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# Virtual Air Traffic Flight Training Device Automated Air Traffic Control

Nickolas D "Dan" Macchiarella

Christian D. Meigs

**FORUM**

# *VIRTUAL AIR TRAFFIC FLIGHT TRAINING DEVICE AUTOMATED AIR TRAFFIC CONTROL*

Nickolas D. "Dan" Macchiarella and Christian D. Meigs

## ABSTRACT

A recent study of the university's Flight Training Device (FTD) use revealed possibilities for improving the training environment for ab initio pilots. One improvement is the design, development, and application of a Virtual Air Traffic (VAT) functionality. VAT will use voice recognition technology linked to semiautonomous and autonomous virtual air traffic integrated into the FTD's virtual environment. Virtual aircraft and controllers will communicate via the radio functionality. The student pilot will communicate with the virtual controller through the radio functionality using voice over (VoIP) and voice recognition software. The virtual controller will respond with a synthetic voice. The desired outcome of using VAT during training is to be better prepare student pilots to function in flight while minimizing the need for actual airplane flight training.

## INTRODUCTION

The application of lessons learned from flight training are critical to the successful, design, development, and integration of new technology into virtual environments for training pilots. The most recent developmental changes, to the university's flight training devices (FTD), are intended to enhance training through the behavioral aspect of the FTD-based flight experience. The impetus for the developmental changes draws from results of the *Ab Initio Flight Training Device Effectiveness Study* (Macchiarella, Arban, & Dogherty, 2006). The decision to adopt new virtual environment technologies must consider cost, transfer of training (ToT), and similarity. Roscoe and Williges (1980) (see Figure 1) present a simplified representation of the complex relationship between ToT and simulator cost as differential functions of user response versus stimulus fidelity. Negatively accelerating increments in transfer are associated with increasing stimulus fidelity (i.e., the degree of apparent reality integrated for the training device) beyond a level necessary to meet training needs and sustain user motivation. Roscoe and Williges identify an optimal level of fidelity as a level that ensures positive transfer without undue costs associated with obtaining the highest levels of fidelity.

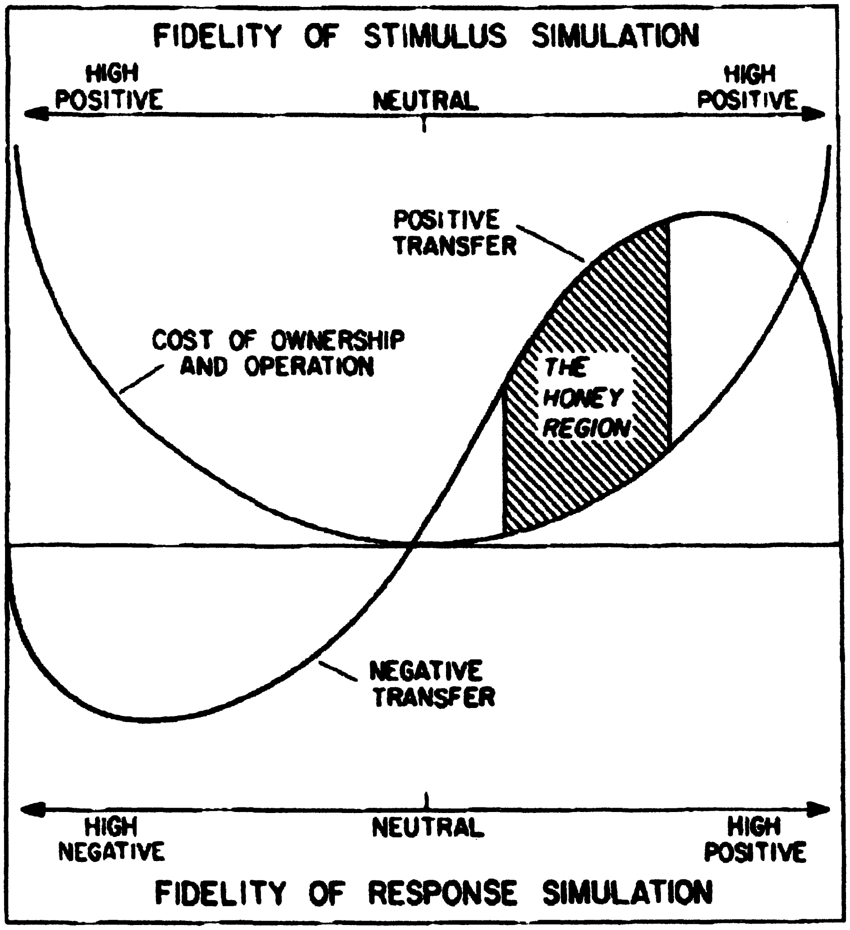


Figure 1. Cost of flight simulators and the positive and negative transfer of training as respective functions of stimulus and response fidelity (Roscoe & Williges, 1980, p. 159).

However, cost efficiencies maybe secondary for situations where a simulator is the only training option. As an example, training astronauts for space flight before a launch can only occur in simulation; small incremental increases in transfer may be intentionally obtained at great expense. Flight simulators are economical. This economy is evidenced by lives saved through reduced accident rates following the implementation of simulator-based training under the Advanced Qualification Program (AQP). Additionally, after the FAA certified flight simulators for airline pilot check rides and training, the airlines were able to amortize the cost of the simulator in less than two years through flight operations savings (Cardullo, 2005).

Advanced modern cockpit technology has moved into general aviation aircraft during this decade. These aircraft, known as Technically Advanced Aircraft (TAA), are equipped with most of the technology found in large transport aircraft (Dahlstrom, Dekker, & Nahlinder, 2006). According to a report by the AOPA Air Safety Foundation (2005) many new TAAs go beyond having a moving map and a multi-function display (MFD) with weather, traffic, or terrain graphics. The TAAs also including a Primary Flight Display (PFD) to replace the traditional *six-pack* and are approaching a level of fidelity found in the glass cockpit concept used in large transport aircraft. The AOPA report states that the technology emerges with favorable and unfavorable consequences. It increases pilot and aircraft capabilities, but frequently at the price of increased pilot workload and necessary higher levels education and training.

Since the introduction of advanced computer technology in the cockpit, research has investigated how to effectively train student pilots to function in a modern cockpit environment (Dahlstrom et al., 2006). Advances in computer hardware and software offer promising opportunities for increasing the behavioral fidelity associated with training in virtual flight environments. High levels of fidelity in the forms of physical fidelity, control loading fidelity, and aerodynamic fidelity enables the university's FTDs to properly replicate airplane flight. However, replication of the behavioral aspects of the FTD-based training experience is directly connected to the instructor pilot's ability to role play air traffic and air traffic control. While facilitating training in the FTD, the instructor pilot, at times, is task saturated making role playing a demanding activity that could draw attention away from the other aspects of successful instruction. A desired objective for FTD-based training is for the instructor to have the opportunity to interact with the student in the same manner as would occur in actual flight. Additionally, during specified training modules having the student interact with a complex air traffic environment could engage the student pilot in higher levels of cognitive activity while learning to fly in the FTD.

## VIRTUAL AIR TRAFFIC (VAT)

The university in collaboration with Frasca International Inc. is developing VAT for its FTDs. The design goal of VAT is to create a system that eliminates the instructor's need to role play and simultaneously increases the behavioral fidelity of the training environment. Researchers in the Aeronautical Science Department are teaming with instructor pilots in the Flight Training Department to define the communications phraseology necessary to enable the VAT functionality to mirror real world flight in the local training area.

VAT offers the potential to eliminate the need for instructor pilots to role play air traffic and air traffic control, thus freeing them to focus their attention on other instructional tasks necessary in the FTD. VAT will respond to individual students by parsing transmitted radio messages into understandable text that can be matched to appropriate responses. These responses will be transmitted back to the student via the FTD's radio functionality that enables a two way communication. In a sense, VAT will be a form of an embedded training system within the FTD. This embedded training functionality will help ensure delivery of a training environment that replicates the real world. Strasel et al. (1988) identified that a fully functional embedded training system should require students to perform normal tasks in response to simulated inputs, present realistic scenarios, provide an interactive capability whereby the system would assess the action of the student and respond realistically, and record performance and provide feedback after the session. VAT's design incorporates these principles.

A focus group comprised of senior flight instructors and a graduate research assistant from the Aeronautical Science Department are compiling specific flight communications for Embry-Riddle Aeronautical University Flight Operations, KDAB Clearance Delivery, KDAB Ground, KDAB Tower, Daytona TRACON, and Jacksonville Air Traffic Control Center (JAX ARTCC). This set of communications phraseology will enhance the voice recognition software's ability to parse speech into text and communicate properly with the student pilot.

## TRANSFER OF TRAINING AND VAT

The concept of transfer of training (ToT) is the most common method to measure the degree of skill transfer between simulation and performance in the aircraft in order to determine simulation effectiveness (Roscoe & Williges, 1980; Macchiarella, Brady & Lyon, 2008). ToT is a methodology for measuring the knowledge, skills, and attitudes (KSA) acquired from a training environment and subsequently demonstrated during real world application. Positive transfer manifests itself as reduced time on task that can lead to reduced training costs as students master a real world tasks (e.g., student pilots that practice traffic patterns in the FTDs virtual environment require fewer actual flight iterations in a traffic pattern to achieve the practical test standard). Negative transfer is possible and undesirable. It is evidenced by a decline in skills, perseverance, or motivation from the trainee's standpoint. Positive transfer is desired and is an objective of simulation-based training (Liu, Blickensderer, Vincenzi, & Macchiarella
, in press). Researchers hypothesize that VAT could

positively affect ToT by enabling student pilots to interacting with a virtual air traffic environment prior to experiencing the real world.

Three factors of particular interest that affect ToT are identical elements, stimulus and response, and trainee motivation (Macchiarella, Arban & Doherty, 2006). The researchers believe that VAT has the potential to have positive affects with regard to the three major factors. Increased identical elements between a training environment and real world environment can manifest an increased rate of transfer (Thorndike, 1906). The first factor is identical elements. This concept dates back to the turn of the previous century. Thorndike (1906) originated an idea that is still applied in the design of simulated environments. Thorndike argued that there would be transfer between a first task (e.g., normal approach in an FTD) and a second task (e.g., normal approach in an airplane) if the first task contained specific component activities that were held by the second task. This approach is predicated on the presence of shared identical elements. The second factor is stimulus and response. This concept is based upon the idea that transfer depends on the extent that similarities exist between stimulus representation and the response demands of the training and the real world (Osgood, 1949). This factor differs from the identical elements approach by pointing out that ToT can be obtained with devices that do not duplicate the real world to the greatest possible extent. The third factor, motivation and ability, focuses on the student pilot as an element of the training system. This factor recognizes the individual differences between student pilots. While numerous individual differences exist, two important ones for training are motivation and ability. In terms of motivation, the student pilot must recognize the value and relevance of the training in order to put forth effort to learn. Therefore, a prerequisite for transfer is the motivation of the trainee to want to acquire new skills and knowledge. In terms of ability, the trainee must also have the raw ability to improve their skills. Consider, a student pilot working on proper performance of a soft field takeoff and climb. The student pilot must be capable of analyzing the situation and realizing that they can take off in ground effect to dramatically shorten the distance the airplane moves across the soft surface. Ultimately, the trainee needs the cognitive ability to identify the element needed to improve his/her performance (Yamnill & McLean, 2001).

## DESIGN CONSIDERATIONS

A major concern while designing VAT addresses how knowledge and skills acquired in the training environment transfer to job performance in the operational environment. This concern leads to consideration regarding the degree of required fidelity or realism. ToT research suggests that single theories of transfer will not hold for both cognitive and motor tasks (Schmidt & Young, 1987). Hays and Singer (1989) suggest starting with an analysis to determine the major emphasis of the task to be trained if the task is cognitively oriented, it is likely that the training system should emphasize functional fidelity (i.e., behavioral fidelity), which refers to the accuracy of representation of the system's procedures. If there are strong psychomotor elements, then physical fidelity should be emphasized. Physical fidelity refers to the accuracy of representation of the physical design and layout of the system. Virtual environment training may be particularly suited to increasing the probability of transfer because of its flexibility and performance feedback capabilities (Durlach & Mavor, 1995).

## PROCEDURAL SIMILARITY

Fidelity in the forms of physical fidelity, cognitive fidelity, control loading fidelity, and aerodynamic fidelity enables the university's FTD to properly replicate airplane flight (Macchiarella & Doherty, 2007). Thorndike (1906) developed the theory of Identical Elements that suggests that transfer only occurs in the presence of specific common elements. Researchers identified that various PTS tasks that are highly procedural in nature showed positive ToT when replicated in the simulated flight environment afforded by the FTDs. The researchers believe that integrating VAT with the FTD will provide a realistic flight environment that increases the similarity to the real world. This increase in similarity to the real world can create an environment with a higher level of behavioral fidelity that affords opportunities for students to incur cognitive activity that matches real world flight.

A design goal of VAT is to ensure that what the pilots say and hear is fully correlated with what they see in the visual scene; these interactions can make the training experience more immersive and realistic. Autonomous and semiautonomous virtual aircraft can be incorporated into flight training scenarios based on the desired level of complexity in the simulated flight environment (e.g., initial training modules include minimal virtual air traffic and advanced training modules include high levels of virtual air traffic with complex virtual air traffic controller to student pilot interaction). As the student pilot interacts with these virtual aircraft realistic responses can be elicited while the flight instructor is freed to demonstrate, observe, and provide feedback.

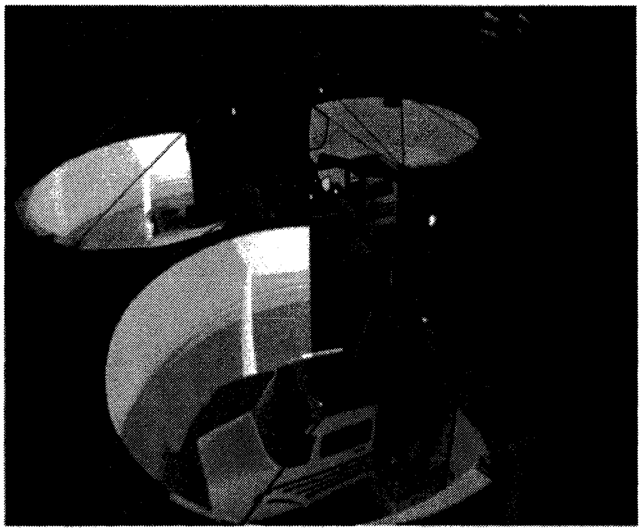

Figure 2. ERAU Frasca Cessna 172 FTD incorporates a 220-degree horizontal visual display.

## CONCLUSION

The integration of VAT into the FTD's training environment has the potential to increase the behavioral fidelity to a level that mirrors the real world. This type of training environment could have two significant benefits. First, it could lead to higher levels of ToT. Second, it could free the instructor from the role playing and enable them to focus more effort onto instruction. The decision to develop VAT, and its associated improvement to training, could result in more effective training that produces competent professional pilots for the industry. The university is continuing its work to refine simulation-based training that will efficiently (i.e., optimally uses resources) and effectively (i.e., readily transfers to the real world task) apply FTDs during ab initio pilot training.✈

**Nickolas D. "Dan" Macchiarella** holds a Ph.D. from Nova Southeastern University, School of Computer and Information Sciences. He is an associate professor at Embry-Riddle Aeronautical University, Daytona Beach campus. He is also a principal investigator at the university's Advanced Flight Simulation Center. His research work includes virtual environment technologies and flight simulation applications to meet the needs of commercial, government, and general aviation. Dan's research interests include transfer of training; simulation system design, development, and evaluation; human computer interaction; and instructional systems design. He has presented at numerous conferences and has over 30 publications. Dan is an experienced fixed and rotary wing pilot with commercial pilot certification and instrument ratings.

**Christian Meigs** holds Master's degrees in Aeronautical Science and Human Factors from Embry-Riddle Aeronautical University. She is an assistant professor in the aeronautical science department at Embry-Riddle Aeronautical University's Daytona Beach campus. Prior to her employment at ERAU, she was captain at Continental Express flying the EMB-145. She was recently published in the Aerospace Medical Journal for her research on *Methodological and Postintoxication Hangover Effects of Alcohol on Commercial Airline Pilots.*

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