The Search for Shared Situational Awareness for Enhanced Collaboration in Airport Systems

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ABSTRACT

There is a demand for an enhancement in the collaborative decision making process at airports. To enable this increased collaboration, shared situational awareness is required. This enables adequate decision making in complex systems such as airports. To research this subject, the question "What are the specifics of developing shared situational awareness in airport systems?" is asked. It is concluded that awareness is formed by sharing relevant information on a system wide scale. By identifying the most disruptive factors for airport operations and embedding these in an information system that provides timely and accurate information of each factors' status, the shared information enables stakeholders to improve the performance of the airport system as a whole and to make more efficient use of available infrastructure and slots.

1 Introduction

To take adequate decisions based on facts in dynamic and complex systems such as airports, a high level of situational awareness is required (Eurocontrol, 2016; Endsley, 1995). Airports consist out of a system-of-systems and therefore, the need for increased collaboration and shared situational awareness is evident. This research addresses the details of the development of increased shared situational awareness in airport systems. The research question that is related to this study is: "What are the specifics of developing shared situational awareness in airport systems?".

2 Methodology

The methodology for this research consist out a review of grounded theory and a case study. The grounded theory study is a critical literature review on the subjects of complexity in airport systems, the theory of situational awareness and human factors in decision making. The case study of this research is formed by assessments of the enhancement of shared situational awareness at Amsterdam Airport Schiphol and how it can add value to this airport system. This case study is supported by interviews with representatives of operational parties that are collaborating in this research. These interviews point out the gaps in the system where shared situational awareness should show its benefits.

3 Concept of Shared Situational Awareness

The definition of situational awareness reads: "situational awareness 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, 1988). This quote provides a preliminary insight on the concept of situational awareness. However, there are aspects to this theory that are applicable to airport operations that must be elaborated more thoroughly.

To form a background on the subject of shared situational awareness in airport systems, the research includes the theory of complexity in airports, the concept of situational awareness and the influence of human factors in decision making.

3.2 Complexity in Airport Systems

What is described in the implementation manual of Total Airport Management by Eurocontrol is that airports are the key examples of vast, dynamic and complex systems (Eurocontrol, 2016). A complex system is defined as an entity that consist out of many varied interrelated actors, whether the interrelated actors are passive or active (Baccarini, 1996). In airport operations there are both passive and active actors. Active actors are entities such as passengers, pilots and controllers while passive actors are entities that cannot be controlled such as weather and regulations (Lemoine, 2000). In airport operations, the most common stakeholders that are active actors are (Eurocontrol, 2016):

- Air Traffic Control (ATC)
- Air Traffic Flow and Capacity Management (ATFCM)
- Aircraft Operations centre (AOC)
- Airport Management
- Ground Handlers (GHs)

The main characteristic of complex systems with various actors such as airports is the element of uncertainty. Uncertainty comes in different forms which have to be dealt with accordingly. To deal with complexity and uncertainty, sufficient and timely information is a primary requirement (Cook, Blom, Lillo, Mantegna, Micciche, Rivas, Vázquez & Zanin, 2015). Currently, the flow of information in complex systems is most commonly managed through gaining situational awareness through information systems (Lemoine, 2000). However, these systems are almost always company specific and not shared with relevant partners or stakeholders.

3.2 Concept of Situational Awareness

The requirement for Situational Awareness in airport systems is evident due to the need for rapid decision making based on accurate information in the control centres of airports and carriers (Bruce, 2011). In an assessment of rational decision-making models, the fundaments of each model consisted out of problem identification (1), plan generation (2), assessment of alternatives (3) and decision making (4). These steps require the possession of accurate and timely information in order to make rational decisions (Eurocontrol, 2016).

Complexity has got a major influence on situational awareness. It is hypothesized that system complexity negatively affects workload but also situational awareness through factors such as an increased amount of system components, the degree of interaction between components and the rate of change in these components. Furthermore, the complexity of an agents' tasks may also increase with the number of decisions that have to be made when the complexity of the system is increased. When the required amount of situational awareness or complexity exceeds human capabilities, decision making will suffer. This is where an awareness system would support the decision maker or agent with accurate and timely information (Endsley, 1995).

The background of cognitive processes in decision making is described as "the situation where a decision maker can choose an action from a set of alternatives" and as described in a document by Airbus, decision making and situational awareness are directly linked (Eurocontrol, 2016). To optimize the capability to make rational decisions, human factors must be minimized *or* controlled. There are three levels of situational awareness (Airbus, 2007):

- Perceiving what is happening (Level 1);
- Understanding what is perceived (Level 2);
- To think ahead (Level 3)

When planning an information system to increase shared situational awareness, there are eight characteristics that this system must comply to. These characteristics are connected to the three levels of situational awareness (Endsley, 1995):

- Reduce the requirement to make manual calculations;
- Present data in a manner that makes understanding and predicting easier;
- Organise information in a manner that is consistent with the organisations' goals;
- Indicators of the current mode or status of the system to help to form the appropriate situational awareness;
- Critical cues should be provided to capture attention during critical events;
- Global situational awareness is supported by providing an overview of the situation in relation to the goals of the operator;
- System-generated support for protection of future events and states will support the predicting of future events;
- The system design should allow presenting data from different sources

While the above points of attention may seem obvious and confirm what was previously thought, these ideas bring the concept of situational awareness together (Stanton, Chambers & Piggott, 2001).

3.3 The Influence of Human Factors in Decision Making

Due to the presence of human factors in the subjects of airport systems, complexity and situational awareness, the human factors are seen as crucial to the processes involved. As described by Gaver and Jacobs (1998), humans are limited in information processing and memory capabilities. This can result in biases in decision making. Therefore, it is of importance to actively feed the decision makers with accurate and timely information to allow the formation of situational awareness. This is seen by Eurocontrol as one of the most important aspects for the correct implementation of TAM (Eurocontrol, 2016).

To get an understanding of the importance of human factors in decision making, it is important to get an insight in common problems of gaining Situational Awareness.

As described by Kaber and Endsley (1997), the following human factors characteristics are involved in operational decision making with inadequate situational awareness that can be problematic:

- Failure to detect critical cues regarding the state of the system;
- Failure to interpret the meaning of perceived information;
- Failure to understand individual task responsibilities and the responsibilities of others;
- Failure to communicate with other operators in the team;
- Failure to communicate with other teams

It is concluded that the above mentioned factors are to be dealt with when creating Shared situational awareness in Airport Systems.

Another potential problematic factor is the 'machine age' in which decision makers in airport systems must cope with vast amounts of data that is changing continuously. The challenge is to adequately process this data to readable information. This challenge is called the information gap (Figure 1).
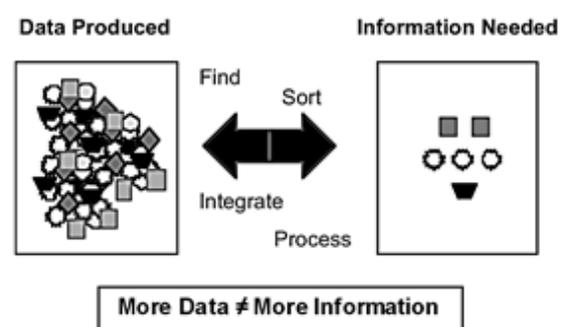

Figure 1 The Information Gap (Endsley & Garland, 2000)

The risk of the vastness of today's data production is that actors become less informed because of the gap between the received data and the ability to identify the necessary factors and process them in order to make adequate and well informed decisions (Endsley & Garland, 2000).

It is recognized that more data does not equal more information. The risk of an excessive amount of information in the situational awareness system must be mitigated in the designing phase of the system. Therefore, this needs to be considered when making use of a shared situational awareness system (Sarter & Woods, 1994).

4 The Search for Shared Situational Awareness

Due to the high priority to maximize the utilization of assets, infrastructure and resources, the aviation industry stressed the urgency for industry wide improvements in efficiency (SESAR, 2012). The response by Eurocontrol was the initiation of the Airport Collaborative Decision Making Programme (A-CDM).

The concept of A-CDM is to improve operational efficiency at airports by reducing delays, improving predictability of events during the progress of a flight and optimizing the utilization of resources (Schiphol Group, 2010). These improvements are called into life after the finalization of the Air Traffic Management Masterplan by SESAR (2012) where the objective is to share more accurate and timely information to improve capacity planning. To enable the improvement of operational performance, all sector parties must share accurate and timely information that is in relation to the flight process. This sharing of information was a first step towards creating increased shared situational awareness of flight information.

At Amsterdam Airport Schiphol, this step of flight information sharing is operational. The next step is focusing on sharing airport-wide operational information system under the name of Total Airport Management. The main goal of TAM is the creation of an environment where airport partners can maintain a joint plan. In this joint plan, the Airport Operations Plan

(AOP), there is a requirement for consensus between all involved stakeholders in order to work towards the dynamically agreed goals to get full benefits of A-CDM (Eurocontrol, 2016). To maintain the AOP, a common distribution of information that forms situational awareness is required. (SESAR JU, 2014).

The aviation industry as a whole has been searching for a continuous optimization in shared situational awareness and is still ongoing. There are multiple projects by Eurocontrol that address this. However, due to the uniqueness and complexity of each individual airport, the exact level of added value that shared situational awareness offers differs for each airport respectively.

5 The added value of Common Situational Awareness

To determine the added value of shared situational awareness in airport systems a case study has been conducted. The case study has been conducted at Amsterdam Airport Schiphol in cooperation with stakeholders. The scope of the research was to assess the collaborative decision making bodies that are currently in place in relation to the level of situational awareness that is required to take informed decisions.

In the decision making bodies, which are unique in terms of scope, the involved stakeholders brief their operational status to other stakeholders of the airport. After the status has been determined and the (possible) disruptive factors have been identified, an operational plan is formulated in order to ensure continuity. To formulate a plan, there can be no discrepancies between the used information amongst stakeholders. There must be a homogenous flow of information throughout the system. This homogenous flow of information must feed decision makers with

correct and timely information regarding disruptive factors in the system.

To have a homogenous flow of information, the factors that are seen as most disruptive or influential to the airport system must be known. These factors are determined by the stakeholders at Amsterdam Airport Schiphol as follows. Note that these are only the components related directly to airport capacity and are applicable for each stakeholder:

- Aircraft Stand Availability;
- European Airspace Status;
- Infrastructure Maintenance;
- Calamities;
- Disruptions at Stakeholders;
- Departure Delays
- Technical Related Disruptions;
- Weather Related Disruptions;

To ensure a homogenous distribution of information as well as supporting decision making processes for all stakeholders, these factors must be secured by an information system that accurately reports the status of these factors.

To successfully implement a system that supports the formation of shared situational awareness, there are steps to be taken for each airport as a whole. The degree of difficulty that each airport will have to face is airport specific. However, there are some gaps that must be faced that are applicable to the majority of systems (Eurocontrol, 2016).

The changes that the formation of shared situational awareness requires include the reporting of status through a system that has not been used before. This change in methods required mutual trust amongst stakeholders from two perspectives: to trust that the received information is correct and to trust that the provided information is treated as confidential (Eurocontrol, unknown).

6 Conclusion

This research was initiated to research the requirement details of the creation of shared situational awareness in Airport Systems. Concluding this research, the main question is answered. The main question is: "What are the specifics of developing shared situational awareness in airport systems?"

It is concluded that the requirement for shared situational awareness in airport systems is present. This is due to the complex nature of these systems and its demand for correct and timely information based decision making. To enable the creation of shared situational awareness, an information system that is designed following the guidelines of Endsley that describes the requirements of the information system and the formation of the three levels of situation awareness.

To successfully develop situational awareness it must be noted that the only correct method of developing the system is bottom-up. By bottom-up it is meant that the operational staff should provide their demands to what the system should enable (ACI, 2010; Eurocontrol, 2003; Eurocontrol, 2008).

Before Shared Situational Awareness is achievable, the mutual trust between all involved parties is crucial. Due to the possible sensitivity of the information the participants of this study all stressed that there must be a memorandum of understandings before the sharing of information commences.

Shared situational awareness can bring stakeholders of the airport system closer together in operations. As concluded by Riemens (2011) in his PhD thesis is that a successful collaborative relationship between stakeholders is key to a successful airport system.

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