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Development of Training Scenarios in the Flight Training Device for Flight Courses at Embry-Riddle Aeronautical University

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Introduction

Ways to improve and enhance pilot training has always been a goal of the Federal Aviation Administration (FAA) and flight schools in the United States. One of the more recent initiatives launched by the FAA was the FAA/Industry Training Standards (FITS) Program. This program was initiated in order to create "scenario-based, learner-focused training materials that encourage practical application of knowledge and skills" (Federal Aviation Administration [FAA], 2006, para. 1). Scenario Based Training (SBT) uses real-world scripted scenarios to replicate situations that would force student pilots to make timely decisions and exercise effective aeronautical decision-making (ADM) skills (FAA, 2006).

Background

Embry-Riddle Aeronautical University's (ERAU) Daytona Beach Campus operates a certificated flight school under 14 Code of Federal Regulations (CFR) Part 141. Each flight course offered by the school has an FAA approved training curriculum. Additionally, ERAU employs the use of Frasca Level 6 Flight Training Devices (FTD) qualified under 14 CFR Part 60 for each of the flight courses. The flight courses consist of three different types of lessons: oral training, a FTD, and a flight.

SBT modules teaching cross-country flight operations were added to two FTD units in each of the private pilot, instrument rating, commercial pilot, and multi-engine additional rating courses. Flight instructors were tasked with creating their own scenarios to meet the objective of the lesson and allowing the flight students to achieve the lesson's completion standards.

Scenarios vary between flight instructors and while each student will meet the completion standards by the end of the lesson, the individual students do not receive the same training. Non-standardization during training can lead to gaps in learning which has the potential to affect the student later in the flight course. To ensure each student received the same level of training, a standard set of scenarios were developed. These scenarios consisted of a written outline and script for the instructor to follow as the student performed a cross-country flight in the FTD (M. Avellino, personal communication, May 20, 2014).

Each FTD is equipped with software that allows a programmable lesson plan to be created and replayed for each student. The lesson plan allows for voice recognition from the student, "real" radio calls and background chatter, automatic dependent surveillance – broadcast (ADS-B), and visual traffic displays. Instead of a linear scenario, the software allows each scenario to have a tree-like structure with multiple outcomes possible. While the student is flying, they will be presented with a situation that will force them to make a decision. The software will allow the instructor to select the appropriate segment of the scenario and enable the student to experience the result of that decision. Multiple branches and decisions can be made, if needed, for the duration of the simulation. This form of decision-based scenario training was created with the goal of training the flight students to the application or correlation level of learning. A team of flight instructors and support staff was tasked with using this software and their experience to create a more realistic and immersive flight training experience.

Literature Review

A review of the existing literature reveals a significant body of knowledge with respect to the fields of SBT and aeronautical decision making (ADM). A thorough examination of the current research in each of these areas will serve as an excellent foundation upon which to build the authors' approach to design, develop, and field decision-tree based training scenarios within the operational construct of a flight simulator environment.

Scenario Based Training

The FAA's Aviation Instructor's Handbook provides insightful information regarding the incorporation of SBT with ADM through the use of decision-based learning objectives (FAA, 2008). The FAA defines SBT as a "training method that uses a highly structured script of real world experiences to address training objectives in an operational environment" (2008, pp. 6-9). The SBT methodology involves the development of realistic scenarios that allow student pilots to practice the skills that they have learned (FAA, 2008, pp. 2-26). Furthermore, the FAA stipulates that a "good scenario" is characterized by a clear set of objectives, which are tailored to meet the needs of the student, and capitalize on the nuances of the local environment (2008, pp. 2-26). In an aviation learning environment, decision-based objectives are specifically intended "to develop pilot judgment and ADM skills" by facilitating a higher level of learning and application (FAA, 2008, pp. 4-7). Incorporating decision-based objectives into a SBT environment teaches the student pilot how to gather information and make informed, timely decisions in accordance with the principles of ADM (FAA, 2008, pp. 4-7).

As part of the FITS program, ERAU conducted a study in 2005 to compare the traditional maneuver based training (MBT) method to SBT method of teaching. Twenty-seven instrument-rated pilots were divided into two groups to learn how to fly a Technically Advanced Aircraft (TAA). In this case, the TAA was a glass cockpit aircraft simulator replicating a Cirrus SR20. Each pilot was given eight hours of instrument training in the TAA either using MBT or SBT. After the training, the "two instrument flight instruction methods were assessed using subjective questionnaires regarding workload, situational awareness, self-efficacy, and decision-making skills, as well as expert evaluation of instrument piloting and navigation performance in a controlled double blind statistical paradigm" (French, Blickensderfer, Ayers, & Connolly, 2005, p.

3). The final test consisted of the pilot flying a cross-country flight in instrument conditions in the TAA simulator. The pilots were graded over the course of the simulation on eight phases of the flight: flight planning, pre-flight preparation, pre-take-off, take-off and departure, re-route, en-route, approach, and missed approach. The results indicated that pilots who learned from SBT always obtained a score equal to or higher than those who learned with MBT. Additionally, pilots trained in the SBT method also reported having a reduced workload and better situational awareness compared to the MBT trained pilots (French et al., 2005).

Aeronautical Decision Making

Developing sound ADM skills in student pilots is a key objective of the decision-tree based training scenario development. Therefore, it is important to establish a foundational definition of ADM based upon the existing research. This will ensure that the training created will not only be effective, but maximize the benefit to the students.

The FAA published Advisory Circular (AC) 60-22, "Aeronautical Decision Making", in 1991 to provide a "systematic approach to risk assessment and stress management in aviation", to illustrate the influence of personal attitudes on decision-making, and demonstrate the ways in which those attitudes can be modified to enhance cockpit safety (1991, p. i). ADM builds upon a conventional decision making approach through a six-step process that entails:

1. Identifying personal attitudes that are hazardous to safe flight.
2. Learning behavior modification techniques.
3. Learning how to recognize and cope with stress.
4. Developing risk assessment skills.
5. Using all resources in a multicrew situation.
6. Evaluating the effectiveness of one's ADM skills (FAA, 1991, p. 1).

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In addition, AC 60-22 provides aviators with the DECIDE model to assist in making good aeronautical decisions (FAA, 1991). Each letter of the acronym DECIDE represents a distinct step in a continuous loop decision process: Detect that change has occurred; Estimate a need to counter the change; Choose a desirable outcome; Identify actions to control the change; Do (take) the necessary action; and Evaluate the effect of the action upon the change (1991, p. 21).

A variety of models, consisting of both classical approaches and naturalistic theories, have been developed over the years in order to improve ADM instructional techniques. Classical decision making methods include the conventional FAA model, as prescribed in AC 60-22, Jensen's judgment model, "drawing a box" model, setting decision points model, and the Aircraft Owners and Pilots Association (AOPA) model (Jensen, 1997; Wright, 2004; Peterson, 2006). Naturalistic theories include the situation assessment and course of action (COA) model, the ADM expertise model, and the cognitive sensing, organizing, analyzing, and responding (SOAR) model.

Jensen's judgment model is based upon the assumption that good decision making is predicated upon good judgment and decision-making skills which can be taught (1997, p. 262). In addition, expert decision-making consists of five components: 1) experience, 2) risk management, 3) dynamic problem solving, 4) crew resource management, and 5) attention control (Jensen, 1997, p. 262). Experience is impacted by training, flight hours, variety, and recent flight type (Jensen, 1997, p. 263). Risk management involves the pilot's awareness of flight risks, as well as the ability to assess and prioritize these risks with respect to their impact on the overall safety of each flight (Jensen, 1997, p. 264). Dynamic problem solving refers to a pilot's ability to make appropriate decisions in the face of changing flight conditions (Jensen, 1997, p. 264). Crew resource management (CRM) is defined as "the effective management of all resources available to operators", and focuses on the application of ADM to multi-person flight crews (Jensen, 1997, p. 265). Finally, attention control involves a pilot's ability to focus on the task at hand as well as to shift his or her focus when priorities change (Jensen, 1997, p. 265).

Wright's "drawing a box" model involves a teaching methodology in which a student pilot sets boundaries with respect to their own capabilities, and then operates safely within those constraints (Wright, 2004). The three-step ADM process is as follows. The first step includes having insight into one's own limitations, then evaluating a given situation in terms of individual skills. Second, the pilot will set limitations as appropriate. Finally, the pilot will operate within the boundaries that have been set (Wright, 2004).

The "setting decision points" model is based upon the premise that most aviation mishaps caused by pilot error frequently originate with a poor decision at some point during the flight where the following sequence of events will take place and lead to the mishap (Belanger, 2001). According to Belanger, five factors contribute to poor decision making: 1) hazardous attitudes, 2) random risks, 3) information availability, 4) the setting, and 5) decision points (2001).

Hazardous attitudes refer to personality traits such as "anti-authority, impulsive, invulnerable, and macho" (Belanger, 2001). Random risk consists of repeatedly engaging in dangerous behaviors and escaping unscathed, thereby reducing the perception of danger (Belanger, 2001). Information availability refers to the fact that a pilot must have just enough data to make sound decisions, but not so much as to overwhelm his or her capacity to function (Belanger, 2001). The setting, or environment, also plays a critical role in the pilot's ability make sound decisions (Belanger, 2001). Belanger discusses the existence of key timelines – or decision points – during which the pilot's actions are especially critical (2001).

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Put very simply, the AOPA model for ADM may be summarized as "doing the right thing, at the right time" (Peterson, 2006, p. 1). The AOPA decision-making process consists of three steps: anticipate, recognize, and act (Peterson, 2006, p. 3). Effective decision-making begins with anticipation: contemplating what could possibly go wrong prior to it actually happening (Peterson, 2006, p. 3). Recognition involves paying attention, and identifying a problem as soon as it becomes evident (Peterson, 2006, p. 3). Once a problem has been recognized, it is the pilot's duty to make a decision – based upon the type and seriousness of the problem, the rate at which the situation is deteriorating, and the availability of alternatives – and confront the issue with a solution (Peterson, 2006, p. 4).

The Situation Assessment and Course of Action model, developed by Orasanu and Fischer (as cited by Cassens, Young, Greenan, & Brown), consists of two primary phases: situation assessment and the selection of a course of action (CoA) (2011, p. 14). Situation assessment involves problem definition, risk assessment, and time available to solve the issue (Cassens et al., 2011). Selecting a course of action may be based upon rules, choice, or creativity (Cassens et al., 2011, p. 14). A rule-based selection offers only one choice to the pilot in accordance with established guidelines and expertise. A decision based upon choice offers multiple options in accordance with prevailing goals and constraints. Creativity comes into play when the pilot is presented with no suitable options, and must develop his or her own choices in response to a given situation (Cassens et al., 2011, p. 14).

The ADM expertise model approaches decision making with the intention, as the name suggests, of creating expert pilots (Kochan, Jensen, Chubb, & Hunter, 1997, p. 1). Based upon a belief that conventional approaches to ADM have reached their maximum potential, the authors set out to determine how expert pilots think based upon the assumption that expertise and skill level leads to better decisions (Kochan et al., 1997, p. 1).

It was determined that four factors contribute to the development of an expert pilot: 1) aviation experience, 2) risk management, 3) dynamic problem solving, and 4) attentional control (Kochan et al,. 1997, p. 27). Aviation experience is defined in terms of total flight hours, the variety of aircraft flown, the meaningfulness and relevance of the flights, and recent flight experience (Kochan et al., 1997, p. 26). Risk management requires an awareness of potential flight hazards and the likelihood of each hazard affecting a given flight scenario (Kochan et al., 1997, p. 26). Dynamic problem solving, also known as “satisficing”, is characterized by a “clear understanding of the situation and making decisions that have a good chance of leading to the optimum solution” (Kochan et al., 1997, p. 27). Attentional control involves developing an ability to focus on the task at hand in the cockpit to the virtual exclusion of everything else, but with the goal of retaining the capability to address other issues quickly as needed (Kochan et al., 1997, p. 27).

The cognitive SOAR model, developed by Adams (as cited in Cassens et al.), involves a four step process focused on preparation and execution (2011, p. 14). The first step addresses the pilot’s use of their senses to detect any changes in the environment (Cassens et al., 2011, p. 14). The next step, organizing, constitutes the “sorting, prioritizing, and structuring” of the information sensed in step one (Cassens et al., 2011, p. 14). Analyzing involves processing and evaluating the organized information (Cassens et al., 2011, p. 14). The final step, responding, consists of “taking an action to change or control the situation and evaluating its effectiveness using conceptual and procedural knowledge” (Adams, 1994, as cited by Cassens et al., 2011, p. 15).

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Scenario Design Process

A team was created by the chair of the Flight Department to develop training scenarios which consisted of:

- Team Lead: The Flight Media Coordinator (FMC) (also a flight instructor and co-author of this paper)
- 4 ERAU Line Instructors Pilots (IP)
- 1 Advanced Flight Simulation Center (AFSC) technician/engineer

The FMC led a meeting where the team was briefed on the primary purpose of the group, and subsequently directed the group to create scenario based training using the features of the Frasca FTDs. The FMC then briefed the team on the features of the FTD scenario software capabilities and limitations. The software only allows a linear lesson plan to be run. The software has minimal voice recognition capability and can play recorded audio files as voice communications from ATC on the correct frequency. The software also interfaces into the simulator settings as well as weather and aircraft systems settings as needed.

Scenario Development

The group planned to build two scenarios for the private, instrument, commercial, and multi-engine courses. The group also considered each course's specific set of items that must be completed to ensure lesson completion. To begin the scenario building process (Figure 1), a series of four brainstorming sessions were conducted to plan the basic outline of each of the scenarios required by ERAU's Part 141 approved training course outline (TCO). The IPs provided suggestions as to possible cross-country routes and what, if any, difficulties or mechanical failures could arise during the flight that would be appropriate to the specific flight course. After the brainstorming sessions were conducted, a final meeting was held to finalize the details of each scenario.

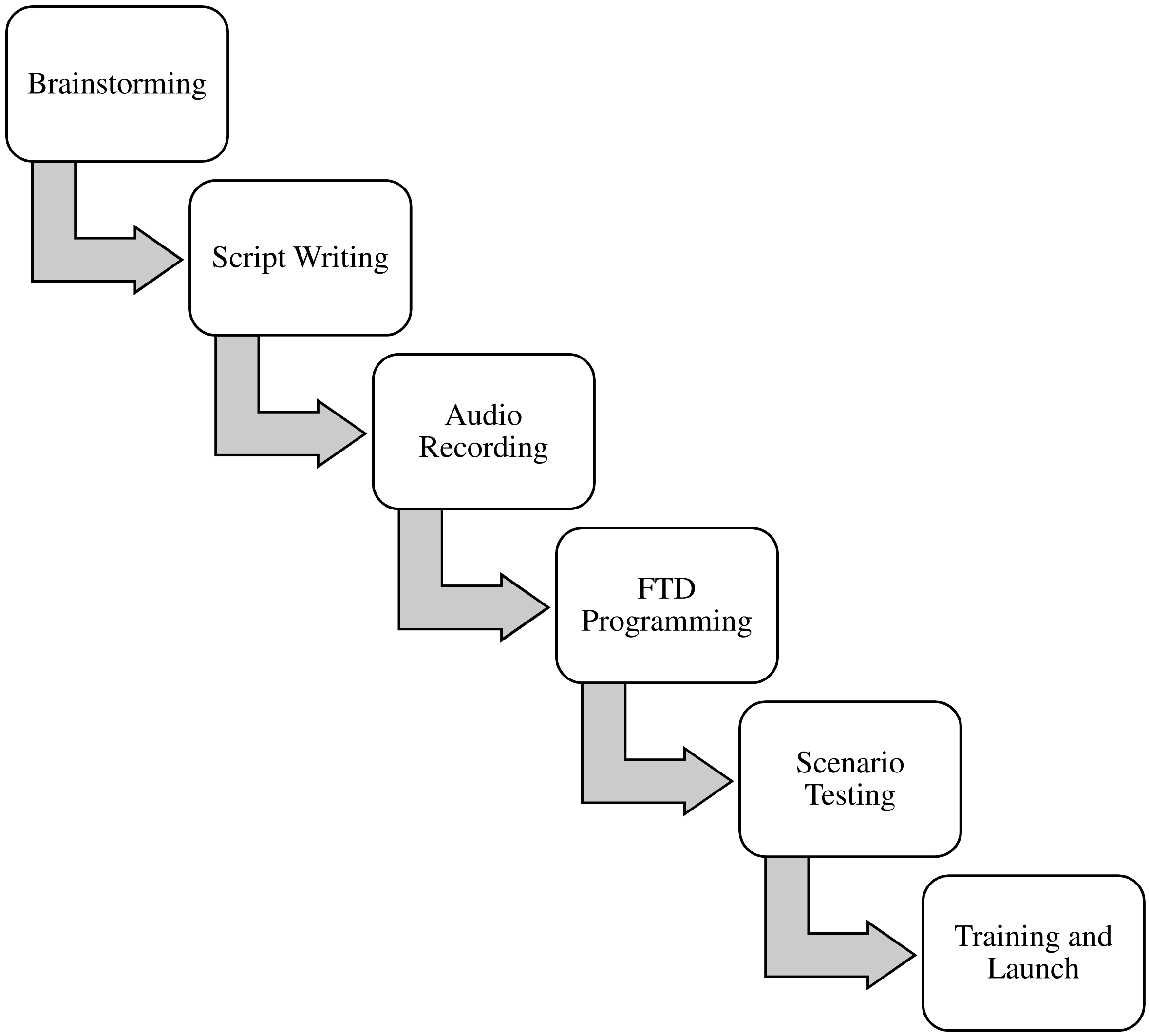

Figure 1. Scenario Design Process.

With the basic idea of each one of the scenarios completed, the FMC divided the IPs into two smaller groups of two. The two groups were assigned to build four scenarios each. The groups were required to have weekly check-ins with the FMC to report updates and any possible issues. For each scenario, the groups used a written script that contained the following:

1. Weather conditions for the flight.
2. An exact route of the flight, including airports to be used.
3. A full weather briefing to allow students to plan as if it were a real flight.
4. A complete script with ATC radio calls and realistic background traffic radio calls.
5. A list of location and voice recognition triggers and resulting actions.

Once the script was complete for each scenario, the group met with the FMC to review and make any changes as needed. After the changes were made, the final script was approved.

With an approved written script for each scenario, the project moved on to the programming and building phase. The parts of this step in the process required the recording of all ATC, radio communication, and scenario building in the lesson planning software on the FTD. Over several weeks, the FMC set up times to record volunteers reading the radio calls into a microphone. Each scenario required over 150 sound files and totaled over 1,200 sound files for the testing period. With the help of the AFSC staff, the sound files were placed on the FTD. The FMC also conducted a training session for all the IPs to teach them how to use the lesson planning software and to provide tips on how to test the scenarios.

During the programming process, edits were made to the FTD visual database. This included the creation of new airports in the FTD database and editing the location of some navigational aids. This information was given to the AFSC staff and the required changes were completed within a few days.

Several weeks later the scenarios were completed and ready to be tested. To test the scenarios, the two smaller IP groups swapped and flew each other's scenarios from start to finish. The IPs would then keep a detailed list of problems and provide it to the FMC after the test. This method proved to be effective in finding all the issues and problems that needed to be corrected.

The FMC then compiled all corrections into a master list and each group went back and made corrections to their respective scenarios.

Scenario Implementation and Instructor Training

Once all the scenarios were deemed 100% complete, the FMC created a training presentation on the usage of the scenarios and how they would fit into the TCOs. This initial training was provided to all the flight instructors at an IP meeting held during the beginning of the Fall 2013 semester. The presentations included a summary of all the scenarios as well as a demonstration on how to run the scenario in the FTD.

The chair of the Flight Department also emphasized that these scenarios were mandatory and must subsequently be used in flight courses. As new IPs are hired, they will receive the same training that was presented to all the IPs in their new-hire training course. The FMC also created a common file location where the IPs can review the training and details about each specific scenario prior to their scheduled student activities.

Improvement of the Scenarios

One year after implementation of the scenarios, the FMC created an anonymous survey which asked approximately 150 IPs to provide feedback on the scenarios. The results were overwhelmingly positive, with 90% giving a positive review (Thomas, 2014). The FMC was given permission from management to try and further improve the scenarios.

The FMC gathered two IPs from the original group as well as two new IPs and an AFSC flight simulation engineer to conduct another brainstorming session. New updates in the FTD software allowed the input of traffic on both the visual display and cockpit displays that match the background radio calls for added realism. In addition, the survey revealed that the existing scenarios were too linear and needed to be modified in order to allow for decisions to be made by the flight student and follow that path to see the results. This would effectively create a decision tree that would enable a student to make multiple decisions during the flight and to apply their critical thinking skills. The AFSC flight simulation engineer was tasked with creating a software interface that would interface with the FTD software and allow this to occur.

After two weeks, a working prototype was created, tested, and delivered to the design team. The newly created software interfaced with the existing FTD software and allowed the development team the ability to augment the existing scenarios. With this new capability in mind, the FMC divided the scenarios among the four IPs with the direction to review the scenarios, add two to four realistic decisions, and create the accompanying scripts. Following the process as completed before and after the new scripts were approved by the FMC, several actions had to occur:

1. New weather briefing packets were created.
2. New radio calls were recorded.
3. Programming of the new element for scenarios.
4. Programming of new traffic features.
5. New airports were created by the AFSC staff to meet the needs of the new elements of the scenarios.

After these steps were completed, testing began on all possible avenues for each scenario (Figure 2). Again, a different IP than the one who wrote and programmed the scenarios was used for testing. This entire process took considerably longer as each scenario had various outcomes and branches that each had to be thoroughly tested.

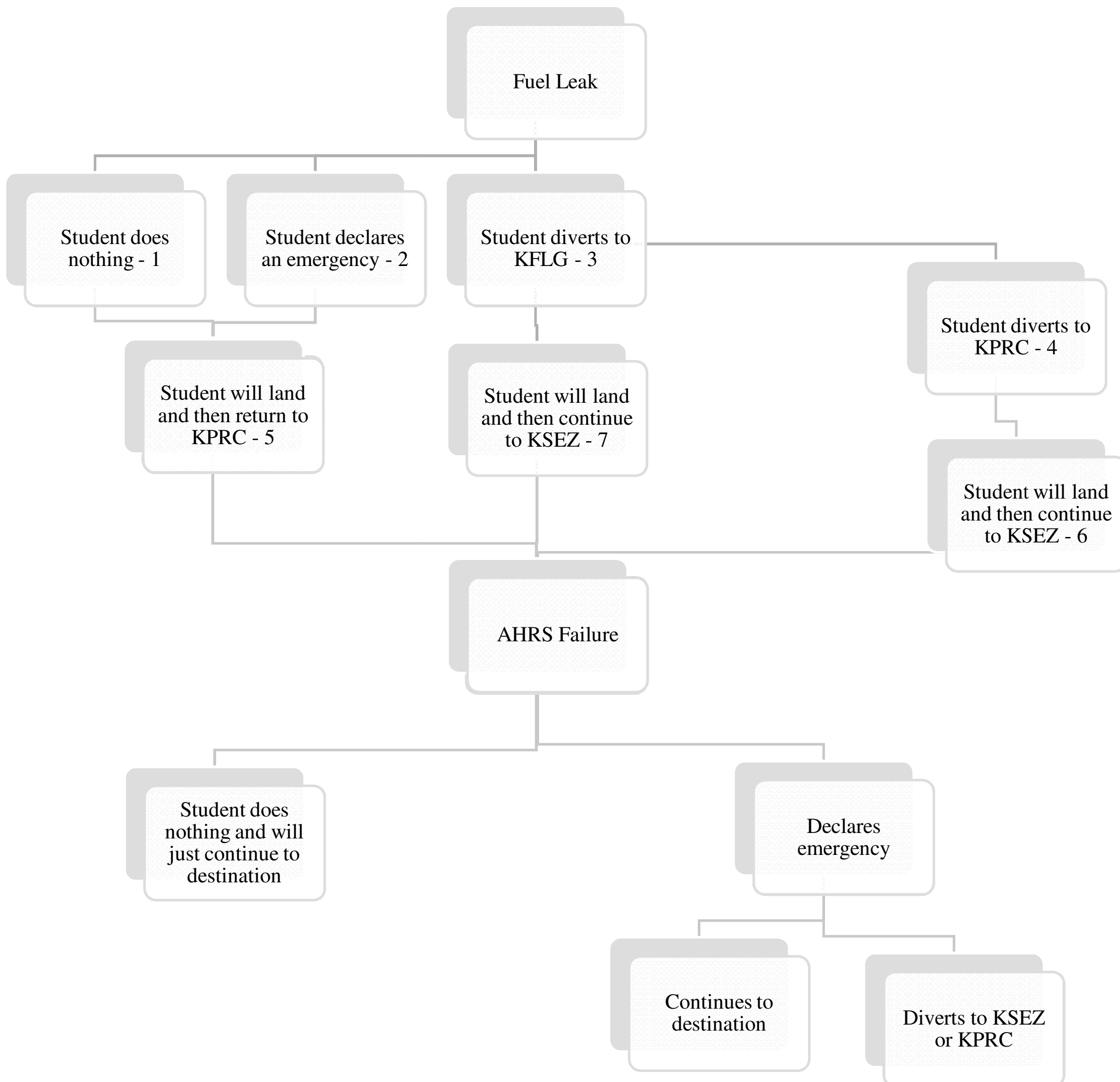

Figure 2. Example of the decision trees of the updated scenario.

The FMC updated the training materials and presented the results to all IPs at the annual IP meeting.

Continual Improvement

A feedback form was created in order to establish a formalized way of reporting problems or suggestions. This form is attached to the dispatch clipboard that is issued to every IP conducting training with a student in the FTD. This form asks for specific and detailed information about which scenario was running, when the problem occurred, and a brief narrative of what happened. The IP can then submit this form to the dispatcher, who will send it to the FMC. The FMC will review each of the forms, investigate the problem, and implement a fix to correct the problem. The FMC will also keep a log of all comments for future consideration. Each summer, the FMC will review the list of comments and see what, if any, changes will be made and what software development ideas for the future will arise.

Risk Management

During the first brainstorming session, an effort was made to identify any risks or challenges that may affect the scenario creation process. Some risks that were identified fit into the categories of technical risks, cost risks, and schedule risk.

Technical Risks. The FTD and its operating software are proven technologies which are certified by the FAA as a level 6 FTD. The software created by the AFSC engineer to allow decision trees to be an option also relied on this software and did not pose any risks to the system. The team also needed to learn the capabilities of the software to ensure that scripted scenarios could, in fact, occur on the FTDs.

Cost Risks. Since a scenario creation on this scale was never attempted before at ERAU, no specific budget was developed for the project. The FMC and those involved did their best to maximize their time in the FTD to keep costs down. The first phase of the project took close to 94 hours and consisted of development, programing, and testing. The second phase consisted of further development of the scenarios and required180 hours.

Schedule Risk. Schedule risk posed the biggest problem to the team. The goal was to have the scenarios tested and ready for use by the beginning of the fall semester of 2014. Students, who use the FTDs year-round, receive priority scheduling for the devices. To ensure minimal impact on the team, the timing of the process was aimed to allow scenarios to be programmed and tested over the summer semester (June and July) when FTD usage is low.

Scheduling of resources became a challenge due to the unexpected number of flight students enrolled at ERAU during the summer. The IPs had to work around student schedules, which usually meant working during early or late hours of the day when the FTDs were primarily in use. The scenarios were designed and ready for student use before the fall semester began.

Conclusion

Scenario based training is a proven and effective way to teach pilots. A disciplined and iterative approach to the scenario creation process included brainstorming sessions to facilitate the creation of flight scenarios with potential decision trees and script development to fill in the details. Next, the audio recordings of radio communications for each scenario and programming of the FTDs with scripts and potential decision trees were created. This was followed by scenario testing to identify and correct discrepancies, as well as highlighting training strengths. Finally, training and launch with actual instructors and students before the fall semester began. By using this process, ERAU was able to effectively create and update training scenarios in a timely manner and improve the training experience for all flight students.

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