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High Fidelity Simulation and Aviation Training to Improve Problem Solving Skills and Coordination

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As part of an ongoing collaborative project, a high fidelity simulation lab was developed to address teamwork deficiencies exhibited by newly minted aviation professionals. This lab, referred to as the Flight Operations Center-Unified Simulation (FOCUS) lab, was enhanced with greater fidelity, realistic and complex scenario triggers, and robust after action reviews. Student teams participate in a simulated work shift to further improve problem solving skills and coordination among senior-level undergraduate students.

In safety-critical industries such as aviation, safe and efficient operations require harmonious coordination and effective team performance across disciplines. Quite often, non-routine events that occur during flight operations require immediate and accurate responses from pilots, maintenance technicians, flight dispatchers, and air traffic controllers. Familiarity with the duties of other specializations, along with teamwork training in a simulated environment can result in more effective coordination. Currently, simulation training for such interfaces is rare. Abundant throughout the literature, the usefulness of simulation as an effective tool to improve team performance has been explored in many different safety-critical domains characterized by interdependent teams such as aviation, military, healthcare, and nuclear power industries (Andrew, Plachta, Salud, & Pugh, 2012; Burtscher, Kolbe, Wacker, & Manser, 2011; Howard, 2011; Salas, Bowers, & Rhodenizer, 1998; Waller, Gupta, & Giambatista, 2004). The ultimate goal of integrating simulation is to foster a learning environment which affords the unique opportunity to practice skills and develop strategies for effective teamwork (Arora et al., 2010; Bond et al., 2007). Errors made during a simulation should be viewed as an opportunity to learn how to improve one's level of knowledge and capabilities so as to not make the same mistakes when performing in real-world teams.

Exploring the usefulness of Simulation-Based Training (SBT) in an aviation collegiate environment, this research is a continuation of an ongoing collaborative project of a one of a kind high-fidelity simulation lab. The Flight Operations Center - Unified Simulation (FOCUS) lab is a replica of a regional airline operations center. Undergraduate students from six aerospace specializations interactively complete a simulated work shift as employees in various roles of dispatchers, pilots, ramp controllers, maintenance technicians, crew schedulers, and weather briefers. Routine and non-routine events occur during the simulation in which students must effectively communicate and coordinate with one another to reach solutions that adhere to federal regulations and standard operating procedures, all while running an airline as safely and smoothly as possible. Different from the traditional classroom training, participation in the technological innovative FOCUS lab immerses the students in a realistic airline operations center and provides the platform for increasing the knowledge, skills, and abilities (KSA's) necessary to work in a multi-team environment. Additionally, quantitative and qualitative research from the simulation lab is used to address best practices for communication, disruption management, teamwork, and group situational awareness.

FOCUS Lab Background and Concept

The conceptualization and construction for the Flight Operations Center-Unified Simulation (FOCUS) lab began in 2010 with initial funding from a NASA grant. The idea of the lab generated from industry feedback that it takes approximately 5-10 years for newly minted aviation professionals to understand the big picture of an airline and how their role and decisions impact the organization. Prior to the FOCUS lab, students were in educational silos in which they received the appropriate level of

education in their specific specialization. For example, pilots trained mostly with other pilots in the program in a "silo" manner and learned all the necessary KSA's to fly an aircraft. The problem with this type of training is it fostered an atmosphere of isolation and failed to expose students as to how their role interacted with others within an organization. Understanding the importance of teamwork is vital to safe and efficient operations. In response to a need for comprehensive student training to better meet industry needs, the FOCUS project was designed to address teamwork deficiencies of senior-level undergraduate students.

What started with a round table, a few monitors, and tabletop discussions of various airline operational scenarios has evolved into a highly realistic replica of a regional airline operations center. The simulation includes complex and real-world scenarios with immediate feedback and ramifications of team member's decisions, real-time performance analysis, and in-depth debriefing procedures. Students are afforded the opportunity to work in a high-fidelity simulated operational environment and apply the knowledge learned in the classroom setting to work together and run a virtual airline. Various individual and team performance measures are utilized to analyze their problem-solving capabilities, coordination, and communication. After completion of the simulation lab, students participate in a robust debriefing procedure to review their performance and develop strategies for improvements for the next time they participate in the lab.

Teams are comprised of 10-13 senior-level undergraduate aerospace students from various specializations and they must use all available resources to effectively communication and coordinate together to meet the organizational goals of the lab. The following are the distinct positions in the lab: flight operations coordinator, flight tracking and schedule management, fuel and cargo management, weather and forecasting, crew scheduling, pseudo pilot, CRJ simulated flight crew, maintenance planning, maintenance control, and ramp tower. There are 4 sites that coordinate together during the simulation. Located on the university campus, the main operations center houses a majority of the positions and those students can interact with face-to-face communication or other methods they decide as a team. There are two more sites on the campus but in different locations which are the ramp tower for gate-to-gate management of the aircraft in the simulation and the pseudo pilot position for requesting dispatch releases prior to departures. The final simulation site is based at the local airport for the flight crew in the CRJ-200 flight training device (FTD).

Implementation of Scenario Triggers

With the overall goal to provide individuals with opportunities to practice working together as a team, scenarios must be carefully crafted in a manner that allows such opportunities. Most often, people reach out to Subject Matter Experts (SME) when developing scenarios to ensure the simulation training is an accurate reflection of the real-world environment (Georgiou, Littlepage, & Henslee, 2011). The research team for the FOCUS lab actively consults with industry experts, including line mechanics, flight dispatchers, pilots, and aerospace professors to build a library of realistic triggers for complex scenarios. Lazzara et al., (2010) explains individuals writing the scripts for scenarios need to design them in a way that promotes the KSA's identified in the performance competencies. Supporting this position, all the scenarios are designed in a manner that requires problem solving, coordination, and communication among various members within the team.

Vital for successful implementation of the scenario triggers, all teams are given scenarios that mimic real-world problems and disruptions that must be solved quickly and with minimal impact to the airline. As the FOCUS research team monitors the simulations, the triggers they issue have the potential to cause compounding downstream impacts if not handled correctly. The actions and decisions of the team determine how the research team will formulate the direction of the scenario. This allows for a great degree of flexibility and realism as students will learn that their decisions impact the degree of safety and economics of the virtual airline.

High-Fidelity Components of the Simulation

The FOCUS lab relies heavily on technology to achieve the level of realism and interactivity required by project goals. The degree to which a simulator replicates reality is referred to as fidelity and can improve the external validity of an experiment in the ability to extend the results from the simulation lab to actual working conditions (Leedy & Ormrod, 2010; Beaubien & Baker, 2004). Since a facility of this kind was unique, many technologies had to be adapted and merged to form a functional system. These technologies are comprised of both hardware and software components, some of which are commercially available, while others were customized or developed for lab-specific purposes.

All stations in the lab utilize desktop-class computer workstations with dual screen monitors. The monitors provide the needed desktop space to display multiple sources of information management and communication applications. Headsets are also available at each station, allowing for direct hands free voice communication to other workers. Above the central control desk on opposite walls lie a bank of three large LCD displays that show common-use weather maps, flight tracking radar, and flight status boards. An advanced matrix switch is in place between the source computers and the displays, allowing users to reassign screens as needed. Adjacent to the main control room is the ramp tower room. This room houses 12 computers, three large display screens, and various control stations. This equipment supports the core simulation of flights progressing along flight routes within the service area. It also depicts a photo-realistic 150-degree view of the terminal ramp environment of the hubs used by the virtual airline.

An FAA-certified professional flight training device (FTD), housed at a satellite campus training center, replicates a Canadair Regional Jet (CRJ) 200 series aircraft. As pilots fly the simulator, it electronically interfaces to simulation equipment in the FOCUS lab over a proprietary network architecture and communication protocol. As a result, the CRJ200 simulator appears on radar tracking screens and visual displays just like the other computer generated flights. The flight crew can also communicate with any station in the operations center to solve problems and share information.

Both faculty observers and students utilize a host of software applications to manage information and communicate effectively. First, Skype is used to host single and multi-party voice and text-based communication between stations. Skype is widely available, flexible, and runs on multiple platforms, so it was a clear choice for project use. Another internet application, ‘join.me’ is used to electronically duplicate station screens so observers can monitor individual performance on any internet enabled device.

To support their individual roles, students use Excel-based operations ‘modules’. These modules were developed specifically to help students manage and interpret data for their jobs. An airline back-story is embedded in the file, that each module references, like crew duty times, flight passenger manifests, weather conditions, and cargo loads. This data can then be manipulated and shared with other stations that may need this information. The file also contains a detailed flight status board that automatically displays flight times, status, and routes. Additionally, the flight status board calculates the team’s performance, indicated by average arrival and departure delays, and financial calculations.

The After Action Review (AAR) Debriefing Process

The evaluation process is of utmost importance as it facilities the feedback process. Simulations require robust debriefing protocols to provide for valuable feedback to team members (Lazzara et al., 2010; Shapiro et al., 2008). Rapid and accurate feedback is important to reinforce the lessons learned during simulated training sessions and help team members learn from their mistakes and develop action plans for future improvements (Beaubien & Baker, 2004; Hoffman, 2010; Petranek, 2000). Often with some type of debriefing procedure, team members receive feedback which should link to the learning outcomes (Shapiro et al., 2008). The Federal Aviation Administration recognizes the importance of

feedback during debriefing of LOFT training (FAA, 2004). Flight crewmembers must participate in line oriented flight training (LOFT) simulations with an entire crew and all segments of flight. After completion of the videotaped simulations, the crews are debriefed and provided feedback. According to the FAA (2004), the feedback from the LOFT simulations is an excellent way for flight crewmembers to assess their skills as individuals and as team members. Based on the literature, providing feedback after simulation is the most important component that leads to improvements in team performance.

After completion of the FOCUS lab simulation, students participate in a debriefing session, referred to as the After Action Review (AAR). In this session, expert Industrial and Organizational psychologists facilitate the discussion to include identification of the positive and negative outcomes of the simulation, along with the behaviors that led to those outcomes. If there were any violations to federal aviation regulations or standard operating procedures it is discussed by the AAR facilitator to ensure these same mistakes are not made when they perform in real-world aviation teams. Students are encouraged to be professional, open, honest, and focus on the situations not identify team members with weak performance areas. Most often, during the AAR the teams develop objectives and strategies as to how to improve for the next simulation sessions. Considerations such as safety, adherence to regulations and procedures, and financial impact are the most frequent areas in which students focus on improving.

Discussion

The FOCUS lab is a powerful tool, as both a training facility and research platform. Students gain valuable experience working with others from different specializations to solve complex, time-sensitive problems. The merits of simulation to improve team performance are evident in the ability to measure and evaluate the knowledge, skills, and abilities (KSA's) of individuals interacting in a team environment (Alinier, Hunt, Gordon, & Harwood, 2006; Beaubien & Baker, 2004; Lazzara et al., 2010; Shapiro, 2008). From the data collection and analysis, feedback from simulations helps assess individual and team member skills and performance (FAA, 2004; Lazzara, 2010). Furthermore, team feedback, especially within the team, reinforces critical problem solving, teamwork, and group situational awareness. For faculty, the process of evaluating student performance often reveals potential educational deficiencies that can be utilized to influence future curriculum. The high level of realism students experience in the FOCUS lab increases participant adoption of assigned roles, thereby reducing possible disparities in motivation and 'buy-in'. High fidelity simulation benefits from interactivity, detailed user interfaces, and real-world scenarios and consequences. The After Action Reviews cement positive behaviors and learning experiences, while identifying and addressing areas of needed improvement.

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