The History and Evolution of the NASA (National Aeronautics and Space Administration) FOCUS (Flight Operations Center – Unified Simulation) Lab

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Abstract

The NASA (National Aeronautics and Space Administration) FOCUS (Flight Operations Center – Unified Simulation) Lab is the brainchild of Dr. Paul Craig, who was responsible for establishing the lab after receiving two NASA grants between 2009 and 2010. This high-fidelity simulation lab combines Aerospace students from every concentration into teams and allows these teams to gain real-world operations experience in a safe, nonconsequential environment, while reinforcing essential crew resource management skills. Due to its success and recognition, organizations from major airliners to distinguished schools and academic institutions often come to tour the NASA FOCUS Lab. This thesis on the history and evolution of the NASA FOCUS Lab has been created for the purpose of documenting the genesis and progression of the lab both for posterity and to act as a reference, recording the steps and processes necessary to create the FOCUS Lab.

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CHAPTER I – INTRODUCTION

The NASA FOCUS Lab

The National Aeronautics and Space Administration Flight Operations Center-Unified Simulation Lab, also known as the NASA FOCUS Lab, is a capstone Aerospace course including both a class and a simulation lab. The NASA-funded lab operates a virtual airline called Universal E-Lines that includes various positions needed to coordinate airline operations. Realistic conditions, such as icing along a route and in-flight medical emergencies, are implemented into the lab that require the students to work together to effectively solve the issues. Triggers are implemented into the lab to test participants' abilities to communicate, collaborate, and problem solve.

The purpose of the lab is to instill in senior aerospace undergraduate students the pertinent skills such as teamwork, communication, situational awareness, and coordination required to perform daily airline operations. These skills are taught in a non-consequential environment, allowing students to make mistakes without the often fatal consequences that accompany real mistakes in airline operations. Furthermore, students gain airline operations experience by simulating the positions and duties required to safely and efficiently operate a virtual airline. The high-fidelity simulation allows students to grasp the "big picture" of the aerospace industry. The lab helps students understand how all components of aviation work together and depend on one another by forcing students out of their silos into a demanding atmosphere requiring collaboration across the board.

Purpose

The purpose of this Honors thesis project is to document the history and evolution of the NASA FOCUS Lab both for posterity and so that others might have a guide by which they can implement similar programs into their own institutions. This thesis is intended to record all of the effort and sacrifice that went into creating the lab. After reading this document, individuals should understand the purpose for which the lab was created and have a better appreciation for both the simulation itself and its success in instilling in students the key traits and characteristics that will benefit them in real world operations.

Thesis Sections

This Honors thesis on the history and evolution of the NASA FOCUS Lab contains eight sections: the introduction, literature review, genesis and evolution of the lab, reflection, conclusion, epilogue, references, and appendixes.

The introduction will serve as the entrance to this thesis, introducing the subject and purpose of this research project. The literature review compiles studies and research in the areas of teamwork, simulation-based training, communication, situational awareness, and decision-making skills. The genesis and evolution of the lab will focus on the history of the lab, from initial birth to present day operations. This section will discuss the events leading up to the creation of the NASA FOCUS Lab and the original intentions for the design and implementation of the lab. Challenges and obstacles that were faced in the process of creating and running the lab will be highlighted in this section as well. Additionally, any major changes or upgrades made to the lab equipment or processes since its induction will be discussed. The reflection discusses the processes used to collect data, mostly via interviews. It also includes personal experiences, obstacles, and any challenges encountered throughout this creative process. The conclusion wraps up the thesis and reiterates the outcome of this project. The reference page lists all sources and interviewees that were consulted in order to collect data. The epilogue will project the future progression of the lab, and how it is predicted to continue to evolve and develop in the years to come. Appendix A is a timeline that depicts the history of the lab from its conception to its present-day functions and includes markings of any notable changes or upgrades made to lab equipment and procedures. Appendix B features a copy of the first NASA grant obtained by Dr. Craig for the establishment and development of the lab.

Interviewees

The information about the history and evolution of the NASA FOCUS Lab was compiled largely from interviews conducted with former and current members of the FOCUS Lab team. From the beginning, the team has been composed of faculty and GAs (graduate assistants) from the Aerospace and Psychology departments. The FOCUS Lab has also provided opportunities for other departments outside the field of aviation, specifically the Psychology department, to interact and conduct research in the lab as part of a mutually beneficial agreement with the Aerospace department. From this group of aerospace and psychology faculty and GA students, several individuals were interviewed, including Dr. Paul Craig, Gerald Hill, Dr. Andrea Georgiou, Paul Carlson, Evan Lester, Dr. Glenn Littlepage, Dr. Michael Hein, Chelsea Jones, and Christopher (Ryan) Bearden.

Dr. Paul A. Craig is the procreator of the lab, brainstorming the initial lab idea and working to see his dream become a reality. He holds several degrees, the paramount being his Ed.D. from Tennessee State University in 1998. Dr. Craig holds 11 Federal Aviation Administration Flight Certificates. He has also received awards for teaching and flight instructing. Dr. Craig is the author of six books and has written articles for renowned aviation magazines. He is also active in many aviation organizations and programs.

Professor Gerald L. Hill partnered with Dr. Craig on the genesis of the lab, helping flesh out ideas and participating in critical decision-making processes. Professor Hill teaches a number of classes at MTSU, and he specializes in Aviation and Transportation Management. He coached the MTSU flight team and, in 1992, received recognition as “Coach of the Year” for region 8 from the National Intercollegiate Flight Association. He also participates in several aviation organizations, serving as a board and committee member in several associations.

Dr. Andrea Georgiou has been part of the NASA FOCUS lab since its early stages of development. She received both her B.S. in Aerospace and her M.Ed. from Middle Tennessee State University. In 2014, she also earned her Ph.D. from Capella University in General Psychology. In addition to teaching a range of Aerospace classes, Andrea Georgiou is also the flight dispatch coordinator, holds an FAA Flight Dispatch certificate, and often acts as an Honors advisor for Aerospace students pursuing an Honors minor. Her research efforts focus on effective teamwork, coordination, and communication among aviation professionals. The majority of her research is completed in the NASA FOCUS lab.

Dr. Michael Hein was involved with the psychology research portion of the lab, collecting and analyzing data on the lab and the students. Dr. Hein is the Director of the

Center for Organizational and Human Resource Effectiveness (COHRE) and a Professor of Psychology at Middle Tennessee State University (MTSU). He received his Ph.D. in Industrial/Organizational (I/O) Psychology from Georgia Institute of Technology in 1990. His research interests include leadership, best use of training/practice time, the determinants of skilled task performance, and the development of expertise. Dr. Hein has taught in several areas of I/O psychology, research design, and statistics such as job performance and appraisal, training, research methodology and factor analysis. He was awarded the prestigious MTSU 2016 Career Achievement Award.

Dr. Glenn E. Littlepage is a social psychologist specializing in group performance. He received his Ph.D. in Psychology at Kansas State University. For two years, he worked for the Department of the Army conducting applied research and program evaluation. He has worked at Middle Tennessee State University for more than 40 years. His teaching interests are in social psychology, group dynamics, workgroups effectiveness, and research methods. He was a recipient of the MTSU Distinguished Research Award and has published more than 50 journal articles, chapters, and proceedings. He served as associate editor for the *Group Dynamics* journal and serves or has served on the editorial board of three journals.

Paul Carlson was a Graduate Assistant (GA) from the Aerospace department. After meeting Dr. Craig and learning about the idea for the NASA FOCUS lab, Mr. Carlson became very passionate about the project. Using his technological skills, Mr. Carlson was largely responsible for setting up the physical components of the NASA FOCUS lab, from computers to programming to wiring. After the lab became operational, Mr. Carlson continued working as the administrator of the lab, often handling the responsibility of initiating the simulation and shutting the lab down afterwards. He also participated in running the simulations, helping teach students how to interact with the program and software, as well as assisting by initiating triggers and scenarios into the simulations. After graduating from MTSU, Mr. Carlson went on to pursue his aviation career, leaving behind a fully equipped, fully functioning lab and a legacy.

Evan Lester was the second GA to oversee the lab, following in Carlson's shoes. During his time in the lab, Mr. Lester wrote an exhaustive Honors thesis in which he detailed every component of the lab and how each component operated. Mr. Lester was integral in taking the lab to the next level educationally, and he also worked on installing new programs and upgrades in the lab. Mr. Lester took full responsibility for the operations in the lab. He made changes to lab equipment and procedures, updated documents in the lab, implemented new policies, and added triggers to lab scenarios.

Christopher (Ryan) Bearden began working as a GA in the lab in the fall of 2015. Following Evan Lester, Mr. Bearden led operations in the lab. He was influential in standardizing many of the lab operations, introducing new lab procedures, and updating lab equipment. During his time in the lab, Mr. Bearden prepared and presented 12 lab-related conference papers and presentations. He was deeply involved with after action reviews (AARs), facilitating and transcribing the surveys as needed.

Chelsea Jones is the current lead GA working in the lab. She enrolled in the NASA FOCUS lab capstone course as a senior undergraduate student and enjoyed participating in the simulations. After graduation, she decided to continue her education. She is now working towards her Master's degree, while acting as the lab administrator.

Since her involvement with the lab, several technical adjustments have been made to the lab and capstone course, from altering the number of simulations students participate in to reducing lab simulation hours.

CHAPTER II – LITERATURE REVIEW

According to Beaufore (2015), students generally face difficulty adjusting to their workplace environment after college. Often, this difficulty results from a lack of familiarity with equipment and processes, but it also occurs because students lack the basic, intuitional skills needed to perform the job. College graduates are typically deficient in these areas because they have not yet had the opportunity to develop these skills. High fidelity simulators are key to giving students the opportunity to cultivate these fundamental skills during their college education before entering the workplace. Studies have shown that active teaching is the best way to teach students operational and performance skills, as well as how to interact and work cohesively with others (Lester & Craig, 2015). Simulations have proven invaluable to this active teaching concept by allowing students to experience real-life scenarios in a realistic environment, but without the risks and consequences that accompany reality. While simulators can help teach and reiterate safety skills on the job, simulators, such as the NASA FOCUS Lab, also provide space for the students to gain real-life experience in a safe atmosphere before engaging in the real-time workplace environment. According to Robert, Smith, and Stratchan (2012), "Simulation is positively associated with significantly improved interpersonal communication skills… and it has also been clearly shown to improve team behaviors… associated with improved team performance in the management of crisis situations," (para. 3). Simulators introduce and reinforce the positive skills and behaviors required of aviation professionals in real-world operations. Additionally, via simulations, students can graduate college with a firm grasp of fundamental safety and operating skills that will be required of them in the workplace.

According to Shappell and Wiegmann (2001), human error has been a factor in 70 to 80 percent of all aviation accidents and incidents. Often these errors can be contributed to poor teamwork and communication skills, a lack of situational awareness, and faulty or inadequate decision-making processes. High fidelity simulators, like those found in the NASA FOCUS Lab, allow participants to experience simulations that mimic real-life scenarios and provide space for learning and making mistakes, without the consequences that such errors might have in real life (Lester & Craig, 2015; Robert, Smith, & Stratchan, 2012).

Teamwork

Teamwork and communication are mutually inclusive and often work hand-in-hand (Richard, 1998; Wertheimer & Littlepage, 2016). Successful communication breeds effective teamwork and vice versa. Groups that exhibit higher levels of teamwork often express fluent communication skills and vice versa (Wertheimer & Littlepage, 2016). Additionally, as teams communicate and share information, both the individual and the team as a whole will be able to make more accurate, informative decisions (Lester & Craig, 2015). Thus, fluent communication increases both the knowledge and decision-making skills of the team and the individual, resulting in higher teamwork and team productivity. Simultaneously, as the group dynamic increases, the elevated level of team coordination and cohesiveness naturally lends itself to greater communication (Lester & Craig, 2015).

High fidelity simulators emphasize the teamwork aspect of aviation by strategically implementing scenarios that promote teamwork among participants (Robert et al., 2012). Teamwork provides the opportunity for people to generate ideas and solutions in a team setting, rather than on an individual basis (Morgan, 2012). According to the Glenn Research Center (2015), teamwork is about learning to overcome difficulties and differences of opinions, personalities, preferences, and backgrounds to serve the greater good. The team structure itself encourages ideas to be discussed and examined and offers opportunity for finding the best possible solution (Morgan, 2012). According to Morgan (2012), “Once a team becomes empowered, they tend to grow in both confidence and skill. A team that understands the importance of what they do will be much more effective in doing it” (p. 1). The aviation industry employs thousands of people who practice professional coordination and collaboration as a basic part of routine, daily operations. As a result, it is imperative that effective teamwork and communication skills be continuously promoted and exemplified throughout all aspects of the aviation industry in order to ensure safe and efficient business operations.

The NASA FOCUS Lab emphasizes the instruction of teamwork skills during simulations (Wertheimer & Littlepage, 2016). First, the nature of the lab itself is designed to break down students’ tendencies to work individually. The simulations are virtually impossible to complete successfully without some level of teamwork and coordination. Furthermore, as the simulations run, lab managers are able to implement triggers that test the teamwork capabilities and cohesiveness of the teams. These teams are comprised of students from every Aerospace concentration. Before the installation of the FOCUS Lab, students at MTSU were taught in “silos.” Classes were arranged in a homogenous manner; students were enrolled in classes that were suited only to students of their same concentration. As a result, students would often graduate with little knowledge of the operations or even existence of any other division outside their own concentration. The

FOCUS Lab simulations are intended to enlighten students about the operations and importance of the other departments within aviation. It is integral that students recognize the crucial role that every division plays in the aviation industry. It is intended that as students acknowledge the importance of the other members of aviation outside their own concentration, they will begin to understand how vital cooperation is between divisions, and, consequently, they will be spurred to cultivate their own personal teamwork and communication skills (Wertheimer & Littlepage, 2016).

Communication

In addition to teamwork, high fidelity simulations teach essential communication skills by simulating situations that require participants to share relevant information and work together as a team in order to resolve problems (Robert et al., 2012). According to Toolwire, “real learning about communication dynamics does not take place in a vacuum, but by interacting and interfacing with others in different contextual situations” (2016, para. 4). The NASA FOCUS Lab is ideal because it provides the opportunity for students to learn communication skills that they would otherwise be forced to learn in the workplace after college (Beaufore, 2015).

Communication is a key function of any team, but it is especially important in aerospace (Krivonos, 2007). In order to have effective coordination, crews must strive to have efficient communication. Teams use communication to share information, establish and reinforce professional behaviors and procedures, and maintain situational awareness. It is through the medium of communication that problems and errors can be recognized and resolved. When communication is stifled, the crew’s ability to recognize and absolve threats, as well as prevent making any additional mistakes or errors of their own, decreases rapidly (Krivonos, 2007).

Among professionals, the closed-loop communication process is generally accepted as the most effective means of communicating (Lester & Craig, 2015; Peyre, 2014). Indeed, the NASA FOCUS Lab teaches its students communication skills based on the same principle. Closed-loop communication must include both a sender, who sends messages, and a receiver, who receives and interprets the message. After receiving the message, the receiver should provide feedback by sending a signal to the sender to indicate that the message was received. From the feedback, the sender can determine whether or not the message was accurately received and understood (Lester & Craig, 2015; Peyre, 2014).

In addition to the closed-loop communication process, there are many factors to consider in communication (Baron, 2017). According to Skills You Need (2019), prime communication skills can be taught based on four principles. First, learn to listen. One of the most important aspects of communicating is actually knowing how to listen. Instead of trying to think of what to say next, true listening requires giving undivided attention to the speaker and listening with the intent to understand what the speaker is trying to communicate. Second, studying and understanding both verbal and non-verbal communication is important in order to be able to communicate clearly. Being able to read and recognize the tone and intonations of the human voice, as well as the nuances of body language, can help both parties involved in the communication process to accurately interpret the real message that is being sent. Third, in order to be able to communicate effectively, one must have an appropriate level of emotional self-awareness and management. Understanding one's own motivations and reactions is key to being able to understand and respond to others in an appropriate, professional manner. Lastly, effective communicators know how to ask questions. It is not just about asking questions, but rather asking the right questions at the right time. For instance, if a copilot is verbally communicating one message, but his body language is sending conflicting signals, the pilot should recognize that now is the time to ask questions to clarify what the copilot is actually trying to communicate (Baron, 2017). There are many aspects involved in communication, but by using the closed-loop process, learning how to listen and ask questions, and being aware of both verbal and non-verbal signals; clear, effective communication can be achieved (Lester & Craig, 2015; Peyre, 2014; Baron, 2017).

Situational Awareness

In addition to teamwork and communication skills, high fidelity simulations contributed to increased situational awareness among participants (Robert et al., 2012). According to Endsley and Robertson, "situation awareness is the detection of the elements in the environment within a volume of space and time, the comprehension of their meaning, and the projection of their status in the near future" (2000, para. 6). Situational awareness is delineated into three levels: perception, comprehension, and projection (Endsley & Robertson, 2000; Henricks, 2018). In level-one situational awareness, perception involves receiving and recognizing the factors and elements in play in the environment. For level-two situational awareness, comprehension is achieved by analyzing all of the data and information received in order to be able to make informed decisions. Finally, level-three situational awareness concerns projection. In this stage, one must predict how the factors perceived and the information comprehended will affect future operations. Each stage of situational awareness builds upon the other. One cannot have level-two situational awareness without first having level-one situational awareness. In the same manner, one cannot achieve level-three situational awareness without having first obtained level-one and level-two situational awareness. Complete situational awareness can only be achieved by having a firm grasp of all three levels of situational awareness (Endsley & Robertson, 2000; Henricks, 2018).

Situational awareness is most often considered in terms of piloting an aircraft (Endsley & Robertson, 2000). While superb situational awareness is required when commanding an aircraft, situational awareness is an essential skill that should be practiced across all divisions of aviation, not just in relation to pilots. The aviation industry would cease to function if only pilots practiced situational awareness. For example, Endsley and Robertson stated that “in more than 60% of avionics repairs, the incorrect avionics system is replaced in an aircraft” (2000, para. 3). Thus, it seems apparent that flight dispatchers, air traffic controllers, maintenance professionals, and more all require situational awareness in order to be able to perform their respective jobs properly. If all members of aviation need situational awareness in order to work and operate, then it would be well-advised that all members of aviation experience situational awareness training (Endsley & Robertson, 2000). The NASA FOCUS Lab provides the perfect environment for students to begin their initial training in situational awareness.

The nature of the NASA FOCUS Lab is unique in that it provides situational awareness training for teams composed of individuals from different aerospace concentrations. As a result, anyone from any division of aerospace can learn situational awareness skills while participating in the NASA FOCUS Lab. High fidelity simulators trigger numerous circumstances requiring students to efficiently tackle and resolve multiple situations, while simultaneously maintaining their normal duties and operations. Students working in the lab also realize the importance of situational awareness in all areas of aviation, whether maintenance, pilot, or flight dispatch. This revelation also increases teamwork and communication across departmental lines, and positively affects the efficiency and effectiveness of the aviation industry as a whole. Situational awareness is an important skill that should be consistently practiced in all aspects of aviation (Robert et al., 2012).

Decision-Making Skills

High fidelity simulators have also been proven to increase critical thinking and decision-making skills among participants (Robert et al., 2012). In the world of aviation, decision-making is referred to as aeronautical decision making or ADM. According to, the Federal Aviation Administration (FAA), "ADM is a systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set or circumstances" (1991, p. 2). However, ADM does not apply to just pilots (Skybrary, 2010). Many operators within aviation, including flight dispatchers and air traffic controllers, use ADM in their daily operations. Therefore, ADM involves any environment in which an individual must choose between multiple alternatives in order to produce a desired outcome (Skybrary, 2010).

Developing effective ADM skills requires a firm grasp of both risk and stress management (FAA, 1991). According to the FAA "stress is...the body's nonspecific response to demands placed on it" (1991, p. 17). Stress in and of itself is not necessarily negative. In fact, initial stress often heightens a person's performance. Upon initial stress, the body's senses become sharper and more honed, and adrenaline begins pumping through the body. However, complications arise when stress exceeds a person's capacity to handle stress. Stress is both insidious and cumulative (FAA, 1991). Sustained stress, even in a seemingly small amount, over a period of time can begin to overwhelm and wear down on an individual's ability to perform well and respond to situations appropriately. Because stress has a tendency to compound slowly, individuals often fail to recognize the early warning signs that they are reaching their stress capacity. Everyone copes with and reacts to stress in different ways. Self-awareness is key to decreasing the effects of stress and ensuring that one does not exceed one's personal capacity for stress. Recognizing and understanding one's own tendencies to stress decreases the possibility of exceeding one's personal stress capacity and increases one's ADM skills (FAA, 1991).

In addition to stress, risk management is key to establishing effective ADM skills (FAA 1991). According to the FAA, "risk management is the responsibility of everyone in aviation" (1991, p. 21). Risk involves the possibility of any negative or harmful outcome as a result of an action or decision (Business Dictionary, 2019). In order to increase effective risk management, many aviation professionals use the DECIDE model, which stands for detect, estimate, choose, identify, do, and evaluate, to assist them in accurately assessing risk and making appropriate decisions (FAA, 1991). The Decide model uses six elements to help negate risk. First, any change in the environment must be detected. Secondly, the decision maker must estimate the need to respond to said change. Next, a desirable outcome must be chosen. Then, after identifying the desired end result, the decision maker must determine the course of action in order to achieve the desired outcome. After deciding on a course of action, the decision maker must follow through and put the plan into action. Lastly, the decision maker must evaluate the situation after responding to the change. The ADM process relies heavily on a firm understanding of the Decide model and effective risk management skills (FAA, 1991).

Training and experience are key to developing proficient decision-making capabilities (Celemi, 2018). High fidelity simulations provide the basis for establishing foundational decision-making skills that students can build upon for the rest of their aviation careers. In the NASA FOCUS Lab, students are exposed to situations that require efficient decision-making processes in order to be resolved. As a result, students learn to address and resolve situations using their own knowledge, as well as the resources around them. As triggers are implemented throughout the lab, students analyze and categorize situations in the hierarchy of priority. The simulations conducted in the lab directly correlate to improved decision-making skills among participants, contributing to the superior development of future aviation professionals (Robert et al., 2012).

Conclusion

Many factors contribute to the structure of effective teams, and a high fidelity simulator, such as the NASA FOCUS Lab, with appropriate management and oversight, can help students practice these fundamental skills before going into the industry (Lester & Craig, 2015; Toolwire, 2016). It is generally understood that anyone employed in the aviation industry has a basic understanding of the tasks required for their position or operation. For instance, pilots know how to fly airplanes, mechanics understand how to work on aircraft, and air traffic controllers possess the ability to direct air traffic flow. However, it is the “soft skills,” such as teamwork, communication, situational awareness, and accurate decision-making capabilities that aviation professionals often lack. At first, these qualities can be less apparent, and deficiencies in these areas are often undetected until a major event, such as an accident or incident, occurs. The NASA FOCUS Lab aims to instill these often neglected, but invaluable, traits of teamwork and crew resource management into aerospace students before they graduate and join the ranks of aviation professionals worldwide. The lab program teaches and reinforces these “soft skills” by simulating realistic situations that occur daily in real-life airline operations. By requiring participants to collaborate and share information in order to solve problems and perform routine operations, the lab emphasizes the importance of skills such as teamwork, communication, situational awareness, and enhanced decision-making capabilities.

CHAPTER III – THE GENESIS AND EVOLUTION OF THE LAB

Inception

The NASA FOCUS Lab was the brainchild of Dr. Paul Craig. Dr. Craig recognized the need for simulation-based training long before the lab was ever conceived. As a young flight instructor, Dr. Craig's first student was an older gentleman who owned a private airplane. After the gentleman successfully passed his checkride, he remarked that he wanted to fly his family down to Orlando to attend one of the amusement parks in that area. Dr. Craig recalls

> I remember thinking, that's a long flight. Way longer than I had ever trained him [for]. That means you've got to fly through the Atlanta airspace, the busiest in the world. It just hit me that, you know, we hadn't done any of that. We hadn't trained [for] any of that stuff. We were just checking boxes so he could pass the checkride. And so, I just didn't think he was very prepared for that, even though legally he was. I guess that is when it first hit me that we should train people based in real-world experiences (personal communication, February 28, 2019).

Dr. Craig began to realize that the training his student had received had not adequately prepared him to take on real-world situations. Somehow, more needed to be done to expose students to real-world experiences, before they actually enter the workplace.

In 2003, the Garmin G1000 flight display system was introduced. Middle Tennessee State University (MTSU) was the first flight school to buy any of these systems. This was a big transition, as students went from piloting with only round dial instruments, to flying with two display screens in the cockpit. Dr. Craig realized that these systems were being introduced before any studies had been conducted on how to train pilots according to this new system. He also knew that any time new technology had been introduced in the past, it was always followed by a spike in accidents, because people didn't know how to use the technology. Dr. Craig then wrote a proposal requesting to study the effects of this new technology on pilots and their ability to adapt to it in the cockpit. The intent of his project was to study pilots interacting with the new Garmin G1000 system in order understand how to train people in the advanced system more efficiently and effectively. The research team also introduced a new syllabus that involved scenario-based training, a concept which Dr. Craig would later include in his creation of the FOCUS Lab.

From these past experiences, Dr. Craig recognized the importance of scenario-based, real world training in educating students in new systems and preparing them for real-life jobs. However, the initial idea for the lab did not come until later, when Dr. Craig went on a FedEx tour in Memphis with a group of students. As they were observing the airport operations and watching airplanes take off and land, the tour guide remarked to Dr. Craig that "sometimes it takes a person like 8 or 10 years to really get the big picture of what's going on up here" (personal communication, February 28, 2019). What the tour guide meant was that employees are hired with full knowledge of their specialty and how to operate in their specific position. However, they usually failed to understand how their specialty interacted with other departments and positions and how it all has to work in tandem in order to operate effectively. For instance, if all the aircraft were pushed back simultaneously, just because they were ready, all the aircraft would end up sitting at the end of the runway, waiting their turn to take off and burning gas, costing the airline millions in wasted fuel.

As he listened to the tour guide, Dr. Craig thought to himself that 8 to 10 years of on-the-job training is a long time for someone finally to understand how all components of aviation work together to accomplish safe, efficient flight. As Dr. Craig ruminated on the thought, he began to wonder if something more could be done to prepare students for operations in the real world - some sort of training that would cut down on the amount of time it takes people finally to understand the full concept of how an airline really works. It was then that Dr. Craig began to wonder if he could take the same scenario-based training that he had created for pilots and apply it to the whole curriculum or field of aviation.

Dr. Craig knew that a training program, such as what he had in mind, would need to be implemented in a coordinated atmosphere where all aspects of aviation intersect. Flight dispatch proved to be the ideal concentration for this setting. Airline dispatch centers function because all of the disciplines in aviation are working together and coordinating with one another in order to keep the airline operating. Using the FOCUS Lab to simulate a dispatch center for a virtual airline, a capstone course could be created that all senior aerospace students from every concentration would be required to enroll in.

Dr. Craig conferred with Professor Hill, who had his own share of crew resource management (CRM) experience from participating in various airline CRM training programs. Together, Dr. Craig and Professor Hill combined their experiences and backgrounds to create the idea of a capstone lab where Aerospace students from all concentrations would participate. The lab would use high-fidelity simulations to teach students CRM skills by operating a virtual airline. Student pilots, mechanics, dispatchers, and more would be forced to interact and work together in order to run the virtual airline, breaking down communication barriers between aerospace divisions and forcing students out of their departmental silos.

Initially, the lab was called the MTSU Center for Research on Aviation Training. However, after receiving NASA funding, the name was changed to the NASA FOCUS Lab to represent both the donor and the functions of the lab.

When working with pilots on his other project in the past, Dr. Craig had received a NASA grant in order to fund his program. He decided to return to NASA to see if they would be willing to provide the funding needed to create the lab. Ultimately, Dr. Craig secured two grants from NASA. The first grant, received in 2009, was for $400,000, and the second, received in 2011, was for $700,000. With over a million dollars in funding, Dr. Craig and Professor Hill turned their attention to securing a space in which they could establish the lab.

The Original Team

Dr. Craig and Professor Hill knew that they would need a team of people to help design and create the lab, as well as run operations once the lab was built. Dr. Andrea Georgiou, MTSU's flight dispatch coordinator, first joined the lab largely as an advisor or consultant, bringing her dispatch experience to the team in order to help design and create the lab. Today, she is currently spearheading operations in the lab. Several Aerospace Graduate Assistants (GAs) were also employed to help with the lab. One such GA was Paul Carlson. Mr. Carlson quickly became a crucial component of the team and was essential in installing most of the technology and programming in the lab. Other GAs included Nora Cole and Jeff Tipton. There were also several volunteer students who offered their services in the lab, including Joe Cooper, an Aerospace undergraduate student, and Durant Bridges, a doctoral student who specialized in maintenance and was essential to developing the maintenance aspects of the lab. Several faculty members from the Psychology department were also involved in the lab, specifically Dr. Rick Moffett, Dr. Glenn Littlepage, and Dr. Michael Hein. Jennifer Hensley and Emily Sanders were both Psychology graduate students who also worked in the lab.

The Progression of Leadership in the NASA FOCUS Lab

Originally, Dr. Paul Craig was in charge of the NASA FOCUS lab. The lab was his brainchild, and he was responsible for procuring the NASA grants and paving the foundation for the creation of the lab. Of course, he had assistance in designing and building the lab, the efforts of Paul Carlson being extremely noteworthy. As a graduate student working towards his master's degree, Mr. Carlson joined the original FOCUS lab team in its beginning stages of conceptualization. He proved to be an invaluable member of the team, using his technological skills and passion for aviation to fuel his efforts. Mr. Carlson was largely responsible for installing most of the original lab equipment, creating the lab programs, and writing up vast excel documents to be used in the FOCUS lab operations. Although Dr. Craig was still the overarching authority figure, Mr. Carlson spearheaded the lab for most of the three and a half years he was involved with the lab. After Mr. Carlson graduated, Evan Lester, another graduate student, took his place heading up the lab. Mr. Lester's contributions to lab were extensive, including upgrading equipment and procedures in the lab, updating lab documents, and helping run lab simulations for the students. Perhaps one of his most significant achievements was completing his own honors thesis project – a manual that detailed every function and procedure of the lab. After Evan Lester, Christopher Bearden, or Ryan as he is known, took over operations in the lab. Dr. Georgiou now heads up the lab, with Chelsea Jones acting as the lead GA in the lab. They are continuing to ensure forward progress in the lab, constantly seeking to improve and upgrade operations and procedures in the lab and looking to the promising future of the lab.

The NASA FOCUS Lab Design

The MTSU Aerospace Department had a space which had previously been used as an FAA testing center for aviation students. The testing center was composed of two rooms: a larger, rectangular room with cubicles where the students were tested, and a smaller office room attached to one end as well. However, due to complications, the Aerospace Department discontinued their FAA testing services, leaving the room vacant. Dr. Craig was granted permission by the Aerospace Department to turn the space into the high-fidelity simulation lab.

A lot of thought went into the design of the lab, including the orientation of the room. The desks were centered in the middle of the main room, with chairs arranged around the outside of the tables. With this arrangement, students would be facing each other while working. The monitors were set on sliding bases, so that they could be strategically lowered, allowing students to see one another over the monitors. This setup would be helpful in facilitating communication and encouraging teamwork and interaction throughout the simulation. Additionally, six large television screens are mounted on the walls around the lab, which provide the students with current weather data and flight information crucial to the airline. The wall displays were crucial as a central component of information sharing.

The ramp tower was constructed within what had been the FAA testing center office. The ramp tower controls aircraft traffic to and from the gate. The tower manages the flow of traffic at the virtual airport, including clearing flights for pushback and assigning aircraft to gates. Additionally, the tower is also responsible for organizing aircraft movement and maintaining gate operations. The CRJ-200 simulator was installed at the Murfreesboro Municipal Airport. This simulator was connected to the Ramp Tower within the NASA FOCUS Lab on campus.

The Psychology Department

The Psychology Department was involved with the lab in its early stages of conception. Dr. Craig reached out to Richard Moffett, who connected him to Dr. Michael Hein and Dr. Glenn Littlepage, both professors and faculty members of the Psychology Department at MTSU. The lab appeals to the Psychology aspect because it provides a research platform from which to study group performance. Coupling highly involved participants with the high-fidelity simulation that the FOCUS Lab boasts made this appeal even more tantalizing.

The psychology members were influential in introducing after action reviews (AARs) to the FOCUS Lab and capstone course. These reviews evaluate student performance after each simulation and are to be completed within a certain time frame following the lab scenario. AARs and similar surveys provide data for the Psychology Department to analyze.

The research conducted by the Psychology Department on the NASA FOCUS Lab has been mutually beneficial to both the Psychology and Aerospace Departments. The FOCUS Lab has provided opportunities for research projects, theses, and two dissertations. Two dissertations have resulted from the lab. Studies based on research conducted in the lab have been published in recognized Aviation and Psychology journals. Students from both departments have had the opportunity to work in the lab as volunteers or GAs.

As a result of the research conducted by the Psychology Department, the FOCUS Lab leaders were able to determine how students were performing. They could decipher the extent to which the students were learning the critical crew resource management skills the lab seeks to embed in its participants. Student feedback also allowed them to grasp students' responses to the simulations. Using this information, adjustments could be made to better fit the students' needs and ensure that the lab was still obtaining its original purpose of providing real-world experiences in a safe, simulated environment, while also instilling those core essential teamwork and communication skills in its participants.

Challenges and Obstacles

As with any major project or creation, challenges and obstacles are inherent, and the NASA FOCUS Lab was not exempt from these challenges. Deciding on a suitable name for the lab, the layout of the lab, and developing all the suitable programs that would be used in each position were all obstacles that had to be hurdled in the process of establishing the lab. Designing the lab itself and developing scenarios to integrate in the lab proved to be tedious and time-consuming as well.

Another hurdle was deciding on the technology and programs to be used in the lab. The FOCUS Lab is intended to simulate realistic flight center operations, thus requiring equipment that is capable of replicating the duties and operations of a flight dispatcher. However, the original team was often forced to tweak or adapt some of the systems and technology installed in the lab to better resemble flight dispatch procedures. For instance, equipment provided by CSC, one of the vendors that supplied technology for the lab, was originally intended for air traffic control operations, not flight dispatch. Equipment from Talon Systems, another vendor, was intended to be used for flight scheduling and tracking. However, after installing the technology, the FOCUS Lab team realized that the equipment would be inadequate for the types of procedures they had in mind. Instead, they were able to use the systems for maintenance tracking. Although not all of the programming and technology was designed specifically with the functions of the lab in mind, by altering and adapting the equipment and working with the vendors, the lab was able to produce satisfactory flight operations center simulations.

One challenge the Psychology Department faced was the lack of standardization in the FOCUS Lab. Each simulation, the experience was different. Weather was based on real-time atmospheric conditions, resulting in different, unpredictable weather factors for every scenario. Additionally, triggers were implemented at random, and there was no set pattern for when the triggers might occur or what the triggers might be. Thus, with constant, ever changing elements that differed for each lab and each group of students, it was hard to measure and compare group performances because of the lack of standardization.

Changes and Upgrades to Lab Equipment and Procedures

Throughout its existence, numerous changes and upgrades have been made to both procedures and equipment in the NASA FOCUS Lab. Some of these changes have been minute shifts and adjustments made as the lab progressed. Other alterations have proved to be major, noteworthy events in the history and evolution of the lab. The flexibility of the lab allows the team to remove or upgrade any old equipment and also abandon old procedures or implement new ones as the lab progresses. Occasionally, changes implemented in the lab were not successful, and they would revert back to a former process. One instance of this was the decision to reduce the number of simulations per semester from three to two. However, after evaluating student learning and performance, it was determined that allowing students to participate in three labs per semester was preferable because it allowed students more time to learn from their previous mistakes in the past two labs and provided them with another opportunity to correct those mistakes in the third lab. However, the lab was shortened from three hour lab scenarios to only two hours.

A few notable lab upgrades included the display and computer equipment. Seven new, 4K, 65 inch television screens were installed in the lab. These provided better graphics and viewing capabilities for the students. New network routers also allowed the computers to show multiple different functions on a screen simultaneously. Several iPads were also purchased which allowed the different positions to communicate via Skype and provided internet searching capabilities for the students to look up information as needed during simulations.

The pilot position in the lab has also been altered to a pseudo-pilot position. Students acting as the pilot no longer go to the airport to fly the CRJ simulator. Instead, they are able to operate as a pilot using a computer station with radar capabilities. This change was implemented partly because the CRJ simulator was proving to be unreliable, but also because, due to the influx of students in the pilot concentration, availability in the CRJ simulator was becoming limited.

One major change to lab procedures was the transition from a somewhat randomized lab format to standardized simulations, allowing all teams to experience the same scenarios with the exact same components. For instance, crew scheduling was standardized to ensure that the same number of crewmembers and other resources were allocated for each simulation. Maintenance functions were likewise standardized along a similar format. Additionally, the secondary flight operations director (FOD 2) position, in charge of weight and balance, was standardized to ensure the same number of passengers that needed to be bumped and moved were implemented in every lab scenario.

The lab was further impacted by the standardization of weather with the installation of the WSI Fusion program – a weather software program donated from Southwest Airlines and IBM. With the introduction of this program, real-time weather could now be recorded, and the same weather scenarios could be implemented for all of the teams.

The triggers implemented into the simulations were also standardized to allow all students to experience the same factors and situations. Previously, triggers were implemented based on student performance in the lab. However, with the standardization of these triggers, the lab operators could now implement the same scenarios into every lab. This allowed the lab to transition to measured simulations, where difficulty of the simulations could be determined based on the level of triggers implemented into each lab scenario: 3 triggers for low difficulty, 5 for medium difficulty, and 7-8 for high difficulty simulations. Standardizing the triggers and scenarios in the lab not only improved student learning, but it also allowed the psychology department to collect better data because they could better analyze and compare data and information across the board.

On the Psychology side of the lab, after action reviews (AARs) were implemented after each lab scenario to evaluate the student performance of that simulation. During the AARs, students discussed the positive operations of the lab (what went right), the negative outcomes (what went wrong), and how they could perform better both individually and as a team in the next simulation. Due to time constraints, these AARs are now conducted online instead of in a personal, classroom setting.

CHAPTER IV – REFLECTION

Working on this honors thesis project of the history and evolution of the NASA FOCUS Lab has been both challenging and invigorating. When I first began searching for a project that would be suitable for my honors thesis, I was unsure which direction I wanted to go. I conferred with Dr. Andrea Georgiou, who introduced me to Ryan Bearden. We had a short, informal brainstorming session, and Mr. Bearden threw several good ideas at me. Ultimately, I decided that a thesis project detailing the history and development of the FOCUS Lab was the best choice for me. I have always enjoyed reading and learning about history of any kind, and I was intrigued by the idea of creating my own history book of sorts. I believed there were several reasons why this study would be beneficial. First, the creation and progression of the lab should be conducted for posterity. Second, I hope this thesis will be a guide to assist others seeking to implement similar simulations and procedures in their academic or organizational trainings. Finally, a thesis documenting both the history of the lab and the reason for its creation would help others to better understand the purpose and objective of the lab. In recognizing these needs, I found a passion to conduct this research project with the goal of compiling information about the general evolution of the lab into one complete, coherent document.

Throughout the process of creating this thesis, I experienced personal growth and development. This project stretched me outside my comfort zone at times, for the better. I depended largely on interviews to gather information for my project. Several of these interviews were conducted in person, a challenge which I found somewhat uncomfortable and intimidating. However, I am now less fearful of such future interactions, and I have grown more comfortable in my own skin as a result. Working on this thesis has allowed me to meet and connect with numerous individuals, many of whom I foresee having a major impact on the future of aviation. Furthermore, as I conducted interviews and analyzed data for my project, I myself gained a better understanding of the purpose for the NASA FOCUS Lab. Through this revelation, I am now more aware of the importance of grasping the bigger picture of aviation and the concept of how any decision I make has the potential to impact not only myself or my small circle, but also can have ripple effects throughout an entire airline.

As of yet, I have not had the opportunity to participate in the NASA FOCUS Lab as part of a team of students. However, I will be enrolling in the lab and its complimentary capstone course in the Spring 2020 semester. I am looking forward to further developing my crew resource management skills and further grasping the complexities of the aviation industry. I am grateful for the opportunity to have conducted interviews with such prominent individuals that I believe have the potential to radically impact the aviation industry. I am especially appreciative of my honors thesis advisor Dr. Andrea Georgiou, for assisting me in first deciding on a thesis project and then agreeing to be honors thesis advisor. She has put many hours into working with me, outlining plans of action, deciding who to interview, setting personal deadlines, and editing, editing, editing. This thesis project would not have been possible without her thoughtful advice and expertise. I am further thankful for the connections I have been provided, the knowledge I have gained, and the opportunities I have been granted while conducting research and creating my honors thesis project on the history and evolution of the NASA FOCUS Lab.

CHAPTER V – CONCLUSION

This thesis has highlighted the initial steps taken to establish the lab, emphasized the challenges and obstacles that had to be faced, and recorded the major changes made to lab equipment and procedures from its inception to present day operations. The NASA FOCUS Lab was created as a training platform intended to prepare students for real-world aviation industry operations. It was intended to break down the educational silos that aerospace students traditionally find themselves in, especially during their junior and senior years when they are training in upper-level classes designed for their concentration alone. In the FOCUS Lab, each discipline has the opportunity to interact with other disciplines in an environment simulating real-world experiences. The NASA FOCUS Lab exposes students to the importance of teamwork and communication, while running operations for a virtual airline.

As they interact, students also gain a better understanding of the “bigger picture” of aviation. They recognize that any decision made can have a ripple effect throughout all departments in an airline and potentially across the aviation industry as a whole. The FOCUS Lab allows students to grasp this concept with the intent of better preparing them to work in the aviation industry. With such a team-minded background and an understanding of the “big picture,” aviation employees are more likely to make smart, calculated decisions. As a result, they will save their company time and money, create a safer, smoother experience for passengers, and work to allow the aviation industry to operate efficiently and effectively.

The general response towards the NASA FOCUS Lab has been very positive. While, several challenges and obstacles have been faced in the process of creating and running the lab, it has been a worthy undertaking. The lab has been successful in reaching its original intentions of simulating realistic environments that provide students with essential crew resource management skills and prepare them for real-world airline operations. Additionally, everyone involved with the lab has given very positive feedback. Not only is the lab a success in reaching its goal, but the labs have been simulated in an open, positive environment that allows for flexibility and adaptability as the occasion requires. As a result, the lab is continuously being tweaked and adjusted to provide the optimum experience possible for both students and lab faculty alike.

EPILOGUE

The NASA FOCUS Lab has made great strides in its operational and technological advancements since its inception. However, as the aviation industry is constantly evolving, the NASA FOCUS Lab must also continue to grow and adapt in order to maintain operations as close to reality as possible. The aviation industry is also experiencing a surge in Aerospace professional applicants; thus, leaders of the MTSU Aerospace depart predict a physical expansion of the FOCUS Lab in order to manage the influx of Aerospace students. Dr. Georgiou envisions

"A lab three times the size and expanding the simulated airline…a future collaboration with a major airline company to sponsor the course and provide new software for use in the lab. Additionally, I see the lab moving off campus to a location that would allow for larger operations and an expanded (virtual) fleet." (personal communication, April 29, 2019).

With a more spacious lab and updated equipment there would be changes to procedures, training, and other areas of the simulation lab. One of the wonderful aspects of the NASA FOCUS Lab is the ability to grow and adapt as new technology is integrated into the lab, as well as make changes for improvement based on student feedback. The MTSU Aerospace Department is committed to doing its utmost to prepare qualified professionals for the aviation industry. The NASA FOCUS Lab is a crucial part of this education process, and as the future of aviation remains bright, so also does the future of the NASA FOCUS Lab.

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Appendices

Appendix A

Table 1

A Timeline of the History and Evolution of the NASA FOCUS Lab

Year	Event
• 2003	- G1000 first came out. Dr. Craig started working on a training program for pilots, from which he first got the idea for scenario-based training.
• Fall 2009	- Received first NASA grant for $400,000.
• 2010	- Received second NASA grant for $700,000
• Spring 2010	- Compiled a team to begin table-top discussion on lab design, identified the goals for the lab and how to accomplish them, determined how to use the money from the NASA grants.
• Fall 2010	- NASA FOCUS Lab and conjunctive capstone course officially opens to students

Table 1

A Timeline of the History and Evolution of the NASA FOCUS Lab

Year	Event
• Spring 2013	- Paul Carlson finished his Master's degree and graduated from MTSU. - Evan Lester took over a lab manager.
• 2015	- Lab operations standardized to ensure all student experienced the same factors and triggers, the same scenarios and outcomes. - New monitors and screens installed in the NASA FOCUS Lab as a replacement for the outdated equipment.
• Fall 2017	- Christopher (Ryan) Bearden began operating as lab manager.
• Fall 2019	- Dr. Andrea Georgiou is the current lab manager, with Chelsea Jones acting as the head GA in the lab.

Appendix B

Appendix B features a copy of the first NASA grant for $400,00 that Dr. Paul Craig received in 2009.

Proposal for Earmark

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	PLEASE FILL OUT
	DUNS NO: 07-764-8780
SOLICITED PROPOSAL APPLICATION	CAGE CODE: 1GNW9
PLEASE FOLLOW INSTRUCTIONS CAREFULLY	TIN 62-6005-794:

1. COMPLETE TITLE OF PROJECT
MTSU Center for Research on Aviation Training

2. PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR *(Paul Craig, Doctor of Education, Professor of Aerospace)*

3. COMPLETE MAILING ADDRESS
Middle Tennessee State University
Aerospace Department
MTSU Box 67
Murfreesboro, TN 37132

4. TELEPHONE NUMBER
615-898-2788
FAX NUMBER 615-898-5028
E-MAIL ADDRESS pcraig@mtsu.edu

5. CONGRESSIONAL DISTRICT: TN-06

6. SOCIAL SECURITY # 413-13-3391

7. IS THIS PROPOSAL ☐ NEW ☐ RENEWAL ☐ REVISED

8. HAS THIS PROPOSAL (OR SIMILAR REQUEST) BEEN SUBMITTED TO NASA OR ANY OTHER AGENCY?
☐ No ☐ Yes IF YES, SPECIFY AGENCY AND YEAR SUBMITTED:

9. CO-INVESTIGATORS *N/A)*

10. CO-INVESTIGATOR'S ORGANIZATION

11. DATES OF ENTIRE PROPOSED PROJECT PERIOD	12. COSTS REQUESTED FOR FIRST 12-MONTH BUDGET PERIOD		13. COSTS REQUESTED FOR ENTIRE PROPOSED PROJECT PERIOD	
	12a. Direct Costs	12b. Total Costs	13a. Direct Costs	13b. Total Costs
From: September 30, 2009: Through: September 29, 2010:	$ 377,490	$22,510	$377,490	$22,510

14. APPLICANT ORGANIZATION *(Middle Tennessee State University*

15. TYPE OF ORGANIZATION
☐ Non Profit ☐ For Profit*(General)* ☐ For Profit*(Small Business)* ☐ Public, Specify: ☐ Federal ☐ State ☐ Local

16. ORGANIZATION OFFICIAL TO BE NOTIFIED IF AN AWARD IS MADE *Myra Norman*
Director, Research Services
1301 East Main Street
Murfreesboro, TN 37132
615-898-5010

17. OFFICIAL SIGNING FOR APPLICANT ORGANIZATION
Myra Norman
Director, Research Services
615-898-5010

18. PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR ASSURANCE: I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if a grant is awarded as a result of this application. Willful provision of false information is a criminal offense (U.S. Code, Title 18, Section 1001).

SIGNATURE OF PERSON NAMED IN 2
(In ink "Per" signature not acceptable.)
DATE 9-01-09

19. CERTIFICATION AND ACCEPTANCE: I certify that the statements herein are true and complete to the best of my knowledge, and accept the obligation to comply with NASA terms and conditions if a grant is awarded as the result of this application. A willfully false certification is a criminal offense (U.S. Code, Title 18, Section 1001).

SIGNATURE OF PERSON NAMED IN 17
(In ink "Per" signature not acceptable.)
Myra Norman
DATE 9/1/09

Instructions: The Recipient may attach their own standard formatted budget (spreadsheet) in lieu of the form below but must include all the requested information. Fringe Benefits should be broken out as a separate line item. Fringe and Overhead Rates proposed should be noted by % for evaluation purposes. If cost sharing is proposed, it should be noted in the proposal. If NASA civil service costs are proposed these should also be noted in the proposal. Earmark awards will be delayed if adequate budget detail is not submitted as requested. Recipients should propose those indirect rates which have been **approved** by their most recent audit (if available). Proposing rates higher than those approved by audit (i.e., fringe benefits) will result in a delay in your award. NASA uses those rates approved or recommended by audit for estimating and award purposes.

PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR: **Paul Craig**

DETAILED BUDGET FOR 12-MONTH BUDGET PERIOD DIRECT COSTS ONLY		FROM 9/30/09		THROUGH 9/29/10	
Duplicate this form for each year of grant support requested		DOLLAR AMOUNT REQUESTS *(Omit cents)*			
PERSONNEL *(Applicant Organization Only)*					
NAME	ROLE IN PROJECT	EFFORT ON PROJECT	SALARY	FRINGE BENEFITS	TOTALS
Paul Craig	Principal Investigato	Fall-40% Spring-40%	$ 8,125 $16,249	$ 1,679 $5,346	$ 9,804 $21,595
		Sum-47%	$13,076	$2,703	$15,778
Graduates Students-2	Assistants		$8,533 per student	N/A	$17,066
		SUBTOTALS ⟶	$54,515	$ 9,728	$64,243
CONSULTANT COSTS					
EQUIPMENT : ADS-B Service-$7,500 ATC Control Tower Simulator-$210,000 Flight Dispatcher Lab Equipment-$78,095					$295,595
SUPPLIES					
TRAVEL	DOMESTIC				
	FOREIGN				
OTHER EXPENSES Tuition & fees for graduate students-$10,316 X 2 students					$20,632
TOTAL DIRECT COSTS FOR FIRST 12-MONTH BUDGET PERIOD *(Item 12a, Form A)*					$ 380,470
INDIRECT COSTS FOR FIRST 12-MONTH BUDGET PERIOD					$ 19,530
TOTAL COSTS FOR FIRST 12-MONTH BUDGET PERIOD *(Item 12b, Form A)*					$400,000

PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR: Paul Craig

BUDGET FOR ENTIRE PROJECT PERIOD DIRECT COSTS ONLY

BUDGET CATEGORY TOTALS		1st BUDGET PERIOD	ADDITIONAL YEARS OF SUPPORT REQUESTED		
			2nd	3rd	4th
PERSONNEL (Salary and Fringe Benefits) (Applicant organization only)		$ 64,243			
CONSULTANT COSTS					
EQUIPMENT		$295,595			
SUPPLIES					
TRAVEL	DOMESTIC				
	FOREIGN				
OTHER EXPENSES		$ 20,632			
TOTAL DIRECT COSTS FOR EACH BUDGET PERIOD		$ 380,470	$	$	$
TOTAL INDIRECT COSTS FOR EACH BUDGET PERIOD		$ 19,530	$	$	$
TOTAL DIRECT + INDIRECT COSTS FOR EACH PERIOD		$400,000	$	$	$
TOTAL DIRECT + INDIRECT COSTS FOR ENTIRE PROJECT					$400,000

JUSTIFICATION FOR UNUSUAL EXPENSES (Detail Justification in Cost Section of Proposal)

MTSU Center for Research on Aviation Training
Middle Tennessee State University
Principal Investigator and Project Coordinator
Dr. Paul A. Craig
Professor of Aerospace

September 2009

Two issues have come together that has made this research imperative. First, new technologies are being thrust onto the aviation industry. Automated cockpits, ADS-B, Required Navigation Performance (RNP), satellite navigation with the Wide Area Augmentation System (WAAS), new regulations and Very Light Jets are simultaneously converging on the industry and this is producing a great challenge to aviation training. Second, following the Colgan accident this year in Buffalo, New York, there is a focus of crew training and crew coordination. The term "crew" is being redefined. An airplane's crew is no longer just those flying in the air. The crew is at least a five-way collaboration between pilots, controllers, dispatchers, maintenance and management. The MTSU Center for Research on Aviation Training (not just pilot training) will conduct research on how we should best deal with these rapid changes and how diverse groups, who traditionally are trained separately, can work together to produce the safest and most efficient aviation system.

Today, students are trained in various disciplines of aviation in isolated clusters. The pilots train with pilots, the maintenance technicians with other technicians, dispatchers with dispatchers, controllers with controllers, and so forth. Prospective employees are coming to the job market through independent "silos" of training, but this training does not always reflect the way operations run in the real world. Once students enter the job market, they realize that success and efficiency depend on cross-disciplinary communications and understanding. By dismantling the silos, we want to prepare the next generation of aviation professionals in a real-world environment and enable employees to perform better on the job from the first day of hire.

Imagine a situation where students from all aviation and certain business disciplines come together in a laboratory. Instead of attending a typical classroom lecture, they are immersed in a practical, hands-on experience as they "work a shift." They enter a room with a bank of projection screens on the far wall, where they find projected real-time weather, aircraft tracking maps, aircraft status boards, and any other information required to run that shift. The students' shift in the simulator might begin with incoming flights that have maintenance issues. Pilots in the scenario would have to troubleshoot the problem while in flight and communicate to flight dispatch and maintenance technicians the nature of the problems. When the airplane lands, the technicians would go to work on the problem and soon a decision would have to be made about that airplane's availability. Can the problem be repaired before it is time for the airplane to be loaded and prepared for its next flight, or will another airplane be required? Do we even have another airplane that can do the job? When it was time for the push of departing aircraft to begin, the action would shift to an air traffic control ramp/tower simulation. The simulation could reproduce the size and layout of a control tower with "out the window" visual systems, allowing students to look out of a virtual window onto the flight line. Controllers would orchestrate the entire departure sequence from push back to takeoff. At the time of departure, a scenario could be presented of deteriorating weather. Thunderstorms in the south might delay departures, and snowstorms mid-west will delay arrivals—all of this must be worked out using a total employee scenario-based approach. Solutions to the problems proposed by one group might create even more difficult problems for others. To avoid complicating the problem, students would have to learn the other group's concerns and issues—just like in the real world.

In creating the Center for Research on Aviation Training, the Aerospace Program at MTSU will set a new standard for preparing students to work in the aviation industry. We are not aware of any other university or training center that is planning to teach using this approach.

Research Plan

The amount of the award, $400,000 is for one year. In order to accomplish the research objectives two laboratories must be enhanced or developed at MTSU. First it will be necessary to upgrade the Air Traffic Control lab with control tower simulation that has just become available. Second a Flight Dispatcher lab must be established. This lab will resemble an airline's "war room" where dispatchers, maintenance personnel, managers and pilots coordinate the flight operations. By funding these labs the research agenda of observing and taking data on actual pilots, controllers, maintenance, management and dispatchers in training as they use the new technology will be possible.

Plan for Deliverables

The most visible of the deliverables from the project will be a series of data assessments that lead to a "best practices" body of knowledge. At the end of the year, the researchers will report in the academic, scholarly, and popular journals of the progress and discoveries made. A final report to NASA will be made at the end of the project. Curriculum writers, regulation writers, and policy makers of the future will be able to use this baseline information to teach the next generation of aviation professionals. The information and discoveries from this project will be the seminal knowledge base for training students of the 21st Century with the technology of the 21st Century.

Management Approach

Dr. Paul A. Craig will be the Principal Investigator of the research and will manage the acquisition of equipment, the research assistants, and be primarily responsible for the collection of data, analysis of that data, and the deliverables. Dr. Craig will work in coordination with other experts in the fields of pilot training, aircraft dispatch, and air traffic control.

Plan for Personnel

Dr. Paul A. Craig will serve as the Principal Investigator and manager of the project. Other MTSU faculty members and students will participate in the project based on their expertise and available budget.

Plan for Cost of the Project

Personnel: Salaries, Wages & Fringe Benefits

The budget does not allow for a full time Project Coordinator. Therefore the management of the project, data collection, data analysis and deliverables will be done by the principal investigator. Dr. Craig will devote 10% time to the project in the Fall of 2009 and receive extra compensation, 40% time in the Spring of 2010 and be released from 6 credit hours of teaching, and 47% time during the Summer of 2010 and receive five hours of Summer pay. Graduate Research Assistants: 2 Graduate Assistants @ 8,533 per year each. One GA primarily working in the ATC lab and one in the Flight Dispatcher lab. Fringe benefits for Paul Craig are calculated as followed: Fall 2009-20.67% (extra comp), Spring 2010-32.9%, and Summer-20.67%. There are no fringe benefits calculated on stipends for the GAs.

Equipment:

ADS-B Service (ITT)

In January of 2010, ITT will begin operating the ADS-B system nationwide. This project will require access and information from the ITT system. The ADS-B system, to this point, has been a "proof-of-concept" project and was free of charge. But ITT is a for-profit company that will charge a fee for the use of this service. The fee for this service, during the year of this project is projected to be $7,500.00

ATC Tower Simulator & Accessories

X-TowerVis Turnkey Simulator with a 180 degree display system. System consist of four 46" LCD flat screen monitors with floor stands. Permanent software license for three control positions (local, ground, clearance delivery), two pseudo pilot positions, and tower console. ITT system access. $210,000.00.

Flight Dispatcher Lab Equipment

Computer equipment, software, ITT system access, large screen and/or projection equipment. Student lab equipment. $78,095.00.

Other Expenses

Tuition and fees for the two graduate research assistants for the 12 month project period will be $20,632.

MTSU Facilities and Administration (Indirect Costs)

MTSU's negotiated indirect cost rate is 30.4% of modified total direct costs excluding equipment costs and graduate student tuition and fees. $19,530.00

Summary of all Budget items

Personnel		
PI-Craig		
Extra Comp– Fall 2009	$ 8,125	
Release Time-Spring 2010	$ 16,249	
Summer 2010 (5 hrs)	$ 13,076	
Fringe Benefits	$ 9,728	
Graduate Research Assistants (2)	$ 17,066	(2 x $8,533)
Equipment		
ADS-B Service (ITT)	$ 7,500	
ATC Tower Simulator & Accessories	$ 210,000	
Flight Dispatcher Lab equipment	$ 78,095	
Other Expenses: Tuition for GAs	$ 20,632	
Facilities and Administration	$ 19,530	
Total	$400,000	

Timeline

Fall 2009 – Once the funds have been allocated, the project PI will meet with site officials to set up the project, write safety plans, establish accident reporting protocols, agree on deliverables, identify budget contacts and set a timetable. Approvals will be sought and obtained from both the MTSU and NASA's Institutional Review Boards for the research components of the project.

Spring 2010 – Acquisition of equipment begins. Curriculum development to incorporate new equipment and facilities begins.

Summer 2010 – Implementation of curriculum, student use of new facilities, data collection begins.

Fall 2010 – Continuation of data collection and analysis. Deliverables and final reports prepared. Conclusion of project.

NASA Contacts

NASA Technical Officer: Jim Burley, Telephone: 757-864-2008, Email: james.r.burley@nasa.gov

NASA Grant Officer: Tina M. Landes, Telephone: 228-813-6175, Email: Tina.M.Landes@nasa.gov

NASA Grants Certifications and Assurances

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Applicants should refer to the regulations cited above to determine the certification to which they are required to attest. Applicants should also review the instructions for certification included in the regulations before completing these forms. Signature of these forms provides for compliance with certification requirements under 34 CFR Part 82, "New Restrictions on Lobbying", and 34 CFR Part 85, Government-wide Debarment and Suspension (Nonprocurement). The certifications shall be treated as a material representation of fact upon which reliance will be placed when the NASA determines to award the covered transaction, grant, or cooperative agreement.

National Aeronautics and Space Administration

Assurance of Compliance with the National Aeronautics and Space Administration Regulations Pursuant to Nondiscrimination in Federally Assisted Programs

The Middle Tennessee State University,

(Institution, corporation, firm, or other organization on whose behalf this assurance is signed, hereinafter called "Applicant")

HEREBY AGREES THAT it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), Title IX of the Education Amendments of 1962 (20 U.S.C. 1680 et seq.), Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and the Age Discrimination Act of 1975 (42 U.S.C. 16101 et seq), and all requirements imposed by or pursuant to the Regulation of the National Aeronautics and Space Administration (14 CFR Part 1250) (hereinafter call "NASA") issued pursuant to these laws, to the end that in accordance with these laws and regulations, no person in the United States shall, on the basis of race, color, national origin, sex, handicapped condition, or age be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant receives federal financial assistance from NASA; and HEREBY GIVE ASSURANCE THAT it will immediately take any measure necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of federal financial assistance extended to the Applicant by NASA, this assurance shall obligate the Applicant, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the federal financial assistance is extended or for another purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant for the period during which it retains ownership or possession of the property. In all other cases, this assurance shall obligate the Applicant for the period during which the federal financial assistance is extended to it by NASA.

THIS ASSURANCE is given in consideration of and for the purpose of obtaining any and all federal grants, loans, contracts, property, discounts, or other federal financial assistance extended after the date hereof to the Applicant by NASA, including installment payments after such date on account of applications for federal financial assistance which were approved before such date. The Applicant recognized and agrees that such federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign on behalf of the Applicant.

Dated: 8/28/09

Middle Tennessee State University
(Applicant)

By [signature]
(President, Chairman of Board, or comparable authorized official)

1301 East Main Street

Murfreesboro, TN 37132-0001
(Applicant's mailing address)

NASA FORM1206 MAY 2000 PREVIOUS EDITIONS ARE OBSOLETE.

Certification Regarding Lobbying
for Contracts, Grants, Loans, and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connnection with the Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form - LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Proposal Identification:__________

Organization Name: Middle Tennessee State University

Name and Title of Authorized Representative: Myra Norman, Director-Research Services

Signature: Myra Norman Date: 8/28/09

Certification Regarding
Debarment, Suspension, and Other Responsibility Matters
Primary Covered Transactions

(1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:

(a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;

(b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and

(d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State, or local) terminated for cause or default.

(2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

Proposal Identification:____________________

Organization Name: Middle Tennessee State University

Name and Title of Authorized Representative: Myra Norman, Director-Research Services

Signature: Myra Norman Date: 8/28/09

Figure 1. A copy of the first original NASA grant.