CHALLENGES FOR CO-OPERATION IN ACHIEVING MARITIME SITUATIONAL AWARENESS (MSA) FROM THE OPERATOR'S PERSPECTIVE

Lessons learned from MNE5 MSA Experimentations

Anne Koskinen

Chief of Systems Development in Navy Command Finland, Engineer, M.Sc.

Finland's Lead Analyst in MNE5 MSA and MNE6 MISA-EM

Abstract

Achieving Maritime Situational Awareness (MSA) is a challenge whether we are operating nationally or internationally. When operating internationally, the situational awareness plays even a bigger role. Many issues from cultural differences to language barriers can affect the smoothness of co-operation. Co-operation is a crucial key to a successful operation throughout national boundaries. Co-operation requires all participants to share relevant information in order to collaborate and act in a challenging environment.

The main initiative in this article is to cover lessons learned from the MNE5 MSA Experimentation (Multinational Experimentation 5 Maritime Situational Awareness). Results from the Experimentation cover factors that affect the situational awareness and this is done from the perspective of co-operation and information sharing. The objective of the Experimentation 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.

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 Maritime Situational Awareness during two different Events (Event 2 and 3) that included two separate scenarios. Event 1 was conducted to baseline our national MOC processes to facilitate a better understanding of MOC operations nationally and when working as part of an international effort. MNE5 MSA Experimentation Events explored the influence of social, technical and organizational factors of problem solving and information sharing in the maritime domain.

This study gave us significant information for the future development - both nationally and internationally: Findings from the MNE5 MSA Experimentation gave input to our national development. Some of the findings have already been and will be implemented to the development of our national MSA capabilities. Because situational awareness (SA) is an essential element in co-operations, Experimentation results are presented and analyzed in this article from the SA perspective.

I would like to thank everyone in the MNE5 MSA team and especially my analyst colleagues Candace Eshelman-Haynes and Chris Brunett from Allied Command Transformation (ACT), Fredrik Utterström and Mattias Fransson from Swedish Naval Warfare Center and Boon Kee Soh and Kenny Choo from Defence Science Organisation Singapore.

Introduction

This article presents results from MNE5 MSA Experimentation from the perspective of co-operation and national ambitions from three different Events. MNE5 MSA Experimentation Events 2 and 3 were conducted in partnership by the Navy Command

Finland, Naval Warfare Center of Sweden, NATO Allied Command Transformation (ACT) and the Singaporean Armed Forces (SAF) Future Systems Directorate. Event 1 was conducted before two main Events to study our national processes in order to understand MOC operations nationally and expand the current situation to international environment. MNE5 MSA Experimentation Events were determined to discover the influence of social, technical and organizational factors especially from the problem solving and information sharing perspective of maritime situational awareness (MSA).

In international operations it is important to ensure that situational awareness is shared among all participants. 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. Different types of qualitative methods were used to capture data from the Experimentation. These findings from the MNE5 MSA Experimentation gave important information to our national development and they will be implemented in the future study of our national MSA capabilities.

The main goal of this article is to examine issues that affect team's performance from collaboration and information sharing perspective in respect to situational awareness. Results from the participating teams were reflected to the research questions and overall results are presented in this article. 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 participating MOC teams to learn differences and similarities. Research questions covered issues categorized to social, organizational and technical factors as follows:

- *Information sharing and processes* - what affects the problem solving and achieving situational awareness (organizational),
- *problem solving process* - what kind of work practices are we able to discover from the operator's way of working (social),
- *technical problems* - what affects the problem solving process and hinders or enhances achieving the situational awareness (technical).

These issues were covered in MNE5 MSA Experimentation.

Overall background

There are a number of reasons, including security and economy, why co-operation is needed in the maritime environment. Terrorist attacks and illegal immigration in addition to drug and human trafficking are issues that concern many nations. In MNE5 MSA the purpose was to improve situational awareness against these 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 build up structures, processes and tools to improve future multinational co-operations. The Maritime Situational Awareness (MSA) track of Multi National 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 (Maritime Operation Centre).

The general goal was to help MOC teams detect, determine, recognize and identify possible suspicious behaviour in the maritime environment. The key element was information sharing between participants in order to prevent behaviour harmful to the security, wealth and economic stability of all the partners involved. 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).

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: SOP, MOU (Memorandum of Understanding) and TA (Technical Agreement) were written to support the information sharing. MOC structure consisted of at least two persons; one Intel Officer and one Operator. Each MOC was given their own AOR's (Area Of Responsibility). 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 to enable the teams to successfully identify the COIs (Contacts of Interest) based on scenario play across two seven hour sessions. 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 environment and technical solutions

The technical system setup from the Finnish MOC perspective is presented in image 1. When participants all agree to work under the TIDE (Technology for Information, Decision and Execution Superiority) specifications, they do not need to know other participants technological solutions.

The Technology for Information, Decision and Execution Superiority (TIDE) Conceptual Framework is shown in image 2. 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).

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 (co-operation between Navy – Boarder Guard – The Maritime Administration) authorities and Defence Forces the near-real time Recognized Maritime Picture (RMP). Operational version of MEVAT can utilize data from following data sources:

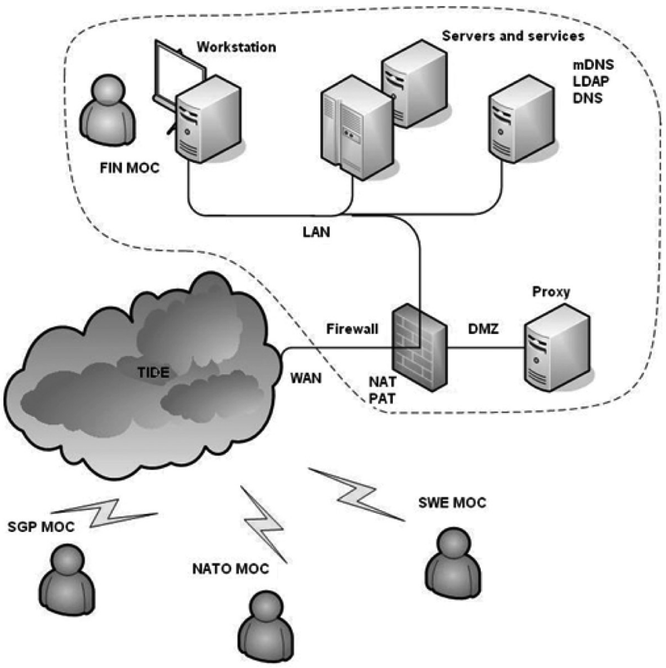

Image 1. Technical setup from the Finnish MOC

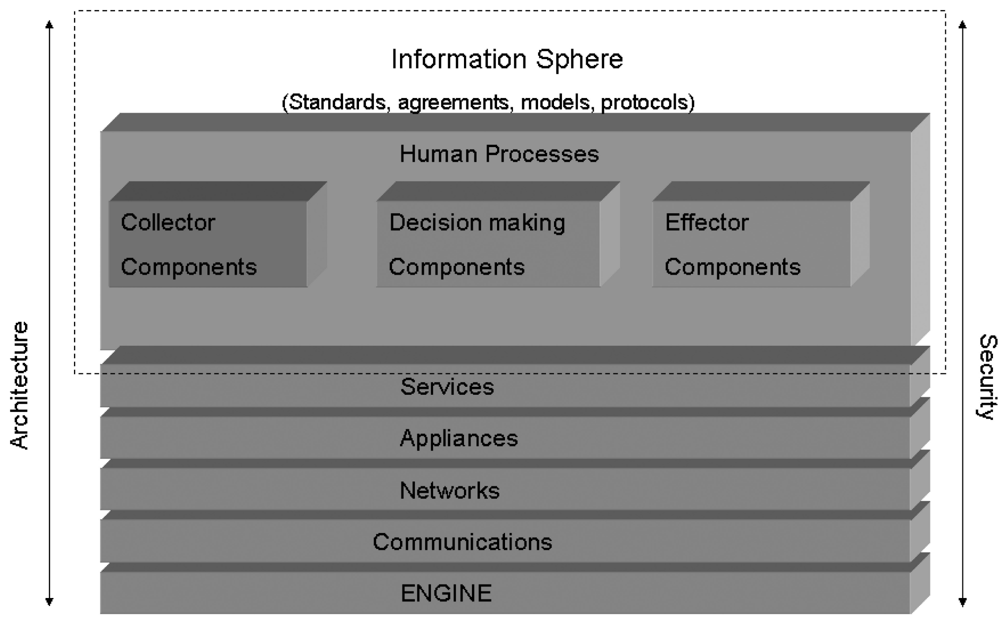

Image 2. TIDE Conceptual Framework (Goossens et al., 2006b)

- Sensors:
  - Primary surveillance radars
  - Sonar systems
  - Eye observer information
  - Mobile radar units
  - Mobile units
- Sources:
  - AIS
  - VTS information
  - PortNet (National gateway to EMSA SafeSeaNet)
  - MSSIS AIS.

MEVAT is capable of making history queries of one or more selected vessels based on time and/or area. As TIDE compliant, MEVAT is able to discover services and information from systems that are following the TIDE specifications (e.g. BRITE). The implementation of the BRITE framework is based on Service Oriented Architecture (SOA). The purpose of BRITE is the ability to discover, acquire and exploit information from various sources (Cheasley et al., 2009). MEVAT has collaboration tools, which provides email (SMTP), chat (XMPP) and voice (VoIP) to be used. MEVAT is also able to validate the target information against different vessel databases by Smart Agents; some of the reference information is actively scraped from the Internet (Soininen, 2008).

Development of MEVAT system during the Experimentation was made in several levels: MEVAT systems existing simulation and play engine was modified to support the simulation in the Experimentation (for example capability to alter data fields of real time AIS feed) and also the whole concept of analyzing data with smart agents was developed. Many technological improvements and development in different levels were done and tested during the preparations for the Experimentation. Improvements are now or will be in operational use in the near future (MNE5 MSA Final report 2008, 26-27).

Experimentation and used methods

Many different methods were used in the Experimentation in order to capture as much vital data as possible. Methods were mostly qualitative and supported sufficiently the Experimentation goals. From the analysis perspective the ideal situation was to capture the interactions and understand the reasons behind certain behavior. Usage of different types of questionnaires, observation, interviews and logs allowed analysts to gather a timeline that described the actions and reasons behind them.

One of the used questionnaires was **The NASA Task Load Index** which is a multidimensional 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 teams individually to gain understanding from their perspective of the overall task load during scenario play (MNE5 MSA final report 2008, 35).

The Analyst Assessment Report Performance Rating Questionnaire (AAR PRQ) was used as a subjective measure of MOC team performance from the observation perspective. After completing scenario observation and post-scenario interviews, 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. The AAR PRQ included different type of questions, for example: "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 questions established an analyst's representation of MOC team performance (MNE5 MSA final report 2008, 35).

STORS (Social Technical Organizational Rating Scale) – This is a 5 point rating scale where 1 means very harmful and 5 indicates very helpful, 3 meaning neutral. STORS is the research tool, which was developed during the first experiment design meeting when it became evident that the research questions were not clear enough. STORS included variables categorized to social, technical and organizational factors that were ranked. These types of variable measurements facilitate a better understanding of how factors influence performance from an operators' perspective. STORS is a tool that helped analysts in scoping research objectives. Using it helped determine whether to focus efforts on social/technical relationships or the organizational aspects (MNE5 MSA final report 2008, 35).

Post-scenario interviews were specifically designed to understand MOC team's decision points influencing information sharing and problem solving. MOC teams 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. Analysts observed MOC operators as they worked though the inject-based scenarios. Interactions were observed within and between MOC teams. Based on paper surveys and interviews, it was possible to verify the findings from observations and draw conclusions based on those (MNE5 MSA final report 2008, 35-36).

Interaction Diagrams were used to visualize communication between the MOC teams. The interactions were constructed to see how information was shared and to see the results of that sharing. Image 3 is an example of created Interaction Diagram. It includes all the crucial elements needed to be identified in order to capture co-operation between participating teams (MNE5 MSA final report 2008, 36-37).

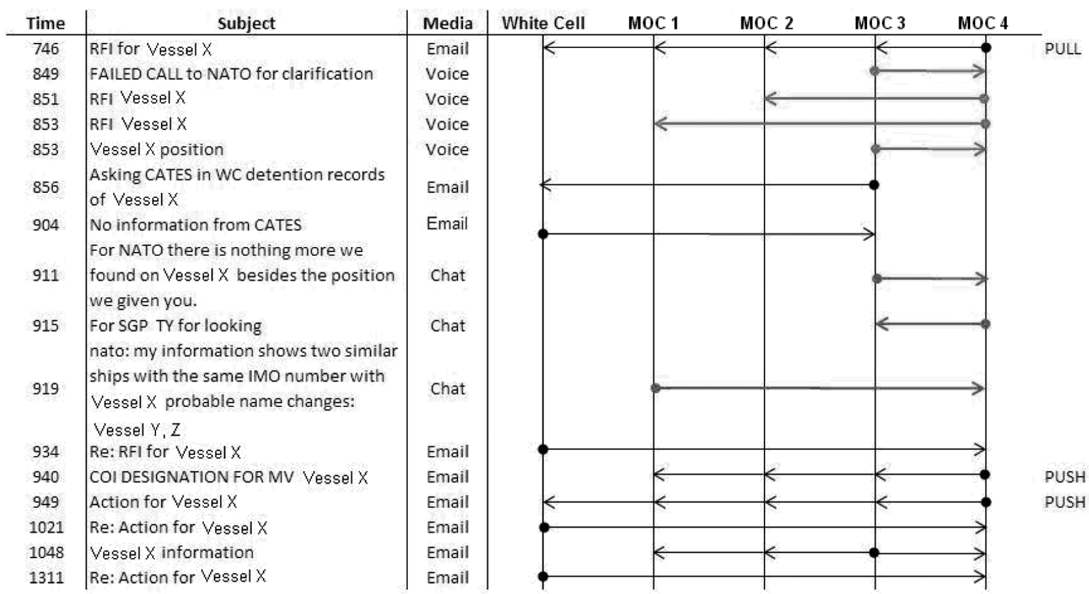

Image 3. Interaction Diagram of information sharing between MOC teams

Theoretical background - reflections to the experimentation

SenseMaking is the process of trying to understand events. SenseMaking is typically triggered by unexpected changes causing the actor to question his or her previous understanding of a situation. It is an active process where the actor builds and refines questions and recovers situational awareness. As Klein et al. (2006b) explain and Experimentation confirms, active processes must be supported by technologies and training. To help actors achieve current and accurate understanding of a situation, they must have the necessary tools and training (Klein et al., 2006b; 2007).

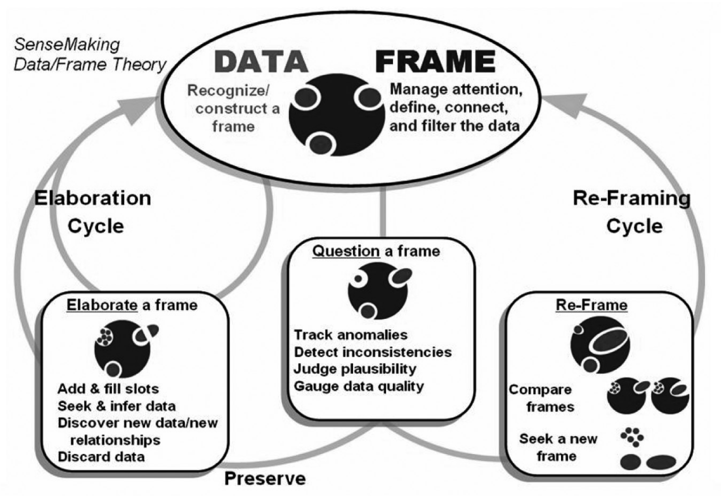

Image 4. SenseMaking Data/Frame Model (Klein et al., 2006b)

Image 4 represents the Data-Frame Theory of SenseMaking. Model describes how people generate an initial way of explaining events in different steps: 1) how actors elaborate on that when they are presented with new information, 2) how actors question the justification when some of the new data does not fit the story, 3) how actors sometimes fixate on a current rationalization even when they notice that new piece of information is not in line with the current knowledge and 4) how actors reframe their explanations. Data Frame model is used for detecting problems, making new discoveries, generating expectations about how the situation might evolve, and identifying problem solving points and making decisions (Klein et al., 2006a; 2006b; Hutton et al., 2008). Image 4 also shows the cyclic nature of interplay between data and explanation in the data Frame model by defining different entities and their relationships.

A frame can be presented as a plan or a mental model. As a structure it accounts for the data but it also guides how actor searches new data and identifies data. SenseMaking is the identification of meaningful information and data, and the process of getting more information. SenseMaking describes functional understanding to support making decisions and acting based on them (Klein & Steele-Johnson, 2007; Hutton et al., 2008). The SenseMaking theory has been used as an integral part of human factors work made in MSA. Referring to Eshelman-Haynes (2008) about adopting SenseMaking to the focus of experimental exploration of operators' cognitive models in MSA, this model frame is useful when training the operators in their problem solving processes and information sharing. It is possible to guide the operators in their thinking process and to help them to expand their scope of the problem solving area and resources that can be used (Eshelman-Haynes 2008). SenseMaking was used as the main theoretical framework for understanding actions and information sharing inside a MOC and between MOC teams in MNE5 MSA Experimentation.

In order to understand how we are able to improve situational awareness in co-operations, we need to understand the elements behind it. Endsley (1988, 36) has stated situation awareness to be *"the perception of the elements in the environment within the volume of time and space, the comprehension of their meaning, and the projection of their status in the near future".* From the co-operation perspective SenseMaking ideology is one way of looking at the actors performing their tasks. When we are focusing on information sharing, we need to understand that it requires collaboration. Artman (1998) has also acknowledged that shared situation awareness is required for successful co-ordination and awareness need to be of the vital parts of the system, sharing of resources and co-ordination of action that are also depended on information sharing (Artman 1998, 118; see also Artman 1999). Actors need to know the environment and other actors and their capabilities in order to co-operate efficiently. This was highlighted also in MNE5 MSA Experimentation. Actors had difficulties co-operating when they did not understand other actors' capabilities. Created SOP and other teams' technical capability training were developed to enhance sharing and situational awareness.

If we continue further to the core of SA, we need to understand that in order for the team to perform effectively, SA is needed to support the collaboration. Endsley (1993) has stated that generally speaking one might expect reduction in SA to be associating with reduction in performance but the loss of SA simply puts the actor at increasing risk of a performance error. In a challenging environment such as maritime operation we want to minimize that risk (Endsley 1993, 3). 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 MNE5 MSA (Bolstad & Endsley 1999, 1). Conducted Experimentation gave crucial information about how currently teams can be supported when collaborating with different teams in distributed environment, when teams are trying to solve the given tasks under irregular conditions. It was valuable to see how well co-operation and team work succeeded. Similar to Team SA, which has been defined as: *"the degree to which every team member possesses the SA required for his or her responsibilities"* (Bolstad & Endsley 1999, 1), important element in the co-operation was the awareness of other teams and participants involved. Endsley & Jones (1997) presented team SA model and its four components that include: 1) Shared SA Requirements 2) Shared SA Devices 3) Shared SA Mechanisms and 4) Shared SA Processes. In MNE5 MSA the task was to support the MOC teams with

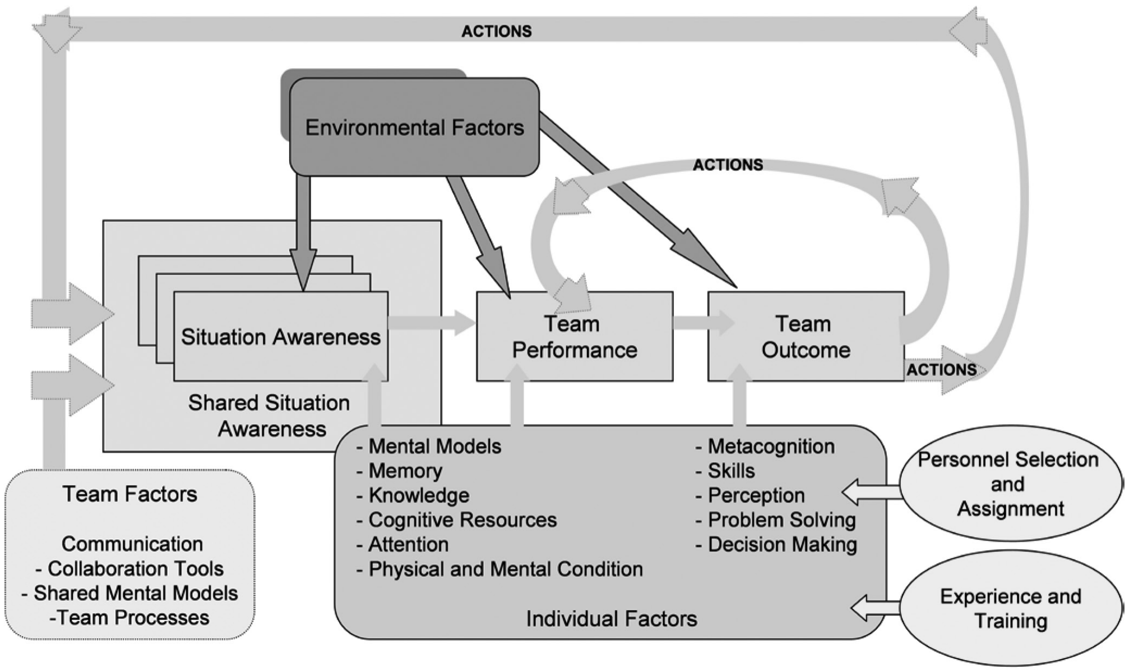

Image 5. Model of Situation Awareness (Bolstad et al., 2005)

collaboration tools, provide them with Standard Operating Procedure (SOP), along with providing them required awareness of other participants and their capabilities and supporting teams with their problem solving process. From that perspective the Experimentation covered all of the four components that support team SA.

Model of Situation Awareness presented in Image 6 is based on Endsley's (1995) work. Model describes the variables and potential relationships between them affecting the level of SA, decision-making and action performance (Bolstad et al., 2005, 2). 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 1, 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).

		Collaboration	Characteristics	
Tool Category	**Time**	**Predictability**	**Place**	**Interaction**
Face-to-Face	Synchronous	Scheduled or Unscheduled	Collocated	High
Telephone	Med-High synchron-icity	Unscheduled	Distributed	Medium-High
Chat	Med-High synchron-icity	Semi-scheduled or Un-scheduled	Distributed	Medium-High
White board	Synchronous or asynchronous	Scheduled or Unscheduled	Distributed or Col-located	Moderate
File transfer	Asynchronous	Unscheduled	Distributed or Col-located	Low
Email	Asynchronous	Unscheduled	Distributed or Col-located	Moderate-Low
Domain Specific Tools	Synchronous or asynchronous	Scheduled or Unscheduled	Distributed or Col-located	Low

Table 1. Taxonomy of Collaboration and Collaboration Characteristics (original Bolstad & Endsley 2003a, 4, table 1).

Table 1 describes how tools can be categorized based on the collaboration characteristics. The original Tool Category includes wider list of special type of tools. Table 1 describes tools used in MNE5 MSA Experimentation. Like in Table 1, 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 1) reflects 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.

In table 2 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 more confident while using tools and sharing information.

	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

Table 2 Taxonomy of Collaboration and Tool Characteristics modified for the MNE5 MSA framework (original Bolstad & Endsley 2003a, 4, table 2).

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 3 as modified version of the original Bolstad & Endsley (2003, 5, table 3). Information types that may be involved in a 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).

		Information	Types			
Tool Category	**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)

Table 3 Taxonomy of Collaboration and Information Types modified for the MNE5 MSA framework (original Bolstad & Endsley 2003a, 5, table 3).

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 requires 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.

Results from the Experimentation

Experimentation results and lessons learned are categorized to social, technical and organizational factors from the information sharing and problem solving perspective. A successful co-operation consists of different types of elements, such as understanding different information requirements and sharing relevant information to relevant actors, which are crucial pieces of the whole picture that need to fit in order to ensure basic elements for co-operation.

Holistic problem solving approach was used in the Experimentation. In this case it meant team members looking outside of the typical boundaries of their responsibility. It was desired that team members considered what other participants might want or need to know and attempt to create a complete understanding of who is doing or has done what in the scope of the scenario. Furthermore, the goal was to make team members understand where they are making assumptions and then compare those assumptions against the frame or scope of the problem. The problem solving process was designed to be iterative and to support team members in developing an intentional awareness of the scope and depth of their own understanding of the problem space. In this model, scope is referring to the geo-spatial, political, and temporal elements of the problem space. Depth in this case means the fit between facts, assumptions and the frame of the problem space (MNE5 MSA Final report 2008, 50).

Arrangements were made in the Experimentation to formalize the information exchange and to train the operators on information sharing. It was crucial for the operators to understand the importance of the information sharing. Operator confidence in decision making about sharing information was directly affected by their understanding of where they fit in the decision making process. If operators felt they were protected by formal agreements, they had confidence to make a decision of sharing information. When guidance was that the operator had responsibility for the decision, they typically refused to share in spite of having been encouraged to share.

With formal agreements in place and understood, it was possible for operators to provide amplifying information that they would normally withhold. This amplifying information was a key for enabling shared situational awareness and sufficient understanding of the problem space (MNE5 MSA Final report 2008, 50).

Social factors affecting co-operation and information sharing

From the Events it was possible to point out several issues that affected the information sharing and co-operation. Other elements had an enhancing effect and other elements had a diminishing effect. From the social factors some of the most influential elements, such as 1) informal social networking, 2) problem solving process, 3) confidence and 4) language, are described.

MOC teams did not vet new information from other MOC teams 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 participants to treat information from all sources with the same level of objectivity. With adequate training it is possible to support the operators and their confidence in sharing. Commonality in language enhanced communication, when 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. For some participants the familiar ways of working and common cultural experiences resulted in easier working relationship. Lack of communication business rules, for example simply acknowledging receipt of messages, reduced shared situational awareness (MNE5 MSA Final report 2008, 50-51; Brunett et al., 2008).

Informal social networking was greater during Scenario 2 than it was in Scenario 1 in both Events possibly due to an informal network been developed between scenarios through social interaction among participants. This informal interaction improved MOC to MOC communications too. When scenario 2 began, in both Events, teams were much more comfortable contacting other MOC teams. The informal network enhanced less formal way of communicating and co-operation, (e.g. chat) when the information could be shared without formal RFIs (Request For Information) that took time for the operators to prepare. 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. The STORS survey results helped guide experiment design by focusing our ambitions. For example Event 2 showed that operators view social factors as important supporting elements to accomplishing their tasks. Still, there are many technical factors that need to be tackled in order to support the MOC operators work in the future. Less formal channels of communication like chat seemed to facilitate information exchange. Chat was easy and faster way to communicate and react to information requests and replies. Also one discovery was that team members did not handle information received from other MOC teams as critically as they did with information received from their technical systems. From this study the conclusion is that it was easier for actors to trust information from other human actors than from technical systems. The finding means that actors must be trained to handle every piece of received information with the same level of objectivity, whether the source is technical or another human actor (MNE5 MSA Final report 2008, 51-52; Brunett et al., 2008).

The 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 problem solving process 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 analyzing. 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 problem solving 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 specificity. 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. 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).

Confidence of the participating team members was dependent upon individual personality and can be encouraged by clear instructions and training. As an example MOC A received information from MOC B regarding the location of a vessel. The information received from MOC B conflicted with the information that was in MOC A system. The MOC A team critically evaluated the information and questioned the location of the vessel. However, there were also times when a MOC A received information from another MOC that they did not question at all, even if their analysis conflicted with the sending MOC. This process seemed to depend on individuals and how confident they felt in the decision making process. Participants' understanding of where they fit in the decision making process affected directly their confidence in making decisions about information sharing. If during the Experimentation we did not have a policy for unlimited information sharing in the form of simulated MOUs/TAs then information sharing would have been severely limited. During the Experimentation it was shown that operator confidence can be encouraged by clear instructions and training: Information sharing policies should be simple, clear and understood by all participants involved. These policies should ensure understanding of what, how and with whom information can be shared among the participants. This will ensure that MOC team members feel comfortable with the tools that they are using and with rules that they need to follow (MNE5 MSA Final report, 51).

Networking played a significant role because MOC teams received crucial information from other MOC teams which enabled them to work towards solving the puzzle. Without the option to share information, teams would have not been able to act as efficiently as they did during the Experimentation. Teams interacted with each other but still teams did not have a good understanding of other MOC team's capabilities. Understanding other MOC team's capabilities helps communicating and lowers the amount of MOC to MOC communication when looking for amplifying information. Similarities in the work practices or even in the same type of message formats can help the teams to interact together easier and more effectively. The familiar ways of working and common cultural experiences resulted in easier working relationship for some participants. This enabled MOC teams to get crucial information from other

MOC teams. Without sharing this information the MOC teams would have not been able to identify the correct vessels in the scenarios. Training is required to ensure that teams have a good understanding of other MOC teams' capabilities which supports the needed SA (MNE5 MSA Final report, 52).

Language becomes an affecting issue or not depending on the participating individual. In general, language was not an overriding issue. When operators used email or chat there were few issues. However, speaking on the phone could be a problem. It is dependent on individuals' language skills on how comfortable they felt using different means of communication. The initial lines of communication should be primarily email and chat as most people are confident using these tools for communication (MNE5 MSA Final report, 52).

Technical factors affecting co-operation and information sharing

All the data - both value added and raw AIS - where treated the same. At the technical level, raw AIS data was shared meaning that stakeholders contributed to a common AIS picture. The difference between raw data and value added data was not clarified to the teams, so they had little awareness of the difference between these two types of data. In the Event 2 when teams were facing decisions about information sharing during the first scenario, they 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 scenarios the MOC teams were given permission to freely share information through a simulated Memorandum of Understanding (MOU). Permission to share supported the teams and the change was made to gain a better understanding of how information sharing policies affect information sharing. In the Event 3 the teams were from the beginning guided to share information according to the agreements. Based on the Experimentation technical tools are only one part of the MSA solution because often operators did not understand how to use the information that was being presented by the tool. When there was no clear process and understanding of the situation, teams were not able to use the technical tools as effectively. This means that usage of the technical tools should be trained with example scenario in parallel with a problem solving process in order to support the operators in their challenging task to achieve and maintain situational awareness in the maritime environment (MNE5 MSA Final report 2008, 52-53; Brunett et al., 2008).

Data Conflicts and failures occurred occasionally when teams where trying to use other MOC teams technical services. It is important for MOC teams to understand the limits and capabilities of their own technical system and also have a basic understanding of partner capabilities and how the systems interact with each other (MNE5 MSA Final report, 53).

Decision Support Tools such as smartboards, concept mapping, and Google Earth aided MOC teams in their problem solving and decision making process. In one case during the Experimentation the usage of a smartboard for problem solving enabled the team to demonstrate and present, capture and share their thinking. Open source tools for visualization, decision making and collaboration (i.e. Google Earth, Google Documents, etc.) are good tools that can support collaboration but new technology does not support the actual work and information sharing without proper training (MNE5 MSA Final report, 53).

Communication Tools used in the Experimentation were mainly voice, email and chat. Teams felt traditional message reports to be laborious and time consuming, often diminishing the quantity and quality of information shared. There were cases where the same information was transmitted by the same MOC via more than one communication medium (chat, email, voice). Chat and voice appeared to be more effective and efficient for communicating in these particular cases. For example, in one case, one of the team members in a MOC spent more than 30 minutes drafting an RFI message while the same information was communicated via chat in a fraction of the time. Also duplicative manual data entry that was seen in the Experimentation should be at least minimized (MNE5 MSA Final report, 53-54).

Automated Information Sharing and especially automated information push did not decrease human to human interaction through traditional channels of communication (email, voice and chat). These traditional communication methods were essential to MOC teams' ability to solve the given tasks within the scenarios. Participants did not always understand the information being presented to them from other systems. There were cases where one system generated automated alerts which were interpreted as VOIs in other systems causing the total number of VOI's to rise to an unmanageable level. MOC teams shared often information through traditional channels of communication while that same information was available to all MOC teams through their open sources and/or their own system. On the other hand, shared VOI lists usually increased shared situational awareness and enabled MOC teams to focus resources on a particular list of vessels. Based on observation from the Experimentation, MOC tools should include a simple and secure way to share vessel lists either manually or automatically. This means that there must be a standard for identifying vessels as VOI (Vessel Of Interest), COI (Contact of Interest) and CCOI (Critical

Contact of Interest). Tools should focus on enhancing the social network within and between MOC teams (MNE5 MSA Final report, 54).

Technical systems also need to undergo some transformations in order to fully support MSA. Participants in the co-operation need access to common data and shared networks in order to achieve and maintain reasonable situation awareness. Shared networks must be defined to include channels for both formal and informal communication. During the Experimentation it was observed that team members regularly misinterpreted results of system processing. Visualization of search results therefore requires more research (MNE5 MSA Final report 2008, 54).

Organizational factors affecting co-operation and information sharing

The organizational MOC structure for the Experimentation was artificial. At times participants had difficulties understanding who to contact and how when they were requesting information. External entities such as national intelligence or port authority were played by the White Cell to manage MOC teams RFIs. Inside MOC teams' participants decided the MOC structure informally which resulted in some mismanagement and duplication of effort. At times it was possible to see two team members from the same MOC team working on the same task. The redundant tasking caused delays and resulted in some information being missed or dropped from awareness which increased operators' frustration level. Operators were provided with communication channels (e.g. voice, chat, and email), but teams did not receive guidance on how and when to share and that caused problems from time to time (MNE5 MSA Final report, 54-55; Brunett et al., 2008).

Overall, participants tended to view the problem space from their own comfort zones and AORs. By supporting the teams with problem solving process, it was also intended to highlight the interaction between problem solving and information sharing. These two important aspects linked together supports also co-operation with other MOC teams. With combined process 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. From the organizational perspective this means clear guidance from the organizational policy which empowers participants to share information across traditional boundaries. From both legal and security aspects operators have to believe that they are "safe" to share the information they possess. Operators are with current work practices encouraged to use the technical systems rather than interact with other MOC teams. Interacting socially with external actors should be seen as equally important resource among technical tools. When during the Experimentation technical systems failed, operators stopped the problem solving process and, at times even stopped working. This proves that operators should be trained in the event of technical failures to proceed with the problem solving process and explore other possible solutions, for example other MOC teams systems (MNE5 MSA Final report 2008, 52; Brunett et al., 2008).

Information Sources were not always understood by the operators. There were situations were 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. Training should provide a basic understanding of different information sources (MNE5 MSA Final report 2008, 55).

Intelligence experience was crucial in the Experimentation. Lack of intelligence experience often limited that MOC team's ability to completely analyze the situation and task at hand (MNE5 MSA Final report 2008, 55).

Information Management caused difficulties when participants tried to manage information from several sources. This sometimes led to a failure to notice and/or to unintended omissions. Training in problem solving and source thinking helped to diminish these problems, but it is evident that needs for clearly defined and trained information management processes do exist. It is important to continue investigating and refining best practices for information management especially with respect to gathering, processing and sharing information (MNE5 MSA Final report 2008, 55).

MOC Organization needs to be structured because based on the Experimentation results well defined roles for operators enhanced information sharing and problem solving. Three main functions 1) operation, 2) communication and 3) intelligence should be clear inside the MOC team. Within the problem solving frame the importance of leadership needs to be highlighted. Nevertheless leaders should focus on the entire problem space rather than being distracted with usage of technical tools. This is why MOC organization should be well structured for every team member to understand their role and responsibilities (MNE5 MSA Final report 2008, 55).

Area of Responsibility played an important role in operator decision making about information handling. There were several situations were MOC teams stopped acting on a vessel when it left or was not coming to their own AOR. Participants should understand how to take a holistic approach to understanding the problem space and how to relate that to own AOR as well other nations AORs. Based on the

Experimentation there should be clear guidance for participants about how to treat information external to their own AOR in respect of situational awareness (MNE5 MSA Final report 2008, 56).

Multinational experimentation and co-operation - benefits and challenges

MNE5 MSA Experimentation results reveal number of factors that affect information sharing and co-operation. These social, technical and organizational factors affect in achieving and maintaining situational awareness. Social factors include issues such as operator confidence and culture that are elements influencing information sharing and situational awareness. Technical factors have the same impact; they hinder or enhance information sharing and co-operation. From the organizational perspective information sharing policies play a very important role in co-operations. These multiple elements affect the collaboration and success of the operations. Co-operation can be supported with clear information sharing policies and rules for information exchange. Technological tools support communicating if the participating team members are properly trained for using them. Most importantly social networking and communication has an enormous impact in co-operation. When in the MNE5 MSA Experimentation the MOC teams were allowed to interact directly, teams were able to be more efficient and solve the tasks given to them. It was also clear that training on the problem solving process improved teams' ability to manage information.

When we are focusing on information sharing in co-operations we need to acknowledge requirements for shared situational awareness that cannot be underestimated; Participants need to have awareness of the vital parts of the system, sharing of the resources and co-ordination of the actions. In a successful co-operation participants need to be familiar with the environment and other participants with their capabilities in order to gain needed situational awareness. This was discovered also from the lessons learned from the Experimentation; MOC teams had difficulties collaborating with other MOC teams when they did not understand other's capabilities. Knowledge of other teams' technical capabilities and common way of operating were therefore developed to support information sharing and situational awareness. Developed processes were shown to have a supporting effect on MOC teams' collaboration and overall co-operation. As Endsley (1993) has stated, a risk of performance error can be caused by the reduction in SA. With the procedures developed in MNE5 MSA Experimentation we tried to minimize the risk when we are operating in a challenging maritime environment (Endsley 1993, 3).

By implementing lessons learned from the MNE5 MSA Experimentation we are able to enhance our co-operations both nationally and internationally. By identifying problem areas in current co-operations and providing possible solutions to solve them were important steps toward better situational awareness in the future. Common understanding about the task at hand and sources available support the actors operating in challenging situations. Crucial elements of a successful co-operation were learned from the MNE5 MSA Experimentation which properly deployed can help teams in achieving and maintaining adequate situational awareness needed for the operations in the maritime environment.

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