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RESEARCH ARTICLE OPEN ACCESS

The Importance of Simulator-based Training in Air Traffic Control

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ABSTRACT
Air traffic controllers rely on simulator-based training heavily, to help provide efficient and safe operations and improve learning. Simulator-based training is important since it helps equip air traffic controllers with confidence, readiness, and teamwork. Apart from the acquisition of skills, simulator-based training helps air traffic controllers learn the latest variations and procedures in their routine activities. A simulation should be realistic and provide many possibilities – where air traffic controllers can apply different choices and decisions until they experience a favorable outcome. Airport authorities often use strong regulations to protect air traffic controller training. Therefore; simulator-based training is essential to preparing personnel before they come into actual contact with air traffic activities. This research is crucial to examine the importance of simulator-based training and offer recommendations to enhance learning and improve safety and efficiency.
Keywords: Air Traffic Control (ATC); ATC Simulators; Air navigation service provider (ANSP)

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I. INTRODUCTION

Simulation refers to the imitation of the real-world environment, in most cases, to enhance learning. Simulation is a crucial part of air traffic control (ATC) since it helps the translation of theory to practice. With the emergence of augmented reality technology, simulator-based training is an even more important tool to air traffic control (ATC). The use of simulators allows participants to mimic reality in a particular context without being subjected to risks and physical danger. The main importance of simulator-based training is helping air traffic controllers gain confidence in their routine activities. Simulation-based training provides readiness for air traffic controllers, helps them practice in a safe environment, and improves teamwork. Simulator-based training is pertinent to enhancing ATC knowledge, which helps create a safe, orderly, and fast flow of air traffic.

Aim

The aim of this research is to investigate the importance of simulator-based training in air traffic control. Air navigation service providers (ANSPs) are public or private organizations that manage in-flight aircraft or those within the maneuvering area. The Federal Aviation Administration (FAA); for instance, is the main air navigation service provided in the U.S. This research is essential since it highlights the importance of simulator-based training when ANSPs purchase or install new air traffic control simulators. The aim of this research is to explore the future possibilities of simulation training; for instance, the use of simulation labs instead of the operational environment to offer more realism. High-technology simulation is advantageous to the training of air traffic controllers since it better prepares student pilots for in-flight operations without the need for actual airplane flight training (Macchiarella and Christian, 13). Simulation-based training only takes up a few months on average three years of ATC training. This paper aims to emphasize the importance of brief simulation-based training in air traffic control.

Simulator-based Training Helps Instill Confidence

Simulation-based training is important in air traffic control since it helps instill confidence in the ATC students. Simulation training is interactive, engaging, and mimics real-world scenarios. ATC students acquire knowledge faster, through simulation training, because they practice in an operational error-free environment. Therefore, if conducted efficiently, simulation training will translate to better on-the-job performance. Simulation training ensures that aair traffic controller is qualified to manage a particular plane before taking control of an aircraft filled with passengers. The most modern simulators for aviation have voice activation and speech

recognition software. The ATCstudents can speak to the computer directly and expect an audible response, which increases confidence in the training exercise. Leading companies, such as Adacel, which makes advanced simulation equipment use 3D computer digital imaging, which also improves the student pilot's confidence.

Most simulator-based training programs have various instructional objectives for the ATC students to help improve their confidence. Simulator training consists of emergency procedures and assistance, site-specific orientation, phraseology, procedures and coordination, teamwork, strip-marking, and flight data. Therefore, simulator training helps build confidence since the ATC students work with high-intensity traffic problems and complex runway configurations (Taylor et al., 2). Simulator training is important since it equips controllers with the necessary skills, readiness, and confidence to handle high-pressure situations, such as wake turbulence in all kinds of weather conditions. The ATC students also learn to deal with simultaneous arrivals and departures on intersecting and parallel runways. Simulator training often teaches anticipated separation, precision timing, and priority of duties. These nodes of simulated training ensure that the controllers can use rhythmic radio transmissions while simultaneously using the minimum runway departure separation. Simulation training helps instill confidence by serving as an instructional supplement to air traffic control training.

Simulator-based Training Improves Skill Acquisition and Demonstration

Simulator-based training is crucial to air traffic control because it adds to the knowledge required to advance new virtual technology further. The lessons learned from simulation-based training will help in the design, development, and integration of new technologies in the training of controllers. Such an example is the use of voice recognition technology as a Virtual Air Traffic (VAT) functionality. The use of voice recognition systems relies heavily on the lessons learned from Flight Training Devices (FTDs). The virtual environment used to train pilots can now incorporate newer autonomous and semiautonomous technologies, such as voice assistance, due to the skills acquired in previous simulator-based training. Although flight simulators for pilots are expensive, the systems save many lives by reducing the rate of accidents. Simulator-based training provides the necessary skills to avert accidents and improve future virtual technologies.

Simulation training is crucial in skill acquisition and demonstration since it offers a wide variety of scenarios within a condensed amount of time compared to what a pilot would experience in the 'real world'. Simulation training facilitates the transfer of knowledge to skills since the student pilot must execute a skill and utilize some form of knowledge to accomplish a specific goal. Student pilots rely on classroom instruction, simulation exercises, and assigned readings to facilitate the transfer of knowledge to skills. Flight training devices (simulators) improve skill acquisition by mimicking an aircraft's flight dynamics, instrument panel, and behavior characteristics. Therefore, the design of the simulator should maximize the total skill transfer to the student pilot, while offering a safe and low flight training cost environment (Lindenfeld et al., 33). Simulation training is one of the most favorable avenues of skill acquisition for student pilots where they gain the self-efficacy to execute the designated type of performance.

Simulator-based Training Enhances Practice in a Safe Environment

Simulation-based training is important in ATC because it equips the ATC students and pilots with the skills and knowledge to work in the modern cockpit environment. Advanced modern cockpit technology has undergone many improvements over the past decades. Some of these advancements include a Primary Flight Display (PFD), on Technically Advanced Aircraft (TAA) which replaces the traditional *six-pack*. The advanced modern cockpit increases the pilot and aircraft capabilities, especially on TAA. However, the modern cockpit also increases pilot workload and the education, training, and experience required to operate such systems. Pilots would have a hard time operating the multi-function display and moving map equipped on TAA. Simulation-based training allows student pilots to train on how to use advanced equipment in safe environments. Simulators do not risk the life of the pilot or passengers. Simulators provide a similar experience to technically advanced aircraft, such as terrain, weather, and traffic graphics, within a safe environment.

Simulations are critical when recreating rare but time-critical scenarios to enhance the learning process for student pilots. Pilots can learn the required protocols and communication channels to take when an emergency or time-critical situation arises. The use of simulators by airlines has proven to enhance the transfer of knowledge to on-the-job performance since the time-critical scenarios are created within a safe environment where the ATC students and pilots have enough time to practice without risking human lives. Simulators in aviation help to maximize the Time to Certification (TTC)

since ATC students can practice high-risk scenarios with zero compromises on safety. Many organizations rely on simulation training to churn out highly qualified air traffic controllers. Simulator-based training in aviation helps to maximize safe controller training by reducing the dependency on operational on-the-job training. AnATC student can acquire their Certified Professional Controller (CPC) status more easily we relying on simulators with voice recognition and synthesis (VRS) and an intelligent tutoring system (ITS).

Simulator-based Training Improves Team Behavior

Simulation-based training is important in improving team behavior since both pilots and controllers undergo rigorous practice to work as an effective team. Flight crews can attain higher levels of competence during simulation training compared to actual aircraft. Simulation training is necessary when qualifying contollers for employment, emergency procedures, and type ratings (Le Tellier, 8). Air traffic controller training is often divided into three phases; namely, the initial training, unit training, and continuation training (See figure 1 below). Each of the three stages relies extensively on practical training exercises performed on computer-based simulation devices. Under the three-phase training, air traffic controllers learn to provide separation between aircraft by guiding them through the airspace efficiently and safely. Team behavior is crucial to air traffic controllers since the airport personnel must work together to detect and solve potential problems between aircraft. Air traffic controllers must also work together because each airspace has its unique characteristics.

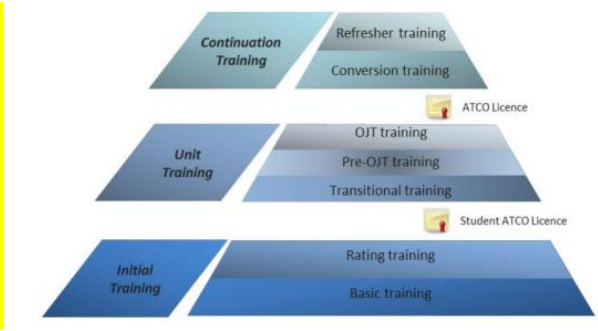

Figure 1: Stages of air traffic controller training (Pavlinović et al., 1026)

The initial phase for simulator-based training consists of basic and rating training. At this stage, the ATC students learn the theoretical and practical aspects that are relevant to impart fundamental knowledge of the basic operational procedure. Students who excel in the first phase have an air traffic controller (ATCO) license. The unit training phase consists of transitional, pre-on-the-job, and on-the-job training, which provides knowledge and skills on a particular job category. Excelling in this second phase of simulator-training awards ATC students with an air traffic controller (ATCO) license, which enables them to work with live traffic. The final phase of simulator training is continuation training where air traffic controllers can upgrade their existing knowledge and skills. The three stages of simulator training imply that the trainees must work together to succeed in each phase. Regulations set by air navigation space providers (ANSPs) and high international standards help to protect simulator training for air traffic controllers.

Simulator-based Training Helps Understand Human Behavior

Simulator-based training helps to understand human behavior since every simulation exercise has a different number of aircraft involved, different flows of traffic, and the number of conflicts. Each trainee would react and perform differently when the conditions of the simulation are not the same. Simulation training starts with a practical training session to familiarize trainees with the equipment and functionalities. Simulation-based training allows for one-on-one contact between the trainee and instructor. The qualified instructor usually leads each candidate through an exercise while explaining the expectations, goals, and outcomes of the training exercise. Candidates often take the exercise run (shown in figure 2 below) on their own, which can help the instructor understand human behavior well. The exercise run in simulation training could take about 45 minutes while using daily performance lists to evaluate and track the candidate's progress.

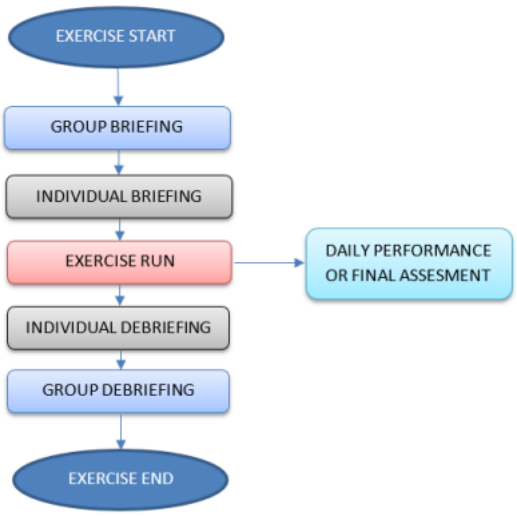

Figure 2: Practical exercises for air traffic controllers (Pavlinović et al., 1028)

Simulation training is important in predicting human behavior since trainees can gauge their reactions when interacting with the imitated version of reality. Simulations prepare both the conscious and unconscious mind to handle an array of specific scenarios that might affect air traffic controllers. Simulation training is predictive of human behavior since the student pilots use trial and error to optimize their responses in critical situations and help prevent errors. Automated air traffic controllers use a behavior engine (shown in figure 4 in the appendix) to improve efficacy. The behavior engine is a knowledge-rich cognitive system, which can execute real-time behavior interaction. This component of automated air traffic control systems is essential in capturing and reproducing the behavior of ATCs in ways that seem believable to human controllers. Figure 5 in the appendix shows how an automated ATC works in a standard simulation network.

II. RECOMMENDATIONS

The first recommendation for organizations wishing to install an ATC simulator is to make the right purchasing decision. Some organizations purchase complex ATC simulators without understanding the technical aspects of maintaining and managing the system. The technical personnel or managers might also fail to fully understand the operational and teaching requirements of the ATC simulator. Therefore; the organization must consider what the simulator is for, why they need it, the cost of ownership, and how to implement and maintain the technology. When purchasing an ATC simulator, ANSPs must consider the number of personnel they wish to train at once – since simulators can only be used a finite number of times each day. The ANSP must also consider the available time for each trainee to complete their course. All these factors will help the ANSP decide the type (tower or radar training) and the number of simulators required.

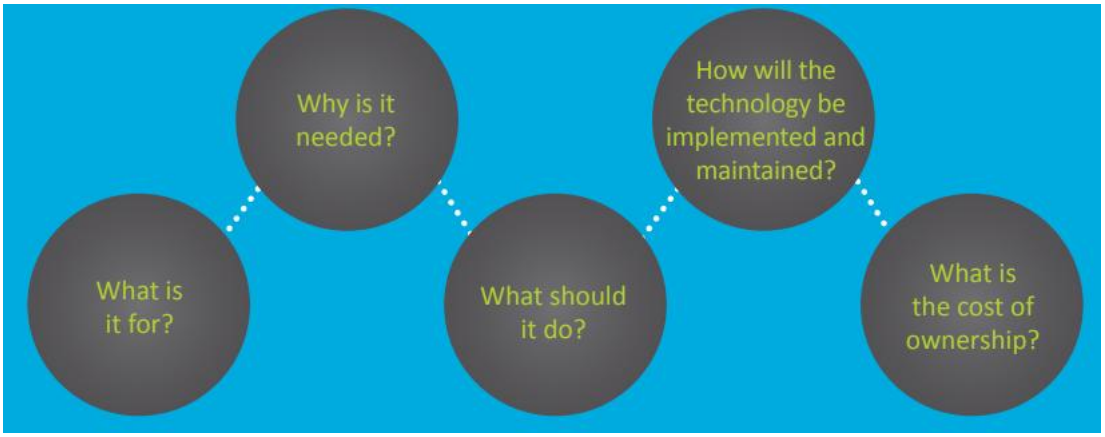

Figure 3: Training factors to consider when purchasing an ATC simulator (Airways NZ., 10)

The second recommendation to any organization wishing to purchase an ATC simulator is to provide quality and sufficient training to their technical support staff. The cost of purchasing an ATC simulator should also include the training required to maintain and use the system efficiently. ANSPs should ensure that they provide at least one week of quality assurance each year, after purchasing and installing an ATC simulator. A specialist must come to the site and monitor the skills of air traffic controllers and offer to retrain if necessary (Airways NZ., 10). When installing ATC simulators, ANSPs should obtain a copy of the training plan from the vendor. The training plan contains the necessary components to prepare the air traffic controllers for the first use of the simulator.

The ANSP should also create a timeline, which determines how to provide training relative to simulator usage.

The third recommendation is to use advanced technologies, for instance, intelligent tutoring systems, high fidelity simulation, web-based apps, and video teleconferencing. These core technologies could help support the dynamic, efficient, and consistent creation and delivery of training material. High-fidelity intelligent training systems are a crucial recommendation to help reduce resource utilization, improve certification time, and ensure adequate performance assessment. Another exemplary use of advanced technology in air traffic control is the application of eye-tracking software within simulation-based ATC training (Martinez-Marquez et al., 4289). Visual scanning is an important part of air traffic control, which involves the systemic and continuous awareness of all the situations and activities that affect the controller's area of responsibility. Using advanced technologies in aviation training helps reduce human error, which accounts for the bulk of accidents. Advanced technologies, such as eye-tracking software could record eye movement information and help assess the mental, cognitive, and behavioral state of the student pilots.

The final recommendation is to streamline the air traffic control training process. According to Updegrove and Shafagh (8), the Federal Aviation Agency and other ANSPs should survey the industry of simulation providers to ensure that the available simulation technologies are upgraded to include instructor support features and advanced technologies. Streamlining simulator-based training requires intensive investment in web-based training, voice recognition and synthesis, and intelligent tutoring systems. Instructor support features for simulation-based training should contain playback and recording capabilities and eye-tracking tools. The four recommendations are crucial to ensuring that training simulators for air traffic controllers keep pace with current technology. Upgrading the current simulator technologies is a viable option as the simulators in use only require a few changes to the training programs. However, any new changes to simulators for ATC must meet the high fidelity demands.

III. CONCLUSION

Conclusively, simulator-based training is an important aspect of air traffic control. Simulation training is useful for instilling confidence among ATC students, it improves skill acquisition and demonstration, and enhances practice in a safe environment. Simulation training helps understand human behavior while also improving teamwork. ATC Controllers undergo simulation training so they can work as a unit in response to different scenarios that might affect the traffic. The first recommendation for safe and efficient simulator-based training is making the right purchasing decision so that the trainees complete their course with the highest competence level. The second recommendation for reaping the full benefits of ATC simulators is relying on highly qualified technical support staff. The third recommendation is to use advanced technologies, such as intelligent tutoring systems, high fidelity simulation, web-based apps, and video teleconferencing to improve efficiency in the creation and delivery of training material. The final recommendation is to streamline the air traffic control training process to include instructor support features and advanced technologies. Upgrading the current simulator technologies (with high degrees of fidelity) is a viable option as the simulators in use only require a few changes to the training programs.

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Appendix (Pictures and Charts)

Figure 4: Initial architectural design for an AutoATC

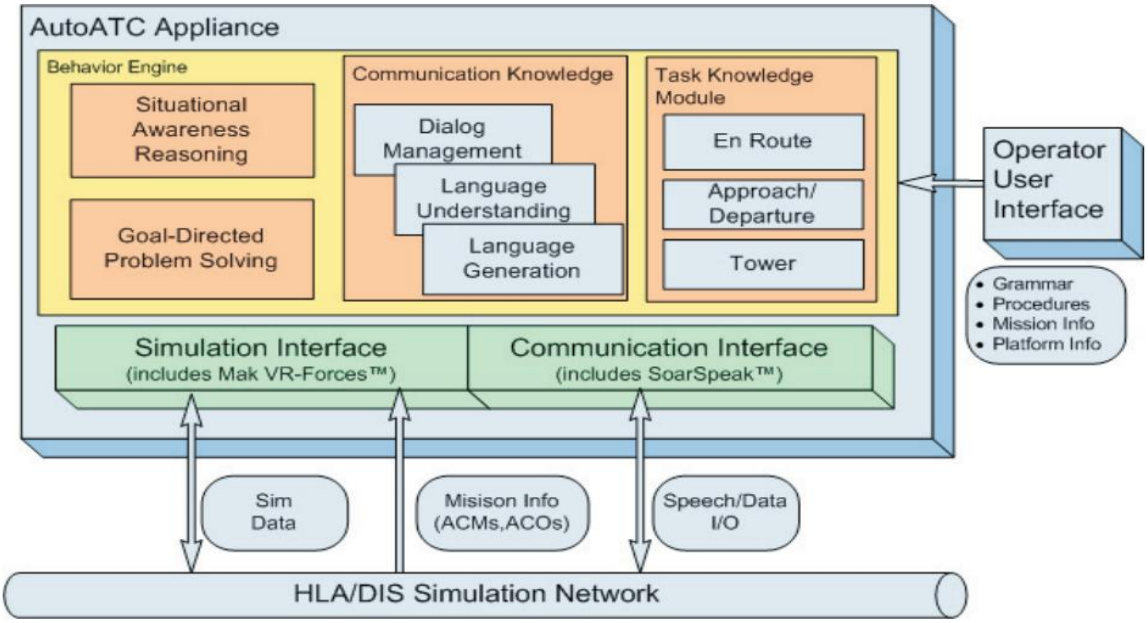

Figure 5: AutoATC Network Appliance Conceptual Diagram