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

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HIGH FIDELITY SIMULATION AND AVIATION TRAINING TO IMPROVE PROBLEM SOLVING SKILLS AND COORDINATION

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The Flight Operations Center – Unified Simulation (FOCUS) lab was created in 2010 to break down the "barrier" between aerospace concentrations at Middle Tennessee State University (MTSU) and address several aspects of teamwork in aviation. While participating in the FOCUS lab's high-fidelity simulations, teams of senior undergraduate aerospace students work together to solve complex and real-world scenarios, which helps improve each student's coordination, teamwork, problem-solving, and communication skills. Each team's performance in the FOCUS lab's simulations is evaluated by the FOCUS lab research team and discussed at the team's After Action Review (AAR) to determine how the team can improve its performance in the next simulation. Overall, the FOCUS lab helps prepare all undergraduate aerospace students at MTSU for working in the aviation industry.

In the last several decades, a high number of accidents and incidents have occurred in the aviation industry due to complications within teams comprised of members from different areas of aviation (Burke, Donnelly, Priest, & Salas, 2004; Hamman, 2004). These complications exist because each area of aviation focuses on teaching the skills and techniques that are vital for completing its tasks and goals. This method excludes teaching those skills and techniques that are needed to interact with the other areas of aviation (Baker, Day, & Salas, 2006). However, colleges have noticed that this method of teaching is not effective. The most effective teaching method is the use of active learning techniques (DeNeve & Heppner, 1997). Therefore, the use of simulations has been implemented in order to break down the "barrier" between aviation concentrations and to help aviation college students refine their teamwork skills in order to become exceptional performers in the aviation industry (Bowers, Rhodenizer, & Salas, 2009; Gordon, Issenberg, McGaghie, Petrusa, & Scalese, 2005).

A simulation is a device that allows teams to work in a safe environment and is similar to the actual aviation environment (Baker & Beaubien, 2004; Bond et al., 2007). In addition, it allows researchers to embed scenarios with various levels of difficulty and interject triggers into a simulation to generate a teamwork response (Burke & Salas, 2002; Gardner et al., 2008). The team can evaluate its responses to a scenario or trigger to determine the positive and negative consequences from the decisions that are made. The team is then able to prevent similar negative decisions from being made in the next simulation or the real world (Breuer & Tennyson, 2002; Burke & Salas, 2002; Hunt, Nelson, Shilkofski, & Stavroudis, 2007). Not only can the use of simulations help teams reduce the number of errors that occur in a simulation and the real world, but it can also help members from each aviation concentration to develop effective communication (Hall & Kuehster, 2010).

Simulations help members from each aviation concentration develop effective communication by practicing closed-loop communication (Hunt et al., 2007). During closed-loop communication, a team member sends a message, the receiver receives, interprets, and acknowledges the receipt of the message, and the sender follows up to ensure that the message was interpreted correctly (Burke et al., 2004; Hunt et al., 2007). The use of closed-loop communication has been found to increase team performance, enhance each team member's decision-making skills, increase team knowledge, and help team members understand the vital importance of each team member's communication and input in a team setting (Fiore & Salas, 2004; Hall & Kuehster, 2010; Krivonos, 2007).

Based on the literature, it is important to bring members from all aviation concentrations together through simulations to enhance communication, increase safety, and reduce the number of errors that occur in a team setting. One simulation that allows members from all aviation concentrations to come together is the Flight Operations Center – Unified Simulation (FOCUS) lab. The FOCUS lab is a high-fidelity simulation that replicates a regional airline operations center. Senior undergraduate aerospace students from all concentrations at Middle Tennessee State

University (MTSU) are placed into teams to work a "shift" in a position that is directly related to their concentration, such as the maintenance controller, pilot, flight operations coordinator, ramp controller, and crew scheduler, in the FOCUS lab's virtual airline called Universal E-Lines. This virtual airline allows teams to operate and manage 30 aircraft, specifically Canadair Regional Jets (CRJ) – 200s. During their three-hour simulation, a team handles approximately 80 flights that fly on 16 designated flight routes throughout the southeastern United States. A team also has to manage and solve routine and non-routine events that occur during the team's simulation by effectively communicating and coordinating with each team member while adhering to federal regulations and standard operating procedures. In addition, research is continuously conducted during the FOCUS lab's simulations by the FOCUS lab research team to discover the best practices for teamwork, information utilization, and communication in an aviation team setting.

FOCUS Lab Background and Concept

Before the creation of the FOCUS lab, MTSU undergraduate aerospace students were taught in educational "silos," which means that each aerospace concentration taught its students the information and skills that were only needed for its concentration. For example, flight dispatchers trained only with other flight dispatchers in MTSU's aerospace program to learn how to safely and effectively dispatch aircraft. The issue with this educational technique was that undergraduate aerospace students were not able to interact with other undergraduate aerospace students from every aerospace concentration. This situation caused students to not fully understand how members from all areas of aviation work together in teams to perform various tasks in an aviation team setting. Also, many experts in the aviation industry have reported that it takes up to 10 years for newly hired aviation professionals to fully understand how an airline operates and how their performance and decisions impact an airline. Therefore, Dr. Paul A. Craig, an aerospace professor at MTSU, received a NASA grant in 2010 to create the FOCUS lab in order to decrease the number of years it takes for a newly hired aviation professional to fully understand the big picture of an airline and break down the educational "silos" in order to give senior undergraduate aerospace students the opportunity to work together in teams to enhance their teamwork skills that are vital for working in the aviation industry.

Each team that participates in the FOCUS lab's simulation is composed of 10 to 12 senior undergraduate aerospace students that are placed in a specific position that is most related to his or her aerospace concentration. However, the students do not work together in a single location. There are four distinct locations that are utilized during a simulation. The FOCUS lab houses Universal E-Lines' operations center. The positions that are located in the operations center include the flight operations coordinator, flight operations data, flight tracking and scheduling, weather and forecasting, crew scheduling, maintenance control, and maintenance planning and scheduling. In a room adjacent to the FOCUS lab, the ramp tower position manages all aircraft arriving and departing from one of the airports that is used by Universal E-Lines, specifically Nashville International Airport (KBNA). In an office across from the FOCUS lab, the pseudo pilot position plays the role of the pilot for each Universal E-Lines' simulated aircraft, except for one. The one aircraft that is not controlled by the pseudo pilot is controlled by two students in the position known as the Canadair Regional Jet (CRJ) – 200 simulator flight crew. At the Murfreesboro Municipal Airport (KMBT) there is a CRJ – 200 flight training device (FTD) that two students fly for Universal E-Lines during a simulation.

Throughout a simulation, the FOCUS lab research team, which consists of undergraduate students, graduate students, and professors from MTSU's Aerospace and Industrial and Organizational Psychology Departments, implements complex and real-world scenarios into a simulation to give students the opportunity to apply their knowledge that they have gained from the classroom to solve the scenarios. Once a team determines and executes a solution for a particular scenario, a team quickly learns how its solution affected Universal E-Lines through immediate feedback and real-time performance analysis, which includes simulated financial data. In addition, various measures are conducted by the FOCUS lab research team during a simulation to give effective feedback to a team at its After Action Review (AAR). An AAR is a debriefing process where a team identifies ways to improve its performance the next time it participates in a FOCUS lab simulation.

Implementation of Scenario Triggers

The FOCUS lab research team implements real-world scenarios, or triggers, that vary in difficulty into a FOCUS lab simulation. These scenarios must be resolved by a team in a safe, effective, efficient, and quick manner

that has a minimal to no impact to Universal E-Lines. Also, the team's solution for each scenario must comply with federal regulations and standard operating procedures. However, each scenario has the potential to cause downstream implications if it is not correctly handled by a team. Therefore, once a team determines and executes a solution to a specific scenario, the FOCUS lab research team will evaluate the team's solution and determine the direction in which the scenario will go based on the team's solution. For example, if a team dispatches an aircraft overweight, then there will be both simulated legal and financial ramifications that the team will face. Ultimately, this realistic method helps each student on a team understand how his or her performance and decisions impact the virtual airline's safety and economics.

High-Fidelity Components of the Simulation

To make the FOCUS lab's operations center and simulations realistic, the FOCUS lab relies on various types of technology that are both commercially available and specifically developed for the FOCUS lab.

At each position's station in the FOCUS lab, there are desktop computers with dual monitors that give each team member space to organize and display multiples sources of information and special programs that he or she needs to perform the tasks associated with his or her position. Headsets are also connected to each position's desktop computer that can be used for verbally communicating with any team member. In addition, three large LCD television screens on each sidewall in the FOCUS lab display information that is commonly used by each position. Specifically, the television screens display real-time weather maps, the flight tracking radar, and the flight status board. Adjacent to the FOCUS lab, the ramp tower room houses three large LCD television screens, 12 computers, and several control stations. These pieces of equipment operate the software that controls the movement of Universal E-Lines' simulated aircraft on the flight tracking radar along 16 designated flight routes in the southeastern United States. Also, the television screens in the ramp tower room display a 150-degree view of Concourse C at Nashville International Airport (KBNA), which is one of 16 airports utilized by Universal E-Lines. This view allows the ramp tower position to monitor and manage the movement of Universal E-Lines' simulated aircraft at the airport.

Each position in the FOCUS lab utilizes an interactive Microsoft Excel document that is specifically made to help students retrieve the data they need to perform their position and tasks. The data in the Excel documents can also be manipulated by students to gather the information that needs to be given to the other positions. In addition, each Excel document consists of a detailed flight status board that displays the flight number, departure airport's International Civil Aviation Organization (ICAO) identifier code, departure time, arrival airport's ICAO identifier code, and arrival time for every simulated flight. The flight status board also utilizes status lights for every flight that automatically update based on Greenwich Mean Time (GMT). Also, the flight status board displays and calculates the total time of delays, average departure performance time, daily revenue, and financial delay loss based on a team's performance in a simulation.

There are two computer applications that are used by both students at each position and the FOCUS lab research team to effectively communicate and manage information. One of the computer applications used is Skype. By using Skype, each position in the FOCUS Lab, ramp tower room, and pseudo pilot room can communicate via voice or text with any team member to conduct tasks as a team during a simulation. The FOCUS lab research team uses Skype to communicate via voice or text with each position during a simulation to respond to a team's solution for each scenario that is implemented into the simulation. The second computer application used is an internet application called "join.me." This application gives the FOCUS lab research team the capability of observing the computer screens at each position on an internet-enabled device, such as a smartphone, tablet, or a computer, to assess each student's performance during a simulation.

At the Murfreesboro Municipal Airport (KMBT), a Federal Aviation Administration (FAA) – certified Canadair Regional Jet (CRJ) - 200 flight training device (FTD), or simulator, is used during the FOCUS lab's simulations. Due to the network connections that connect the CRJ - 200 simulator to the FOCUS lab, every position in the FOCUS lab can track the flight path of the CRJ - 200 simulator on the flight tracking radar screen while the CRJ – 200 simulator flight crew flies the CRJ - 200 simulator. The CRJ – 200 simulator flight crew can also communicate with the flight operations coordinator, ramp tower, weather and forecasting, and maintenance controller positions in the FOCUS lab through various communication protocols to gather essential information during all phases of flight.

Recently, 17 documents were made to help the FOCUS lab research team determine whether or not each student was performing his or her tasks correctly. Also, these documents keep track of simulated financial penalties that a team receives during a simulation for negatively affecting the safety of Universal E-Lines, not adhering to federal regulations, or not following standard operating procedures. After a simulation, these documents are used during the After Action Review (AAR) to give each student concrete feedback on his or her performance. Ultimately, these documents help students realize that their performance and decisions actually affect the virtual airline

The After Action Review (AAR)

The primary source of learning in the simulation process is the debriefing process (Holtschneider, 2007). A debrief is defined as reviewing a simulation after its completion to determine a team's positive and negative actions during a simulation (Bonacum, Graham, & Leonard, 2004; Hunt et al., 2007). During a debrief, a professional and experienced facilitator guides the debriefing process by allowing each team member to discuss what he or she believes contributed to the team's success and what contributed to undesirable outcomes (Bond et al., 2007; Hall & Kuehster, 2010). Once each team member discusses his or her views on the simulation, the facilitator reviews both positive and negative aspects of the team's performance (Burke et al., 2004). As a result of a simulation debrief, the team learns how to focus on repeating the types of performances that were successful, avoiding the types of performances that were detrimental to the team, reducing the number of errors that were made, and increasing the level of safety in the decision-making process in both a simulation and the real world (Burtscher, Kolbe, Manser, & Wacker, 2011; Gardner et al., 2008; Hall & Kuehster, 2010).

Throughout a simulation, the FOCUS lab research team monitors and evaluates each team's performance. Once the evaluations are completed, MTSU Industrial and Organizational (I/O) Psychology graduate students and professors perform and facilitate an After Action Review (AAR), which gives a team feedback on its performance during its simulation. Also, the AAR gives each team member the opportunity to discuss aspects of the team's performance that were successful and unsuccessful in order to learn from the team's mistakes. This reinforces a team's positive performances and helps a team build new strategies and goals to prevent similar mistakes from being made in the next simulation. In addition, the MTSU I/O Psychology graduate students and professors discuss decisions that were made by the team that violated standard operating procedures or federal regulations, if any, to ensure those decisions are not made in the actual aviation industry. By participating in an AAR, students ultimately improve their teamwork, problem-solving, and coordination skills, develop strategies to combat their weaknesses, and enhance their strengths to help them become exceptional aviation professionals.

Summary

In conclusion, the FOCUS lab is an invaluable tool for an aerospace student's collegiate training, researchers, and the aviation industry. By participating in the FOCUS lab's high-fidelity simulations of a regional airline operations center and After Action Reviews (AAR), senior undergraduate aerospace students are capable of refining their teamwork, coordination, communication, problem-solving, and decision making skills that are needed to become a successful aviation professional. Also, their participation helps reduce the amount of time they need to fully understand how an airline operates and how their performance and decisions ultimately impact an airline. The FOCUS lab also gives the FOCUS lab research team the opportunity to conduct research during the lab's simulations in order to address several key areas of teamwork in aviation, including communication, information utilization, coordination, and team performance. With the continuous advancements being made to the FOCUS lab's high-fidelity simulations, the FOCUS lab will continue to be an invaluable tool for all MTSU undergraduate aerospace students, researchers, and the aviation industry.

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References

Baker, D. P., & Beaubien, J. M. (2004). The use of simulation for training teamwork skills in health care: How low can you go?. *Quality and Safety in Health Care, 13,* 51-56. doi: 10.1136/qshc.2004.009845

Baker, D. P., Day, R., & Salas, E. (2006). Teamwork as an essential component of high-reliability organizations. *Health Services Research, 41*(4), 1576-1598. doi: 10.1111/j.1475-6773.2006.00566.x

Bond, W. F., Coggins, R. S., Fernandez, R., Gordon, J. A., Lammers, R. L., Reznek, M. A., … Vozenilek, J. A. (2007). The use of simulation in emergency medicine: A research agenda. *Academic Emergency Medicine, 14*, 353-364. doi: 10.1197/j.aem.2006.11.021

Bowers, C. A., Rhodenizer, L., & Salas, E. (2009). It is now how much you have but how you use it: Toward a rational use of simulation to support aviation training. *The International Journal of Aviation Psychology, 8*(3), 197-208. doi: 10.1207/s15327108ijap0803_2

Breuer, K., & Tennyson, R. D. (2002). Improving problem solving and creativity through use of complex-dynamic simulations. *Computers in Human Behavior, 18*, 650-668. doi: 10.1016/S0747-5632(02)00022-5

Burke, C. S., Donnelly, K. W., Priest, H., & Salas, E. (2004). How to turn a team of experts into an expert medical team: Guidance from the aviation and military communities. *Quality and Safety in Health Care, 13*, 96-104. doi: 10.1136/qshc.2004.009829

Burke, C. S., & Salas E. (2002). Simulation for training is effective when …. *Quality and Safety in Health Care, 11*, 119-120. doi: 10.1136/qhc.11.2.119

DeNeve, K. M., & Heppner, M. J. (1997). Role play simulations: The assessment of an active learning technique and comparisons with traditional lectures. *Innovative Higher Education, 21*(3), 231-246. doi: 10.1007/BF01243718

Fiore, S. M., & Salas, E. (2004). Why we need team cognition. In *Team cognition: Understanding the factors that drive process and performance* (pp. 235-248). Retrieved from http://tpl.ucf.edu/summit/ss_research/theory/Fiore_and_Salas_(2004)_TeamCog.pdf

Gardner, R., Godwin, S. A., Jay, G. D., Lindquist, D. G., Salas, E., Salisbury, M. L., & Shapiro, M. J. (2008). Defining team performance for simulation-based training: Methodology, metrics, and opportunities for emergency medicine. *Academic Emergency Medicine, 15*, 1088-1097. doi: 10.1111/j.1553-2712.2008.00251.x

Gordon, D. L., Issenberg, S. B., McGaghie, W. C., Petrusa, E. R., & Scalese, R. J. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review. *Medical Teacher, 27*(1), 10-28. doi: 10.1080/01421590500046924

Hall, C. D., & Kuehster, C. R. (2010). Simulation: Learning from mistakes while building communication and teamwork. *Journal for Nurses in Staff Development, 26*(3), 123-127. doi: 10.1097/NND.0b013e3181993a95

Hamman, W. R. (2004). The complexity of team training: What we have learned from aviation and its applications to medicine. *Quality and Safety in Health Care, 13*, 72-79. doi: 10.1136/qshc.2004.009910

Hunt, E. C., Nelson, K. L., Shilkofski, N. A., & Stavroudis, T. A. (2007). Simulation: Translation to improved team performance. *Anesthesiology Clinics, 25*, 301-319. doi: 10.1016/j.anclin.2007.03.004

Krivonos, P. D. (2007, June). *Communication in aviation safety: Lessons learned and lessons required*. Paper presented at the meeting of Australia and New Zealand Societies of Air Safety Investigators, Wellington, Australia.