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## WHAT WE KNOW ABOUT TEAMWORK AND MULTITEAM COORDINATION IN AVIATION: CONTEXTUAL FACTORS AFFECTING TEAMWORK IN AVIATION

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Technology and culture are two major influences that play a role in team processes and performance. Technology can lessen the cognitive workload; however, the use of technology has the potential to undermine shared cognition and teamwork. Aviation technology has been developed to support individual performance, without sufficient analysis of the impact on team performance. Due to the international nature of aviation, cultural differences can play a role in teamwork. Dimensions of national culture, such as power distance and gender roles, along with inadequate English proficiency may impact the effectiveness of communication and teamwork. Status barriers and physical barriers such as the closed cockpit door can compromise communication and coordination between pilots and flight attendants. Teamwork issues related to status and power differences within the cockpit were a primary motivation for the development of CRM. These findings suggest that a wide range of contextual factors can affect teamwork attitudes and behaviors.

### **Technology and Teams**

Aviation is heavily based in technology and technological advances continue to be introduced. Some view technology as functioning as a teammate (Fiore & Wiltshire, 2016; Hoefl et al., 2006). Technology can lessen the cognitive load by allowing for the offloading of duties (i.e., the use of autopilots and automated airspace management tools) and by providing shared displays and memory archives (such as the onboard Flight Management System-FMS with navigation, communication, performance, etc.) Despite the benefits of technology, the relationship between technology and performance is complex. Aviation technology is highly reliable, but not infallible. For example, highly sophisticated Air Traffic Control (ATC) technology can identify airspace conflicts, but the algorithms do not fully account for factors such as winds and airplane handling characteristics. In an ATC simulation study, Rovira & Parasuraman (2010) found that when an automated airspace conflict management system was perfectly reliable, airspace conflicts were noticed and handled more quickly. However, when the technology occasionally provided false alarms or failed to note airspace conflicts, performance declined markedly. These findings highlight the issue of trust in technology.

If teams underestimate the reliability and accuracy of information provided by technology, they may discount accurate information. If they overestimate the accuracy and reliability of

technology, they may discount information from other sources. Reports of aviation accidents and near misses indicate that either too much or too little trust in technology can have serious consequences (Rovira & Parasuraman, 2010). Under time pressure, decisions suggested by technology tend to have very high salience and lead to the under-utilization of other sources of information. Another issue is that an overreliance on technology may result in the erosion of skills and expertise (Mosier & Fischer, 2015).

Communication technology can affect communication effectiveness and team performance. While text-based communication, such as ACARS, is asynchronous and less rich, this digital data can be stored for future reference. Comparison of voice and text chat communication among teams operating unmanned aircraft systems revealed that text-based communication involved greater communication lag and different patterns of coordination. There is also concern that the use of text-based communication can impede situational awareness. Agent-based modeling predicted only small performance differences between voice communication and text communication utilizing a single display window. However, performance degraded quickly when multiple windows were used (Cooke et al., 2014).

While technology often reduces the workload and cognitive load of human operators, this is not always the case. Monitoring of automated systems is a critical component of the jobs of some aviation personnel, such as flight crewmembers and ATC tower operators (Sarter & Woods, 1994). This creates demands for vigilance, a task that is difficult to consistently maintain. Eye tracking data indicate that pilots monitored basic flight indicators, such as altitude and airspeed, but often failed to monitor information related to automated flight modes. In addition, they sometimes failed to understand the meaning or significance of annunciations from automated systems (Sarter et al., 2007).

A great deal of the technology in aviation has been developed to support individual performance, often without an analysis of how to implement the technology to maximize performance at the team level (Maynard & Rantanen, 2005). Wright and Kaber (2005) found that differing levels of automation to support decision-making affected team processes in different ways. They suggest using a team-based task analysis that includes the impact of technology on individual work and team processes.

### **Emerging Issues with Technology and Automation**

Dismukes et al.(2007) suggested that accidents should be viewed as a failure of the sociotechnical system. This is especially relevant as new technologies are introduced. NextGen and SESAR (Single European Sky ATM Research Joint Undertaking) are two major platforms for the modernization of aviation with extensive sets of technological changes planned for aviation. The implementation of these programs is designed to accommodate greater air traffic and they will involve the introduction of several interdependent technological changes (FAA, 2016). These changes will result in new navigation and communication systems, including a greater use of text communication between ATC and pilots and greater autonomous action by technological systems. Technology and automation have great potential to improve functioning in aviation and will be relied on more and more as technological innovations are implemented. However, there are potential threats to team processes and performance in technological change

and we need a much better understanding of how technology and teams in aviation interact as we move forward. Especially needed is research on how proposed technological changes impact teamwork and multiteam systems.

Cooke and colleagues (2014) examined one aspect of technology (communication technology) that affects team and multiteam performance. The multiteam nature of aviation requires communication across teams, such as between ATC and pilots. The expanding use of text-based communication technology raises interesting issues. Text-based communication has both advantages and disadvantages. Examination of nonessential text messages can be delayed so as to avoid conflict with high workload demands. Text messages can provide a more lasting record that can serve as a memory aid. However, asynchronous text-based communications can impede performance in time critical situations. In addition, text-based communication lacks the richness of verbal communication (Cooke et al., 2014). Teamwork issues can arise from a greater use of text-based communication. For example, in the cockpit environment both pilots are generally aware that voice (radio) communication is occurring. This shared awareness allows the pilot not actively involved in the conversation to monitor the conversation and/or ask the other pilot to relay information. If a single text display is provided, only one crewmember may be aware of the message and the second member may not be aware that a message was received. On the other hand, if each crew member has a display, there may be uncertainty about whether each member has noticed the information. Thus, both information sharing and the maintenance of shared situation awareness may be more difficult with text communication.

### **National and Professional Culture**

Culture can exert strong, but often unrecognized influences on behavior, including team behavior (Markus & Conner, 2013). Cultural influences exist within the aviation industry on the professional, organizational, and national levels and can positively and negatively affect operations (Cookson, 2015; Helmreich et al., 2001). Cultural differences can negatively affect team and multiteam performance, especially during high workload and high stress periods (Strauch, 2010). Based on data from 9,400 pilots in 19 countries, Merritt (2000) found that national culture had a greater influence than professional culture in the cockpit. One facet of national culture that affects safety is language. The International Civil Aviation Organization (ICAO) has cited inadequate English language proficiency as a contributing factor in several past accidents, yet Cookson et al. (2011) concluded that language proficiency was rarely the sole issue. Dimensions of national culture such as power distance, gender roles, individualism/collectivism, and uncertainty avoidance affect teamwork in aviation (Wilson et al., 2010). For example, Avianca flight 052 crashed due to the pilots' failure to request immediate landing clearance due to extreme fuel shortage. Helmerich (1994) identified cultural norms as the cause of the Columbian pilots' mitigated communication with ATC.

Mjos (2004) examined dimensions of professional culture among pilots and found that, with increasing experience, captains became more individualistic and focused more on individual needs and less on team cooperation. Pilot perceptions of higher captain dominance coupled with higher individualistic tendencies in the cockpit resulted in first officers feeling less encouragement, conflict tolerance, and reward. These negative professional and social perceptions are dangerous as they create an unsafe atmosphere that restricts communication.

Merritt and Helmreich (1996) discovered that an organization's culture can affect the professional culture in that a positive organizational climate was correlated with more positive CRM attitudes and behaviors. Likewise, the perception of a negative organizational culture that does not support positive CRM attitudes was correlated with a more negative professional culture. A positive professional culture amongst pilots consists of professional pride and motivation, which results in a higher probability of safe flights. On the other hand, a negative professional culture can increase the chances of an accident and is associated with unrealistic pilot perceptions of vulnerabilities, disregard for approved safety procedures, and disregard for teamwork (Helmreich, et al., 2001). Accident rates vary greatly across air carriers and these differences have been attributed to differences in organizational safety culture (Mjos, 2004). A study of small commercial air services in Alaska illustrates how organizational culture can create pressures to take risks. Pilots reported flying in challenging conditions due to explicit or implicit norms, pressure from other pilots, and in some cases policies that paid pilots only if flights were completed (Bearman et al., 2009). These findings suggest that the organizational and professional culture of an airline can affect teamwork attitudes and behaviors.

Expanding outside the cockpit for safety culture issues, culture barriers exist between pilots and flight attendants, which can compromise their abilities to effectively communicate and coordinate. In addition to differences in roles and responsibilities between pilots and flight attendants, there are status differences and social categorization differences in their uniforms, scheduling, travel, and hotel accommodations (Ford et al., 2013). The closed cockpit door creates a physical and cultural barrier between the two entities, which can cause a reduction in pilot and flight attendant communications. It is vital that pilots communicate with flight attendants prior to encountering turbulence to avoid serious injuries to crewmembers and passengers. Chute and Weiner (1995) collected surveys from 177 United States line pilots and 125 flight attendants and discovered 87% of the flight attendants said they sometimes experience turbulence without warning from the pilots. Likewise, as previously noted, flight attendants are frequently reluctant to communicate with pilots. This breakdown in communication could be related to the culture barriers that exist between the two teams.

## **Conclusion**

With the increasing efforts and research of national and international groups, such as NextGen, ICAO, and SESAR, it is important we continue to research how technology and culture influences individual and team performance. Technological advances provide a vast range of benefits with automation and safety, but users must be aware of the potential negative effects such as overreliance, loss of situational awareness, and complacency. Dimensions of national culture and professional culture impacts communication, coordination, and teamwork. A review of the teamwork literature suggests the need for future quantitative and qualitative research in the areas of technology and culture in aviation.

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