human agency in many ways: we attend to shape the implications of technologies when they became part of our everyday tradition (Orlikowski, 2000). Related to technological capabilities, definition Quality of Service (QoS) is also important when analyzing the level of quality of the technological solution used as an enabler of communication. Originally QoS was designed to include technical parameters such as service response time, loss, interrupts etc. (For more information, see for example Sanchez-Macian, 2006; Lock & Sommerville, 2005; Liu et al., 2004)

This is why Barley (1986) states that since similar technologies can be embedded in many different ways to different social systems it will create

altered social outcomes.

Barrett et al., (2006) raises again the importance of ICT (Information and Communication Technology) associating with several aspects of organizational change, as presented in his early work. The connections between ICT and change, has not been studied as much as needed and as Orlikowski & Barley (2001, 158) declare:

> *"research that embraces the importance of simultaneously understanding the role of human agency as embedded in institutional contexts as well as the constraints and affordances of technologies as material systems".*

Like Avgerou (2000) has already discovered in a long-term historical case study that Information Technology (IT) cannot be seen a merely response to organizational change dynamics. Just the opposite Avgerou (2000) argues that IT itself with its own set of norms and patterns is an institution that interacts with organizational practices. It is an alarming signal to see current organizations struggling with IT problems that reflect more severe problems than just technical malfunctions. The unfortunate trend has been to create new IT systems, but forgetting the main part of the organizations: the actors, the individuals working for and committed to achieve the goals of the organization.

As Barrett et al. (2006) have also pointed out that technological aspects in organizational change need to be viewed both from the organizational and information system studies in order to understand fully phenomenon related to IT today. In this dissertation both sides of the coin will be studied order to get best possible view of the field today. Berends & Lammers (2010) talk about the comprehensive 4I framework that integrates and extends previous findings, while its conceptualization of interacting processes at multiple levels allows for the analysis of complex process dynamics. The framework created by Crossan et al. (1999) includes processes that are intuiting, interpreting, integrating and institutionalizing. This framework is interesting since it also includes important aspect, collective sense making from the interpretation level all the way to institutionalizing level, where the learning of individuals and teams is embedded to organization level.

Chiva & Alegre (2005) discuss about technological frames and how

they are constructed by organizational actors who discover how technologies can be incorporated into ones specific activities in the organization. The case studies presented later on, can confirm that individuals are innovative and they can find multiple ways of using technology in their tasks. This can be seen as a beneficial asset or it can be seen as a challenge and deviation in organizational processes. Nevertheless, this issue needs to be acknowledged and tackled in order to support the work of the individuals and by that to reach the organizational goals. (For more technological perspectives, see for example Hugh & Holtzblatt, 2009; Menold, 2008; Mausolff, 2004).

2.1.6 Organizational knowledge and learning

As mentioned earlier, it is important to understand how technology has an wide range impact to the organizational change as well as individuals using it. This is why it is also important to mention and discuss about organizational knowledge and learning as well.

Chiva & Alegre (2005) define organizational learning as social activity since the organizational learning arises from social interactions in the working place. This is why the organizational learning focuses on individuals' interpretations and/or sense making of their experiences at work. If we agree on that reality is a product of social construction, and if we accept that knowledge is based on social interaction, we treat knowledge as an act that constructs or creates – not just represents as Chiva & Alagre (2005) define it. This highlights the importance of supporting individuals at work in their learning processes and team effort in order to perform the tasks at hand. (For more information related to organizational issues, see for example Miller & Lin., 2011; Fischer et al., 2005; Santos & Eisenhardt, 2005; Nevis, Ghoreishi & Gould, 1995; Meindl, Stubbart & Porac, 1994; Lyytinen & Nurminen, 1992).

2.1.7 Military decision making – OODA-loop

Since the case study environments are related to maritime and military environment, it is evident that this context also influences the chosen

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perspectives. The Observe, Orient, Decide and Act (OODA)-model is well known in military studies and logical approach to use to analyze the case studies and try to develop the framework.

OODA-loop, originally defined by John Boyd (1987), consists of four main steps: observe, orient, decide and act. Modified loop of OODA is presented in Figure 11 (Grant & Kooter, 2005; Brehmer, 2005).
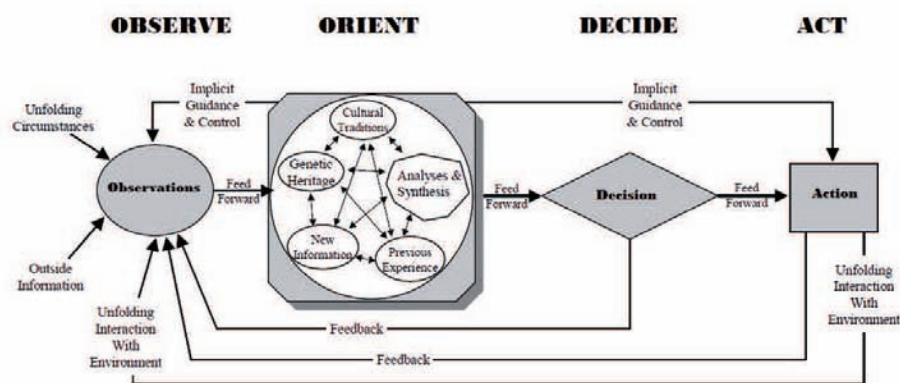
Figure 11: Modified OODA-loop

It has been identified, that OODA-loop does not address an important parameter such as time. The basic foundation of the OODA-loop is in the sequential way of collecting information, processing it, making decisions based on the information and acting according to the decisions. This simplified way of presenting the decision making lacks the dimension of multi-processing, that is today implemented in real-time systems, also in this model the decision making is seen as sequential event instead of parallel process.

OODA-loop fits to a world of sequences, to the step by step moving processes, but when the focus is shifted to crisis situations, is the process staying continuously in the decide-phase? This way in the decide-mode, the decisions are made based on the rules from the orientation stage and inputs from the observe stage. The decisions are the outputs that reflect the act-stage in the original loop. It has also been identified, that OODA-loop does not consider all the possible delays that affect the reaction time

since individuals processing abilities are limited, which causes delays especially in the observe and orient stages.

Dynamic decision loop in Figure 12 presents relevant sources of delay that are **ramp up time**, meaning the time between the initiation of an act and that when the act starts, **the time constant**, which is the interval between start of the action and taking effect, and **information delay,** which is the interval between achieving the result and decision maker being aware of the result. One relevant source of delay is also the **decision time**, the time from information to decision, which relates to the observation stage (Grant & Kooter, 2005).

Guitouni, et al. (2006) underline that in the Command and Control (C2) context, OODA-loop has been useful from the military decision making perspective to understand the commander's decision making process. The critique focuses on OODA-loop being deficient in a common context.
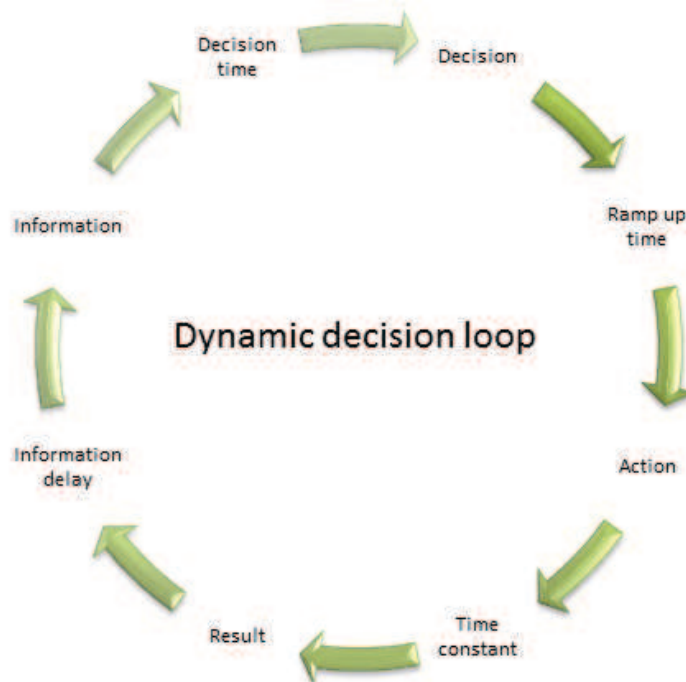
Figure 12: Dynamic Decision Loop

It is obvious that several uncertainties, effects and outcomes are involved in military decision making but as Guitouni et al., (2006) also state that despite the organizational function, decision making also in other environments influence the behavior and the wellbeing of organizations, employees and in some cases also communities and countries.

This dissertation focuses especially on decision making in the MOC team level by supporting the individuals in their attempt to gain needed SA for decision making. Higher decision making levels benefit from the end product, the conceptual model, which aims in better situational awareness that influences also the higher decision making levels.

Since the goal is to create a concept to support gaining adequate level of situational awareness, in order to have enough relevant information for decision making, OODA-loop and aspects related to military decision making are also relevant. Since the attempt is also to focus on adaptability and to create a concept that is applicable in other environments, the literature presented in this dissertation gives the empowerment to pursuit this goal since it has been noticed that there are many correlations from the military environment to different organizational contexts.

Next, more literature reviews of theories behind situational awareness are presented and explained how they can be used as an supporting way of understanding the multinational collaboration with all the possibilities and challenges. (For more information related to decision making, see for example Gustavsson et al., 2011; Strong & Volkoff, 2010; Walker et all, 2009; Klein & Steele-Johnson, 2007; McLucas, 2003; Heath & Sitkin, 2001; Weber, & Hsee, 2000; Corner, Kinicki & Keats, 1994).

2.2 Theoretical foundations of situational awareness

By being aware of what is happening around you, in order to understand how information, events and your own behavior will affect on your goals, you have situation awareness. SA is required especially in working environments where information flow can be high and serious incidents may occur based on poor judgment and decisions. In order to make successful decisions in complex environment and dynamic situations,

it requires SA. (See for example Durso & Sethumadhavan 2008; Carayon 2006). As Wickens (2008) states that when addressing situational awareness, we need to understand that it is not action or performance. It is not either same as long-term memory knowledge or the SA product is not same as the situational awareness updating process.

If we continue further deeper to SA, we need to understand that in order for the team to perform effectively, SA is needed to support the collaboration. Endsley (1993) states that generally speaking one might expect reduction in SA to be associated with reduction in performance but the loss of SA simply puts the actor at increasing risk of a performance error such as false action. In a challenging environment such as maritime operation we want to minimize that risk of making a wrong decision (Artman, 1999, 1998; Endsley & Rodgers 1994; Endsley 1993).

2.2.1 Individual SA

According to Endsley (1995b) the main stages of SA are perception, comprehension, and projection. The first level of SA, perception is to perceive the status, attributes, and dynamics of relevant elements in the situation. It also involves the processes of monitoring and simple recognition, which leads to multiple SA elements (objects, events, people, systems, environmental factors) and their current states.

The second level is comprehension. It involves a synthesis of disjointed perception elements during the pattern of recognition, interpretation, and evaluation. Comprehension requires information to be integrated to understand how it will impact upon the individual's goals and objectives. A comprehensive picture of the world or of the portion of the world is being developed.

The third level is the highest level of SA, projection. This level involves the individuals' capability to project to the future actions of the environment's elements. Individual achieves the level of SA through knowledge of the status and dynamics of the two previous steps and by using this information forward in time to define how it will change the operational environment's future state.

It is crucial to understand that individuals have their own awareness and elements that inside a team are being shared in a different setting

when the ways of communicating, the team processes and shared models affect the team performance (See Bolstad & Endsley 2003a; Redmiles 2002; Endsley & Jones, 1997. For further reading about team performance, see also Bresman, 2010; Solansky, 2008; Mathieu et al., 2000). Perception is recognizing elements around you, comprehension is interpreting information, creating understanding of the situation and projection of what will happen next. It is also important to include the temporal and spatial elements to the SA discussion (See Langan-Fox, Sankey & Canty 2009).

2.2.2 Team SA

When we are looking at team SA, it does not mean that every team member needs to have high SA about everything, but they need to have high SA of the factors that are relevant for their tasks. Inside a team the team SA consists of the individual team members SA from their own responsibilities. Figure 13 presents the team SA, where each team member with their own goals contribute to the team goal by having needed SA level of their own SA requirements. It needs to be noted that situational awareness is not symmetric, as discussed later related to the shared situational awareness (Endsley & Jones 1997, 36).
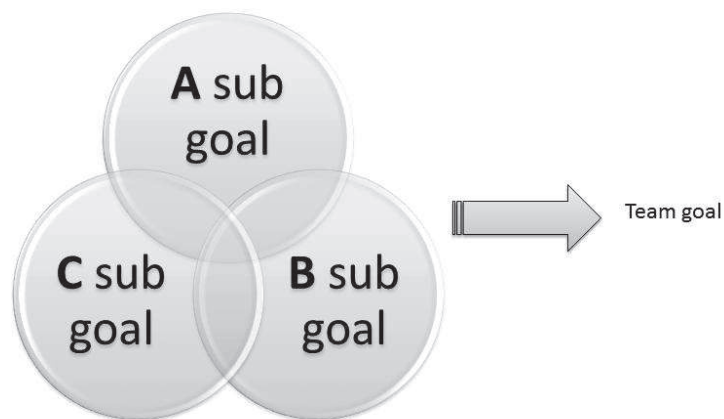
Figure 13: Team SA

Similar to team SA, which has been defined as: *"the degree to which every team member possesses SA required for his or her responsibilities"* (Bolstad & Endsley 1999, 1), important element in the co-operation is the awareness of other teams and participants involved in collaboration.

2.2.3 Shared situational awareness

Shared SA is a challenge within teams and between teams especially in cases, where teams are distributed in terms of space, time or physical barriers like demonstrated in the case studies (Bolstad & Endsley 1999). As Endsley & Jones (1997, 38) stated the shared situation awareness means the state where the individuals inside the team possess the same SA on shared SA requirements. Figure 14 demonstrates the basic structure of SSA according to Endsley & Jones (1997), where team members as A, B and C. Areas marked as AB, BC, and AC represent the extent, where the team members are creating a common situational awareness. ABC represents the same SA on shared requirements inside the team. In order to build Team SA, it requires SA of team processes, team devices, team mechanisms and team requirements. SA steps from creating an individual level SA to team SA requirements guide towards the shared SA (SSA) Endsley & Jones 1997, 38). Endsley's model raises important question about, how we see team SA and SSA, reflecting the Figures 13 and 14. They can demonstrate the reality, information that individual truly possess, relevant for the team. This leads to the question of individual differences and asymmetric activities. This, on the other hand, gives the possibility to see the Figures 13 and 14 also as descriptions of the ideology, on what individuals should possess, in order for the team to gain the needed level of awareness. This highlights the dilemma in research, since we cannot observe individuals own SA directly and measure it. How can we be sure of the level of awareness of the individual being observed? The study requires observing also the reactions to the injects and information given and received by the individual. This always has the possibility of misinterpretation, both ways, since individuals creation and maintaining SA is not aligned with others.

Ideology or reality – main support from the models is the understanding of the challenge of gaining and maintaining SA. It is very individual depended but also team is facing challenges in getting adequate level of awareness to function better as a team towards set goal.
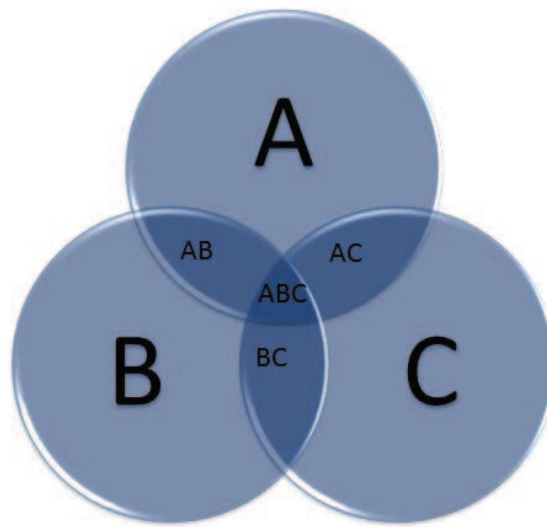
Figure 14: Shared Situational Awareness

If we simplify, SA stands for knowing what is happening around you (Endsley, 2000a). Cannon-Bowers, Salas, & Converse (1993); Peterson et al., (2000) describe shared mental models as cognitive representations of task requirements, procedures and role responsibilities that members hold in common. Shared mental models are seen as concepts aiming for the development of shared understanding among group members. In order to work as a team in a coordinated way, a shared understanding between group members need to be established (Cannon-Bowers, Salas, & Converse, 1993).

Rapidly changing environments, such as the maritime environment, forces team members to perform in complex situations. If team members have identical models of how their team, their task and their environment function, they can coordinate their actions implicitly, even though is not

necessary or even a wanted that the team member would have completely overlapping awareness (Peterson et al., 2000).

There are identified differences among individuals on what their ability is to develop needed SA according to Endsley & Bolstad (1994). The demanding military environment causes challenges for developing SA but there is also a significant difference between individuals on how well they are able to detect and assimilate information and to gain a complete understanding of the situation. Endsley et al. (2000) state that number of factors most likely have an effect on SA ability and they may involve pattern matching skills, perceptual speed and attention sharing capacity. Having said that about the basic capabilities, it is necessary to point out that training and experience support the development of mental models in order to form SA. This is one of the key issues: First we need to identify the needed elements to support us gaining the adequate level of awareness and then we need to focus also on the training and providing the team members with concrete situations where they can develop their abilities and get more needed experience.

As Endsley et al. (2000) point out the need for training and experience; Strater et al. (2001) emphasize the importance of feedback in learning process. It is not useful to repeat tasks without the knowledge of results on what was done right and what needs to be improved. Strater et al. (2001) point out studies that have shown the improvement in individuals performances in trials were feedback was given as a part of the whole process. Also, the organizational level feedback has been recognized to be highly valuable: To support the individuals in understanding how their actions have an impact also to other organizational levels, can be a motivation factor. Nofi (2000) characterizes SA to be a subjective view which elements are affected by different circumstances. This means that SA changes are dependent upon individual's situation, and how situation evolves. SA is a dynamic phenomenon that constantly evolves, and for that reason it is also important to understand why and how individual and team level SA differ from each other.

Nofi (2000) describes individual SA as personal attributes that reflect the world based on our structural factors such as cultural background, education, experiences and personality. Situational factors such as mission type and circumstances affect also the individual SA. This is why

the measurement of individual SA seems like mission impossible, but that has not diminished the effort and attempts that have been taken in order to understand the individual level elements in building up SA. Shared SA differs from individual view since it involves multiple team members trying to achieve the understanding of the current situation.

Team members have their individual SA and in order for the team members to get shared SA, it requires building up the individual SA related to the task that needs to be accomplished as a team. It also requires individuals to share their individual SA that again requires awareness of other team member's information requirements and capabilities. SA is not build up sequentially in these different stages because gaining of individual or SSA is an iterative process. How this iterative process can be supported, is an intriguing challenge and this dissertation aims at capturing the essence of it and providing alternative solutions to tackle it.

2.2.4 Situational awareness and decision making

Endsley (2000a, 2) wants to make a distinction between shared mental models and SSA to clarify the differences between them by defining shared mental models as *"the degree of commonality among the mental models of two or more peopl*e" and shared situational awareness as "*the degree of commonality among the situation models of two or more people"*.

Mathieu et al. (2005) remind of the importance of team work in complex surroundings since it allows team members to share their workload, monitor the behaviors of others, and line up expertise with task demands. This observation is applicable in both civilian and military environments. Bolstad & Endsley (1999) make also a distinction between SA as a stage separate from making decisions and performance as described in Figure 15 (Endsley 1995b). The individual SA is represented as the inner model which allows the *operator* to decide what to do in the current situation. Endsley (2000b) emphasizes the influence of IT and information flows; how complex the current tools are. With technological solutions, we are able to receive numerous amounts of data and this causes the problem focus to shift: The lack of information is not the problem but the actual problem today is to find the information needed.
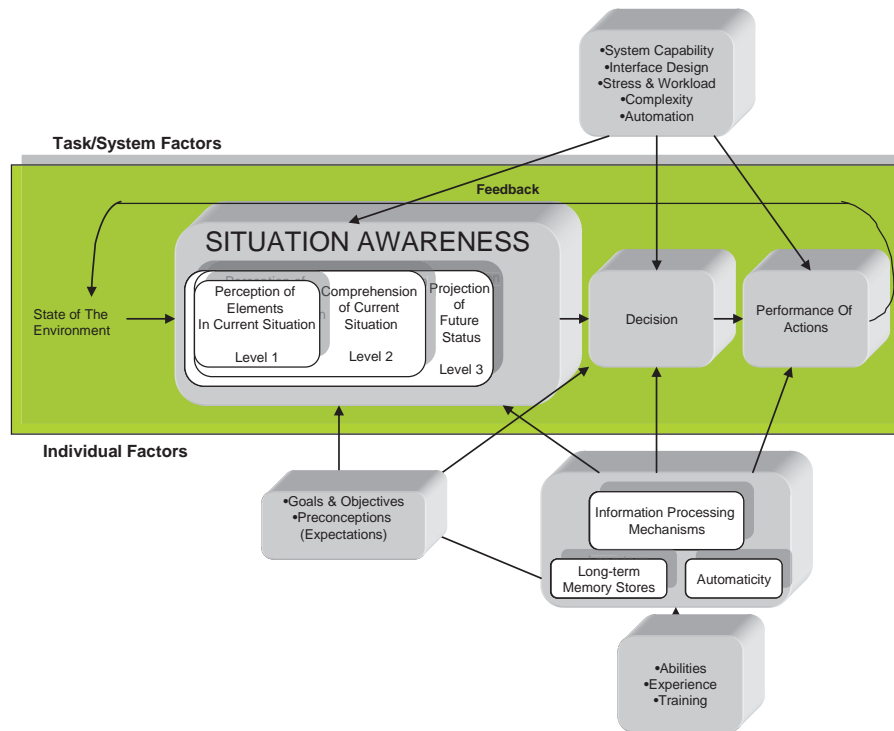
Figure 15: Model of situational awareness in dynamic decision making

In order to gain the required level of awareness, it is crucial to understand upper level goals as well. Endsley (2000b) refers to this challenge as the information gap which is presented in Figure 16 that visualizes the problematic overload of data that needs to be processed before the needed information is received (Endsley 2000b, 2).

Endsley & Robertson (2000) state that in order to discover possible methods for improving SA is to observe in what conditions and how SA errors occur. Other alternative way is to identify situations when individuals are able to develop and maintain SA.

Several studies related especially to aviation have been conducted to solve this mystery. Possible reasons for causing SA errors have been identified in aviation as Endsley & Robertson (2000) present and there are some general observations that are also applicable in the maritime environment such as workload and distraction, communication and coordination issues, improper procedures, time pressure and unfamiliarity.
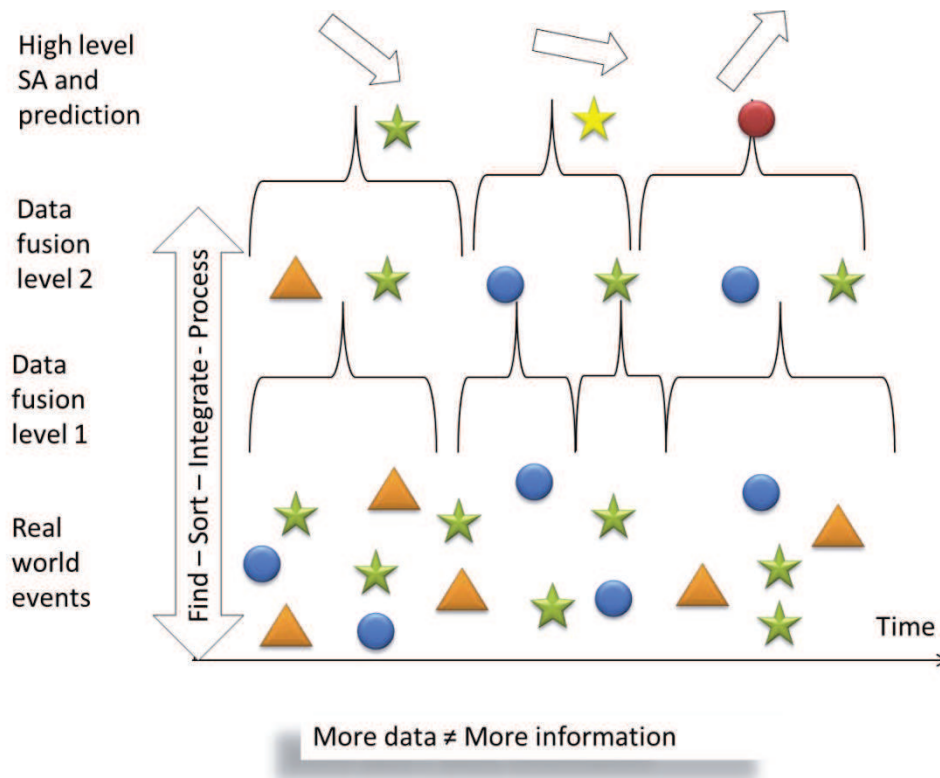
Figure 16: The information gap

As Endsley et al. (2003) argue that need for processing and understanding large volumes of data is – not only a military issue – but relevant in other environments as well. This justifies why it is essential to realize that in these complex dynamic environments the need for SA to support different level of decision making is evident. This is why all the necessary steps related to, for example technological and procedural actions should be taken into account in every organization.

In the respect to these views of organizational studies and theoretical background of SA the journey continues with the presentation of the case studies where these issues were intensively engaged.

2.3 Processes and process modeling

Process modeling can be used to support research in understanding the environment and elements of the research target. Process modeling ideology has also supported with the case study research used in this dissertation. Discovering elements within the fascinating collaboration context offered by the MNE case studies has been also a learning process in many ways. This dissertation and research questions have affected the case studies and vice versa. This is why it is important to also take into account the process perspective affecting the overall end product, the conceptual model. Bandara et al. (2007) present procedural guidelines for process modeling. Guidelines include six core phases; goal identification, process identification, information gathering, process model generation, analysis, and continuous improvement.

It seems obvious that identifying goals is a good starting point but in this overall process, I need to be honest and confess that the goals have been identified along this journey related to this dissertation. In similar ways, the learning process of this dissertation has affected the experimentation goals of the case studies.

Process identification is according to Bandara et al. (2007) identifying target processes and the prioritizing, which should be modeled, analyzed or improved. This has been generally done in an ad hoc manner, as described by Bandera et al. (2007). When focusing to the case studies, the research motivation from the dissertation perspective affected especially from the best practices perspective, when I had the opportunity to transfer the knowledge and lessons learned from a case study to another, and also the same effect concerns the end result of this dissertation.

Information gathering means according to Bandara et al., (2007) critical information that is needed for creating models. Bandara et al., (2007) state there is not a lot of formal empirical research that examines the process by which model information is collected. It could be argued whether this dissertation is one step towards presenting a formal way providing the examined information in a formal way explaining the process how the information was created and used in different stages.

The last elements, model generation, analysis and continuous improvement are according to Bandara et al., (2007) yet unknown for larger audience and the suggestion is to integrate change management as a part of the process modeling lifecycle. When referring to the learning

process all the way from the beginning of the MNE5 MSA case study, through the MNE6 MISA-EM to the finalization of this dissertation, it can be stated that the learning curve and process is a contribution to this way of thinking. As my knowledge increased along the case studies, I was able to implement the evolving knowledge to the case studies and at the same time I was able to improve the research process and get clearer vision of the goals I wanted to reach with this dissertation. As a contribution to the continuous improvement, I hope that this dissertation reaches the decision makers that are responsible and able to decide how to continue with multinational experimentations, and how this type of process modeling can be used to support the learning and improvement of our actions in a more systematic and analytic way.

One supporting ideology is Design Rationale that is defined by Lee & Lai (1992) to be historical record of the analysis that has led to the choice of particular feature as demonstrated in Figure 17. This type of way of thinking is a tool to demonstrate the main highlights of the entire lessons learned along this several year experience. The main decision points and changes are demonstrated in the final Chapter 8 along with the conclusions.

Buckingham Shum & Hammond (1994, 8) and Lee & Lai (1992, 31) present the Decision Representation Language (DRL) notation as demonstrated in a simplified model in Figure 18. DRL includes elements of decision problems, alternatives, claims and goals (see also Branham, Harrison & McCrickard, 2010). This type of notation is beneficial in reconstructing the learning process, how we ended up with the results we ended up with. As Lee (1997) talks about representing rationales, the attempt in this dissertation is to give the reader a clear image of the entire process and how the discovered findings and decisions made during this journey have affected the end result, the conceptual model.
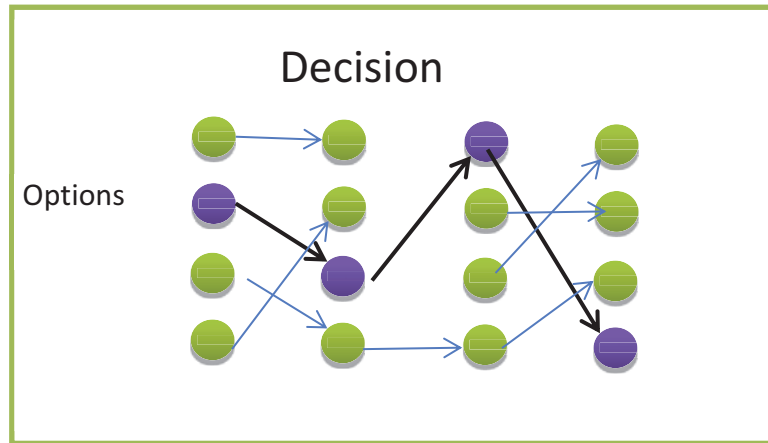
Figure 17: Design rationale simplified ideology
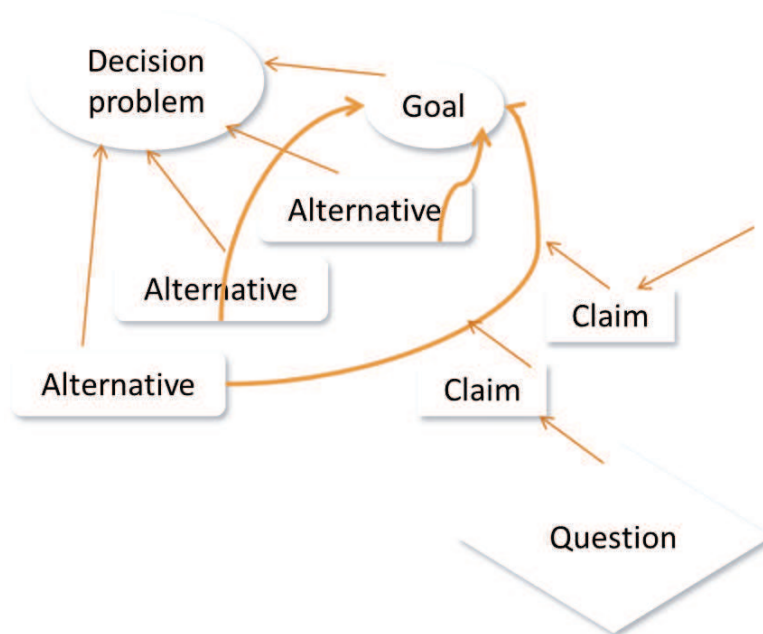
Figure 18: Design Representation Language (DRL) notation

As Lee (1997) highlights, the representation depends on the language. Lee (1997) refers to services and systems but by using reconstruction, I am also producing design rationales without systems, using the data from the field work and case studies. Gregor (2006, 620) has determined theory types as presented in Figure 19. According to this type of classification, it gives support as Bandara (2007) states that this could be used as a way to position work related to new areas that are not clearly defined. I have had difficulties in finding myself clearly in a particular corner with theoretical foundations as discussed in Introduction Chapter. The Figure 19 allows me to define this dissertation research to be a mixture of analysis, explanation but also design and action.

Analysis
•What is?

Explanation
•What is, how, why, when and where?

Prediction
•What is and what will be?

Explanation and prediction
•What is, how, why, when, where and what will be?

Design and action
•How to do something?
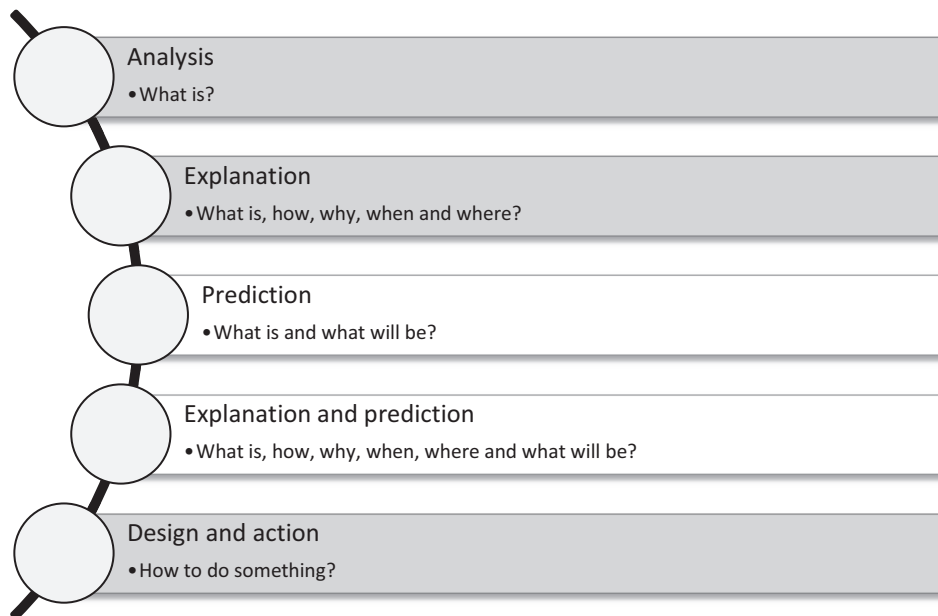
Figure 19: Theory of Classification

Applying the theoretical view for analysis can be seen according to Bansera (2007) as describing and classifying characteristics or dimensions and the case study description fit the analytical perspective. From the explanation view this dissertation provides one possible way to view the complex time critical environment by explaining the

phenomenon. As Bandera (2007) identifies this to how "why" and "how" are asked and answered. As the main contribution of this dissertation, applying the theoretical approach for design and action, is the most important aspect. As Bandera (2007) and Gregor (2006) stated, in this type of theoretical approach we are discussing how to do something and providing guidelines by describing the tasks and steps needed to be taken in order to obtain a certain goal.

2.4 NATO standards and definitions

Since capability is defined to be "*the ability to execute a specified course of action or achieve a certain effect,*" (NATO MC 0583, 2010) this can be expanded to include functional components of DOTMLPFI (Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities and Interoperability). It is crucial to understand that capability is more than one piece of hardware or software. It is a combination of one or more of these functional elements: Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, Interoperability. How to define a concept to support the capability development? Concept is determined to be "*solution-oriented transformational idea that addresses a capability shortfall or gap*" (de Njis 2010, 9; MC 0583 2010).

The level of effect of the concept is defined by concept's scope. By following NATO standards and definitions, the scope can be strategic, operational or tactical. Once we have defined the purpose of the concept, we are able to identify its type that can be capstone, operating or functional. Capstone concept is defined as

> "*An overarching concept with the purpose of leading force development and employment primarily by providing a broad description of how to operate across significant portions of the complete spectrum of operations and describes what is required to meet strategic objectives*"(NATO MC 0583, 2010).

Operating concept is defined to be

> *"A concept that describes how a commander will perform a military function or type of operation. It identifies the effects necessary to achieve the end state and the capabilities required"* (NATO MC 0583, 2010).

Functional concept is described to be

> *"A concept that describes a particular capability and/or set of effects which suggest a solution to a specific or applied requirement. Its purpose is to identify in a detailed manner how to solve an explicit or practical capability problem and what solution sets, tactics, techniques and/or procedures should be employed"* (NATO MC 0583, 2010).

When a concept process is started, fundamental issues need to be clear: We need to be able to articulate what is a concept and why it is needed. After visioning this we should have some ideas on how it might be done and suppose capability examples needed in order for the concept to succeed in its goal. We need to keep in mind the concept development provides the foundation for the DOTMLPFI capability development and implementation. Certain qualities, such as consistency, credibility, authority, clarity, robustness and timeliness are elements of a constructive concept.

2.4.1 DOTMLPFI stages

Doctrine is defined by NATO as: "*Fundamental principles by which the military forces guide their actions in support of objectives. It is authoritative but requires judgment in application*" (NATO glossary of terms and definitions, AAP-6, 2008). This is through the strategic level all the way to tactical level.

   Organization and different views to it have been discussed earlier but the meaning and challenges related to organizational issues cannot be highlighted enough. Organization that consists of individuals working as

teams contributing to different tasks in order to achieve the collective goal that is defined by the organization.

As presented in the case studies, the meaning of **training** is also critical. Despite the capacity and advancement of technical tools and processes designed to aim for the common goal, if the individuals working in teams are not properly trained, the performance levels will decrease since individuals are not able to gain the needed awareness.

Material can be seen in this context as all the technological equipment and tools that are used to share information.

Leadership is needed in order to set goals and making sure the goals are reached. In the military context, for example Singapore Armed Forces Centre of Leadership Development has defined it (2006) as

"A process of influencing people to accomplish the mission, inspiring their commitment, and improving the organization." Canadian Forces Doctrine defines (2005) it as *"Directly or indirectly influencing others, by means of formal authority or personal attributes, to act in accordance with one's intent or a shared purpose."* And also as *"Directing, motivating and enabling others to accomplish the mission professionally and ethically, while developing or improving capabilities that contribute to mission success"* (Australian defense doctrine, 2006).

Personnel are the formation of the individuals that perform in the organization. All the social elements identified from the case studies are related to the human factors of the personnel.

Facilities provide the place where the action occurs. In this case it is the MOC. From the case studies I was able to get evidence on how also the facilities and setup of the MOC also influences on teams ability to work efficiently.

Interoperability is defined in NATO as

> *"The ability to act together coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objectives"* (NATO glossary of terms and definitions, AAP-6, 2008).

The interoperability, as all the other previously mentioned elements, is

crucial in co-operations. This is why these elements are tightly included in the capability development steps and in the concept development process that will be presented next. The developed SA Concept presented in this dissertation was build up according to the CD&E-process. The end product, SA Concept is presented in Chapter 6.

2.4.2 General steps of the CD&E process

One important part of the NATO guidelines provides 14 principles in order to execute an effective experimentation. The principles of effective experimentation are presented (briefly):

1. investigating cause-and effect relationships underlying capability development,
2. need for understanding the logic of experimentation,
3. experiment design should meet validity requirements,
4. integration into a campaigns to maximize the utility,
5. iterative process formulation process,
6. integration of studies, observations and experiments,
7. usage of multiple methods,
8. additional experiment design considerations because of human variability,
9. conducting experiments during collective training and operational test,
10. exploitation of modeling and simulation,
11. an effective experimentation control management,
12. comprehensive data analysis and collection plan,
13. including relevant considerations of ethical, environmental, political, multinational, and security issues and
14. frequent dialect with relevant stakeholders (NATO GUIDEx, 2006).

Next the types of experimentations that can be used in this process are illustrated: Discovery experimentation is described as a

> *"…type that introduces novel systems, concepts, organizational structures, technologies, or other elements to*

a setting where their use can be observed and catalogued" (Alberts & Hayes 2005, 19).

Hypothesis experimentation is defined as

"*advance knowledge by seeking to prove/disprove specific hypotheses or to discover their limiting conditions, ...to test whole theories (systems of consistent, related hypotheses that attempt to explain some domain of knowledge) or observable hypotheses derived from such theories. In a scientific sense, hypothesis testing experiment build knowledge or refine our understanding of a knowledge domain*" (Alberts & Hayes 2005, 22).

Validation experimentation is described as an attempt

"*to provide the final demonstrated evidence that the prototype capability can operate within theatre and will improve operational effectiveness*" (NATO GUIDEx, 2005, 10).

3 CASE STUDY MNE5 MSA

As explained in the introduction, co-operations are needed both nationally and internationally against severe threats such as terrorist attacks, illegal immigration in addition to drug and human trafficking. A successful international co-operation shared situational awareness and there are several issues from cultural differences to language barriers that can influence the effectiveness of co-operation and basic working practices within a Maritime Operation Centre (MOC).

Related to previous MNE series, in August 2007 MSA Sense Making Limited Objective Experiment (LOE3) was conducted by U.S Joint Forces Command (J9 / Joint Transformation Command – Intelligence); Singapore Armed Forces and NATO Allied Command Transformation. The experimental objectives were to provide a better understanding of the basic activities for sense making in the maritime domain, identify or develop measures that assess the matches and gaps between system capabilities and *operator* requirements in maritime operations and also to evaluate the effectiveness of measures in testing operationally relevant empirical hypotheses. (Eshelman-Haynes, 2007). While this experiment provided good background information for this study, it did not address same type of research questions and approach as MNE5 MSA experimentation. The Maritime Situational Awareness (MSA) track of Multinational Experiment 5 (MNE5) was launched to help develop processes and tools in a federated and distributed environment to increase information exchange and collaboration between MOC's.

This Chapter will address the results and lessons learned from the Multinational Experimentation 5 (MNE 5) MSA. MNE5 MSA experimentation was conducted in partnership with the Navy Command Finland, Naval Warfare Centre of Sweden and NATO Allied Command Transformation (ACT) and the Singaporean Armed Forces (SAF) Future Systems Directorate. The main goal was to study how MOC teams are able to achieve and maintain MSA during two scenarios. I was privileged to be part of the experimentation team, as the Finnish lead analyst. The experiment data was a collective effort and I was able to benefit from the overall data collection, when analyzing discovered elements related to this dissertation.

I focused on observing the Finnish MOC and was able to reflect the findings especially from the national perspective. The entire research team worked closely together in this case study, and the results were compared and validated also inside the experimentation team in order to understand the phenomenon and to diminish the error margin. The collected data gave the input needed to understand the context of the case studies. The data also supported and guided the creation of the concept presented in this dissertation.

Referring back to the case study, the experimental objective was to discover issues that affect the MOC team's performance but also to observe the co-operation inside a MOC and between MOC teams. In multinational operations it is important to ensure that situational awareness is shared among all participants. *Operator*s from Finland, Sweden, NATO and Singapore were given the same settings and scenarios, and their MOC processes for information management and information sharing were observed as they attempted to solve scenario-based problems. Additionally, best practices were captured to assist nations in enhancing their own MOC processes. Also, at the same time the co-operation and interaction with the technical systems and other social actors were studied.

In MNE5 MSA the purpose was to improve situational awareness against maritime threats. Official statement for the MNE5 MSA was: *"The understanding of military and non-military events, activities and circumstances within and associated with the maritime environment that are relevant for current and future operations and exercises"*. This description is based on NATO's working definition but without the restrictive interpretation of the term "*maritime environment*". In the context of MNE5 MSA, each partner is allowed to define a "*maritime environment*" most suitable to their roles, responsibilities and mission" (MNE5 MSA final report 2008, 13-14).

3.1 General goal

The general goal was to help MOC teams detect, determine, recognize and identify possible suspicious behavior in the maritime environment by

identifying Contacts Of Interest (COI) based on the scenarios. The key element was information sharing between participants in order to prevent behavior harmful to the security, wealth and economic stability of the all partners involved. The scenarios were designed so that no MOC team could solve them without information sharing. There were a number of ambitions in MNE5 MSA that included for example creation of standard operating procedures (SOP), including recommendations and guidelines for carrying out maritime operations. Technological development, designed scenarios and concept were enabled by multiple workshops. Event 1 was conducted by each nation independently. The purpose of event 1 was to examine and baseline national MSA processes. Our national event 1 was conducted in the end of August 2008. MNE5 MSA event 2 was conducted late September and beginning of October 2008. It took place in Enköping, Sweden. Experiment personnel were co-located and the distributed environment was simulated: Finland, Sweden, Singapore and NATO represented separate MOC teams. Event 3 was conducted in December 2008 with same scenarios used as in event 2. The exception compared to event 2 was that the environment was truly federated and distributed (MNE5 MSA Final report 2008, 5-6). Scenarios were identical, but for event 3 life AIS feed was used instead of recorded data used in event 2. Each scenario began by giving the operators vessel of interest (VOI) lists. Intel reports were given to operators at designated times throughout the scenarios. In addition a white cell was established to role play higher authorities such as port, customs etc.

Participating nations used their own technical systems for the experimentation. Finland used MEVAT, Sweden used DSG2, Singapore used SMART and NATO used BRITE as their technical sea surveillance systems in an unclassified environment. Some services were shared automatically (for example database information, radar and AIS) through systems, and MOC teams were also able to share information via chat, email and voice. MOC teams were encouraged to share information: Standard Operating Procedures (SOP), Memorandum Of Understanding (MOU) and Technical Agreement (TA) were written to support the information sharing. Before the experimentation the MOC teams were given training that included technical training of their systems but also SOP training and problem solving process guidance. Teams were also briefed about other MOC teams' technical capabilities. The idea behind

created scenarios was for the teams to successfully identify the contacts of interest (COIs) based on scenario play across two seven hour scenarios. Scenarios were made so that no MOC team alone could solve them without receiving information from other participating MOC teams (MNE5 MSA Final report 2008, 6-7).

Experimentation aimed at observing problem solving and information sharing behaviors of MOC teams working with shared data. Experimentation included three separate events. First event 1 was each nation's independent study of national MOC processes. In the event 2 the distributed environment was simulated to allow close observation and coordination for experimenters and analysts. In the event 3 the MOC teams were operating from their own actual environments. The MOC teams were given distinct areas of responsibility (AOR) and teams operated on two maritime threat scenarios. Every stakeholder used their own technical systems. In the experimentation events there were four MOC teams each from participating parties and teams we formed by at least one operator and one intelligence (Intel) officer. Collaboration tools provided for the teams were information exchange via email, chat and phone, including different open source databases and web pages or usage of a smart board for analyzing and information gathering purposes.

My amazing journey started in April 2008 in Ede, when I was for the first time introduced to my future experimentation and analyst team. After this workshop I had the inspiration that I wanted to focus on this type of research also in my dissertation. I was able to introduce my ideas about social interaction, when though the overall goal was mostly technical experimentation and improvement. This workshop was the kick start for my dissertation journey. We were able to create analysis plan that supported the experimentation plan. The timeline of the execution of MNE5 MSA track is presented in Figure 20.

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┌─────────────────────────────────────────────────────────────────┐
│ 1. Workshop in Karlskrona, Sweden (12th to 16th Nov  2007)        │
├─────────────────────────────────────────────────────────────────┤
│                     technical integration                         │
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                               ▼
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│ 2. Workshop in Toledo, Spain (21st to 25th Jan 2008)              │
├─────────────────────────────────────────────────────────────────┤
│ storyboards, experimentation design and campaign plan drafts for  │
│                 the experimentations                              │
└─────────────────────────────────────────────────────────────────┘
                               ▼
┌─────────────────────────────────────────────────────────────────┐
│ 3. Workshop in Turku, Finland (25th to 29 th Jan 2008)            │
├─────────────────────────────────────────────────────────────────┤
│                     technical integration                         │
└─────────────────────────────────────────────────────────────────┘
                               ▼
┌─────────────────────────────────────────────────────────────────┐
│ 4. Workshop in Ede, Netherlands (14th to 18th Apr 2008)           │
├─────────────────────────────────────────────────────────────────┤
│              methodologies, experiment analysis                   │
└─────────────────────────────────────────────────────────────────┘
                               ▼
┌─────────────────────────────────────────────────────────────────┐
│ 5. Workshop in Lillehammer, Norway  (3rd to 12th Jun 2008)        │
├─────────────────────────────────────────────────────────────────┤
│     interoperability tests, experimentation design finalization   │
└─────────────────────────────────────────────────────────────────┘
                               ▼
┌─────────────────────────────────────────────────────────────────┐
│ 6. MNE5 MSA experimentation event 1 in Upinniemi Finland (28th to │
│                     29th Aug 2008)                                │
├─────────────────────────────────────────────────────────────────┤
│              individual tools and process testing                 │
└─────────────────────────────────────────────────────────────────┘
                               ▼
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│ 7. MNE5 MSA experimentation event 2 in Enköping, Sweden (29th Sep │
│                     to 10th Nov 2008)                             │
├─────────────────────────────────────────────────────────────────┤
│            simulated and distributed experimentation              │
└─────────────────────────────────────────────────────────────────┘
                               ▼
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│ 8. Workshop 9 in Virginia Beach, USA (27th to 31st Nov 2008)      │
├─────────────────────────────────────────────────────────────────┤
│        lessons learnt from event 2, preparations for event 3      │
└─────────────────────────────────────────────────────────────────┘
                               ▼
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│ 9. MNE5 MSA experimentation event 3 (1st to 5th Dec 2008)         │
├─────────────────────────────────────────────────────────────────┤
│                  federated experimentation                        │
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                               ▼
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│ 10. Workshop 10 in Turku, Finland December 2008)                  │
├─────────────────────────────────────────────────────────────────┤
│                 analysis report, lessons learnt                   │
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Figure 20:   Timeline of MNE5 MSA case study events

3.2 Experimentation settings

Events were built of two seven hour long scenarios, followed by data collection through surveys and interviews based on observations during the scenario run. Quantitative methods used in this research were the NASA task load index (TLX) and the Social technical organizational rating scale (STORS) to capture operators' subjective view. The Analyst Assessment Report Performance Rating Questionnaire (AAR PRQ) was used by the analysts as a subjective measure of MOC performance and workload. The NASA Task Load Index is a multi-dimensional rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales. This survey was completed by the MOC operators to gain understanding about their perspective of the overall task load during scenario play. The Analyst Assessment Report Performance Rating Questionnaire (AAR PRQ) was used as a subjective measure of MOC team performance from the analyst/observer perspective. After the scenario observation and post-scenario interviews were completed, analysts ranked MOC team performance on a scale that ranged from above average to below average. STORS is a 5 point rating scale. Listed issues were social, technical and organizational factors such as network connection or roles in side a team. This was the research tool, which was developed during the experimentation planning (Koskinen, 2008). These types of variable measurements facilitate a better understanding on how factors influence performance from operators' perspective.

These surveys provided amplifying information that was compared with information from interviews and observation. Post-scenario interviews were specifically designed to understand MOC team decision points about information sharing and problem solving. MOC teams also prepared out-brief's at the end of each scenario and also kept event logs for all communications.

Following the first scenario, the collected data was reviewed by the analysts and then feedback was prepared for each MOC regarding problem solving and information sharing strategies for the second scenario. Interviews were designed to elicit decision points regarding problem solving and information sharing. Analysts observed MOC operators as they worked though the inject-based scenarios. Observation was focused on both within and between MOC teams. Interaction

Diagrams were used to visualize communication between the MOC teams. The interactions were constructed to see how information was shared and the results of that sharing Interaction diagrams were used to visualize how the interaction occurred within and between MOC teams. MOC teams were asked to keep event logs for every communication, and those logs were used in verifying the data. After the first scenario, based on the collected data reviewed by the analysts, the MOC teams were given feedback and brief training concerning problem solving and information sharing strategies (Brunett, Eshelman-Haynes, Koskinen, Soh & Utterstöm, 2008). Event 2 is described in more detail to give the reader an idea of the experimentation setting.

3.3 MNE5 MSA Event 2

The experiment was conducted in Enköping Sweden, 29th September to 10th October 2008. First week was mostly for technical setup and testing. The Event was designed so that participants, including technicians, *operator*s, white cell and analysts, were co-located. The distributed environment was simulated; four MOCs were established representing each of the participating nations. This setting enabled each nation to fully test the functionalities before the truly distributed event, event 3, in December 2008.

MNE5 MSA experimentation event 2 focused on the influence of social, technical and organizational factors specifically on information sharing and problem solving in Maritime Situational Awareness (MSA). These findings from the MNE MSA experimentation gave important information also to national level development.

The main goal was to examine issues that affect team's performance from an information sharing perspective within the Finnish MOC. Other participating MOC teams' results were also reflected to the research questions. The first ambition was to discover the aspects from the research questions that occur in operators' way of working and secondly to do general comparison between MOC teams to learn differences and similarities, and possible reasons for differences.

When interactions within and between MOC teams are discovered and developed together, we were able to improve the future co-operation as

well. Experimentation event 2, reflecting the national study (event 1) led to the discovery of issues that affect the information sharing and situational awareness in an international setting.

3.3.1 Technical systems and settings

The technical system setup, including concrete firewalls and workstations, from the Finnish MOC perspective is presented in Figure 21. When participants all agree to work under the Technology for Information, Decision and Execution Superiority (TIDE) specifications, they do not need to know other participants technological solutions. TIDE conceptual framework is shown in Figure 22. The Baseline for Rapid Iterative Transformational Experimentation (BRITE) is an experimentation framework which works by reusing existing systems and encouraging openness and co-operation. TIDE compliant systems are able to discover each other on the network and work together to provide a richer information environment (Goossens et al., 2006a; Cheasley, et al., 2009).
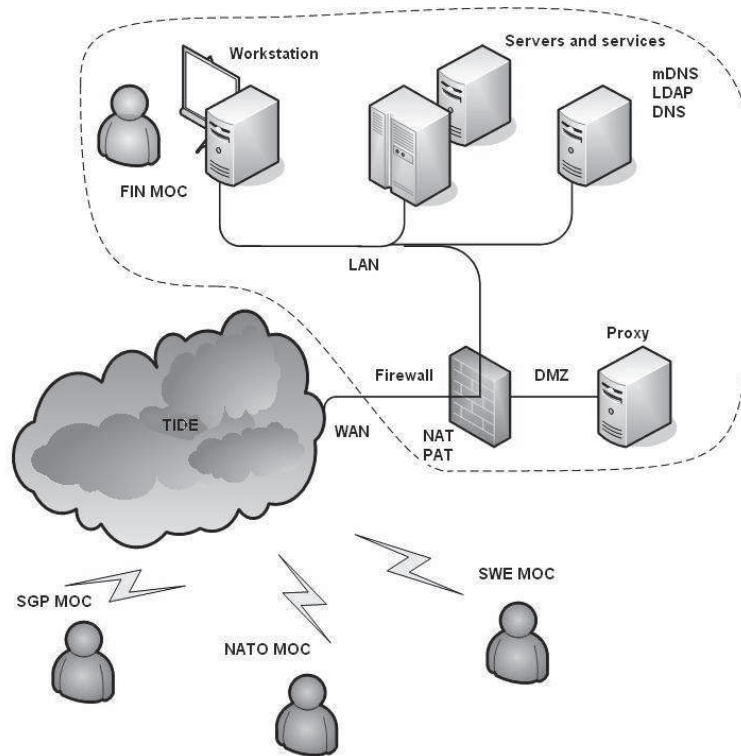
Figure 21: Technical setup from the Finnish MOC

3.3.1.1 TIDE and BRITE

Figure 22 shows TIDE conceptual framework, which was developed within the TIDE initiative and describes how Network Enabled Capabilities (NEC) will transform raw data into intended effects to aid in achieving NATO's Transformation Goals and Objectives. Baseline for Rapid Iterative Transformational Experimentation (BRITE) is an experimentation framework which works by reusing existing systems and encouraging openness and co-operation. TIDE compliant systems are able to discover each other on the network and work together to provide a richer information environment (Goossens, et al., 2006; Brite Overview, 2008).

BRITE is an experimentation framework that enables the rapid implementation of new ideas and capabilities to support experimentation. The BRITE framework is implemented as a Service Oriented Architecture (SOA). In a SOA environment, resources on a network are made available as independent services that can be accessed as required from distributed users and servers. The ability to discover, acquire and exploit information from various sources is the purpose of BRITE. BRITE can be used isolated from general network as it provides complete capability from the acquisition to the presentation of information to improve situational awareness and support the decision making process. The real benefit of BRITE, however, is realized when BRITE is installed on a network with other TIDE compliant systems (Brite Overview, 2008; Goossens, et al., 2006).
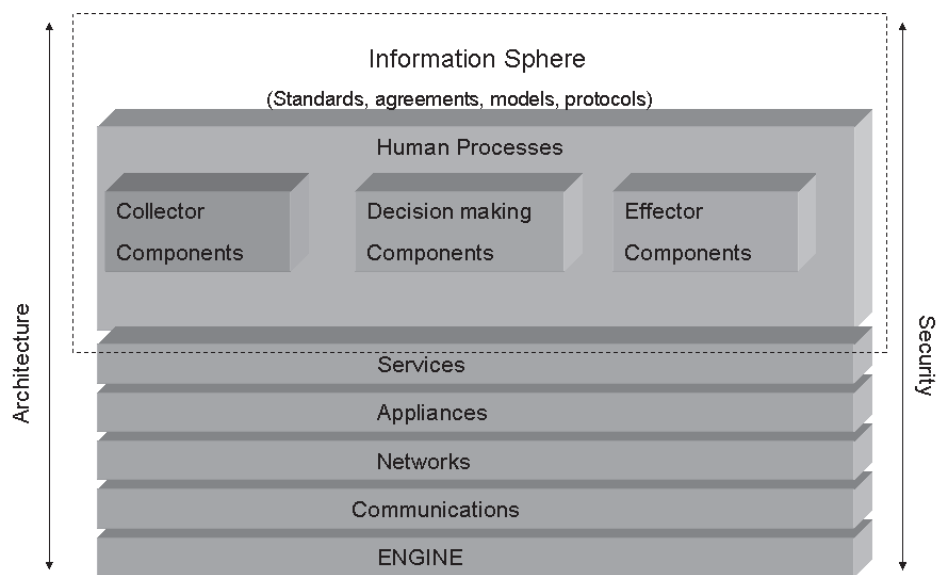
Figure 22: TIDE conceptual framework

3.3.1.2 MEVAT

MEVAT is the Finnish Sea Surveillance System that is used by the main authorities in the maritime domain in Finland. As a multisensor

datafusion system, MEVAT provides the Finnish METO (cooperation between Navy – Boarder Guard - The Maritime Administration) authorities and Defense Forces the near-real time Recognized Maritime Picture (RMP). Operational version of MEVAT can utilize data from following data sources:

- Sensors:
    o Primary surveillance radars
    o Sonar systems
    o Eye observer information
    o Mobile radar units
    o Mobile units
- Sources:
    o Automatic Identification System (AIS)
    o Vessel Traffic Service (VTS) information
    o Port Net (National gateway to EMSA Safe Sea Net)
    o The Maritime Safety & Security Information System (MSSI).

MEVAT is capable of making history queries based on time and/or area of one or more selected vessels. MEVAT is TIDE compliant, so it is able to discover services and information from systems that are following the TIDE specifications (e.g. BRITE). MEVAT has collaboration tools and it is possible to use E-mail (SMTP), Chat (XMPP), and Voice (VoIP). MEVAT is also able to validate the target information against different vessel databases by Smart Agents; some of the reference information is actively retrieved from the Internet (Soininen, 2008).

3.3.2 Used Methods

Next, the used research methods, NASA TLX, PRQ, STORS, interview, observation and interaction diagrams are described.

3.3.2.1 NASA TLX

The NASA Task Load Index is a multi-dimensional rating procedure that provides an overall workload score based on a weighted average of

ratings on six subscales: Mental demands, physical demands, temporal demands, own performance, effort, and frustration. This survey was completed by the MOC *operator*s to gain understanding about their perspective of the overall task load during scenario play (NASA TLX, 2005). NASA TLX basic structure is presented in Appendix A.

3.3.2.2 PRQ

The Analyst Assessment Report Performance Rating Questionnaire (AAR PRQ) was used as a subjective measure of MOC team performance from the analyst/observer perspective. After scenario observation and post-scenario interviews were completed, analysts ranked MOC team performance on a scale that ranged from above average to below average. Between the scenarios, some teams went from below average overall ratings to above average overall ratings, while some teams maintained the same rating across both scenarios. No teams, however, went from above average to below average compared to the team average in the overall experimentation. The AAR PRQ included questions similar to: "The MOC TEAM backs up answers with facts/information;" "the MOC TEAM was able to report the basics of the story: who, what, when, where, and how;", "the MOC TEAM description of events was organized well; it has a logical flow." Answers to these types of questions established an analyst's representation of MOC team performance. Basic structure of the AAR PRQ is presented in Appendix B.

3.3.2.3 STORS

Social Technical Organizational Rating Scale (STORS) – This is a 5 point rating scale where 1 is very harmful and 5 is very helpful, 3 meaning neutral. This was the research tool, which was developed during the first experiment design meeting in Ede, the Netherlands, when it became evident that the research questions were not completely clear. These types of variable measurements facilitate a better understanding of how factors influence performance from an *operator*s' perspective. STORS is a tool that helped guide us in scoping our research objectives. Using it helped us

determine whether to focus our efforts on social/technical relationships or the organizational aspects. Based on national study, event 1, and findings from technical testing in Lillehammer, Norway, we were able to improve the STORS survey to properly align it with the experimental environment (Koskinen, 2008). STORS structure is presented in Appendix C.

3.3.2.3 Interview

Post-scenario interviews were specifically designed to understand MOC team decision points about information sharing and problem solving. MOC teams also prepared out-brief's at the end of each scenario and MOC teams also kept event logs for all communications. Following the first scenario, the collected data was reviewed by the analysts and then feedback was prepared for each MOC regarding problem solving and information sharing strategies for the second scenario. Interview structure is presented in Appendix D.

3.3.2.4 Observation

Analysts observed MOC operators as they worked though the inject-based scenarios. We observed the interactions within and between MOC teams. Based on paper surveys and interviews, we were able to verify and the findings from observations matched and made sense.

3.3.2.4 Interaction diagram

Interaction diagrams were used to visualize communication between the MOC teams. The interactions were constructed to see how information was shared and the results of that sharing. Figure 24 is an example of a part of one Interaction diagram.

Findings from the experimentation are categorized to technical, information sharing and experiment specific issues which were interesting in both Scenario 1 and Scenario 2 from the Finnish MOC team's perspective.

3.3.3 Findings from the Scenario 1 from the Finnish MOC team's perspective

3.3.3.1 Technical issues

In the scenario 1, the Finnish MOC team's technical system was stable. There were some situations where the *operator* did not understand how to use the search tool as designed. The team felt more comfortable working with their own technical system than requesting the information from other MOC teams. This was confirmed by the observation that the number of technical interactions was greater than that of social interactions with other actors. There were also some disconnections in communicating as results of incorrect contact lists, email addresses etc.

3.3.3.2 Information sharing issues

Within the Finnish MOC, actors performing as an *operator* and as an intelligence officer, later on referred as *Intel*, worked well as a team and had clearly defined roles and responsibilities. The *operator* searched for information through different technical sources and *Intel* managed all communication channels (chat, email, voice). He also maintained the Event log. Most of the information sharing occurred between the Finnish and the Swedish MOC teams. The Swedish MOC pulled mostly information from the Finnish MOC and Finnish MOC pushed more information to the Swedish MOC compared to the other MOCs. One reason the Finnish MOC did not often request specific information from external actors was that the team did not feel that they could accurately articulate and formalize their questions. This also affected their behavior in that they felt much more comfortable relying to their technical system than interacting socially with the other MOC teams. Another identified issue was the lack of clear problem solving process. Often, the team had several pieces of information that they were not able to connect and draw conclusions. This reinforced the findings of the sense making data frame theory. From the information perspective, the Finnish team had difficulty putting together pieces of information into a logical, comprehensive story

of what was happening. Often, operators were observed focusing on their own AOR and sometimes disregarded information from other social resources. When operators were not able to articulate their thinking and decision making processes, they had difficulty communicating with other actors because they lacked the necessary detail to effectively express their ideas. Observation and interviews confirmed that the team was not able to identify their actions and their problem solving process, which resulted in a limited number of contacts with the other MOC teams. It also made it difficult to maintain the record of the event log.

3.3.3.2 Experiment specific issues

The Finnish MOC team felt that they should have solved scenario problems including identifying and designating Contacts of Interest (COI). NASA TLX results indicated that the team felt they had to do a lot of thinking and there were some peaks when they had to work harder in order to maintain their awareness. Overall, however, they felt that the work load was reasonable particularly due to their familiarity with the systems. From an interaction viewpoint, they were pleased with their performance in assisting the Swedish MOC, but still they felt they were not able to fully benefit from other MOC team's knowledge. The Finnish team felt that they should have done more to solve the problem. This illuminates an issue that must be clarified in the future experimentation – that the teams are being observed not evaluated, and successful solution of the scenario problem is not necessarily the goal. Rather, the goal is to capture processes so they can be evaluated and improved.

After Scenario 1, analysts provided feedback to MOC *operator*s in the areas of: 1) Scoping the problem space, 2) determining assumptions vs. facts. After the feedback session, the Finnish MOC team understood how to change their behavior for following scenario regarding information sharing and problem solving. They understood that they were to take a more holistic view of the problem space and relate all information to all actors.

3.3.4 Findings from the Scenario 2 from the Finnish MOC team's perspective

3.3.4.1 Technical issues

The Finnish MOC team experienced more technical difficulties in the scenario 2 compared to the scenario 1. After approximately four hours of operation without defect, the system failed and the team was unable to search or query the system during the Scenario play. Over again, contact lists were problematic. Even when email addresses and chat rooms were checked, some messages were send to wrong chat room at the beginning. Voice was not used at all in scenario 2 and chat seemingly replaced it. After the system broke down unintentionally, the team was unable search for vessels and the team stopped working entirely.

3.3.4.2 Information sharing issues

In the beginning of scenario 2, the Finnish MOC was effective as a team as they did in scenario 1. The team felt that sometimes there was too much information flowing through chat, email and other channels resulting in a breakdown of team dynamics. The team was not able to process the received data efficiently and it sometimes took valuable time before they were able to make sense of it. At times, there were two actors performing tasks without an awareness of what the other actor was doing. There were sometimes duplication of effort when actors were working on the same issues at the same time without knowledge of each other. When the team began to work together again, information sharing within the MOC and external to it improved; *operator*s were more likely to push and pull information from other MOC teams. Also, they were able to clearly articulate their reasoning concerning the decisions they made with respect to information sharing. The team was able to better manage and process received information, verifying and sharing when they deemed it was necessary. There were several improvements compared to scenario 1. Excessive information led to situations where the team had to refocus and work more diligently in order to maintain situational awareness within the

MOC. In these cases, it took much more effort to filter and search for information that was important for the team compared to situations where the information flow was easier to control. This highlights a need to provide teams with guidelines, best practices or SOP for the management of information. Excessive information made it difficult to respond and react as quickly as participants were able to react during the first scenario. The team had no problems articulating their thinking process and the results that they were able to assemble.

3.3.4.2 Experiment specific issues

The feedback session between scenarios improved the MOC team's performance. After the problem solving training, the team was better at scoping the problem and analyzing the given facts. They were able to think outside their own AOR and open their minds to other possibilities. Team also felt that interaction with other social actors was much easier when using the problem solving paradigm. While the open chat room occasionally presented excessive information, through observation it was clear that *operator*s preferred it to the other communication methods. There can be several issues influencing this behavior such as the control of receiving and sending, timeliness of responding compared for example to phone calls; Chat messages can be read and send when it suites the situation best, and it diminishes disturbance of individuals thinking process and information management. During the second scenario, the Finnish MOC experienced notable technical failures; this was not the case in the first scenario. These failures suppressed the team and, as a result of further technical issues, they became passive. Unable to assist the other MOC teams or respond to Request For Information (RFIs), internal and external communication for the Finnish MOC decreased significantly. In the end they stopped working completely.

3.3.5 Overall findings from MNE5 MSA event 2

The overall findings were categorized according to the research questions to social, technical and organizational aspects of information sharing.

Social aspects include the operators' way of working and handling the information. Technical aspects address questions about how technology affects information sharing and problem solving process. Organizational aspects cover for example structural issues affecting the problem solving process and possibility to achieve situational awareness.

3.3.5.1 Social aspects of information sharing

MOC teams did not vet new information in the same way that they vetted information received through inject or via technical systems. Some participants, however, reported that they were less willing to share information with other MOC teams when they were uncertain about their analysis. To enable effective information sharing, it is necessary for operators to treat information from all sources with the same level of objectivity. Commonality in language enhanced communication, while a lack of commonality caused operators to be hesitant and less communicative. When participants decided to share information, they took great care in crafting the message to be sure that they had precisely articulated their thoughts. Operators frequently double checked messages to confirm that the information they were sending was correct. This often delayed information flow from MOC to MOC. Cultural factors also influenced information sharing. The familiar ways of working and common cultural experiences resulted in easier working relationship for some participants. Lack of communication business rules, for example simply acknowledging receipt of messages, reduced shared situational awareness.

Informal social networking was greater during scenario 2 than it was in Scenario 1 possibly due to an informal network developed between scenarios through social interaction among operators. This informal interaction improved MOC to MOC communications too. When scenario 2 began, Finnish MOC team was much more comfortable contacting operators from other MOC teams compared to the scenario 1. The informal network enhanced less formal method of communication and co-operation, (e.g. chat) when the information could be shared without formal RFIs that took time for the operators to prepare. Another factor in scenario 2 that enhanced networking was the existence of a clear

information-sharing policy, which encouraged co-operation by enabling MOC teams to interact with each other directly without asking permission from higher authority.

From the operators point of view based on the STORS, it was possible to identify future challenges. The data showed that the variables with the highest overall ratings were non-technical: (1) Team roles; (2) social interactions within the MOC; and (3) past experience. Variables with the lowest overall ratings were largely technical in nature: (1) Anomaly detection; (2) interaction with technical system; (3) ability of system to filter noise; and (4) flexible database query. The STORS survey results helped guide our experiment design by focusing our ambitions. Event 2 showed us that operators view social factors as important supporting elements to accomplishing their tasks. Social factors that affected the teams were analyzed to be team roles, willingness to share, cultural differences, informal social networking and different experience levels. Still, there are many technical factors that must to be tackled in order to support the MOC operators work in the future.

3.3.5.2 Technical aspects of information sharing

The main technical aspects that were found to have influence on information sharing were information sharing process, data types, channels of communication and information management. All Event 2 data was treated the same. At the technical level, raw AIS data was shared and meaning that stakeholders contributed to a common AIS picture. The distinction between raw data and value added data was not revealed to participants, so they had little awareness of the difference between these two types of data. When faced with decisions about information sharing during the first scenario, MOC teams chose to contact their national chain of command (i.e. White Cell) for guidance, for even the most basic information such as vessel identity and position. Between scenario 1 and scenario 2, MOC teams were given permission to freely share information through a simulated Memorandum of Understanding (MOU). During Scenario 2, *operator*s understood that they were allowed to share without requesting further guidance from their national chain of command. This change was made to gain a better understanding of how information

sharing policies affect information sharing (Brunett, Eshelman-Haynes, Koskinen, Soh & Utterstöm, 2008).

Less formal channels of communication like chat seemed to facilitate information exchange. Chat made it easier and faster to communicate and react to information requests and replies. We also observed that *operator*s did not handle information received from other MOC teams in a such critical view as they did with information received from their technical systems. From this study we conclude, that it was easier for actors to trust information from other human actors that from technical systems. Actors must be trained handle every piece of received information with the same level of objectivity, whether the source is technical or another human actor (Brunett, Eshelman-Haynes, Koskinen, Soh & Utterstöm, 2008).

3.3.5.3 Organizational aspects of information sharing

The main organizational aspects, MOC structure, SOP, organizational cultures and rules and training are factors influencing information sharing. The organizational structure for the event 2 was very artificial. In some cases, *operator*s had difficulty understanding who and how to contact when requesting information. An experimental White Cell (WC) was created to manage MOC RFIs from external entities such as national intelligence or port authority. The internal MOC structure was decided informally and as a result it led to some mismanagement and duplication of effort. It was not unusual to see two people in the same MOC working on the same task. In addition to frustrating operators, the redundant tasking caused delays and resulted in some information being missed or dropped from awareness. Operators did not receive clear guidance for information sharing. Though operators were provided with communication channels (e.g. voice, chat, phone), there was no guidance on how and when to share. There was some misunderstanding about using private chat and public chat. Also, in the scenario 1, operators had difficulties with email addresses, which led to miscommunications for some of the MOC teams.

During the first scenario, operators tended to view the problem space from their own comfort zones and AORs. In addition to helping with problem solving this discussion was intended to highlight the interaction

between problem solving and information sharing. By linking these two important aspects together and giving a process that helps co-operation with other MOC teams it is possible also in international operations to ensure shared situational awareness among all participants. This means that we must find ways to support teamwork.

Organizational policy should provide clear guidance and empower operators to share information across traditional boundaries. Operators have to believe that they are "safe" to share the information they possess, from both security and legal perspectives. Current work practices encourage the operators to use the technical systems rather than interact with other MOC teams. Social interaction with external actors should be considered by operators to be an equally valuable tool or a resource among the technical tools and other resources. When technical systems failed, operators stopped the problem solving process and, at times even stopped working.

Should be trained in the event of technical failures to proceed with the problem solving process and explore other possible solutions (e.g. other MOC systems) (Brunett, Eshelman-Haynes, Koskinen, Soh & Utterstöm, 2008; MSA experimentation event 2 documentation).

Figures 23 and 26 show how information sharing changed between scenarios 1 and 2. The amount of information sharing increased, especially in the Finnish MOC, when the MOC teams were briefed about the problem solving and information sharing. Teams were able to scope the problem and articulate their way of thinking much more clearly. The policy that encouraged co-operation enhanced sharing of information. In the end, operators were much more confident about communicating with other MOC teams to push or pull information. Improvement in problem solving and information sharing is also evident in Figures 24 and 25. These Figures are representative examples of interaction diagrams that present the communication flow between MOC teams during both scenarios.
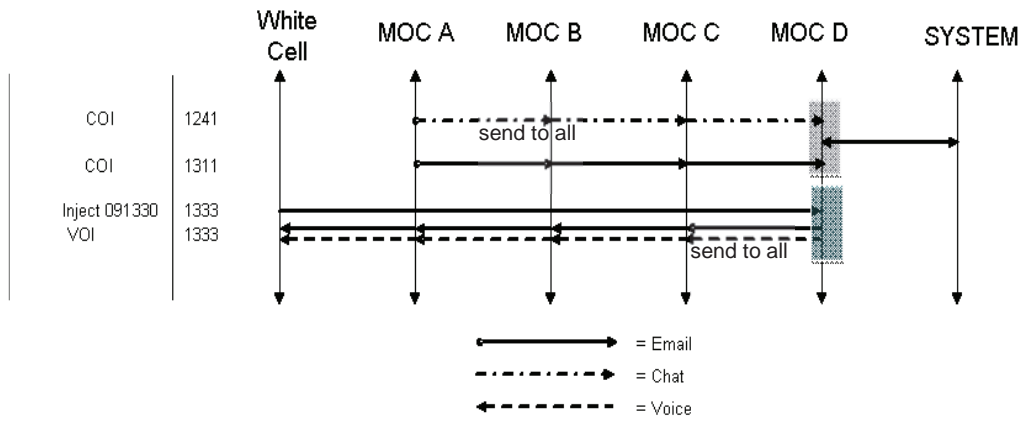
Figure 23: Example of broken information flow in scenario 1
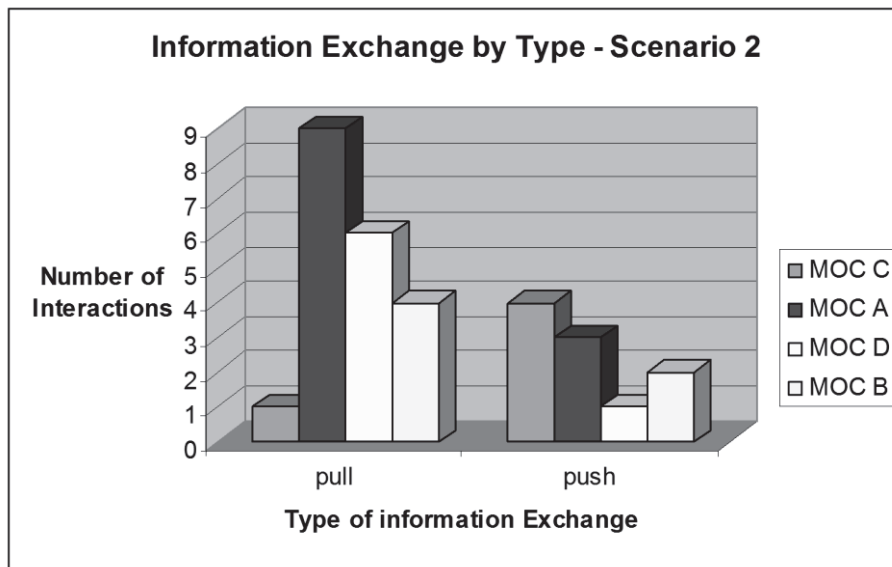
Figure 24: Graph of information exchange type in scenario 1
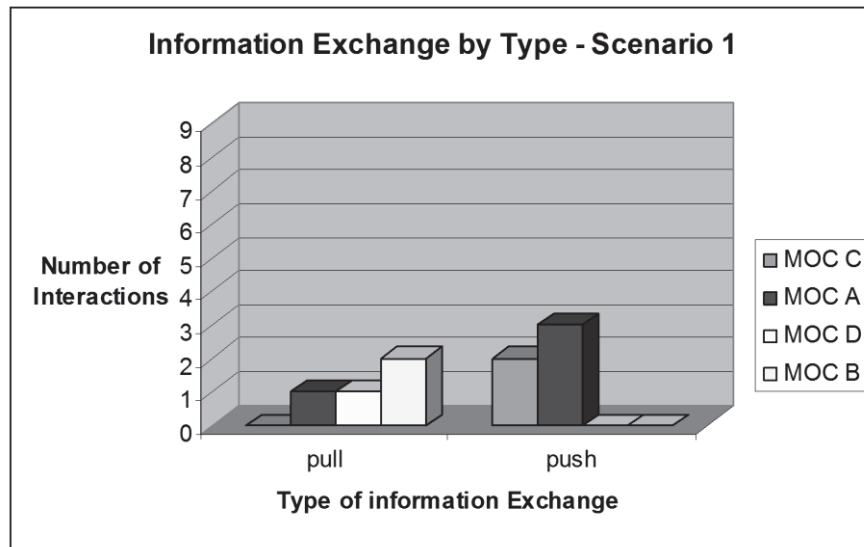
Figure 25: Graph of information exchange type in scenario 2

In Figure 26 MOC team D receives information from MOC team A but MOC team D does not react on it. The information does not cause actions and the team does not even acknowledge the other team about the information. Later on, MOC team D receives information from another source and acts on it, but does not inform other MOC teams about it.
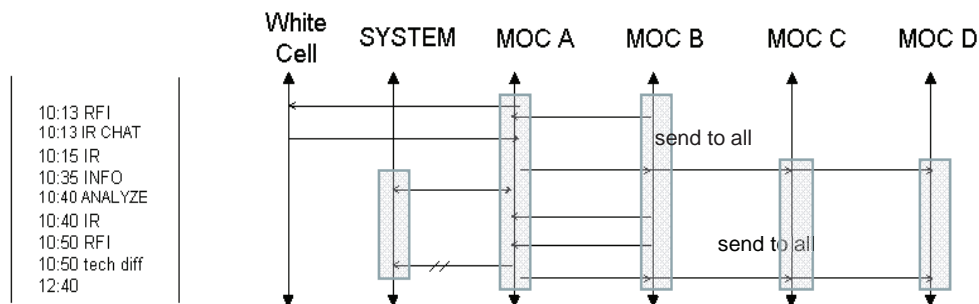
Figure 26: Example of good information flow in scenario 2

In Figure 26 MOC team A receives information that the team shares to other MOC teams. That increases other teams' situational awareness and MOC team B reacts and sends more information to MOC team A.

In this information flow is shown how the situational awareness is increased through sharing and how the information sharing can activate others to react to the situation. When MOC team A suffers from technical difficulties, they contact other MOC teams for assistance.

3.3.6 Conclusions from the event 2

Reflecting back to the research questions, MNE 5 MSA experimentation event 2 revealed there are number of factors about information sharing that affect also problem solving and operators' situational awareness. Aspects can be categorized to social, technical and organizational factors. Social factors include issues such as operator confidence and culture. Technical factors can be tools that hinder or enhance social interaction and information sharing. Chat was a good example of a technical tool that enhanced information sharing. As a method of communication, chat also caused information overload occasionally. In the future, operators should be trained to use a problem solving process and information management best practices to cope with the volume of incoming data and information. From an organizational perspective, information sharing policies play an important role. Clear information sharing policies and rules for information exchange support co-operation and sharing. In this study, when MOC teams were allowed to interact directly (scenario 2), the quantity of MOC to MOC communication and information sharing increased. The study also addressed research question about work practices, and it was clear that training on the problem solving process improved teams' ability to manage information and view the problem holistically. One output of this experimental event was more formalized problem solving training material for event 3.

3.4 MNE 5 MSA event 3

The experimentation was conducted 1st to 5th December 2008. Event 3 reused the event 2 scenarios but in a truly federated and distributed environment. Each nation participated from their home base either the national MOC or in NATO's case from US 6th fleet using a combination

of NATO and 6th fleet operators. The MOCs were networked technically through the internet. SOP and PSP training was included and new teams were provided with the same tools and settings as the event 1 teams. Now the Problem Solving Process (PSP) was given from the beginning and usage of the process was also observed. This section will provide the reader an overview of the findings from the event 3 and how the results relate to previous event. The difference from the event2 is the truly distributed environment. The Finnish MOC located in the Navy Command HQ, Turku, Finland. The event 2 gave a lot of good information about the factors affecting the team's ability to work with the scenario-based problems. PSP was added from the beginning to the operator training. Operators were different persons playing with the same scenarios as in the event 2. Since the experimentation setting and used methods were described earlier, next the findings from the event 3 are presented.

3.4.1 Overall findings from the MNE5 MSA event 3

Figure 27 shows an example from the observed MOC receiving information from an external source then utilized the technical system to verify it and search for more information. The team then received a Request for Information (RFI) and responded to it. Figure presents the information flow from different MOCs with different tools.

There were six aspects that are considered to be social and affecting the team, that are MOC structure, trust, process model, confidence, language and networking issues. Main factors found from the experimentation to influence on information sharing that are MOC structure, trust, language, individual level confidence, process models, and networking. Some MOC's structure was very organized. Roles were clear; operator using the technical system and Intel giving instructions and using the communication tools. Structure also affected problem solving and the usage of different tools and interaction with others.

Trust was also one major factor: For some MOCs it was easier to trust the given information from MOCs with same cultural experiences than from MOC that they did not share common culture. This was identified both from the observations and interviews.

TIME	SUBJECT	MEDIA	WHITE CELL	MOC 1	MOC 2	MOC 3	MOC 4	
746	RFI for Vessel X	Email						PULL
849	FAILED CALL TO NATO for clarification	Voice						
851	RFI Vessel X	Voice						
853	RFI Vessel X	Voice						
853	Vessel X position	Voice						
856	Asking CATES in WC detention records of Vessel X	Email						
904	No information from CATES	Email						
911	For MOC 4 there is nothing we found on Vessel X besides the position we given you	Chat						
915	For MOC 3 TY for looking	Chat						
919	MOC 4: my information shows two similar ships with the same IMO number with Vessel X, propable name changes Vessel Y, Z	Chat						
934	Re: RFI for Vessel X	Email						
940	COI DESIGNATION FOR VESSEL X	Email						PUSH
949	Action for Vessel X	Email						PUSH
1021	Re: Action for Vessel X	Email						
1048	Vessel X information	Email						
1311	Re: Action for Vessel X	Email						

Figure 27: An example of interaction diagram from the Finnish MOC team's point of view

Result of communication should not rely on actor's personality and it is an important aspect to be notified.

In event 3 the actors made personal decisions about what source to trust and what not. Teams should critically analyze the received information and compare their own information to that. The supporting process model, problem solving process (PSP) could be seen in action but every time something interrupted (new information, technical search from the system) the problem solving loop stopped. When there were low phases, the model was used but as soon as more information and distracters appeared, they skipped the process. AOR played a huge role. There were many situations when MOC teams stopped acting on a vessel after it was leaving their own AOR or was not coming to their AOR. What had changed from event 2 was that now there were more interaction and information sharing so that other MOC teams were given information about those vessels. AOR needs more rethinking, because you have a responsibility towards others to notify if some information is crucial for others to get true maritime situational awareness. Confidence depended on individuals personality and confidence can be encouraged by clear instructions and training. Language can be an issue, like in event 2, but it was not an issue in the event 3. That depends on individuals language skills. Networking is supported by the familiar ways of working and

common cultural experiences which resulted in easier working relationship for some participants. MOC teams got crucial information from other MOCs and without sharing they would have not been able to find right vessels.

There were five major technical factors such as information analysis, information push and pull, information access and data that affected the operators. First of all data needs to be clarified when dealing with raw data vs. value added data. It caused confusion. This needs to be defined in more detail. We assumed that in the Event 3 we would see lower communication between MOC teams because of automation and automatically shared data but it did not happen. We were able to see more sharing including Inter Reports (IR) and a lot of Request for Information (RFIs) through chat, email and voice. A lot of informal communication like asking for more details happened through chat and formal messages and information sharing happened through email. In some cases Vessel Of Interest (VOI)-lists were also shared through email so automation did not decrease the amount on social information sharing.

Information analysis experience levels of teams varied a lot. Lack of intelligence experience affected the analysis of the scenario. One MOC had to rely to other MOCs information because they were suffering from user errors with using their own system. This demonstrated that the source-thinking and training had worked. Using encryption and Gmail caused frustration at times because there were so many details needed to remember in order to send encrypted RFIs, those were factors that slowed down the information analysis and problem solving. This is a common problem; Information security solutions have weakened usability because of the extra work demanded by the security solutions. This overall diminishes the easiness of communication.

Chat was used often as a tool for asking for more information. At times when a lot of information was coming at the same time, the teams made decision of prioritizing messages and that caused that they forgot the previous messages when they received new data. Also, when trying to use other teams technical services, there were failures a couple of time in information access. The automation of technical information sharing did not decrease the amount of human interaction. Email, chat and voice were used to share information and sharing was crucial in order to teams put pieces together to solve the scenario. The automation did not decrease the

amount of pulling information. Different types of communication means were used to pull information.

There are three organizational level factors such as MOC structure, SOP and training are affecting the team. As a result the problem solving process needs to be implemented as a SOP. SOP should be built on problem solving process. MOC teams understood the basic idea of the problem solving process but the implementation of it in the teams during the scenarios was not executed well.

We need to have more practical instructions how to execute the problem solving process and provide the tools for that. White Cell (WC) was organized in a sufficient way. There were times when the teams had difficulties using all of the available resources because they felt limited because of the scenario. Limitations regarded issues such as contacting higher headquarters, getting historical data and mismatches in the AIS feed related to the scenario. Nevertheless, the White Cell's role was as clear as it can be in this kind of experimentation. Some MOC teams were well structured so there were not people in the same MOC working on the same task without knowing about the duplication. If the MOC teams had informally decided the division of tasks, it was possible to see redundant tasking. SOP was not used efficiently enough. It did not support as much the MOC teams as it could be. In the future problem solving process should correlate with each other.

The MOC teams were not trained with an example scenario that would have helped them to understand the experimentation. Lack of knowledge of other MOC team's technical capabilities caused some MOC teams to hesitate contacting and asking for more information from other MOCs. Knowledge of other MOC team's capabilities is vital when teams are encouraged to share information and consider other team's capabilities as sources and tools.

3.5 Overall MNE5 MSA findings

According to Bolstad & Endsley (2003a) supporting of situational awareness can be done through the use of collaborative tools and techniques that support different type of collaboration and co-operation. The list of collaborative tools is quite wide; face to face interaction, video

conferencing, audio conferencing, telephone, networked radio, chat/instant messaging, white board, file transfer, program sharing, email, groupware, bulletin board and domain specific tools (Bolstad & Endsley 2003, 1). In MNE5 MSA experimentations we provided voice, chat, email, file transfer and whiteboards as the main collaborative tools for the participating teams to interact within the team and with other teams. In Table 2, depending of the type of and need for co-operation, collaboration characteristics can be described as follows according to Bolstad & Endsley (2003): 1) Type of collaboration – whether the collaboration will occur at the same time (synchronously or asynchronously), 2) predictability of collaboration – whether the collaboration will occur as scheduled or at unscheduled times 3), place of collaboration – whether the collaboration will occur in co-located or distributed environment and 4) degree of interaction – whether the collaboration will need simple one-way communications or a lot of interactivity (Bolstad & Endsley 2003a, 3-4; see also Bolstad & Endsley (2003b).

The basic types of communication have distinctive features. Real-time and interactive communication such as phone call and video conference require simultaneous presence. This interruption can affect individual's concentration. One way, real-time communication such as bulletin boards and radio have the problem of verifying at the information is received. Two ways, non-real-time communication such as chat and email are less distractive and allows prioritization but the interaction suffers and there is a possibility for misinterpretation. Spoken communication is easier and faster way to communicate but the difficulty is that is not repeatable. Written communication is more accurate, although it also includes the possibility for misunderstanding, but it is easy to refer back to the text and check the content.

Table 2 describes how tools can be categorized based on the collaboration characteristics. The original tool category includes wider list of special type of tools. In Table 2 tools used in MNE5 MSA experimentation are described. Like in the Table 2, different levels of interactions were also seen in the experimentation. Depending on the collaboration characteristics, tools were used in different situations. The most used collaboration tool was chat. It was informal and easy way to get in contact with other teams for more information.

The collaboration characteristics (Table 2) reflect also the experimentation; in the distributed environment teams received almost instant reply or feedback after sending messages via chat. Teams were more aware of each other while using chat. The usage of email was more formal and times to reply where a lot longer than with using chat. Teams were focusing a lot to the format and form of the email which caused the time delays. Informal chat communication was unstructured and more efficient way for quick communication and details. It is also an important aspect to understand that if there were several cases going on, following of the chat discussion might be more challenging but in this particular setting it supported efficient information exchange (Bolstad & Endsley 2003a, 4, Table 1).

Table 2. Taxonomy of collaboration and collaboration characteristics

		Collaboration	characteristics	
Tool Category	Time	Predictability	Place	Inter-action
Face-to-Face	Synchronous	Scheduled or Unscheduled	Collocated	High
Telephone	Medium-High synchronicity	Unscheduled	Distributed	Medium-High
Chat	Med-High synchronicity	Semi-scheduled or Unscheduled	Distributed	Medium-High
White board	Synchronous or asynchronous	Scheduled or Unscheduled	Distributed or Collocated	Mode-rate
File transfer	Asynchronous	Unscheduled	Distributed or Collocated	Low
Email	Asynchronous	Unscheduled	Distributed or Collocated	Mode-rate-Low
Domain Specific Tools	Synchronous or asynchronous	Scheduled or Unscheduled	Distributed or Collocated	Low

In Table 3 tool characteristics are divided to three different categories:

1) Recordable/traceable - does the tool provide traceability of the collaboration,
2) identifiable – does the tool reliably identify others involved in the collaboration and
3) structured – does the tool allow unstructured or structured communications?

From the experimentation we got evidence that when team members had a good level of confidence in identifying other participants and collaboration was more unstructured, participants were much confident using tools and sharing information (Bolstad & Endsley 2003a, 4, Table 2).

Table 3. Taxonomy of collaboration and tool characteristics modified for the MNE5 MSA framework

	Tool	*characteristics*	
Tool Category	*Recordable*	*Identifiable*	*Structured*
Face-to-Face	*No*	*High*	*Unstructured*
Telephone	*Possible*	*Good*	*Unstructured*
Chat	*Moderate*	*Good*	*Unstructured*
White board	*Moderate*	*Moderate or Good*	*Unstructured*
File transfer	*Good*	*??*	*Unstructured or Structured*
Email	*Good*	*Good*	*Semi-structured*
Domain Specific Tools	*Low*	*Poor*	*Structured*

Bolstad & Endsley (2003a) also identify different Information Types. The degree to which the various collaborative tools support the transmission of different information types is presented in Table 4 as modified version of the original Bolstad & Endsley (2003, 5, Table 3). Information types that may be involved in collaboration include:

1. verbal (speech) information,
2. textual information,

3. spatial/graphical information,
4. emotional information – including for example workload, competence, and anxiety,
5. photographic information and
6. video information.

In face-to-face communications it is possible to include the transmission of all these information types, but there are also tools that are very poor or unable to support the transmission of certain information types well (Bolstad & Endsley 2003a, 5, Table 3).

Table 4. Taxonomy of collaboration and information types modified for the MNE5 MSA framework

Tool Category	Verbal	Information	types			
	Verbal	Textual	Spatial/ Graphical	Emotional	Photographic	Video
Face-to-Face	Good	Good	Good	High	Good	Good
Telephone	Good	None	None	Moderate	None	None
Chat	None	Good	None	Poor	None	None
White Board	None	Moderate	Good	Poor	Good	None
File Transfer	None	Good	Good	None	Good	Moderate (pre-recorded)
Email	None	Good	None	Poor	None	None
Domain Specific Tools	Poor	Good (if program supports)	Good (if program supports)	Poor	Good (if program supports)	Good (if program supports)

The tools used in the MNE5 MSA experimentation, support in different ways the shared situational awareness that is crucial for a successful co-operation. In face-to-face interaction and using telephone the support for the shared SA is in the level of Medium-High, but when teams start using chat or email, shared SA is at Moderately-Low -level according to Bolstad & Endsley (2003a, 5-6, Table 4). Dedicated specific tools are ranked to have high-level support to shared SA but this means systems that are dedicated for supporting data gathering and information tracking. In MNE5 MSA this meant teams' own technical systems such as MEVAT.

After the description of the experimentation environment, technological setup and used methods, we can continue to analyze the findings according to the previously described theoretical basics of situational awareness affecting information sharing and co-operation. Based on the lessons learned from the overall MNE5 MSA an improved process model was developed and it will be presented after the MNE6 presentation.

4 CASE STUDY MNE6 MISA-EM

While MNE5 MSA focused on situational awareness in domestic waters, Multinational Experimentation 6, Multinational Interagency Situational Awareness of the Extended Maritime environment, MISA-EM, focused on remote or distant areas, where indigenous capabilities hardly exist and the environment is not well understood. MISA-EM conceptual framework was developed to create an accurate awareness of unprepared maritime environment, shared by the spectrum of involved stakeholders in a multinational framework, to facilitate safety, security and environmental protection. I was, like in MNE 5, the Finnish lead analyst, co-leading the case study experimentation with my Spanish colleague. The data collection was a team effort and I was able to closely observe the MISA-EM team. All the data was verified also with the experimentation team to diminish the error margin. Basic data collection methods, such as observation and interviews and special methods to capture SA were used to understand the entire collected raw data in order to understand the whole. The basic raw collected data form the case study provided critical insights to develop the concept presented in this dissertation.

The Multinational Experiment 6, Objective 4.2, MISA-EM was divided into two separate Limited Objective Experiment (LOEs). LOE 1 was organized in Helsinki, Finland 9th–11th March, 2010. The aim of the LOE 1 was to 1) prioritize the most important challenges in the maritime situational awareness in unprepared waters and, 2) analyze some of the solutions that MISA-EM conceptual framework has proposed to address those challenges. 3) new innovative solutions were also welcomed. The experiment was an expert panel where both the facilitated discussions and the orchestrated assessments were captured through a collaboration tool and analyst observations. Scenario-based LOE 2 took place in Cartagena, Spain 26th – 30th April 2010. The MNE6 MISA-EM timeline is presented in Figure 28.

1. Concept development workshop in Madrid, Spain (27th to 29th May 2009)

2. CD&E training in Tuusula, Finland (1st to 3rd Sep 2009)
experiment design draft

3. Concept development workshop in Cartagena, Spain (5th to 9th Oct 2009)

4. Concept development workshop in Madrid, Spain (24th to 26th Nov 2009)
theoretical framework

5. Concept Development in Singapore (18th to 22nd Jan 2010)
data collection plan

6. LOE 1 in Helsinki, Finland (9th to 11th Mar 2010)

7. LOE 2 rock drill in Cartagena, Spain (22th to 25th Mar 2010)
tool and procedure testing

8. LOE 2 in Cartagena, Spain (26th to 30th Apr 2010)

9. Technical capability demonstration in Turku, Finland (11th May 2010)

10. LOE analysis in Madrid, Spain (24th to 28th May 2010)
analysis report

11. Concept development in Madrid, Spain (21st to 23rd Jun 2010)

12. Concept development in Riihimäki , Finland (17th Aug 2010)

13. Concept development in Helsinki, Finland (4th to 7th Oct 2010)
lessons learnt, concept finalization

Figure 28: Timeline of MNE6 MISA-EM case study events

4.1 MNE6 MISA-EM LOE-1

In the LOE 1 the expert panel was separated to three groups. Three sequential sessions: 1) information requirements/cultural aspects, 2) processes/structures and 3) technological aspects) dealt with information sharing and interaction or coordination among the relevant stakeholders in building better situational awareness. The experiment was executed via facilitated discussion with pre-drafted challenges and solutions (statements), together with computer-assisted assessment (surveys) and information collection. The facilitators were given freedom to adjust and focus their group discussions to maximize the yield of new insights and innovations. Facilitators had to find the balance between creative discussions and more orchestrated assessments and surveys. All three facilitators created different but successful approach to reach the goals. It should be noted that the groups differed in their voting pattern: Group1 stopped using the voting system after the first session – thus all data from sessions 2 and 3 are from groups 2 and 3 (Koskinen, Vuorisalo & Boseaus, 2010).

4.1.1 Session 1: Information requirements and cultural aspects

The presented challenges and solutions in session 1 were related to understanding other actors, sensitive information, new information and cultural understanding. The challenges and solutions were developed by the MNE 6 team to test the participants' views on information requirement and culture related issues. The proposed challenges and solutions were taken as such, and results were analyzed reflecting how the experimentation audience reflected their own views to these issues. (Koskinen, Vuorisalo & Bosaeus, 2010).

Highlights relevant for this dissertation context from the session 1 are presented below. For example participants felt that understanding other actors, issues related to sensitive or new information and cultural understanding solutions are affordable but they are not complete.

Observations and Subject Matter Expert (SME) comments are

categorized by themes, in bold. Quotes from SME inputs are in italics.

The conversations focused on reasons to share information; it should not be based on each ones benefit but on the goal of the project, the common good. For example comments on stopping the piracy and asking the question to whom to share information. Groups identified actors/**stakeholders**. Participants listed actors such as communities, owners, government, secure, non-secure, industry, taxpayers, public, research, military, environment protection, safety, other countries, media, criminals, terrorists, commercial companies, international agencies and consumers. Different domains such as government secure and public, research, industry/owners (economical), environment, communities, and tax-payers were mentioned. Identifying different stakeholders raises also the importance of being able to identify all the stakeholders that may have an impact related to the situation we are building the SA of.

"When different actors are involved we have to face the different interests these countries or entities have with regard to this particular state."
"Some technical solutions exist like ontologies and culture free map symbologies. Much more could be done on technical level starting from different ways of communication in different cultures: in some cultures you cannot talk just straightforwardly face-to-face etc. Culture dependent communication processes should be analyzed."
"It is important to analyze each stakeholder: using the willingness to share vs. capable to share matrix. Only then, you can identify each of the stakeholders´ need. For someone who is not willing to share, then you develop confidence building measure, for someone who is not capable to share, then you develop capacity building program, and for those who are willing and capable to share, then you develop interoperability solutions."

After identifying the actors around the maritime environment, the question of sharing rose. There was a question of individuals and organizations wanting to receive but not having the **willingness to share**. There was also discussion about *"what's in it for me?"* How the information sharing needs to be institutionalized beyond simple point-to-point contact. Sharing was seen as a risk, so discussions were linked also

to cultural awareness.

A lot of discussion concerned the lack of **trust** and trust meaning willingness to share. Trust was seen the basic building block that supports and allows sharing of information. The SMEs emphasized the issue of trust is crucial: Trust is more important than technology. While building trust, one should also build a process of cooperation and not only focus on information sharing. The cooperation should build on common goals and interests and should highlight the benefits of cooperation. Moreover, it is important to highlight the benefits of cooperation and cooperation should also include local actors.

"Cultural and legal issues need more analyzing".
"More training and awareness is particularly required to ensure trust is achieved between owners and third parties."

There was also the question of **the nature of the information**. Information was considered as power. It is also important to understand financial, legal and cultural aspects of other actors. There are actors that do not share because they are afraid information misuse. The different levels of information were discussed. There were also comparison of maritime traffic and air traffic; what are the similarities and differences in these contexts that we could learn about? And also we need to categorize the type of information that we want to share; whether it is AIS, radar, satellite, Intel, etc. In another words, we need to identify the information sources but also content, whether is secure or non-secure and also different data types. The focus need to be not only on security advantages, but also maritime safety and environment protection as well, according to the discussions of the participants.

There was also the question of **the quality of the information**, and understanding others capabilities, if we are expecting higher quality than we are receiving. There are real life examples, how the information control is done and group comments stated that global network is the solution but the problem is how to build it.

According to the discussions, there should be a commonly agreed **standard** how to share information. Context also became an issue; are we talking about normal situation or crisis. What are the motivations for sharing information? There should be a permanent basis for normal

activities to help confidence building.

Trust is always built on respect. It is important to acknowledge that there are also issues like corruption affecting possible collaboration. Based on the conversations, respect is the starting point. Only then can a fruitful co-operation work. It is also important to respect the limitations given around the information being exchanged. But first we need **the need for exchanging**. Key issues raised are: Common concern, basic global structure, framework that is scalable, mechanism to distinct relevant information, a system to rank information in terms of usefulness. We need the basic building block, the foundation before we can talk about technology. Information sharing at all levels is very difficult to achieve. Common goals must clearly be defined for all stake holders to achieve success, referring to the discussions of the SMEs.

A set of predefined information requirements should be developed for each general or broad area such as piracy and human smuggling, etc. Stakeholders can agree in advance on levels of information sharing.

> *"Every kind of information is not needed by every stakeholder. Only those who are legally authorized to act and use sensitive information are able to use it. They can of course ask help for actions from other actors."*
> *"Organization and individuals need to have adequate understanding about the independencies between the stakeholders to balance between trust, risk, effort and reward in sharing information. "*

Technology is not an opposite to trust or similar issues, as stated in the results of the discussions. Technology does not solve the problem of trust, but it can be used in a way that it supports the establishment of trust and enforcement. Technology is not one single-shaped thing but can have bad or good implementations. Developing trust-making human processes and technical development should advance as an iterative process.

> *"Once the trust and purpose has been established, the overcoming of legal and cultural aspects can be made easier. Technology is just an enabler, not the solution."*

The SMEs comments included situations where many persons within

the intelligence community mistakenly use their security clearance as an indication of their competency - just because they have clearance. This creates a false impression. Most **classified information** may be scrubbed and then availed to the greater group for the greater good. Often agencies will "hide" behind a classification in order to protect that information from being shared. There were also comments that the 'intelligence' community should only collect intelligent data. Base or core data that is not sensitive should be collected by another agency so it is freely available for other purposes. There was a discussion about sharing raw data because most "raw data" is not classified. Most of the "elaborated information" is sensitive. Raw data exchange could work as a confidence building tool. After this the next step is when elaborated information is tailored by user. There has to be mechanisms to request for information (pull).

Sensitive information is not automatically shared with everybody (push). There is the possibility that competition may prevent from sharing even if trust exists. There is also information that can be time sensitive. The participants also need the permission to share – in an operation the mandate (e.g. UN) allows stakeholders to share data. SMEs noted that sensitive information is often used as an excuse for not sharing information and that it takes time to make people understand that we should move forward to achieve a real "need to share" environment. Further, it is quite a different problem to share information within your own coalition and build up co-operation with local actors.

"Meta information for datasets should be available when dealing with sensitive information. Sometimes you have to give information without conditions in order to create functional conditions. Follow up is needed. Solution should discuss more about declassifying information, making it less sensitive in order to share it with others. "

"Again the benefits of exchange should be the motivation for the information sharing. This should be stated in the agreement. There has to be a will, a clear need, and a strong agreement before one can start sharing sensitive information. "

"Acknowledging differing security environments is an important step."

"More emphasis should be made on simplifying how sensitive

information is classified and on declassification. "

"There is a challenge in putting the system in affect."

"How to enforce non willing actors to cooperate and give the information demanded?"

There was discussion about **the will** and **an agreement**. Trust is always built on respect. It is important to understand the difference of the trust in the person with whom you are sharing, value of the information you are sharing (risk to share), effort you need to expend to share and reward you would expect from sharing. Organizational agreements can be in conflict with individual values. There may be a political unanimity but still the individual attitudes can vary.

How to pull and push new information? When developing something it is important to remember that without being open you'll end up situation with different models, approaches etc. Based on the discussions, there is a need for procedures on how to navigate and operate in new areas. These rules should be discussed and accepted by all the parties (stakeholders). These rules should include **procedures** how to inform of your movement when entering the area.

There are a lot of challenges that individual actors face in new cultures, next challenge is about comprehensive cultural analysis. Some of the audience felt that if the aviation can do it there is hope for the maritime environment as well. But we also need to understand that the environment is always a **context-driven**. There was also a question could certain areas/environments be monitored continuously to make them more well-known? We would need to emphasize info sharing in that way as well.

Trust is built upon treating parties, but the trust might not be equally built. Sophisticated interagency sharing is achievable but after first identifying common and mutual benefits about why to share. Issue of lowest common denominator information exchange by other groups was a very valid point. It is always the *operator*s that benefit from shared information as they have to deal with changing operational situations. There was a discussion about the need for a baseline agreement; each stakeholder will provide minimum level of information. Terms of reference (TOR) are to be created. Cohesion is an important issue; baseline should be created according to the participants' discussion.

"Once political will has gathered countries or any other stakeholders, there is evidently room to share info. Now the most efficient way to do so seems to quickly identify the lowest common denominator (in terms of sensitivity) that will gather the largest number of actors. Any more enriched info or Intel should be shared from point to point. From my experience, this enables to address 80 pct of a problem."

There is also the challenge of creating **generic solutions** for a successful MSA. Solutions should derive from a unique context. An example of MSA around the Gulf of Aden was given. All agencies involved are keen stakeholders who are ready to go cross-sector in this operation. Connecting all the countries in Europe is a completely different issue.

Overall discussion included concerns about in what ways we can find out information, how to learn about other countries when we are going to areas that we are not familiar with. How to define and get relevant information, different stakeholders, different needs and what are the relevant stakeholders. Presented challenges seem to reflect the participants' views. The solutions were a good starting point for discussions but there are still several steps need to be taken before we are able to build concrete solutions to address the information requirements and cultural aspects. One might disagree with the views given by the SMEs but their explanations are good examples of the complexity and multi-layer environment we are dealing with. Different stakeholders and interest groups have their own professional and personal views, how they reflect the reality. In this dissertation the comments are considered as one possible way interpret the co-operation framework. From the SME's comments and discussions, it was possible to gain point of views to support the creation of the conceptual model. (Koskinen, Vuorisalo & Bosaeus, 2010).

4.1.2 Session 2: Processes and structures

The challenges and solutions in session 2 were related to commonly agreed processes, co-operative structure, modeling and preparedness for

transitions. The challenges and solutions were developed by the MNE 6 team to test the participants views, related to processes and structures issues. The proposed challenges and solutions were taken as such, and results were analyzed reflecting how the experimentation audience reflected their own views to these issues (Koskinen, Vuorisalo & Bosaeus, 2010).

The highlights relevant for this dissertation from the session 2 are described below. For example participants felt that understanding other actors, issues related to sensitive or new information and cultural understanding solutions are affordable but they are not complete. The SMEs were not convinced of the adequacy, feasibility or affordability of the challenges and solutions. Observations and SME comments are categorized by themes, in bold. Quotes from SME inputs are in italics.

Rather than looking at information **sharing mechanisms** it was suggested that focus should be drawn on standards for information sharing. Moreover, when discussing mechanisms, classified information sharing mechanisms should not be left out. A good way ahead could be the identification and definition of the Information Exchange Requirements (IER) and based on these build up a Business Process Model (BPM). There were some examples given during the conversations about airlines and banking/credit cards; how to take advantage of existing global system, which has already tackled most of the information sharing issues. A model is a step towards measurements and verification of the goodness of the solution. In the model creation process we need to take the risk management and planning and before that we can do the stakeholder analysis.

For the co-operative **structure** a challenge is that there is no historical data from distant waters, understanding of the new area of interest, we have not been successful in integrating the different actors and coordinating it. There are issues back home that need to be tackled before understanding activities in new areas of interest. Without modeling there is no comprehensive approach. Activities will never be realized as they were modeled, but it is important to learn the modeling process so that it can be applied when needed in the real situation.

Different interests of different actors raised concern. It was noted that setting the info-sharing **governance** in place is key because sharing of maritime info across agencies and countries is not inherently natural. The

navy may find it what the big deal of sharing AIS info is but the commercial companies may not think so. Therefore it is fundamental to set the governance right in info-security and assurance when debating information sharing.

Human intervention/participation in info-sharing process is an important aspect. Face to face communication prior to an event (crisis/operation) is essential to establishing **trust** during a crisis. It should be noted that the question of trust was articulated across sessions and challenges. The fact that processes have a very strong human dimension should not be forgotten. Often opinions tended to focus on technical issues.

When creating SA, **pre-crisis action** was discussed. There is a need to identify possible crisis scenarios and then establish small permanent cells that will become the basis for the co-operative structure when crisis escalates. The competence of those local experts and liaison officers is deemed important, in order to have an information network already before the crises situation. Some SMEs felt that creating **common operating centers** in distant theatres is difficult or impossible, and at the same time others felt that common coordinating center can be achievable.

"Very feasible. Perhaps a concept for a standard common situational awareness center could be agreed among key players before any crisis."

The need for a **standard operating procedure** was recognized in suggestions that the framework could be kind of standard procedure which ensures the right communication between all the stakeholders.

When developing models you need validation platforms to understand their accuracy and reliability. Models of co-operation and development of situational awareness is based on observations and theory on communication contexts. When the first model is outlined it is then **tested** in various exercises or real life situations. This model can help actors to find their roles and relationships as well as the various communication modes that are useful in different contexts.

We should not look information sharing as processes only. Information is shared in different contexts and identifying them is important. Various contexts overlap and in one "process" many types of

communication happen.

Complement the solution explaining that validation of the model must be done through the observation of exercises.

To really know if a model is sustainable it has to be tested over time. Only then does one know if it has the capability to change with the challenges.

The use of existing solutions was highlighted. For example in modeling, we should take into account: existing architecture frameworks such as NATO Architectural Framework (NAF) or Ministry of Defense Architectural Framework (MoDAF) etc. Moreover, research on communication and information contexts was mentioned.

> *"Use of recognized models will enable more ready acceptance by the various actors, rather than creating a new one."*

Transitions raised a lot of debate and inputs from the SMEs. Regionalism was emphasized in claims that the definition of the challenge should be more oriented to the achievement of a regional solution for the maritime situational awareness rather than host nation. The SA capacity development must be seen and planned in the overall Security Sector Reform (SSR) framework. Recognized Maritime Picture (RMP) is essential for any nation, and part of nation building. Nation building and local ownership were themes that were also present in the inputs, while, at the same time recognizing that transitions might increase the mission scope since a successful transition might require support beyond the dock.

> *"Local ownership is probably more important than an optimal solution. "*
> *"Local ownership probably requires compromises between optimal solution (from coalition point of view) and what sustainable and doable and needed from the local perspective. "*
> *"The need of transitions is not situational awareness but capacity and infrastructure building. "*

During the session 2 the focus were on the procedures and finding concrete working examples that could be modified and modeled to serve the maritime community. Discussion focused on social networking, the

need to put people before technology. There was a discussion of proactive steps.

Evolving network of highly committed stakeholders that requires common interest, common benefits and open sources. Standard foundation (products & services) that needs to be mutually beneficial and have a dataset/baseline. Need to feed the social network by identifying point of contact.

There was a discussion of information sharing: Fear, loss of power of control, over clarification/de-clarification, dependency on technology. Real power is in the social networking. The challenges related to processes and structures are tried to tackle with issues such as standardization, common models and procedures but the solutions still lack the element of concrete steps to take upon. The discussion related to the processes and structures confirm that these issues are important and need to be tackled to support the collaboration and gaining adequate level of awareness. (Koskinen, Vuorisalo & Bosaeus, 2010).

4.1.3 Session 3: Technology

The challenges in session 3 were related to information sharing, interoperability, missing information, customer focus and information overload. The challenges and solutions were developed by the MNE 6 team to test the participants views, related to processes and structures issues. The proposed challenges and solutions were taken as such, and results were analyzed reflecting how the experimentation audience reflected their own views to these issues (Koskinen, Vuorisalo & Bosaeus, 2010).

The highlights related to this dissertation of the session 3 are described next. For example information overload and interoperability where considered to be most challenging regarding the completeness of the proposed solutions. SMEs were not convinced of the adequacy, and they also raised questions of the feasibility of the challenges and solutions. Observations and SME comments are categorized by themes, in bold. Quotes from SME inputs are in italics.

Overall, the technological frame suffers from issues of technological maturity and legal acceptability. Moreover, the cost-benefit ratio of

building new vs. enhancing existing systems should be examined. Overall, technology's role should be to help with decision-making, that is, technology should not be developed just for technology's sake. Further, all technological possibilities should be explored when aiming to gain a better situational awareness.

Smart agents and anomalies were often at the center of attention as smart agents were seen as key to detect anomalies and anomaly detection is the key to reduce workloads.

> "I see here the smart agents as a generic set of tools to analyze data and visualize it for decision making. System can be designed to concentrate to anomalies, thus helping operators job."

It was discussed that detection of anomalies happens in two phases: first analysis of the data sets and identifying the "normal"; then comparing the situation with the normal behaviors and detection the difference. Critique was raised as well:

> "Need to define terms. Anomaly means different things to different organizations."

Moreover, it was felt that smart agents were still not enough. Filtering of data is needed to gain the wanted information, and all computational methods (not just "smart agents") are needed in this task. It was suggested that a more general term than smart agents is used in the solution, for example, advanced computational and visual methods. This term covers all from programming smart agent type solutions, use of spatial-temporal statistical analysis or other spatial data mining (Trajectory data mining methods) like identifying typical patterns, densities etc.

Harmonization was seen as important:

> "Here harmonization is a key word and the joint agreed interfaces for data transfer", yet it was also stated that "This shouldn't only be about harmonization. Also, completely different types of info should be fused."

Regarding the question of **interoperability**, the solution would make

it difficult for a new actor to partake in a process. If this actor is deemed as important, a new system would have to be constructed anyway. Moreover, there are four aspects to Interoperability between applications:

1. It is partially a technical question; this part can be solved by applying standardized data formats and interfaces.
2. Another issue in interoperability is the harmonization of the data bases, data contents; that can be solved by ontologies up to some extent at least.
3. The third question is then the organizational part; how easily organizations want to follow the standards and participate in the harmonization process.
4. The fourth part is the presentation of the data contents; that can be solved by generating common symbologies for example to the situation picture map.

Furthermore, when thinking about interoperability, ongoing interoperability initiatives, such as the ones managed by the EU, should not be ignored. The SMEs commented on interoperability actively:

"It is risky to state that organizations need to develop their own systems because there are already developed systems that could be shared by different organizations."
"There will be legacy systems. Need to adopt parallel tracks to interface legacy systems and at same time to agree on protocols/standard for new info sharing systems."
"Need to focus on problem solving and less on getting more data. "
"There are still some technical issues if we want to include interfaces to new technologies such as S-AIS for instance. IMO and IMSO should be seen always as key for the achievement of standardization and interoperability."
"Again a new temporary actor would have it difficult to integrate into the new community. A plug and play solution-platform might therefore be important, at least as a complement."

AIS Information always stayed in the debates, focusing on the fact that smaller vessels are not required to have AIS and AIS for larger vessels not always required to be on, that is to say that AIS is insufficient.

One suggestion was that:

> "AIS information should be encrypted and verified so that there will be no possibility to switch it off, give false information or even to use another ship's transponder in another ship/boat."

The importance of trust remained underlined – especially in a situation where anyone can access and add data etc. Then, we come immediately to **the problem of trust**. When the system is open, nobody can guarantee the quality of the information.

When sharing information, there is the issue of **public vs. private information**, and how to identify the source of information.

Switches between *operator* **vs. decision-maker** –point of view was observed as some solutions were seen to benefit *operator*s rather than the decision-makers.

> "Scalability must be very well analyzed because there are tools for filtering information also for the decision makers and not only for the operators."

Pre-crisis action was emphasized in this session as well.

> "The challenge is that the capability needs to be built before the mission. Multi-sensor tracking is fairly difficult to implement. "

Moreover, local ownership was discussed once more. Dialogue with locals was seen as an ideal, yet one must be careful that this is not misused (against the coalition / for internal political purposes). Moreover, it should be realized that information is not the first in a list of needs: often there is a greater need for basics, e.g. electricity.

> "..local ownership is crucial. A) The local communities need to have a stake in building SA - not just selling info, but using it too! B) Technical solutions need to be configured to support the local ways and culture - there is no one size fits all solution, especially in terms of technology."
>
> "Also need to bear in mind the overall local security capacity

building. Link and synergies e.g. to overall criminal investigation or intelligence capacity building should be made. Relating to this, one needs to make sure that the capability that coalition is building is not being used A) against the coalition B) as a tool for repression or internal power play."

"Human intelligence is probably as important in addressing communities."

"A close dialogue with local communities must take place in order to listen to their requirements, instead of imposing them a solution."

It was also considered that are current internet security protocols are valid to protect the kind of info needed to share? This underlines the importance of validation. In addition, other SME comments included.

"Use unmanned vehicles."

"The solution has to focus on the AOR. (Area of responsibility)."

"Solutions already exists using public interfaces (for example BRITE.)"

The discussion related to technology shows that technological solutions are only enablers and in fact the steps need to be taken are more related to standardization, information availability and relevance. The discussions related to technological solutions confirm that right type of challenges has been identified but there need to be work done in order to implement the solutions. Once again the comments from the SMEs can be critically analyzed and argue that they are relevant/ not relevant. For the context related to this dissertation the most important aspect is the participants' interpretations of the problems and solutions, their view of the reality. Since decision making should be based on the best facts available, one more challenge is revealed with these answers: The individual influence and perspective to comprehend and interpret is a relevant and influencing factor in both gaining situational awareness and making decisions. SME's comments also highlight the demanding maritime environment, where several dimensions need to be understood to support the collaboration and adequate level of information sharing. (Koskinen, Vuorisalo & Bosaeus, 2010).

4.1.4 Conclusions and recommendations from the LOE-1

A useful visualization tool was built based on the discussions, reflecting the data gained from the experimentation. The willingness-capability matrix, presented in Figure 29, can be used to map stakeholders. If the willingness exists, it is possible to focus on building needed capacity to enhance interoperability. If the capabilities exist, it is important to focus on building trust in order to enhance the interoperability (Koskinen, Vuorisalo & Bosaeus, 2010).
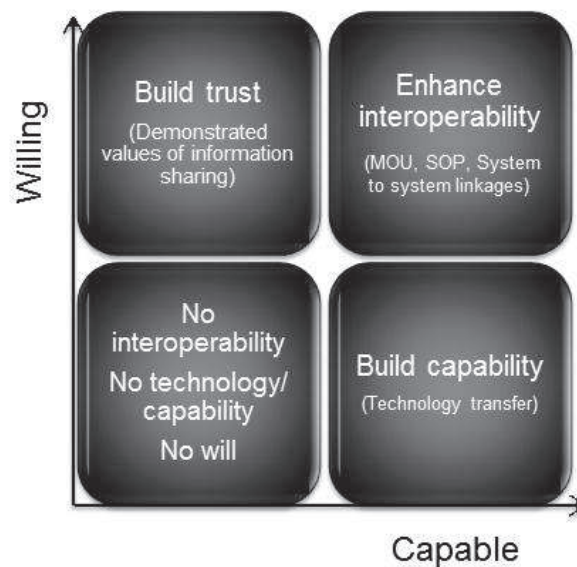
Figure 29:   Willingness-capability matrix

Instead of any detailed final solutions, a logical generic procedure to build "common" situational awareness should be shared and implemented before crises emerge. An incremental approach should be utilized. Technology gets better but it is not the only possible solution. The issue remains in understanding the interdependencies (mutual benefit) and the power of networking. Understand - and recognize - other stakeholders' objectives, activities, intentions and capabilities.

This may be obvious but calls for changes in resource allocations and education (comprehensive mindset and cultural awareness). Individuals and organizations need to have adequate level of education to balance between trust, risk, effort and reward in sharing information. Need for early regional inclusion and later local capacity building and transitions. Concentrate on collecting, analyzing and sharing the most relevant and workable (often unstructured human-to-human) information, instead of most/all data between the systems. Much of that information can only be changed bilaterally between trusted individuals and only in certain circumstances. It is important to make clear that while technology is seen enablers, they process information with black and white-mentality. With technological solutions we can ensure that the information is transferred to the sender without any changes but human behavior is much more complicated than zeros and ones. The human logic and inner thinking process allow the usage of different grey-levels as well. This has both good and bad influences and because of this conflict the human-technology interface is challenging. These aspects are also taken into account in the created conceptual model presented later.

4.2. MNE6 MISA-EM LOE 2

The ideology behind MISA-EM was to look into new affordable, sustainable, scalable, deployable and flexible SA-solutions taking into account the multinational and interagency nature of the maritime environment. MISA-EM included the development of situational awareness of maritime environment, shared by many different involved agencies in a multinational framework in order to enable safety, security and environmental protection against deliberate attacks in distant areas where local capabilities hardly exist.

4.2.1 Experiment objectives

The objective for the LOE 2 focused on the suitability of MISA-EM

processes and structures to solve the situation awareness problem at the maritime realm in support of a military operation in distant theatres. The objective of the experiment was to measure the level of Situational Awareness in the MISA-EM organization and compare the level of Situational Awareness in organization that does not use the MISA-EM concept. Goal was to analyze the data and information fusion process using deployed mechanisms in remote areas while being supported by relevant stakeholders. Mission was to explore whether a standard data and information set is suitable to support the required level of situation awareness and also to analyze the use of collaborative tools, technology-related and pull-push procedures as part of the MISA-EM solution. The experimentation was build up to three different MOCs that were cooperating, designated and deployable MOCs. Skills and functionalities of INTERPOL, ECSA, UN, CFCA, NGO and HHQ were played by role players. These role players were character actors that helped to establish the environment for the experiment by representing, international agencies and local entities. (Alvaréz, Koskinen & Vuorisalo et al., 2010).

4.2.2 Experiment design and execution

The LOE-2 was conducted during five days in the ALMART HQ in Cartagena, Spain (26th – 30th April 2010). The first day was devoted to training the audience, three days of actual experimentation, and a final day for hot wash-up and first impressions reports. With this time available, instead of using one experimental unit and conduct multiple runs with different treatments, a multi-group design was chosen. Separate treatments were administered to two different MOCs and the same scenario was run simultaneously for both; The baseline treatment consisted on a set of tools and procedures already available in a standard MOC. BRITE was used as the standard COP tool with all the on-line help, additional applications, data bases and smart agents. The SOP for the baseline MOC was based on the Maritime Operation and Surveillance Centre, Centro de Operaciones y Vigilancía de Acción Marítima (COVAM) procedures tied with add-ins from contributing nations. MISA-EM treatment consisted on a different Standard Operating

Procedures that included a more detailed stakeholder analysis, a data set with an automatic classification matrix and a collaborative portal for interagency interaction. MOCs were physically separated in two rooms and they were working in different networks so that information flow was not possible from one MOC to the other and vice versa. MISA-EM MOC consisted of the following roles: Watch Captain (WC), Assistant Watch Captain (AWC); two Tool Managers, and Information Manager. Roles inside Non MISA-EM MOC consisted of Watch Captain, Assistant Watch Captain, Data Base Manager, Recognized Maritime Picture (RMP) Manager and Information Manager. For Inter Agency (IA) roles there were two persons. For the experiment control Experiment Control (EXCON) team consisted of EXCON Leader, two EXCON Supervisors (one for each MOC), two EXCON Operators and two Technical Operators. In the experimentation there were six data collectors for each MOC and one data collector for each IA experiment player. Analysis were handled with lead analysts one for both MOC and four analysts, two for each MOC.

The specified observations made during the experimentation are presented from the MISA-EM MOC 1 and observations are focusing on the leadership role of the Watch Captain (WC). The Experiment Design and hypothesis with the MISA-EM treatment and none MISA-EM treatment is presented in Figure 30 (Alvaréz, Koskinen & Vuorisalo et al., 2010).

4.2.3 Experiment design and execution

The scenario for the event was set in the Gulf of Aden and the eastern coast of Africa where data gathering is difficult and conditions match the MISA-EM definitions for unprepared theatres. Circumstances required an interagency and military effort to build up SA in support of a multinational maritime. Three main vignettes were prepared for each one of the experiment days.
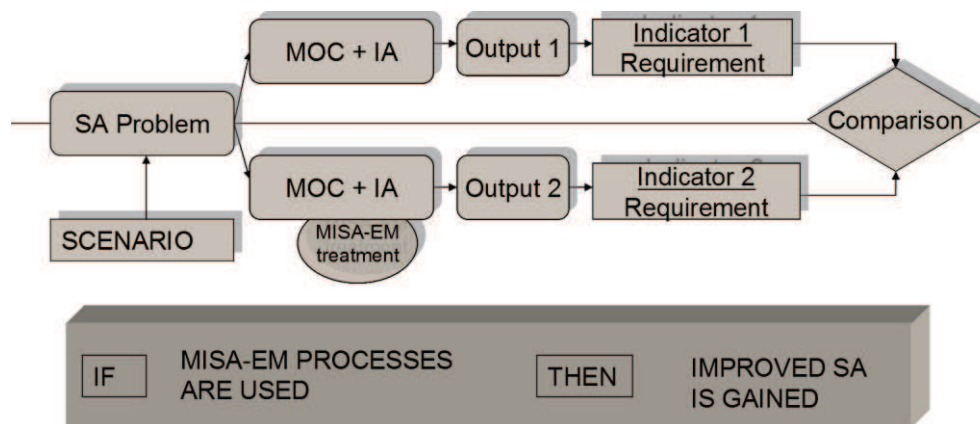
Figure 30: Experiment design

The scenario involved up to seven different agencies with which the designated MOC had to interact to solve and clarify the picture and obtain situation awareness. The scenario injects were given from different sources, by smart agent detection and reports send to the MOCs by the Higher Headquarter (HHQ) or directly by the stakeholders using the established communication channels. These channels were the collaborative tool and email for the MOC 2 and fax/email for the MOC 1.

4.2.4 Experiment design and execution

MOC teams were building up SA while they were reacting to scenario injects. Used methods were Situation Awareness Global Assessment Technique (SAGAT) presented in Appendix G and subjective SA for self-based evaluation, Situation Awareness Behaviorally Anchored Rating Scale (SABARS) presented in Appendix E, interviews and observations in addition to system logs and recordings to measure the levels of SA attained by each team. Unstructured interview is presented in Appendix F. The subjective SA test was designed to capture the confidence of each operator on their performance and ability to perceive data elements, comprehend the situation and make projections of future event in support of the team SA. Many SA studies have used these subjective measures as an interesting way to compare what the players think they knew about the

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developing situation with what they actually did know. These tests were administered to operators via Internet by sending links to the web site once for each experiment session (morning-afternoon). Observer-based measures were designed to capture subjective performance of MOC operators as well as single actions in respond to scenario injects and reasons behind these actions. A simple data collection tool was developed and distributed to data collectors for this task. For the purposes of this dissertation it was possible to observe especially MISA-EM treatment MOC, the MOC 2 and reflect observations particularly to teams subjective scoring and test results. (Alvaréz, Koskinen & Vuorisalo et al., 2010).

4.2.5 Observation and findings

Mental demand followed by temporal demand, effort and frustration were the most significant factors that affected the operators' tasks during the experiment according to the NASA TLX findings. Workload measure is constructed by combining scores for the six different factors of the NASA TLX index presented in Appendix A. Both of the MOCs workload are presented in Figure 31 (Alvaréz, Koskinen & Vuorisalo et al., 2010).
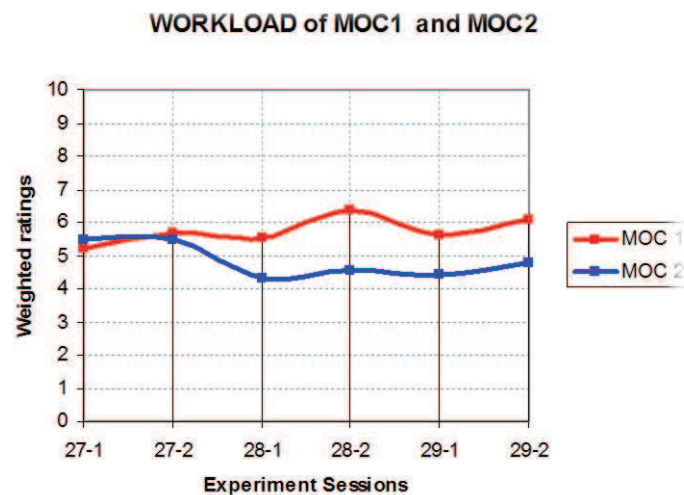
Figure 31: Workloads of both teams

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Figure 32 is visualized as sliding transition from each experiment session to make the graph more readable, like the other following graphs related to the experimentation. It needs to be noted that in reality there were breaks between the Experiment sessions described. For example 27-1 is reflecting to the 27th of April's first session, 27-2 reflecting to the 27th of April's second session.

Both MOC teams started with the same TLX weighted rating and they moved forward in opposing directions. The level of frustration for MOC2 was high at the beginning, which was probably related to the new collaborative tool and the lack of training on both, the tool and the MISA-EM processes. During the first session of the second day, this level was even lower than the one shown by MOC 1, which was still struggling to find the correct way to contact stakeholders. These findings seem to support the hypothesis of two different learning curves for each team, and also the fact that having a collaborative portal and a comprehensive stakeholder analysis eases the task for MOC 2 operators.
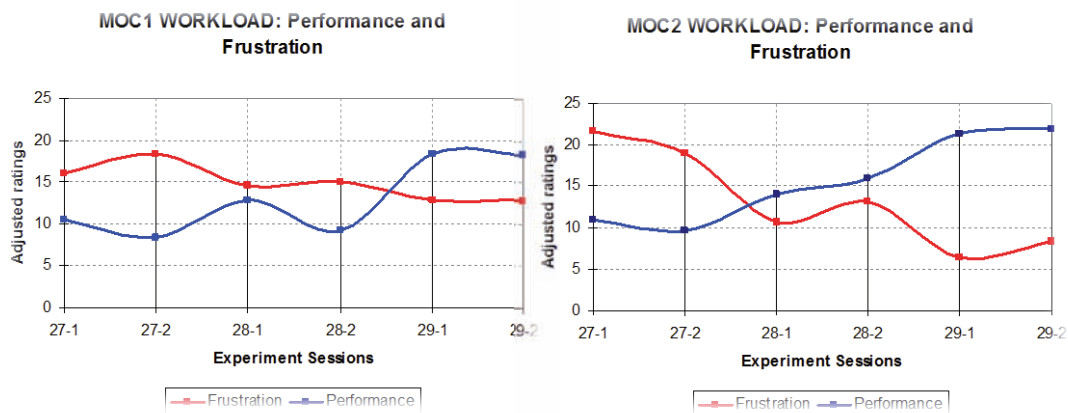
Figure 32: Both MOCs performance and frustration levels

Figure 33 present performance and frustration levels of the MOC teams adjusted by the group member average. As the frustration level went down, the perceived performance did just the opposite. As operators advanced in their knowledge of the scenario, tools and processes, their perceived performance went up except for the afternoon of the second day in MOC 1, whose curve shows a local minimum. MOC 2 performance curve follows very closely the frustration level.
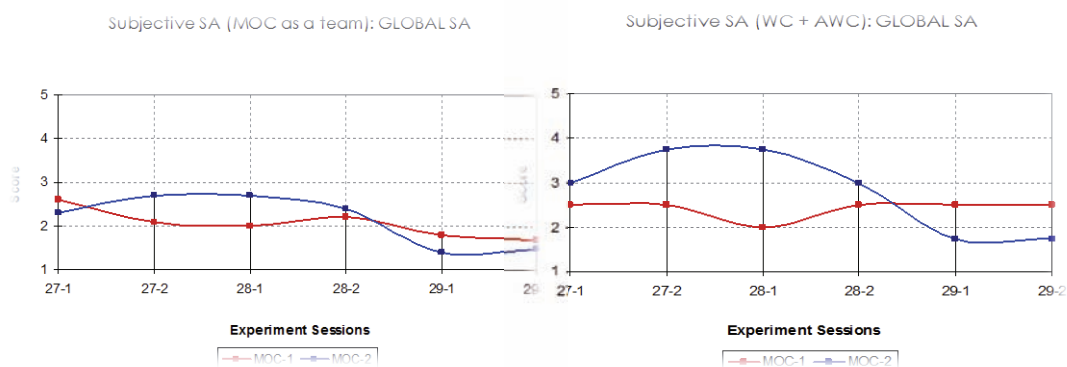
Figure 33: Global Subjective SA for a) the MOC's and b) the WC and AWC. Lower score represents more confidence and better picture of the situation, since the Likert scales were determined to be (1= very effective, very well, totally agree, 5=very ineffective

It was seen during the experimentation and could be captured with subjective measures that frustration levels correlate with the performance: When the team had issues such as problems with the systems, or too much information to be handled, it increased the level of frustration and decreased the level of their performance. The change of trend for the MOC 2 is outcome of the team starting to feel more confident in their performance. MOC 2 began to use the collaborative tool more effectively to exchange information as seen in Figure 32 (Alvaréz, Koskinen & Vuorisalo et al., 2010).

Operators had different roles and the scores obtained were individual perceptions of the workload they were experiencing. The sum across all members of the team to get an overall index of task load for the team

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seemed appropriate for several reasons. The scores for the global SA in Figure 33 present how the teams rated the subjective SA. Larger changes occurred comparing the decision makers of the teams (Watch Captain (WC) and Assistant Watch Captain (AWC)). MOC 1 decision makers had smoother level of SA during the entire experimentation while the MOC 2 started to increase their level of SA at the afternoon session during the second experiment day. This concurs with the level of confidence that they gained during the experiment presented in the Figure 34 (Alvaréz, Koskinen & Vuorisalo et al., 2010).
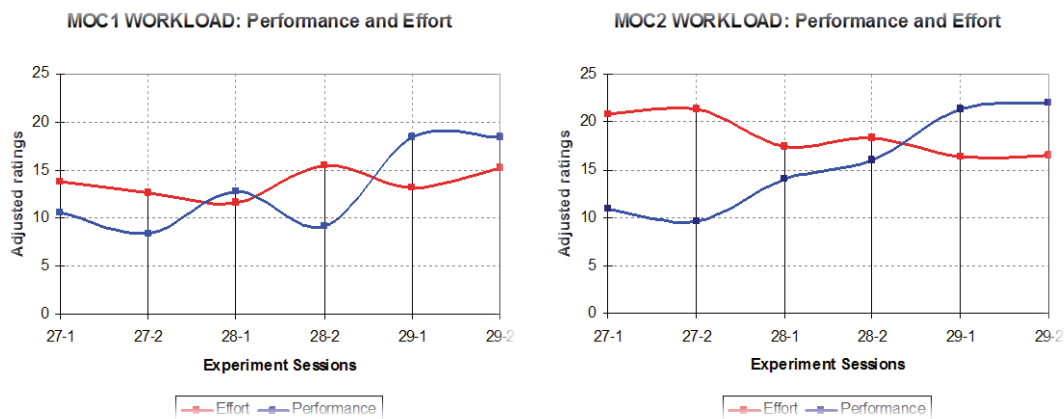
Figure 34: Both MOCs performance and effort levels

Figure 34 presents both MOC teams workload related to performance and effort. It does not seem to be relevant to compare MOC 1 with MOC 2 related to the performance and effort in the context of this dissertation, since they are formed with different individuals and different structure and tool set. But what is relevant, and can be learned from this, is how both teams felt at times that they had to put much more effort and they were not able to perform as effectively as they would have wanted to. The issues affecting this phenomenon are much more interesting and relevant.

For the MOC 1 the performance curve seem to have clear ups and downs: At the start of every session, the team felt performing better, but the performance started to drop during time. For example during afternoon Session at the second day, the team felt they had to put more

effort related to the rated performance during that time. For the MOC 2 the graph support observation findings: when the systems and inner working process started to work, the team members did not need to put so much effort in order to keep a good level of performance compared to the beginning of the experimentation. This also points out the value of the decision making process, the human involved and tools used in order to get the needed awareness to make valid decisions.

The SAGAT scores proved to be very useful to get SA objective measures. Even though, some questionnaires were difficult, operators somewhat managed to remember key things that were needed to build up the SA picture. The following Figure 35 shows the raw data grouped by MOC for each SAGAT query (Alvaréz, Koskinen & Vuorisalo et al., 2010).

1-1, 1-2 to 3-6 are referring to the SAGAT questions. The teams were asked a total of 18 question patterns during the experimentation. First number indicates the day of the experiment and the second number is the ordinal number of the query.

MOC 2 got higher scores on almost every SAGAT query. The first thing observed was the variability of the data related to the Figure 36. This was presumably caused by the difference on difficulty from one SAGAT query to the next. Even though probe questions were semi-randomized, it turned out that some queries were more difficult than other. This is why it made more sense to look at the difference in means than to look at the absolute values of the SAGAT scores.

At the beginning of the day, there was little difference in MOC's SA, since each day was started with a new vignette. But the differences grew larger as the experiment days went on. In the initial phase of seeking key information there were not much difference in the SA, but later in the day when the needed to build up SA, MISA-EM processes and tools improved teams SA.
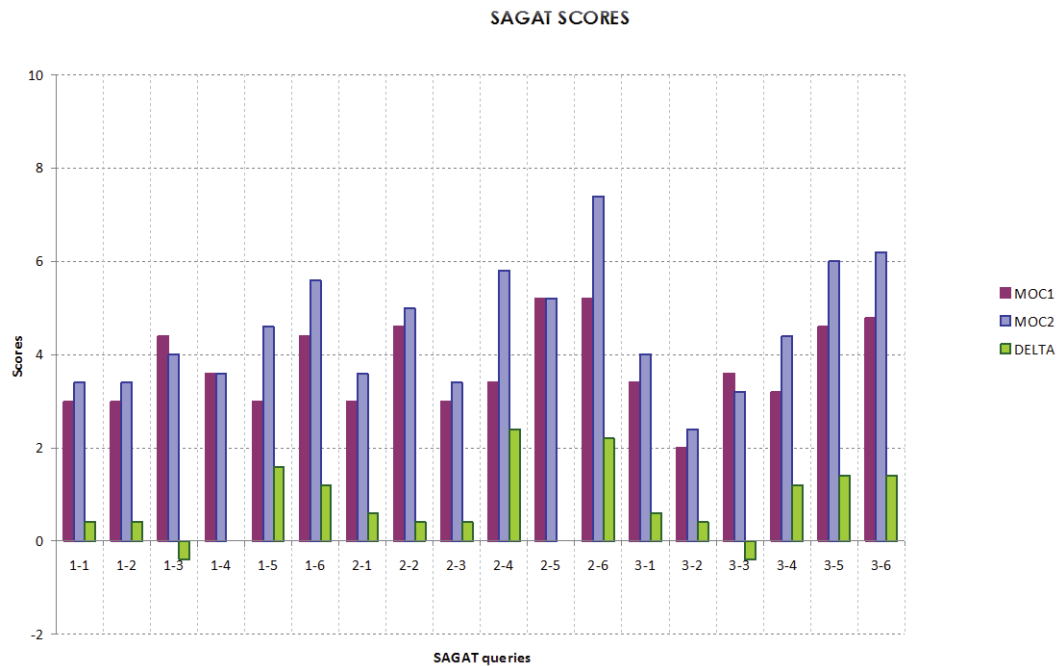
SAGAT SCORES

Figure 35: SAGAT scores for MOC 1 and MOC 2 and the difference between them. The values were obtained summing the individual scores of all the operators of the MOC for each query

It was interesting to study the level of SA that could have been possible to reach by the MOC teams, had they perfectly shared information among all team members. To answer this question, a new measure was devised. Instead of getting a score for each operator for each SAGAT questionnaire did earlier, the number of questions that remained unanswered were counted and taken into account of all team members. (Alvaréz, Koskinen & Vuorisalo et al., 2010).

The theoretical maximum of SA score is presented in Figure 36. For example, in the last SAGAT questionnaire, MOC 2 might have had a perfect score of 100 % (instead of 60 %) if they had shared all the knowledge. Same issues occur for example related to the SAGAT questionnaire 2-5. If we go back to the Figure 35 and take a look at SAGAT question from the second day (2-5), we can see that the scores are equal (~55 %) for both teams but when comparing to the theoretical

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maximum, it shows that theoretical maximum for MOC2 was ~70 %, when the theoretical maximum for MOC 1 was ~90 %. This also reflects to the same issue, if the teams had shared all possible, relevant information, they would have had a possibility to gain higher level of awareness of the situation. This may reveal the issues around the team work validate the need for supporting teams in information sharing and managing the information inside the team. These graphs intrigue and guide in the search for explanation for these variations but not everything can be interpreted based on these graphs. These can be used very effectively to point out interesting exceptions and changes in behavior that can be further studied with the support of for example observations and other methods used in the experimentation (Alvaréz, Koskinen & Vuorisalo et al., 2010).

The SABARS instrument represented a developed subjective scale of situation awareness behaviors that could be useful tool for evaluating maritime operation centers.
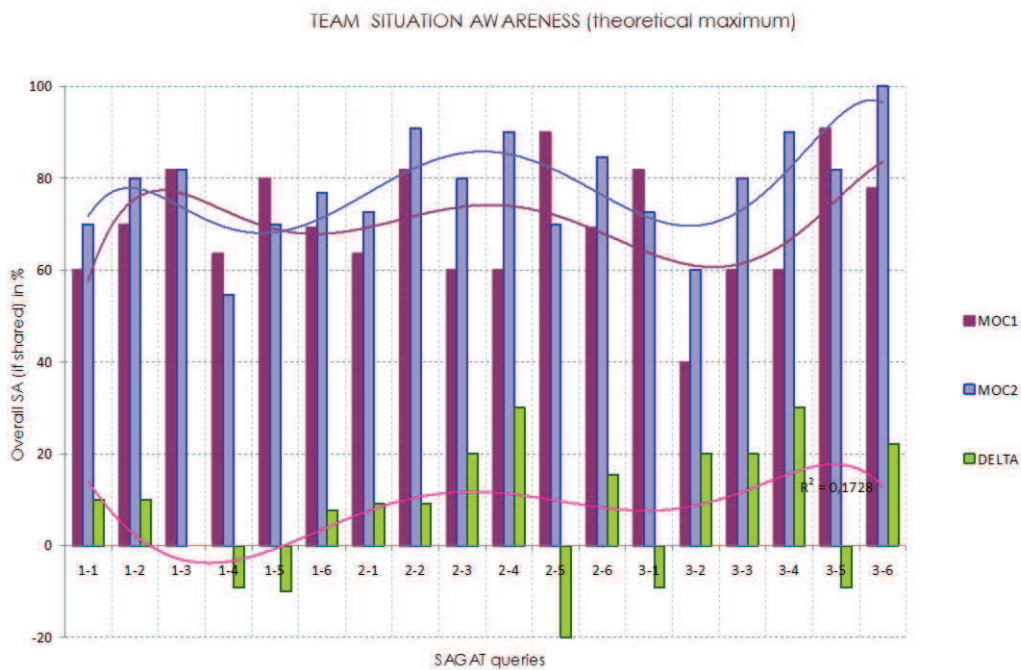
Figure 36: Theoretical maximum team situation awareness score

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Since SABARS analysis is provided by several data collector as an uncontrolled source of variability, it does not give any added value to compare grades obtained from the data collection observers, since distinct observers look at *operator*s through different point of views. There are two ways to proceed with the analysis, either normalize the data or look at the values of the paired differences between MOC's scores; and examine one-to-one grades looking for trends and patterns instead of absolute scores. The following Figure 37 shows the sums of scores for all members of the MOC as well as the difference between MOCs (Alvaréz, Koskinen & Vuorisalo et al., 2010).

Disregarding the absolute values of the SABARS scale, MOC 2 made a better progress along the execution of the experiment. In trying to understand the reasons of this progress, conducted a factor analysis with the SABARS questions supported highlighting three topics: 1) Gathering information and following procedures, 2) proactively seeking key information, and 3) focusing on the big picture. While MOC 2 showed a constant increasing trend on the three factors especially after the first day of experimentation, MOC 1 displayed behavior that was just the opposite.
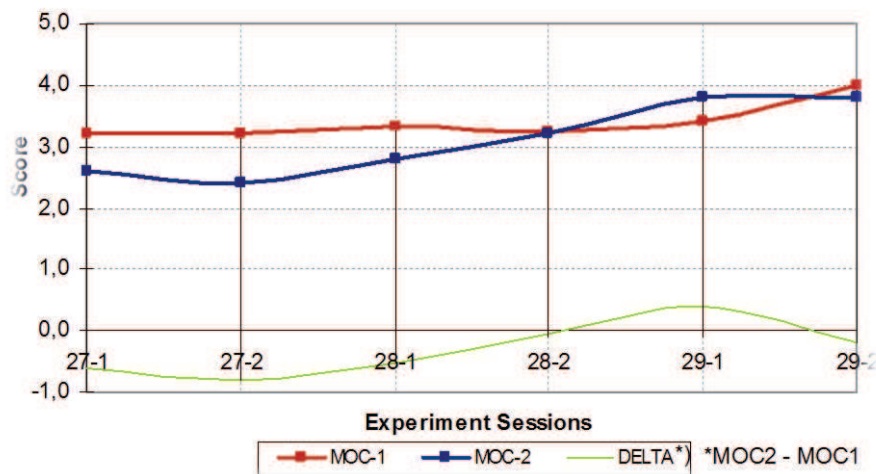
Figure 37: Global SABARS rating for the MOC teams across time. Higher scores mean better attitudes, behaviors and performance

SSA scores were self-based measures collected via on-line questionnaires given to *operator*s at the end of the experiment. They were designed to capture behavior, attitude towards information sharing and interdependence with interagency. According to the results, MOC 2 tended to believe that cooperation was a key element of success in the SA building process. They were more prone to communicate than MOC 1 with interagency partners and they felt that MOC 2 policy gave them the flexibility to do that. However, they showed some lack in organizational trust. Sometimes the team did not know what to expect from IA partners or what kind of information they were able to provide. Moreover, they had doubts about how partners were going to react or if the information provided to them was ever used. This might be explained by the lack of feedback they got from IA - played by role actors - on the collaborative tool and the fact that just uploading the information on the portal does not encourage personal communications and confidence building (Alvaréz, Koskinen & Vuorisalo et al., 2010).

4.2.6 Conclusions about the experiment design and results

Technical problems caused volatility of tools and players worked around their way to complete their tasks. This caused some disruption in terms of players not following standard procedures. Some intrusiveness was observed of data collection into player's tasks. One reason for this was the seat assignments. They sometimes did not allow for a perfect perception of what players were doing or how they were behaving. Other reason was the one-to-some allocation of data collectors to players.

SAGAT was a valuable tool for SA measurement. However, the questionnaires were difficult since they required too much working memory; mental demand was the factor that contributed the most to the workload of MOC players. The SAGAT questionnaires forced them to memorize things that otherwise would be available in any easy-access-data storage. For this kind of experiments it is recommended that players be allowed to use their notes. SA for one person in a complex situation such as in a MOC probably includes much more than just what is in their working or storage memory. The use of notes might be considered as an

active extension of his working memory. Sometimes SAGAT seemed to drive operator's tasks. If the questions have induced an adaptive behavior on the operators, this should have been in favor of the best practices of maritime situation awareness.

Importance of data collection was not sufficiently pointed out to MOC operators. They felt they were bothered with too many questionnaires that did not allow them complete their tasks. Data collection for them was secondary.

According to the final LOE survey, almost all participants agreed on that scenario artificialities and injects were very realistic as well as the interchange information model and the role played by IA representatives. But there was a general lack of training on tools, processes, and data collection. This was partially caused by the technical difficulties experienced during the rock-drill. The execution of the rock-drill turned out to be crucial to detect technical shortfalls in time. Another extra week before the LOE should have been programmed just for training.

Eight hours of experimentation in one day, was too long time period according to the participants opinions. We also observed a decreasing trend in performance and slight carelessness on the last questionnaires of the day (Alvaréz, Koskinen & Vuorisalo et al., 2010). MISA-EM tools and processes, as the treatment of the Experiment have proven to increase Situation Awareness on the designated MOC. The new suite of tools and procedures required longer learning times; however, interestingly enough, they allowed better task assignment within MOC 2. Having more independent jobs allowed players to focus on their tasks, find pieces of information using the established channels and be ready to assess WC and AWC in the SA building processes. The MOC showed a constant increasing trend in their objective SA as the experiment day went by.

Breaking down SA into Endsley's levels, MISA-EM helped MOC 2 to perceive more data and to project how the situation may evolve more accurately. However, MOC 2 did not prove to be much better in the comprehension process, the difference was lower than expected. The evolution across time of the SA gap index, the difference between the theoretical maximum SA value and the achieved SA, was favorable to MOC 2 only at the end of the day, when they shared the information obtained and collaborated with WC to assess the situation.

This increasing trend on SA is supported by the subjective SA results:

Not only MOC 2 was doing better, but also they thought that they were making good progress. However, their perceived effectiveness was poor at the beginning. This might be explained by the fact that they were given a set of tools and procedures they were not familiar with since the provided training was clearly insufficient.

Surprisingly enough, the subjective workload that MOC 2 was experiencing was lower than the one of MOC 1. This conveys the idea that the new tools did not overload operators with additional tasks as was expected at the beginning. The two factors of workload where larger differences were observed between MOCs were frustration and performance. The frustration level for MOC 2 was high at the beginning, in fashion with the unfamiliarity on tools and procedures mentioned above. Technical implementation of the collaborative tool was not mature enough and participants experienced some difficulties with logic of the tools. The lack of feedback from alerts and posts on the portal decrease their trust in interagency representatives. They did not know who was reading their comments or if they were ever read. Related to this, the LOE 2 results show a lack in confidence by MOC 2 players on how to provide information to partners. Even though they understood the role of IA players and the importance of the relationship with IA in respect to information sharing, there were some issues regarding the awareness of external actors and information requirements. Although they were provided with a comprehensive stakeholder analysis, the confidence, trust, and understanding of IA needs and capabilities was not sufficient. The stakeholder analysis should include some more guidance to MOCs in this respect. MOC standard operating procedures did not include role assignments and responsibilities with respect to the new tools. MOC 2 took more time to organize themselves and to discover all communication channels and available tool features. This was also seen in the Performance Figure. (Alvaréz, Koskinen & Vuorisalo et al., 2010).

5 COMPARISON BETWEEN THE CASE STUDIES – National vs. multinational team and Individual vs. team level analysis

As presented in the previous chapters, maritime related case studies provided useful information to succeed in the attempt to understand the complexity of the decision making in a time critical environment. The case study data collection was a joint effort and I am grateful that I had the opportunity to be involved in planning, designing, capturing and collecting the vital data that I could further use for this dissertation purposes. Next, the findings from the case studies are presented from the national and multinational perspectives as well from the individual and shared situational awareness (SSA) point of view based on my observations and drawn conclusions according to the gathered data. This chapter concludes the lessons learned especially from this dissertations research question perspective, while the case study descriptions in Chapter 3 and 4 were more related to the case study goals added with my observation notes from this focus area of this dissertation. There are differences on how individual level SA is formed and how it affects the team and gaining of the shared situational awareness and these differences are discussed next.

5.1 Individual perspective vs. shared situational awareness perspective inside and between teams

In the MNE5 MSA from the individual level the actions were quite independent and information sharing was relatively easy. There were some miscommunication and false conclusions, but with the support of the PSP (Problem Solving Process) there were improvement in gathering the facts and with the usage of the tools. In the MNE6 MISA-EM the standard operating procedures and MOC structures were different, but it was possible to observe how in both cases the actors changed their way of using the tools and roles inside the MOCs.

Clear difference between these cases was that the PSP was not used in the MNE6. In the individual level inside the team the amount of

information pieces became so large that the entire team was needed to solve the issues at hand. The adequate level of awareness would not have been able to be attained without combining pieces of information together as a team. A lot of energy was wasted in both cases while team members where learning the new environment, techniques and roles. After the rough start when the team members got to know each other better, the information sharing started to function better.

This is one important aspect that needs proper attention: the ways of working, group/team formation and roles need to be clearly defined. Used tools need to be properly trained and this is something that needs more than quick technical training. It is also crucial to have efficient level of understanding of other actor's roles and their influence to your own actions. Understanding is required to both of what I need to do, and what the others are doing. This needs to be practiced so that the actions in crisis situations and time critical situations come as naturally as possible.

In the case studies there were some differences in the individual level between teams. Individuals are able to commit to the task at hand when they understand the meaning of their role as well as the roles of the other team members. Based on that they are able to shape what information needs to be shared. In the MNE5 the challenges between teams were the interaction, understanding other teams with their abilities and needs. In many situations this caused problems related to the information sharing. There were also challenges in relying on others. Many times team tried to rely on own tools and the threshold for contacting others for information purposes was very high. This requires changes in mindsets to see that information possibly provided by other organizations and teams should be seen as important to use of own technical systems. Also, the transparency of the technical systems needs to be improved and the feedback provided for the individuals. Social contacts should be highlighted in this case. In the MNE6 other actors were left outside because of the portal tool. The information shared via portal left the team unclear whether anyone received their information or whether anyone would respond to their request for information. It was not easy to identify other parties like it was in the MNE5 MSA. This is why the team focused more on the information gained inside the team even though they tried to use sources outside the team as well.

Recognition of individual needs, tasks and tools are highly relevant

factors in successful operations. These needs can be processed through different views from the individual perspective such as processes, tools and communication habits. It is clear that teams, in both cases, were different already because of the size of the teams and used tools but still it is highly recommendable based on the case study results that these findings are taken into account. It can be estimated whether the size of the teams affect certain behavior, or the cultural and language differences or whether the amount and variety of tools affect the team performance. In MNE5 the focus was on the entire team, how the information was processed and shared inside the team and between the teams. The Problem Solving Process (PSP) was created to support the intel officer in individual thinking process, and very promising results were received from it. In the MNE 6 MISA-EM the problems with the focus was also in the teams working and mainly identifying issues related to the Watch Captains (WC) and/or Assistant Watch Captains (AWC) role in the information sharing process.

Based on the observations there were some issues that need to be highlighted. First of all the importance of a feedback, whether is received from a person inside the team or whether the feedback is received from a used information system. The WC did not receive feedback from the team whether they accomplished the given tasks or not. Since the SOP did not include a process support such as PSP or PSAS, it was clear that following of the orders was difficult for the team members because of the lack of clear process.

Lack of understanding and misuse of the tools resulted in occurring errors that affected the team's performance. These type of challenges were seen mostly in the beginning of the experimentation, but as the experimentation continued and they got acquainted with each other and the tools, the error decreased: The team had severe difficulties with the portal use but as the experimentation continued, the team was able to recognize and identify some of the technical problems and also some of the user errors. There were times when the WC needed to assist others with the use of tools. The training issues raises: Participants involved in co-operations, need to have proper training with all the possible tools that can be used in information sharing. Also, usage experience of the tools in actual environment gives better possibility for the individual to understand the logic of the system and how it can be used in real life

activities. There were situations when they lacked the awareness of whether for example there were any receivers in the portal to access and receive critical information from them. The amount of possible tools for information sharing should be carefully thought. If a team consists of more than 3 persons, there should be a clear understanding what are the situations when to use chat, phone, Skype, portal, email etc. Occasionally too many communication channels can cause distraction. Also, the level of sensitivity of the information narrows down the channels used to share the information. Since there was no visual tool for the WC to support his thinking process, he used the basic whiteboard to write down facts. There were also incidents where the data management was not up to the needed level, that caused confusion and miscommunication when the right information was not given to the decision making level. In many cases the problems were caused by language barriers and misuse of tools.

Decision maker, here referring to the watch captain (WC), was struggling with the problem solving and analysis since he had to focus all of his energy at times just to give tasks to other members of the team. Information management could support in processing previous, current and future actions. Since the WC did not have a clear understanding of the current status, the given tasks for example to the data operator cause them to have multiple lists to follow. The number of vessels to be checked exceeded the capability of operators.

There was a lot of evidence of the miscommunication inside the team. For example the Recognized Maritime Picture (RMP) manager had notified the WC with changed information about Vessels Of Interest (VOI) but the WC has no recognition of it. Many tools and ways to use them, different tasks and persons doing tasks simultaneously made it difficult to control the teams SA. WC had difficulties gaining the situational awareness because WC was having difficulties in doing the problem solving because he did not have anything to support his memory. He missed information about details given by the RMP manager, because he did not have a tool to support his memory. One major improvement in the future is a RMP picture that is stable and it supports the WC to draw the current situation to it and keep track of the changing variables.

During the experimentation, before the last day the team gave feedback about the issues that were affecting their performance. They brought up basic issues like showing the vessel list, and map on the big

screen in order to go through the previous reports. The team felt it would be easier to follow the action from the larger screen when there were communication problems between MOCs and also occasionally problems with communication inside the team. The requested modifications were allowed and executed before the last day of the experimentation.

When the team was getting to know each other better, and they were using more fluently the systems, they were also getting used to the working roles and the overall performance of the team improved. This verified that the support for the individuals on how to collect and manage data and how to do problem solving individually related to own duties, as part of the team, are elements that affect the level of awareness both at the individual and team level.

5.2 National vs. multinational teams' differences and similarities

Based on interviews and my observations of the national teams behavior in MNE5 MSA and of the multinational team in MNE6 MISA-EM, some differences that can have an effect on the teams overall performance, can be identified.

In MNE5 MSA inside the national team there seemed not to be any communication problems if the group members had the same cultural or language background. Also, the size of the team had an effect on how easy it is to share information inside the team, and how manageable the information flow is. In the multinational team in MNE6 MISA-EM the language issues became more relevant and dominant: The oral communication was not used in the same ways as in the smaller national group where the tasks were given orally, and thinking process was done speaking out loud. In the multinational team the amount of team members was larger and the pre-defined roles affected drastically in the beginning of the experimentation, before the team was able to modify tasks and roles after getting to know each other and each other's capabilities better.

The information flow improved during the three days in the MISA-EM experimentation. There were difficulties with the language and communication: Individuals inside the team had information but did not

pass the information to the WC or to the AWC who were leading the team. That caused the biggest problem since WC had to constantly ask for information and this interrupted his thinking process. Based on the interviews, the overall impression from the leading perspective was that the team had the tools to establish communication despite some technical problems, but it was the lack of clear tasking and pre-determined MOC structure that was seen not supportive enough for the task given to the team. Like mentioned earlier, the MOC structure in MNE6 MISA-EM did not support gaining the adequate level of awareness since comprehension was difficult due to the lack of the memory support (need for taking notes and visualizing thoughts) and the support of logical thinking. Projection was also difficult since the team did not have in the beginning the maritime picture available on a screen where they could add all the incidents according to the information received and given. Once the team was able to manage their documents visually, the creation of the RMP picture was easier for the team.

Based on the interviews it was possible to improve the team's performance by giving more individual training on the systems and guidance on their tasks and of course the reliable systems are needed to support to complete the tasks. It is also crucial to understand other participants, and in this case interagency needs, this was an issue also in the experimentation to be able to identify and understand what information others are asking for and what information they need. This same issue rise also in MNE5 MSA, as a learning experience. It was discovered, that by training the participants to understand other participants capabilities, and letting them get to know each other, it supported the interaction between the teams and also supported in understanding their information requirements.

As a conclusion of the findings from both case studies, Figure 38 presents all the found elements that have impacts on situational awareness and information sharing.
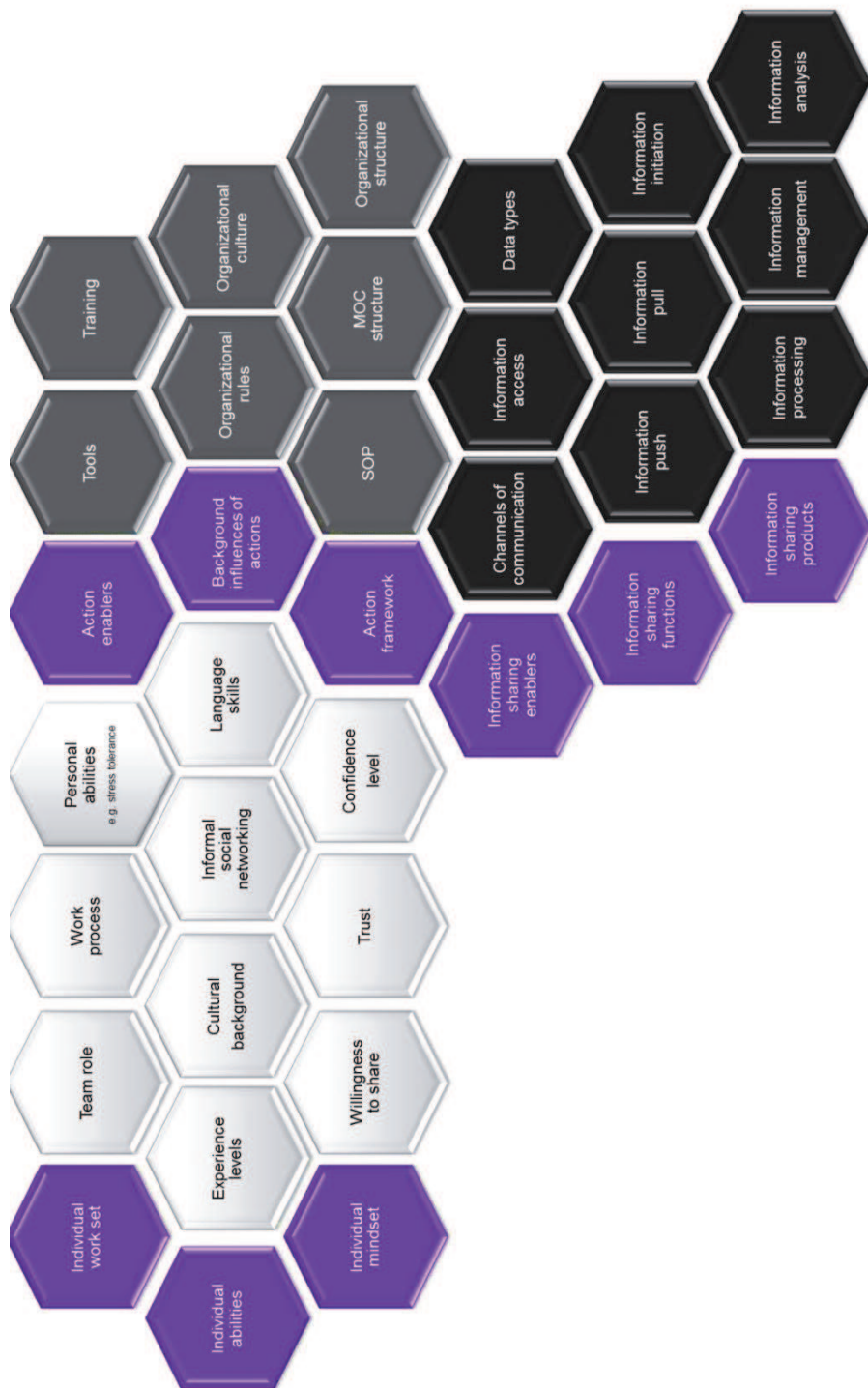
Figure 38: Elements found from the case studies that affect situational awareness and information sharing

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Figure 38 combines all the individual, organizational and technical factors that influence the situational awareness. Social factors are categorized related to individual work set, individual abilities and individual mindset. Organizational factors are categorized related to action enablers, background influences of actions and action framework. Technological factors are categorized related to information sharing enablers, information sharing functions and information sharing products. It is challenging to claim whether for example trust affects only information sharing, since it is also required when individual is trying to gain the needed level of awareness. On the other hand there are clearly information sharing elements more related to technological factors that support information sharing and from that perspective supports also gaining situational awareness. It can be concluded that all of the elements are supporting gaining situational awareness. Based on the level of awareness, confidence and trust, individuals make their decisions to share information.

6 BACKGROUND OF THE CREATED CONCEPTUAL MODEL

As a contribution to the situational awareness concept, the baseline assessment and strategic environmental understanding was provided with the MNE5 MSA and MNE6 MISA-EM case studies. From these case studies it was possible to identify special needs for multinational collaboration in an information sharing framework. These identified needs and proposed solutions are also highlighted in this Chapter. The identified needs and baseline assessment provided the list of different type of requirements and gap-analysis were also gained from the case studies. Main focus in this chapter is the identified solutions as products of the CD&E process which presents the proposed solutions that have the potential to support gaining adequate level of situational awareness in order for the participants to share information and collaborate in a multinational environment.

The conceptual model is not designed to be an answer to everything or solve all the challenges but it is designed to wake up ideas and discussion in different levels of organizational structure – all the way from the individuals to the highest decision making level. It supports critical evaluation of situations and how the time critical challenges are handled at different organizational levels.

Challenges in communication, differences in individual SA-models, need for applying different procedures in different situations, and also the time constraint of gaining situational awareness in crisis situations are elements that challenge individuals in collaboration. For decision making it is crucial to determine individually what information is needed for reliable decision making and what information individual needs to share to support the goal of collaboration and decision making? Questions that can be raised in this framework are: How does the crisis situation affect the individual's normal behavior? How can the conceptual model be used for individual purposes in self-development? How can it be used in organizational development? How can it be used in technological development?

The conceptual model seeks to provide solutions for the challenges provided by the questions presented. Individual way of reacting can be supported with training and a process (PSAS). Organizations are

supported with the SA-model to reveal points that need to be taken into account when trying to identify possible development areas supported also by the check lists. This type of development can be done also from the technological perspective and the usability monitoring tool gives insights on how tools can be measured to support the collaboration and information sharing. These are presented next as identified products by the CD&E process.

6.1 Identified solutions as products of the CD&E process

In this Chapter all the created methods and processes are combined to form the conceptual model that is designed to support the SA and information sharing. Conceptual model is a combination created to take into account the individual and organizational level needs in information sharing context when the mission is to gain the adequate level of SA in order to perform and make fact-based decisions. Individual perspective is supported by the Process of Situational Awareness Support (PSAS) in the information sharing context. First this process will be described in detail. The organizational decision making level is supported with a modified SA-model that presents all the elements from the individual perspective that affect the SA and from that also the information sharing. Organization is also supported with guidelines and a check list to provide a wide range view from individual factors all the way to the technological issues and processes. These are presented in more detail in the second part. The technological affect is also indisputable, even though it is acknowledged that technology should be seen as an enabler, not always the solution, nevertheless technology has become more and more integrated to the line of work. The Monitoring-tools is developed to get the maximum performance of the technological tools that are being used as the moderators for information sharing. The monitoring ideology revisits and presents elements that can hinder or support information sharing from the technological perspective and it is described in detail in the last part.

6.2 Support to gain SA from the individual perspective

The Problem Solving Process (PSP) was developed during MNE5 MSA to support operators in achieving and maintaining Situational Awareness from the information requirements perspective: Operators needs to have awareness of the pieces of information from what one gains and maintains the Situational Awareness and that is supported by the provided tools and the PSP model. The created Process of Situational Awareness Support was created based on the first draft of the problem solving process, since the usage of the process demonstrated promising results in the MNE5 MSA event 3. Figure 39 presents the timeline of the development of the enhanced process and its validation steps in MNE6 MISA-EM.
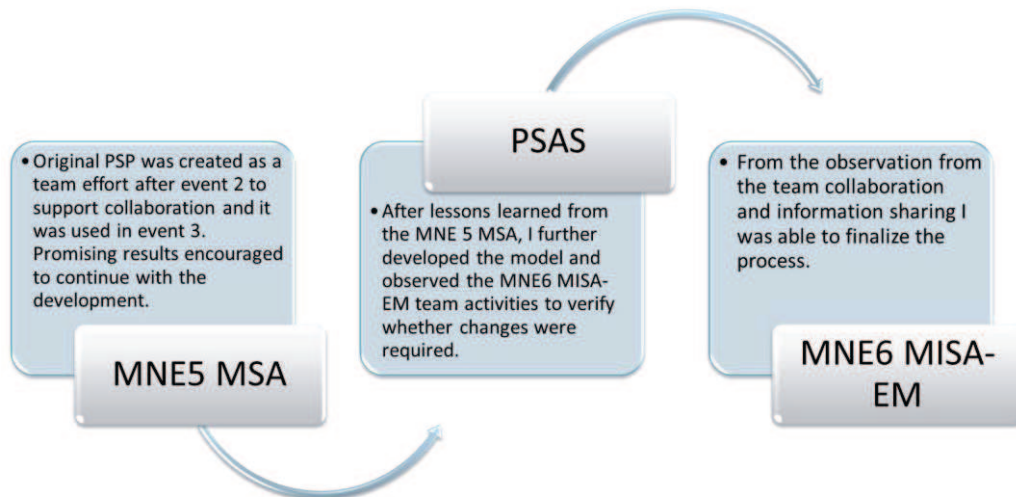
Figure 39: Development of the Process of Situational Awareness Support

Figure 40 presents the original PSP that was designed for the particular experimentation to support the operators in their work. The SA levels are highlighted in Figure 40. Original Problem Solving Process starts with the new piece of information that is reflected with different types of facts from the geographical, political and time perspectives and then moving forward listing the events on a map. It is crucial to list possible assumptions and separate them from the known facts and compare them. Next step is to search sources, meaning all the possible tools and other

human collaboration needed to generate a list and picture of the situation and question the assumptions, again reflecting back to the facts based on the information. As presented, the original PSP model was designed for the experimentation purposes. The facts are listed according to the maritime scenarios. Based on the lessons learned from the experimentation results, it was obvious that the model had potential but it needed to be generalized so that it can be used also in different settings.

Experimentation methods from observation and interviews to event log data collection of the used communication means provided the confidence that the created Problem Solving Process seemed to make a difference in MOC team's ability to process information and make decisions about whether to share the information. The process support should be trained using a scenario-based method at the same time with system training. That would help the operators to get acquainted with the technical tools and also to understand how systems can be used. Scenario-based method provides a "real-life" example for the operator to study and exercise the usage of the tools and to practice the process of gaining and maintaining situational awareness. During the experimentation some actors also made personal decisions about how they treated information based on trust, familiarity and common culture. For some MOC teams it was easier to trust information from MOC teams with same cultural experiences than to trust information coming from MOC team that they did not share common culture with. It is alerting because teams should critically analyze the received information and compare it to their own information. As mentioned before, training the operators on how to treat the received information with the same level of objectivity is an important part of the process. Also, one important observation was that operators seemed to prefer less formal means of communicating. Chat (instant messaging) was often used as a tool for requesting more information or specify details. For the most part, email messages were used as formal and official communication where voice was used as a backup or to acknowledge receipt.

Overall, MOC teams seemed to benefit from having more than one mode of communication. This means that MOC teams should be outfitted with the full spectrum of communication tools. However, operators should learn to accept less formal methods along with the formal methods.
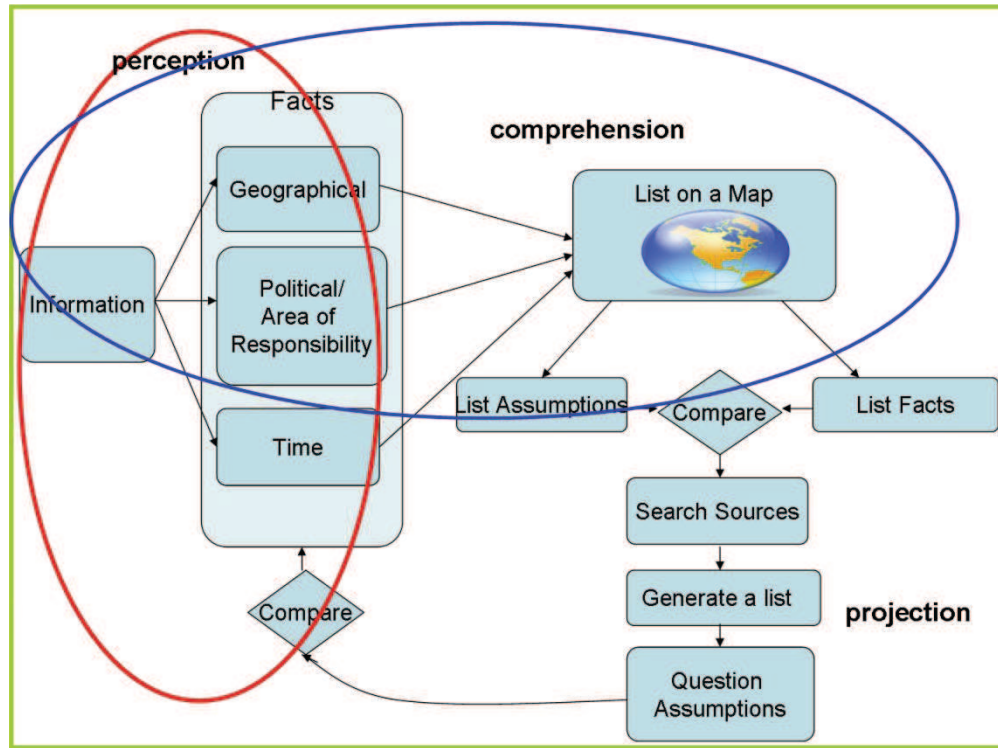
Figure 40: Original Problem Solving Process

There were also differences in MOC team behavior on which communication tools were preferred, but whether the differences were caused by cultural differences, technical capabilities, language issues; it is difficult to point out only one possible factor. Team members also need to understand why information is being requested in order to provide an appropriate response. That is all part of achieving situational awareness, by understanding all the elements involved and understanding possible resources that can be used for gathering the needed information (MNE5 MSA Final report, 50-51).

Training should provide a basic understanding of different information sources (MNE5 MSA Final report 2008, 55). It was seen in the experimentation that if the operators had technical difficulties with their own systems, they stopped working. That is why the Problem Solving Process helps the operator to identify also other sources outside the own

team; whether the sources are own technical systems, web-based services, open databases, other MOC teams and their capabilities. This aspect supported operator's thinking and continuing to work even though system failures occurred. We were able to see for example chat and email communication when the MOC teams had difficulties with their own systems. This requires training and awareness of other team's capabilities.

Based on interviews conducted we learned that the lack of clear guidance on information sharing resulted in operators defaulting to a non-sharing frame of reference. In several examples information was not passed on to other Areas of Responsibility (AOR's) simply because it was never considered that it should be shared. There was a tendency to focus on one's own AOR and not consider the possible connections or linkages with other AOR's even when data points might have suggested that there were connections with other partners.

Individual's way of thinking and rationalizing is very complex and it is quite difficult to identify the logic of thinking in particular situations. Logical thinking can mix facts and assumptions. This is why it is important to support operators problem solving and decision making based on facts by separating the facts from the assumptions. Listing the facts:

- What are the pieces of information that one knows as fact?
- What are the verified pieces of the occurred situation?
- Who has done what, when, where?

Listing the assumptions:

- What might have happened, where, when, and how
- How does the incident continue?

By making assumptions based on individual knowledge and experience, different operators might have different conclusions after mixing facts and assumptions. We need to support the operators in this challenging task. For the operators it is very demanding to process all the received information, and they face information overflow at times. By adequate training and providing support with processing the possible scenarios based on the received and processed facts, it is possible to

improve operator's situational awareness.

After listing the facts and possible outcomes the operators are guided to search for different available sources. A source is a better wording than system, because in co-operation it is important to realize that other organization's operator and their technical capabilities. Information sources were not always understood by the operators. There were situations where the presented information was misinterpreted and it led to poor decision making about how to treat the presented information.

There were cases where operators shared information from their own systems between MOC teams even though the sources were identical. That shows the lack of awareness of other participants' technical capabilities. The PSP is a model that was created and validated by the research team in the MNE5 MSA experimentation. From that created model I modified and generalized Process of Situation Awareness Support (PSAS) that has been developed in the respect to the theoretical approach of Situation Awareness and lessons learned from the experimentation. PSAS is presented in Figure 41.

In the experimentation we were able to discover the influence of the process and training on the performance of the MOC teams. But a simple process is not enough. Operators need training and tools; the process and tools need to be integrated to be a working model. Also, because of the information flow the MOC structure should be a combination of operator working with the technical system, operator working with the communication tools such as chat, email and Intel officer who fits all the pieces of information and processes the problem by using smart boards etc. to visualize the scenario and gives tasks to the rest of the team.

In the experimentation the basic operator/Intel officer structure was not enough for the level of information sharing. A lot of information were missed and delayed because of the information overload. This is why the MOC structure is considered to be one crucial element that needs to be taken into account when designing teamwork in cooperation. There are many channels for information exchange technologically available together with time pressure that require clear role and task division to ensure that the team is able to cope with information overload.
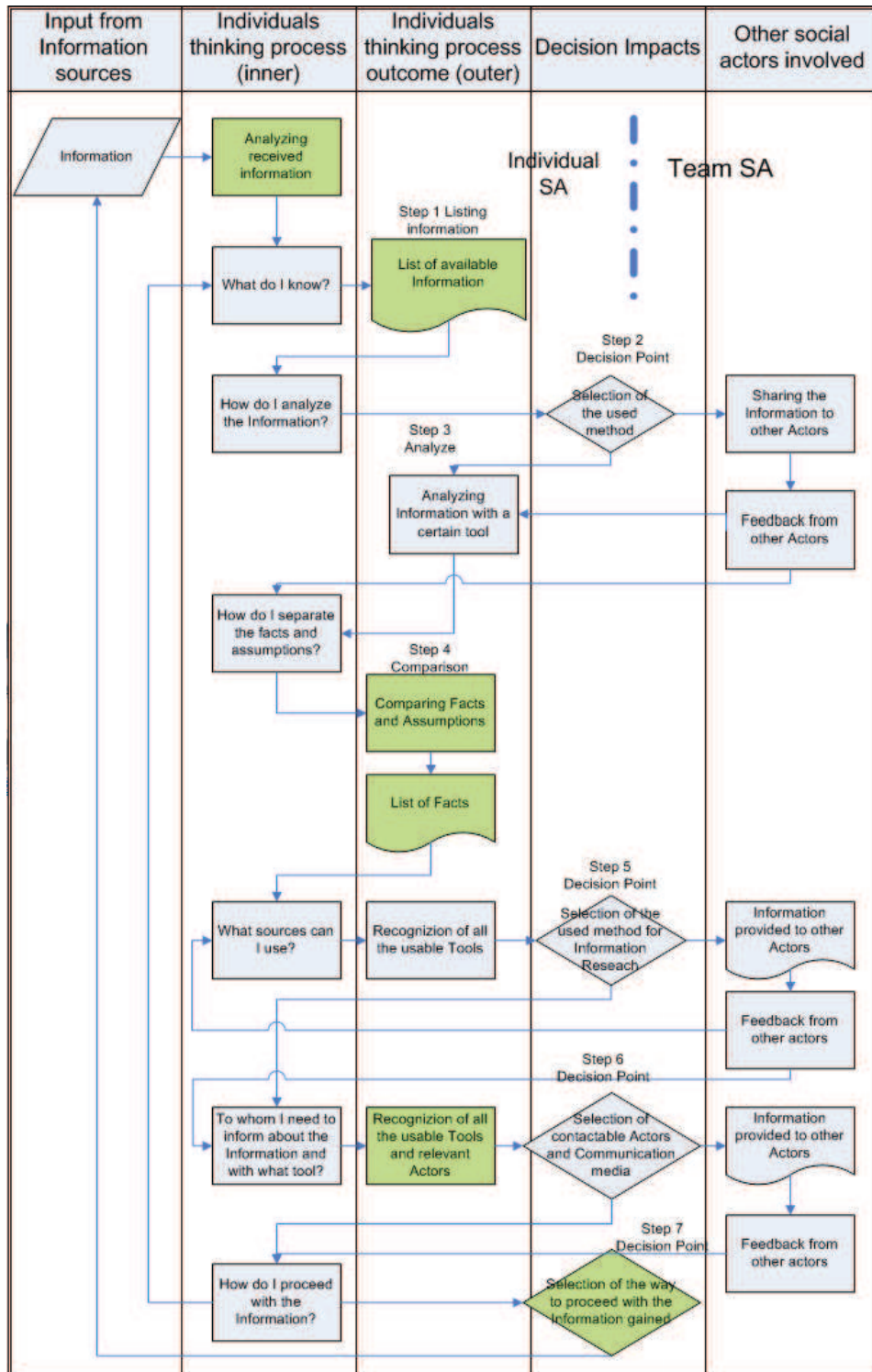
Figure 41: Process of Situational Awareness Support (PSAS)

The PSAS is divided into different sources, individual's inner and outer thinking processes, decision making and also the interaction with other actors. The reason for this is to point out the elements perception, comprehension, and projection of the SA theory: To present what kind of actions can occur in these stages and at what stage do the decisions affect others. The PSAS supports the individuals thinking process. The individual is contributing to the team SA while one is gaining the required SA needed for his or her responsibilities. From the theoretical perspective each team have specific SA requirements that all the individuals inside the team must possess in order to get the shared situational awareness (SSA). With the PSAS we are supporting the individuals in their thinking process when they have to decide which information is needed by other actors. This finding is critical: Not every piece of information need to be shared with everyone in the team. By doing so, based on the lessons learned from the experimentation, it causes major information overload. This is why the SA requirements are important elements and PSAS supports the *operator* in identifying and analyzing which information is needed by whom and how can the *operator* find resources that one needs.

Perception phase is seen as the part of the process where the individual analyzes the information (what do I know), and lists the information available. At the comprehension phase individual decides what method to use to analyze the information. In this stage, while trying to comprehend the situation, individual also impacts the other team members by the choice of informing others or making a decision not to share the information. By analyzing the information with the chosen tool and trying to compare the facts and assumptions, the individual proceeds with the comprehension phase. After listing the facts, the individual reaches the point when one has to make a decision about the tools and actors one wants to involve. One might argue that in this phase, the individual actions reflect both comprehension and projection level since the individual needs to articulate his or her needs for information. This is why the line between comprehension and projection levels cannot be too strict.

One might also argue, that is not possible to clearly separate facts from assumptions by claiming that everything needs to be categorized as assumptions that can be later on reversed. Based on the observations and results from the case studies, I would still argue, that it is beneficial to

stop with the thinking process, and question whether all the information available and connected from pieces are still relevant and fact-based, how much logical thinking and assumptions have affected the way of handling the information and understanding of the situation? The inner thinking and analyzing process varies among individuals. However, in this model it is assumed that after getting feedback from the system and/or other actor the individual reaches the projection phase, when one starts to think how to proceed with the processed and validated information. In this phase the individual makes the decision about how to proceed by knowing the facts and forming an expert analysis of the situation. The projection phase continues as a loop with the particular case. Every new piece of information starts the process from the beginning but since the individual already has the basic knowledge concerning this particular case, it continues the projection. By these steps, the individual has increased one's own awareness and as an end product, increased the team's SA as well.

It is important to highlight at this point that the steps described are not sequential. The steps can be parallel, incidents happening at the same time while processing previous inputs. But for the visualization and training purposes, it is better to describe it step by step, even though in real life input processing is parallel and includes several layers simultaneous activities. It is possible that some of the inputs disturb and interfere activities, and may cause stopping of the parallel activity for a while and that might lead for losing some of the inputs. Individuals inner thinking process is constantly on going, and senses filter the stimulation through different physical, psychological or skill filters for example eye sight, attitude, stress level and language skills. It needs also to be noted, that in different roles and in different situations individuals may use this developed process for several purposes such as roles of processing of raw data for information, and end user of the produced data without forgetting possible decision makers in different organizational levels that need to have adequate level of awareness for valid decision making.

It is important to notice, that there is an evident route from individuals' inner thinking process to producing visible outcome, making decision and that decision having an impact on the target. This has been noted and taken into account while creating the PSAS from the individual perspective, to highlight key steps that affect the perception level,

comprehension level and finally the projection level. As one individual in the team affects the entire team, it is beneficial to support the individuals with the same general process that supports critically observing their own behavior and understanding issues related to team work. By supporting the team achieving better situational awareness, it gives the team the advantage to perform more efficiently.

From the PSAS it is possible to identify issues that come from the outside as inputs from different sources. Individual analyses the information. It is seen as ones inner thinking process. Based on the thinking that is not visible to others, one does something concrete for example text on a piece of paper or asks a question, which is countered for outer thinking process that has visible dimensions. The actual impact and visibility happens in the decision phase, when the individual decides how to act based on the information. The decisions of acting and deciding not to act have consequences that affect others inside and outside the team. The team members and other actors outside the team can also influence the decisions of the particular individual.

This process is a simplified description of the certain steps that the individual should go through while one is facing new situations and information flow. Without a structured way of operating, based on the experimentation observations, it was seen that operators draw wrong conclusions and were not able to use the available systems or resources as effectively comparing to the situation when they followed the structured process. Of course, this type of process requires enough time for training and actual implementation, but even with small amount of time and training the improvement could be seen in the operators' way of working.

Based on the observations particularly from the Finnish MOC operations in the MNE5 MSA experimentation, it was obvious that when the time element and data flow became harder, the team lost focus and they lacked a structured way of handling the situation. This is a real-life problem, that handling of a difficult situation is been just in the hands of the individuals own capabilities for problem solving and methods for gaining and maintaining situation awareness. With this type of PSAS it is possible to link the usable resources and a structured method together, in order to support the individual and one's decision making so that the individual can make the most accurate decision possible in an emergent situation such as national or international operation at maritime

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environment. Basic levels of supporting information sharing in a MOC are described in Figure 42.

Standard Operating Procedures (SOP) and Problem Solving Process (PSP) are the foundation of the team work. SOP provides the basic framework for the information sharing and PSP supports the team's work in processing the information and decision making. Next level is the MOC structure that is formed according to the framework provided with the SOP and PSP. MOC teams are able to identify their roles and divide tasks inside the team. After this, they are ready to use all the available tools to accomplish their tasks. It is crucial that the team is provided with support with the information management. The team members need to be trained to know how to use the tools, to which purpose and how to handle pieces of information based on different categorizations.
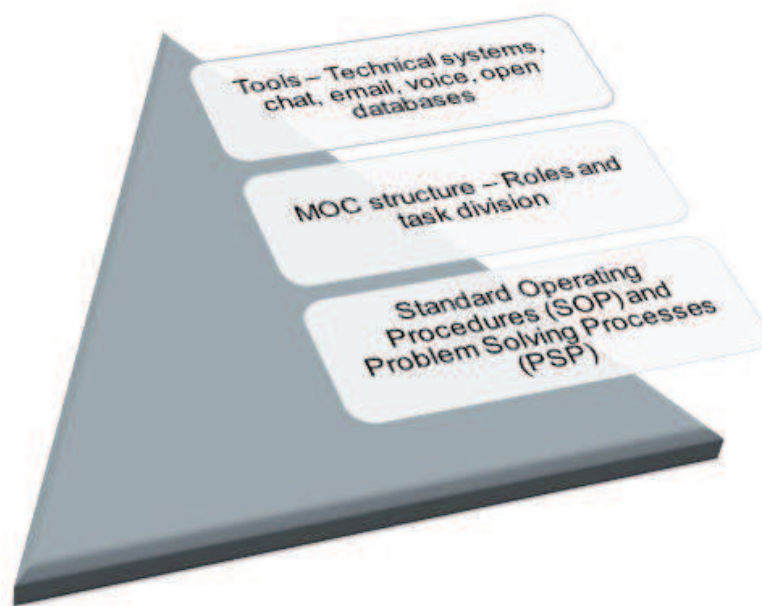
Figure 42: Basic levels for supporting team work and information sharing in a MOC

As a reflection back to the presented research question at the beginning of this dissertation, Table 5 shows the differences in Finnish MOC team's performance comparing with the situation when they did not have the PSP in use to a situation when the team actively used the process. Table was made by gathering information from the observations and interviews during and after the scenarios.

MOC teams were able to use the PSP while performing their tasks. There were some difficulties using the tools and that distracted the team at times from following the Problem Solving Process. When the teams were able to use the process, they were able to focus on the information categorizing and identifying information requirements and the context behind it. Based on the research results, it is obvious that supporting individuals inside a team supports the overall team work and improves the shared SA. Role definitions are important because they identify what are the individuals responsibilities according to the tasks and what is the expected outcome and input for the team.

Table 5. Differences in Finnish team's performance with and without the support of the PSP according to observation findings

	Without the PSP	*With the PSP*
during the scenario	*unable to articulate and formalize questions*	*better processing of the information -> more pushing and pulling information*
	uncomfortable contacting others -> rely on own system	*more usage of other sources than own system*
	difficulties connecting pieces of information	*better management of the information flow -> better processing of the facts*

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	difficulties drawing conclusions -> lack of confidence	*more confidence in making decisions based on conclusions*
	too much focus on own AOR	*more collaboration and extending the scope*
	overload in thinking process	*more team work*
	duplication of effort	*better coordination inside the team*
	miscommunication	*better communication and division of tasks*
after the scenario		
	team felt disappointed to their own performance	*team had not difficulties articulating their thinking process*
	team had difficulties articulating their thinking process and end result logically	*team was able to describe the incidents -> draw a storyline by grounding the decisions based on analyzed facts*

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The findings and lessons learned from the case study gave important feedback for the development of PSAS. PSAS was developed to reflect the SA theory elements to support the individual in gaining situational awareness with certain steps and identifying especially phases when the individual's decisions affect the team. The results from the experimentation provided measurable parameters that supported the development of PSAS.

Individuals face a lot of challenges in information sharing when acting in a multinational cooperation. Even basic information sharing within a team can be interfered with too much information. This is why the developed and modified PSAS model supports the operator continuing the thinking process even though there are many distractions and side steps that can be taken. In the MNE5 MSA experimentation it was possible to see the effect of the PSP model, even though it was not completely integrated into use. Based on the observation from the national MOC it was possible to point out situations when the team used the process, they were able to focus better, but they still had difficulties continuously following the process, because of the information flow. This is why as a lessons learned, discovery of the roles of the team members and the used tools should be clarified; which tool is used for what type of information sharing and who is responsible for that. This type of task division is necessary when we are trying to build up a team that uses the available capabilities efficiently.

The updated PSAS has not been validated with an actual experimentation. However, PSAS has been modified by implementing the SA theory elements and lessons learned from the usage of the PSP model from both of the MNE5 MSA and MNE6 MISA-EM case studies. The main ideology from the PSP exists in PSAS and it has been generalized and updated, so that it can be used in other settings as well. Because the updated version has the same experimented ideology, including with the SA-theory elements, it is recommended to be taken into consideration as a useful tool for team members to identify their process of gathering, analyzing and sharing information. The PSAS consists of smaller steps that have first of all impact on individuals own SA, but it also supports the individual to search for the crucial SA elements that are needed for the SSA in the team. Team SA is achieved, when everyone inside the team has the required awareness level to carry out their responsibilities. PSAS

model can support operators in gaining and maintaining situational awareness in complex environments, when the amount of information flow can cause problems in focusing on facts and prioritizing based on the valid information. With this type of tool, the operators are more confident in their work and are able to structuralize their actions. By supporting the team members with a process like PSAS, it is possible to help the team to take relevant information requirements into account and achieve better team SA and SSA, which will decrease the risk of possible errors in information sharing and decision making.

PSAS is the first steps taken to give the individuals more support to gain situational awareness and perform more efficiently in a constantly changing environment. Generalized model reflects the theoretical foundations of SA and future mission is to have it implemented as one of the tools for the training tool pack to support the effort.

6.3 Support to understand all the relevant factors affecting the team performance in the respect to information sharing from the organizational perspective

The idea of the SA model and check list, is to give an overall impression of the state of the organization being monitored with this tool. Issues that need to be covered are technological and organizational issues. Individuals play highly important role in action level and this check list supports in making sure that the basic elements are in place to support the individuals in proper actions. SA model was created based on the requirements of the concept development in MNE6 MISA-EM, when the theoretical framework was established for the concept developers and experiment team to have a joint framework to study issues related to extended maritime. I had started to collect, based on my observations, the list of all the possible influencing elements already in the MNE5 MSA case study, and the MNE 6 MISA-EM provided a good forum to double check whether the list was valid also in that context. The SA model supported in understanding also the trauma center activities and with the support of the literature related to health care, it was possible to analyze its usability and scalability for other time critical environments as well.

The timeline of the development of SA model and check list is presented in Figure 43.
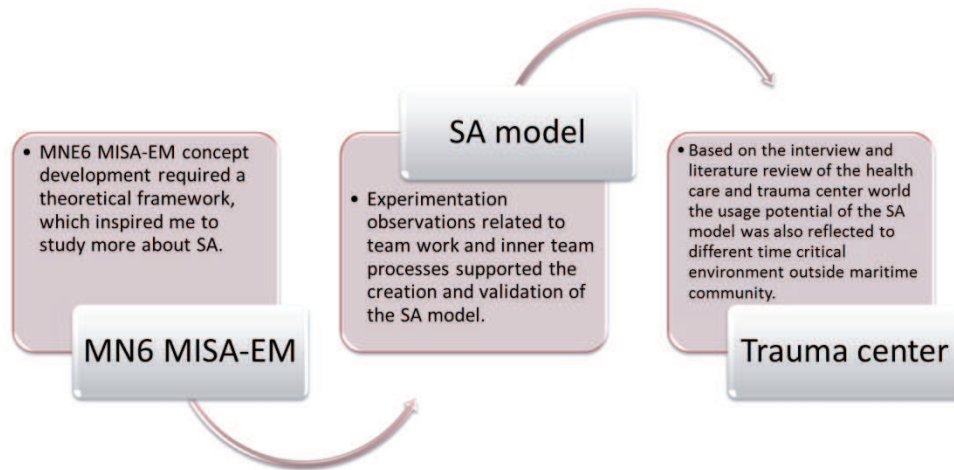
Figure 43: Development of the SA model and check list

The overall ideology is presented in Figure 44 that combines all the necessary levels and factors together to support in understanding all the elements related to SA. The check list of categorized elements, possible problem areas and guidance are introduced in Table 6. I was able create the list based on my observations from the case studies, when I was able to see certain patterns repeated. The SA model captures the essence of Endsley's model, and combines all the elements and levels together. It is possible to observe the reality from the individual's perspective, and understand that these factors affect the individual SA levels.

When the individual is a member of a team, his or her individual factors become an asset of the team. The individual needs to be aware of the team SA requirements and understand the devices, mechanisms and processes that are related to the team's activities. With them one can form individual view of the team member SA requirements and understand what is needed in order to act and perform as a team towards the general goal. This can also be viewed from the organizational perspective; how to build up teams that are able to fulfill the needed SA requirements as a

team with the right rules, roles and tools? Eventually which individuals are most capable to perform as member of a team in these build conditions.

Of course, also from the technological aspect the capabilities needed to be build up in order for a team to perform are important and should be viewed as well.
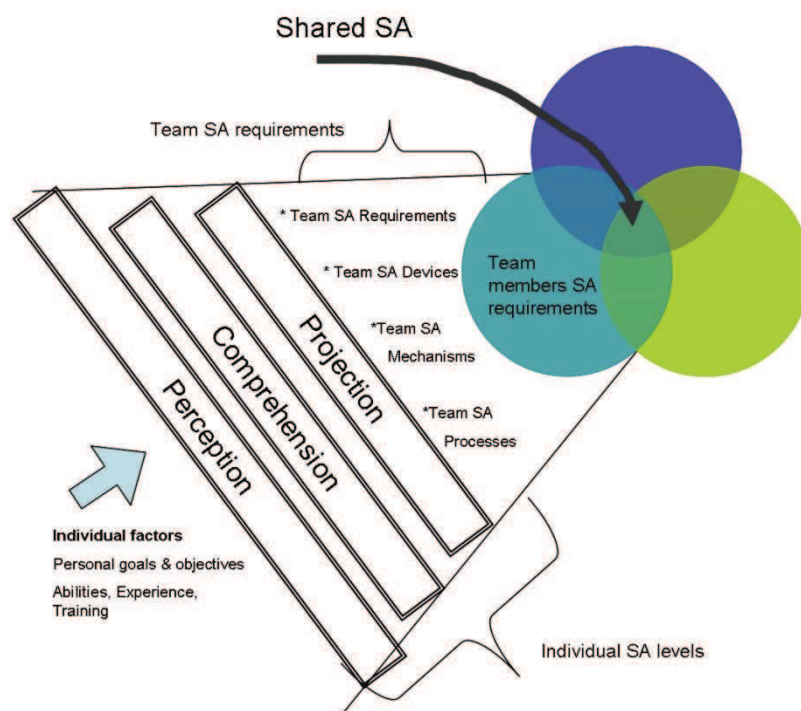
Figure 44: SA model combining all the SA elements needed to be taken into account in the organizational level to support decision making in collaboration.

Table 6.   Check list example of element affecting the performance

Problem Statement	Problem identification	Problem owner	Supportive Step
Unclear leadership/ roles/ tasks	Process challenge	Management	Process needs to be defined to identify roles, tasks and used tool*s*
Information sharing problems inside the team	Process challenge	Team leader	Individuals need to be supported by providing information and guidance
Information sharing problems with other stakeholders	Process challenge	Management	Individuals need to be supported by providing information and guidance
Problems in following the SOPs	Process challenge	Management	Individuals need to be supported by providing information and guidance
Differences in participants levels of expertise	Process challenge	Management	Is supported by training of the individuals
Problems in social interaction inside the team	Process challenge	Management, Team leader	Individuals need to be supported by providing information and guidance

Table 6 continues

Problem Statement	Problem identification	Problem owner	Supportive Step
Problems in social interaction with other stakeholders	*Process challenge*	*Management*	*Individuals need to be supported by providing information and guidance*
Differences in participants operational experience	*Process challenge*	*Management*	*Is supported by training of the individuals*
Conflicts in information exchange	*Process error*	*Team leader*	*Is supported by training the individuals both the rules and tools*
Team or a task conflicts	*Process error*	*Team leader*	*Is supported by training of the individuals*
Problems understanding the command structure	*Process error*	*Management*	*Is supported by the management and training*
Problems accessing the chain of command	*Process error*	*Management*	*Is supported by the management*
Conflicts in SOPs	*Process error*	*Management*	*Is supported by the management*

Table 6 continues

Problem Statement	Problem identification	Problem owner	Supportive Step
Cultural aspects affecting the work related to other stakeholders	*Social or process challenge*	*Management*	*Individuals need to be supported by providing information and guidance*
Language problems affecting the work related to other stakeholders	*Social or process challenge*	*Management*	*Individuals need to be supported by providing information and guidance*
Cultural aspects affecting the work inside the team	*Social challenge*	*Management, Team leader*	*Individuals need to be supported by providing information and guidance*
Language problems affecting the work inside the team	*Social challenge*	*Management*	*Individuals need to be supported by providing information and guidance*
Information conflicts	*Technical or social error*	*Team leader*	*Is supported by training of the individuals*
Network errors	*Technical error*	*Technical support*	*Is supported by training of the individuals*
Usability problems with the usage of the tools available	*Technical problem*	*Management, Technical support*	*Is supported by training of the individuals*

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Table 6 continues

Problem Statement	Problem identification	Problem owner	Supportive Step
Accessibility problems with the needed tools	*Technical problem*	*Technical support*	*Process needs to be defined*
Problems in information search of systems	*Technical challenge*	*Technical support, Team leader*	*Individuals need to be supported by providing information and guidance*
System breakdown	*Technical error*	*Technical support, Team leader*	*Is supported by training of the individuals*
Accessibility problems with the needed tools	*Technical problem*	*Technical support*	*Process needs to be defined*
Problems in information search of systems	*Technical challenge*	*Technical support, Team leader*	*Individuals need to be supported by providing information and guidance*
System breakdown	*Technical error*	*Technical support, Team leader*	*Is supported by training of the individuals*

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6.4 Supporting development of technological solutions to maintain the supporting tools functional and suitable for information sharing

From the technological perspective, I was able to use the MNE5 MSA case study setting and data for discovering whether it was possible to create a monitoring tool that could support in avoiding challenges identified in case study context. It was not a part of the experimentation plan, but the experimentation provided enough information that could be used to analyze and create monitoring tool suitable for information sharing purposes. Figure 45 demonstrates the timeline when the usability monitoring development took place. It started as inspiration from the observations from the MNE5 MSA and I had the opportunity to observe from the created model perspective also in the MNE6 MISA-EM experimentation, whether the tool could support the function I designed to be.
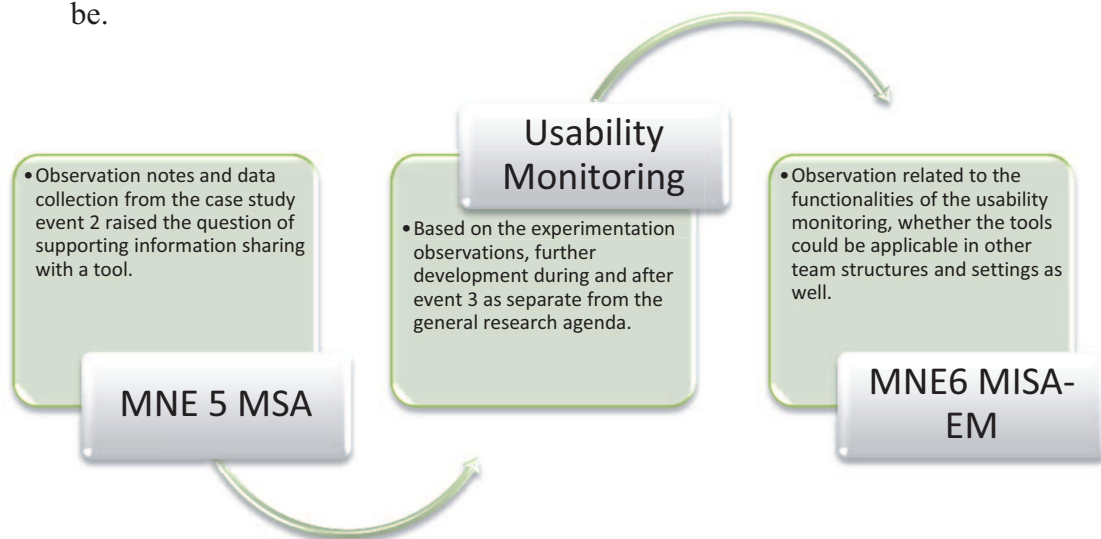
Figure 45: Development of the Usability monitoring tool

6.4.1. QoS and OODA -ideology

Created monitoring tool merges ideas from QoS monitoring, usability

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research and the OODA-loop. Quality-of-service (QoS) as defined in ITU-T Recommendation E.800 is a general term for all parameters that are visible to a user of a networked system (ITU-T). There is a solid engineering approach connected with technical QoS parameters. It involves defining QoS parameters and reference connections where target values for QoS parameters are given for normal and high traffic load. The target values for QoS are used as constraints in network dimensioning. They are also included in Service Level Agreements (SLA). QoS parameters are monitored for network management purposes and for checking the agreed QoS in SLAs. Well dimensioned networks usually satisfy the QoS target values and QoS monitoring notices problems, such as faults or configuration errors. Many IP networks are not dimensioned, and thus QoS monitoring is sometimes seen as a way to manage performance through feedback control. In the military environment QoS monitoring is seen as a way to detect problems in exceptional conditions, e.g. the Finnish Defense Forces use QoS monitoring in the IP core network for this purpose usability is presently treated as a factor that should be considered in the design phase, and usability research focuses on user trials. Then, it does not address changes in usability caused by network problems, different hardware/software configurations, or actions of the adversary. The QoS approach can potentially fill this gap. User experience is connected to QoS parameters by Mean of Score (MoS) measurements. MoS is a subjective measure given by test persons, typically on the scale 1-5, for perceived quality. In usability monitoring all qualitative tests and measures of usability correspond to MoS measurements, thus the QoS approach does not replace usability research. The methods of usability research (see Gulliksen, et al., 2004 for a list of typical methods) remain as the ways to evaluate user experience, find improvements to usability, and to obtain the MoS functions. The gain from the QoS approach is that it enables monitoring of usability and mathematical evaluation and optimization of some aspects of usability through technical QoS parameters when the system is operational. There seems to be much potential in extending this approach, especially since usability of networked systems is often relatively poor and something should be done to improve it. Aurrecoechea, Campbell & Hauw, (1998) states that many current network architectures address QoS, focusing to the provider's perspective to analyze the network performance without

taking into account the quality needs from the user's perspective.

The ideology of usability monitoring tool is to propose a wider application of the QoS approach in usability research. It measures usability experienced by the end user indirectly by looking at technical parameters that are influencing usability. The presented tool is a more general model of usability monitoring and can be applied to a more restricted case of a C4ISR or a C4IS system, where a set of technical parameters can be selected, though they do not necessarily measure all aspects of usability. The usability monitoring tool has been partially evaluated in a case study in MNE5 MSA. From the experimentation, it was possible to get input for the concept development of the usability monitoring by creating meters that can measure OODA-loop steps based on QoS ideology. Service is understood in this context as a subjective definition of the end user; how the end user feels the system supports the work done by the user.

Based on the data from MNE5 MSA event 3 allowed to confirm the basic principles of four different meter levels corresponding to the OODA-loop. This new tool will support system developers in identifying issues that affect the end user's performance and decision making throughout the decision making loop. With the combination of quantitative and qualitative methods, it is possible to support the information systems development especially in the design and implementation phase.

The main idea is that there is a connection between user experience and some measurable parameters, called the QoS parameters. While QoS according to ITU-T Recommendation E.800 includes a large selection of user visible parameters, including the goodness of customer service of the operator (operator here refers to the organization operating a network, such as a telephone company, not to the person who is called the operator of the C4ISR application), most of the QoS approach focuses on technical QoS parameters (ITU-T).

In the early times the most important factor was the Bit Error Ratio (BER) but in TCP/IP protocols these QoS parameters are measured on the IP level and usually include the end-to-end delay of IP packets, the delay variation (jitter) of IP packets in a stream, and the packet loss ratio. Throughput is traditionally a network performance (NP) parameter, i.e., a traffic parameter that is not visible to the user. This is because in the

telephony service, the user always got the same bit rate and throughput was only relevant for trunks. There is another set of QoS parameters related to availability, such as Mean-Time- Between-Failures (MTBF) and Mean-Time-To-Repair (MTTR) (Siewiorek & Swarz, 1998). The main idea is that the technical QoS parameters are measurable and they can be connected to the user experience by user tests. The user tests give the MoS tables and the goal is to set target values to the QoS parameters in such a way that a sufficiently high MoS is reached. This idea is clearest in voice quality. If the MoS value is at least 4.5/5, users experience the voice as very good. The idea is the same in all of these cases: it is possible to select some target values to the QoS parameters that guarantee good user experience. Obviously, technical QoS parameters depend on the connection and on the traffic. If the connection is for instance routed through very many nodes, connection establishment delay is bound to be longer. Therefore the target values for QoS parameters are given for a set of reference connections. Without defining the reference connections it is not possible to require that the QoS values are measured in the same way and the target values for QoS are reached. In this ITU-T approach it is essential that good QoS is obtained by agreeing that the target values that are declared in the recommendations are reached by all operators. The technical QoS parameters are measured and monitored by the network management by the measurements, usually done by the Operations and Maintenance (OAM). In the TCP/IP world, QoS measurements are not readily available and may need to be implemented, as Jormakka & Heikkinen (2000) states.

Some of the target values for the QoS parameters can be agreed in international recommendations. SLAs between operators, and between operators and customers specify the target values also for non-standardized parameters, such as the throughput. The ITU-T approach is an engineering practice and ITU-T Recommendations by Study Group 2 show applications of the approach (ITU-T). The connection between the QoS approach and usability is that the relevant QoS parameters must be chosen and target values for the QoS parameters must be set. Setting the parameters is best done by usability trials. When the target values for the QoS parameters are available, the problem of reaching good user experience reduces to a technical problem of fulfilling the target values. In the ITU-T approach this problem is basically solved by dimensioning,

i.e, the network is built to give good QoS. Thus, the reference model is as in Figure 46. There is a number of problems with QoS monitoring.

One is that traffic measurements from different points should be correlated. Such correlation, if done correctly, requires moving large data files containing packet headers and time stamps. It is too difficult to match requests and responses of user traffic by observing network traffic often used. Test traffic consumes some capacity, and especially if there is congestion QoS of test traffic may be different from QoS that the user sees for various reasons. For all these reasons QoS monitoring as in Figure 45 is usually not a continuous activity but done periodically to check the QoS level that is promised in the SLA.

6.4.2 General goal of the monitoring tool

The goal of monitoring tool is to widen the area of applications. In order to do this a better reference model needs to be found. In the QoS approach, the focus is on user visible problems caused by the network.
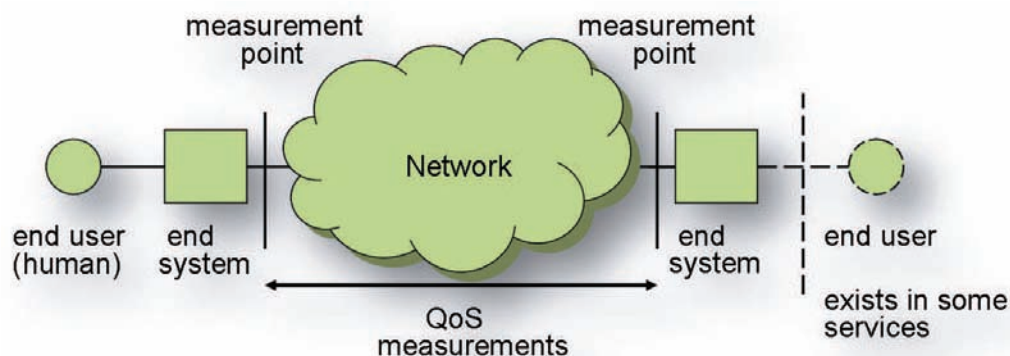
Figure 46: Reference model for QoS monitoring parameters are traffic parameters (losses, delays, jitter, errors) or availability parameters (e.g Mean-Time-To-Error)

The user visible problems in Figure 46 derive from losses, delays, and errors in the network, and lack of availability, delays and errors in the peer end system. In order to enhance the usability monitoring, end user is required as a part of the system.

The end user can get confused, make errors, or not notice something

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to find an analogy between user errors and network/end system errors. There is also similarity between the user being confused because of too many inputs and with the network being congested because of too high traffic. The case study supports these intuitive ideas: Analogies between social and technical network problems that can be seen on a higher level were found. Different types of errors and problems in MNE5 MSA event 3 while observing different MOC operators interacting with each other were also discovered.

In a normal situation a user is using the system in order to achieve some goal. Reaching the goal gives a reward. What can happen is that the goal is not attained and the reward is not obtained. Another thing that can happen is that reaching the goal takes too much time. Thus, the delay is important. If the delay is too long, the effort is typically abandoned. If the delay is short enough, it does not bother the user. Between these two values is some grey area where waiting for the task to finish causes some degree of irritation in the user.

A third aspect is the effort needed for reaching the goal. The effort may be counted in some applications e.g. by the number of clicks, opened windows or menus etc. If the effort is too large it causes irritation. An application is, or at least should be, tested by a rather extensive test set before it is taken to wider use. Therefore, with the set of test cases presented that cover much of typical usage of the system can be used reference cases. It is possible to enhance the test set by assigning the effort and reward to a reference case. So far the model is very simple:

The user has a goal – The user performs some tasks – The user gets a reward (or in some cases avoids possible punishment). Possible motive can be to reach the reward or to avoid punishment.

The usability problems are:
Failure to reach the reward.
Delay in reaching the reward.
Effort in reaching the reward.
Difficulty in understanding the situation.
Difficulty in deciding what to do next.
Having a set of reference cases where the effort and
the reward have been given.

This simple model does not describe all relevant aspects of the user's experience and it does not give measurable parameters. One approach is to enhance the model with some existing model describing observation and to try to get to measurable parameters. Every model emphasizes different aspects and none of them fully describe the reality. A model must be sufficiently simple, but it is possible to add some aspects of some other model to our initial model without complicating it too much and gaining better insight to the problem. Goal is to enhance the simple model by the Observe-Orient-Decide-Act (OODA) loop. It should be understood, as is pointed out by Grant (2005), that the OODA-loop is not the only model and several arguments have been made against it from a cognitive point of view. Nevertheless, the OODA-loop includes the actions of the adversary to the system in a natural way. A main goal in network-centric warfare is to get inside the OODA-loop of the adversary, and the adversary tries to mix up or to slow down decisions. Most decisions are made through a networked computer system, and in this sense usability of such systems is of crucial importance. It is valid to know if the system supports fast decision making and if the adversary can influence the behavior of the system for confusing the decision making process. In the civilian sector, usability of an information system is mainly important for customer satisfaction, and there is no adversary who tries to disturb the system. In military C4ISR and C4IS systems, the important tasks are decision making, poor usability results in poor decisions, and there is an active adversary who tries to gain on poor decisions.

User satisfaction in usability of the system is still a secondary goal. The main goal is that the tasks can be done well: The system does not slow down decisions, cause mistakes, or make decisions harder to take. The main concepts of the OODA model must be given a meaning in usability monitoring: Observation for the user of a networked information system is what user sees on the screen. Orientation means understanding the information that user sees. Decision means deciding what to do next. Action is the set of responses the user makes, but here actions are restricted only to the new input the user gives to the information system. Focusing on the OODA-loop illuminates several drawbacks both of the simple goal-reward model and of QoS monitoring as in Figure 39, and it stresses the importance of time: the key to success is fast decision

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making. Two main observations are highlighted in this case. Firstly, in Figure 46 traffic monitoring is needed in several places and correlate the measurements. This difficulty is the consequence of trying to solve the wrong problem. QoS monitoring is for verifying that the cause of the user's problems is not the operator's network. The correct problem is to monitor if the user has any difficulties in his decision making process. Then, it is essential to compare user's experiences to ones expectations. This can be done with a set of reference cases for actions that the user can take and compare the real message exchanges at the user end with the message exchanges in the reference cases. The next observation by focusing on to the OODA-loop is that the simple model of goal and reward is actually a model only for the act-phase. If the system is slow, observe and act-phases are slow.

The main problem is that the user cannot perform well in the decision phase but e.g. abandons the system. If the system has errors, the act-phase does not result in a predictable outcome and the decision maker does not have control. The adversary can try to deny the actions. Clearly, monitoring delays, losses and errors is important, but such measurements only cover the act-phase. Problems in the observe-phase are that the user does not get information or it is corrupted. It is important also to monitor delays, losses and errors of this data. In order to do it in the user end system, it is important to know when the information should be coming. In the orient-phase the problems are that the user cannot understand the situation. Finally, there is the decide-phase. Some decision systems support decision making by calculating different scenarios that may result from a choice of actions. In the general case, it is impossible to know in advance what information is coming to a user, but in Service-Oriented Architecture (SOA) it is in many cases possible.

In a SOA based C4ISR messages often follow the publish/subscribe Message Exchange Protocol (see for example Erl, 2006) where the end user subscribes to periodic updates of data. The SLA for the SOA service gives the promised update period and to monitor that the updates arrive. The adversary can try to deny observation by influencing the network but QoS measurements can detect these efforts. Integrity can be guaranteed by cryptographic means, therefore corruption of data by the adversary can also be detected. SOA based C4ISR applications are of current interest in many countries (Bunge, Chung, Endicott-Popovsky & McLane, 2008;

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Russel, Lookes, Lu & Xu, 2008; Russel, Lookes & Xu, 2008; Meyer, 2007) therefore this advantage of SOA can be used in the future.

The nature of a particular system is an important aspect in selection of QoS parameters for usability monitoring because software systems have different purposes and the users have different abilities and goals. The meaning of good usability is different if discussion is related to difficult computer games or of bank automation. C4ISR systems are networked applications that have a particular set of desirable characteristics. These characteristics should be taken into account when considering usability. Some conclusions of what is important for usability can be drawn from these characteristics.

Continuing to study the set of characteristics for a C4ISR application for situational awareness: 1) The system is transparent: the user does not spend effort in the system but can focus on the task, 2) the system demands a task to be done correctly even if it reduces usability, 3) the system helps the user to understand the situation correctly. The system is transparent - Many users want the system to be totally transparent and let them achieve their goal as easily and fast as possible. However, it depends on the particular system if the system should be totally transparent or if a part of a good user experience of the system is that it is suitably challenging and the user experiences good command of the system as a reward, like often is with a single person computer game or an operating system. The assumption is that military C4ISR systems should be as transparent as possible because the primary task is too important to take any risks of failure. This is reasonable and may be true, but one should keep in mind that a fully transparent system is not always the system that gives the best user experience.

The system demands a task to be done correctly – It is not necessarily the same thing if the user finds the system usable and if the task is done well. For instance, handling classified information is clumsy and time demanding but it must be so if the task is done correctly. This is not quite the same as functionality versus usability (Goodwin, 1987.) There is a need for a system that does not allow a task to be done incorrectly, even if it is clumsy. This situation often appears with security. User understands the situation correctly – Situational awareness is a central concept in all network-centric approaches, also in the Finnish Network Enabled Defense (NED). Situational awareness has three levels: seeing the situation,

understanding the situation, and being able to predict the development of the situation; the last level being very difficult to reach. A system should try to assist the second level: understanding the situation.

It follows from transparency, that all effort in doing tasks is only a nuisance to the user. It is possible to assign a positive value to the reward and assign a negative value to the effort to reach the reward. The effort may be number of clicks, opened windows etc. The numerical value of the effort can be evaluated by usability tests. From the characteristics of demanding correct operations follows that users sometimes must follow certain procedures. Therefore it is possible to assume that users also in other tasks easily accept that they have to follow certain procedures. This means that the user interface of the system should not offer many ways of doing the same thing, which reduces the possible cases to be measured. Since a main goal of the system is that the user understands the situation correctly, monitoring of the understanding should be done some way. Understanding a situation is not a directly measurable parameter but by assuming that if the number of events that are visible to the user in a given time increases too much, then the user may find it harder to understand correctly. Thus, with a measure taken of events is shown to the user as an indirect measure of understanding. The end system often can be configured to take logs of events and therefore the measure is easy to implement. User tests are needed in order to connect the measure to user understanding.

As a conclusion, the special characteristics of C4ISR applications for situational awareness are quite suitable for the presented model. These systems do not try to present as many choices to the user as possible for better usability but the users are accustomed to following fixed procedures. Therefore, the set of reference cases that have to be monitored is rather small. It is possible to keep track of the parameters for effort and reward for a representative set of reference cases, possibly for all. It is also easier to match the responses of the system to each request of the user when there is a small set of reference cases.

With usability monitoring it is possible to compare the logs of the events and identify the message chain as one of the reference cases. Then, it is possible to evaluate the effort and the reward of this message chain to the use by comparing delays, additional messages etc. to the target values of the reference case. The users do not like additional effort, and without

considering any deeper cognitive aspects of using the system than only to look at the effort the user must exert in order to reach the reward. The user effort is derived from the delays that he experiences and how many events he must generate. The reward is seen from the way the message chain completes. If it does not complete in a similar way as in the reference case then the user does not get a reward. A simple example is that the user sends a message, but it is answered with an error message. It is possible to detect this case. Another example is that the user gets no reply. It is also possible to detect this case. These examples show the possibility to form some measure of effort and reward to the message chains. Figure 47 presents local usability measurements enhancing the QoS measurement of Figure 46, by including measurement points to every level of the OODA-loop.

6.4.3 Measurement and usage of the monitoring tool

It is crucial to recognize that the OODA-loop and measuring the decision points occur behind the end system. This is why the new aspect for usability monitoring is needed.
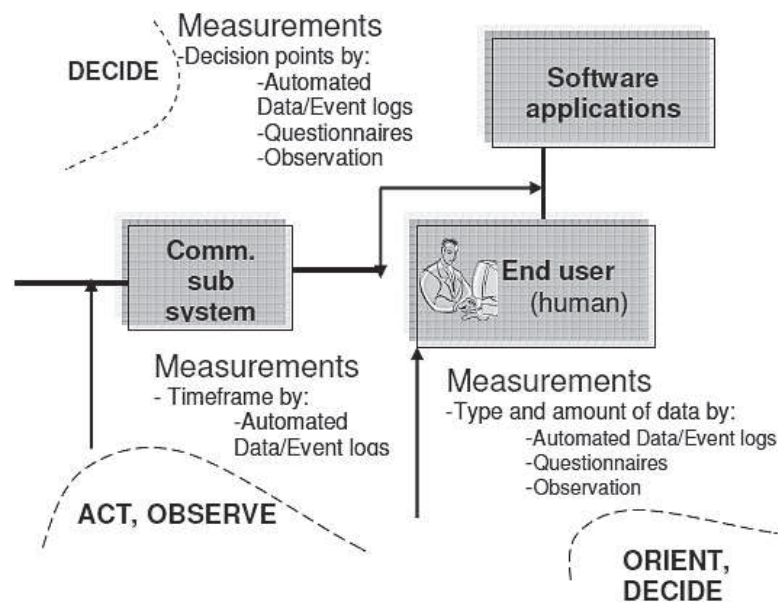
Figure 47: Local usability measurements missing from the QoS monitoring of Figure 46

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It is recognized that the case study and the environment was much more complex and human factors affect the results, but still it is possible to point out factors that affect the performance and by that the QoS. Those factors can be generalized and transformed into the new tool of usability monitoring.

As stated, there have been attempts to measure SA but not adequate techniques to tackle the C4 environment. It has been recognized that in order to measure SA, a technique that measures SA only is needed, it has the required level of sensitivity so that it detects possible changes is SA, and that it does not change SA during the process of the measurement (Salmon, Stanton, Walker & Green, 2006).

In order to fully understand the requirements of the monitoring, acknowledgement is needed from the systems level; SA enables decisions to be made in real time. When focusing on, for example, the maritime environment, these types of socio-technical systems need to be orientated towards the dynamics of the environment (Walker et al., 2009). It is important to provide the operators with tools that support them building and maintaining SA (Durso & Sethumadhavan, 2008) but this does not mean only technological innovations. Focus is not only on technical details but widening the scope of monitoring social aspects and issues that need to be tackled in order to gain situational awareness in evolving environments with their own challenges.

There are several causes to usability problems: System design problems (for example software is poorly designed), hardware and/or software configuration causing permanent problems (for example too slow machine), transient problems (for example errors or delays because of network load, software updates), and intentional errors/adversary action. In the usability monitoring approach it is assumed that system is well designed in the opinion of those who introduced it but it does not work well in the opinion of those who use it. Thus, the usability problems are caused by poor configuration, network problems, or by adversary action, and they can be found by usability monitoring. Usability monitoring does not measure usability, since the quantitative methods used in the usability monitoring notice signs that indicate poor usability and the qualitative methods provide a tool for understanding the reason behind the poor usability. In the MNE5 MSA case study (Brunett, Choo, Eshelman-Haynes, Koskinen, Soh & Utterstöm, 2008; Koskinen, 2008),

the focus was on the system design and implementation phases. It was possible to identify meters for usability monitoring and performed qualitative usability tests that can be used for defining MoS functions. The development did not continue further to set reference connections and target values, that is, the case study does not verify the whole usability monitoring approach.

The scope of usability monitoring in the MNE5 MSA experiment was to identify characteristics, which are important when we are monitoring the system and to see if it is possible to implement measurements to every level of the OODA-loop. From this MNE5 MSA case study a confirmation was established of the necessity to expand the usability monitoring and to develop a tool to meet the demands for adequate response to usability problems. Monitoring tool was created based on the lessons learned from MNE5 MSA. MNE6 MISA-EM supported in validating that same elements exist also in that setting and gave the confidence that the created monitoring tool can be used in supporting information sharing in a multinational collaboration.

With this framework it is possible to point out issues such as different channels (formal/informal) for communication, types of information, and usage of tools. It is possible to identify issues that affect operators' way of using technical systems, why and how they used certain social networks and to follow the information flow. Based on the MNE5 MSA case study, later confirmed also with data form MNE6 MISA-EM, evidence was found of the possibility to identify situations when it is crucial to look at the timeframe and focus on issues concerning QoS. All the presented statistics are taken from the MNE5 MSA event3 for demonstration purposes. When looking at the OODA loop, in the observe stage can be seen usage of different resources; own technical system, open databases or email, chat or voice to contact other MOC teams. At this stage analyzing of the type of data received and also the channels used can be done. In the orient stage target is in scoping the task and from the analyzing perspective focusing on the amount of data in the given time frame. The decide phase includes decision points when the team or user decides to act based on the information they received. From the analyzing point of view this means counting the number of decision points. In the act phase observing focuses on the actions based on the previous steps and analyzing the time to complete the task (sending information if

requested or finishing other type of action).

Figure 48 is an example of the gathered data from the MNE5 MSA experimentation. This Figure presents the amount of information sharing of MOCs in two separate events; how much MOCs pushed and pulled information and initiated information sharing.

Figure 48 shows the amount of initiations and number of push and pulls from each MOC team. This type of information was crucial when searching reasons behind actions. Initiations represent how many times the MOC team was initiating an exchange of information. Pull is referred to situations when MOC asked for example for more information about some particular topic. Push refers to situations when MOC team has sent more information to others.

Reflecting back to the OODA-loop, it is possible to identify aspects and meters that measure how capturing and eventually measuring the time between the different steps of the OODA-loop can be executed.
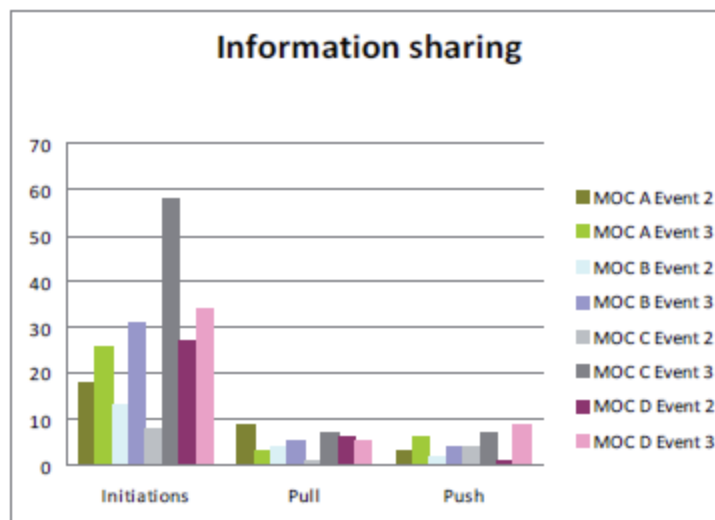
Figure 48: An example of MOCs information sharing amounts in both events

o **Meter 1 Observe (Type of data received)**
   o Counting the types of information and the means of receiving and sending information.
   o How many times the MOC was unable to receive or react to the sent information (what means of communication causes delays)?

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- o **Meter 2 Orient (Amount of data)**
  - o Too much data leads to mental overload.
  - o Too little data means that the system does not offer adequate SA.
  - o How many times there were failures (reasons for delays, social or organizational)?

- o **Meter 3 Decide (Number of decision points)**
  - o How many decision points are found (the number of decision points)?
- o **Meter 4 Act (Time to act from the first step)**
  - o Time counted from the sent to the action (information about time delay).

With the list of meters and Figure 49 of an example of different meters in different stages of the OODA-loop, is presented a way to create meters that collect the needed data in certain stages of the OODA-loop in order to monitor usability. The QoS parameters are selected by taking all phases in the OODA-loop into account. They are not only measures of delays, jitter, errors, losses and availability but also contain parameters related to understandability. It should be understood that most of the variables that were measured in the experimentation were not technical performance variables: there is a lot of crucial information that needed to be collected in more qualitative ways.

At a later stage, MoS functions should be created and target values for reference connections set. At that later stage ideally only quantitative data would be needed, such as the number of messages or response times to a message, i.e., only measurable numbers. Before defining the MoS functions, in order to fully understand the given task and the result, there is a need to look deeper into the process that the user proceeded with. The basic meters help to get pieces of the information, but in order to measure true performance, the pieces must be put together by using qualitative methods.

Both in the MNE5 MSA and MNE6 MISA-EM experimentations quantitative data was interpreted with observations notes, interviews and surveys. In design and deployment stages of a new or updated information system, the QoS monitoring concept gives the basic guidelines where to look for problems, and it provides a framework for understanding the complexity of performing different types of tasks with

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technical systems. The new concept helps evaluators and designers to focus on the actual challenges and how to take an advantage of the user feedback. Figure 49 explains the points that can be used to capture and count when measuring QoS in the act stage. The ideology is that from every step of the OODA-loop, can information be gathered for analyzing possible challenges reflecting to the act-phase.

In order to understand why the response took too much time or the action was false, there is a need to identify the phases of information sharing. Measurement can be taken from the time between different actions with time stamps, and deeper analysis can be performed through observation and interviews. Data collection can also be arranged during run-time by collecting the data for example by online questionnaires that the users take part in. In the original QoS monitoring model of Figure 46 the problems are limited to the act stage only. The new concept extends the scope to cover all of the stages. The act stage is simply the final phase which uses the results of previous stages, and that amplifies the importance of the other steps even more. Table 7 is an example of information sharing delays in the experimentation.
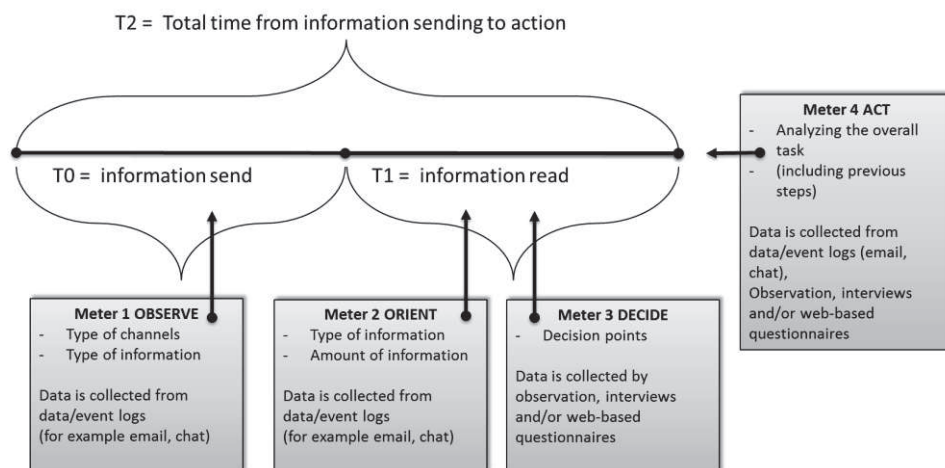
Figure 49: An example of different meters in different stages of the OODA-loop

Measuring the time from sending a request to receiving a reply naturally does not tell us much about the actual quality of service. It is not providing information about the situation where the information exchange took place, and how the information was created. By observation it is not only possible to capture the log files, but the actual times when the *operator*s were able to read the received messages delays. It was interesting to discover that reasons for delays could be a technical, organizational or social issue. Difficulties with the technology can cause distractions and make access to the information more difficult.

Table 7.   An example of information sharing delays in the act stage

Scenario 1 issue	time of sent	time of read	time of action started	time of action finished	mean of communication
RFI reply from another MOC	10:21:00	10:34:00		no action	Email
IR from another MOC	10:40:00	10:55:00		no action	Email
another MOC asks info about mmsi number	11:10:00	10:59:00		no action	Chat

Scenario 2 issue	time of sent	time of read	time of action started	time of action finished	mean of communication
RFI from FIN MOC to WC (coast guard)	8:04:00	-------	7:48:00	8:22	Email
RFI from FIN To WC (National Board of navigation) cc to ALL	9:07:00	-------		8:06	Email
info from another MOC	9:48	10:04		no action	Email
another MOC send information	10:47	11:45		no action	Email
Reply to another MOC	13:32	13:35		13:37	Chat
Information from another MOC	13:34	13:40		no action	Email

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On the other hand, the organizational perspective allows to discover issues that limited authority caused delays because operators had to wait for a response from the higher-level headquarters in order to respond.

From the social aspect the actors' own prioritizing also affected the response time. If the operators received a lot of information and requests at the same time, they prioritized and acted based on their own judgment.

Figure 50 is an example of the interaction between different actors sharing information about one particular subject. From the interaction diagram it is possible to see in a certain time frame, what type of interaction happened, what kind of tools were used and with whom the actual interaction occurred.

TIME	SUBJECT	MEDIA	WHITE CELL	MOC 1	MOC 2	MOC 3	MOC 4
746	RFI for Vessel X	Email					PULL
849	FAILED CALL TO NATO for clarification	Voice					
851	RFI Vessel X	Voice					
853	RFI Vessel X	Voice					
853	Vessel X position	Voice					
856	Asking CATES in WC detention records of Vessel X	Email					
904	No information from CATES	Email					
911	For MOC 4 there is nothing we found on Vessel X besides the position we given you	Chat					
915	For MOC 3 TY for looking	Chat					
919	MOC 4: my information shows two similar ships with the same IMO number with Vessel X, propable name changes Vessel Y, Z	Chat					
934	Re: RFI for Vessel X	Email					
940	COI DESIGNATION FOR VESSEL X	Email					PUSH
949	Action for Vessel X	Email					PUSH
1021	Re: Action for Vessel X	Email					
1048	Vessel X information	Email					
1311	Re: Action for Vessel X	Email					

Figure 50: Interaction diagram of information sharing

To reflect the findings back to the QoS, what actually can be seen as factors affecting the collaboration and usage of different tools? Based on the case study statistics it is possible to identify situations when it is crucial to look at the timeframe and focus on issues concerning QoS and usability monitoring. When looking at the OODA-loop and the observe stage, it is possible to see the usage of different resources that can be our own technical system, open databases or contacting other MOC teams via email, chat or voice. The type of data received at this stage can be analyzed and also the channels used. The orient stage includes scoping the task, and from the analyzing perspective the focus was on the amount of data in the given time frame. The decide phase includes decision points

when the team decides to act based on the information they received, and from the analyzing point of view this means counting the number of decision points. In the final act phase focus in on observing the actions based on previous steps and analyzing the time to complete the task (sending information if requested or finishing other types of action).

Based on the data examples from the MNE5 MSA event 3 describe the basic principles of four different meter levels corresponding to the OODA-loop were explained previously. In the design stage and during the deployment of new information systems the importance of usability monitoring cannot be highlighted enough. According to the concept by using four meters to measure QoS, it is possible to identify usability problems and challenges of the new system.

The actual testing is done in a test environment with a test scenario where users are given a couple of tasks. Meters capture the data and interactions that occur during the test run. By following the concept and adding surveys and interview with observation we get crucial information about issues that hinder information sharing. After testing the new system, reference values for usability monitoring can be created and compared in future usage of the system.

By combining quantitative and qualitative data it is possible to show the influence of delays in information sharing, whether it is caused by the technical system or human error or is simply a delay from using a formalized report form, divided to social, technical and organizational factors. The observe stage is measured by a different type of logs that record actions like sending emails, chat logs, and phone records. From that data statistical information is gathered about the channels of communication and also the amount of shared information. The orient stage focuses more on the amount of data and information management; i.e., how the user reacts to the received data. A simple technical measurement is not covering the entire truth, but we get important information with reference cases for example about the amount of data that can cause overload and also can capture the number of failures in connections. In the decide stage gathering focuses on the number of decision points during one task. There is no simple way to do that automatically, but by end user questionnaires and observation supported by interview it is possible to gather that type of information. In the final stage, act, the time to proceed with the task and possible delays can be

measured. Most of the meters can be formed quite easily for a run-time evaluation and collected for most parts automatically but in order to gain the maximum benefit of the method, observation and interviews are required. Although the level of significance of observation and interviews can be minimized for example by using run-time web-questionnaires in order to collect user's impressions. In the MNE5 MSA and MNE6 MISA-EM experimentations it was possible to obtain information that showed how the tools affected the *operator*s' decision making and what type of process they went through while solving the task at hand. As Walker et al. (2009) states, the focus of analysis is in information; how information is held, exchanged, represented and transformed by users regardless of the existing technological infrastructure and organizational framework. In the MNE5 MSA experimentation the quantity of information exchange, examples of the actions taken by the MOC teams and interactions between them where presented in order to provide a better understanding of the situation. This example case study demonstrates that by monitoring these types of measurable variables it is possible to measure the level of usability and analyze the user's level of situational awareness with the respect to information sharing. Figure 51 represents OODA-loop stages and methods that can be used during each step, from counting the number of events all the way to making questionnaires.

As Redmiles (2002) states that development goals generally include end user views distributed across many disciplines, yet there has not been enough research in order to monitor the usability of a system from the end user perspective. Redmiles (2002) ideology of activities in human-centered software development does not address issues that are central to the usability monitoring concept even though he brings up the importance of the workplace environment and expands the meaning of end user to a much wider area. Cardoso, Sheth & Kochut (2002) presented ideas for workflows with QoS (Georgievski & Sharda, 2003a; Georgievski & Sharda, 2003b). They focus on business processes and for them QoS means analyzing time, cost, reliability, and fidelity metrics. This does not cover the ideology of reflecting QoS to users' views or support for example decision making. Georgievski & Sharda (2003) presented a real time management of QoS with the three layer QoS model including user perspective, application perspective, and transmission perspective. One aim was to investigate how the user can interact with the QoS Processing

System in real-time. The user element was presented, but not in the same context as presented in the Usability Monitoring concept. It is also possible to study usability from other point of views, for example from the system perspective, and use models like ITIL (Ishibashi, 2007).

Nevertheless, decision to focus on the human actor, the actual user was made, and developed the concept to support the end user by using the OODA-loop. End user point of view is crucial, because the actual users are the key actors in the organization processing the given information with the usable tools. By supporting the end user, support is given to the entire organization in achieving its goals. Related studies cover some parts of the metrics of QoS and represent many different ways to measure usability.
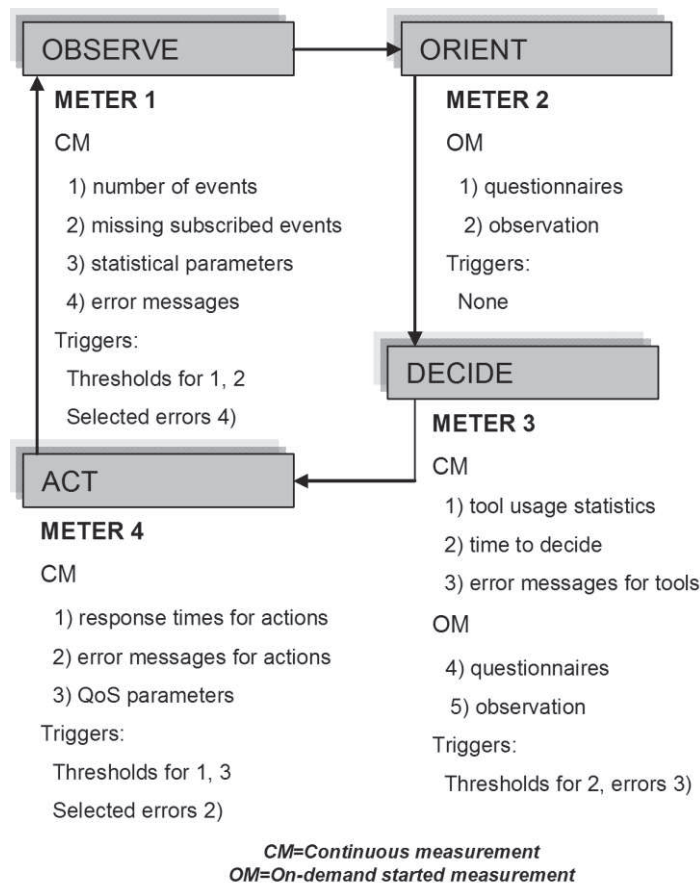
Figure 51: Usability measurement points in the OODA-loop

The new created concept is based on the user's point of view for monitoring usability of systems in the operational phase, and, as the case study shows, it is useful also on the design and implementation phase of new information systems by introducing collected methods following the steps of the OODA-loop.

According to Salmon, Stanton, Walker & Green (2006) existing monitoring methods do not address the problem of situational awareness (SA) because current SA measurement techniques focus only on individual SA and approaches have issues that can detract from obtained SA data (Salmon et al., 2006). As recognized, there are three levels of awareness that are situation awareness, team awareness and organizational awareness (Carayon, 2006). By focusing to the situation awareness also by acknowledging that the level of situation awareness of one user affects the team's awareness and the overall awareness of the organization. That is why the focus is on the actual user and ones level of SA in order to improve the overall SA of the current ongoing task. Information sharing and collaboration has been recognized to be crucial elements also in air traffic situation and it has been stated that researchers have neglected looking at SA from a team perspective. It is also crucial to understand that SA is applicable to dynamic situations with changing variables such as in the maritime environment (Langan-Fox, Sankey & Canty, 2009). The definition of team dynamics is also a problematic: what do the actors know about their own and other actors' workload and how is this supported by technology. The crucial question has been to see and understand that team SA needs to be more than collective average of SA of the individual actors in the team (Wickens, 2008). This is the reason why the focus with the usability monitoring is on the individual actors SA, because by monitoring certain steps, it is possible to gather valid information from all the actors involved in the specified team. This tool is scalable from one individual and ones SA to team SA by taking into account each actors SA to build up the entire picture of the situation.

Usability is an aspect involving human factors and one may ask if the proposed model measures usability, or if any fixed set of technical parameters can measure usability. This question is irrelevant since the proposed model of usability monitoring does not intend to measure usability. Usability monitoring is an extension of QoS monitoring. QoS monitoring does not measure the QoS level, and does not measure all

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aspects of QoS, but it takes continuous or periodical measurements of certain technical parameters in order to detect indications that the system does not offer adequate QoS. If such parameters are well chosen, the small set of monitored parameters indicates a large range of underlying QoS problems without specifically measuring each of them. Furthermore, if the system is well designed it should give good QoS unless there are problems, thus the lack of problems can be taken as an indication that the system offers good QoS. Similarly, usability monitoring does not measure usability but detects by technical measurements signs that the system does not operate in the way as it is intended. If the system is originally designed to have good usability, usability monitoring measurements satisfying target values indicate that usability of the system is as good as designed.

This dissertation presents a usability monitoring tool that suits to C4ISR applications for situational awareness. Usability of such an application is closely related to the ability to make good decisions. If the system is slow, causes mistakes, is prone to errors, or is confusing, it cannot be effectively used in decision making. The improvement to the QoS monitoring model is the extension of the scope. Usability monitoring tackles each stage of the OODA-loop and gives the higher level management a tool to see if the OODA-loop slows down. In the MNE5 MSA and MNE6 MISA-EM experimentations operators needed to collaborate in order to complete their tasks. Case studies gave a platform to partially evaluate the ideology of the usability monitoring tool. Especially, there was an opportunity to select meters for each stage of the OODA-loop. In the observe stage the type of channels used and the data received are analyzed. From the orient stage the amount of data that causes need for information management are identified. In the decide stage the information on how many decision points the operator has and does one have enough information is analyzed. Finally, in the act stage is used to collect information in order to analyze successfulness of the operation and how much time it took for the operator to act and finish the task.

Presented case studies, especially MNE5 MSA event 3 gave provided plenty of usability information and gave insights on what type of usability problems can appear and how they are connected with measurable technical usability monitoring parameters. The basic technical level data

is collected automatically but much of the descriptive qualitative usability data is obtained by questionnaires, observation etc. methods that cannot be collected automatically. The usability monitoring tool was mainly developed for the design and implementation phase when it is easier with a test scenario to analyze the meters and evaluate the system with the quantitative and qualitative methods. With the case study, the idea was not to continue to definition of target values and reference connections because target values need to be set after each test scenarios in different environments.

The usability monitoring is a guideline to proceed with a test during the design or implementation phase and collect the data with the given methods and set target values after identifying the gaps and solving the causes of errors or delays. Focusing on the OODA-loop, and by looking at technical measurable parameters gives us a way systematically to observe the usability of the used system in order to find gaps that are affecting the user's situational awareness.

6.5 Implementation of solutions

This stage is the critical step from conceptual paper to implement the concept to actual use. To have witnesses the implementation of some of the lessons learned from the experimentations especially from the technological solution and procedures has been absolutely rewarding. The main focus in this dissertation is in the steps before the implementation phase to create the awareness of all the possible elements that need to be taken into account before continuing to the implementation stage.

Reflecting back to the presented case studies, the components of the conceptual model have been, at least partially, evaluated and validated that they can be implemented into real life applications. Next, the possibility to use the conceptual model also outside the maritime context will be verified with a health care environment.

7 THE USEFULNESS OF THE CONCEPTUAL MODEL IN OTHER ENVIRONMENTS – Introduction of the framework to the health care environment

While doing the study related to the maritime environment, it was interesting to see elements that could be seen also in other environments as well. This intriguing observation drove to see whether the created conceptual framework could be beneficial in other environments such as health care where the situational awareness of the personnel is crucial in life saving processes. The preliminary examination of the similarities of roles, processes and tools is presented in Table 8. To get the confirmation, whether the conceptual framework could support other environments as well, health care environment was introduced to validate, whether the model could be used also outside the maritime context.

Table 8. Quick analysis of similarities in different environments

Environment	Maritime	Health care
Actor	Operator	Nurse
Actor	Intel Officer	Doctor
Main Process	Sea surveillance	Patience condition surveillance
Sub-Process	Anomaly detection	Disease analysis/detection, laboratory test
Tool	Maritime sea surveillance system (MEVAT)	Patient record system (PEGASOS/EFFICA)

In different environments it is crucial to identify different roles, their task division, organizational processes that are created to control, and to support and organize actions between the actors. SA and information sharing possibilities are given to the individual. It is up to the individual

in the end to make the decision, whether to share information or not. Information sharing is not an automated result of gaining situational awareness. Elements affecting the information sharing, such as devices, are supporting the individual or teams in information sharing affect the team's behavior and also contributing to the SA. Tools and processes are means to support information sharing. It is up to the individual to use or not to use the tools or to share information. It is possible to support the actors in realizing the consequences and possibilities of their actions to improve the needed level of awareness.

Figure 52 demonstrates the general dilemma between time and gaining the needed level of awareness for better decision making. There can be situations, when decisions are made fast with low level of awareness that may cause poor judgment and poor decisions. Or situations, where the needed information is created in a longer period of time, causing the decision to be too late and impacts of not making decision in time, more severe. For example, in hospital environment, if critical trauma patient is not treated fast, it may lead to the loss of the patient, but if the treatment decisions are made in time, but with wrong information and poor SA, the end result can be the same.
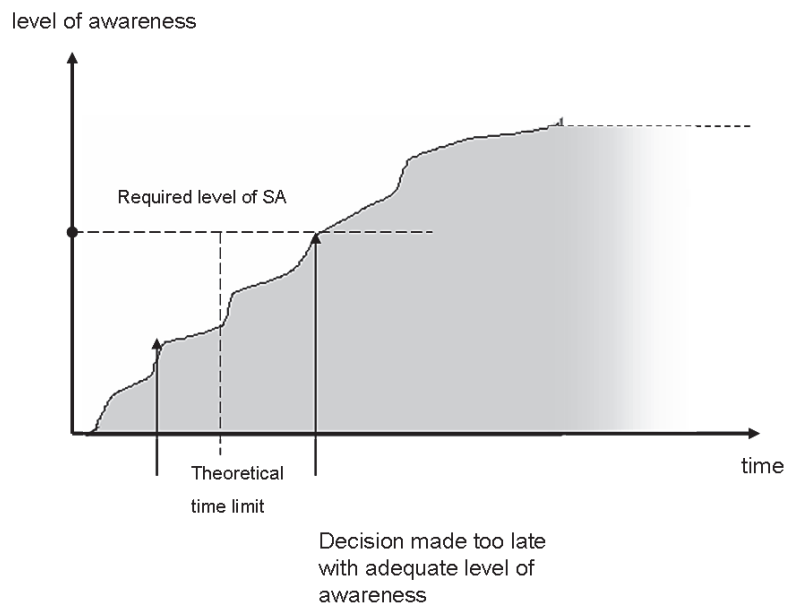
Figure 52: The level of awareness versus time

In order to fully demonstrate, how the created conceptual model can be beneficial in other time critical and emergent cases, a fictive, simple scenario will be presented related to hospital trauma center activities. Imagine a situation where a truck of highly flammable material has been involved in an accident, where the truck is damaged and several casualties were caused. Some of the victims are severely burned, other have minor physical, visible injuries and some are just outsiders of the scene. If we first focus to the accident involving truck accident, it is clear that it involves the individuals in the accident scene; truck driver, other car victims, emergency call receiver, most likely ambulance personnel, fire department personnel, and hospital personnel. All of these actors have their own roles in the situation. Some of the roles are defined by the agencies and some roles are just taken by the individuals themselves, according to their reaction in the crisis situation.

All of authorities have their own perspective to look at the situation in hand, and they all have their own ways of proceeding with the capabilities they have for these types of situations. This emphasizes the need for the developed conceptual model to support all the possible organizations, that are facing these time critical and emergent situation, that require collaboration and massive information sharing in order to succeed, whether is in saving human lives and diminishing the consequences of occurred environmental catastrophe.

Figure 53 presents the overall conceptual model that is designed to support different levels of the organization. Conceptual model supporting achieving of SA in the information sharing framework and comparison between maritime environment and health care environment are made to validate the general purpose and versatile usage of this model: to reveal what are the elements that match and how the model could be improved to better support other environments as well. Next, the support given by the conceptual model to the scenario is explained in more detail.

Conceptual model provides the overall picture of the elements affecting the organization. This general model provides the management level overall understanding of the important elements affecting the processes of the organization. Individuals inside the organization are supported with the PSAS in order to understand all the elements affecting the decision making and to understand how own actions affect the entire team. Monitoring tools is for the technological development.

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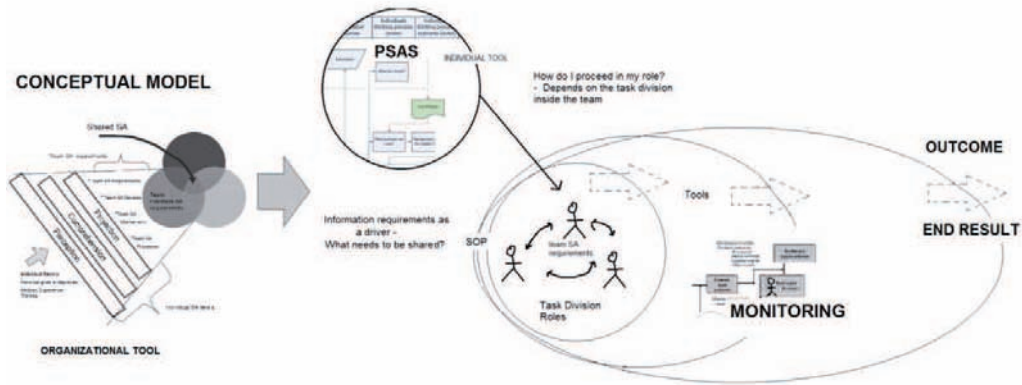
Figure 53: Tool package of the conceptual model

When the organization has understood the relevant factors that affect the information sharing and it has been supported by proper training with the PSAS, monitoring offers possibility to see how the developed information systems support the overall information sharing and gaining of the relevant situational awareness both from the individual and organizational perspective.

With these tools, it is possible to support organizations also outside maritime context to gain adequate level of awareness.

Reflecting back to the scenario, and the usage of the conceptual model to the truck accident, the scenery can be divided to be observed from different perspectives, such as organizational, technical and individual views. The possible actors were identified earlier, and all the mentioned organizations have their own professionals and ways of doing things. The important interface is the collaboration with other organizations and individuals: The interesting question is how the different working procedures and individuals with different tools and ways of thinking, can collaborate in a crisis situation. The scenario was created to emphasize the challenge of collaboration in situations where there are several actors involved and a lot of activities happening: While ambulance drivers take patients to the hospital and the trauma center takes care of the incoming trauma patients, while police directs traffic in the accident scene, there might be a situation, where no one reacts to the fact, that the chemical accident may cause a severe catastrophe, if relevant actors would only

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focus on their priority tasks. For entire situation evaluation, communication and information sharing is relevant to support gaining needed level of awareness of the situation.

Figure 54 is from the U.S Department of human health and services and it was created to provide guidance for decision maker's in the event radiological terrorist attack in a U.S. city (U.S DHH, 2011, 12). The original model focuses on handling the situation of contamination, but it also presents same types of needs for situation assessment, prioritizing and understanding of capabilities available. In each decision making point it is highly important to understand the situation.

Figure 55 demonstrates a modified process of emergency assessment and process of how injuries are categorized in an accident area. Emergency assessment can be taken as a good example of the medical personnel, doctors etc., who need to determine the level of care needed for the emergency patients.
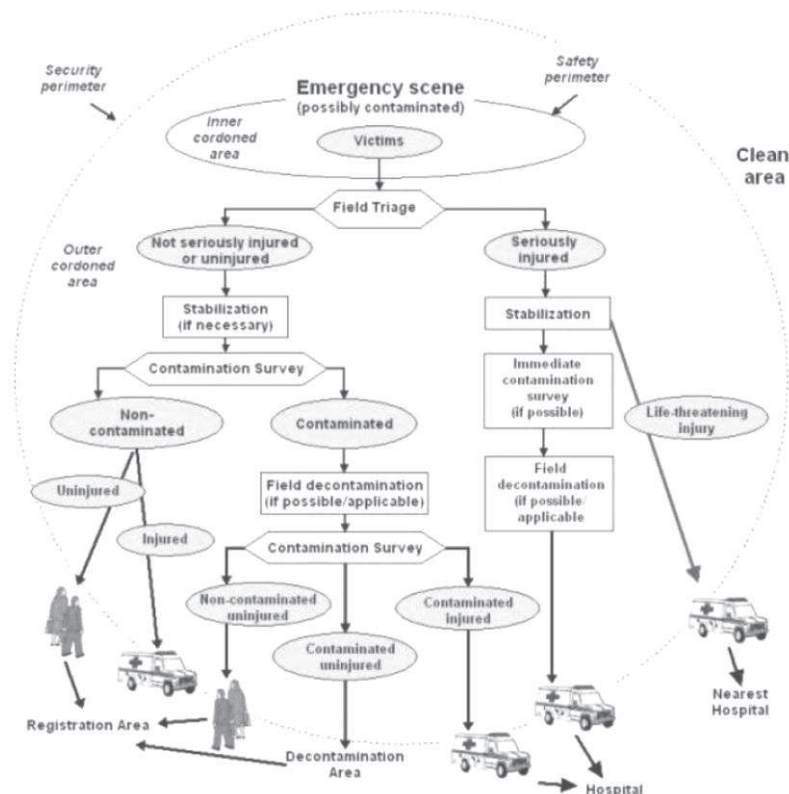
Figure 54: Victim handling process from the emergency
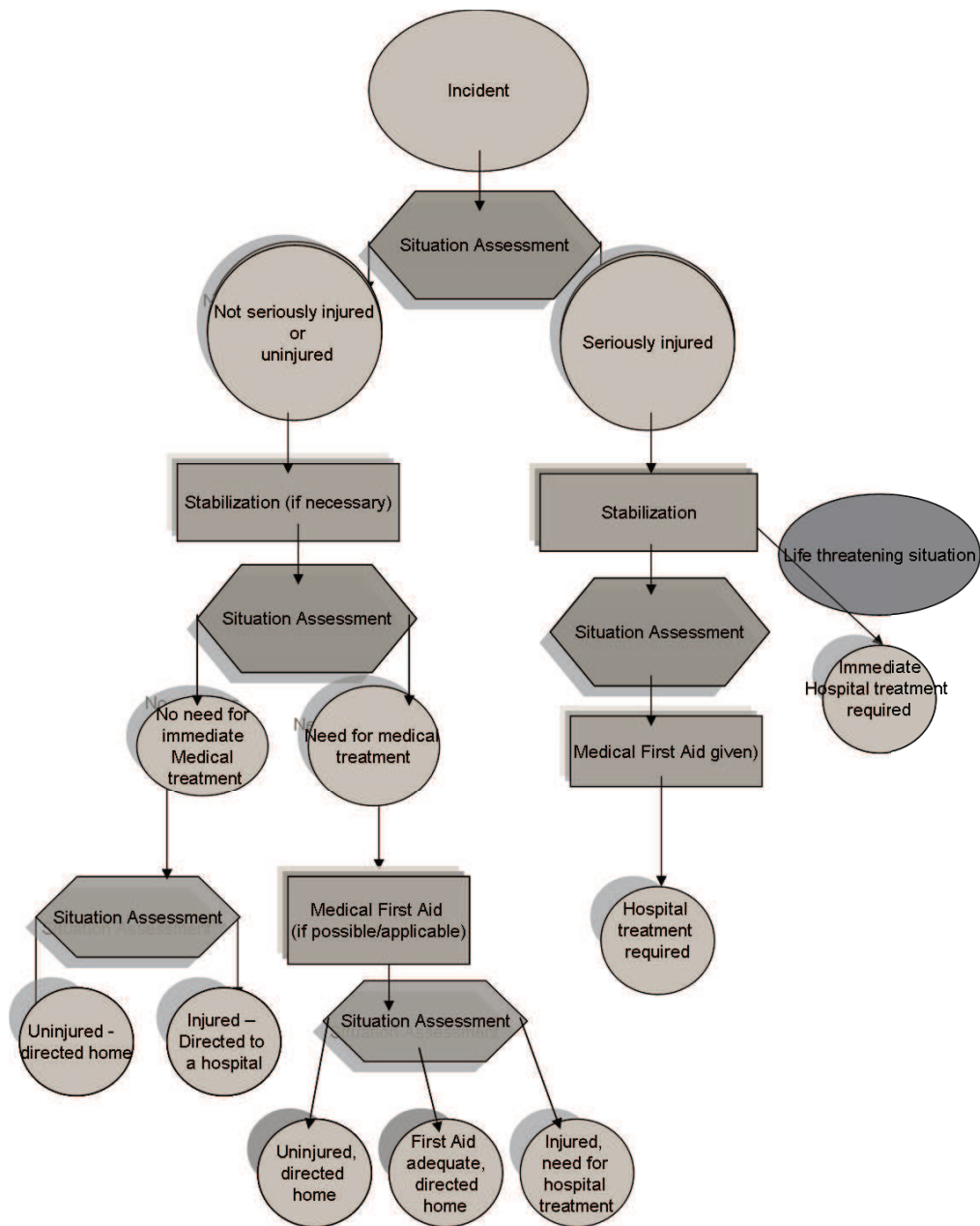
Figure 55: Emergency situation assessment process

As an example, this type of processing needed from the medical care personnel, and in order for them to succeed in the steps, the medical personnel need to have the adequate level of awareness to make right decisions on how to proceed. Especially in the situation assessment stages from the individual level activity perspective, the PSAS process can be used as a tool to process what information is available; how to monitor and predict the patient's condition and to decide the treatment based on that information. The PSAS supports also in the selection of the methods and taking into account all the relevant participants that may need to be informed or who can help in the process. Like in the truck accident scene, from the health care perspective, it is vital to know the medical history of the patients, allergies to medication, diseases, things that can affect the patients' medical care. But also it is important to realize that by focusing on one particular patient, there might be possible challenges in creating the needed level of awareness to support higher decision making level in understanding the overall picture. This type of information can be seen from different perspectives. For example as information resources and viewed them from a technological perspective: How this type of information can be provided to the medical care team as accurately and as timely as possible. On the other hand, it can be viewed from an individual perspective: how the medical personnel evaluate the situation and patient's condition according to the medical training and information gained from the situation. In this view, the PSAS can be used to assess the situation and all the possible influential factors related to the patient's condition. From the organizational view, it can be seen as procedural question: how organization can improve the conditions so that the actions done in the crisis are supported with the best possible working practices and mechanisms available.

From the organizational level, it is important to understand the collaboration demands related to SA. All the individual SA levels have an impact to the team SA level, and for example personal history, stress tolerance, previous experience and training, all these elements affect the team and its way of working. The assessment of the individual capabilities can be done previously by the organization according to the individual's strengths and weaknesses. With the support of the conceptual model, it is possible to identify all the individual elements in order to evaluate, how to support the individuals in their performance in crisis

situations. It is vital for all the team members to understand the value of their individual contribution to the team SA requirements. These types of collaboration scenarios are good ways of looking at possible interfaces and better collaboration ways to work. Different individuals in different roles in medical care can benefit from the conceptual model in reflecting their own behavior and working habits in crisis situations.

The conceptual model should be implemented in common routine activities, so that it would be more fluent in case of an emergency. The check list provides also a good tool for analyzing, whether there are issues that need to be looked into in more detail. Scenario based exercises give a good ground for each organization to check the individual and also organizational level preparedness to react in crisis situations. As demonstrated in the scenario, there are several changing variables affecting the actor's behavior, and it is valuable to observe objectively, how this type of collaboration is executed. If the individuals face problems in information sharing, it is possible to search further and find out what are influencing and causing the problem; whether the changes can be supported with tool development, or with different types of working practices or with more training.

Figure 56 presents a guideline example of the treatment of trauma patient that gives concrete support on how to act related to the source of bleeding regarding intervention and further assessment. (For the entire guideline, see Rossaint et al. Critical Care 2010, 19.) In the individual level, the PSAS can be used to identify the specific decision making steps and to support the individuals in the collaboration situation.

As seen from Figure 56, different occupation, as in health care, have specific processes and guidelines. These have been developed and standardized for a long period of time, evolving year after year based on best practices created, as in this case of bleeding trauma patient treatment. The conceptual model is created to support individuals performing these occupation specific processes, with a general support that can be implemented regardless of the occupation to support the collaboration and gaining needed level of awareness for better decision making. The benefit of the conceptual model is that it is not context or role depended, it is scalable for different roles in different environments. In the truck accident scenario the medical care personnel, by following their own processes of handling trauma patients, are facing a challenging task.
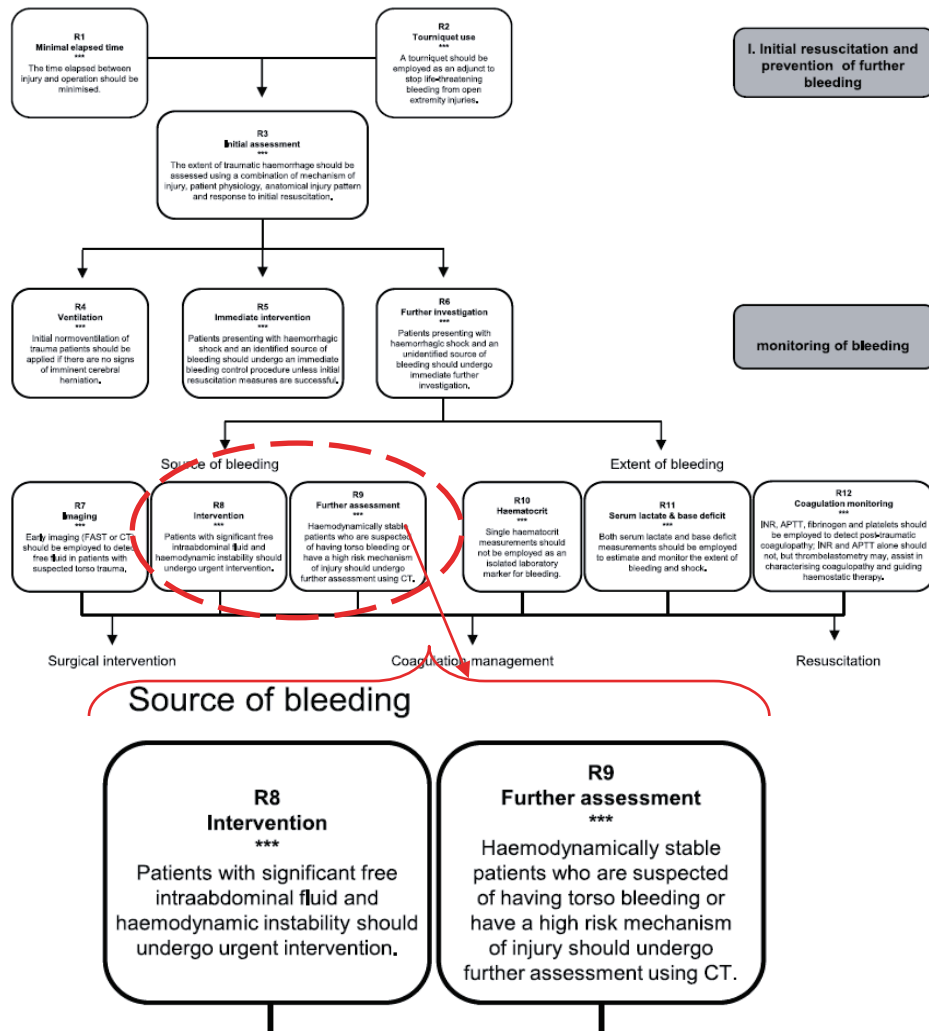
Figure 56: An example of treatment modalities for the bleeding trauma patient

They need to collaborate with several other authorities and create awareness in time-critical situation. With the support of the conceptual model, it is possible to support the medical care personnel in the situation assessment process, and gaining needed level of awareness to provide the best possible medical care for the injured patients. It needs to be also noted that that these context depended best practices can have down sides,

since the incidents occur often and options are limited.

This may result in usage of learned routines used in new situations, where the end result might be different since the situation is different. The benefit and addition to already existing practices, whether they are maritime or health care related, is that conceptual model is scalable and it can be used in all decision making levels with different roles of responsibilities as a supporting guidance on gaining the needed awareness in particular crisis situations – hopefully giving enough power to question the obvious and seeing every situation with fresh eyes.

One important aspect needed to be highlighted again, when analyzing and understanding the practices, is the time criticality, as demonstrated earlier in Figure 51. Figure 57 demonstrates different environments and incidents, giving general view of the time scale. In the trauma center, saving lives can depend on seconds and minutes, while in the maritime surveillance the time scale is more related from minutes to hours. When dealing with an environment catastrophe, such as a tsunami after action, it is an operation that requires days to weeks of time.

Time scale in different environments and incidents
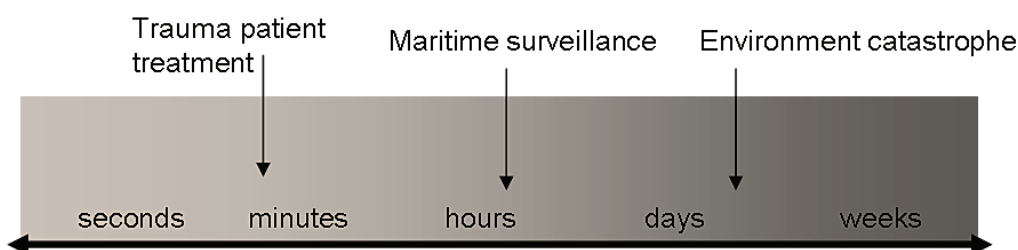
Figure 57: Time scale in different environments and incidents

To validate the differences and similarities between the different working environments, the findings were presented to the representative of Helsinki University Hospital (HUS) trauma center, medical specialist, Dr. Lauri Handolin. As a general difference can be noted, that in the health care world the crisis situation cases are limited (disease and trauma

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patients), but they occur in an intensive phase. In the maritime environment the incidents occur with lower intensity, but the cases are more unpredictable, compared to the health care. This raises a question of what is the influence of practicing certain "normal crisis cases"? Does it give the wanted ability to react in actual crisis situations, or does it actually hinder the individual's decision making, by blurring their ability to see the incident as unique as it is? Since there is no ultimate answer to this, the conceptual model provides its aid, also in this case because of its scalability, and not being context depended. These types of questions were raised in the expert interview that provided unique opportunity to reflect the findings from the maritime case studies to the trauma center world.

Key findings and aspects from this research were sent to Dr. Handolin in forehand. Research background and aim of the dissertation were explained in the beginning of the interview. The goal was to discover, whether traumatology and trauma center activities are faced with same type of elements, that need to be taken into account, when trying to collaborate in time critical situation, compared to the maritime surveillance environment. Dr. Handolin described in the beginning of the interview the biggest challenge, non-rational behavior, when processes are not followed. This is why the importance of training and preparedness is highlighted: It is in everyone's benefit to know how one acts in time critical situations, under pressure. Team leading is challenging and important capability is clear communication. SOP reflects the agreed way of working and Dr. Handolin explained that there are not so many different scenarios; typical injuries are the same, but the difficulty levels of different trauma types vary. This concurs with characterization done before the interview: Incidents are rare in the maritime environment, but the scale of possible scenarios is wide, while in the traumatology, the scenarios are much narrower, but the variations in the difficulty levels are different (see for example Briere & Scott, 2006).

One important issue highlighted in the beginning of the interview was the abilities of the trauma team. What individuals inside the team are able to do? This type of capability evaluation is not used automatically in the maritime environment. In traumatology the reason for this type of quality and ability check is obvious - if the true abilities are not known, it is a potential risk to patient safety. In traumatology routine check lists have

been created to make sure all the participants in a team are aware of the status of the situation. Trauma center uses ABCDE-working process principle that as simplified, directs the treatment from the deadliest part first (see for example Oakley et al., 2001). ABCDE principle to critical patient treatment means checking first Airway, then Breathing, Circulation, Disability (neurological) and Exposure (Carley & Driscoll, 2001). This type of routine checking is not common in the maritime environment. The basic communication testing check-ups were done in the beginning of collaboration in case studies, but it was not automated to be done continuously during the collaboration session. The work model in trauma center seems to be more interactive, where the team leader keeps asking of the basic ABCDE-principles in the operation room. This is an important aspect: by engaging all the actors focusing on their particular tasks at times to focus on the "big picture," can help the participants in being more aware of the entire situation. The check list is justified with the control aspect, and forcing to take a look at the broader picture. The communication inside the team is face to face, so called focused communication, where the team leader asks a specific person by name of the patient's situation. Different levels of team work, important SA-levels and decision making points are discovered especially between patient transfers. Within these transfers, it is important that the needed SA is gained (see for example Flowerdew et al., 2012).

In traumatology the interaction between teams is crucial; how to gain and maintain needed awareness of the patient's condition, when the patient is handed over to different team in the process. If there are not standardized way to transmit and forward the information, it is impossible to get the needed SA (see for example FitzGerald et al., 2012). This is why in the trauma center, the goal has been to train also other relevant participants, such as the ambulance staff and emergency medicine units) to inform the hospital with a standardized form, and when the patient is handed over with a structured report to get the necessary information. In the maritime environment information classification related to VOIs and COIs are used, while in the medical environment, a MIST model is used, where the letters stands for M – Mechanism of injury/illness, I – Injuries (sustained or suspected), S – Signs, including observations and monitoring, T – Treatment given (see more for example Talbot & Bleetman, 2007). As confirmed by Dr. Handolin and literature (see

Bleetman et al., 2012), the needed support for teams are

- briefings and debriefings,
- checklists,
- effective question types,
- assertion techniques
- closed-loop communication,
- standardized handover and
- red flags to indicate loss of situation awareness.

These elements are equally important and valid support in the maritime collaboration as well. In fact, based on the interview, the impression got stronger, that military functions such as maritime security operations and traumatology activities should interact and learn from each other's protocols and processes. Since the environments have similar basic structures, and as demonstrated in this dissertation, the individuals in their activities, whether they are involved in trauma or maritime context, are facing the same type of basic challenges that need to be tackled in order to support gaining of situational awareness.

Dr. Handolin described situations where decision points can be clearly identified. Different scenarios can be built of single patient, multi-patient and catastrophe situations. Single patient requires the same basic team structure with a leading doctor, and situational awareness is critical inside the team, when deciding and acting according to the treatment process. Multi-patient situation requires several teams parallel. Parallel activities require consultation of the order of medical imaging (for example X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI)) and surgery. Making right decisions require situational awareness of the patients' conditions, resources and capabilities to make operational level decisions. Less than 8 patients are prioritized by the responsible doctor by requiring situational awareness from the team leaders based on the ABCDE-assessment. This type of situation highlights the importance of standardized ways presenting crucial information – both orally and in writing. In a multi-patient situation, also the communication between trauma teams becomes important. In case of a catastrophe situation, a readiness leader, triage doctor is assigned to make treatment decisions, and to control the resources. This type of activity requires certain type of

character and mental pressure is larger in traumatology, especially in certain cases, when the patient is for example a child or the patient is carrying a disease, possibly dangerous to the medical personnel, causing more strict safety protocols.

When discussing about the possible downsides of training, from Dr. Handolin's perspective, routine activities are more challenging, when individuals start skipping procedures and stop objectively evaluating possible risks, relying too much on personal experience. This is why training in the trauma center is made to break the routines and to support reacting in emergent situations. Also, language skills, impact of professional slang and usage of abbreviations affect the collaboration, not only between different nationalities but also between Finnish professionals. This is why it is important to make sure that generally accepted formats are used, for example when ordering an ambulance.

Once interesting point of situational awareness was raised by Dr. Handolin explaining, how in time critical situations the decision maker needs to ask a specific question or questions. Because of the time limit, not everything can be reported, and this is why it is important to be able to ask focused questions. This requires certain level of awareness of the decision maker to be able to ask specific questions, and it gives huge responsibility for the person providing the answers, according to one's own level of awareness. This type of intensive interaction should be provided with reliable tools, to get the needed confirmation.

Inside the team, an active engagement is required in order for the team members to have some level of knowledge of the overall situation. For this purpose, the team leader uses focused discussion by activating different team members with questions related to their situation awareness. This type of communication inside Maritime Operation Centers (MOCs) should be also considered, so that the leader (Watch Captain, officer) can be aware of the level of SA the team members possess. If the team leader does not have the overall picture, it is not possible to make fact based decisions with pieces of information. The decision making gets complicated in multi-layer decision making levels. There are situations, when decisions need to be made, even with partial information. This requires the ability to change plans, when receiving new information supporting decision making. This type of action required personal ability to tolerate uncertainty and to be able to follow the

process, such as the OODA-loop, to continuously analyze the decisions and the consequences of the decisions. In traumatology the psychological elements are much stronger than in the maritime surveillance environment, since in the medical care the human interaction is closely related directly with the patients.

One example of the critical steps related to decision making, is the handover of the patient (see for example Farhan, Brown, Woloshynowych, & Vincent, 2012). If the doctor, receiving the patient, and making decisions of the treatment, does not question the previous decisions and facts related to patient's treatment history, it can cause mistreatment. This type of handover requires the ability to question the received information and to test hypotheses. This same aspect applies also in the maritime environment, when reflecting to the case studies, there were challenges in objectively handling the received information. Filtering and reporting is vital. Every possible information should be reported, but in a time critical situation the ability to filter the crucial information is important. This arrangement raises the question, who should do the filtering, the sender or the receiver of the information, since there are individual level differences in information sharing. Some individuals prefer giving raw data and some prefer analyzed information.

Structured formats of information sharing are supporting at least partially, and in the trauma center, the focus is on continuously improving of working processes according to the analysis of the patient treatment results. This type of open atmosphere and experience changing forum should be considered also in the maritime environment.

When discussing about tools, everything from pen and paper to electrical systems are used, depending on the situation. As a conclusion of the expert interview, all the elements found from the maritime environment, presented in Figure 38, were also relevant in traumatology according to Dr. Handolin. Individual skills (including stress tolerance, experience level), language skills as an important aspect of communication and effective team work were especially highlighted in the interview. Standard Operating Procedures that are the core of activities were also emphasized in the interview. In order for the team members to perform in the best possible way, the willingness to share information was also seen as an important enabler, when the confidence and trust among team members are supported by the working

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environment.

As reflecting to the interview, when comparing maritime surveillance and traumatology, these three main discoveries were made:

1. The same influences of time criticality and emergent situations can be identified from both of the environments. There can be mild emphasis differences, but both environments have the same elements that are affecting gaining of situational awareness and decision making, those elements were presented in Figure 38.

2. Psychological aspects and the importance of individual personal abilities, such as stress tolerance and expertise levels, are much higher in the health care. The influence and consequences of team work is much more sensitive when there is human lives concretely in question. This should be understood also in the maritime community, that education background and education requirements should be considered and individual abilities tested, to apply in crisis situation activities. The teams in traumatology are more homogeneous, based on the similar training and education background, comparing to the maritime surveillance environment, were the education background and skill levels can vary.

3. Recognition of critical decision making points. There are several levels but there are also similarities in the phases. In traumatology there were three different action levels (single patient, multi-patient and catastrophe) where decision making levels were different. There are similarities found to maritime surveillance decision making levels, at least the challenges are similar. This concurs with the need to support gaining of situational awareness and decision making. Even though action levels might have differences but as the concept is designed to be scalable, it does not have to have exactly similar decision making levels. The most relevant questions is, what are the elements affecting those decision making stages, as reflecting the overall goal of this dissertation. Based on the case studies and discovering elements also in the health care environment, there are similar elements that needs to be taken into account to support gaining needed level of awareness and decision making.

8 CONCLUSIONS AND DISCUSSIONS

8.1 Situational awareness concept

Information sharing in a multinational collaboration, in the maritime environment has been an interesting milieu. This has been amazing journey, which I will conclude to the situational awareness concept – the actual product that I have been building up during these pages. I am happy to present the conclusion and the final product of this journey.

As discovered during this journey, situational awareness is strongly task, role and context depended. The added value of SA measurement does not come from the standardized level that should be required in every circumstances, but the benefit from SA supporting methods and tools, is to support the organizations and individuals to succeed in gaining the adequate level needed in that particular time and case. It is up to the decision makers to determine, what the desired level of awareness is and support the organization to reach the goal of supporting it all the way from the individual training to implementing the changes also to the organizational structures.

Figure 58 concludes this learning process by introducing the main milestones where the most critical changes and/or impacts occurred referring to the Rational Design ideology. This journey started in April 2008, when I was introduced to the MNE 5 MSA community. The focus had been technical and after I joined the team with my personal interest to focus also to the individual level changes and issues affecting information sharing, we were able as the experimentation team to implement also qualitative measurements to collect this type of data. One good example of my influence was the research tool, STORS that I developed and introduced to the experimentation team. The experimentation preparations affected this dissertation since I started to visualize what type of research would be interesting to conduct.

From the MNE5 experimentation data I was able to further develop the created PSP model and to refine my research questions related to this dissertation. With the lessons learned from the MNE5 MSA experience, I had the opportunity to bring the knowledge to the MNE6 MISA-EM team so that we would not face the same challenges we faced in MNE5 MSA

experimentation. Two important aspects are; 1) the importance of planning and design documentation, the awareness of the entire team of the research goals and what we were trying to achieve together as a team, 2) defining of a theoretical framework to create a common language and understanding of the research area and goal.

I had the honor of introducing the situational awareness model and theoretical framework to the concept developers and experiment planners to support the common goal. This presentation also influenced this dissertation since my personal interest related to SA aspects also increased. Data from the MNE6 MISA-EM experimentation supported in continuing development of the PSAS and SA model.

After refining the model and after categorizing the findings from the case studies, I was able to compare the elements to health care world with a literature review and also by interviewing Dr. Handolin about the trauma world and possible similarities and differences of these different time critical environments. I also got the opportunity to participate in December 2011 in NATO CD&E course, where I got the inspiration to structure all the findings and contributions according to the NATO CD&E format, since the structure seemed to support the goal of this dissertation.

As demonstrated in Figure 58, this learning experience had several decision points, where my choices and decisions affected the path that lead to this end result. Looking back and asking myself, if I was given the opportunity to go back in time and change something, what I would change. My honest response is that I would not change a thing, since it was a learning experience, where the used methods and theoretical understanding increased every step of the way. I am pleased that I was able to continue with the MNE-series and to transfer the knowledge I had gained, also to MNE7, and hopefully to future experiments as well. What I hope that the overall lessons learned about the support of theoretical thinking and framework would be standardized and formalized as a procedure in the future, so that all the multinational experimentation teams would have the benefits enabled by theoretical aspects.

Moving back to the main contribution, situational awareness concept, SA is also time depended and it is important to realize, there are time critical situations, demanding fast decisions even though the level of awareness may not be the best possible. This is why it is vital to try to support individuals working in time critical situations, to gain the best
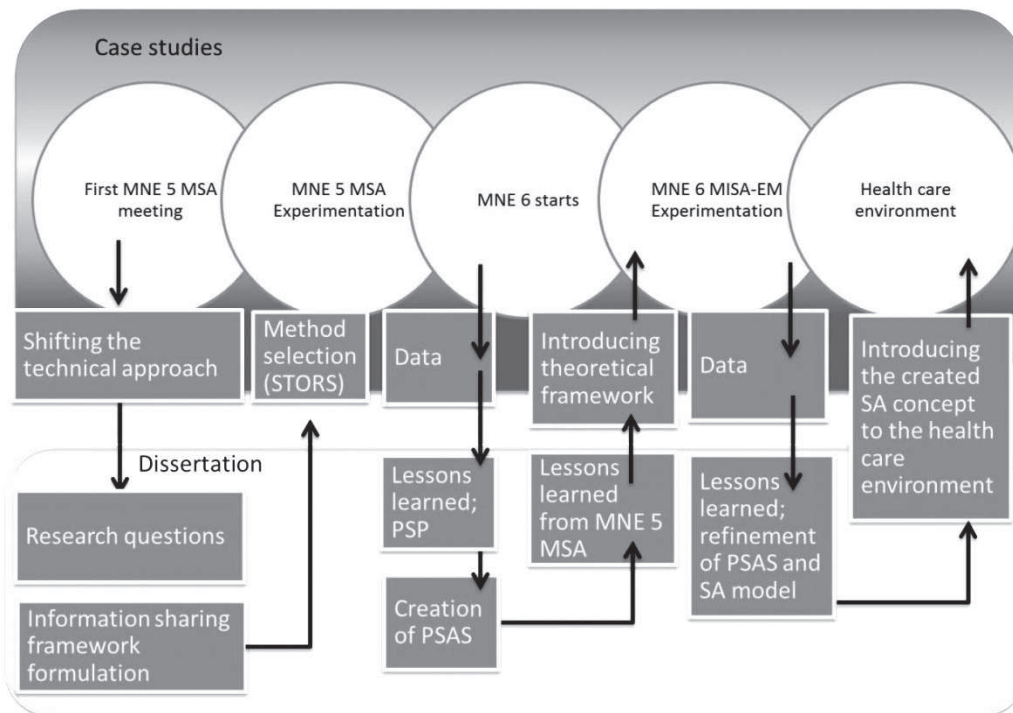
Figure 58: Critical milestones of the entire learning process

possible end result in the challenging task. How the support can be done, is summarized next with the concept description.

8.2 Analysis of the strategic environment

Actors in the maritime environment face a lot of challenges that are among others the intensity of traffic, weather conditions and geographical restrictions. Unlike air traffic, traffic at sea is not controlled in the similar way that would allow us to be aware and control all the actors and actions related to maritime activities. Different maritime organizations in addition to military, such as coast guard, customs and port authorities are trying to secure everyone's safety in this multidimensional maritime environment. Surveillance is done in cooperation within national agencies. The need for collaboration from our national perspective is indisputable: The sea line is

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crucial to Finland's trade; major part of the foreign trade is transported via sea. This is why the awareness of the situations is important because the maritime environment is so wide and dynamic.

Operators in the Maritime Operations Centers, (MOCs), are trying to gain adequate level of awareness of the activities at the sea in the area of their responsibility. Many nations, including Finland, do surveillance around their local areas, but cooperation among nations is becoming more and more relevant. Common threats, such as security risks like terrorist attacks, illegal immigration in addition to drug and human trafficking are questions that concern many nations, not to mention the economic interests and environmental aspects that are valuable to nations. As a result of this, it is a common interest to secure our waters. This task in the demanding environment requires new, major investments for the nations involved. Collaboration is one of the key elements in achieving the goal of tackling the problems caused by the uncontrolled, increased traffic. Multinational collaboration is a good way to tackle this challenging task with a collective effort. Collaboration in a multinational environment also causes other challenges and it is important to overcome them in order to succeed in collaboration that requires situational awareness for decision making and information sharing.

8.3 Identifying capability needs

Based on the strategic environment, it is possible to identify the scope of the concept and certain areas that need more studying. Since the multinational environment requires collaboration, it is critical to identify what is needed in order to support collaboration. It is critically important to address the needs from different levels in the respect to organizational, technical and social factors that can be broken into capability needs as follows:

- Appropriate structures and processes need to be identified to ensure successful information sharing in a multinational collaboration. All the possible capabilities to support different organizational levels need to be identified and implemented to support the attempt to gain adequate level of situational

awareness in order to make decisions based on correct information.

- Individuals in teams need to be supported with clear processes to support the information sharing. Individual factors need to be taken into account since the time critical situations are also affect by individual's abilities to react in emergent situations.
- Technological capabilities need to be developed to support gaining situational awareness in collaboration throughout and beyond all the organizational levels.

8.4 Development of capability requirements

Since previously identified capability needs were addressed in three different levels, next the capability requirements are described: Multinational collaboration and information sharing in a complex and dynamic maritime environment require individuals with adequate level of situational awareness to perform their tasks with certain information sharing tools and processes. With the identified capability needs, it is safe to proceed forward to developing capability requirements. Figure 59 demonstrates the capability requirements derived from the identified capability needs in the current state.

8.5 Conducting gap-analysis and fulfillment

Gap-analysis is an important step to reflect the current situation and found challenges. This step allows identifying the main gaps that can be assessed and proposed a solution for. In this part it is possible to reflect whether the proposed solution fulfills the gap that has been identified in capability needs and formed to a capability requirement. Figure 60 presents the identified gaps derived from all the three perspectives carried out through this dissertation: processes and structures, social aspects and technological aspects.
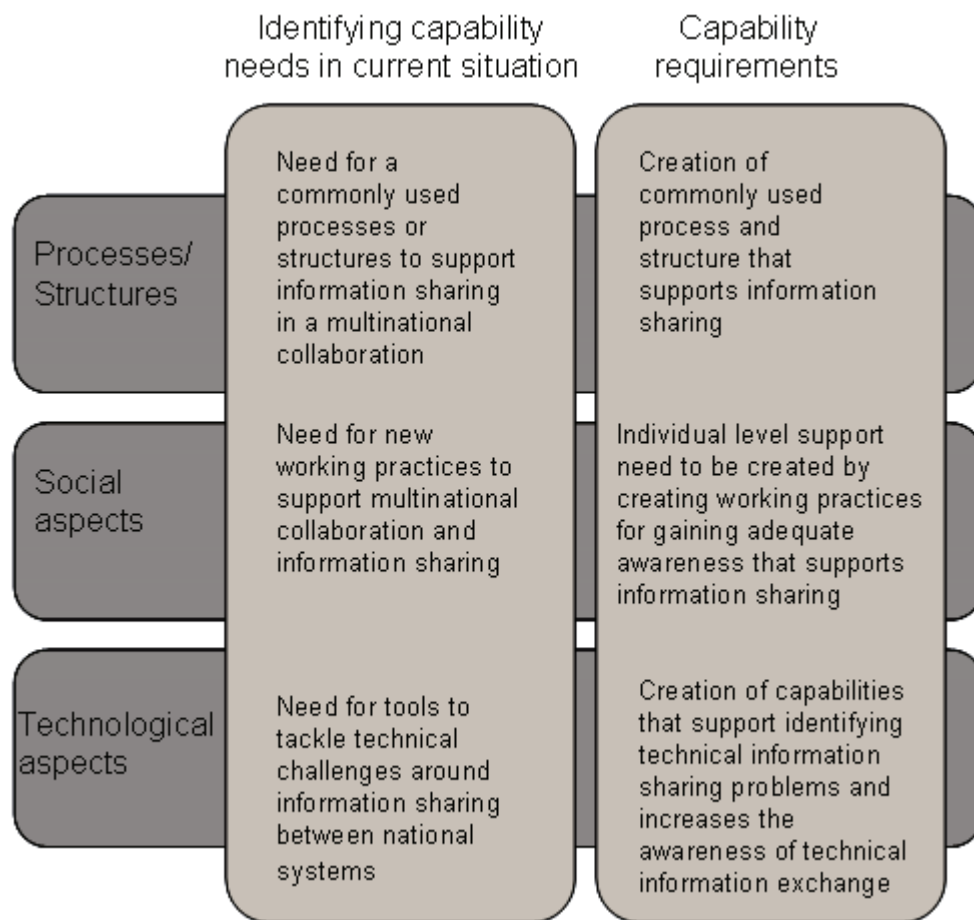
Figure 59: Identified capability needs and derived capability requirements
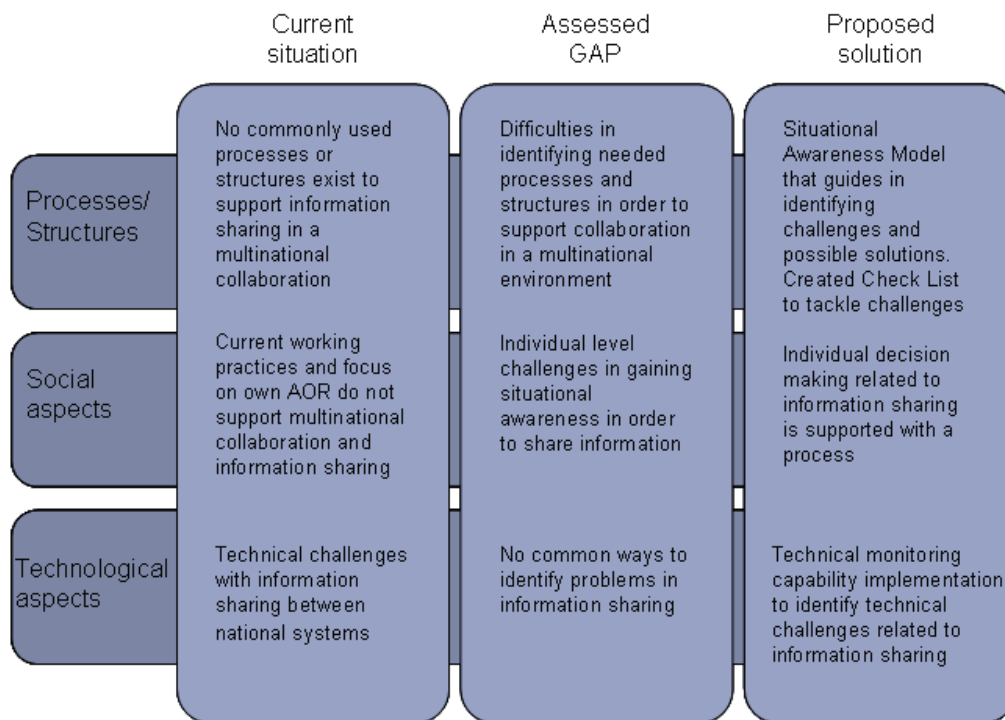
Figure 60: Gap-analysis and solution proposal

8.6 Identifying selected solutions

The aim of the concept is to take the capability requirements and turn them into usable capabilities. The previous chapters were dedicated to introduce the development of these capabilities in more detail.

Three main capabilities were created in this overall process, and conceptual model is a combination that tries to take into account the individual and organizational level needs in information sharing framework when the mission is to gain the adequate level of SA in order to perform and make fact based decisions – without forgetting the technological aspect of the collaboration.

The selected solutions were at least partially experimented in the described case studies, or the creation and modification for example of the

PSAS process was impacted of the promising experimentation results. It was obvious that operators needed a process to follow in order to logically proceed with the given tasks. These observation were the main inspiration to further develop a model that can be used as an integrated part of other process and tool training related to the case studies that provided evidence on whether the hypotheses of possible challenges do exist and also whether the developed capability requirements truly are able to at least some part bridge that gap.

8.7 Organizational level support: SA model and checklist

Organizational level support is provided with the conceptual model and guidelines. The idea of the conceptual model and guidelines is to give an overall impression of the state of the organization being monitored with this method.

The model captures the essence of Endsley's model, and combines all the elements and levels together. It is possible to observe the reality from the individual's perspective and understand that individual factors affect the individual SA levels. When the individual is a member of a team, one's individual factors become an asset of the team. The individual needs to be aware of the team SA requirements and understand the devices, mechanisms and processes that are related to the team's activities. With them one can form individual view of the team member SA requirements and understand what is needed in order to act and perform as a team towards the general goal. This can also be viewed from the organizational perspective; how to build up teams that are able to fulfill the needed SA requirements as a team with the right rules, roles and tools? And eventually, which individuals are most capable to perform as member of a team in these build conditions. Of course also from the technological aspect it is possible to view, what are the capabilities needed to be build up in order for a team to perform efficiently.

The organizational decision making level is supported with a conceptual model that presents all the elements from the individual's perspective that affect the SA and from that also the information sharing and performance. Organization is also supported with guidelines and a

check list to provide a wide range view from individual factors all the way to the technological issues and processes.

8.8 Individual level support: Process of Situational Awareness Support (PSAS)

PSAS supports the operator continuing one's thinking process even though operator may face a lot of interference and distractions. This type of process is needed since individuals face a lot of challenges in information sharing when acting in a multinational cooperation. Even basic information sharing within a team can be interfered with too much information. With this type of tool the operators are more confident in their work and are able to structuralize their actions. By supporting the team members with a process like PSAS, teams are supported in taking relevant information requirements into account and achieve better team SA and SSA, which will decrease the risk of possible errors in information sharing and decision making.

8.9 Technical level support: Usability monitoring

The technological level is also taken into account, even though it has been acknowledged that technology should be seen as an enabler, not always the solution. Still technology has become more and more integrated to the line of work. The monitoring-tool is developed to get the maximum performance of the technological tools that are being used as the moderators for information sharing. The monitoring ideology revisits and presents elements that can hinder or support information sharing from the technological perspective.

8.10 Eye on the future – the next steps

This journey with the maritime surveillance community has been very eye opening and provided a lot of vital information that enabled the

development of the conceptual model and situational awareness concept. Both – MNE5 and MNE6 – case studies gave crucial information about activities related to collaboration in a maritime environment. The case studies were conducted with different study interests, by different experimentation teams, different nations participating. By seeing similarities in these different case studies, gave me the confidence, that following pre-defined data collection and analysis plans, with introduced research methods used, I was able to gain reliable data from the case studies to work with the framework presented in this dissertation. If there were possibility for error/inaccuracy margin related to case study data, it has been reduced by comparing the findings to both of the case studies quantitative and qualitative data, to make sure that observations and findings can be creditably explained and quantitative data correlates with qualitative data. Inside each case study, each MOC were separately observed and also these findings were discussed and verified in order to fully understand the collaboration between teams. Also, to minimize the error margin and false interpretations, the trauma center examination adds the credibility of the findings, since all the main elements discovered in the maritime environment where also identified in the health care environment.

This gave a good and solid foundation for the concept creation, since I can be sure that the different case studies and environments have similar challenges that need to be tackled, in order to support organizations in time critical situations. The findings encouraged to proceed with the development of the conceptual model's versatile usage in different environments. This guides to more structured way to support multinational collaboration in the maritime environment, and I hope that this dissertation inspires authorities from different fields to take benefits from the presented concept and to utilize it in different organizations and environments.

Situational awareness is like the building block of information sharing in the multinational collaboration environment. By successfully identifying possible challenges related to these activities, we are on our way of supporting the core of the activities of the organizational structure – the individuals. Next, also a challenging task, providing tools and ways to tackle the challenges has been the main objective of this dissertation: To provide examples of possible solutions that may improve the level of

awareness, and by that also enhance information sharing in collaboration from the identified social, technical and organizational perspectives.

These perspectives guide us to remember always, that simply by developing something technical does not automatically mean that it supports the actual work done by the individuals. The information sharing framework is a combination of all of these elements that together can provide a good guideline to follow in the attempt to support multinational collaboration.

Time criticality and unexpected events cause challenges to any type of collaboration, whether the collaboration is between national organizations or if it involves multinational actors. Since organizations and their ways of working towards the same end result vary, the SA concept can be a discussion opener for further development of inner preparedness in organizations, but also to collaborate and understand other organizations restrictions and possibilities for future collaboration. Even though nations are putting effort to organize collaboration between authorities, the work is not done: Possible challenges and possibilities can be identified within the organizational context. This dissertation provides a good starting point and possibility for the organizations to implement the proposed solutions in their collaboration structures, to support the main goal: improvement of the level of situational awareness and as a desirable outcome, also to improve the circumstances for better decision making.

When comparing with the trauma world and thinking of possible lessons learned, training is needed in trauma centers to prepare individuals to react in emergent situations and to support decision making in time critical incidents. This type of training and preparedness should also be implemented to other crisis organizations as well, to support all the different levels of decision making in understanding all the necessary elements that are affecting the performance in crisis situations. When I look back at the maritime surveillance community and compare the demands and resources, I am able to identify three major concerns that I feel are important to highlight as a conclusion of this journey:

First, MNE series have provided a good platform to do this type of preparations, to understand what should be improved and what are the possible tools to support that. In the maritime surveillance community, it would be beneficial to create similar standards of training and profession requirements for the personnel operating in MOCs as in the trauma

centers in the health care environment. Especially to deselect persons who are not able work under mental pressure in crisis situations. Based on the experimentation findings, national sea surveillance should be developed more towards collaborative and proactive work. This requires creation of standard procedures of the complex activities in crisis situations, training and mandate from the higher HQ. Technology surrounding current maritime surveillance support widely collaboration in technical level. Now it is time to raise operating procedures and organizational culture to the same level, in order to further develop the maritime surveillance community.

Worst case scenarios and preparedness require certain mental skills that should be tested and trained to support acting in crisis situations. The reality of maritime surveillance situation in Finland does not reflect the setting created in multinational experimentation where the role and appreciation of the surveillance and intelligence needs were raised higher. With that said, it requires similar standardizations as in the trauma context, where there are high standards and requirements for certain tasks and skillsets. The entire definition of roles and task division should be reconsidered and this dissertation hopefully supports the discussion and gives firm view what the situation is, and where we should set our goals if we want to be leaders in crisis prediction and prevention. To avoid the threads of complex catastrophes, we need to be prepared to put our effort in gaining adequate capabilities for the needed preparedness and prevention skills. MNE community and research made related to this environment has provided critical information and lessons learned that I hope will be used in the future to develop our national defense strategies and to enhance our collaboration with our partner organizations and nations. Change requires raising the value and importance of the surveillance function and creation of standard requirements for personnel and their continuous training.

Second, technology should not be handled and observed as a separate from the surrounding context. Crisis management in time critical situations require both human and technical capabilities and lessons learned from the experimentations provide good insights to further develop the surveillance community – not only from the technological perspective – which leads to second important view to take from this dissertation: **the recognition of technology as a supporting function,**

not as value per se. Technological capabilities are not directly answers to any functional challenges, and this is why the recognition of the problem field should be expanded beyond traditional technological aspect. This dissertation proves that with technological solutions it is possible to support for example multinational collaboration, but it requires identifying the boundaries of technology and accepting its limitations and restrictions. Technological solutions should answer a particular identified gap and to be adapted to the functional environment.

The created conceptual model reflecting multidisciplinary view is one step taken towards supporting organizations in tackling the challenges related to time critical situations. This is done by shifting the focus on the organizational framework combining all the strategic and functional level elements – not only from the technological perspective – but by identifying the elements supporting and hindering information sharing and gaining needed level of awareness, all the way from the individual level to the highest decision making levels.

Third, **there is no such thing as doing research "by the book" or "textbook research"**. In the beginning of this journey I tried to hold on to the basic principles of making science. Before being able to participate in the first experimentation, I had to face the fact that things change: scenarios were modified at the last minute, experimentation personnel changed we were not able to follow exactly the written and agreed plans. After recovering from the first shock, I realized that it is okay. Research plans and focus are made to support us as researchers getting the needed data, and the world we are exploring is not perfect, nor are we, the people, tools and ideas of the experimentation team. This is why I feel it is important for me to give the readers the retro perspective view of this journey and with the process description to demonstrate that if we tolerate insecurity and accept the changes in situations, we are able to use science and research methods as powerful development tools and to give the experimented context the added value that would have not been possible without the attempt to use scientific approach in development. I have always believed in saying/hypothesis "**best science is applied in practice**" in Finnish "*hyvä teoria toimii käytännössä*". With this journey I am more than happy to conclude being re-assured that my hypothesis is still valid.

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APPENDIXES

Appendix A NASA TLX (MNE5 MSA & MNE6 MISA-EM)

Appendix B AAR PRQ (MNE5 MSA)

Appendix C STORS (MNE5 MSA)

Appendix D Unstructured Interview (MNE5 MSA)

Appendix E SABARS (MNE6 MISA-EM)

Appendix F Unstructured interview (MNE6 MISA-EM)

Appendix G SAGAT (MNE6 MISA-EM)

NASA Task Load Index (TLX)

Team: _____	Date: _____
Scenario Number:_____	Player team position: _____

Directions

Please complete this quick survey regarding the workload you experienced during the scenario. Workload is split up among Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration Level. These six aspects of workload are defined on the sheet. Please note that all scales go continuously from Low to High *except* Performance, which goes from Good to Poor.   Please   place   a   mark   **anywhere**   along   the   scale.

Place a mark at the desired point on each scale:

MENTAL DEMAND

|Low | | | | | | | | | | | | | | | | | | | |High|

PHYSICAL DEMAND

|Low | | | | | | | | | | | | | | | | | | | |High|

TEMPORAL DEMAND

|Low | | | | | | | | | | | | | | | | | | | |High|

PERFORMANCE

|Low | | | | | | | | | | | | | | | | | | | |High|

EFFORT

|Low | | | | | | | | | | | | | | | | | | | |High|

FRUSTRATION LEVEL

|Low | | | | | | | | | | | | | | | | | | | |High|

Rating Definitions

Title	Descriptions
MENTAL DEMAND	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

2

APPENDIX B

Analyst Assessment Report Performance Rating Questionnaire (AAR PRQ)

Team: _____   Date: _____

Scenario Number: _____   Configuration: _____

Please rate how well the following statements describe the fused product.

1. The MOC TEAM backs up answers with facts/information.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

2. The MOC TEAM story contains flaws in logic or unsupported recommendations (NEGATIVELY WORDED).

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

3. The MOC TEAM considered the complexities and intricate relationships among underlying issues or problems.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

4. The MOC TEAM identified the gaps in existing information important for fully understanding the issue or problem.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

APPENDIX B

5. The MOC TEAM describes how they came to their conclusions.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

6. The MOC TEAM story contains inconsistencies (NEGATIVELY WORDED).

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

7. The MOC TEAM explains the limitations of the available facts and methods of collecting information.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

8. The MOC TEAM was able to report the basics of the story: who, what, when, where, and how.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

9. The MOC TEAM was able to communicate a logical flow of thoughts and ideas.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

10. The MOC TEAM makes an overall case using the important facts.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

APPENDIX B

11. The MOC TEAM clearly identifies the issues.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

12. The MOC TEAM clearly answers the questions.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

13. The MOC TEAM broke down the story into component parts to identify the underlying issues.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

14. The MOC TEAM thoroughly answers the questions.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

15. The MOC TEAM answers were both brief and complete.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

16. The dates of the events used in the explanation are relevant for the given timeframe.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

17. The MOC TEAM description of events was organized well; it has a logical flow.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

18. The MOC TEAM description of events is confusing and contains ambiguities (NEGATIVELY WORDED).

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

19. Please provide an overall rating of the MOC TEAM description of events.

Poor		Weak		Below Average	Above average		Good		Excellent
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

20. Rate the quality of the supporting facts.

1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

No evidence of supporting facts   Exceeds expectations

Additional comments about the MOC TEAM:

_____
_____
_____
_____
_____
_____
_____

APPENDIX C

STORS

Instructions: The following is a list of variables that may or may not have affected your ability to carry out your duties during the scenario. In the first column to the right, for each variable listed, assign a number from 1 to 5, where 1 is a very harmful, 5 is very helpful and 3 is neutral. In the second column, indicate with a + the top three variables you feel were most helpful and indicate with a - the bottom three variables you feel were least helpful.

1 = Very harmful
2 = Harmful
3 = Neither harmful, nor helpful
4 = Helpful
5 = Very helpful

VARIABLE	1 to 5	+ or -
rules for information exchange		
team roles/tasks		
access to command structure	N/A	N/A
access to technical system		
chain of command	N/A	N/A
empowerment		
business processes/SOP's		
familiarity with system		
intel		
leadership		
track history		
database access		
chat		
email		

APPENDIX C

voice		
anomaly detection		
network performance		
map sharing	N/A	N/A
information from other MOC		
ability of system to filter out noise in data		
interaction with the system		
past operational training		
social interaction with co-workers within MOC		
social interaction with other MOC's		
cultural influences		
flexible database query		
language		
past operational experience		

APPENDIX D

INTERVIEW

MOC teams should be able to provide the following specific pieces of information related to the scenario model of maritime threat. This is a structured interview and the questions are based on the concept maps developed from the Data/Frame theory of Sensemaking. These maps were produced during previous experimentation and represent operator mental models of maritime threats. A representative Concept map is on page 2 of this Appendix. Analysts should know and use specific information from the scenario to guide questions.

PRIMARY ANCHORS:
- **Ports:** previous and future
- **Crew List:** too many crew for type of ship, known or suspected ties to bad people or organizations, nations typically have, NATO typically does not but receives on occasion
- **Vessel Type:** limits search and identifies capabilities
- **Flag:** identifies motive and opportunity (hostile or uncooperative nation)

ELABORATING CONCEPTS:
- **Detention List:** might indicate a vessel more willing to accept risk
- **Vessel Type:** additional details
- **Departure from expected path:** rendezvous, coastal hugger (avoiding interdiction), non-economic behavior, dead in water, collision course
- **Cargo Type:** opportunity

MITIGATING EVIDENCE (+/-):
- **Weather:** wind direction may increase risk, storm might explain course change
- **Intel events:** news stories, increased chatter
- **Normative behavior:** normal for type of ship (ferry, tug, pilot vessel, pleasure craft), not normal for type of ship, port area, etc…

APPENDIX D

INTERVIEW PROCEDURE:

- **Begin with the end:** Identify the operators' understanding of the scenario end state. Identify the earliest known position for each VOI and information based on the anchors, concepts, and evidence identified above. Maintain a non-sequential interview so that the interviewer is in control of the focus. People naturally want to tell stories and these stories will focus on the things that are important to them. However, what is important for an interview and what is important for a person telling a story typically are not the same. Story telling can result in loss of focus and should be avoided.

- **Key Events:** Identify key events occurring during course of the scenario story as operators understand them.

- **Decision Points**: Identify the relationship between the key events and decisions about the problem solving process and information sharing. How does the interpretation of event and VOI information affect decisions about inclusion/exclusion of vessels and information haring/collaboration?

APPENDIX E

SITUATION AWARENESS BEHAVIORALLY ANCHORED
RATING SCALE (SABARS)

You, as a <u>data collector</u>, are invited to participate in our survey SITUATION AWARENESS BEHAVIORAL ANCHORED RATING SCALE (SABARS). It will take approximately 2 minutes to complete the questionnaire.

The survey responses will be strictly confidential and data from this research will be reported only in the aggregate. The information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact xx at the EXCON desk or by email at xx@xx. This survey has been designed to capture how well the operators exhibited behaviours consistent with acquiring, processing and disseminating SA information during the experiment. It requires that you rate on a 1-5 scale (from POOR to EXCELLENT) the concepts that are presented to you.

It may be the case that the operator is not expected to show a specific behaviour due to his role (e.g. RMP manager). Rank POOR, regardless of the operators overall performance. (Operators performance is not being evaluated here)This questionnaire by itself, does not rate actual SA, rather it looks at actions that indicate a greater likelihood of good internal representations.

These actions can be an important indicator of SA mental processes. The information you provide within this survey can be used and shared for analytical purposes within MNE 6 (obj. 4.2) and for research purposes at the Operation Research Center of the Spanish NAVY. Please start with the survey now by clicking on the Continue button below.

Select your assigned MOC
1.   MOC 1
2.   MOC 2

What is your role within the MOC of the person you are evaluating? (If you are evaluating two, operators, remember to take this survey again)

1

APPENDIX E

1.   Watch Captain (WC)
2.   Assistant Watch Captain (AWC)
3.   DataBase Manager (DMAN)
4.   DataOperator (DO)
5.   RMP manager (RMP)

When are you taking this survey?

	MORNING SEGMENT	AFTERNOON SEGMENT
DAY 1 (20 APR)	❏	❏
DAY 2 (21 APR)	❏	❏
DAY 3 (22 APR)	❏	❏

Uses available assest (tools, maps, etc.) to effectivelly assess environment

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

Utilizes standard reporting procedures

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

Raises appropriate levels of alert

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

APPENDIX E

Assess information received

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

Gathers follow-up information when needed

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

Monitors MOC communications

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

Solicits information from IA partners

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

Solicits information from other MOC members

1.   Poor
2.   Below Average
3.   Average
4.   Good
5.   Excellent

APPENDIX E

Communicates key information to MOC Watch Captain

1. Poor
2. Below Average
3. Average
4. Good
5. Excellent
6. N/A

Asks for pertinent intelligent information

1. Poor
2. Below Average
3. Average
4. Good
5. Excellent

Assesses key findings and unusual events

1. Poor
2. Below Average
3. Average
4. Good
5. Excellent

Discerns key information from reports received

1. Poor
2. Below Average
3. Average
4. Good
5. Excellent

Uses sources and resources to gather needed information

1. Poor
2. Below Average
3. Average
4. Good
5. Excellent

APPENDIX E

Overall SA rating according to his knowledge of the situation

1. Poor
2. Below Average
3. Average
4. Good
5. Excellent

Overall performance rating according to his role

6. Poor
7. Below Average
8. Average
9. Good
10. Excellent

APPENDIX F

MOC OPERATORS UNSTRUCTURED INTERVIEW

1. OBJECTIVE

The objective of the unstructured interview is to capture ideas, opinions, subjective SA, people interactions, experience and information flow, in order to assess MOC's performance as a team.

2. PARTICIPANTS

Analyst supervisors of each MOC will interview Watch Captain and Assistant Watch Captain at the end of the experiment.

3. INTERVIEW GUIDELINES

Although no specific questionnaire is to be delivered, the following questions will help analysts conduct the interview:

SA processes. Information Flow.
How was the flow of information within the MOC?

Were there any specific instructions given by the WC and AWC to MOC members related to tasks and processes not contemplated in the SOPs?

Perceived Situation Awareness
What was the level of Perception?

What was the level of Comprehension?

What was the level of Projection?

What was the overall level of SA attained?

Brief summary of scenario and vignettes

1

APPENDIX F

<u>MOC performance</u>
What is the overall view of the MOC performance?

How can the performance be improved?

What were the major issues that affected the MOC performance?

<u>LOE design</u>
Was the scenario realistic?

How feasible is the transition of the concepts to real life? Was the experiment too artificial?

4. REPORTS
   Analyst supervisors will write a report with the interview results and their personal comments on the overall MOC performance. Their expertise is key to evaluate the extent to which subjective SA and players' perception match with the simulated scenario; and to investigate the reasons behind the taken actions and observed behaviors.

APPENDIX G

SAGAT PROBE QUESTIONS

NUMBER	QUESTION	DAY	QUERY
1	Which of these information requirements has been published by X?	1	1
8	What is the most likely time delay to get acknowledge of a message sent to Y?	1	1
13	What is the bandwidth of the network which gives you access to the internet?	1	1
16	Who is the point of contact at Z to ask for information?	1	1
29	What is the job of your point of contact (POC) as the Z representative?	1	1
35	How many tracks are transiting eastbound in the A?	1	1
37	Do I hold any track in the system that might be classified as COI or higher? Locate on the map	1	1
39	What is the flag of B?	1	1
67	Are there any major Naval Bases in the Area? Locate on the map	1	1
83	Are the weather conditions for navigation worsening?	1	1

2	Which of these information requirements has been published by Y?	1	2
14	Who is the point of contact at X to ask for information?	1	2
21	Who is the point of contact at Y to whom submit you RFI´s?	1	2
31	Which of these stakeholders may best support your current information requirements?	1	2
33	Which of these statements best describe the MOC required level of effort?	1	2
36	How many tracks are transiting the C?	1	2
43	Where is AZ heading to?	1	2
60	How long does a ship take to cross the A from D to E at an average speed?	1	2
65	According to the information you were able to gather, what would you say is the most frequent activity on the area?	1	2

APPENDIX G

26	What is the job of your point of contact (POC) in the X?	1	3
34	Which one of these is not a priority of the operational commander?	1	3
40	What is the destination port of F?	1	3
68	Locate on the map the most important fishing areas	1	3
69	Are there any navigation exclusion area? Locate on the map	1	3
74	What is the sea state in A?	1	3
82	Is the sea state increasing or decreasing?	1	3
88	Am I suffering, up to certain extent, data acquisition problems due to current weather conditions?	1	3
92	How many navigational warnings have been issued for the area in the last 24h?	1	3
136	According to the evidence you were able to gather what would be a possible future classification of vessel G?	1	3

41	What is the previous port of call of H	1	4
70	Are there any marine reserved area? Locate on the map	1	4
84	Will the weather conditions improve and favor navigation in the next 24h? (with some probability)	1	4
90	Is the local traffic scarce due to current weather conditions?	1	4
95	Select the available means of communications to contact X	1	4
101	What is the RFI published by X that needs to be addressed the soonest?	1	4
111	What is the most likely depth contour 50nm off I (eastbound)?	1	4
115	Would it be reasonable to assume that a trawler is conducting fishing activities 100nm off I (eastbound)?	1	4
130	What smart agent triggered the alarm on vessel J	1	4
133	What smart agent triggered the alarm on vessel K	1	4

APPENDIX G

7	What is the most likely time delay to get acknowledge of a message sent to X?	1	5
38	What is the vessel type of L?	1	5
61	How long does a ship take to cross the C from E to O at an average speed?	1	5
71	Are there any naval operation area? Locate on the map	1	5
81	Is the wind increasing or decreasing?	1	5
96	Select the available means of communications to contact HHQ	1	5
103	What is the RFI published by KK that needs to be addressed the soonest?	1	5
129	What smart agent triggered the alarm on vessel M	1	5
132	What smart agent triggered the alarm on vessel N	1	5
134	According to the evidence you were able to gather what would be a possible future classification of vessel P?	1	5

42	What will be the future position of Q in 24h time period?	1	6
59	How many ships in C are showing a speed too high according to normal standards?	1	6
66	Are there any major ship builder ports in the area?	1	6
72	Are there any firing zones for naval exercises on area? Locate on the map	1	6
107	What is the westbound traffic density in the A?	1	6
112	What is the most likely depth contour 100nm off I (eastbound)?	1	6
121	How many vessel name discrepancies have been pointed out by the BRITE Smart agents in the area?	1	6
125	What is the smart agent's tolerance with regard to wrong-course anomalies detection?	1	6
131	What smart agent triggered the alarm on vessel R	1	6
135	According to the evidence you were able to gather what would be a possible future classification of vessel L?	1	6

179	Locate on the map if possible, the vessel S	1	6
180	Locate on the map if possible, the vessel T	1	6
181	Locate on the map if possible, the vessel U	1	6
182	Locate on the map if possible, the vessel V	1	6
183	Locate on the map if possible, the vessel W	1	6
184	Locate on the map if possible, the vessel Å	1	6
185	Locate on the map if possible, the vessel Ä	1	6
186	Locate on the map if possible, the vessel AA	1	6
187	Locate on the map if possible, the vessel BB	1	6
188	Locate on the map if possible, the vessel FG	1	6
189	What is the speed of the vessels: S, V, W, Ä, SA CC, DD		
190	What is the destination of T, U?	1	6

3	Which of these information requirements has been published by Z?	2	1
9	What is the most likely time delay to get acknowledge of a message sent to Z?	2	1
22	Who is the point of contact at Z to whom submit you RFI´s?	2	1
23	Who is the point of contact at EE to whom submit you RFI´s?	2	1
27	What is the job of your point of contact (POC) in the EE?	2	1
49	What will be the future position of FF in 24h time period?	2	1
76	Is the current sea state favorable to small craft navigation?	2	1
114	What is the most likely depth contour 100nm off I (northbound)?	2	1
137	What smart agent triggered the alarm on vessel GG	2	1
155	How would you classify a contact that shows the following anomalies: AIS discrepancy, loitering at slow speed?	2	1
4	Which of these information requirements has been published by EE?	2	2
15	Who is the point of contact at Y to ask for information?	2	2

48	Where is HH heading to?	2	2
73	Are there any naval forces operating in the area? Locate on the map	2	2
79	Is the current wind force favorable to small craft navigation?	2	2
117	Are there any traffic separation schemes in the area? Locate on the map	2	2
122	How many X number discrepancies have been pointed out by the BRITE Smart agents in the area?	2	2
126	What is the smart agent's sensitivity level to trigger high-speed-vessel anomalies?	2	2
138	What smart agent triggered the alarm on vessel II	2	2
143	According to the evidence you were able to gather what would be a possible future classification of vessel JJ?	2	2

17	Who is the point of contact at EE to ask for information?	2	3
24	Who is the point of contact at Z to whom submit you RFI´s?	2	3
28	What is the job of your point of contact (POC) as the KK representative?		
47	What is the previous port of call of LL?	2	3
57	How many ships in C are showing a speed too slow according to normal standards?	2	3
93	How many navigational safety warnings have been issued for the area in the last 24h?	2	3
116	Would it be reasonable to assume that a trawler is conducting fishing activities 50nm off I (northbound)?	2	3
120	How many smart agents are available in the COP compilation tool?	2	3
139	What smart agent triggered the alarm on vessel "MM"	2	3
156	How would you classify a contact that shows the following anomalies: discrepancy on vessel name that changed course without a reason?	2	3

32	What is your information requirement that needs to be addressed the soonest?	2	4
46	What is the destination port of NN?	2	4
56	How many ships in A are showing a speed too slow according to normal standards?	2	4
64	Mark on the map the 5 most important choke points in the OO. (Sea lines of communications)	2	4
85	Will the weather conditions improve and favor navigation in the next 48h? (with some probability)	2	4
97	Select the available means of communications to contact KK	2	4
102	What is the RFI published by HHQ that needs to be addressed the soonest?	2	4
140	What smart agent triggered the alarm on vessel PP	2	4
157	How would you classify a contact that shows the following anomalies: speed too high, not following traffic?	2	4
166	How many tracks in A are possibly involved in illegal traffic?	2	4

10	What is the most likely time delay to get acknowledge of a message sent to HHQ?	2	5
45	What is the flag of QQ?	2	5
62	Which of the following would you choose as the average time delay shown by tracks in the area? (time passed since that last update)	2	5
91	Is the commercial traffic low due to current weather conditions?	2	5
98	Select the available means of communications to contact Z	2	5
118	Are there any specific recreational zones in the area? Locate on the Map	2	5
123	How many AIS discrepancies have been pointed out by the BRITE Smart agents in the area?	2	5
162	How many incidents at sea, regulations violations, etc have been reported in the last 72h?	2	5

164	How many tracks in the C have been previously related with suspicious activities?	2	5
170	Is there any developing terrorism situation in the area that might require intervention of naval forces? Locate on the map.	2	5

44	What type of vessel is RR?	2	6
63	Rank the following ports in descending order of importance (Importance as most frequently visited and tons handled per day)	2	6
86	Is there any worth-noting seasonal weather effect?	2	6
104	What is the RFI published by Z that needs to be addressed the soonest?	2	6
108	What is the eastbound traffic density in the A?	2	6
127	What is the smart agent's sensitivity level to trigger low-speed-vessel anomalies?	2	6
141	What smart agent triggered the alarm on vessel SS	2	6
142	What smart agent triggered the alarm on vessel TT	2	6
144	According to the evidence you were able to gather what would be a possible future classification of vessel LL?	2	6
173	Locate on the map if possible, the vessel UU	2	6
191	Locate on the map if possible, the vessel VV	2	6
192	Locate on the map if possible, the vessel WW	2	6
193	Locate on the map if possible, the vessel UU	2	6
194	Locate on the map if possible, the vessel XX	2	6
195	Locate on the map if possible, the vessel YY	2	6
196	Locate on the map if possible, the vessel ZZ	2	6
197	Locate on the map if possible, the vessel AA	2	6
199	What is the speed of the vessels: ÅÅ, L, ÄÄ, ÖÖ, UU	2	6
200	What is the destination of VV, XX, YY, ZZ?		

11	What is the most likely time delay to get acknowledge of a message sent to Z?	3	1
18	Who is the point of contact at Z to ask for information?	3	1
30	What is the job of your point of contact (POC) in the NGO?	3	1
50	What type of vessel is AAA?	3	1
77	What is the wind force in A?	3	1
105	What is the RFI published by NGO that needs to be addressed the soonest?	3	1
109	What is the north-eastbound traffic density in the C?	3	1
154	According to the evidence you were able to gather what would be a possible future classification of vessel BBB?	3	1
158	How would you classify a contact that shows the following anomalies: Shows no AIS and has a history of maritime pollution?	3	1
168	How many tracks in C are possibly involved in illegal traffic?	3	1
174	Locate on the map if possible, the vessel AAA	3	1

25	Who is the point of contact at NGO to whom submit you RFI´s?	3	2
51	What is the flag of CCC?	3	2
110	What is the south-westbound traffic density in the C?	3	2
119	What are the most likely type of vessels involved in local activities?	3	2
145	According to the evidence you were able to gather what would be a possible future classification of vessel "EVER ELITE"?	3	2
146	What smart agent triggered the alarm on vessel DDD	3	2
159	How would you classify a contact that shows the following anomalies: has been conducting activities on restricted areas?	3	2
167	How many tracks in C are possibly conducting terrorist or piracy activities?	3	2

172	Is there any illegal-trafficking situation under development in the area that might require further intervention of local forces? Locate on the map.	3	2
175	Locate on the map if possible, the vessel EEE	3	2

5	Which of these information requirements has been published by Z?	3	3
19	Who is the point of contact at NGO to ask for information?	3	3
52	What is the destination port of FFF?	3	3
58	How many ships in A are showing a speed too high according to normal standards?	3	3
89	Am I suffering, up to certain extent, data acquisition problems due to seasonal weather effect (if there is any)?	3	3
94	How many navigational security warnings have been issued for the area in the last 24h?	3	3
106	What is the RFI published by Y that needs to be addressed the soonest?	3	3
147	What smart agent triggered the alarm on vessel "EEE 1"	3	3
152	According to the evidence you were able to gather what would be a possible future classification of vessel GGG?	3	3
163	How many tracks in A have been previously related with suspicious activities?	3	3

6	Which of these information requirements has been published by NGO?	3	4
20	Who is the point of contact at X to whom submit you RFI´s?	3	4
53	What is the previous port of call of AAA?	3	4
80	Are there any low pressures crossing the area? Locate in the map the center of the atmospheric depression	3	4
99	Select the available means of communications to contact Y	3	4
128	What would you say is the smart agent's false-rate detection of anomalous behavior?	3	4

APPENDIX G

148	What smart agent triggered the alarm on vessel HHH	3	4
153	According to the evidence you were able to gather what would be a possible future classification of vessel III?	3	4
160	How would you classify a contact that shows the following anomalies: wrong AIS, wrong course according to destination and cargo inconsistency?	3	4
171	Is there any developing environmental-threatening situation in the area that might require further intervention? Locate on the map.	3	4

12	What is the most likely time delay to get acknowledge of a message sent to NGO?	3	5
54	Where is JJJ heading to?	3	5
78	What is the wind force in C?	3	5
87	Is the seasonal weather effect disturbing local traffic?	3	5
100	Select the available means of communications to contact NGO	3	5
149	What smart agent triggered the alarm on vessel KKK	3	5
151	What smart agent triggered the alarm on vessel "LAA"	3	5
161	How would you classify a contact that shows the following anomalies: high speed and changed course without a reason?	3	5
165	How many tracks in A are possibly conducting terrorist or piracy activities?	3	5
169	How many vessels in the area might be a potential hazard for the environment?	3	5
176	Locate on the map if possible, the vessel JJJ	3	5

55	What will be the future position of LLL in 24h time period?	3	6
75	What is the sea state in C?	3	6
113	What is the most likely depth contour 50nm off I (northbound)?	3	6
150	What smart agent triggered the alarm on vessel MMM	3	6
177	Are there any signs that may indicate some piracy activity on the area? Locate on the map.		
178	Is there any terrorism developing situation in the C? Locate on the map.		
201	Locate on the map if possible, the vessel NNN	3	6
202	Locate on the map if possible, the vessel WW	3	6
203	Locate on the map if possible, the vessel EEE 1	3	6
204	Locate on the map if possible, the vessel OOO	3	6
205	Locate on the map if possible, the vessel PPP	3	6
206	Locate on the map if possible, the vessel AAA	3	6
207	Locate on the map if possible, the vessel QQQ	3	6
208	Locate on the map if possible, the vessel RRR	3	6
209	Locate on the map if possible, the vessel SSS	3	6
210	Locate on the map if possible, the vessel TTT	3	6
211	What is the speed of the vessels: EEE 1, PPP, RRR?	3	6
124	How many wrong-course discrepancies have been pointed out by the BRITE Smart agents in the area?		