Integrating Advanced Technology into Air Traffic Controller Training

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Effective training for air traffic controllers is a critical component of the Federal Aviation Administration's (FAA's) mission of providing a safe and efficient national aerospace system. The Air Traffic Control (ATC) training program must address the training needs of newly hired controllers (students), ongoing refresher and skill enhancement training for Certified Professional Controllers (CPCs), and new technology and procedures training for students and CPCs. The current ATC training practices and methods have not kept pace with advancements in training technology and design. As a result, training for students and CPCs is costly, inefficient, subjective, and inconsistent. The current training system also does not have the flexibility or adaptability necessary to meet the need for training new technologies which may reduce the expected benefit of acquisitions. Since 2004, The MITRE Corporation's Center for Advanced Aviation System Development has been analyzing the FAA's training processes and capabilities and exploring the application of advanced training technology to air traffic controller training. This research has demonstrated that training quality, standardization, efficiency, and availability can all be improved throught the use of advanced training technology.

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I. Introduction

Effective training for air traffic controllers is a critical component of the Federal Aviation Administration's (FAA's) mission of providing a safe and efficient national aerospace system. The Air Traffic Control (ATC) training program must address the training needs of newly hired controllers (students), ongoing refresher and skill enhancement training for Certified Professional Controllers (CPCs), and new technology and procedures training for students and CPCs. The current ATC training practices and methods have not kept pace with advancements in training technology and design. They continue to rely heavily on instructor-led classroom training augmented with basic computer-based instruction and high-fidelity simulation. As a result, training for students and CPCs is costly, inefficient, subjective, and inconsistent. The current training system also does not have the flexibility or adaptability necessary to meet the need for training new technologies which may reduce the expected benefit of acquisitions. The need for improved training will only become more critical as the FAA hires and trains nearly 12,000 controllers over the next 10 years, while continuing with the incremental implementation of the Next Generation Air Transportation System (NextGen).

The shortcomings of the current ATC training program have been documented in a variety of reports[1, 2, 3, 4, 5] and since 2004, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) has been analyzing the FAA's training processes and capabilities and exploring the applicationand benefits of advanced training technology to air traffic controller training. As part of this work, MITRE has developed prototype platforms upon which a broad range of training capabilities have undergone testing and evaluation at the Miami Terminal Radar Approach Control (TRACON), the Potomac Consolidated TRACON (PCT), the Indianapolis Air Route Traffic Control Center (ARTCC), and the FAA Academy. The prototype evaluations have demonstrated the benefits of incorporating advanced training technology into ATC training. These benefits include:

- Improved student skill development and operational understanding
- Improved student preparation for later stages of training (e.g., simulation and On-the-Job Training [OJT])
- Improved training quality, effectiveness, and efficiency
- Improved training consistency, standardization, and objective performance assessment
- Improved training availability
- Ability for training to support self-paced, independent learning
- Reduced reliance on human resources
- Reduced training time

II. Summary of Training Technology Development and Research

In 2006 MITRE began to research ways to address critical ATC training issues and the role of technology in training. Using prototype platforms MITRE developed a variety of technologies and applied them to elements of the ATC training curriculum. Using these prototypes and working in partnership with the FAA and ATC field facilities MITRE conducted extensive training technology evaluations with ATC students and facility training staff. As part of the evaluation model, ATC students used the prototype capabilities to receive portions of their training curriculum and MITRE collected data assessing each capabilities application to training, usability, effectiveness, and benefits. The benefits assessed during the evaluations included not only how training technology improved training quality but also an examination of how specific technologies could support changing the ATC training structure, and improving training availability and efficiency. From 2006 through 2013 MITRE conducted field evaluations of advanced training technologies with students and staff at the Indianapolis ARTCC (ZID), the Miami TRACON (MIA), and the Potomac Consolidated TRACON (PCT).

Over the course of 8 years, MITRE developed and evaluated a number of prototype training capabilities that included a variety of techniques and technologies. The results of the evaluations and the descriptions and requirements for beneficial capabilities have been transferred to the FAA to support acquisition and operationalization. This paper is not an exhaustive presentation of all of the MITRE ATC training research or all of the capabilities that were developed and evaluated, rather it will describe several key technology areas that were proven through evaluation to be beneficial, these include:

- Automated Speech Recognition and Synthesis
- Game Technology and Intelligent Training System (ITS)Design
- Automated Student Performance Assessment and Feedback

The application and benefits of these capabilities that were validated through evaluation will be discussed in the following subsections.

A. Automated Speech Recognition and Synthesis

Initial MITRE training research focused on the development of technologies that would improve training efficiency and reduce costs. In 2006, it was anticipated that the FAA would be hiring thousands of new controllers to replace its retiring workforce and that this influx of students would place a tremendous burden on an already costly and inefficient training program. Using an ATC training prototype to support the development and evaluation of training capabilities, MITRE initially focused on integrating speech recognition and speech synthesis into simulation training in an attempt to demonstrate its use and to reduce the human resources required to support simulation training. Speech recognition is the ability of a machine or program to identify spoken words and phrases, and convert them into a machine-readable format[6]; speech synthesis is the artificial production of human speech[7]. MITRE demonstarated that when integrated with air traffic simulation, speech recognition and speech synthesis can simulate pilot communications with, and responses to, air traffic controllers and serve as a replacement for the existing human-assisted capability (e.g., remote pilot operators [RPOs]). By proving that speech technology could effectively replace the need for RPOs in a significant portion of en route simulation training, MITRE was able to support the FAA's decision to pursue the integration of this technology into the En Route Automation Modernization (ERAM) training system. MITRE also demonstrated the benefits of integrating speech synthesis and text-to-speech generation in a variety of other training capabilities beyond high fidelity simulation training. The benefits of speech technology integration include improved training standardization and efficient and cost effective training content development and maintenance. Speech synthesis also supports the use of avatars in training capabilities to serve as automated instructors providing real time coaching, instruction, and student performance feedback.

B. Game Technology and Design

One over-arching area of training that presents opportunities for significant improvement is the area of targeted ATC skill training. Successful ATC operation consists in part of the application of many individual skills that are combined to provide safe and efficient air traffic control. The current ATC training methods do not specifically identify and isolate individual skills that students need to develop in order to be successful controllers. Rather the current training curriculum and methods focus on data acquisition learned in a classroom setting followed by skill acquisition through extensive high fidelity simulation and on-the-job training. Acquiring and becoming proficient in basic ATC skills while trying to successfully control traffic in simulation and OJT is difficult and inefficient. OJT especially can be a very lengthy and costly stage of training as students struggle to master skills and then combine them in operation. In order to address this issue, a significant portion of the MITRE training research was spent assessing the most effective methods of providing part-task, targeted skill development training.

In 2009, MITRE created a set of prototype part-task training capabilities in order to demonstrate the application of game technology to skill development curriculum. Game technology not only provides an engaging and intrinsically rewarding training environment, but it has also been proven to be successful in supporting the learning of complex cognitive tasks[5]. The integration of part-task, skill focused training capabilities also provided MITRE with the opportunity to begin evaluating some initial elements of ITS design integrated into game technology. Research has shown that ITS capabilities can support more effective, standardized, efficient, and flexible training. These capabilities can enable training automation to provide “instructor-like” interaction with the student including automated student performance measures and automated performance feedback that is objective and quantitative. Ultimately, this feedback can be used to provide real-time coaching to guide students through training lessons.

The part-task training capabilities that were developed in the prototype targeted specific skill development training that enabled students to master one skill at a time. Over the span of several years MITRE created and evaluated skill training games that focused on teaching basic and advanced vectoring skills, scanning and conflict detection skills, and phraseology and communication skills. They key features of these capabilities included:

- Leveled and scaffolded lessons presented as “game levels” that enabled students to move from very basic skill development and practice through more complex and difficult operation and application and that also enabled students to skip levels based on expertise and current stage of training as well as repeatedly practice levels to achieve mastery
- Automated performance assessment, real-time and “after action” performance feedback
- Game features including scores, audio, animation and simulation
- Speech recognition and synthesis where appropriate to support instruction and tutorials, avatar speech, and student communication
- Stand-alone autonomous design that provided 24/7 game availability
- Development on commercial off-the-shelf platforms including portable platforms to increase availability

Field evaluations demonstrated that students who were used the skill training capabilities were able to master basic skills and were better prepared for later stages of training.[8,9,10, 11-15] In addition, a number of specific benefits from the creation of targeted skill training capabilities and the application of game technology and design were demonstrated including:

- Customized and individualized training curriculum and access supporting:
  - Self-paced training
  - Scaffolded training that meets individual student needs
  - Automation support in identifying specific areas that a student may need to practice
- Instant and standardized feedback that identifies both correct and incorrect understanding of information or actions so that they can be rectified as early as possible
- Individual skill mastery, allowing critical ATC skills to be trained in isolation rather than having students learn multiple skills and information at one time
- An additive approach to training that enables knowledge and skills learned in previous lessons to be built upon and expanded in later lessons, thus reinforcing what has been learned
- Stand-alone, self-supporting, always available instruction that reduces the reliance on and cost of human resources.

C. Standardized Training Delivery and Objective Performance Assessment

Current ATC training employs an “apprenticeship” model in which students receive training curriculum from instructors and are assessed largely subjectively by those same instructors. This method of training delivery and assessment results in extensive variability in both the information students receive and in the determination of their performance and readiness for certification. It also contributes to overall training inefficiency and cost since the lack of objective, standardized performance assessment makes it difficult to form a clear picture of a student’s abilities and skills. As a result students sometimes stay in the training program when they should be released since it is not clear whether or not they will be successful. It is recommended that training delivery and student performance assessment be made more standardized and objective where possible[1] to improve overall quality and efficiency. MITRE research has shown that using automated training technology is one important way to standardize and objectify curriculum delivery and performance assessment. MITRE has demonstrated that it is possible to define specific performance criteria and objectives, and then to use automation to measure student performance against those criteria and objectives. This is particularly straightforward for part-task, skill development training, but it is more challenging for later-stage simulation training and OJT. Objective performance measures should be integrated into early stage training, and research should continue to define and validate measures that can be used during simulation training and OJT.

III. Conclusion

MITRE research has shown that implementing advanced training technology is a key to overcoming many ATC training issues not only because technology has the potential to more effectively deliver training but also because technology enables beneficial changes in training design, availability, standardization, and adaptability to new curriculum. Integrating training technology into ATC training also presents the opportunity to redefine the training curriculum or, perhaps more accurately, to better emphasize and teach important elements of the curriculum that are currently not explicitly isolated and taught. Advancements in technology in general (not just in training technology) also present opportunities to host training capabilities on commercially available and relatively inexpensive platforms which can make training accessible in ways that meet students' expectations and potentially reduce training costs to the FAA. The capabilities recommended to support needed training improvements have been described and documented through the MITRE technology transfer process. MITRE looks forward to working in partnership with the FAA to create the overall training plan and roadmap to the future that will include the recommendations described and the steps necessary to implement them.

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