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Developing a High-Fidelity Simulation Lab: Challenges and Lessons Learned

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DEVELOPING A HIGH-FIDELITY SIMULATION LAB: CHALLENGES AND LESSONS LEARNED

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With a decade of experience, the Middle Tennessee State University (MTSU) NASA FOCUS (Flight Operations Center- Unified Simulation) lab is a vital part of the educational experience for senior aerospace students. The NASA FOCUS Lab is a high-fidelity simulation of a flight dispatch center in a collegiate setting. Students are trained in specific positions in the lab and must operate within a complex team environment to run the virtual airline within their shift. The purpose of the lab is to provide a learning platform for students to practice the requisite teamwork skills necessary to effectively work in airline operations. Designing effective simulation experiences and providing adequate performance feedback is complex. This paper discusses some of the challenges we encountered and lessons learned through a ten-year span of operation and refinement. By presenting this information, it may help future researchers in the design and development of high-fidelity simulation labs.

In 2008, Middle Tennessee State University (MTSU) developed the first high-fidelity simulation lab of a flight dispatch center in a collegiate setting. Originally funded by a NASA grant, the NASA Flight Operations Center- Unified Simulation (FOCUS) lab mirrors a Part 121 regional airline operations center. The simulation lab offers a unique, collaborative, and interdisciplinary opportunity for both faculty and students in the fields of aerospace and psychology. Additionally, and most importantly, the FOCUS lab provides MTSU undergraduate aerospace students the opportunity to participate in airline operation simulations in a nonconsequential environment. Simulation training has been identified as an effective approach to team training (Kozlowski & Ilgen, 2006; Salas, Cooke, & Gorman, 2010). The purpose of the lab is to provide a learning platform for students to practice the fundamental teamwork, communication, and coordination skills necessary to run an airline. A major component of the simulation is to integrate triggers during their shift that require them to effectively handle emergency and abnormal situations that have potential to disrupt operations.

The FOCUS lab consists of a simulated flight dispatch center of a regional airline and associated activities. The main lab room houses the following positions: flight operations coordinator, crew scheduling, weight and balance and fuel management, weather and forecasting, maintenance control, and passenger/cargo rescheduling. The dispatch center also interfaces with a flight crew in a CRJ-200 flight simulator, a pseudo pilot providing general direction for multiple flights, and a ramp tower controlling runway and gate activities. Participants are senior Aerospace majors in a capstone course from six difference aerospace concentrations. They are assigned to specific positions within the lab, receive training, and participate in up to three 2.5-hour simulation sessions. Since After Action Reviews (AAR's) are considered an effective component of team training, the teams participate in an after-action review (AAR) after each simulation that includes debriefing and discussing ways to improve their performance in their upcoming simulations (Tannenbaum & Cerasoli, 2013; Villado & Arthur, 2013).

From the initial onboard training to the hands-on training in the simulation lab, every training component was developed in-house and includes job-specific duties for roles within the lab. To encourage the consideration of downstream consequences prior to participation in the simulations, software training and exercises are provided to assist the students. In addition to learning a specific role within the lab, students learn the critical skills of communication and coordination in a learning environment that encourages making mistakes and learning from them prior to entering the industry. With over ten years of experience and expertise with the lab, there have been ample challenges and lessons learned along the way. Through weekly feedback and observations, the lab constantly evolves and changes to ensure student experiences are realistic and beneficial. By presenting a summary of the challenges and lessons learned with a decade of continuous improvement efforts, it is our hope that others can glean some beneficial information in the areas of simulation-based training. For additional information regarding the MTSU NASA FOCUS lab, refer to Littlepage, G. E., Hein, M. B., Moffett, R. G., Craig, P. A., & Georgiou, A. M. (2016).

Challenges Encountered

An initial challenge encountered during the genesis of the FOCUS lab involved assembling the expertise needed to design the lab. This required input from multiple aviation specializations including flight dispatch, maintenance, weather, professional pilot, as well as expertise in training, organizational behavior, and teams. Faculty members from the Aerospace and Psychology departments provided this knowledge and technological expertise was provided by consultants and a graduate student. The most effective method to gather everyone's input was in face to face meetings, rather than emails or phone conversations. It became apparent early in the process, that the researchers and staff members must work as an effective team in order to design an effective team simulation.

Funding was and is an ongoing issue. Initial equipment funding was obtained by two NASA grants and subsequent operational funding was cobbled from internal grants, departmental graduate student support, and from lab fees charged to students. Equipment maintenance is an issue as well, as there are often technological issues with the computers, LCD television screens, and communication headsets.

Faculty members provide the overall direction for both training and research and are involved in these activities and supervise other staff members. On the other hand, the actual operation of the lab and data management is conducted by graduate students, along with some assistance from undergraduates. Graduate students are funded through the two departments and undergraduates are paid as student workers. Due to the natural turnover amongst the student staff members with their eventual graduation, there is a challenge to ensure proper staff training for the incoming students selected to help run the simulation lab. A constant succession plan is imperative to ensure adequate transfer of knowledge and skills for the staff members.

Another challenge faced in the lab is the development and implementation of realistic simulations. This portion involved a great deal of planning and attention to detail. For example, flight routes and schedules needed to be developed, along with detailed information about each flight leg. This foundational information included the number of passengers per flight, pounds of cargo, and procedures for fuel calculation. Detailed weather information needed to be developed, along with procedures for determining alternate airports and additional fuel requirements. For crew scheduling, it was necessary to develop a list of crewmembers and their associated legal flight hour availability. An extensive listing of maintenance procedures for inoperative items prior to departure, in-flight mechanical issues, ferrying procedures, and more were included in the development of the maintenance control position. All these activities required substantial time commitments and ample revisions through trial and error.

A variety of training materials needed to be developed to include the following: onboarding to discuss the airline expectations, company policies, etc., orientation training, online positional training, hands-on positional training, and the development of job aids to assist during the simulations. Each training component was labor intensive and the difficult portion was to ensure we developed relevant training materials that aligned with the objectives of the lab.

As we encountered and tackled the various challenges in the development and operation of the MTSU NASA FOCUS lab, the simulations and training were meticulously refined over time. The collaborative efforts and dedication of the Aerospace and Psychology faculty and students resulted in simulations that were more involved, more realistic, and beneficial to student learning.

Lessons Learned

Student and Staff Training

We quickly learned that students needed more training than anticipated. Initially, we developed PowerPoint materials and conducted lecture-based orientation training to provide an overview of the lab and the duties of the various positions. Next, students were provided approximately 30 minutes of on-the-job training to learn their specific work duties in the lab. Over time, it was observed that more training would be needed to help them be successful during the simulations. The training was expanded to include an online overview module and position-specific online modules. Later, we required students to pass tests based on the online training prior to entering the lab for hands-on positional training. Job aids were developed to serve as training refreshers and include brief printed materials, online manuals (maintenance), and software to aid in calculations (fuel and weight calculations, duty-time calculations, etc.). The goal of the training is to ensure the students understand how to complete the technical aspects of their job and the duties and resources of other positions.

The lab is staffed with a team of faculty members, graduate, and undergraduate students. The consistency and realism of the simulations are greatly affected by how well trained the team of researchers and staff members are in the lab. New staff members are trained by the veteran members, along with annual frame of reference training to ensure that staff members make comparable ratings of team performance and fully understand the simulation objectives and procedures.

After-Action Reviews (AARs)

The simulations provide some natural performance feedback, but it was observed that students frequently were unaware of issues that were unresolved or handled improperly. For example, they might not be aware of an incorrect fuel load, passengers missing connecting flights due to delays, or a potential tarmac delay violation. As part of the educational component of the lab, it is imperative students receive feedback on their performance. This feedback allows them to learn from their errors, as well as learn from their successes. To close the loop from the simulation to learning, after-action reviews were implemented and it has been an extremely successful and vital part of the FOCUS lab. The after-action reviews (AARs) are facilitator-led discussions of positive and negative outcomes and specific team member actions that led to those outcomes. Participants are encouraged to discuss strategies that could be used to improve processes and performance. Because students are sometimes unprepared for the AARs, we require them to complete a form identifying effective and ineffective outcomes and the actions leading to each outcome. These are to be submitted within 48 hours and brought to the AAR for the round-table discussion.

Measures

A variety of measures are utilized from the simulation software, observer ratings, and instruments completed by students. As the simulation lab evolved, it became apparent that the measures obtained in the lab must also evolve. Careful attention to the measures is important to ensure the collection of valid and reliable data. Initially, the objective measures were primarily based on the team's on-time performance, such as delay loss and revenue. Eventually, the measures were supplemented with additional costs related to suboptimal performance (e.g. hotel vouchers) and penalties for safety and company violations (e.g. overweight flight, unsafe route). With the complexities present in the airline operation simulation, it became necessary to collect several types of data to measure their individual and team performance.

There are numerous participant-rated instruments administered after the completion of the simulations and there was concern for inattentive responses due to overload. Students consistently provided feedback stating they were tired of taking the surveys and felt it was excessive. This was addressed by spacing out the measures and administering them at various times such as onboarding, after positional training, and after each AAR. Additionally, certain measures were reduced in length and rotated between semesters.

Observer ratings tended to have relatively low inter-rater reliability and this seemed to reflect gaps in observer knowledge. Some observers served administrative roles (e.g. pseudo pilot and local maintenance facility) and were not in the main simulation room. For these staff members, they monitored the operations via electronic communication and would often be unaware of the verbal and nonverbal behaviors occurring during the simulations. The same was true for the staff members in the simulation lab in that they might be unaware of electronic communications. To remedy this issue, weekly staff meetings were held after the simulations to discuss the team's performance. In addition, we equipped observers with I-Pads and share an active document to enter immediate observations of the team performance as triggers are implemented throughout the simulation. Behaviorally anchored rating scales (BARS) were developed to assess team adaptation to non-routine events. These actions resulted in high levels of inter-rater reliability.

Maintaining a Professional Atmosphere

Efforts are made to ensure that students see the value in the lab and act in a professional manner. The professional benefits of the lab experience are highlighted and expectations communicated that the lab should be treated as a professional job. The necessity for regular attendance at the lab and AARs are emphasized and when a member of the team cannot attend the simulation, they are expected to give prior notice to the team leader (the flight operations coordinator). Cell phones and tablets are permitted for legitimate purposes in the lab, such as searching travel sites for flights that can be used to carry stranded passengers and cargo or researching contract maintenance services at off-site airports. When inappropriate use of these electronic devices is observed, corrective action is implemented by a staff member. Additionally, it is important the staff members are an example of professionalism and should not use their cell phones during down times or engage in non-task relevant conversations.

Balancing Standardization and Flexibility

The FOCUS lab has both training and research objectives and sometimes tradeoffs are needed. Training models suggest that simulation difficulty should increase as teams gain competence, but research models suggest consistency across simulations. This issue has not been fully resolved, but the movement has been for greater consistency. Initially, live weather was used which meant sometimes there were ample weather issues like icing and turbulence, and other simulations had calm winds and minimal weather effects on operations. To attempt standardization, previously recorded weather was captured and used in the simulations across the teams. Weather still varies across simulations, but the conditions were selected to reflect relatively comparable conditions.

A variety of non-routine events (triggers) are programmed into the simulations. The number of triggers increases with each simulation that a team faces, but there is some standardization with the creation of sets of non-routine events per simulation. Within each set, events were designed to represent similar levels of difficulty and similar actions to resolve the issue. For example, one team might encounter an unruly passenger, while another might be faced with a passenger with an in-flight medical issue. The use of sets of comparable triggers allows different teams to experience comparable events, but reduces the likelihood that communication across teams would make the triggers predictable. While the researchers plan the triggers in advance, some flexibility is needed about the specific flight that experiences the event. An event might have been planned to occur at a specific time on a specific flight, but if the team was slow in dispatching that flight, it becomes necessary to adapt the scenario.

Need to See the Big Picture

A major goal of the FOCUS lab is to enhance student understanding of the coordinated and nuanced nature of airline operations. This involves knowledge of how one's position relates to other positions within the team. The importance of situational awareness and how everyone works together is discussed in their training and reinforced in AARs; however, it is still difficult for students to see how their actions could affect other parts of the operation. Perhaps the most recurring problem is the failure to foresee downstream consequences. For example, if a plane must divert because of an in-flight emergency, teams almost always handle the diversion properly and generally get the affected passengers to their destination. However, they often fail to plan for another aircraft and crew to take over additional flight legs, along with other downstream issues. To correct this problem, we implemented a procedure borrowed from emergency medicine, known as the pause procedure. When an abnormal event occurs, the flight operations coordinator calls a "pause" and briefly explains the issue to the team. Next, one person is assigned to manage the problem and uses a checklist that evaluates potential implications and develops an appropriate action plan.

Need for Continuous Improvement

Throughout the evolutionary process of the development and implementation of the NASA FOCUS lab, there has been ample challenges faced and lessons learned for improvements. The initial semester involved only a round table description of the simulated airline and the various lab positions. In the following semesters, full simulations and AARs were conducted. Simulation triggers, training materials, and measures are continually developed and refined. While it does require continual funding and improvements, we have learned that dedication and passion for student learning are the two most important factors to keep the lab running.

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