

22nd ICCRTS

Track 4: Cognitive and Socio-technical Challenges

**The common operational picture:
A powerful enabler or a cause of severe misunderstanding?**

Author:

Ulrik Spak, PhD, Swedish Defence University

Point of contact:

Ulrik Spak

Swedish Defence University

P.O Box 27 805

SE-115 93 Stockholm

SWEDEN

Telephone: +46 8 553 425 00

E-mail: ulrik.spak@fhs.se

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Abstract

The representation of the operational environment is crucial in all military operations because it is a necessity for the command and control (C2) function that provides the operation with direction and coordination. The representation, typically in the form of a common operational picture (COP), is considered the key element for establishing situation awareness and understanding for the commander and his/her staff. This article begins by presenting a theoretical overview of the COP concept. Thereafter, empirical support is given that officers conceptualize the COP differently, relating it to different stages of the C2 process and referring to the COP as sometimes an artifact and sometimes a mental state or a product in the human mind. For example, some officers may focus on the representation of the current operational environment; others may focus on representations of courses of actions whereas others may focus on future planned events. This may cause severe misunderstanding when officers use the COP concept in communication.

This article provides a proposition to make the COP concept more specific – connecting the different stages in the C2 process to specific instantiations of the COP. Moreover, regardless of which stage in the C2 process the instantiations of the COP relate to, it has to be adapted to that specific stage in order to be a powerful enabler. This article concludes by introducing a new concept, the Prepared Common Operational Picture (PCOP).

Introduction

The common operational picture (COP) is still as important a construct, as it has ever been during the most intense period of network centricity in defense concept development. About two decades ago, the main interest in the COP was connected to its assumed capacity to share information within the defense enterprise, resulting from the fast emerging development in information technology in general, and networks in particular, as described by Alberts, Garstka and Stein (1999, p. 133):

Battlespace knowledge is derived from shared battlespace awareness and involves the fusion of information into a set of COPs and the dissemination and display of COPs...Providing battlespace awareness to warfighters across the Joint force with requisite accuracy and timeliness requires that data and information from multiple sources be collected, processed (analyzed when necessary), transported, fused, placed in appropriate contexts, and presented in ways that facilitate rapid and accurate inferences.

In the quotation above, a value chain or tenet is evident. This is important because the *purpose* of the COP becomes discernible; data and information from multiple sources is processed and fused into COPs that provide shared battlespace awareness. This in turn derives battlespace knowledge. At “the end” of this value chain, collaboration and self-synchronization would be enabled, ultimately increasing mission effectiveness dramatically (see Alberts, 2016, slide 14). Accordingly, the specific role of the COP is to provide shared battlespace awareness.

Naturally, several questions arise about the different steps in this value chain. For instance, who are the “warfighters across the Joint Force” specifically? Do they all have the same needs (commanders and their staff at different levels of command, individual seamen, pilots, and soldiers in the field)? How are the various activities mentioned (the collection, analysis, transportation, fusion, dissemination and presentation of data and information) supposed to be conducted? What is the specific context in which this value chain is valid (e.g. level of conflict: interstate war, peace keeping, peace enforcement etc.) or is it completely general across contexts? What kind of technology is needed concerning “multiple sources”, to perform the necessary activities and to create the COP(s)? These are some of the questions that come to my mind when applying a PACT (People, Activities, Contexts, and Technologies) framework (Benyon, Turner and Turner, 2005).

This battery of questions should not be interpreted as a general critique against the quoted lines above or lack of precision. No, that section of text is probably best understood as a high-level vision for concept development. If read that way, it is a positive attribute to stimulate the type of deductive reasoning and the generation of more precise questions as exemplified above. On the other hand, if read and understood in a more “cookbook recipe” fashion, unfortunate conclusions might be reached. One such inference could be that *more* sources (sensors and communication networks) result in *more* information that results in a *better* COP(s) that generates *better* battlespace awareness and knowledge. This implication is not likely to create successful warfighters (because of an increased risk of information overload on the decision maker behalf, and an elevated burden of having to send more reports by the human sensor) but rather, benefit merchants and consultants in the information technology business.

This article investigates the overall question of *how to make the construct of the COP more unified and useful by determining a more specific purpose for the COP*. By relating the COP to C2-science and the activity of C2 (in the military and emergency response domains), the article claims that the problems of ambiguity, including the risk of severe misunderstanding, will be reduced. This will be an important step forward since a well-defined COP construct can assist in effective decision-making in life-threatening situations.

Background: (Context, COP, SA, C2)

The context

The context in this article is military C2 and emergency response. These two fields have much in common and their use of COP(s) is one of them. There are also certain differences though. The instance of a thinking human adversary is not common in the case of emergency response (exceptions can be identified though in for example police work) and emergency response activities are typically activated as a response to an accident. In contrast, military C2 often have a more developed planning phase (before execution).

The operational environment is typically considered to be complex (dynamic with uncertain shifting relations between elements in the system(s) of interest). The level of complexity is raised because of hybrid warfare, terror, cyber threats and the “gray zone”¹ (Försvarsmakten, 2016; Bachman &

¹ The concept of a “gray zone” (“gråzon” in Swedish) refers to a situation when it is difficult to establish whether a state is under armed attack, by another state actor or by some other entity (criminal etc.), thereby creating strategic ambiguity. This ambiguity can result in legal problems about how (e.g. assisting other civil

Gunneriusson, 2015). The level of complexity further relates to the sorts of problems actors/organizations in military C2 and emergency response are supposed to solve.

The Common Operational Picture

In the literature, the COP construct has various definitions and is referred to as a product, a process or an operating environment (Copeland, 2008). Wolbers and Boersma (2013, p. 188) have identified two classes of definitions: “one that focuses on capabilities of information dissemination and another that stresses the need for reaching a sufficient level of shared understanding”. The first class of definitions can, according to Wolbers and Boersma (2013), be clustered into a perspective called “the information warehouse”. Leedom (2003, p. 2) writes about the COP with reference to the information management systems found in corporate industry:

[C]apture the information and put it in a place where it can easily [sic] accessed. As a result, the current generation COP has become an “information warehouse” for enormous amounts of information, much of which is (1) poorly organized and validated, (2) difficult to search, and (3) of marginal relevance to the military decision makers.

The second class of definitions and corresponding perspective is labeled: “the trading zone” which is a “process of negotiation”. Wolbers and Boersma (2013, p. 189) summarize their reasoning on the two perspectives:

[T]he COP resembles not an information warehouse but a form of materiality that facilitates the ongoing negotiation process that takes place in a trading zone, in which actors share and give meaning to information to synchronize their actions.”

McNeese, Pfaff, Connors, Obieta, Terrell and Friedenber (2006) consider the COP to be: “[A] visual representation of tactical, operational, and strategic information to support rapid assimilation and integration by team members”. Luukkala, Nikander, Korpi, Virrantaus and Torkki (2017) define a COP to mean:

[A]n information system which enables the situational information to be produced, shared, and visually presented in such a way that all the situational information is available to all the actors involved in the crises response in as real-time a manner as possible.

Baber, Stanton, Atkinson, McMaster and Houghton (2013) define a COP as:

[A] representation of incident-relevant information that could be shared between agencies during a multi-agency response...The concept of the COP is akin to a blackboard architecture...where team members are able to post information to, and retrieve information from, a shared space to which they all have equal access.

At the risk of over-generalizing, the main issue regarding the information warehouse perspective seems to be putting enough data into the different warehouse departments (and making the data accessible), thereby avoiding the problem of missing data. The second perspective, shared

authorities such as the police) and when (in case of cyber-attacks and hostile information operations?) the military instrument should be applied.

understanding, focuses mainly on the interaction between actors and within teams in order to reach a rich enough understanding relative a complex operational environment. A common view of the problem in this perspective is the issue of information overload. However, both perspectives indicate a certain connection between what information should be collected, how that information should be displayed, and the purpose of this information management, i.e. some sort of understanding.

If indeed the COP is a requisite for battlespace awareness (or awareness of the accident space), the key question is: *awareness of what specifically?* By answering this question, it is possible to get to the heart of the purpose of the COP, thereby providing an adequate starting point for concrete design at the level of function and form².

Situation awareness

Because of the close relation between the COP and battlespace awareness, it is necessary to take into account another severely influential construct; situation awareness (Endsley, 1995). Situation awareness (SA) is derived from the same context as Boyds C2-model "Observe-Orient-Decide-Act loop" (OODA) (Boyd, 1995/96). This context consists of an individual (a pilot) performing an activity (military "dog-fight") supported by technology (the cockpit or the entire aircraft). This original perspective on SA based on human information processing and with its roots in cognitive psychology, has over the years evolved into three different branches. These branches have three different focuses concerning the unit of analysis. Beside the original individual focus, an interest in shared team SA, and also recently, distributed SA, stemming from the socio-technical system approach has evolved (for a recent and useful review see: Stanton, Salmon, Walker, Salas & Hancock, 2017).

The definition and model of individual SA that has gained the most attention over the years is Endsley's (1995) three-level model of SA. In this paper, SA is referred to 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". Endsley brings more precision to this definition by further describing its parts or "levels". Thus SA level 1 is "Perception of the Elements in the Environment". SA level 2 is "Comprehension of the current situation". SA level 3 is "Projection of future states". As mentioned above regarding "awareness of what", in relation to the purpose of the COP (a requisite for battlespace awareness), SA level 1 becomes very central. What "elements" does the author refer to? Endsley (1995) writes:

Understanding of SA in a given environment rests on a clear elucidation of the elements in the definition...identifying which things the operator needs to perceive and understand. These are specific to individual systems and contexts, and as such are the one part of SA that cannot be described in any valid way across arenas.

From this quotation I conclude: There is no general SA. If you try to imagine a pedestrian about to enter a road-crossing while he or she is intensively paying attention to his or her cell phone (perhaps reading a text message) and then ask you're self whether that person has good situation awareness, what would your answer be? Well, this particular cell phone user may very well exhibit a high level of SA in regard to what is going on in the cell phone display, but would it be adequate in relation to the other activity simultaneously performed? (I notice this kind of behavior almost on a daily basis when I bike to work).

² See Brehmer, 2010 and Jensen, 2010 concerning the relation between C2 and design.

As will be evident in the next section on C2, an individual perspective of SA would probably gain from being complemented with a systems thinking approach. This implies that the technology in focus (the COP), and the task (the performance of C2) is used and conducted, not primarily by individual humans, but by joint cognitive systems (Hollnagel, 2006) or complex sociotechnical systems where SA is distributed among the systems agents (both humans and technology). This perspective also affects the view of the “C” in the COP construct. The author suggests that the “C” should refer to the various agents in the system of interest or the unit of analysis. On the design level of form this could, for example, be an operational level of command (including the commander, her or his staff, and the supporting technology such as the COP(s)).

What is good SA? So far, the article has put forward arguments as to why ideas about a generally good COP or generally good SA are questionable. In order to make the COP and SA constructs more useful, I will present two frameworks of C2.

Command and control

The quality of both the COP and SA constructs must be related to a specific activity/task – in this article the specific task and framework is C2. There exists no generally good COP or SA. Therefore, two perspectives on C2 will be presented. One is the framework of necessary and requisite functions as developed within C2 science at the Swedish Defense University (SEDU) (Brehmer, 2013). The other is the actual method for planning and C2 [Svensk planerings- och ledningsmetod, “SPL”] used by the Swedish Armed Forces at the operational and strategic level of C2 (Försvarsmakten, 2016; A. Josefsson [personal communication], June 13, 2017).

Figure 1 presents the sufficient and necessary functions to fulfil the purpose of C2, which is direction and coordination. These functions are best understood as “black boxes” and they are defined by their input and output products. Brehmer (2010; 2013) claims the need of five functions to fulfil the purpose of C2:

- The *data providing function*³. Supports the orientation and planning functions with demanded data. Input data are received from a broad range of sensors (including humans). Prominent output products are various types of COPs.
- The *orientation function*⁴. Receives the products from the data providing function but also the mission from the influence function on the C2 level above. The orientation function decides on the course of action (COA) to be applied (“what to do”) and produces a commanders intent as a significant output.
- The *planning function*. Receives the commander’s intent and transforms the intent into a plan in the form of an order (“how to do it”). It is important, given the design approach taken in this paper, to remember that for any given “what” there may be several possible “hows”

³ The data providing function has in earlier versions of this functional framework (e.g. Brehmer, 2010) been referred to as the data collection function. In this paper the label is changed to the data providing function in order to emphasize that the output products (e.g. COPs) are a response to a specified information request (formulated by the orientation function), not just any data or as much data as possible.

⁴ The orientation function has in earlier versions of this framework (e.g. Brehmer, 2010) been referred to as the sensemaking function. In Brehmer (2013), this label has altered to the orientation function because Brehmer considered the term sensemaking to have lost its original and technical meaning and therefore become less useful.

(this is indeed a significant argument to keep the orientation- and planning functions separate).

- The *influence function*. This function provides the legitimacy of the C2 system by the given mandate to perform the activity of C2. The mandate in combination with the leadership performed by the commander is what transforms the order to a communicated mission (“how to get it done”).
- The *communication function*⁵. This function can be understood as the “glue” both within one specific level of C2, between different levels of C2, and importantly, between the C2 system and the unit system. Input and output can be formal such as reports in well-defined formats or informal such as ordinary conversation.

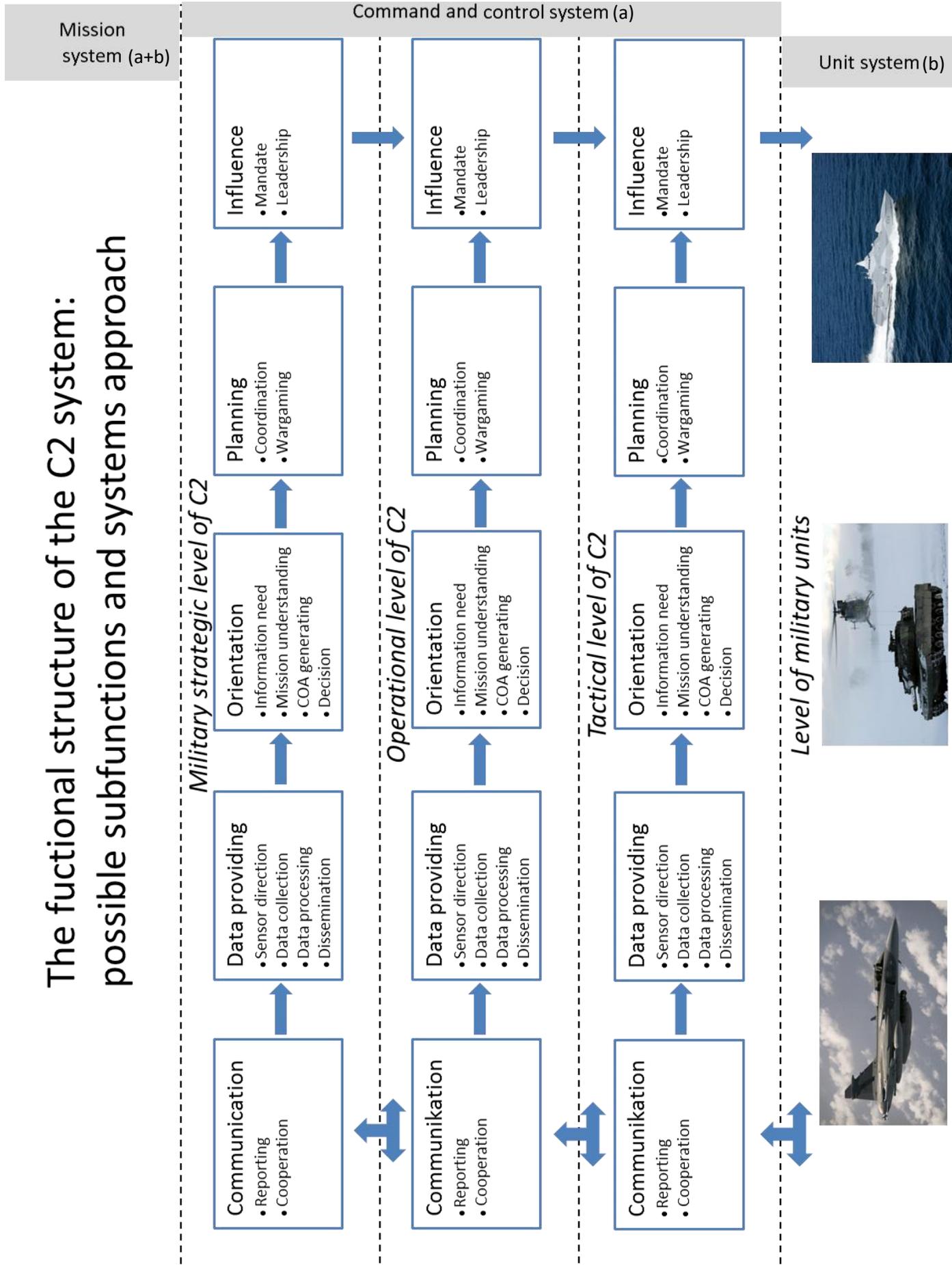
Figure 1 is also a first attempt to present a collection of possible sub-functions within each main function. The concrete fulfillment of the presented abstract functions is carried out by the C2 system on the level of form. In this paper, the C2 system on the level of form consists of method, organization, personnel and technology. The blue arrows in figure 1 represent the primary relations⁶ between functions in terms of input and output; they do not represent causal relations. The functions are generic and independent of time (this implies that they are necessary and sufficient both before and during execution). Even though the functions are generic, the specific form elements fulfilling the functions, such as actual processes, will most certainly be different in respect to time. For instance, the planning *process* will differ before execution compared with during execution.

The choice of system borders, as depicted in figure 1, follows from Brehmer’s view on what C2 is and what it is not. Brehmer argues that a central criterion for defining C2 is the need for active problem solving which in turn means that there is no obvious, known solution for a given problem (Mayer, 2013). This is typical for the complex conditions and “fluffy” tasks (e.g. “establish a safe and secure environment in a country”) found at higher levels of C2. Brehmer contrasts this with the conditions often found in the unit system, which naturally can be severely problematic but still on a much more concrete order (going left or right of that hill etc.). Instead of C2, Brehmer suggests that direction and coordination is fulfilled with, for example, direct work management in the unit system. I try to be quite explicit in the description of the applied systems approach because it has important consequences when it comes to evaluation. What is a good C2 system? Since the functions mentioned above are “black boxes” they have to be evaluated in terms of their products (the COP for example). This also implies that if a mission system would be given a task under two different C2 conditions (for instance, one with centralized C2 and the other with decentralized C2) and the effects in the operational environment could be measured, then any differences in results could not be claimed to be a result of the manipulated C2 condition because the effects could have arisen from activities within the unit system independently of the C2 system. To conclude this reasoning; a good order could result in bad effects, and a bad order could result in good effects.

⁵ The influence – and the communication functions are the two most recent functions in the framework of necessary and requisite functions presented in Brehmer (2013). They are also the least developed but they make good sense to the author given the systems approach shown in figure 1. By representing the different levels of C2 in a hierarchical organization and also the relation between the C2 system and the unit system, it becomes clear that specific functions are needed to fulfill these relations.

⁶ There are other (secondary) relations that have been left out in figure 1 in order to make it as clear as possible. One example of a secondary relation, that still is important for the overall understanding, is the information requirements that is an output product from the orientation function and is received as input to the data providing function.

The functional structure of the C2 system: possible subfunctions and systems approach



The explicit purpose of the “SPL” method is to support decision-making for commanders at the Swedish headquarters. Figure 2 presents a cybernetic model of the C2-process at a specific C2 level during the execution phase.

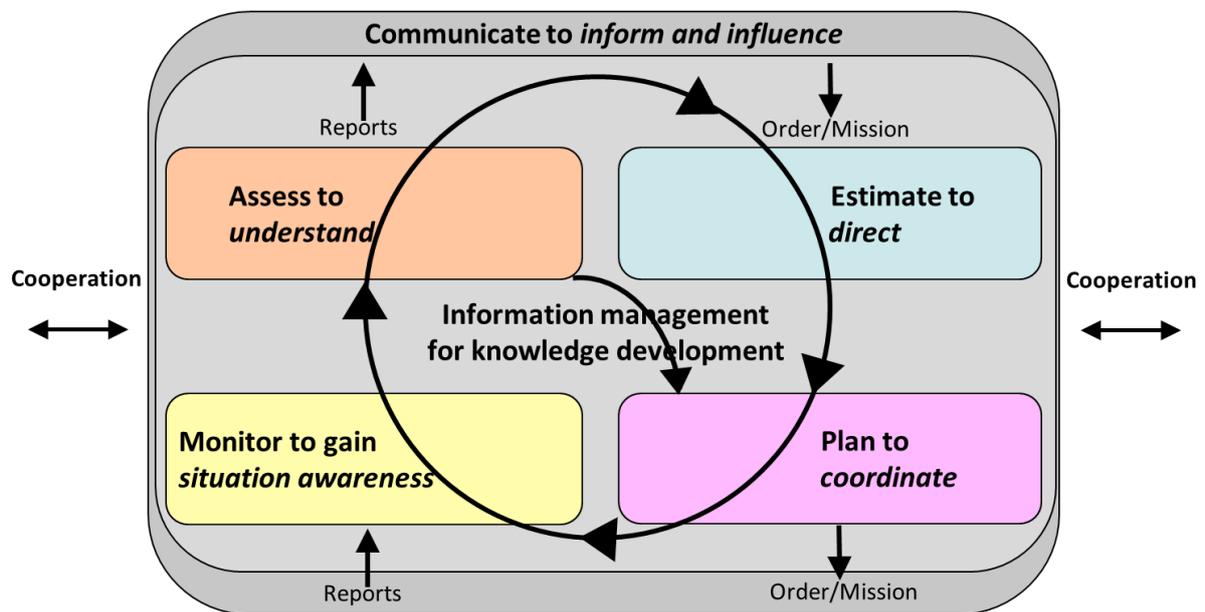


Figure 2. The SPL C2 process during execution phase (adapted from SPL, 2016, fig. 27, 28 & 31).

According to SPL (p. 34) there are four main activities needed to achieve direction and coordination when conducting C2 of an operation:

- Estimate to aim for decision about direction (direction describes *what* must be achieved to accomplish the mission).
- Plan to aim for coordination of units in time and space (coordination describes *how* subordinate units missions/tasks should be coordinated in time and space).
- Monitor to aim for continuous situation awareness and detection of changes (monitoring denotes actively searching for information and receiving reports). The monitoring activity puts together collected information into a COP.
- Assess to aim for understanding of the situation and the meaning of detected changes in relation to the mission and the problem that needs to be solved. The assessment activity provides understanding of whether the operation needs new direction or coordination⁷ to accomplish the given mission.

Besides the four main activities, there are also two supporting activities according to SPL (p. 34):

- Information management supports knowledge development by making all information accessible and comprehensible. The information management activity should provide information to all roles in the C2 process with the specified information quality..
- Communicate with subordinate units and higher commander in order to inform others, one self, and influence others.

⁷ Hence the arrow going from the activity “Assess to understand” to “Plan to coordinate” in figure 2.

Figure 2 above also presents some typical products in cybernetic C2 process models for hierarchical organizations. These are reports going upwards in the model (feedback control) and orders/missions going downwards (feedforward command). In addition, a special form of communication is displayed in the model. That is the cooperation with other units on the same level. The cooperation activity is always a dialogue and may result in an agreement in the form of a contract.

So far, the article has presented basic theoretical foundations about the COP, SA and also two perspectives on C2 (a systemic framework of general functions and a process-oriented model to guide actual performance of C2). The purpose of this exposition has been to show that the construct of the COP (and also SA) are dependent on a context in terms of a primary task (the act of C2) to be of real relevance. However, the relevance of support by a COP in the act of C2, depends on whether professionals within the systems of interest (a defense mission system or an emergency response system) actually consider the typical activities to be difficult (i.e. need support). To explore this, a set of inquiries, asking questions and observing professionals) have been accomplished as presented below.

Method

Data collection activities were conducted as two types of interview based surveys and one series of scenario driven exercises. The method presented here should be regarded as an explorative approach with the purpose of giving direction for further research.

First interview survey (tactical C2 level)

The first series of interviews were conducted as semi structured interviews with five participants who were officers, selected for having extensive experience of performing C2 (specifically making estimates) on real missions and or in educational contexts (as teachers) at the SEDU. All participants were men with the rank of lieutenant colonel actively serving in the army. The questions were mainly based on the Swedish method for planning on the tactical C2 level; the Planning Under Time-pressure model (PUT) (Thunholm, 2006). A similar method was applied in Waldenström (2008, see figure 2). The participants were informed that their experiences of difficulties concerning the different headings in the questionnaire were of particular interest to the interviewer. This series of interviews was carried out as part of a larger scope; the “C2 and Cooperation in Crises and War Project”. Each participant signed an informed consent document before the respective interview. The interviews lasted between 57 and 100 minutes. Participant’s statements were selected by the author (who also conducted the interviews) with the criterion of being directly related to the COP.

Second interview and observation survey (tactical, operational and strategic C2 level)

The second series of interviews were conducted during an exercise ([Ledningsövning 16], “C2 exercise 16”) at the Swedish Armed Forces headquarters. All three C2 levels (strategic, operational and tactical) participated in this exercise. The author served as a member of the lessons learned team during this exercise and the author’s responsibilities concentrated on the management of COPs. Individual and group interviews were conducted with commanders at the different C2 levels (the “consumer perspective”) and one workshop with members mainly from the staff at the operational level of C2 (representatives from the functions/environments such as logistics, personnel, air-, maritime-, land- and information environments). This workshop evaluated on the “producer perspective”. All interviews and the workshop were focused around two general questions:

1. What information should the COP contain?
2. How should this information be presented?

The interview based data collection was complemented with direct observation during activities specified by the “SPL” method such as the Commanders Update Brief (CUB) and the Joint Operations Center (JOC) Update.

Data collection from three scenario-driven exercises

The third data collection activity consisted of three scenario-driven exercises. The purpose of the exercises was the exploration of design criteria for development of the Swedish Armed Forces’ new C2 system in the year 2030. Briefly, experienced officers (teachers at the Swedish Defence University) participated as representatives for the strategic-, operational, and tactical (land- sea- and air components) levels of command. The participants were tasked with initially managing a scenario⁸, conducting mission analysis and courses of action. Thereafter they presented their specific C2 requirements in relation to that scenario and their given roles. Each exercise lasted about one day and the oral presentations given by the participants were recorded. The audio data was interpreted and selected by the research team who worked together (listening to the recordings) throughout the procedure in order to reduce possible individual biases. A more detailed description of the method used in these exercises is presented in Andersson and Spak (2016). Statements with relevance for the COP have been selected by the author.

Results

The results are presented in relation to respective data collection activity as described above in the method section.

Results from first interview survey (tactical C2 level)

Participant 1 (P1) has served as chief of staff on battalion level in an international mission and also as chief of staff at brigade level in a national context. His experiences include exercises, training and real missions.

Many people are very concerned with having an operational picture. A common operational picture. Yes there’s a lot of technology and blips around. It doesn’t tell us very much though. It only tells us about a specific situation at a specific time. But when we look at it, it’s not certain, it’s not actually true, because it’s not the real-time situation. Instead, it’s a question of having to discuss situation awareness. Because there’s quite a [difference] between picture and awareness...and today I think this is one of the biggest problems, situation awareness from the common operational picture.

P1 continues regarding the COP, under the PUT step “own and enemy forces fighting power”, that physical values are not particularly difficult. However, other factors such as morals and spirit are much more difficult to represent in the COP. Further, P1 would prefer a more realistic COP when it

⁸ Three types of scenarios were used which varied along two variables. These were *level of escalation* (war-fighting and war-avoidance) and *strategy* (offensive and defensive): a) war-fighting offensive strategy, b) war-fighting defensive strategy, and c) war-avoidance offensive strategy. The fourth possible scenario (war-avoidance defensive) was excluded due to time constraints.

comes to the representation of units. He exemplifies with the traditional unit envelopes which, according to P1, is not very informative. Instead he would like to see the units as an amoebic shape on the map, displaying the battalion's real whereabouts including its companies and platoons. P1 also emphasizes the need to present the COP in as near real-time as possible (possibly supported by a "blue force tracking system", although important to remember the risk of detection when sending signals).

From the perspective of execution and specifically the assessment phase, P1 reckons that at the beginning of the execution the management of the COP is working, but as time passes, it becomes more difficult to keep the COP updated, because things happen too fast. On the other hand, P1 also points out that it is important to stay in different spatial and time space (for example midterm and long term planning) in order to avoid concentrating too much on the immediate problem (thereby behaving reactive and losing initiative).

Participant 2 (P2) has, among other positions, served as commander at the battalion level, chief of staff and chief operations officer at the brigade level. His experiences are from both national and international contexts, exercises and real missions. The following quotation is from the step "own forces fighting power" during the assessment phase under execution:

P2: It used to be more difficult, and that has to do with the technical C2 support system being much better today than before. I still remember when I lost a whole company, that didn't report, that we had no contact with, during a battalion exercise. It actually turned out to be the radio communication that was completely out. Radio shadow, and they were gone for hours. It caused some...

I: Anxiety?

P2: A certain amount of anxiety, which means that you get a little bit stuck on thinking about what to do. Or you hesitate to take action at least. Today conditions are much better with GPS localization and also the means of communication and C2 support systems with ready to use map pictures displaying the positions of the units. So, I have better control of my own situation actually.

I: These things help in other words?

P2: Yes, they help. Information can come from a number of sources. In addition, there used to be so few devices. But now several individuals can provide information in a C2 support system and you get the collected picture. So, it's much, much easier. There's possibly too much information sometimes, and then it's difficult to sift. I guess that is the problem today.

P2 continues regarding the role of the COP during assessment to emphasize the need to integrate the different perspectives in the staff (the views from different branch heads). P2 mentions for example that sometimes there was not enough information from the intelligence function, which led to a higher degree of risk taking and assumption based decisions. Further, P2 highlights the difficulties of unforeseen events in relation to cooperation with civilian authorities. P2 claims this is more difficult today because of less training between military and civilian parties. P2 also addresses the "gray zone" during the planning stage before execution (PUT step: the enemy's courses of action)

in terms of enhanced difficulties. More problems arise when civilian resources can be used for the achievement of military goals and when affiliations are not clear (who is a combatant and who is not etc.).

Participant 3 (P3) has served as company commander, and in the staff at battalion and brigade level in both national and international contexts. P3 has experiences from exercises, training and a real mission. When asked about assessment and the specific step in the PUT covering own forces and fighting power, P3 comments:

Yes, it's always difficult to do this with operational pictures and situation awareness, because really there are no operational pictures only situation awareness...And you have to understand what's happened and get the information, and when they get the information it's already old because, it's you know, happening right then and there, there's an actual dynamic in this. And it's really about communication. Especially at higher levels, this is supposed to be filtered upwards you know. Then of course, technical support comes in and so on...Technology can facilitate in a way, for example at the battalion C2 support system, you can see where all the combat vehicles and the platoons are. This makes things easier, because then you only need to see to your own situation, otherwise it would be difficult. Because otherwise there are X number of reports needing to be processed and transformed into a situation map.

P3 concludes this part of the interview by complementing the beneficial aspects of blue force tracking (see above) with the risks of being detected by the enemy. P3 further points out the difficulties occurring within the army because of divergent C2 support systems (different systems in different units). P3 argues (PUT step: "third party") that a similar problem can occur within multinational missions (exemplified by five different C2 support systems in the five battalions constituting the brigade) added by cultural and language differences causing raised complexity and risk of misunderstanding. Finally P3 appreciates the PUT step: "understanding the mission" (during the planning phase) and the step: "decide whether it proceeds according to plan" (during execution phase) to be linked, difficult and important. He explains that if the mission has been lacking in clarity from the beginning it is very difficult to evaluate mission outcomes – to know what and how to measure.

Participant 4 (P4) has served as deputy company commander and chief operations officer at the battalion and brigade level. P4 has experience from both national and international contexts (including real combat), exercises, education and real missions. P4 comments about finding new possibilities during assessment in the execution phase:

This is actually the task at hand during C2 execution, to identify that. Searching for it all the time. To be one step ahead and have mental preparedness, to have a decision support plan. And it doesn't have to be a "sync matrix" in an Excel sheet. The white board and sketches are enough to identify this. And that was what I tried to explain before, that is what C2 is about.

P4 continues on the same theme in the next step of the PUT (assessing enemy COA):

P4: Yes that's exactly what I said. INTEL continues to search all the time, and the purpose is to identify the unexpected. When will the unexpected occur? That is, to have the view that we're going to be surprised, but we can't just deflect or counter what happens but think: how can we act?

I: Think of the unexpected in other words?

P4: Yes, and yes it's really difficult.

P4 emphasizes repeatedly during the interview (in relation to several steps in the PUT model) that the time factor is crucial – one has to think 6-12 hours ahead. P4 mentions a memory aid, the three Ts: Time, Troops, and Terrain (P4 also considers the map to be of great importance). Further, in conformity with other participants, P4 stresses the importance of understanding the mission, of having a dialogue with the higher commander. This is especially important in a “gray zone” context when perhaps the tasks and legal aspects are less clear. P4 also holds the opinion (when discussing own forces and fighting power) that the cost of implementing for example a blue force tracking system, must not exceed the value of having enough quantitative fighting capability (number of tanks etc.). P4 concludes the interview, choosing his own topic, to stress the importance of continuity and training.

Participant 5 (P5) has served as company commander, chief of staff and commander at the battalion level, chief operations officer at the brigade level and chief of plans at the operational level of C2. His experiences are based on both national and international contexts including exercises, training and real missions. P5 reasons concerning assessment during the execution phase (PUT step; develop own COA):

So that you assess the right stuff. Otherwise it will just...otherwise you will only have situation awareness. That's great. But situation awareness has a purpose, that purpose is decision-making, and then you have to know what to look for. And that's where I believe we could get better at knowing...then a lot of things will happen. But you have to know, what are you looking for in this myriad of information?

P5 reckons, like other participants, that “understanding the mission” is of crucial importance and that sometimes, this is rather difficult, especially at higher levels of C2. To deal with this problem, a close dialogue with the higher commander is necessary (e.g. level of ambition and risk), in order to share the goal state image of what is to be accomplished according to P5. He also appreciates a strong link between the PUT steps; “understanding the mission” and “deciding on whether the mission has been solved”. Regarding C2 support systems, P5 sees a clear connection between the technical possibilities to control units several echelons below, and the occurrence of commanders actually doing so. P5 thinks this may be a threat against mission command in general and regarding “freedom of action” in particular. The tendency towards more direct command may also be influenced by more centralized processes in international missions (P5 exemplifies, citing the targeting process, direction of sensors and the intelligence process).

P5 argues about the relation between constraints and success factors that in the beginning of the planning phase it is important to focus relatively more on the success factors (so that “your head doesn't get congested” with constraints). P5 makes two points about the PUT step: “own forces and

fighting power". First, P5 believes, that detailed knowledge about the tactical instrument (the units and their capabilities) has decreased somewhat because of less training. P5 feels that such knowledge is very important. Secondly, P5 asserts that today's C2 support systems may display many physical facts about the units but do not take into account soft factors such as morality and motivation. Finally, P5 highlights the PUT step; "terrain, weather, visibility" as a decisive factor for army units. He, like P4, thinks about the trinity of time, troops and terrain. P5 emphasizes the skill or the "art" of integrating the analysis of each "t" including the enemy and own forces perspective, into one coherent context.

Results from the second interview and observation survey (tactical, operational and strategic C2 level)

As mentioned in the method section, the second series of interviews were conducted during the exercise ([Ledningsövning 16], "C2 exercise 16") at the Swedish Armed Forces' Headquarters. Because of high levels of confidentiality on this occasion, no detailed results can be presented. Nevertheless, on an overall level the author observed that the term COP had different meanings according to different employees. I will return to this circumstance in the discussion below.

Results generated by the data collection from three scenario-driven exercises

The third data collection activity consisted of three scenario driven exercises (see Andersson & Spak, 2016). These exercises generated 109 explicit C2 requirements categorized in respect to the five generic C2 functions; the data providing function (D), the orientation function (O), the planning function (P), the influence function (I), and the communication function (C) (see figure 1). The requirements were also categorized under respective exercise (1-3) and respective C2 level (tactical, operational, and strategic). Here, the author has listed the requirements (R 1-13) with perceived direct relevance to the COP.

1. The strategic level must be able to assess and evaluate the strategic situation (D, O).
2. The operational level must have access to an accurate operational picture with timeliness (hour) information (D, C).
3. The tactical level (air) should be able to share the recognized operational picture with maritime fighting units, the operational level, and the strategic level (D, C).
4. The tactical level (air) should be able to deliver recognized air picture to others as close to real time as possible (D, C).
5. The tactical level (air) should be able to share the operational picture with maritime fighting units (D, C).
6. The tactical level (air) should have access to a clear intelligence situation (D).
7. The tactical level (air) should have access to a shared operational picture, containing target data and intelligence, in near real time (D, C).
8. The tactical level (land) should be able to share operational picture, target data, and intelligence with air fighting units, and the total defense (D, C).
9. Common sharing of intelligence and operational pictures should be possible both horizontally and vertically (D, C).
10. The technical part of the C2 system should be robust, but not necessarily, the most advanced (D, O, P, I, C).
11. The content of the operational picture should be adaptable to the level of conflict (D, O).
12. There should be a picture of the sensor coverage (D).

13. Transfer of target data, and intelligence between the land-, maritime- and air components is required (C).

Discussion

The need for operational definitions and a double perspective regarding the COP

First, when discussing the COP, and this is valid in both academia and professional contexts, the meaning of the construct must be clear to those involved in that discussion. This need becomes evident both in the theoretical background section (e.g. see Copeland, 2008), and from the results section in this article. I believe “the key success factor” might be to make the specific purpose of the COP more explicit.

As described previously, a common sense belief about the COP construct seems to be the relationship with “situation awareness” (SA) and understanding. The most severe pitfall in this belief is the notion of similarity and even exchangeability between the COP and SA. Perhaps this problem is much more frequent in Swedish contexts because of specific difficulties regarding the Swedish language. In Swedish the word for operational picture is “*lägesbild*” and the word for situation awareness is often referred to as “*lägesuppfattning*”. Even though the reader is not expected to read and understand Swedish, it is still noticeable that the first parts of the two Swedish words are identical, that is: “*läges-*”. This is likely to be part of the problem. The other linguistically problem is the second part of the Swedish word “*lägesbild*” that is; “*-bild*”. This word can be translated to both “picture” and to “image”. When thought of as “image” it is easy to associate with for example a “mental image”. Consequently it may be easy to confuse the meaning of an artefact (the COP/“*lägesbild*”) and a product inside the head of humans (SA/“*lägesuppfattning*”). One way to decrease this risk of misunderstanding is to use the Swedish word “*situationsförståelse*” (translated to English it would be situational comprehension or situational understanding) instead of the word “*lägesuppfattning*”.

The author’s observations from the exercises reported above have reinforced the notion of an existing misconception regarding the artifact perspective on the COP and the perspective of the COP being mental products in the heads of professionals. Even though the two perspectives are closely connected (which becomes clear when applying a systems thinking approach, including a sociotechnical view, to the unit of analysis). At the same time, it is important to keep the two perspectives separate. The systems view is applicable when thinking about how, for instance, courses of action can be generated (a professional team interacting with each other and with technology such as a COP). In addition, the COP must sometimes be considered more in isolation as an artefact in order to allow for concrete technical design of the COP. This requisite for a double perspective is not always apparent in the literature. For example in Wolbers and Boersma (2013) the “process of negotiation” perspective seems to be regarded as the favorable viewpoint. Undoubtedly, this is an important aspect of the use of COP(s), but thinking in terms of one perspective instead of another (more technical artefact oriented) is not recommended when the aim is for adequate design of C2 environments.

Connecting the COP to C2

In order to promote a more unified view of the COP construct, I suggest connecting it to C2 in the following manner: Figure 1 describes the necessary and sufficient functions in a generic model of C2 (applicable to both military C2 and emergency response) to accomplish direction and coordination of

the mission in pursuit of given mission goals. According to Brehmer (2010; 2013) the functions are defined by their input and output products. Within this theory and framework of C2, I regard the COP as the central product leaving the data providing function and going into the orientation function. It is important to emphasize that the COP generation within the data providing function, is a reflection of input from the orientation function, and specifically from the sub-function "Information need" (this relation has for visual clarity reasons been omitted in this modeled version of the mission system in figure 1).

On the design level of form (a C2 process), I suggest that the COP construct is connected to the main activities of the SPL framework (figure 2) as follows: To start with, there is the "classic" COP product from the process-step: *"Monitor to aim for continuous situation awareness and detection of changes"*. I remind the reader about the question asked in the background section; *"awareness of what?"* One answer could be that facts related to variables selected in the analysis of the operational environment (during the planning phase before execution) are a minimum requisite. Those variables (compare to Endsley's [1995] "elements") could be arranged according to the memory aid "PMESII" (i.e. Political, Military, Economic, Social, Infrastructure, Information) (NATO, 2013). Further, a fair assumption is that the actors perspective always will be of major importance (own forces, neutral, allied, enemy, unknown). The visual representation of actors in the COP should have attributes connected to those objects such as present status. This may seem relatively easy at first; a specific object related to an actor is displayed with a symbol according to conventional standard with a spatially defined position on a map.

However, what does for example a blue battalion symbol positioned somewhere in the terrain (the COP) mean? Remember what participant 1 said concerning the need for realism in the COP and display of soft factors such as morale. What is the status of this particular unit? Is the unit activated/mobilized? Is all equipment in place and in usable condition? Are the staff/personnel on site with the right education? Are there missing key components that could affect the whole unit? What mission/task is the unit performing at the moment? Where is the unit expected to be in the next 24 hours? What significant events have the unit been involved with in the last 12 hours? How has the overall status of the unit changed during the last week? Does the unit have any information needs towards higher C2-levels? What capacities does the unit have (sensor ranges, weapon ranges, capacity to move in different terrain types)? These are some of the attributes that should be visible or accessible via the visual symbol in the COP.

There are two main problems related to the questions above: (1) How should all this information be collected and adequately stored in the C2 support system⁹ (without causing the unit's fighting power to decrease because of a raised burden of reporting)? (2) How should all this information be efficiently presented in the COP in order to fulfill the purpose of SPL activity: *"Monitor to aim for continuous situation awareness and detection of changes"*? This purpose, together with the explicit requirements acquired from the scenario-driven exercises regarding the "need for speed" (R 2, 4, 7), indicates a demand for high levels of automaticity regarding data collection, processing and dissemination. Predefined filters could perhaps be used to ensure that data requested by the orientation function are presented in an adequate style, adapted to that specific level of command and the level of conflict (R 11). These filters or maybe the actual files (such as "recognized"

⁹ If asked for by the orientation function (figure 1) or demanded by the SPL (figure 2) process steps before execution.

operational pictures) should be possible to share among large proportions of the mission system, and with other agencies outside the mission system. This is necessary to achieve shared views of data accessed from databases in the network (R 3, 5, 8, 9, 10, 12, 13).

The staff needs a double or two-fold approach during the monitoring process. In part, monitoring must be oriented towards the plan, and in part it also has to be oriented towards the assumptions made when the plan was created – a broader perspective (Bryant, 2003; Brehmer & Thunholm, 2011; Andersson, 2016). There are some research results to use as a starting point regarding the purpose of detecting changes during monitoring (Spak & Nygren 2016). Spak's research is rooted in the conceptual need for a preserved broader attention in order not to miss potentially important events outside the plan centric and focused attention.

The next step in the SPL process-model is: *“Assess to aim for understanding of the situation and the meaning of detected changes in relation to the mission and the problem that needs to be solved”*. The assessed COP should be able to display the prerequisite for own forces courses of actions. This implies quantifying variables that constitute constraints to own forces courses of action. A typical example could be that the expected wave height on the Baltic Sea the next 24 hours is estimated to 1.5 – 2 meters, which could possibly result in decreased speed regarding sea-surface units.¹⁰ By adding different types of constraints from the operational environment to the assessed COP (information fusion), the commander and her/his staff could gain a satisfactory comprehension of own forces maneuver-space. Since the action of C2 and its effects are conducted in a dynamic reality, it is naturally of significance that the assessed COP can display how maneuver-space expands or shrinks over time. There are promising research results regarding this type of dynamic visualizations in the context of tactical sea-surface warfare (Waldenström, 2011).

A possible problem with this approach is the raised level of complexity that emerges on higher levels of C2. Modelling the real world is always an approximation to a lesser or greater degree. Representing constraints in considering own forces' courses of action must probably be executed with different levels of detail on various levels of C2. Level of detail is likely to decrease on higher levels of C2 in order to permit a sufficient overview instead. This circumstance could mean that the assessed COP would need to be equipped with a representation of the level of detail available regarding the data for a specific variable. One idea to cope with uncertainties regarding continuous variables such as sensor range is the use of visualizations. For example, a sensor range could be represented with decreased brightness with increased distance from the sensor, instead of drawing a sharp circle at a specific distance around the sensor (regarding effective visualizations in a COP relevant context, see Forsell, 2007; Kjellin, 2008 & Pettersson, 2008). Both monitoring and assessment are crucial when it comes to finding new possible solutions to the prevalent C2 problem which, according to participant 4, is “what C2 is about”.

The next step in the SPL process-model is: *Estimate to aim for decision about direction*. If the estimate is conducted during execution, the assessed COP can serve as input for a new or adjusted direction of the operation. The process of developing own and enemy courses of action should be facilitated by the use of a COP visualization. The same apply to analysis and comparison of options and courses of action with support of war-gaming. In this step, when perhaps different staff

¹⁰ The weather service can serve as a source of inspiration when it comes to the visualization aspects of the COP. The weather service has plenty experience about representing the important weather variable.

representatives present their view on the situation, it is of great importance that the team members can interact with the COP visualization in a straightforward way (compare with the “camp-fire” metaphor used in the SEDU project “A Mobile Joint Command and Control Function 2010” [Persson, 2014, p. 115]). The need to integrate different perspectives in the staff, with support of the COP, was specifically emphasized by participant 2. Both participant 4 and 5 choose to point out the need to integrate information from key variables such as the time, the troops, and the terrain (“3T”) in combination with the perspective of own and enemy forces (P5). Indeed, the integrative perspective on the COP is apparent in several COP definitions (McNeese et al., 2006; Wolbers & Boersma, 2013; Luukkala et al. Baber, 2017; Baber et al., 2013). The COP used in this stage of the SPL process could be labeled the *estimated COP*.

The final step in the SPL process-model is: *Plan to aim for coordination of units in time and space*. The statement most reiterated by the participants in the first interview series concerned the difficulties and importance of “understanding the mission”. This is very important when considering the *planned COP*. This product could be used for enhanced communication with subordinate C2 levels about the desired end-state and the different phases leading to that end-state.

Even though relating the COP construct to C2 theory and to an actual C2 process description is important to make the purpose of the COP clearer and less ambiguous, the perhaps most significant issue remains. The literature review and the empirical results have led the author to the following proposal, referred to here as the “PCOP” – the *Prepared Common Operational Picture*. The PCOP is a concept that will possibly reduce several of the problems reported from the fields of military C2 and emergency response in relation to the usage of COPs. The PCOP concept is especially suitable for the complex contexts, in terms of for example hybrid warfare, terrorism and the “gray zone”, to which today’s emergency responders and military commanders are exposed. The PCOP is a representation and a visualization of a potential operational environment for future scenarios of the complex character as exemplified above.

Comfort (2007, p. 192) writes in relation to the inter-governmental response in Hurricane Katrina:

The operating picture was anything but common, and errors, misjudgments, frustrations, and abuse characterized the disaster operations instead. The useful lesson from this set of conditions is that the common operating picture must be established before the disaster.

When a severe accident, a terror attack or the signs of subversion becomes noticeable, it is already too late to reflect upon questions such as: Who will need what information in what format and when? How can appropriate data be collected, processed, and disseminated to fulfil information requirements? How can effective cooperation between actors be established in order to reach negotiated understanding of what actions to make, and how those actions must be coordinated and communicated? As pointed out by participant 4, training is most important. I suggest that relevant representatives (e.g. the police, the armed forces, emergency response personnel, and medical service) must be provided with resources (time and training facilities with adequate technology support) for a common creation of the environmental model – the PCOP. The concept of PCOP may resemble the military product “CPOE” (Comprehensive Preparation of the Operational Environment) (NATO, 2013) but the PCOP provides an inter-organizational perspective (see also Andersson, 2016

about the “situation model”). To conclude, the PCOP is a real potential powerful enabler and a safeguard against the occurrence of severe misunderstandings.

Future research

The data collection method in this paper (first interview survey) should be complemented with interviews on the operational and strategic levels of command and with representatives from emergency response agencies. More research is needed regarding the effects of the proposed use of the COP. First, is the suggested linkage between the COP instantiations, with the main activities in the command and control process, beneficial for the products generated? Secondly, how might the new concept of a prepared common operational picture – the PCOP, be elaborated? Several obvious challenges remain to be solved. One key issue is the fact that information exchange agreements are needed between agencies. Another challenge concerns how to implement the approach of more *continuous command and control* while permitting the environmental model, necessary for underpinning the PCOP concept, to be updated.

Acknowledgements

I am grateful for useful review comments on an earlier draft of this paper, and for valuable suggestions for improvements provided by my fellow research colleges at the SEDU command and control section.

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