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What We Know About Teamwork and Multiteam Coordination in Aviation: Teamwork Processes in Aviation

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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 third in a five-article series discussing theory and research relating to teamwork in aviation. This article presents a core piece of the comprehensive model of teamwork in aviation.

The airline industry involves complex interdependent tasks where planning and implementation are required and adaptation is needed. Under such conditions, teamwork is especially important (e.g., LePine et al., 2008). Teamwork has been studied extensively with respect to cockpit crews, but is important in other teams and across the entire multiteam system.

Sequential Teamwork Processes

Planning (Transition Processes)

In team research, planning activities have been discussed as transition processes (Marks et al., 2001). Flight crews are frequently composed of members with little experience working together. Flight crews were more effective when the captain used the initial preflight briefing to establish norms of safety, effective communication, and cooperation (Ginnett, 2019). Other studies demonstrated the importance of initial planning (Lei et al., 2016), contingency planning (Thomas, 2004), and workload assignment (Hausler et al., 2004). Zijlstra, et al., (2012) found that effective crews had more consistent and more reciprocal communication patterns during initial planning. These studies indicate that transition processes of mission analysis and strategy formulation are related to aircrew performance.

Implementation

Implementation involves attempts to carry out the plans and decisions that have been made Implementation includes action processes needed to carry out the work. Under non-routine situations adaptation may be needed as well.

Action processes. Four teamwork action processes were proposed by Marks and colleagues (2001): goal monitoring, systems monitoring, team monitoring and backup, and

coordination. All are important components of teamwork in aviation. Two simulator studies provide evidence of the importance of monitoring progress toward goals and systems monitoring. Compared to less effective teams, more effective teams maintained standards, managed contingencies more effectively, and were more aware of time and the status of aircraft systems (Hausler et al., 2004). Likewise, effective time management was correlated with more effective performance of cockpit teams (Nullmeyer et al., 2003).

Another important aspect of teamwork in aviation is team backup behavior. An observational study of pilots conducting scheduled flight operations indicated that monitoring and cross-checking was related to effective error management (Thomas et al., 2006). Backup behavior by the flight attendants was associated with more effective performance during a simulated emergency (Bienefeld et al., 2014). Interviews with ATC personnel indicated the frequent use of backup behavior (Owen, 2004). Experienced ATC teams displayed teamwork behaviors such as team monitoring and backup behavior, workload balancing, contingency planning, and proactive communication of information to a larger degree than novice controllers (Malakis et al., 2010). Coordination involves the proper timing and sequencing and compatibility of interdependent actions (Marks et al., 2001). Clear assignment of responsibilities among cockpit crews facilitates coordinated action and is related to effective performance (Nullmeyer et al., 2003) and to managing errors (Thomas et al., 2006). Coordination between pilots and ATC can be an issue because of differential access to information, differing risk assessments, and differences in the preferred actions and timing of actions to prevent traffic conflicts (Davison et al., 1999). Coordination issues between pilots and ATC have led to violations of clearances, unnecessary weather encounters, and near collisions (Bearman et al., 2010).

Adaptation. Hatano and Inagaki (1986) distinguish between routine expertise and adaptive expertise and Kozlowski (1998) extended the concepts to the team level. Routine expertise allows for effective team performance under familiar conditions, but adaptive expertise is needed when teams face unfamiliar situations. Adaptive expertise allows for team adaptation and adjustments in team processes in response to non-routine events (Burke,et al, 2006). In aviation, the need to adapt can be triggered by a wide range of circumstances such as changes in weather, mechanical issues, events aboard the aircraft, air traffic, or human error (Loukopoulos et al., 2009). Tschan, et al., (2018) found nonsignificant or modest relations between performance on routine and non-routine tasks. In an airline simulation study, Littlepage and Wertheimer (2017) found that routine and adaptive performance were unrelated. These findings suggest the importance of separate analysis of performance in routine and non-routine situations. In a flight simulation study, Chen, et al., (2005) found effects of both transition and action phase teamwork processes on adaptive performance. Nullmeyer et al., (2003) found that effective performance was related to situation awareness, clear allocation of responsibilities, use of sound tactics, time management, and willingness to change plans. Waller (1999) indicated that the adaptation of cockpit crews was enhanced when they reactively and proactively acquired and shared information in an attempt to establish shared situation awareness, quickly reassessed task priorities, and assigned tasks. While longer, more complex, and more interactive communication was associated with routine performance, Waller observed a different pattern for situations requiring adaptation. Under non-routine situations, adaptive performance was associated with shorter, simpler communications with less discussion. This pattern allows the team to quickly assess a situation and take corrective action (Lei et al., 2016). Under routine conditions, initial

planning and contingency planning can facilitate team performance. When unanticipated events occur, however, in-process planning is needed and it may need to be done very quickly (Lei et al., 2016). Across studies, a pattern of results emerges suggesting that many of the factors that facilitate performance in routine situations also apply when adaption is needed. However, non-routine situations require greater flexibility, more rapid response, and simpler communication patterns. Next, we describe research on teamwork processes that impact both the transition and action phases.

Permeating Teamwork Processes

Four overriding teamwork processes are involved in both of the sequential processes of teamwork (planning and implementation) and in the development and maintenance of emergent states. The permeating processes of interpersonal teamwork processes, leadership, communication and decision-making are necessary to effectively accomplish both collaborative planning and implementation.

Interpersonal processes

The quality of interpersonal processes impacts each of the other teamwork categories. The Marks et al. teamwork model (2001) includes three categories of interpersonal processes: conflict management, motivation and confidence building, and affect management. Standards for CRM training emphasize the importance of interpersonal processes, including positive interpersonal relations, conflict resolution, and a climate supporting assertiveness. Occasionally, incident reports indicate safety issues resulting from conflict or poor interpersonal relations. For example, in a classic article, Foushee (1984) reported an incident where a first officer was reprimanded by the captain for making legitimate safety warnings. The captain instructed the first officer to "just look out the damn window" (p. 888). Although interpersonal skills are implied in the discussion of CRM training, and research in other areas (e.g., communication, leadership) and is relevant, there is very little aviation research that directly examines the impact of specific interpersonal processes such as proactive and reactive conflict management, maintenance of motivation, and affect management.

Leadership

Salas et al., (2005) identified leadership as an important component of teamwork. Leadership has been found to be related to team performance in a variety of aviation contexts including pilots during normal conditions (Brannick et al., 1995) and flight crews in emergency situations, (Bienefeld et al., 2014). Leadership also impacts the quality of error management (Thomas et al., 2006), and pre-flight planning (Cahill et al., 2013). Three leadership theories seem to have special relevance to aviation: LMX theory, shared leadership, and functional leadership. Both LMX and shared leadership emphasize the importance of trust, respect, and open communication. LMX theory suggests the quality of leader-member relationships is based on perceptions of competence, dependability, and interpersonal compatibility (Graen et al., 1995). Wilson et al., (2010) suggest that LMX theory is especially relevant to leadership in the cockpit.

Shared leadership is also beneficial in aviation. A typical cockpit crew consists of a captain and a first officer who alternate primary control of the aircraft. While the captain has final authority, open discussion and collaborative problem solving are expected between both cockpit crewmembers. The captain is expected to create a culture of psychological safety where crewmembers feel free to raise questions, suggest alternative courses of action, and engage in mutual monitoring. Mandatory CRM training is designed, in part, to emphasize shared leadership, but findings that errors are less likely to be corrected if they are made by the captain suggest that shared leadership is not fully embraced (Thomas, 2004). Brannick and colleagues (1995) found that shared leadership in the cockpit was related to effective team performance. Directive facets of leadership such as clearly assigning task responsibilities (Bowers et al., 1998; Foushee & Manos, 1981) and establishing norms (Ginnett, 2019) are related to effective performance of cockpit crews. Thus, a balance between formal and shared leadership may be appropriate (Grote, 2016). The shared nature of leadership is apparent in multiteam situations involving pilots and dispatchers and pilots and ATC. When a plane is preparing for flight or in flight, the dispatcher and the pilot have joint responsibility for making the best decisions possible (e.g., fuel load, alternate airports). While the final authority lies with the captain, dispatchers are expected to assertively advocate their preferred course of action (Federal Aviation Administration, 2005). Likewise, ATC personnel provide altitude and course instructions, but the pilot can make requests, discuss options, or even fail to comply if he or she feels safety is threatened. Bienefield & Grote (2014) observed leadership of pilots and flight attendants during simulated emergency situations. Both formal leadership and shared leadership strongly correlated with the quality of the decision and crew performance. Likewise, perception of leader inclusiveness predicted speaking up among both pilot crews and cabin crews. Functional leadership involves the leader assessment of the situation and actions to correct deficiencies (Hackman & Walton, 1986). These actions can include addressing teamwork-related issues such as goals, procedures, and responsibilities. Studies of leadership in coordinated aviation combat simulations revealed that functional leader behaviors increase coordination and performance (DeChurch & Marks, 2006; Murase et al., 2014). In a recent description of leadership in cockpit teams, Grote (2016) indicated that a large portion of the research is based on a functional approach, stressing leadership processes rather than the formal leadership role.

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