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WHAT WE KNOW ABOUT TEAMWORK AND MULTITEAM COORDINATION IN AVIATION: OVERVIEW MODEL

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Much of the work of pilots, flight attendants, air traffic controllers, aircraft mechanics, and flight operations center personnel is done in teams and coordination within and between teams is required. This is the first in a five-article series discussing theory and research relating to teamwork in aviation. This article presents a comprehensive model of teamwork in aviation. It builds on leading teamwork theories and integrates other aviation-relevant constructs such as decision making, technology, and culture. All components of the model have been extensively supported in the general team literature, but the extent of aviation-specific research varies considerably across constructs. Additional articles in this series examine the various components in greater detail.

In this article, we discuss the importance of effective teamwork within and across the multiple facets of commercial aviation. We provide a broad framework of factors affecting teamwork including teamwork processes, factors supporting teamwork, and contextual features affecting teamwork. In the other articles in this series, we review the extant literature on teamwork in aviation. We also identify gaps in research, and provide conclusions and suggestions for research and practice.

Airline operations require coordinated action and information flow among multiple components including airline flight operations, maintenance, ground operations, airport management, air traffic control (ATC), pilots, and cabin crew (Loukopoulos et al., 2009). Teamwork is required within each of these components, but coordination is also needed between components. Thus, the airline industry is composed of multiteam systems (Cahil et al., 2014; Shuffler et al. 2015).

Operating as an effective team is vital for safe airline operations (Helmreich, & Foushee, 2019). Within aviation, this is often referred to as crew resource management (CRM), a term developed to describe effective team interaction, decision-making, and safety management. CRM training has emphasized team-related factors such as leadership, climate, communication, and decision-making (Kanki et al., 2019). Teamwork failures have been identified as major proximal causes of mishaps among both pilot (Miranda, 2018) and ATC teams (Read & Charles, 2018). Although the importance of teamwork in aviation is well-recognized, a comprehensive model of teamwork in aviation is lacking and researchers have expressed the need for a multifactor model of teamwork in aviation (Edwards et al., 2012).

Although teamwork is critical in many contexts, high-risk organizations such as aviation present some challenges to effective teamwork that are not generally found in most other contexts. These include challenges related to safety, culture, technology, decision requirements, need for adaptation, and aviation-specific organizational policies. These challenges suggest the need for an analysis of teamwork within and among the various aviation specializations.

Figure 1 provides an organizational framework for the presentation of the specific aviation-related research on teamwork. It is not intended to supplant extant teamwork models. Rather it is meant to present the teamwork constructs that are discussed and to illustrate the relationships between these teamwork constructs. These constructs apply to teamwork within each of the teams that operate within the aviation industry and also to the multiteam systems. For simplicity, the figure is presented as a path model, but in actuality, complex recursive patterns exist.

Although numerous models of teamwork have been identified (Rousseau et al. (2009), we draw heavily on the work of Salas et al. (2005) and Marks et al. (2001). The Marks and Salas models are among the most influential models of teamwork. We also draw heavily on the work of Klein (2008) as he provides a perspective on decision-making especially relevant to aviation.

Marks et al. (2001) proposed a hierarchical model of teamwork processes including three major categories of teamwork processes: transition processes, action processes, and interpersonal processes. Marks and colleagues emphasize the sequential nature of teamwork processes by conceptualizing teamwork as consisting of recurring patterns of transition and action phases. Transition processes involve planning activities that occur before or between active performance-episodes and provide the basis for coordinated goal directed team behavior. Transition performance includes teamwork behaviors related to mission analysis, goal specification, and strategy formulation. Action processes consist of behaviors occurring while the team is actively seeking to accomplish the task. Action processes include monitoring progress toward goals, monitoring resources, monitoring the performance of team members to provide assistance as needed, and coordination (sequencing and timing of actions). Interpersonal processes involve proactive and reactive conflict management, maintaining confidence and motivation, and managing member emotions and cohesion. Interpersonal processes are conceptualized as occurring during both transition and action phases. Meta-analytic results support the construct validity of the Marks model, including the relationship between effective team performance and both overall teamwork and each of the teamwork processes (LePine et al., 2008).

Salas et al. (2005) proposed a teamwork model with five teamwork processes and three coordinating mechanisms that support effective teamwork. Some of the teamwork processes are similar to those proposed by Marks and colleagues, but three additional teamwork processes were proposed: team orientation, adaptability, and team leadership. An additional facet of teamwork is communication. Communication plays a major role in effective team performance (Mesmer-Magnus & DeChurch, 2009). Communication is recognized as critical for effective teamwork in aviation (Kanki, 2019).

The third theoretical perspective incorporated in analysis is decision-making. Although decision-making has been identified as an important teamwork competency (Cannon-Bowers et al., 1995), it is implicit, but not prominent, in most teamwork models including the Marks et al (2001) and Salas et al. (2005) models. Despite its limited emphasis in most teamwork models,

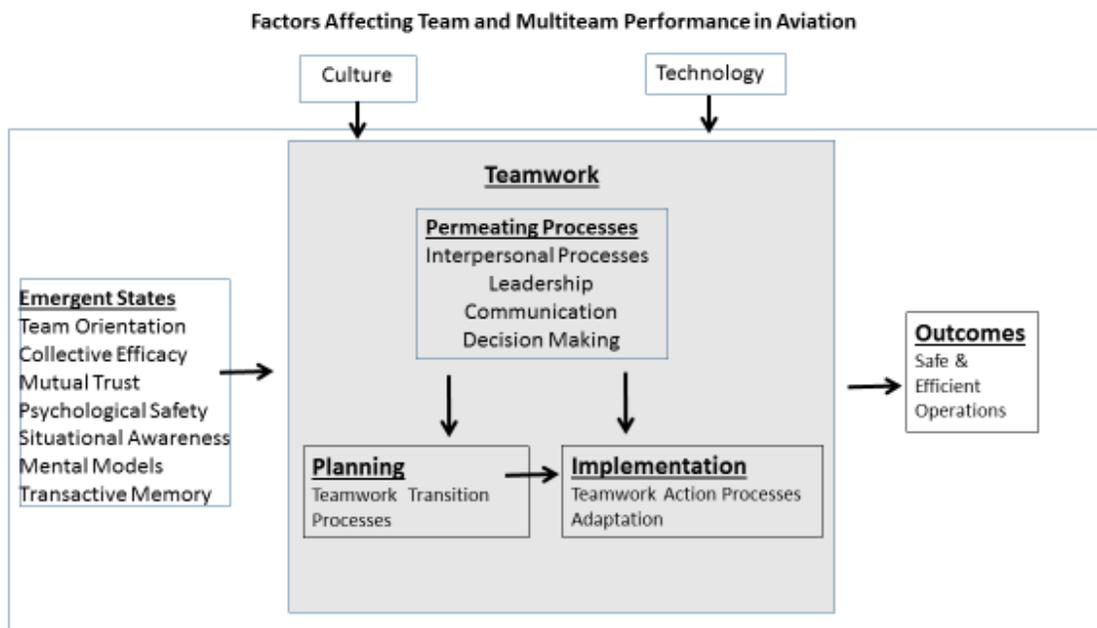
the importance of group decision-making is well established (Castellan, 1993; Forsyth, 2019; Janis, 1989) and is prominent in aviation research. Because some decision situations are routine while others require rapid response, effective team performance in aviation involves both vigilant (e.g., Forsyth, 2019; Janis, 1989) and naturalistic decision-making (e.g., Klein, 2008).

Following Marks et al. (2001), transition and action processes are conceptualized as *sequential processes*. The quality of interpersonal processes, leadership, decision making, and communication, affect both planning and implementation and are conceptualized as *permeating processes*.

Salas and colleagues (2005) also proposed conditions that support teamwork: mutual trust, effective communication, and shared mental models. We expand on these coordinating mechanisms by including the additional emergent states of situation awareness, psychological safety, transactive memory, and collective efficacy.

Finally, two *exogenous influences* are included: technology and culture. Both factors represent contextual features that affect teamwork and performance in aviation. Within aviation, technology has major impact on both individual task performance and teamwork. Many types of culture (international, organizational, and professional) can affect teamwork and team and multiteam performance. (Merritt, 2000; Strauch, 2010).

Figure 1.



Method

We searched for relevant articles using the PsycINFO database by entering the term aviation paired with various teamwork related search terms (e.g., teamwork, decision-making, communication, etc.). We also examined conference proceedings of the International Symposium on Aviation Psychology, FAA resources, reference sections of relevant articles, and other articles and conference papers of which we were aware. The search yielded 116 articles dealing specifically with teamwork in aviation. While it is unlikely that the search identified all relevant articles, it provides a relatively comprehensive picture of literature relating to teamwork in aviation.

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