Acquiring team-level performance for UAS mission

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Abstract

1. Introduction

Several reports published in the United States have stressed the importance of human factors on the Unmanned Aerial Vehicle (UAV) systems attrition rate. Indeed, the number of incidents involving UAVs in the U.S. is a hundred times higher than the number of incidents related to aircraft with crew on board (Blazakis, 2004) [1]. The lack of experience and ground training can explain this high attrition rate. Thirty-two percent of the incidents considered in this study were due to human factors and are linked to errors in decision making, perception of environmental elements, or lack of skills in vector control (Manning et al. , 2004) [2]. Therefore, both the operators training and the optimization of steering situation became the investigation keys for the future of UAV system.

The aim of these paper presented here is to put the crew at the center of the Human. More specifically, we will prove that only the emergence of collaborative competence will allow to the complexity and the constraints of the UAV system. The concepts of Situational Awareness (Endsley, 1988) [3] and Shared Mental Models - MMS (Canon-Bowers, Salas, & Converse, 1993) [4] will be developed in this report in order to describe the genesis of that collaborative skill within the crew.

The discussions held throughout this report are based on the example of the Unmanned Aerial System (UAS) / Medium Altitude and Long Endurance (MALE) called "Harfang" the French Air Force’s UAV. The EED (Experimental Drone Squadron) of Mont-de-Marsan has received “Harfang” in February 2008 and has deployed it in Afghanistan. Note here that operators had very little time to familiarize themselves with the system before it was projected in operations field (i.e. in a complex environment). Operators are now trained in Afghanistan directly. The "youth" of the system within forces, where everything is to be discovered, including the notion of crew, and the operators’ feedback on experiences of this evolving system, offers an exceptional opportunity to study the emergence of a collaborative competence necessary to conduct the missions assigned to Harfang.

2. Unmanned Aircraft System definition

2.1. A complex system

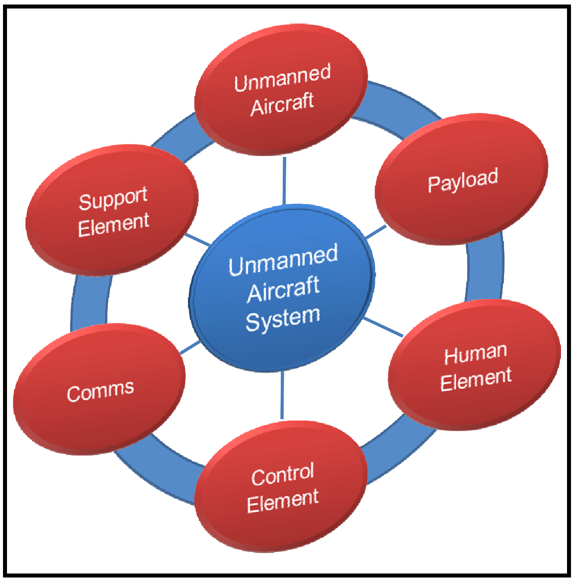

Figure. 1: a system of systems

An UAS is a complex system composed of several components (see figure.1):

- Unmanned Aircraft Vehicles (air segment);
- A payload and control element (ground segment including several modules);
- Communications (satellite and Line Of Sight – LOS – communications)
- Human element (the team).

The ground segment is modular:

- Module 1 for mission planning
- Module 2 for takeoff/landing/transit
- Module 3 for UAV and payload control on the battle area
- Module 4 for intelligence analyses

The complexity is also due to the heterogeneity of UAS operators. In the case of Harfang, the team consists of a pilot operator who controls the vehicle and the payload, an image operator who collects the data, and a tactical coordinator who both manages the UAS team and takes Command and Control orders into account. In other words, each operator is an expert in his own domain but is not used to working in a UAS team.

2.2. A binding system

In addition to being a complex system, an UAV system has very strong constraints. Indeed, an UAS is a deported environment controlled from the ground, which must provide continuous surveillance over specified areas of interest or potential.

- A remote environment: Flying an UAV means controlling an unmanned board situated thousands of kilometers away through an interface that provides vector's data (e.g. speed, altitude, heading, etc..) and pictures of the system's useful specifications (video, infrared, etc.). The operator therefore has no steering feelings, and despite this, he has, for several hours, situation awareness precise enough to make up the lack of direct sensory-motor information.

- The area permanence: The primary mission of UAV systems is to "permanently" monitor an area determined by alternating two or three vehicles for a range of 12H each (in the case of the Harfang). How to ensure this persistence in the HF view? We will make a distinction between the issues of work organization (reports, time on station, handover, etc.) and informational problems (how to create, store and share a good situational awareness on such a long period, how to collect and treat information continuously, etc.).

3. Conceptual background

3.1. Emergence of team-level performance

The complexity of an UAV system and the constraints related a remote-controlled environment that must provide continuous surveillance, require the emergence of a

collaborative competence. This skill is not only the ability to apprehend situations by several operators that couldn't be taken into account by a single individual (Bataille, 1999) [5], it is mostly the emergence of skills and knowledge that an individual may not invent or develop individually (Beillerot, 1991) [6]. This collaborative competence emerges from the cooperation and synergy between individual skills existing in the team. The simultaneity and synchronization of individual work to produce collectively (Mohammed & Ringseis, 2001) [7] is essential for the team issue. The team members construct a complex web of interrelationships and thus reinforce the interdependence of their tasks, their trade and their goals (Saavedra, Earley, & Van Dyne, 1993) [8].
Weick and Roberts [9] suggest the concept of collective mind to highlight interrelations between different actors within an organized system (e.g. an UAV). To address the reasoning "uniqueness" that an isolated operator may have, team members are organized into networks, using collaborative technologies such as text-chat. In doing so, they reduce ambiguity due to misinterpretations (Weick, 1993) [10]. The concept of collective mind stresses the importance of pooling expertise to link every actor into network in the one hand, and reducing the amount of circulating information, in the other hand.

3.2. From SA to SMM

In this paper, we consider that an effective way to increase the crew synergy is promoting and organizing interactions between members (e.g. joint training, information exchanges from collaborative technologies, shared knowledge). To address such a research question, we first seek to determine the way each operator builds its own SA. In a second time, we provide a comprehensive understanding of the way collective knowledge structure is developed by team members. To fulfill these two objectives, we draw on a precise analysis of the real work processed by an UAS crew's members. Finally, we suggest Human Machine Interaction (HMI) solutions to support the emergence of team-shared knowledge.

4. Research methodology

4.1. Situation Awareness

Literature recognizes the importance of studying SA [11; 12] both in the field of classic aviation and of UAV system. The main feature of an UAV system concerns the deported environment within which the operator controls the UAV (physical separation between the UAV and the operator). In these deported conditions, the operator may have some difficulties to acquire an accurate perception of the vector current situation. In addition, the flight operator (in the case of the Harfang system) controls the vector and the payloads. When the second task is cognitively costly (e.g. tracking a moving target), the operator pays insufficient attention to the vector's control, degrading his situational awareness. In this circumstance, the risk to lose the vector is high.
The SA represents an individual knowledge structure, which is not systematically shared by other crew members. We reckon that the collaborative competence of UAV team relies on the ability of its members to share a common SA. We call that ability the SMM.

4.2. Shared Mental Models – SMM

In 1993, Canon-Bowers, Salas and Converse broaden the scope of the SA showing a positive effect on SMM that facilitates the SA.

A mental model is a knowledge structure which allows to recognize and to integrate relations between environmental elements and to anticipate the environmental next states. The SMM provide all team members with common references, and allow them to select the actions which are coherent and coordinated with other team members' actions. When communication is difficult, SMM are decisive because it is essential to understand "who does what and when."

4.3. Operators' actual task analysis

This investigation requires having access to the field of operations. In order to conceive the optimal technical assistance one has to be aware of the way operators cooperate and coordinate their actions.

A first task analysis consists in describing the prescribed task and the actual task (tasks really carried out by the operators) and will allow to build the model of their activities (Leplat & Hoc, 1983; Leplat, 1997) [13]. Several criteria such as the task goal, the task distribution, the operations' interdependence, the purpose of the task and the materials and intellectuals resources, can be used. A second approach engages a quantitative method as well as a qualitative method. The qualitative method includes observations and interviews. It is necessary to understand the context and to discover more about the process and the team coordination. The quantitative method includes various characteristics as complex tasks and priority tasks. We also need to study some objective measures of coordination to achieve missions.

A third approach is experimental and consists in a study on system's operators. This method allows describing precisely the different strategies used during the three last steps. Thanks to this description, we can identify which strategies were the most relevant to achieve the mission. It requires four steps: the CT defines a virtual mission, the briefing, the mission implementation on computers, the debriefing with auto-confrontation method. The briefing step can used different strategies and this approach enables to formalize several strategies used during the briefing and to study contextual variables that led operators to revise or drop the planned strategies.

5. Technical propositions for team-level performance

5.1. Training to work in synergy

Cooke, Gorman, Duran and Taylor (2007) [14] suggests that the goal of an UAS crew is to detect and interpret targets, to anticipate, to solve problems, to extract environment information and make collective decisions. According to the authors, the training of the crew should focus on acquiring strategies to share and distribute each one's knowledge. The Cross-Training is relevant. Indeed, the operators must understand and use skills close but different from theirs and these news skills allow a more global approach with those recommendations. They involve, for an individual, the opening of its expertise domain to integrate skills from related areas of expertise, and thus enable a more holistic, integrative, problem approach - which would be inaccessible to an isolated expert. It is an approach geared towards interdisciplinary. For the UAV team, the expected result is to reduce the difference between each operator's skills so that the operators can understand each one point of view on a same problem.

5.2. Communicating and sharing

The material resources sharing degree influences the cooperation between operators. Communicating and sharing need to increase, it's important, for instance, to develop a chat communication between operators the possibility to communicate between operators by a shared chat and the system of Rover (Remotely Operated Video Enhanced Receiver). The Rover is a system that allows to observe what Harfang is seeing. The teamwork receive the images acquired by the Harfang sensors, that allows the UAV team work to see the ground forces that Harfang observe. The team works receives the images acquired by the Harfang sensors and realizes the mission of reconnaissance and target identification. Communicating and sharing information is necessary to achieve the mission, moreover involving for operators have to share a common operative language. The operative language can be direct face to face or not. In this case, operators use phones, paper or computer networks. The operative language consists in the utilization of specialized and simplified words but nevertheless adapted to the work situation (Falzon, 1995) [15]. Improving the information sharing is a solution to achieve each one's mission. For that, an optimal human machine interaction must be conceived (e.g. an electronic board was elaborated for a hospital).

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