Situational Awareness: A core component in the development of a humanitarian common logistic operating picture

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Abstract
The onset of a natural disaster or complex emergency frequently sees multiple agencies responding in a relatively uncoordinated way. One potential solution is that of developing a ‘Humanitarian Common Logistic Operating Picture’ (H-CLOP) that would capture, analyse, validate, distribute and present the disposition of both existing and forecast demands, and the status and location of material in transit as the basis for improved inter-agency logistic decision making. This paper considers the challenges inherent in the development of ‘situational awareness’ as a core component of the H-CLOP concept, and it highlights a number of areas for further research.

Keywords: Humanitarian logistics; humanitarian common logistic operating picture; inter agency coordination; situational awareness

Topic: Humanitarian operations and crisis management

Methodology: Theory and/or research framework

Introduction
There is a growing recognition that achieving an improved logistic response in the preparation for, and response to, natural disasters and complex emergencies has the potential both to save lives and/or reduce the impact on those affected, as well as allowing donated funds to be spent more efficiently and effectively (Kovács and Spens, 2011). At least in part, this reflects estimates that humanitarian logistic (HL) operations, which include the procurement, transport into and within the affected country, warehousing and ‘last mile’ distribution (together with the associated information management), consume some 60-80% of the income of aid agencies – i.e. some $US10-15Bn/year (Tatham and Pettit, 2010).

Within the HL literature, and indeed more broadly within that relating to the general field of emergency management, there is a clear recognition that the achievement of successful inter-agency coordination is a huge challenge (see, for example, Capucu; 2006; Comfort and Capucu, 2006; Donahue and Tuohy, 2006; Faraj and Xiao, 2006;
Vohr, 2011). This is equally true in the HL context where, especially in relation to a major disaster, a massive number of agencies respond. Thus, the UN Office for Coordination of Humanitarian Affairs (OCHA) reported that over 2,000 agencies operate in Haiti in response to the earthquake (Altay and Labonte, 2014), whilst Völz (2005) reported that there were over 70 coordination meetings/week in Banda Aceh (Indonesia) in the aftermath of the 2004 SE Asia tsunami. Even though both these disasters were unusually complex because of their sheer scale, at the same time they underline the fact that the coordination challenge becomes disproportionately larger when the responders are dealing with such catastrophic events.

Of equal importance is the recognition that there is a clear distinction between those contexts which reflect the presence of a central player with the authority to direct the relief operation – an approach described by Dolinskaya et al. (2011) as ‘centralised’ which they compare with the ‘decentralised’ approach that reflects the relatively uncoordinated response of the humanitarian agencies. The former model is typified by a domestic context in which the operations of various emergency response organisations such as fire, police, ambulance and military forces, are directed through a unitary command approach – for example the United Kingdom (UK) Integrated Emergency Management (IEM) structure described by Salmon et al. (2011). By comparison, the inter-agency coordination of logistic preparation and response activities remains weak, particularly at the field level (Tatham and Pettit, 2010; Clarke, 2013) with the absence of a central directing body reflecting, at least in part, the pseudo-competitive environment of the non-government organisations (NGOs) and other participants (Bharosa et al., 2009; Kovács and Spens, 2011).

That said, there is a growing recognition of the benefits of improved inter-agency coordination, and this has led to calls for the development of suitable mechanisms to operationalise this. One such proposal is that of creating and maintaining a Humanitarian Common Logistic Operating Picture (H-CLOP) that, in a similar way to its counterparts that exist in the armed forces and the ‘blue light’ organisations of many nations, would underpin the creation, capture, analysis, validation, distribution and presentation of the real-time (or near real-time) disposition of both existing and forecast demands, and the status and location of material in transit. This would, in turn, provide the basis for coordinated inter-agency logistic decision making (Capucu, 2006; Bharosa et al., 2009; Tatham et al., 2013).

A generic common operating picture (COP) is a means of providing communication between, and the coordination of the actions of, the relevant parties (Copeland, 2008). This, according to Comfort (2007), would support the achievement of “...a sufficient level of shared information among the different organizations and jurisdictions participating in disaster operations at different locations, so all actors readily understand the constraints on each and the possible combinations of collaboration and support among them under a given set of conditions” Comfort (2007, p. 191). This generic COP concept would apply to the proposed H-CLOP which would be focused on the supply chain/logistics subset and would be designed in such a way as to provide an improved means by which demand is balanced with supply in an efficient and effective way.

However, a fundamental cornerstone in the achievement of the H-CLOP concept is that of delivering an appropriate level of ‘situational awareness’ (SA) which is informally and intuitively defined as knowing what’s going on (Wickens, 2008). A more formal and often used definition of SA is “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, 1995, p. 36; Uhlarik and
The body of knowledge that has been developed on SA over the last 25 years is impressive and this has been used in multiple domains including air traffic control (Endsley, 1988; Endsley and Rogers, 1994), medical procedures (Gaba et al., 1995) and military operations (French et al., 2004; Salmon et al., 2010). In addition, a broad spectrum of literature exists discussing different SA methods and techniques, the most reliable and valid being claimed to be the Situation Awareness Global Assessment Technique (SAGAT) which through which three levels can be measured covering “perception” and “understanding” of the situation and their “prediction” of future events (Cooper et al., 2014).

With this introduction in mind, the overall aim of this paper is to utilise the body of knowledge on SA to support the development of the H-CLOP concept. More specifically, the aim is to demonstrate how an understanding of SA has the potential to improve the design and effectiveness of humanitarian supply networks in a disaster context. In doing so, we are following the prescription of Stock (1997) who recommended that logistics “borrows” from other disciplines as a means of advancing knowledge and understanding.

In doing so, the next section offers a more detailed introduction to the concept of SA in which we introduce several different dimensions of SA including spatial awareness (where), identity awareness (what), temporal awareness (when) and the responsibility or automation awareness (who). Section three then discusses different levels of SA: perception, comprehension and projection. Section four applies the literature on situational awareness to the context of humanitarian logistics. The final section of the paper contains a discussion and provides conclusions.

**Introducing Situational awareness**

The term SA has its origin in the world of military aviation, where achieving high levels of SA was found to be both critical and challenging early in aviation history (Endsley et al., 2003). These military pilots were confronted by a constantly evolving picture of the state of their environment and, as a result, they depended heavily on what became to be known as situational awareness in their decision making processes. In this context, situation awareness (SA) means appreciating all you need to know about what is going on in relation to the full scope of your task. For example, for a fighter pilot, SA means knowing the threats and intentions of the enemy forces but at the same time knowing the capabilities, responses and intentions of one’s own aircraft. In the context of an air traffic controller, SA again means knowing about current aircraft positions and flight plans, as well as predicting future states so as to foresee possible conflicts. Therefore, in operational terms, SA means “having an understanding of the current state and dynamics of a system and being able to anticipate future change and developments”.

Despite the wide use of the concept of SA, there is no universally accepted definition (Salmon et al., 2008) - indeed Sarter and Woods (1991) go so far as to refer to SA as an “ill-defined phenomenon”. Nevertheless, the most cited definition of SA, and one that appears to have stood the test of time (Wickens, 2008), is that suggested by Endsley (1995) and which was included in the introduction of this paper. While defining SA in this way, Endsley also emphasizes what SA is not. First, she states that SA is not action or performance. As such, the understanding of a situation is quite distinct from the manual or vocal actions taken in response to that situation (Wickens, 2008). Secondly, Endsley stresses that SA is not the same as long-term memory. Wickens (2008) adds to

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this point by stressing that the construct of SA is primarily applicable in dynamic situations where variables are changing. This aligns with the definition of SA offered by Durso et al. (2007, p. 164): “comprehension or understanding of a dynamic environment” (emphasis added). Hence, static knowledge about the state of the system is less directly relevant to the concept of SA (Wickens, 2008).

Acknowledging the difficulties in defining the concept, the seminal paper of Harwood et al. (1988) distilled four dimensions that characterise SA. These are: where (spatial awareness), what (identity awareness), when (temporal awareness), who (responsibility or automation awareness). Each of these dimensions is now considered in greater detail:

- **Where (spatial awareness).** This is the operator’s knowledge of his/her location in space and of the spatial relationships between objects (Harwood et al., 1988). In the context of commercial airline pilots Regal et al. (1987) suggest several components to be relevant for spatial awareness. These include knowledge of issue such as the location and movements of other aircraft, your own location relative to the terrain, and your speed.

- **What (identity awareness).** This relates to the operator’s knowledge of the presence of threats and their objectives (Harwood et al., 1988). It also includes the operator’s awareness of system state variables such as engine status and flight performance parameters (in case where the operator is a pilot).

- **When (temporal awareness).** The temporal dynamics of various elements play an important role in SA (Endsley et al., 2003). A critical aspect of SA is often that of understanding how much time is available until some event occurs or some action must be undertaken.

- **Who (responsibility or automation awareness).** This is associated with the knowledge of “who is in charge”.

It is difficult if not impossible to determine which of these SA dimensions is most critical given the fact that, in a dynamic environment, the relevance of data and events depends on their context (Sarter and Woods, 1991). Moreover, various SA researchers and practitioners have urged caution in assuming that merely presenting more information will lead to increased SA (Stanton et al., 2010). For example Bolia et al. (2007) argue against the proposition that the increased availability of information means that operators will make better decisions. Rather, other factors such as information overload, poor interpretation and the presence of non-relevant information and false data are likely to degrade rather than enhance SA in this scenario (Stanton et al., 2010).

**Different Levels of situational awareness**

Although several different SA models have been developed, Endsley’s three-level model (Endsley, 1995) is by far the most cited in the literature (Stanton et al., 2010). Her model is generic and presents a relatively simple and intuitive description of SA which has since been applied in a broad range of different domains (Salmon, 2008). The model uses a linear information processing chain and, in drilling down, Endsley draws a careful distinction between three levels of SA which, from the bottom up, she refers to as: ‘perception’ (including ‘noticing’) – Level 1; ‘comprehension’ – Level 2; and ‘projection’ – Level 3.

A key point in Endsley’s model is that the higher levels of SA depend on the success of lower levels. Thus, an air traffic controller may first notice a change in an aircraft’s trajectory, then comprehend that this means that two aircraft are on converging trajectories and, finally, understand that an accident may take place and how serious it
would be. In this respect, Wickens (2008, p. 398) notes that “the diagnostic distinction between these three levels is important, not only because they point to different perceptual/cognitive operations but also because breakdowns in each may have different consequences for addressing them, through training or system design. For example, a breakdown of Level 1 SA would lead to the design of better alerts. A breakdown in Level 3 SA would lead to incorporation of predictive displays”.

Endsley’s model is presented in Figure 1 where it clearly shows that SA acquisition and maintenance is influenced by various factors including individual factors (e.g. experience, training, workload etc), task factors (e.g. complexity) and systemic factors (e.g. interface design) (Endsley, 1995).

Figure 1 - The three level model of situation awareness (adapted from Endsley, 1995; Salmon, 2008).

The first step in achieving SA involves perceiving the status, attributes and dynamics of task-related elements in the surrounding environment (Endsley, 1995). Different sensors may contribute to the perception of information, including visual, auditory, taste or a combination of all of these. At this stage, the data is merely ‘perceived’ and no further processing of the data takes place. In many systems, a strong emphasis is placed on the electronic displays and read-outs that are provided, but Endsley et al. (2003) argue that much of the SA at level 1 comes from the individual directly perceiving the environment. Within the aviation domain, most problems with SA occur at level 1 – for example, Jones and Endsley (1996) found that 76% of the SA errors made by pilots were related to their failure to perceive necessary information. Endsley et al. (2003) identify a number of factors that contribute to uncertainty at level 1 SA and which may lead to these errors. These include missing information, the reliability of the data (or lack thereof), incongruent or conflicting data, the timeliness of the data and ambiguous or noisy data.

The second step in Endsley’s model focuses on understanding what the data and cues perceived mean in relation to relevant goals and objectives. During the acquisition of level 2 SA “the decision maker forms a holistic picture of the environment,
comprehending the significance of objects and events” (Endsley, 1995, p. 37). At this stage it involves integrating multiple pieces of data to form information, and prioritizing that combined information’s importance and meaning as it relates to achieving the present goals (Endsley et al., 2003). Jones and Endsley (1996) suggest that around 19% of the SA errors in the aviation domain reflect problems with level 2 SA. In such cases people are able to see and/or hear the necessary data (level 1 SA), but are not able to understand the meaning of that information correctly. To help mitigate the errors from incorrect level 2 SA, Endsley et al. (2003) suggest that it is very important to present meaningful confidence levels that are associated with both the data categorisation and its aggregation.

The third and highest level of SA involves predicting the future states of the system and elements in the environment (Endsley, 1995). By using both level 1 and 2 SA-related knowledge, and merging this with experience in the form of mental models, individuals can forecast likely future states in the particular situation (Salmon, 2008). Endsley et al. (2003) suggest a number of causes of failure to achieve such accurate predictions. These include workload fatigue issues such as information processing overload and insufficient domain-specific knowledge. These authors also note that many failures occur at SA levels 1 and 2 due, for example, to insufficient expertise or poorly designed information systems and user interfaces and, thus, the particular decision making issue never progresses to level 3.

Situational awareness in humanitarian logistics
This section will discuss the application of SA theories to the novel context of humanitarian logistics noting that Endsley et al. (2003) argue that SA is a foundation stone underpinning decision making and, hence, performance in almost every field of endeavour. This observation is certainly true in the HL field where humanitarian logistics need to know the details of the demand (e.g. numbers of people including their age/gender breakdown, location, specific needs, etc) and supply (location of relief goods, the state of the infrastructure (e.g. roads, bridges), etc) in order to plan and execute their operations. The importance of this dynamic perspective is directly relevant to HL, and especially in the context of what are frequently referred to as ‘rapid onset’ disasters or emergencies such as earthquakes, volcanic eruptions and conflict situations, where the reality on the ground is extremely fast moving. To put these impediments in perspective and to make further sense of the challenges inherent in the concept of SA in support of dynamic decision making, the next section applies the four dimensions as identified by Harwood et al. (1988) as well as the seminal model offered by Endsley (1995) to the HL context.

Spatial awareness
Spatial awareness concerns the operator’s knowledge of his/her location in space and of the spatial relationships between objects (Harwood et al., 1988). Translating these requirements to the HL context, a logistician would wish to be aware of the location of the supplies and status of supplies that are entering the country, are already within the country (whether this be in the agency’s own warehouses or available from the local economy), or in transit towards the beneficiaries. By the same token the logistician needs to know where the beneficiaries are and in what numbers, plus a demographic breakdown that would include age, sex, culture/religion (as the latter may well have an impact on dietary or other needs). The logistician also needs to be aware of a similar information set as it relates to other agencies in order to avoid over- or under- supply to a given location.
Identity awareness
This relates to the operator’s knowledge of the presence of threats and their objectives (Harwood et al., 1988). In the HL context, there are external threats such as those from disruptive forces (warlords, bandits, pirates, etc), as well as internal issues such as the status of the physical communications links (road, bridges, etc) and the transport vehicles themselves. To this must be added the extent and accuracy of the needs assessments that have been undertaken – which, in turn, generate the demand that the logistician is trying to meet – as well as the status of the procurement sources (both internal and external).

Temporal awareness
The temporal dynamics of various elements play an important role in SA (Endsley et al., 2003). An obvious example in the HL context is 2005 Pakistan earthquake which struck the mountainous region North West of Islamabad on 8th October, i.e. approximately one month before the first snow falls of winter. Importantly in the context of temporal awareness is the observation by Endsley et al (2003, p. 19) that “The dynamic aspect of real-world situations is another important temporal aspect of SA. An understanding of the rate at which information is changing allows for projection of future situations (Endsley, 1988; 1995). Since the situation is always changing, the person’s situation awareness must also constantly be change or become outdated and thus inaccurate”.

Responsibility or Automation awareness
This is associated with question of “who is in charge”. As indicated in the introduction to this paper, the humanitarian logistician is generally working in an organisational context in which there is limited coordination – i.e. the ‘decentralised’ scenario of Dolinskaya et al. (2011). That said, the World Food Programme (WFP) acts as the cluster lead for the UN family of organisations is, therefore, responsible for coordination of actions within this sub-set of the response mechanism. Indeed, the logs cluster is keen to try to develop this role to include all NGOs who are responding to the event, but to date this approach has had limited traction. Further important players in this respect are the national and local governmental organisations who, in an ideal world, will lead in the coordination process. Unfortunately, such agencies may not be in a position to do so due, for example, to the impact of the event on their own personnel – such as was the case in the Haiti earthquake of 2010.

Levels of situational awareness
As indicated earlier, Endsley’s model is generic, but its applicability to the HL context can readily be seen. SA acquisition and maintenance is influenced by various factors including individual factors (e.g. experience, training, workload, etc), task factors (e.g. complexity) and systemic factors (e.g. interface design) (Endsley, 1995a). For example, the individual factors such as the extent of the individual logistician’s experience, training and workload apply to this context, as does the extent of the complexity of the particular disaster. Indeed, the design of the interface(s) – which can be considered at multiple levels from the inter-organisational construct down to the user-friendliness of the IT system(s) – is equally relevant.

The first level in achieving SA involves perceiving the status, attributes and dynamics of task-related elements in the surrounding environment (Endsley, 1995). Endsley et al. (2003) argue that much of the SA at level 1 comes from the individual
directly perceiving the environment, with an estimated 76% of the problems occurring at level 1 in the aviation domain (Jones and Endsley, 1996). A similar situation pertains in an HL context especially in the early days/hours after a disaster strikes. This reflects the inevitable chaos and confusion that is exacerbated through the inevitable physical degradation of communication or, in a complex emergency scenario, restrictions imposed by military authorities in the release of relevant security-related information (e.g. on the presence or suspected presence of improvised explosive devices (IEDs)).

The second level in Endsley’s model focuses on the understanding of individuals (in this case the field logisticians) of what the data and cues that have been perceived mean in relation to relevant goals and objectives. The suggested core components of an H-CLOP could provide the base for understanding such data and cues in relation to the overall goal of providing an overarching and real time (or near real time) overview of the demand and supply situation as a basis for improved decision making on an individual or collective basis. In a recent report by Vohr (2011), an attempt to develop an H-CLOP was undertaken by the United States marines responding to the 2010 Haiti earthquake. Vohr (2011, p. 80) concludes that future operations would require a common understanding that “... should at minimum capture and display requirements, daily logistics activities, logistics centers, supply routes, medical centers, and engineering projects. More generally, the core components that could be used to reflect the demand and supply situation are: needs assessment, procurement of relief items, transport and warehousing into and within the affected area and last mile distribution.” (Tatham et al. 2013).

By using both level 1 and 2 SA-related knowledge, and merging this with experience in the form of mental models, individuals can forecast likely future states in relation to the particular situation (Salmon, 2008). The third and highest level of SA involves predicting the future states of the system and it associated elements within the particular environment (Endsley, 1995). In the case of HL, this would be in the format of a visual display of the affected area with a clear indication of the historic, current and estimated demand, and the associated planned and historic movement of relief goods by the individual HA.

Nevertheless, the ultimate goal of a fully operational H-CLOP is that of providing an overarching and, ideally, real time or near real time overview of the demand and supply situation as seen both through the eyes of the individual HAs, as well as at a cumulative level. It is argued that, in this way, the potential for inter-agency gaps and overlaps will be reduced, and the consequential efficiency and effectiveness of the logistic decision making process will be greatly improved. A further important benefit is that the associated data would be available to support the appropriate local authorities in taking full ownership of the recovery process.

**Discussion and conclusions**

The ultimate aim of the H-CLOP concept is to provide a comprehensive, valid, up-to-date and easily understood ‘picture’ of the logistic response to the disaster in question as a basis for improved decision making. In this paper we discuss the potential application of the concept of situation awareness to this challenge. In doing so, we draw on the have drawn on the benefits of the understanding of SA which has long been recognized as an important factor for improved performance not only in the aviation sector in which the concept was launched, but in many other fields including transportation and emergency management. One key problem with the line of reasoning is, however, that most SA models are designed for individual operators within a centralized
organizational construct, but in contrast, the H-CLOP is targeted at a decentralized network of organizations.

This leads to a requirement to consider the literature as it relates to situation awareness in teams (see e.g. Salas et al., 1995) – albeit, at least in part, the output of the multiple responding agencies that from the HL community can only loosely be described as a team effort. Nevertheless, Salas et al. (1995) argue that team SA is more than the sum of its parts and simply adding individual SAs together to provide a measure of team SA is not a satisfactory approach. Within this stream of literature a distinction is also made between shared and distributed situational awareness. Shared SA suggests that members in a team or network have the same understanding of a situation or its elements. However, within this shared understanding, whilst different team members may have access to the same information, differences in their personal experience, goals, roles, training, skills, schema, etc may mean that their resultant situational awareness of it is not shared.

In reflecting on this scenario, Stanton et al. (2006) suggest that agents within a system each hold their own SA which can differ from, but at the same time be compatible with, that of other agents. They also argue that the sharing of this individual awareness might not even be wanted, as different system agents have different purposes/goals. They therefore developed the concept of distributed situation awareness (DSA) which is system rather than individually oriented. DSA can be defined as activated knowledge for a specific task within a system, and in this system, compatible SA is the glue that holds the distributed system together (Stanton et al., 2006). So in the view of Stanton et al. (2006) team members possess unique but compatible elements of the overall system awareness, rather than sharing SA. In respect of the development of the H-CLOP concept, acceptance of this proposition means that even though the H-CLOP may do much to ensure the accuracy and timeliness of the data on which decisions can be made, there is an implicit requirement for a more effective decision making process that will be able to react to the emerging logistic picture in an efficient and effective way. Arguably this implies moving to a centralised system, but this aspect of the problem goes beyond the scope of this paper. Nevertheless, it represents a key challenge will need to be faced by the HL community as a whole.

It is hoped that the ideas explored in this paper will support the development of further research in this area. It is clear from the analysis of the literature that further research on team or, perhaps what might be better termed ‘network’ SA is needed, as is further guidance on how to promote coordination during multi-agency disaster response activities.

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