How Are Situation Picture, Situation Awareness, and Situation Understanding Discussed in Recent Scholarly Literature?

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Keywords: Situation Picture, Common Situation Picture, Situation Awareness, Situation Understanding.

Abstract: There are several different definitions of situation awareness. However, all of them have in common is knowing and understanding of what is happening, an understanding of future changes or problems, and the prediction of the future situation and the decisions to be made on its basis. Situation picture and Situation Awareness are narrow. Situation understanding of the situation is the understanding of the decision-makers and their assistants about what has happened, the circumstances that have affected them, the goals of the different parties and the possible development options of the events needed to make decisions on a particular issue or subject. The results of this study indicate that the recent discussion in scholarly literature focus on situation awareness. A further result is that the context of the many of the recent literature are focused on issues related to cyber security or on intelligent systems, thus on IT systems, which are very relevant to modern situation awareness and understanding in these modern times where more and more systems become digitalized and interconnected..

1 INTRODUCTION

The Security Committee of Finland lists elements of situation leadership. The creation of a situation picture involves a substantial understanding of the situation and an assessment of the development of the situation. Collecting and sharing a situation picture is a prerequisite for situation management. Decision-making requires a quick formation of the situation picture and the creation of situation awareness. Sharing information and technical solutions require enabling authorities to collaborate as comprehensively as possible. (The Security Committee, 2017).

According to Endsley (2000, pp. 4-5) "Situation awareness therefore is represented as the main precursor to decision making, however, many other factors also come into play in turning good situation awareness into successful performance".

In multi-authority operations, the responsible authority is responsible for operational activities; other authorities are involved in the operation and provide official assistance to the extent necessary. Management is based on statutory tasks and responsibility of the competent authority, and with the support of other authorities to the competent authority (The Security Committee, 2017).

It has been, however, noted that a common situation picture is missing within sectors and between authorities. Actors look at this from their own point of view: the data are collected at different locations and the data are not comparable to each other, making it difficult to use the information gathered (FIMAC, 2018).

The development of situational awareness by and for the participating authorities and respondents are carried out through joint monitoring and assessment. Networked cooperation under the collaborative model is important at both national and international levels. Creating, and practising situation picture and situation awareness are important elements (The Security Committee, 2017).

The research question of this study is: How are situation picture, situation awareness, and situation understanding discussed in recent scolarly literature?

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Tikanmäki, I. and Ruoslahti, H.
How Are Situation Picture, Situation Awareness, and Situation Understanding Discussed in Recent Scholarly Literature?.
DOI: 10.5220/0008494104190426
In *Proceedings of the 11th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2019)*, pages 419-426
ISBN: 978-989-758-382-7

1.1 Structure of This Paper

The second chapter of this study defines common situation related terms. The third chapter presents the methods used, the fourth chapter the results, which are divided into four sections; situation picture, common situation picture, situation awareness, and shared situation awareness. The fifth chapter offers discussion and recommendations for future research.

2 DEFINING SITUATION RELATED TERMS

Table 1 provides definitions of Oxford and Merriam-Webster dictionaries for the most common terms in this study (Oxford Dictionary, 2019; Merriam-Webster, 2019).

Table 1: Definitions for situation related terms.

Term	Oxford dictionary	Merriam-Webster dictionary
Picture	A painting or drawing, etc. that shows a scene, a person or thing	A design or representation made by various means such as painting, drawing, or photography
Situation	All the circumstances and things that are happening at a particular time and in a particular place	The way in which something is placed in relation to its surroundings
Awareness	Knowing that something exists and is important	The quality or state of being aware: knowledge and understanding that something is happening or exists
Understanding	The knowledge that somebody has about a particular subject or situation	The capacity to apprehend general relations of particulars or the power to make experience intelligible by applying concepts and categories

Situation picture, situation awareness and understanding arise through the acquisition and interpretation of knowledge (Kuusisto, 2005). According to Alberts et al., (2001), situational awareness focuses on what is known about past and present situations, while situation understanding is how the situation is or can be formed and how the different activities affect the developing situation.

3 METHOD

The research was done as a qualitative study, where according to Yin (2003) the sources of evidence commonly used in case study are qualitative data, which can, be collected by observing interactions, conducting interviews or scrutinising materials (Denzin and Lincoln 1994). Yin (2003) recommends using various sources. Data collection methods are usually combined in case study research and evidence may be qualitative, quantitative or both (Eisenhardt, 1989). The case study is therefore useful when the phenomenon is broad and complex when comprehensive, thorough research is needed (Dubé and Baré, 2003). Conducting qualitative research is an information-based process; most of the time, inductively, empirical observations on more general theories or methods need to be made (Alasuutari, 2004).

This study is a work in progress, and it uses recent (past three years) academic (peer-reviewed) literature sources that were collected in a structured manner by searching the scientific databases ProQuestCentral and EBSCO Host with search words that were directly based on the RQ of this study.

A final sample of 22 papers was selected based on reading their title and abstract (e.g., 10 papers with a medical context, 5 with a device level context, and two with an outer space context were among the papers that were not included in this final sample). These 22 articles are then read entirely and relevant content and mention of situation picture, situation awareness and situation understanding were extracted to a data extraction table (DET) that were directly based on the RQ and one column addressed the context of the paper.

Material from earlier and further scientific reports, articles, and a more general literary review was used to supplement the data collected from the primary source of structured literature review.

4 RESULTS

The results of this study indicate that the recent discussion in scholarly literature focus on situation awareness. Only one paper of the sample was focused on situation understanding. A further result is that the context of the many of the recent literature are focused on issues related to cyber security or on intelligent systems, thus on IT systems, which are very relevant to modern situation awareness and

understanding in these modern times where more and more systems become digitalized and interconnected.

Table 2: The contexts of the sample papers.

Context	Number of papers
Situation awareness within systems	
Cyber	5
Intelligent systems	6
Authority situation awareness	
Big Data usage	3
Disaster recovery	4
Maritime	3
Police	1

The sample of 22 papers were further classified in two major categories. There were 11 papers that deal with how authorities or the military promote situation picture, awareness, and understanding, and 11 papers that deal with situation awareness of systems. These were deemed relevant to the study, as many of today's situation picture and awareness systems are cyber-physical in nature (Rajamäki and Ruoslahti, 2018).

4.1 Situation Picture

Each organization needs information about its environment and its events, and its impact on their own activities. Appropriate and rapid situation awareness, based on correct information and estimates, are emphasized in situations of disruption, in which case it is necessary to quickly make decisions in a very wide range of impressions. The situation picture is a presentation of the situation or performance capabilities compiled from the individual information giving grounds for situational awareness. (Lehto et al., 2018).

According to Kuusisto (2005), a situation picture is a real-time picture of current events and includes an analysis of the current state and an estimate of future events.

The European Union describe Situational Picture as "means of graphical interface to present near-real-time data and information received from different authorities, sensors, platforms and other sources, which is shared across communication and information channels with other authorities in order to achieve situational awareness and support reaction capability along the external borders and pre-frontier area" (European Parliament, 2013 p.14). The situation picture shall be composed information collected from a) surveillance systems, b) stationary and mobile sensors, c) patrols (e.g. vessel, aircraft), d) command and control centres, e) other authorities and systems, and f) other sources. (European Parliament, 2013)

E.g. maritime surveillance data are gathered e.g. by a) physical observation from vessels and aircrafts; b) unmanned vehicles and drones; c) remote sensing; and d) coastal radars and other sensors. Situation Picture should base on raw data from which each organisation builds their own Situation picture according to their needs. A situation picture must be sharable both nationally and internationally.

Figure 1 shows the European maritime user communities that the Common Information Sharing Environment (CISE) better interlinks with one another for an integrated maritime surveillance across the entire European maritime domain, and the waters leading to it. However yet, "In the area of maritime surveillance, there is no inherent complexity, which is due to the fact that numerous systems are not yet interconnected and operate simultaneously" (Tikanmäki, 2017, p. 288).

Figure 1: The Common Information Sharing Environment (CISE) interlinks user communities for integrated maritime surveillance (Tikanmäki and Ruoslahti 2017, p. 392).

4.2 Common Situation Picture

According to Horsmanheimo et al., (2017), a Common Situation Picture should consist of the most important requirements presented in Table 3.

So far, achieving coherence between the many different national Member State processes has been challenging. Crossing sectorial borders can be even more difficult than crossing national ones. A lack of integrated mechanisms for distributing information prevents spreading situational awareness to all who need it in the case of a crisis (Tikanmäki and Ruoslahti, 2017).

According to United States Department of Defence (2017, p. 212) Common operational picture is "A single identical display of relevant information shared by more than one command that facilitates collaborative planning and assists all echelons to achieve situational awareness. Also called COP". European Union and national authorities may gain "faster recognition, assessment, planning, and

reaction capabilities, which lead to a safer, more secure European maritime domain" (Ruoslahti and Tikanmäki, 2017, p. 273).

Table 3: Major important requirements for Common Situation Picture (Horsmanheimo, et al., 2017).

No	Requirement
1	A Situation Picture is a series of presentations whose form does not matter. It is essential that someone manages it, makes analysis and decisions.
2	Information is produced in collaboration with the Situation Picture system. Each actor independently responds to the production and correctness of the information in its field of expertise.
3	The information must be processed, analysed and understandable. It must play a role both for itself and for other recipients.
4	The information should be presented visually and clearly.
5	The information must be presented without unnecessary technical details. The information must be understandable to people from other domains.
6	The data should be automatically transferred between the systems. This reduces the problems caused by human errors.
7	Situation Picture system should be dynamic and tailored to the user groups or domain. The information should have different levels of views.
8	Terminology and classifications should be harmonized.
9	Situation Picture system should be incorporated into the processes of organizations so that there is no additional task to maintain it.
10	Different actors should be able to define what information they need and what information they are able to enter the system.
11	Situation Picture system should be able to exchange information between different actors at different organizational levels. Information should also be shared with supervising organizations.
12	Situation Picture system should provide predictions about what happens in 3, 6, and in 12 hours.
13	Situation Picture system should be able to present the temporal dimension of how things have evolved - whether they are going in the wrong or better direction.

The national situational picture is composed of information collected from the i.e. sources presented in the following Table 4.

Table 4: Sources of information (European Parliament, 2013).

No	Source
1	The national surveillance system in accordance with national law
2	Stationary and mobile sensors operated by national authorities with a responsibility for external border surveillance
3	Surveillance patrols and other monitoring missions
4	Local, regional and other situation centres;
5	Other relevant national authorities and systems, including operational centres and contact points
6	National situation/operations centres in other Member States
7	Authorities of third countries, on the basis of bilateral or multilateral agreements and regional networks;
8	Ship reporting systems in accordance with their respective legal bases
9	Other relevant European and international organisations
10	Other sources

4.3 Situation Awareness

Endsley (1988) defines situation awareness as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future". Situation awareness enables preliminary information gathering and information exchange and is applicable mechanism for real-time monitoring and anomaly detection. Thus, situation awareness is the process of being aware of what is happening in the surroundings. (Ferreira et al., 2017).

Situation awareness (also called as situational awareness) is the result of a situation picture and its analysis. The situation picture and situation awareness are limited concepts and should strive towards a broader concept of situation understanding. Situation awareness and situation understanding require collaboration and knowledge that enable comprehensive monitoring of the operating environment, analysis, and compilation of information, and sharing of information. (Lehto et al., 2018). The absence of an integrated information sharing mechanism prevents the dissemination of the situation awareness to those in need. (Vuorisalo, 2012).

Individuals and organisations are developing new ways to execute their mission by utilising the power of knowledge and applying network-centric concepts. Three domains: physical, information and cognitive must be covered to understand how information influence the capacity to execute operations. The physical is the domain where e.g. manoeuvres take place across environments (ground, sea, air, space), and connected by physical platforms and communications networks.

Information is created, manipulated and shared, and command and control are communicated in the information domain. All information is influenced by the interaction within the information domain. In the cognitive domain perceptions, awareness, understanding, beliefs, and values underlie, and as a result of sense making, decisions are made. (Alberts, Garska, Hayes, and Signori, 2001).

Alberts and Hayes (2003) add the social domain as the fourth domain of command and control. According to Alberts and Hayes "… the interactions between and among individuals and entities that fundamentally define organization and doctrine exist in the social domain". (Alberts and Hayes, 2003, p. 45).

According to Smith and Hancock (1995, p. 2), "Situational awareness is the invariant in the agent-environment system that generates the momentary knowledge and behaviour required to attain the goals specified by an arbiter of performance in the environment". According to Endsley (2000), Situation Awareness is "Most simply put, SA is knowing what is going on around you" (Endsley, 2000, p. 2). Situational awareness bases on perceived information, and the information features affect how information is transmitted (Seppänen, 2015). Basically, SA levels explain: where have we been, where are we now and where are we going?

Perla, Markowitz, Nofi and Weuve (2000, p. 9) define Situation awareness as "a sense of knowing what's going on in our current environment, what could happen next, what options we have for action, and what the possible outcomes of those actions might be". Simply said, "A team must share to understand what's going on, why it's going on, and how will it affect their mission" (Perla et al., p. 34).

Nofi (2000) describes situation awareness as "the result of a dynamic process of perceiving and comprehending events in one's environment, leading to reasonable projections as to possible ways that environment may change, and permitting predictions as to what the outcomes will be in terms of performing one's mission." (Nofi, p. 5)

There are three main schools of thought on explaining Situation Awareness. Endsley (1999) has a three-level model in information processing approach, Smith and Hancock (1995) use the model of the perceptual cycle, while Bedny and Meister (1999) use the model of activity theory to describe SA (Salmon et al., 2007). Endsley (1999) divides SA into three levels.

Table 5: Levels of Situation awareness.

Situation awareness (SA)	
Level 1	Perception of the elements in the environment
Level 2	Comprehension of the current situation
Level 3	Projection of the future status

The first step in achieving SA Level 1 is to discover the state, characteristics, and dynamics of relevant environmental elements. SA Level 2 bases on a synthesis of Level 1 elements. Level 3 SA projects future actions and forms third level SA (Endsley, 1999). Smith and Hancock (1995) consider SA to be a knowledge creation and knowledge-based process. Their description bases on the model of the perceptual cycle, which describes the interaction of an individual's interaction with the world and the influence of the models in our role.

Bedny and Meister (1999) describe SA as an activity theory outlining various cognitive processes related to human behaviour. Activity theory strives to ensure that individuals have goals, which represent an ideal image or the desired end state, motives that guide them in the final state and the policies (or action) that allow for the achievement of these objectives. (Salmon et al., 2007).

According to (Nofi, 2000, p. 71). SA is "the result of a dynamic process of perceiving and comprehending events in one's environment, leading to reasonable projections as to possible ways that environment may change, and permitting predictions as to what outcomes will be in terms of performing one's mission".

4.4 Shared Situation Awareness

In cooperation with expert organizations, each organization has its own specified goals and tasks. The collaboration of expert organizations does not require common situational awareness. In co-operation, a common understanding of the conceptual level is needed. Co-operation can be described by the concept of shared situation awareness. The pursuit of common situation awareness may even be detrimental to the quality and effectiveness of cooperation. Cooperation between expert organisations arises from the task of tied situation awareness and communication. (Luokkala, 2009).

Shared Situation Awareness (SSA) is defined as "the degree to which team members have the same SA on shared SA requirements" (Endsley and Jones, 2001, p. 48). In co-operation, a common understanding of the conceptual level is needed. Co-operation can be described by the concept of shared situation awareness (Luokkala, 2009).

Shared Situation Awareness has several alternative terms: Common Understanding, Team Shared Awareness, Shared Understanding, Distributed Cognition, Distributed Understanding, Group Situational Awareness, Shared Cognition, Shared Visualization, Team Awareness and Coherent Tactical Picture. Despite these terms, SSA seems to remain the term of preference. (Nofi, 2000).

SSA requires building individual SA, sharing individual SA, and developing the group's SSA. We are building individual SA all the time. The most

critical issue in creating SSA is sharing individual SA: it integrates the individual model into a shared model. Building SSA integrates the different individual mental models of the situation. (Perla et al., 2000).

There are clear efforts toward authorities working together on different levels (Table 6 below).

Table 6: Concepts related to how authorities work together (Modified from Frey, Lohmeier, Lee and Tollefson, 2006).

Network	Coordination	Collaboration	Co-creation
Share information for common good	Modify operations to reach common goals	Share resources to reach common goals	Develop common capabilities to reach common goals

In the simplest form, authorities network to share information and their plans. This may then evolve into coordinating plans and operations to reach common goals, and to collaborate on a resource sharing level, and finally to co-create common capacities and innovation (Ruoslahti and Tikanmäki, 2017). In seeking to gain understanding of the process of co-creation of knowledge for innovation, Ruoslahti (2017) finds, by exploring current insights in academic literature on co-creation, that multi-stakeholder networks can be structured for different aims, and four categories of projects were identified.

Co-creation projects may benefit the organization that drives the project, or, secondly, a value chain network (and especially its main driver), a public entity spearheading the co-creation, or in some cases quite evenly the stakeholders of the innovation network. This network cooperation may evolve between these four categories.

Maritime security and its actors are linked to economic and political development (Bueger, 2015). Practices, such as surveillance activities at sea, law enforcement, coordination and naval diplomacy or capacity building may raise the risk of cyber-attacks against shipping and maritime infrastructure. The European Union (EU) raises the potential impacts of natural disasters, extreme events and climate change as security threats on the maritime domain (European Union, 2014). Maintaining a situation picture of these risks help prevent them.

5 CONCLUSIONS

One conclusion is that organizations need information from the environment and events surrounding them and their impact on their own activities. Graphical interfaces that present near real-time information can be shared with other authorities and relevant actors to support reaction capabilities. Situation picture provides a real-time picture of the current situation and an estimate what is going to happen in near future. The United States Department of Defence (2017), for example, describe the Common Situation Picture as an identical display of relevant information shared by multiple commands, which facilitates interactive planning and assists all in the management of situational awareness.

Secondly, there are differences in the definitions of situation awareness, however, what all of them have in common are knowing and understanding of what is happening, and an understanding of possible future changes or problems, predictions of future situations and making decisions on these bases. Situation picture and Situation Awareness are narrow concepts, instead, we recommend (e.g. Lehto et al., 2018), using a broader concept Situation understanding.

Thirdly, Endsley's situation awareness theory can be seen as a fundamental way to make decisions and actions in dynamically changing environment – to realise situation understanding. Organisational theories and models have become an important research challenge, and cybernetics and situation awareness theory relationship is useful to solve issues related to situation awareness-based systems. (e.g. Anjaria and Mishra, 2018). Shared situation awareness remains a reference term, even though it has several synonyms such as common understanding, team shared awareness, shared understanding, distributed cognition, distributed understanding, group situational awareness, shared cognition, shared visualisation, team awareness and coherent tactical picture.

Fourthly, situation understanding of the situation is the understanding of the decision-makers and their assistants about what has happened, the circumstances that have affected them, the goals of the different parties and the possible development options of the events needed to make decisions on a particular issue or subject. (e.g. Lehto et al., 2018).

A further conclusion is that the relative lack of papers dealing with how authorities or the military promote situation picture, awareness, and understanding would seem to indicate that there is a need to further investigate this area. This work is in

progress with systematic searches from master's and PhD level studies and scientific reports. Much is about systems and cyber security of these systems. This is, however, very relevant with today's cyber-physical systems. This work in progress yet lacks an in-depth analysis of the 22 sample articles. This will follow and be published as an extended paper in the near future. Further study of the relevant military context and the study of inter-authority and inter-sector collaboration and co-creation are also recommended.

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