Application of Advanced Technologies for Training the Next Generation of Air Traffic Controllers

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Abstract

Motivated by the large number of air traffic controllers that are expected to be hired within the next decade, the Federal Aviation Administration (FAA) and MITRE Corporation's Center for Advanced Aviation System Development (CAASD) have reviewed training technologies and practices of the FAA, the United States Air Force, and several international air traffic service providers. The intent of this research was to develop a more comprehensive view of the state-of-the-art in controller training throughout the world and to identify ways in which training could be improved. What has emerged from this effort is a set of technology and process changes that could result in substantial gains in the efficacy of FAA controller training, including a reduction in certification time, improvement in the utilization of training resources, and more systematic and objective assessment of student performance. If this potential for improvement is exploited, a training program that is more streamlined, standardized, and performance-based can be enabled, and a substantial reduction in costs can be realized.

While current FAA training processes and technologies are time-tested, they are unlikely to sustain future demands in an efficient manner. Fortunately, advances in core technologies such as high-fidelity simulation, intelligent tutoring systems, video teleconferencing, and web-based applications provide an opportunity for change. Such technologies can support more dynamic, consistent, and effective creation and delivery of training materials, and promote accelerated learning and skill acquisition. Furthermore, skill acquisition methods and techniques can be tailored more to the individual student's strengths and weaknesses, and to the specific air traffic

control facility operations within which those skills will be applied. *High-Fidelity, Intelligent Training Systems*[1] enable the aforementioned gains in certification time, resource utilization, and performance assessment to be realized in an affordable and effective manner.

This paper provides a summary review of state-of-the-art controller training technologies and practices as discovered from earlier research and analysis, examines some of the ways in which advanced technologies can augment and improve existing systems and processes, and discusses some ongoing activities being conducted by FAA and CAASD. It also identifies areas relevant to a broader cross-section of the training community, e.g., other research organizations and educational institutions. This is intended to serve as a framework for potential future research activities and collaborative efforts among those organizations.

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[1] The term used herein to refer to the collective set of traffic simulation, scenario generation, performance assessment, and intelligent tutoring capabilities used for air traffic controller training.

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Section 1

Introduction

After the air traffic controller strike in 1981, the Federal Aviation Administration (FAA) was forced to hire thousands of new controllers to rebuild its workforce. These controllers are now reaching retirement eligibility and are expected to leave the FAA over the next several years. More specifically, the FAA's 10-year *Workforce Strategy*, "A Plan for the Future," projects a loss of over 11,000 of the agency's 15,000 controllers within the next decade (FAA, 2004).

Training and certifying the large number of new hires into the agency over this period will be a substantial undertaking. The rate of hiring will likely triple the rate experienced over the last five years. Furthermore, the training and certification period is lengthy: 3 to 5 years for en route controllers and 2 to 3 years for terminal controllers. This is not only costly, but puts a significant burden on training personnel at the FAA Academy and field sites. In particular, managing an operation at a field site becomes increasingly difficult as the ratio of controller trainees to Certified Professional Controllers (CPC) increases.

The FAA has done a superb job of producing the world's finest controllers. In light of the impending hires and training requirements, continuing to do so will be a challenge in the coming years. Improved training technologies – such as advanced simulation techniques and scenario-based instruction – would not only help the agency deal more effectively with projected hiring increases, but enable operational shifts anticipated in the future air transportation system. These shifts range from handling higher volumes and complexities of air traffic to advances in the decision-support tools used by controllers. Given the constrained budgets anticipated over the next several years as well as the sheer number of controllers that will be trained, new and innovative approaches to controller education and training need to be developed and implemented in order to reduce time and resource requirements.

Based on work conducted by both the FAA and MITRE's Center for Advanced Aviation System Development (CAASD), this paper summarizes current training technologies and processes, and proposes improvements that can likely have substantial benefits in terms of certification time, training costs and resource demands, and overall quality of the training program. Section 2 provides some context as it briefly covers current training technologies and processes of the FAA, the United States Air Force, and selected international air traffic service providers. Section 3 discusses the application of augmented and improved training technologies and their expected benefits. Section 4 summarizes some on-going research on the application of some of those technologies and processes improvements in an en route environment. Finally, Section 5 provides a summary and conclusions.

Section 2

Controller Training Today

2.1 Federal Aviation Administration

FAA controller training requirements are standardized and defined in FAA Order 3120.4, *Air Traffic Technical Training*. The Order provides guidance for all aspects of training, from initial qualification through proficiency training, and establishes the coursework, simulation, and on-the-job training (OJT) requirements for each stage of training. Table 2-1 summarizes the stages for the en route domain. Nominal training times add up to a total certification time of a little over three years; however, variances in the OJT portion of training can extend the overall training time well beyond that period. The sub-sections that follow provide additional detail on the training processes for the en route and terminal domains, and discuss limitations or problem areas at each stage.

Table 2-1. En Route Training Process

Stage	Location	Time (weeks)
Stage I: Initial Qualification	Academy	11-15
Stage II: Assistant Controller	Field Facility	10
Stage III: Non-Radar / Radar Associate	Field Facility	50
Stage IV: Radar	Field Facility	100

2.1.1 Academy Training

Once hired, most candidates attend the FAA Academy for Initial Qualification training, consisting of the following phases:

- *Air Traffic Academics.* Air traffic control basics, including federal air regulations, aircraft performance, weather, procedures, etc.
- *Part-Task Training.* Classroom and laboratory activities, progressing from basic separation techniques to sophisticated separation activities.
- *Skills Building.* Students progress from simple control problems to more complex scenarios, using simulation that closely replicates the control room environment.
- *Performance Verification.* Operational supervisors from the field are brought in to the Academy to assess if students are ready to proceed to facility training.

Former military controllers may bypass the Academy and go directly to a terminal facility. Former (pre-strike) FAA controllers being rehired go through a special refresher course. And graduates from CTI schools skip Air Traffic Academics and go directly to the Part-Task Training phase.

The Academy has automation display systems that accurately mimic the Radar displays in en route facilities, but does not yet have the User Request Evaluation Tool (URET) that is operational at the Radar Associate position in all 20 en route facilities. URET is expected to be installed at the Academy in late 2006.

2.1.2 En Route Facility Training

En route field training consists of a combination of classroom, simulation, and OJT. OJT constitutes the major portion of field training. FAA Order 3120.4 provides guidance on the conduct of OJT, but there is a great degree of variance in the time incurred. Several factors influence this length of time:

- Trainee aptitude and motivation.
- Evenness in the flow of incoming trainees. (Classes may be delayed until a minimum number of trainees are available.)
- Use of qualified trainees to staff sectors, thereby placing their training on hold.
- Degree of "seasoning" time required on certified sectors to build operational awareness and confidence before continuing to more complex and busier sectors.
- Effectiveness and quality of OJT time, which is highly dependent a traffic level and complexity that is appropriate for training.

Simulation training takes 6-8 weeks in both Stages III and IV. Simulation is conducted using the Host System's Dynamic Simulation (DYSIM) capability. DYSIM was deployed in the 1970's and enhanced when possible over the intervening years. Given the current state of this technology, there are several opportunities for improvement:

- Increasing the realism of altitude and speed profiles for simulated aircraft
- Ability to account for wind effects on aircraft maneuvers
- Control of speed adjustments for simulated aircraft
- Reducing the dependence on human "pseudo-pilots" for scenario runs
- Ability to pause/resume a scenario run

- Ability to replay a scenario run for after-action review

As these types of improvements are made in future simulation capabilities, training will be able to rely more on simulation and less on OJT. Moreover, many of the research principles that promote improvements in training processes can start to be applied.

2.1.3 Terminal Facility Training

Terminal facilities and control positions are more diverse than in en route. Terminal facilities are classified by levels (4 through 12) based on the volume and complexity of traffic handled, and are also separated into Tower and Radar positions. Tower positions (flight data, clearance delivery, ground and local control) are worked in the tower cab. Radar positions are worked in Terminal Radar Approach Control (TRACON) facilities.

Terminal training is divided into six stages (excluding Initial Qualification training at the Academy) and, like en route, is comprised of classroom, simulation, and OJT training. Also, like en route, OJT constitutes the major portion of terminal training. The time to certify is largely a function of the facility level, as shown in Table 2-2.

Table 2-2. Average Terminal Facility Certification Time

Facility Level	Time (months)
4 – 5	8
6 – 8	24
9 – 12	36

Trainees are often initially assigned to lower level facilities where they train and certify, later advancing to higher level facilities as opportunities become available. Therefore, the higher level facilities generally provide training to controllers who are already certified – they need to become familiar with the operations, procedures, and airspace of the higher level facility but have already demonstrated basic control skills.

There are two core automation systems that support all TRACON operations: Automated Radar Tracking System (ARTS) and Standard Terminal Automation Replacement System (STARS). ARTS and STARS automation capabilities support both operations and training, and provide a more realistic training environment than DYSIM does for en route. To date, there are roughly 120 ARTS facilities and 50 STARS facilities.

Tower controller training is comprised of classroom and OJT instruction. However, the FAA is currently evaluating the use of high-fidelity tower simulation similar to that used by the military (Section 2.2).

Several factors influence certification time and the quality of training that is provided in the terminal environment:

- Local airspace and procedures are learned through student initiative with limited classroom instruction. In fact, lower level facilities lack dedicated instructors.
- Simulation provides realism, but most facilities lack an effective communication system and flight strip printers in the lab, thus reducing full task training fidelity.
- Many facilities lack dedicated space for simulation equipment and are forced to use control room hardware for training during off hours.
- Simulation training is labor and resource intensive. Opportunities for independent practice in ATC skill application are often unavailable.
- Like en route, OJT is central to the training program, but its effectiveness and quality are highly dependent on traffic levels and complexity.
- Skill-based training is not systematically conducted before OJT commences, and trainee performance measurement and feedback are infrequent, both due to limited instructional resources.

Several of the advanced technology solutions in Section 3 can be applied to these areas and would be expected to have a substantial impact on training time and overall quality.

2.2 United States Air Force

Several years ago, the United States Air Force (USAF) was experiencing shortages of military controllers in its tower and radar approach control facilities with such a severity that the operating hours at 30 of 75 of its bases were forced to be reduced. This prompted an overhaul of its training program. Key aspects of the change:

- The USAF training academy curriculum was changed to focus more on projected assignments to specific tower or radar facilities.
- Self-paced, web-based training – including learning-game applications, interactive simulation, and high-fidelity simulation training – was implemented.
- Simulator training time was increased in order to provide the trainee with more exposure to the complexities of field operations, and to reduce qualification times at facilities.

The new curriculum with advanced simulation and concentrated specialized training mirrors the USAF pilot training program. With the same instructor resources, the number of controllers trained was increased dramatically from 120 to 619 per year. Furthermore, appraisal scores improved and the time for certification was reduced. (Intercom, August 2002)

With a new tower simulation system deployed to over 90 military locations, the USAF has experienced significant training benefits. Simulation training has improved controller performance, increased the confidence of apprentice controllers prior to working live traffic, allowed for training of large numbers of controllers, and reduced training time by about 45 percent. The simulator has also enabled refresher and remedial training for already-certified controllers at some of the low traffic density towers.

Steps have been taken to increase facility specific-training at the USAF training academy. The goal is to provide site-specific airspace indoctrination training prior to arrival at the new facility, thereby reducing the initial orientation time and, thus, overall certification time.

2.3 Selected International Service Providers

Over the last few years, the training approaches and future plans of several international ATC service providers were examined. The significant findings follow.

National Air Traffic Services (NATS) of the United Kingdom has extensive simulation capabilities at their academy in Bournemouth for tower, terminal, and area (en route), and maintains a mix of current controllers and professional teachers on staff as instructors. Academy training typically concentrates on ATC principles and problem solving skills using generic tower and airspace simulation scenarios, requires about 12 to 18 months to complete, and licenses the trainee to move on to any domain (tower, terminal, area) upon graduation. However, NATS is moving toward a more domain-targeted program in order to shorten time at the academy. NATS has also found part-task simulation to be effective in providing their trainees the capability to independently practice and improve skills.

Training and certification conducted at the UK's Swanwick area facility typically occurs over a 27-month period: 6 months of classroom instruction and CBT, 2 months of area-specific simulation, 12 months of OJT for a sector group (4-5 sectors), 3 months of work at those sectors, then 4 months of learning and certifying on another sector group. During the OJT process, trainees certify on both sector positions (the *executive* and *planner* positions, somewhat comparable to the Radar and Radar Associate positions in the United States) before moving on to the next sector. This *concurrent* training is a relatively recent change and is considered to have made the training program more effective.

The Institute of Air Navigation Services (IANS) training academy at Luxembourg provides training primarily for Maastricht Upper Air Center (UAC) and Luxembourg tower and, given this focus, includes site-specific content. Prior to arrival, IANS candidates are provided a Computer-Based Training (CBT) package of basic air traffic procedures and terminology that is studied on their own time. The 8-month academy course includes a substantial amount of high-fidelity simulation, as well as self-paced e-Learning exercises. With efficient conduct of core courses and improvements in simulation, the academy has doubled its output and experiences a high success rate of the trainees as they move on to the facility.

Training and certification at Maastricht's UAC typically occurs over a 24-month period: 6 weeks of classroom instruction, 10 weeks of high-fidelity simulation, 6 weeks of control room observation, and OJT for the remaining time.[2] The trainee traditionally certifies sector-by-sector, first at the executive positions and then at the planner positions, i.e., sequentially. At the time of this study, concurrent certification at executive and planner positions had been tested with positive results. The facility maintains a high-fidelity simulator and believes that these capabilities have greatly aided in reducing training time.

Nav Canada is responsible for Canadian Air Traffic Services. Initial controller training occurs at the Nav Canada Training Institute (NCTI) in Cornwall, Ontario over a 4 to 6 month

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[2] Unlike many other facilities, UAC operates without flight strips, even as a backup. No non-radar or flight strip training is conducted.

period and includes high-fidelity simulation as well as a computer-assisted learning program that puts real-time interactive simulation capabilities on each trainee's desk. After passing NCTI courses, trainees become probationary employees, and move on to qualification training at a flight service station, control tower, or regional training unit. Tower facility training utilizes high-fidelity simulation and averages 3-12 months. En route center training includes 6 months of dedicated simulation training followed by 6-12 months of OJT.

Section 3

Application of Advanced Training Technologies

3.1 High-Fidelity, Intelligent Training Systems

Classroom instruction and CBT are effective for acquiring basic knowledge, but a practice environment with high-fidelity simulation is critical for acquiring the specialized and complex skills of air traffic control in an efficient manner. Such a practice environment allows the trainee to continually go over problem areas, correct errors, and obtain useful performance feedback. Technologies for voice recognition and synthesis, intelligent tutoring, and instructor support capabilities can substantially improve FAA's simulation environment, enabling dramatic benefits in training quality and certification time.

3.1.1 Voice Recognition & Synthesis

In traditional air traffic control training simulation, aircraft are typically controlled by *pseudo pilots* — trained operators who manipulate several aircraft according to clearances issued by the controller trainee on a simulated radio channel, and provide appropriate voice responses as if they were the pilot in command. *Ghost controllers* are also trained operators who play the role of controllers at surrounding sectors and deal with inter-sector coordination and communication. A given simulation exercise may require more than one pseudo pilot and/or ghost controller based on the learning objective as well as the volume of aircraft and complexity of the traffic scenario.

Voice Recognition & Synthesis (VR&S) enables those human operator functions to be replaced by automation. For controller-initiated communications to an aircraft, the VR&S technology recognizes the controller's speech, synthesizes an appropriate pilot readback, and sends appropriate aircraft flight instructions to the simulation in order to affect a pilot/aircraft response. For pilot-initiated communications, e.g., aircraft call-in, it synthesizes and delivers the pilot's speech to the controller. And for inter-sector communications, it recognizes the controller's speech and generates an appropriate response from the simulation and the ghost controller. Guidance for controller phraseology is located in FAA Order 7110.65, *Air Traffic Control*. Guidance for pilot phraseology is located in the FAA Aeronautical Information Manual.

There are several substantial benefits for the use of VR&S technology in this manner:

- It improves the overall practice environment for skill development;
- Supports self-paced, independent learning;
- Enforces the teaching and use of standard ATC phraseology; and
- Reduces costs since it obviates the need for pseudo pilots or ghost controllers.

3.1.2 Intelligent Tutoring

An Intelligent Tutoring System (ITS) is a set of automated capabilities combined with human performance models that provide for an objective assessment of learned skill levels, infer strengths and weaknesses of a student, and enable tailored instruction. ITS processes and technologies have been successfully applied in academic and military contexts; however, they are in their infancy in the ATC training curriculum. Instructional methods instead rely on subjective interpretation of student knowledge and skill proficiencies, and provide little opportunity to *objectively* and *comprehensively* identify and focus on improving weak areas.

ITS human performance models are further defined as follows:

- An **Expert Model** specifies the desired or baseline performance against which a trainee will be compared. This specification focuses on fundamental performance characteristics associated with the execution of ATC tasks, and not on particular methods or techniques.

- A **Student Model** specifies the performance indicators for each trainee that is the basis of comparison to the "expert." These indicators may be organized by course or skill area, and can be used to provide an objective assessment of the trainee's current proficiency levels or to show trends over time.

- An **Instructor Model** guides After-Action Review (AAR) activities, and identifies and prioritizes actions to take as a result of the trainee/expert comparison. Actions may include specific coaching activities, review of relevant course materials, follow-on training exercises, or some combination thereof.

ITS technologies are proven in several domains with similarities to ATC cognitive processes and complexities, and have delivered significant benefits in terms of increased instructional quality and reduced training time [Bloom, 1984; Ericsson, 1996; Gott and Lesgold, 2000; Hays et al, 1998; LaJoi and Lesgold, 1989; Schank et al, 2002; Stottler et al, 2001]. The reduction in training time results primarily from having accurate and objective feedback that helps focus skill acquisition on the right areas. Research has also shown that students who are immersed in a training environment with ITS tend to have a higher desire to learn and master skills, and can progress in a self-paced manner toward performance goals.

3.1.3 Instructor Support

Integrating ITS into the training simulation requires report-generation capabilities that provide relevant information about the trainee's performance during a given simulation run and over time. The instructor would use this to guide AAR, as well as look for performance trends that indicate strengths or weaknesses and then tailor training activities accordingly. In fact, all information about the trainee's progress, including classroom, CBT, and simulation evaluations can be automated and readily available to all involved in the training process, i.e., the trainee, instructor(s), and supervisor.

Recording and Playback is another very powerful capability for AAR, whereby the video and audio recorded from a previous scenario run is reviewed, analyzed, and used to provide instructional feedback. Simulation controls such as a *Pause* capability enable detailed and specific review of air traffic control actions either as part of AAR or in real-time during the simulation run. Finally, the ability to skip to a particular time or event in a previous scenario run provides a mechanism to quickly and conveniently call up specific actions for review and feedback or, even further, to test alternative control actions from that point forward.

3.2 Web-Based Instruction

Web-based instruction is a learning method that utilizes the resources of the internet, e.g., on-line access to instructional and testing materials, e-mail and "chat" interactions between teachers and students, etc. Initial Qualification training is presently conducted at the FAA Academy in Oklahoma City, Oklahoma. However, the first phase of that training (Air Traffic

Academics, described in Section 2.1.1) lends itself to web-based instruction. This first phase is typically 5 weeks in length. There are several benefits of adapting the Air Traffic Academics content to an on-line course:

- Candidates can take the course on their own time and progress through course materials at their own pace.
- Academy training time and resource requirements can be reduced (physical space, equipment, instructors, etc.)
- Access to the course is broadened, thereby increasing the effective hiring pool.
- Aptitude can be tested before entry into the Academy or a field facility.
- Instructors can focus on training the more advanced air traffic skills.

3.3 Location-Independent, Site-Specific Training

Traditionally, site-specific training has been primarily conducted at the target air traffic control facility. However, current networking and video teleconferencing technologies enable physically dispersed educators, operational experts, and trainees to work together and run air traffic simulation exercises in a type of "virtual training environment." Today, the technical barriers to such an environment are greatly reduced, creating opportunities for process improvements that can result in substantial training quality, time, and cost benefits.

A training process enhancement that exploits this technology could, for example, focus on having trainees reach a "near-certification" level of proficiency before ever entering their target facility. Site-specific simulations could be run at a centralized location like the FAA Academy or at regional training facilities, with "virtual" support coming from the operational experts at target sites. A centralized or regional configuration would enforce standardization of instruction and use of dedicated educators, and help alleviate bottlenecks at field facilities. It also promotes the concept of introducing the trainee to the specific operations of a facility or area as early in the process as possible, even though they are not yet physically located at that facility. Location-independent, site-specific training can be particularly effective in a terminal environment, where it is often difficult to maintain local instructors at many of the smaller facilities located throughout the country.

Section 4

Selected On-Going Research

In order to test and evaluate several of the technology improvements discussed, an initial field trial is being conducted at the Indianapolis Air Route Traffic Control Center (ZID ARTCC) using a stand-alone, prototype simulator for *enroute***Training** built largely as an augmentation of the capabilities in CAASD's Air Traffic Management Lab. The prototype combines:

- The advantages of simulation with the realism of OJT;
- Additional training functions that enhance support for active instruction (e.g., Recording and Playback);
- VR&S technology that reduces the reliance on human operator support; and
- Scenarios constructed from existing DYSIM problems, new skill-based scenarios, and scenarios derived from traffic recordings.

The initial field trial focuses on the simulation phase and OJT portions of en route Stage IV Radar Training, during which time the capabilities are to be assessed to determine if:

- Training times are reduced;
- Training content is improved;
- The training process is more streamlined; and
- Trainee preparedness is enhanced.

4.1 The En Route Trainer Concept of Use

The en route trainer is designed to improve the efficiency and effectiveness of simulation training. The following sections describe how the trainer is being used during the ZID field evaluation. Additional uses may be identified throughout the evaluation process.

4.1.1 Skill Training

The trainer supports skill training with the creation of scenarios that are specifically designed to contain events to allow the trainee to concentrate on a designated skill while minimizing emphasis on other skills. During the field trial, skill-based scenarios are used to teach or reinforce targeted skills, tasks and procedures during the simulation, OJT and remediation phases of training.

While an instructor is likely to be present during the field trial to supervise skill training sessions, an instructor is not required to be present for skill scenarios as these scenarios employ the automated sim-pilot (i.e., the simulated pilot provided by the VR&S capability). Thus, trainees are able to run skill scenarios on their own without the need for an instructor or other staff members to act as pseudo pilots. Trainees can save their skill scenario sessions for later playback and review with the instructor.

4.1.2 Full-Length Training

The trainer supports realistic ATC session training through the creation of training scenarios that are full-length (e.g., hour-long), interactive scenarios. Whereas skill-based scenarios target specific skills, tasks, and procedures, full-length training scenarios allow the trainee to practice the integration of skills learned. For the initial field trials, these scenarios replicate to the greatest extent possible the existing DYSIM instructional scenarios. The advantage of translating the DYSIM scenarios and running them on the trainer include more realistic aircraft performance (including wind effects) and the reduced need for pseudo pilots.

While an instructor may supervise simulation phase and OJT training sessions, an instructor is not required to be present because trainees are able to run immersive scenarios on their own and save their sessions for later playback and review with the instructor.

4.1.3 Live Operations Review

The trainer allows the creation of review scenarios from either live traffic recordings or custom crafted traffic for observation. Review scenarios allow trainees to observe scenario events without interacting with the system that can be used during classroom, simulation phase, and OJT portions of Stage IV training. During classroom and simulation training, the trainee can watch review scenarios while the instructor provides commentary as the recording progresses. The instructor can also pause the recording in order to discuss and highlight key aspects of the scenario that illustrate the concepts being taught, to point out good ATC practices, and to point out practices to avoid.

4.1.4 Simulation Phase Training with the En Route Trainer and DYSIM

Under the current training program, there are three parts of Stage IV training, as outlined in FAA Order 3120.4: classroom/situational, simulation, and OJT. The Stage IV simulation phase of ATC training at ZID today consists of hands-on training using DYSIM scenarios. The en route trainer simulation phase training plan has four key differences from the existing ZID simulation training program:

1. A portion of the existing traditional DYSIM scenarios will be delivered on the en route trainer platform.

2. Each trainee runs 54 simulation scenarios instead of 40 simulation scenarios in a condensed time schedule.

3. New "skill-based scenarios" designed to facilitate mastery of specific skills are delivered at the start of simulation training. These will cover the traditional DYSIM familiarization (FAM) scenarios.

4. Calendar time is reduced from 6 weeks to 4.5 weeks. This time reduction is achieved through a specific and balanced daily schedule which will be possible by taking advantage of the flexibility afforded by the en route trainer.

Table 4-1 contrasts the current simulation phase training with DYSIM and the en route trainer plan.

Table 4-1. Comparison of DYSIM and En RouteTrainer Simulation Training

	Current Simulation Training Program with DYSIM	**Simulation Training Program using the En Route Trainer**
Total Number of Scenarios	40	54
Number of Scenarios per day	2 scenarios per day, remaining time to for CBIs, or acting as Radar Associated for other trainees	More than 2 scenarios on certain days, remaining time for CBIs and other supplemental materials.
Calendar Time	6 weeks	4 weeks, 3 days
Actual Time Running Scenarios	40 hours	42 hours
Pause Capability	No pause	Pause allows instructor greater possibilities for coaching developmental.
Playback Capability	No Playback	Playback allows instructor greater possibilities for reviewing performance and coaching developmental.
Skill-Based Scenarios	None	Skill-based scenarios that facilitate mastery of one or more specific skills.
FAM scenarios	DYSIM 10 60-minute scenarios	Replaced by skill scenarios 24 30-minute scenarios
Instructional scenarios	DYSIM 60 minutes each	DYSIM and en route trainer 60 minutes each

Evaluation scenarios	DYSIM 60 minutes each Administered as part of specified sequence of scenarios.	DYSIM 60 minutes each May be administered at any time at the discretion of the instructor.
Additional familiarization scenarios in target sector	DYSIM Scenarios hand-crafted for DYSIM 60 minutes each	En route trainer and DYSIM Some scenarios derived from live sector traffic recordings allowing for higher-fidelity, operational experience. 60 minutes each
Daily debrief and discussion forum with all developmental and simulation instructors	None	15-30 minutes each day

Simulation training with the en route trainer is comprised of six different types of scenarios:

- 24 Skill-based (SKILL) Scenarios: SKILL scenarios are 30-minutes in duration and designed to familiarize the trainee with a particular skill or set of related skills in a targeted way. The SKILL scenarios allow the trainee to master basic ATC skills before moving on to higher-order skills. SKILL scenarios are run in a highly interactive way where the instructor advises and coaches the trainee throughout the process, paying particular attention to the skill being taught. As the en route trainer is used for SKILL scenarios, the instructor and trainee will be encouraged to use the Pause function to facilitate interactive dialogue throughout.

- <u>18 Instructional (INSTR) Scenarios:</u> INSTR scenarios are used in the current ATC simulation training environment and will continue to be used. These scenarios are 60 minutes in duration and are designed to teach the trainee how to perform ATC without real-time guidance or instruction. INSTR scenarios are less interactive where the trainee is encouraged to work on his/her own. The en route trainer or DYSIM may be used to run INSTR scenarios, although all INSTR scenarios are similar to the existing DYSIM INSTR scenarios used today. When the en route trainer is used for INSTR scenarios, the instructor is encouraged to use the Pause function to facilitate interactive dialogue throughout.

- <u>2 Evaluation (EVAL) Scenarios:</u> EVAL scenarios are used in the current ATC simulation training environment and will continue to be used. These scenarios are 60 minutes and are designed to test readiness for OJT. No instructor-developmental interaction is permitted during these scenarios. DYSIM will continue to be used for EVAL scenarios.

- <u>10 Additional familiarization (ADD/FAM) scenarios</u>: ADD/FAM scenarios are used in the current ATC simulation training environment and will continue to be used. These scenarios are 60 minutes and designed to prepare the trainee for the sectors that he/she will be working during OJT.

Each trainee progresses through the scenarios in the following way:

1. Eight days running SKILL scenarios using the en route trainer

2. Ten days running INSTR scenarios using the en route trainer or DYSIM depending on the events in the scenario (note: Two EVAL scenarios are run during this time using DYSIM)

3. Five days running ADD/FAM scenarios in the next targeted sector(s) using DYSIM and live traffic recordings

SKILL scenarios focus on five skill areas:

1. Separation using altitudes, vectors, and speed

2. Scanning, prioritizing, and maintaining situational awareness

3. Reroutes and change requests due to traffic, weather conditions

4. Miles-In-Trail (MIT) spacing

5. Dealing with special, unpredictable events

For each skill area, trainees complete a series of four to five 30-minute SKILL scenarios that are highly focused on specific areas of competence. All SKILL scenarios are run using the VR&S capability.

4.2 Data Collection

In order to measure whether the potential benefits are realized, data will be collected throughout the field trial. Data to be collected will consist of quantitative measures of training times and subjective measures of the simulation capabilities and general level of trainee preparedness. In addition, data related to system performance will be collected. Subjective assessments of the training system from students will be collected. Finally, data collection will also include direct observation of instructors working with trainees during the training sessions. This type of data collection will allow the analysts to observe and record issues or problems with the system that might not be reflected in other forms of data collection or participant debriefs.

4.3 Preliminary Results

The ZID field trial commenced in June 2006 and will extend throughout Stage IV Radar Training. Results, though very preliminary, have been extremely positive. Feedback thus far indicates that the prototype trainer provides a far superior training environment than existing DYSIM capabilities and, thus, better promotes the acquisition of air traffic control skills. The VR&S capabilities also performed very well and, in particular, have helped to enforce proper phraseology. And the recording and playback function has been found to be a highly useful learning tool for after-action review. A comprehensive set of results are pending the completion of this phase of evaluation.

Section 5

Summary and Conclusions

The FAA will soon face a substantial increase in the number of air traffic controller trainees as the agency prepares for the large number of retirements that are anticipated to occur over the next decade. Training these individuals is both time and resource intensive. Fortunately, there exist some real opportunities for improvements in training technologies and processes, changes that could result in reduced certification time and cost, higher utilization of training resources, more objective assessment of student performance, and more streamlining and standardization.

Having examined training advances in the state-of-the-art in instructional methods, and related successes by other air traffic service providers, a number of potential improvements have emerged:

- **Voice Technology.** Voice recognition and synthesis is feasible for air traffic control simulation training and has direct and measurable benefits. It reduces or eliminates the need for pseudo pilots and/or ghost controllers, and promotes a more robust and flexible training environment that enforces standardization of phraseology.
- **Intelligent Tutoring.** While the application of intelligent tutoring technologies for air traffic controller training is relatively immature, the benefits potential is substantial. Intelligent tutoring provides automated, standardized, and objective assessment of student performance; enables self-paced, individualized instruction; and promotes optimal use of training time and resources.
- **Instructor Support.** With automation support for after-action review and simulation control features such as *playback* and *pause* functions, instructors can be more effective and better tailor their guidance to individual students.

- **Web-Based Instruction.** Some elements of controller training, e.g., Air Traffic Academics, lend themselves to web-based instruction. The potential savings in training time and resources are significant.

- **Location-Independent, Site-Specific Training.** Network and teleconferencing technologies enable physically dispersed instructors and students to work together and run site-specific simulations from remote locations. If this technology were exploited, a trainee could reach a "near-certification" level of proficiency before ever entering a target facility.

- **Skill-Based Scenarios.** The skill-based scenarios that are being evaluated in ZID are specifically designed to focus the instruction on acquisition of a particular air traffic control skill (e.g., separation, spacing). These scenarios appear thus far to have improved the benefits of simulation training in general.

- **Concurrent Radar and Radar Associated Training.** Concurrent training has been demonstrated to be beneficial in several instances. It tends to enforce the sector team concept and more effective interaction between the positions.

An evaluation of some of these improvements is currently being conducted at the Indianapolis ARTCC, focusing on the potential for advanced simulation technologies to impact certification time and training quality. While this is on-going work, preliminary results are very encouraging. The high-fidelity simulation environment being evaluated appears to provide a useful and beneficial practice environment for trainees and is expected to reduce certification time, and support expedient acquisition of air traffic control skills in an efficient manner.

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