

Exploring Demons for the Establishment of Team Situational Awareness

Kjetil Rustenberg

Department of Information Systems
University of Agder, Norway
kjetil.rustenberg@uia.no

Jaziar Radianti

Department of Information Systems
University of Agder, Norway
jaziar.radianti@uia.no

Terje Gjørseter

Department of Information Systems
University of Agder, Norway
terje.gjosater@uia.no

ABSTRACT

Individual situational awareness (SA) is crucial for building team SA, which is necessary for achieving a shared understanding of a situation, making informed decisions, and taking appropriate actions. This article examines the communication barriers that emerge when transitioning from individual to team SA in emergency management scenarios. We observed two emergency exercises on "ongoing life-threatening violence" and dam failure causing hospital congestion. The study was complemented with interviews with participants of these exercises, aiming at identifying barriers called SA-demons in the team setting. We discovered barriers that hinder the establishment of team SA, including a vicious cycle of mistrust, a fragmented information trap, a false feeling of mastery trap, and a decaying memory trap. These barriers can stem from individual, organizational, or technological factors. To complement existing SA theories, we applied the Cynefin framework and found that standard operating procedures can be potential barriers when transitioning into chaotic or complex domains.

Keywords

Teams SA, Barriers of Team SA, Trust, Cynefin Framework, Information Sharing, Multi-Agency Collaboration, Standard Operating Procedures (SOPs)

INTRODUCTION

Emergency management (EM) response collaboration is complex, as it requires quickly coordinating different organizations, cultures, procedures, technologies, and experiences to respond effectively to a crisis. This requires a high level of coordination and communication among all parties involved and a clear understanding of the different factors that can impact the response effort. Situational awareness (SA) has been extensively discussed in the literature as a prerequisite for achieving team situational awareness (TSA) and eventually a common operational picture (COP) (Bunker et al., 2015; Steen-Tveit, 2022; Steen-Tveit & Radianti, 2019; Wolbers & Boersma, 2013). This article will not discuss COP per se but recognizes the close relations between COP and TSA (Steen-Tveit, 2022).

TSA is a crucial factor in the success of emergency response operations. However, teams often struggle to maintain TSA when collaborating with other agencies, particularly in dynamic and complex environments. SA barriers have been discussed in the literature and are best known as SA demons (SAD) (Endsley, 2017, 2020; Radianti et al., 2021). SADs often refer to the individual barriers of operators working with a critical mission. This article asks if similar barriers emerge when individuals need to establish TSA.

We examined the barriers to TSA that arose during two collaborative exercises; 1) between the police, fire department, and ambulance services and 2) a local hospital that had to handle an incident that exceeded its capabilities. Standard operating procedures (SOPs) ensure consistency and effectiveness in emergency response

operations. However, our research suggests that SOPs can also impact SA during interagency operations and create barriers to TSA in complex dynamic environments. Therefore, we have formulated two research questions:

RQ1) What organizational and personal factors prevent the information acquisition and sensemaking process from supporting TSA establishment? RQ2) What technological barriers occur when technology support hinders the TSA establishment?

This paper is divided into five sections. The following section provides a theoretical foundation, including an overview of the role of trust in EM, the Cynefin Framework, TSA, and a potential research gap. We then present our research method, data collection, and analysis. Our findings, particularly factors that impede the establishment of TSA, are discussed in relation to previous literature and the research questions. The last section summarizes the results and outlines future research directions.

THEORETICAL BACKGROUND

In EM collaboration exercises trust seems to play a key role in quickly establishing TSA (Roud & Gausdal, 2019). Real-world events can be highly complex, something often reflected in exercise narratives. This section presents theoretical perspectives we find relevant to support this understanding.

Evaluation reports after major national events in Norway have discussed the challenges and the role of trust in EM, highlighting the connection between trust, a shared understanding of the situation, and the sharing of information (DSB, 2014; Halvorsen, 2021; Henriksen, 2022; S nderland, 2012). Trust can thus be understood as a prerequisite for TSA. Trust is a complex term, and there is not one consistent definition of it (Roud et al., 2021). Commonly, trust comprises two main pillars: the other (organization, agency, person) being *competent* and the other having *good intentions*. Traditionally, building trust should be nurtured over time, where actors must prove themselves trustworthy to earn the confidence of other actors (Blomqvist & Cook, 2018). This way of building and maintaining trust can be challenging when incidents demand a temporary organization to work together without previous relations with each other. Yet, collaboration can be highly effective and lead to a successful outcome. Meyerson et al. (1996) first explored the mechanisms behind this and called it *Swift trust*. They observed that in some cases, actors that had to work together towards a common goal without having deeper relationships of trust collaborated as if trust was established. *Swift trust theory* posits that temporary teams intermingle as if trust in a traditional sense is already present. The different actors initially assume trust and seek to check and validate this at later stages - and change the assumption if necessary. Common goals are important, and clarified roles are trust-enhancing. Furthermore, Meyerson et al. (1996) argue that a premise for the rapid trust to be maintained is that the members take responsibility and behave responsibly. A key factor is prioritising effective communication and information sharing (Meyerson et al., 1996).

Complexities, Sensemaking and Decision Making

Cynefin framework (Hasan & Kazlauskas, 2009; Kurtz & Snowden, 2003; Snowden, 2002; Snowden, 2005; Vasilescu, 2011) is a conceptual framework and can be used as a guide to view decision-making processes. The Cynefin framework offers decision-makers a "sense of place" from which to view their perception (Browning & Boud s, 2005).

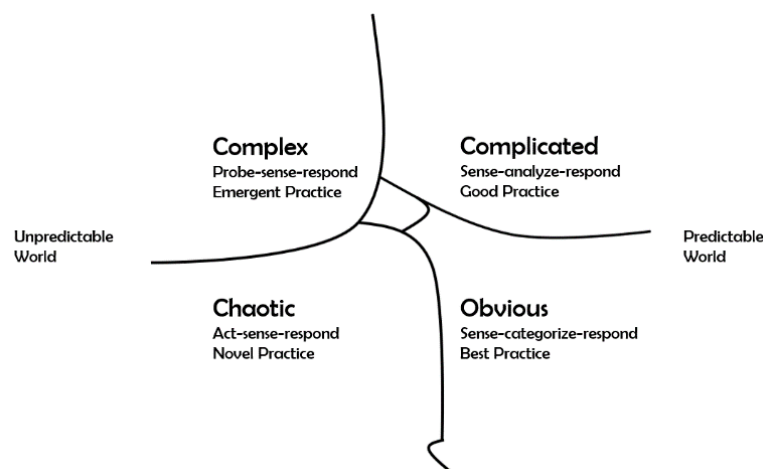


Figure 1 The Cynefin framework.

With the Cynefin framework (Figure 1), Dave Snowden made a distinction between the world of the ordered and the world of un-ordered. A key feature of the ordered is that it is predictable. The unordered is recognized by being unpredictable (Kurtz & Snowden, 2003; Snowden, 2002). In the predictable world, repeating patterns are expected, but in the unpredictable world, events do not repeat like before. The framework separates the predictable world into two domains: the domain of the obvious and the domain of the complicated. In the obvious domain, there is a high level of agreement and a tight connection between cause and effect. Actors can rely on best practices that will give predictable outcomes. Information sharing follows the lowest common denominator, and SOPs and protocols are legitimate. When actors are in this domain an approach to a problem would be to first sense that something is wrong, categorize it as a car accident for example, and then respond to the situation. In the complicated domain, the connection between cause and effect is known but not obvious to everyone. Due to the higher abstraction level, experts are needed to clarify. Opinions among experts may vary, but overall, there is agreement on the fundamentals. In this domain, the understanding of best practices is challenged since experts may disagree on what is the best. A good practice is supported by research and expertise and can give a predictable outcome, but this process demands time, intelligence, and opportunity. Therefore, when sensing that something is wrong the next step will be to analyze the situation, and from that derive a good solution.

When entering the unpredictable, actors cannot expect things to repeat like before. The unpredictable world is separated into the domain of the chaotic and the domain of the complex. In the chaotic domain there are no identifiable patterns since all connections that enable the identification and influence of patterns of interactivity have broken down. Everything in this domain is new. An example of this could be a terrorist attack, or a nuclear accident. When faced with the chaotic domain, actors must first act and try to sense what is going on. By acting they can explore and intervene in the situations and try to make a context that enables them to identify patterns. In the complex domain components and interactions are changing. Thus, a human system is complex because humans have many identities and fill many different roles, making the system irreducible. Cause and effect cannot be separated since they are intertwined. In this domain actors must first probe, and experiment to identify patterns that can be disrupted and reinforced.

Team Situational Awareness (TSA)

Stout (1995) argues that one common feature of all definitions of teams is the need for team members to share and engage in cooperative action. A team is "a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/objective/ mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of membership" (Salas et al., 1992). Critical features of a team include (1) a common goal, (2) interdependence, and (3) specific roles. Communication and cognition are emphasized as important for team performance (Salas et al. 2015). Endsley describes SA as an individual process that only exists in the cognition of the human mind. TSA can be defined as "the degree to which every team member possesses the SA required for his or her responsibilities" (Endsley and Jones 2001). In her stratified model of team SA, she describes how teams develop high levels of SA across its members. The model has the following elements: (1) requirements, (2) mechanisms, (3) devices and (4) processes (Endsley & Jones, 2001).

TSA requirements consist of information at each of the three SA levels: Perception of data, comprehension of relevance to individual and team goals and projection in the form of action of the team members. Devices address means of communication, like verbal or non-verbal, visual, audio and a shared environment. Endsley describes the mechanisms of TSA as dependent on the shared mental models of team members. If two or more team members lack a shared mental model, they will understand and interpret data differently, thus not achieving TSA. There is much research on factors affecting group decision making and performance (Endsley & Robertson, 2000; Salas et al., 2015; Stout et al., 2017). Endsley summarizes some core findings in her category of processes. Ineffective teams are recognized by factors like failure to prioritize, reliance on expectations and unwillingness to deal with false expectations. Effective teams are recognized by strong, internal norms where they question their understandings as a group, they coordinate and prioritize adequately.

Research Gaps

Based on the theoretical background, document reviews and previous studies we can summarize the following research gaps:

- The importance of trust and swift trust in EM is well known (Altschuller & Benbunan-Fich, 2008; Sabou & Videlov, 2016; Weijman & Meesters, 2020; Yu & Khazanchi, 2019), but research is still needed to effectively implement trust, and principles derived from swift trust theory in SOPs for EM.
- Although the Cynefin framework has been used in relation to EM (Browning & Boudès, 2005; French & Niculae, 2005), the framework application for EM exercises and the use of SOPs in this context, is still scarce.

- Limited topics on the role of memory, ad-hoc teams, fragmented information, and technologies have been linked to TSA barriers in the EM context.

METHOD

In this study we apply qualitative research methods to capture the complexities of EM processes and TSA demons emerging in practice.

Data Collection Method

The data in this study emanated from three different sources: an observational study of exercises, interviews, and document reviews. In the observational studies, we followed the fire-, police-, and ambulance department in three full-day exercises (See the cases for further information on trained scenarios). We also observed a full-scale exercise with elements of serious game involving a broad specter of stakeholders from the EM domain. We argue that an observational study approach is well suited to capture the complexities of EM processes as we recognize collaboration during crisis scenarios as demanding an emergent practice, and sometimes novel approach. To minimize observer bias we used a standardized observer guide and triangulated results with extensive interviews with EM practitioners.

Table 1 Informants of the study

Respondent Code	Organizations	Roles/ Responsibilities
R1	Police	Police officer / Incident commander
R2-R5	Police	Police officer
R6	Fire Department	Fire officer / Incident commander
R7-R10, R12	Fire Department	Fire officer
R11	Fire Department	Fire officer / Incident commander
R13	Paramedic/EMT	Paramedic / Instructor / Incident commander
R14	Paramedic/EMT	Paramedics trainee
R15-R19	Paramedic/EMT	Paramedic

The interviews with nineteen emergency practitioners (Table 1) were mostly conducted as focus group interviews, except one interview that was done individually. Depending on circumstances, interviews varied from 10 to 60 minutes. All interviews were transcribed immediately after the exercises and analyzed in NVivo. We used a semi-structured interview guide with open-ended questions. The interviews were conducted during and throughout the exercises, often during the transport stage between exercise elements. Five interviews were done in firetrucks, police cars, and ambulances, while one was conducted in a lounge at a fire station, and one at an ambulance station. This form of interview has an ethnographic pitch. The interviewer has a practitioner's background, knowledge and personal relationships with some actors that gives opportunity to access some situations where it can otherwise be challenging to get, such as insight into procedures and action cards that are classified as secret and excluded from the public. Since he already has this background, he could follow actors from the police, fire, and health closely, without any restrictions, but should comply with non-disclosure of confidential information.

Document Review

We reviewed various local and national guidelines, as well as evaluations of real emergency situations, to understand better of how EM is practiced in Norway at various levels. Our goal was to assess how current regulations, procedures, and work processes operated during real emergency events. By having established procedures and protocols as part of their preparedness, organizations can promote stability in both information sharing and decision-making (Luukkala & Virrantaus, 2014). We had a particular interest in guidelines and SOPs that enabled collaboration and information sharing in incidents requiring interagency collaboration. In a Norwegian context, the National Triple Notification Alert Routines (NTARs) for the emergency centers (110 - fire service, 112-police, and 113-ambulance) is an example of a procedure that ensures collaboration cross sectors and has an early, shared understanding of the situation between the three mentioned organizations as a main goal. The creation of this procedure is a direct result of a real incident occurring in 2013, where what was initially misperceived as a bus accident later turned out to be a terrorist attack (DSB, 2014). The evaluation of the incident response showed that poor information sharing between the agencies resulted in insufficient interaction between the agencies involved. The NTAR ensures early warning of all three agencies, structured information gathering and sharing, and early response in nine defined incidents: bomb threat, fire in a building, CBRNE (Chemical, Biological, Radiological, Nuclear, and Explosive materials), tunnel accident, accident at sea, avalanche, traffic

accident, and Ongoing Life-threatening Violence (OLV, PLIVO in Norwegian). The PLIVO part of the procedure can be seen as a separate procedure. The procedure is designed to ensure a timely response to life-threatening violence. It governs the actions and cooperation of emergency services in hazardous situations. The police, fire, and health departments have collaborated to create a joint procedure for dealing with incidents where multiple individuals are in danger of life-threatening violence. In PLIVO incidents, emergency responders are expected to follow a specified protocol that may involve taking higher risks than normally accepted to save lives and eliminate the threat. This requires proper training, understanding of individual roles, managing procedural elements, and collaborating with other agencies. The procedures establish roles and actions that deviate from normal conditions and supports actors when potentially transitioning from the domain of the obvious to the domain of the chaotic, following challenging incidents.

The Cases for Data Collection

The data collection used in this study originated from two EM exercises. In both exercises participants drilled the use of SOPs that regulated behavior when faced with challenging and potentially chaotic incidents.

PLIVO Exercise

The main author participated in PLIVO exercises together with practitioners from the tactical level of the police department, fire department, and ambulance services, every Monday over a three-week period, during the winter of 2022, except the planning stage. During each exercise, there were approximately fifty participants. The police had, on average, the greatest presence. Then the fire department and ambulance services. The aim of the exercise was to practice the execution of the PLIVO SOP. The exercises were situated at a fire station. The participants were divided into interdisciplinary groups and distributed over three separate locations. At two of the locations, the participants encountered realistic scenarios where they had to interact to deal with ongoing violence. At the last station, participants had plenary debates, and a tabletop exercise where they collaborated on a PLIVO case. While maintaining the role as an observer, the author was also given time slots to conduct interviews.

Titania Exercise

In this exercise the main author observed the collaboration between a local hospital's management, municipalities, ambulance services, and neighboring hospitals from the hospital's command room. The exercise was initiated as a collaboration between the neighboring counties RG and AG, both with a population between 300,000 and 400,000. The state administrator in RG County organized the exercise to practice an evacuation scenario related to the risk of a dam failure in the reservoir at the Titania power plant, which could cause catastrophic damage to a nearby town with approximately two hundred residents. In addition, there were other weather-related incidents, such as rock falls and a minibus accident with students from a neighboring municipality's upper secondary school. Twelve different organizations participated in the exercise, including police and health management from both counties, County Governors, and the Norwegian Water Resources and Energy Directorate. The exercise aimed to train all actors involved in managing a severe incident, plan for such a scenario, and strengthen crisis management skills. The stakeholders' goal was to understand each other's roles, responsibilities, and tasks. The hospital management wanted to train the operational level of the local hospital, test their ability to cooperate internally, across agencies, and county boundaries, and improve communication and interaction across regional healthcare organizations.

Data Analysis Method

Interviews and observations were coded using NVivo, and categorized thematically using Endsley's already-defined SADs (Endsley & Connors, 2008; Stratmann & Boll, 2016). Then the initial codes were categorized as organizational or personal factors, or technological factors, in line with our RQs (Table 2).

Table 2 Overview of Situational Awareness Demons (SADs)

	SAD	Examples of Organization/ Personal Factors	Examples of Technological Factors
SAD 1	Attention Tunneling	Focusing on one element of a major event in the Titania exercise.	Fumbling with radio earbud in a critical moment of PLIVO exercise
SAD 2	Requisite Memory Trap	-	-
SAD 3	Workload, Anxiety, Fatigue, and other Stressors	The connotations of the “PLIVO” (OLV) acronym	
SAD 4	Data Overload	Participant in PLIVO exercise says that receiving information both over radio and on scene was too much	Information was fragmented due to many information systems active in Titania exercise
SAD 5	Misplaced Saliency	-	-
SAD 6	Complexity Creep	Different radio sets challenged information sharing	Emergency managers lacked training in use of digital documentation tool
SAD 7	Errant Mental Models	Differing understandings of core factors in PLIVO procedure	-
SAD 8	Out-of-the-Loop Syndrome	-	-

Our analysis found that SADs 1, 3, 4, 6, and 7 were active as barriers to the establishment of TSA during the observed exercises. In addition to our structured approach, we took an exploratory approach to identify potential new barriers by reflecting on the findings from the perspective of perception and comprehension. We also conducted two small workshops where the insights used to confirm the existence of these potential new barriers. Our analysis led to the discovery of four new explorative barriers to TSA:

Table 3 Overview of new, explorative situational awareness demons

	New SAD	Examples of Organization/ personal Factors	Examples of Technological Factors
New SAD 1	Virtuous Trust Cycle	Reluctancy to share information with collaborating agencies	-
New SAD 2	Decayed Training Memory	Long time between training sessions, and rare examples of real-life incidents	-
New SAD 3	False Feeling of Mastery	Perceived mastery of EM from an exercise setting lead to over confidence in own abilities in real-world situation.	-
New SAD 4	Fragmented Information Trap	-	Multiple channels to communicate and collect information

Note that this paper does not cover all of Endsley's SADs but focuses on a logical connection between empirical findings, the most relevant SADs, and explorative demons.

FINDINGS AND DISCUSSION

In this section we present our findings in relation to our research questions. Our result section is organized into two parts: Organizational and Personal Factors, and Technology as Barriers to receiving Information. We have used closed-loop models to illustrate the complex cause-and-effect relationships of new SADs, as described by our informants.

Organizational and Personal Factors

In an organizational and personal perspective, we will first describe findings of two of Endsley's known Demons: *Workload, Anxiety and Other Stressors*, and *Errant Mental Models*. Then we will present our explorative demons, with findings that support their existence in the EM context, *i.e.*, *Virtuous Trust vs. Vicious Mistrust Cycle*, *Decaying Training Memory*, *False Feeling of Mastery* and *Fragmented Information Trap*.

Workload, Anxiety, and other Stressors

Although the observed exercises were fictional, the participants experienced elements that gave them sensations of high-stress, workload, time pressure and information overload. Even though real stress can be hard to simulate, doing exercises like the ones we observed can help participants build mental models that is applicable in real-life scenarios. Many of the respondents (R1, R2, R9, R10, R13, R15 and R18) argue that using an acronym like PLIVO (OLV) for this kind of exercise helped them in establishing a mental model. R1 says: *“The word PLIVO then. In other words, when the message goes out... then it’s. All right. Just drive on. If it is defined as PLIVO, then we go beyond what we call normal. (...) Personal security, for example (...) if it is PLIVO then it is urgent. Personal safety comes at the expense of completing the assignment.”*

R2 described what it did to her, both mentally and physically:

“You envision dead bodies. Lots of screaming and blood. An absolutely terrible and stressful situation. This is something I think we will all feel strongly about. I imagine that for my own part I will have many bodily reactions. Such as sweating and having to take a few deep breaths. It can probably pay off. To gain control over the body. But you think the worst when you hear PLIVO. You are entering a worst-case scenario state. Because a lot needs to be done before PLIVO is read out.”

Both R1 and R2’s descriptions can be seen in relations to Endsley’s third demon, where stress and anxiety can be a barrier to TSA. R2 describes this in a very precise way when she says:

“Stress levels affect hearing. And high sound levels in the place you are at do something with your hearing. So even if something is said over the radio, it can go unnoticed. Because you see so much, you hear so much, you talk to so many people out there. And then you can’t be in both places. So, there’s a lot in this exercise that I’m not going to get into. It is guaranteed.”

Hearing impairment can fragment information and thus be a barrier to TSA. R2’s description of *being in both places* is interesting. We interpret that R2 understands her physical presence and her *being* in the sense of receiving information from a virtual place as separate entities. Having a presence in two places increases the amount of information that must be individually processed and can further lead actors from SAD 3 and over to SAD 4 where they experience data overload. Also, when basal understanding of terms differs from actor to actor there is a risk of errant mental models.

Errant Mental Models

A discussion between R3 and R4 exemplifies this. R3 says: *“There seems to be several understandings of what “ongoing” really means”*, and R4 replies: *“Definitely. But when you hear PLIVO being called out you are never in doubt.”* From observation of plenary discussions R4’s assumption is challenged. There was actual doubt among actors of how the word *ongoing* should be interpreted. R13 says that to him *ongoing* means: *“It’s an action that happens now. We have little time because it is happening now. And it must be stopped.”* From one discussion we observed the perspective of what was happening *now* varied between organizations. One example would be a person threatening a third party with a weapon. The police were reluctant to call this *ongoing* violence, and by that triggering the PLIVO SOP, while the paramedics argued that if the situation had *potential* of becoming life threatening, they wanted to be alarmed proactively. One police officer argued that events where people were being threatened was “business as usual” and that it most often went well on a low level. Using the triple alert procedure or calling such incidents PLIVO would only create unnecessary noise on the radio and hinder them in doing their job smoothly. This argumentation was counter argued by a paramedic who said that alerting the hospital and preparing a trauma team to receive a gun shooting victim could take up to fifteen minutes at best, so time in such incidents would be of importance. Actors had different strategies when trying to get a mental model before entering the PLIVO scenario. R1 said that: *“I want as much information as possible. The more information we get, the better we can prepare”* while R5 argued for another approach: *“I try to detach myself from it a bit. I have participated in so many exercises before. I am always surprised.”* This suggests that forming mental models is a personal process. When relying on SOPs as aids, trivial details, such as a single word with multiple meanings, can result in errors and hinder effective collaboration. It is important to ensure that all parties involved have a clear understanding of the terminology used to avoid confusion and misunderstandings.

Virtuous Trust vs. Vicious Mistrust Cycle

From *swift trust theory* willingness to share information can be trust strengthening. Reluctance can thus weaken

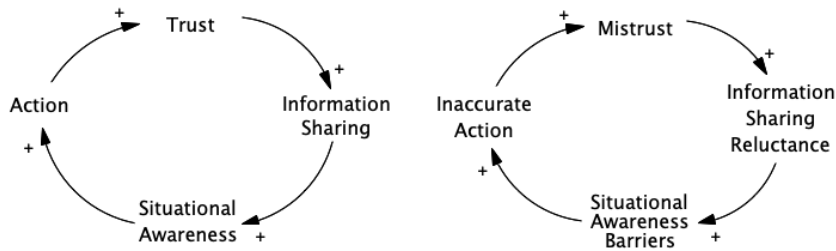


Figure 2 Virtuous Trust (left) and Vicious Mistrust Cycles (right)

trusting behavior. Willingness to share information is illustrated in Figure 2 (left) as a virtuous cycle of trust. In this cycle the collaborators, individual organization or responders are willing to share information to the team. This can contribute to the establishment and strengthening of TSA. Our study found that in a *vicious mistrust cycle* the positive cycle could be counteracted, and thereby weaken TSA (Figure 2. Right). Mistrust could cause individual responders to be reluctant to share information and create impediments for TSA building. This can be exemplified by R1’s statement: “Well, when you are out on the scene people tend to talk freely. But afterwards it is a whole different issue. Then the paramedics will not even tell us what hospital the patients went to.” In the PLIVO collaboration context, trust is crucial for the team’s success. This trust can be challenged when one part is reluctant to share information.

The word “trust” had different meanings for interviewees, but it was often associated with *trusting in* a person or a role. As an example, R13 deemed the role of incident commanders as trusted, thus he put some degree of confidence in that the police’s verbal information was correct. R13 explained why trust in each other was important:

“It’s because we are involved in many time-critical incidents in this job, which means that we must have confidence that we carry out the job as we are supposed to do it. I shouldn’t have to ask a certified colleague to provide open-air ways and put patients in a stable lateral position. I have confidence in that it will be done”.

Collaborating with unfamiliar agencies could be challenging and make it difficult to establish trust. This lack of trust can lead into a cycle of mistrust, making it harder for the agencies to understand each other’s strengths and weaknesses.

Decayed Training Memory

Skill decay is a well-established concept in EM (Arthur Jr et al., 2013; Woodman et al., 2021; Zautcke et al., 1987). Addressing this as a potential TSA demon is deemed appropriate. The similar PLIVO exercises happened every two years. Respondents argue that training for the SOP on your own, or in a small scale was difficult. Real PLIVO incidents are rare in a Norwegian context. From the time the PLIVO procedure was implemented and until 2022 it has been used only fifteen times. In the proximity of observed context, it had never been deployed.

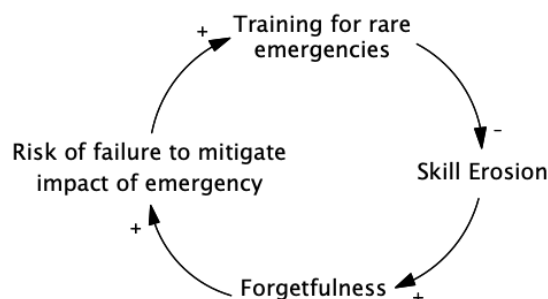


Figure 3 Decayed Training Memory Loop

When time between exercises and real-life events is so long, there is a chance that skills and knowledge of the responder decay so that when faced with an incident that demand a certain type of action, the learned techniques and behaviors may be wrongful and inadequate. This can lead actors in a *Decayed Training Memory*-loop, where

the eroded skills and knowledge can challenge SA on an individual level, and further be a barrier to TSA in the case of a real event (Figure 3).

False Feeling of Mastery

During the PLIVO exercise, the real-play scenarios were played out twice. In the first-round participants were allowed to make mistakes. In the second round they played out fairly exact scenario, but then the participants were familiarized with the incident narrative and went into known surroundings. Instructors and exercise planner argued that this approach was supported in previous experiences where PLIVO exercises tended to get very large and complicated, sending participants off with a feeling of failing and not mastering the procedure. The earlier exercises were dimensioned to meet a large and complex attack, like Norway experienced in a terrorist attack on the 22nd of July 2011. R13 remembered how the first exercises was conducted:

“When we started with PLIVO exercises, then... when we look back on it now, it was almost taken out of context for what it was... All personnel had to enter the building. It was heavy caliber automatic weapons that were fired. So... We had no chance of succeeding in those scenarios.”

The instructors made a change by adapting training scenarios to resemble later actual events from Norway, where the scenario was more limited, and the used weapons were knives, and not bombs or high caliber rifles. They assumed that due to the time limitation, these scenarios had a better learning outcome, and participants would leave with a good feeling of mastery. This would increase self-confidence in the event of a real PLIVO incident. R13 explains:

“You have to have confidence. It is a prerequisite for success. If you don't have confidence in a PLIVO, it's not certain that it will go so well. So, but it shouldn't be a false confidence. The balancing act is, after all, that there should be ... the possibility of success in an PLIVO incident.”

Although we acknowledge the beneficial values of training and experiencing mastery, we also acknowledge that one-time experiences of success can lead to actors having a feeling of mastery that will not be correlating with real abilities that will be needed to take correct actions in the case of a real PLIVO event (Figure 4).

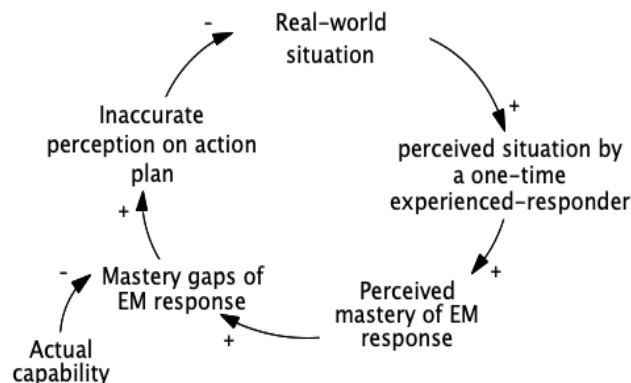


Figure 4 False Feeling of Mastery Loop

R9 reflected on how he would react in the case of a real PLIVO incident:

“It's hard to imagine. Now we know what we are going to do. We know it's an exercise. But it's hard to say. Maybe you do the right things when you're stressed? You're not as stressed now.”

R9 expressed that one of the differences between exercises and real event: *the uncertainty*—both in the actual event, but also how he would react to it on an individual level. If training and experiencing success could have any down sides, R13 considered that there was a danger that leaving the exercise with a feeling of mastery could made participants felt overly confident in their own abilities. Regardless of these disadvantages, R13 noticed more positive benefits by sending the participants off with higher self-esteem.

Technology as Barriers to Receiving Information

We observed that in some situations the technology in use was a barrier for achieving information. In this section we describe demons where changeable technology is the main causal barrier to TSA. First of is the *Fragmented Information Trap*.

Fragmented Information Trap

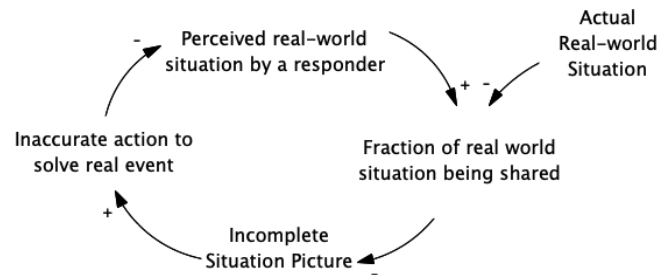


Figure 5 Fragmented Information Trap

The *fragmented information trap* (Figure. 5) captures the discrepancies between the actual-world situation, and the perceived real-world situation that responders understand due to fragmented information. As a result, actors might get incomplete information about the situation which can lead into inaccurate action to solve the real events. R11 as a firefighter and incident commander, explained the fragmented information problem as follows:

“I am the only one who goes with a double set of radios. I am the only one who has contact with the police and the ambulance. So, I have to try to copy the messages I can. The others are only on our work channel, not a common channel.”

Information fragmentation can originate from the fact that there were multiple channels to communicate and collect information, and not all team members were connected to the same channel as the team leader. R11 tried to get his crew to put the radio in the firetruck in a shared radio channel to ensure that all would get the same information during the response phase. Still, they depended on him for further information when they left the vehicle. The first responders typically have only one communication channel through an earplug, so the incident commander plays a crucial role in communicating with them. In the exercise, we observed participants that did not listen to the collaborative channel, something that fragmented their information gathering from an early stage and leading to inaccurate action.

EM responders also depended on the operations center to gather as much information as possible from callers but recognized that the information might be wrongful due to the caller’s perception of reality. For instance, R7 had experienced responding to gunshots, which turned out to be doors slamming. R1 argued that during the initial stage of an operation, it is critical for team members to listen to the information provided by those who arrived on the scene first. This is because information may be fragmented and can give an incomplete situation picture (Figure 5). He argues that communication on the scene is key, and team members should talk to one another, shout out any potential hazards, such as “knife,” and report it to the team leader. R2 experienced another example that we observed. She had to change her earplug, when the alarm went off and a the PLIVO training started. R2 described what happened as: *“The thing is that I can’t get the sound through the earplugs again when I’ve spoken into the radio. When others speak it is completely locked, so I have to wait until it is quiet before I can... and if someone speaks... and in the meantime, all the sound goes out on the speaker. This thing is a bit old fashioned. And then I don’t get to do much. I just have to sit and wait until there is a quiet moment. And it can take time if the radio is busy”*.

In the Titania exercise we also observed the fragmented information trap (Figure 5). Complexity increased when time became sparse and tension rose, when a report of a minibus accident only ten minutes away from the hospital involving fifteen people came in. Initial information reported major damage to the bus, and four ambulances were sent to the scene. This game-element was played out at a time when the hospital management was busy handling the potential outcome of the dam leakage. The management was trying to solve issues related to handling evacuees from the scene and entering the hospital into a higher state of alert when new information came in. Information in this phase came from the medical emergency central to the staff through a third system with no alarms or warnings when new information was published. This led the staff into the fragmented information trap, where information about the actual event was delayed and inadequate, and actions and decisions about how to handle it were hampered.

The aim of our paper is to broaden the understanding of the challenges that EM actors experience when they must collaborate, build and maintain TSA. To do this we have used the Cynefin framework, together with trust- and SA theories as lenses so that we can address identified elements that we argue have the potential to build or maintain *barriers* to TSA. We argue that, although it is not explicitly expressed, the main goal of both exercises was to prepare the participants to face incidents which will require them to make a transition from the predictable to the unpredictable. It is imperative for the temporary organization to commence its endeavors in an efficient

manner in order to facilitate a positive collaboration in the face of uncertainty and potential chaos. The establishment of a strong foundation is crucial for the success of the collaboration and the maintenance of a healthy collaborative environment. They must understand where they are, in place and time, and understand collectively that entering into the unknown can challenge the premises they start off on. We have observed *swift trust* emerging in all exercises. For example, in the PLIVO exercises there was strong focus on building a sense of shared identity. Instructors repeatedly argued that all the participants were in the exercise together, and they used the term “bluelight-family” when they addressed the participants in plenary. Also, focus and understanding of the importance of clear communication and clear goals is trust strengthening, according to swift trust theory. To understand, nurture and build on these mechanisms we argue can be fundamental for a successful outcome of a future crises.

A key learning goal in the Titania exercise was to evaluate whether procedures and protocols that regulated how the hospital should manage a crisis were sufficient, and the main idea behind the PLIVO is to gain a shared understanding of a situation quickly, and to enable a temporary organization to work together. The procedures define roles and tasks, working boundaries and facilitate information sharing. Thus, the procedures can be well suited to prepare EM actors to take the transition from known to a chaotic situation. But “SOPs are only SOPs as long as they work”, as one of the participants at Titania put it. Small details, like the use of the word *ongoing* can influence TSA dramatically in the case of a real event. If SOPs or attempts at following SOPs hinder correct action and decisions, they embody a potential source of failure. The execution of the procedure per se has a potential of success founded on swift trust, but we have identified several challenges that can be seen as barriers to this both on the individual and organizational level and on the technical.

CONCLUSION

In this paper we have pointed at potential TSA barriers from organizational, personal, and technological viewpoints, according to our research questions. These barriers can prevent the information acquisition and sensemaking process from supporting the TSA. Through interviews with EM responders who participated in the exercises discussed in this article, we identified several known barriers, or 'demons' as suggested by Endsley and Connors (2008), that hinder the establishment of a TSA in EM. In this paper, we extend the SAD framework and explore whether these barriers are present in a multi-agency collaboration in the EM context. To elaborate on the barriers towards information acquisition, sensemaking, and the establishment of TSA, we draw on the theories of swift trust and the Cynefin framework as complements to the TSA theory. Our study confirms the relevance of some of the previously identified demons and introduces new concepts as findings.

Our future work will investigate more details on the trading zone process (Bunker et al., 2015; Wolbers & Boersma, 2013), i.e., negotiation process among EM organizations to achieve a common situational understanding. In a team context, situational awareness (SA) can be approached in two ways: TSA, which involves an organization's awareness of information relevant to achieving its objectives, and shared situational awareness (Shared-SA), which involves a team's focus on information relevant to all members. However, in EM settings, where obtaining SA relies on information exchange, it remains unclear how this contributes to TSA and Shared-SA. Many significant questions remain unanswered in this area.

Limitations: the contributions developed in this paper are derived based on *the current practices* in Norway based on two EM exercises and documentation and evaluation of real cases. The authors are aware that when it comes to the technology barriers, we are not considering TSA theories that link to human-automation teaming, ad-hoc human-machine teaming, human-AI teaming, experimental human-robot teaming, which may be relevant especially if such technologies are used more in the day-to-day practices. We also did not consider the TSA measurements that may be relevant for further studies, based on our findings (Cain & Schuster, 2016; Lu et al., 2008; Salmon et al., 2006).

ACKNOWLEDGMENTS

We thank all informants who supported us in this study.

REFERENCES

- Altschuller, S. and Benbunan-Fich, R. (2008) *Potential Antecedents to Trust in Ad Hoc Emergency Response Virtual Teams*. Proceedings of the 5th International ISCRAM Conference.
- Arthur Jr, W. Day, E. A., Bennett Jr, W., and Portrey, A. M. (2013) *Individual and Team Skill Decay: The Science and Implications for Practice*: Routledge.
- Blomqvist, K. and Cook, K. (2018) Swift Trust-State-of-the-Art and Future Research Directions. In (pp. 29-49).
- Browning, L. & Boudès, T. (2005) The Use of Narrative to Understand and Respond to Complexity: A

- Comparative Analysis of the Cynefin and Weickian Models. *E:CO*, 7(3-4), 32-39.
- Bunker, D. Levine, L., and Woody, C. (2015) Repertoires of Collaboration for Common Operating Pictures of Disasters and Extreme Events. *Information Systems Frontiers*, 17(1), 51-65.
- Cain, A. A. & Schuster, D. (2016) *Applying Measurement to Complementary Situation Awareness*. Proceedings of the 2016 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support, CogSIMA 2016.
- DSB, T. N. D. f. C. P. (2014) The Valdres Express: Evaluation of the Authorities' Handling of the November 2013 Incident.
- Endsley, M. and Jones, W. M. (2001) A Model of Inter and Intra Team Situation Awareness: Implications for Design, Training and Measurement. *New Trends in Cooperative Activities: Understanding System Dynamics in Complex Environments*. CA, 46-67.
- Endsley, M. R. (2017) Toward a Theory of Situation Awareness in Dynamic Systems. In Salas, E. (ed.), *Situational Awareness* (pp. 9-42): Routledge.
- Endsley, M. R. (2020) Situation Awareness in Teams: Models and Measures. In *Contemporary Research* (pp. 1-27): CRC Press.
- Endsley, M. R. and Connors, E. S. (2008) *Situation Awareness: State of the Art*. Proceedings of the 2008 IEEE Power and Energy Society General Meeting-Conversion and Delivery of Electrical Energy in the 21st Century.
- Endsley, M. R. and Robertson, M. M. (2000) Situation Awareness in Aircraft Maintenance Teams. *International Journal of Industrial Ergonomics*, 26(2), 301-325.
- French, S. and Niculae, C. (2005) Believe in the Model: Mishandle the Emergency. *Journal of Homeland Security and Emergency Management*, 2(1).
- Halvorsen, J. (2021) *Evaluation: The Rescue Operation and the Acute Handling of the Crisis During the Quick Clay Landslide at Gjerdrum*. The Norwegian Directorate for Civil Protection (DSB)
- Hasan, H., and Kazlauskas, A. (2009). *Making Sense of Is with the Cynefin Framework*. Proceedings of the Pacific Asia Conference on Information Systems (PACIS) Hyderabad, India: Indian School of Business.
- Henriksen, S.V., Hoel, L., Kruke, B.I., Myhrer, T.G. (2022) *Evaluation of Pst's and the Police's Handling in Connection with the Kongsberg Incident on 13th October 2021*. The Norwegian Police Directorate
- Kurtz, C. F. and Snowden, D. J. (2003) The New Dynamics of Strategy: Sense-Making in a Complex and Complicated World. *IBM systems journal*, 42(3), 462-483.
- Lu, J., Zhang, G. and Wu, F. (2008) Team Situation Awareness Using Web-Based Fuzzy Group Decision Support Systems. *International Journal of Computational Intelligence Systems*, 1(1), 50-59. doi:10.1080/18756891.2008.9727604
- Meyerson, D. Weick, K. E., and Kramer, R. M. (1996) Swift Trust and Temporary Groups. *Trust in organizations: Frontiers of theory and research*, 166, 195.
- Radianti, J. Gjørseter, T., and Chen, W. (2021) *Slaying the Sa-Demons–Humans Vs. Technology—a Content Analysis*. Proceedings of the 18th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2021).
- Roud, E., and Gausdal, A. H. (2019) Trust and Emergency Management: Experiences from the Arctic Sea Region. *Journal of Trust Research*, 9(2), 203-225.
- Roud, E., Gausdal, A. H., Asgary, A., and Carlström, E. (2021) Outcome of Collaborative Emergency Exercises: Differences between Full-Scale and Tabletop Exercises. *Journal of Contingencies and Crisis Management*, 29(2), 170-184.
- Sabou, J. and Videlov, S. (2016) *An Analysis on the Role of Trust in Digital Humanitarian Actor Networks*. Proceedings of the ISCRAM 2016 Conference, Rio de Janeiro, Brazil.
- Salas, E. Dickinson, T. L., Converse, S. A., & Tannenbaum, S. I. (1992) Toward an Understanding of Team Performance and Training. In R. W. Swezey & E. Salas (Eds.), *Teams: Their Training and Performance* (pp. 3-29): Ablex Publishing.
- Salas, E. Shuffler, M. L., Thayer, A. L., Bedwell, W. L., and Lazzara, E. H. (2015) Understanding and Improving Teamwork in Organizations: A Scientifically Based Practical Guide. *Human resource management*, 54(4), 599-622.
- Salmon, P. Stanton, N., Walker, G., and Green, D. (2006) Situation Awareness Measurement: A Review of Applicability for C4i Environments. *Applied Ergonomics*, 37(2), 225-238. doi:10.1016/j.apergo.2005.02.001
- Snowden, D. (2002) Complex Acts of Knowing: Paradox and Descriptive Self-Awareness. *Journal of knowledge management*, 6(2), 100-111.
- Snowden, D. (2005) Strategy in the Context of Uncertainty. *Handbook of Business Strategy*, 6(1), 47-54. doi:10.1108/08944310510556955
- Steen-Tveit, K. (2022) From Common Operational Picture to Common Situational Understanding: A Framework for Information Sharing in Multi-Organizational Emergency Management. [Doctoral dissertation].

University of Agder.

- Steen-Tveit, K. and Radianti, J. (2019) *Analysis of Common Operational Picture and Situational Awareness During Multiple Emergency Response Scenarios*. Proceedings of the 16th International ISCRAM Conference.
- Stout, R. J. (1995) *Planning Effects on Communication Strategies: A Shared Mental Model Perspective*. Proceedings of the Human Factors and Ergonomics Society Annual Meeting.
- Stout, R. J. Cannon-Bowers, J. A., and Salas, E. (2017) The Role of Shared Mental Models in Developing Team Situational Awareness: Implications for Training. In Salas, E. (ed.), *Situational Awareness* (pp. 287-318): Routledge.
- Stratmann, T. C. and Boll, S. (2016) Demon Hunt-the Role of Endsley's Demons of Situation Awareness in Maritime Accidents. In *Human-Centered and Error-Resilient Systems Development* (pp. 203-212): Springer.
- Sønderland, O. D., Eriksen, B.K., Frøyland, E., Krogstad, E., Paulsen, T., Stavdal, Ø. (2012) *22 July 2011: Evaluation of the Police's Efforts*. Retrieved from: https://www.regjeringen.no/contentassets/bb3dc76229c64735b4f6eb4dbfcd8/en-gb/pdfs/nou2012_14_eng.pdf
- Vasilescu, C. (2011) Strategic Decision Making Using Sense-Making Models: The Cynefin Framework. *Defense Resources Management in the 21st Century*, 6(6), 68-73.
- Weijman, S. and Meesters, K. (2020) *Shifting Control and Trust: Exploring Implications of Introducing Delegated Decision Support Systems*. Proceedings of the 17th ISCRAM Conference.
- Wolbers, J. and Boersma, K. (2013) The Common Operational Picture as Collective Sensemaking. *Journal of Contingencies and Crisis Management*, 21(4), 186-199.
- Woodman, S. Bearman, C., and Hayes, P. (2021) Understanding Skill Decay and Skill Maintenance in First Responders. *The Australian Journal of Emergency Management*, 36(4), 44-49.
- Yu, X. and Khazanchi, D. (2019) *The Influence of Swift Trust on Virtual Team's Sensemaking in Crisis: A Research Model*. Proceedings of the 16th International ISCRAM Conference
- Zautcke, J. L. Lee, R. W., and Ethington, N. A. (1987) Paramedic Skill Decay. *The Journal of Emergency Medicine*, 5(6), 505-512.