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Managing emergencies and abnormal situations in air traffic control (part II): Teamwork strategies

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ABSTRACT

Team performance has been studied in many safety-critical organizations including aviation, nuclear power plant, offshore oil platforms and health organizations. This study looks into teamwork strategies that air traffic controllers employ to manage emergencies and abnormal situations. Two field studies were carried out in the form of observations of simulator training in emergency and unusual scenarios of novices and experienced controllers. Teamwork strategies covered aspects of team orientation and coordination, information exchange, change management and error handling. Several performance metrics were used to rate the efficiency of teamwork and test the construct validity of a prototype model of teamwork. This is a companion study to an earlier investigation of taskwork strategies in the same field (part I) and contributes to the development of a generic model for Taskwork and Teamwork strategies in Emergencies in Air traffic Management (T^2EAM). Suggestions are made on how to use T^2EAM to develop training programs, assess team performance and improve mishap investigations.

1. Introduction

Teams usually function in environments where task complexity exceeds individual capacity, decisions have multiple aspects to be traded off, information uncertainty prevails, errors may have critical consequences, and peoples' lives depend on collective insights of individuals (Salas et al., 2008). Problems in teamwork have been implicated in a number of high profile aviation accidents, e.g., the collision at Tenerife, the shooting down of civilian aircraft by the USS Vincennes, and the mid-air collision at Uberlingen. Emergencies present controllers with many challenging issues such as, synchronization of interconnected activities, information exchange within a short time, balancing of workload and changing of task priorities. In addition, safety-critical situations are not tolerant of errors and hence, controllers should create their own opportunities for error detection and correction. Teamwork appears to be associated with air traffic control performance especially in handling variations of the environment and abnormal situations; the European Air Traffic Control Harmonization and Integration Programme (EATCHIP) has created guidelines for implementing Team Resource Management courses in air service providers (EATCHIP, 1996).

Traditionally, the focus of controller training has been on fulfilling regulatory requirements. Effective handling of emergencies was considered as a natural by-product of technical skills training. However, a growing number of recent incidents and accidents in ATC and aviation indicated that effective handling of emergencies requires more than technical skills (Kirwan et al., 2005). Formal team training is not offered routinely in most ATC service providers even though teams are expected to function to a high standard in their operating environment. If teamwork is an important aspect of safe and effective performance, an assessment that captures teamwork in air traffic control comprehensively is needed. Such an assessment should include several dimensions that contribute to effective teamwork in ATC teams, and it should be valid (i.e., measuring the dimension it is supposed to measure and predict outcomes) and reliable (i.e., measuring a dimension in a consistent manner). To this end, two field studies were undertaken to probe into the teamwork strategies of controllers in emergency scenarios and contribute towards a taxonomy of teamwork skills. This inventory of skills could provide the core content of team training, assist practitioners in debriefing sessions at the completion of their shift or in their investigation of more critical mishaps.

To date, research that has addressed team performance in ATC has focused on separate behaviours, most often communication, in isolation to other teamwork strategies (e.g., Cardosi, 1993; Morrow

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et al., 1993). While it is important to assess specific team skills, this approach cannot capture the characteristics of the whole team; dimensions of teamwork should also be studied in their context of interactions and this requires the development of a comprehensive model of teamwork in air traffic control.

The focus of this paper is on en-route controllers handling aircraft in the upper airspace during normal cruise. Because of its large airspace, Areal Control is usually divided into a number of sectors that transfer aircraft between them. ATC teams comprise two controller positions, as discussed below, who are responsible for a single sector but must maintain coordination with the adjacent sector teams for the transfer of aircraft that cruise the airspace.

- *The Coordinating Controller* (*CC*) establishes the overall plan for the entry and exit of aircraft in the sector and assists the Executive Controller especially in cases of unusual events. The position also involves coordination with adjacent sectors to manage clearances, revisions, and early transfer of aircraft in accordance with prescribed procedures. Finally, the CC should inform the Watch Supervisor for unusual or emergency situations.
- *The Executive Controller* (*EC*) directly communicates and controls the aircraft in the sector and carries out the overall traffic plan as established by the CC. When traffic builds up to high levels or an unusual event comes up, the EC should inform the CC for managing changes in priorities.

A Watch Supervisor assumes overall responsibility but becomes more actively involved in the management of large scale emergencies.

The main aim of this paper was to produce a taxonomy of team strategies in air traffic control to support the measurement of teamwork based on observations of behaviours either in the simulator or the operating context. The approach was based on ergonomic research methods widely adopted in aviation (Flin et al., 2003), the military (Salas et al., 2008) and acute medicine (Fletcher et al., 2004). The study is divided into the following phases: (i) a literature review to develop a taxonomy of teamwork strategies in ATC, (ii) a validation of the taxonomy in the context of two field studies of novice and expert controllers, and (iii) the application of the taxonomy to team training, debriefing, and investigation of mishaps.

2. Development of a teamwork model

In recent years, a growing body of research in teamwork has emerged in the domain of aviation, military, and acute medicine. This section reviews the main categories and elements of teamwork proposed by earlier research and create a synthesis of findings that would be appropriate in the context of air traffic control. The literature emphasized several concepts of teamwork that are summarized in Table 1.

An adaptation of earlier concepts of teamwork was necessary, however, for a number of reasons: (i) in some cases, the definitions were imprecise, and thus open to interpretation, (ii) there was an overlap between the concepts that made it difficult to categorize teamwork skills with an acceptable level of reliability and (iii) the composition and culture of ATC teams are different to those of military, flight crews and medical practitioners. A model of teamwork was developed – specific for the requirements of handling abnormal situations within the operational context of air traffic control – on the basis of three earlier frameworks of non-specific skills for teamwork.

In the context of aviation, a research project investigated possible ways to evaluate non-technical skills of multi-pilot aircrew (van Avermaete and Kruijsen, 1998; Flin et al., 2003). The teamwork aspects of the NOTECHS framework (Non-Specific Skills) have included: team building and maintenance, considering others, supporting others and conflict resolution. A preliminary evaluation of NOTECHS indicated that the basic psychometric properties were acceptable and that the system was usable and accepted by practitioners (Flin et al., 2008).

In the context of anesthesia, Fletcher et al. (2004) developed a framework for Anesthetists' Non-Technical Skills (ANTS) which examined aspects of taskwork and teamwork strategies. ANTS proposed five elements of teamwork including, coordinating activities, information exchange, authority and assertiveness, assessment of capabilities of team and self, and supporting Others. The evaluation of ANTS (Fletcher et al., 2004) and usability trials (Patey et al., 2005) yielded promising results.

Another more generic framework of teamwork, The Big Five (Salas et al., 2005), has been developed on the basis of empirical studies and theoretical models of team performance over the last decades. The Big Five provides a practical taxonomy of five categories of teamwork and three coordinating mechanisms that are interconnected by ten propositions. The categories that are the backbone of 'The Big Five' model include: team leadership, mutual performance monitoring, backup behaviour, adaptability and team orientation. As it can be seen from Table 2, these frameworks share quite a few categories. Especially, NOTECHS and ANTS have been developed by team of researchers that participated in both projects.

Table 1
Concepts of teamwork in the literature.

Description of teamwork concepts	Selected sources
Shared mental models: Organized knowledge structures about task relationships and team interactions. It is externalized by the degree of common understanding, overlap agreement and congruence of orientations.	Rentch and Klimoski (2001), Rentsch and Woehr (2004), Entin and Entin (2000)
Communication: A process through which knowledge and information is shared between team members. It includes aspects of implicit and explicit information exchange, challenging and negotiating ideas and closed loop communication.	MacMillan et al. (2004), Bowers et al. (1998), Salas et al. (2008)
Cooperation: It is the "*team-ness*" within the team and includes aspects of team orientation, collective mutual trust, willingness to accept individual risks in favor of team goals, and team cohesion.	Smith-Jentch et al. (2000), Smith-Jentch et al. (2006), O'Dea et al. (2007)
Coordination: Efforts of team members to act in concert to achieve a common goal. It includes aspects of knowledge requirements, mutual performance monitoring, backup behavior and adaptability.	Salas and Fiore (2004), Entin and Serfaty (1999), Salas et al. (2008)

Table 2
Taxonomies of teamwork from the reviewed models.

Group	NOTECHS	ANTS	The big five
1	Team building	Coordinating activities	Team orientation and shared models
2	Considering others	Assessment of capabilities	Mutual monitoring of performance
3	Supporting others	Supporting others	Backup Behaviour
4	Conflict resolution	Authority and assertiveness	Team leadership
5		Information exchange	Closed loop communication