Who Trains the Trainers? Towards a Flight Instructors Simulator based on Training Scenarios

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Abstract. Despite all the technological improvements that exist in the aeronautical sector, the majority of accidents are due to human factors. That is why in recent years, the International Civil Aviation Organization has been promoting a new training paradigm that integrates all kinds of skills in crew performance, both technical and non-technical. The training in each session is specific to the training needs of each pilot, all based on the data obtained in both real operations and training. This alternative paradigm is called Evidence-Based Training. In this training paradigm, pilots are subjected to situations specifically designed to test and improve their specific skills. The design of these scenarios is not trivial and is highly dependant on the ability of the flight instructor, who does usually not have much time to generate new and adapted material for each pilot. In this paper we propose the design of a Flight Instructors Simulator that could assist in the training and assessment of these professionals, assuming the mentioned terms.

Keywords: Aerospace Industry · Flight Simulator · Educational Software · Competencies · Assessment

1 Introduction

When we talk about simulators, the first ones that often come to mind are flight simulators. They have become an essential tool for the aerospace sector.

One of the reasons why simulators are so important is because they allow a safe environment in which pilots can develop and improve the skills necessary to operate the aircraft in the safest way possible at all times, minimizing the risk of putting the lives of others and their own in danger [10].

The objective of our simulator will not be the training of pilots, instead we will focus on the training of flight instructors in order to improve their teaching skills in such critical task. A simulation environment gives the instructor the possibility to test his/her own abilities when it comes to detecting errors of pilots in certain situations, as well as to practice the possible ways of giving feedback to optimize learning.

The role of the instructor in our simulator concept is creating training sessions oriented to improve the specific competence profile of the students to be trained, following the principles of Evidence-Based Training (EBT) philosophy. This training approach is promoted by the most important aeronautical institutions like the International Civil Aviation Organization[3] (ICAO) [7] and the International Air Transport Association[4] (IATA) [4,5]. EBT is essentially a competency-based approach. This type of learning paradigm has received enormous interest in many fields in recent decades, although its effective application has proven to be very complex, especially with regard to the role of the trainer/teacher [3].

The development of simulators for the training of flight instructors in EBT is an unexplored field today. The objective of this paper is to make a first approach to the problem in order to identify possible strengths and future challenges of this technology.

The rest of the paper is structured as follows. Section 2 reviews the types of flight simulators, the methodologies that guide the work of the instructors in training sessions and the justification of a simulation software to be trained in these tasks. Section 3 defines the competency model used in this work, analyzing how it is related to our methodology. Section 4 explains the role of each part of the work done. Section 5 explains how the proof of concept of our system has been tested on future users, presenting the results that we have obtained. And finally in Section 6, our conclusions, and the possibilities and limitations of this line of research are discussed.

2 Related Work

Simulators are virtual learning environments that allow the acquisition, application and practice of knowledge and skills necessary for the performance of a certain job. The use of this technology allows improving the learning curve while offering a safe environment while reducing costs at the same time [16]. In the aerospace field there is an enormous background in the use of simulators for training. The first simulators date back to 1910 [1]. One of these early trainers, the so-called *apprentice barrel*, consisted of a barrel split in half resting on a flat surface on which a seat was mounted. The instructors manually moved the barrel to represent the pitch and roll of the plane. Today, we could hardly relate this artifact to a simulator due to the high technological load of current flight simulators.

It was not until the 1940's that flight simulators that used computers able to solve flight mechanics equations appear. Following this line, in 1948 *Curtiss-*

[3] https://www.icao.int

[4] https://www.iata.org

Wright developed the first flight simulator that was used by an airline [12]. From here, different elements were added to improve the experience until in 1954 the first modern flight simulators for commercial aviation were developed, incorporating motion [13].

Flight simulators would continue to evolve, reaching our days, where they have high graphic quality and the ability to recreate aircraft and environment issues with great fidelity. Simulators could be differentiated today based on their motivation:

- **For professional use**: Its objective is the training of pilots, allowing them to acquire and improve both knowledge and skills. This type of simulator must be approved by the responsible organizations such as the Federal Aviation Administration (FAA), the European Union Aviation Safety Agency (EASA) or the Civil Aviation Authorities of the different countries.
- **For recreational use**: Its objective is the entertainment of the user and although it can get the user to acquire a series of knowledge, in no case is their motivation to train the user to become a pilot. In some cases, as in the case of the X-Plane videogame, organizations such as the FAA give the possibility of being approved for professional training when used with specific hardware. Nowadays, the possibilities offered by web mapping services and cloud computing for rendering have raised the visual fidelity of this software to the highest level. The most recent example of this is *Microsoft Flight Simulator 2020* [8].

However, the suitability of a flight simulator training session is not limited to the ability to accurately represent the stimuli (visual, auditory, kinesthetic and tactile) of the environment, but it is also necessary to pay attention to cognitive fidelity. With current technology, practically any situation that may arise in flight can be simulated, but the way in which events occur must conform to consistency criteria. Otherwise, the proposed training scenario would not be credible and could spoil the usefulness of the session, regardless of the technical sophistication of the simulator [11].

The approach based on exposing the trainee to situations suitable to improve their skills is called Scenario-Based Training (SBT). Balance between repetitive and unexpected settings are of great importance, as some skills are not always used during normal work, but are useful in emergency situations. Although the case at hand is that of flight simulators, SBT has also successfully used in the medical [15] and military fields [14].

The complexity involved in designing suitable scenarios is very high. The number of highly qualified personnel to carry out these tasks has been a limiting factor in the number of suitable scenarios available in the airlines, hence the reuse of them has been a common practice [2].

However, the competency-based EBT approach currently promoted by the aeronautical authorities requires not only having well-designed scenarios, but that these be adapted to the competency profile of the pilot to be trained, according to the information available by the airline. Knowing what conditions and events have to be combined during the session, their temporal distribution, as well as what behaviors of the pilots are to be expected, how they should be evaluated and, most importantly, what feedback should be given to optimize learning, require from the instructor a very complete training [6]. The need for computer tools that provide support in this regard has already been identified in the specialized literature [2].

Although the use of simulators for pilot training has a very extensive background, there are no precedents for similar tools for the training and assessment of instructors. While there have been tools for the design of scenarios, their suitability as well as the skill in their application were always evaluated with real pilots [9].

Therefore, instructors' performance on the simulator continues to be directly monitored by another evaluator. In this way, the instructor is assessed while performing the work in the simulator with pilots in a real simulator session. This work aims to explore the suitability of a simulator concept that trains the instructor himself, so that he/she can develop the skills necessary for his performance before performing real training sessions.

3 Competency Model

The tool presented is a flight instructor simulator and the idea is to recreate the work that the instructor requires. We focus on the EBT approach and use the competencies identified as relevant to a pilot by IATA in their guide [4], so that the simulator's recommendations will be based on the pilot's competency set listed below:

- **Application Procedures (APK)**: Identify and apply procedures in accordance with published operating instructions and applicable regulations using directed knowledge.
- **Communication (COM)**: Demonstrates effective oral, non-verbal, and written communications under normal and non-normal conditions.
- **Aircraft Flight Path Management, Automation (FPA)**: Control the aircraft's flight path through automation including the use of flight management systems and guidance.
- **Aircraft Flight Path Management, Manual Control (FPM)**: Control the aircraft flight path through the flight manual, including the use of flight management systems and systems flight guide.
- **Leadership and Teamwork (LTW)**: Demonstrates effective leadership and teamwork.
- **Problem Solving and Decision Making (PSD)**: Accurately identify risks and solve problems. Use the right decision-making processes.
- **Situation Awareness (SAW)**: Perceives and understands all relevant information available and anticipates what could happen that may affect the operation.
- **Workload Management (WLM)**: Manage available resources efficiently to prioritize and perform tasks in a timely manner in all circumstances.

Taking these competences into account, the choices the instructor will have to make will focus on the competencies in which the virtual pilot has the most weaknesses.

It is important to highlight that the elements chosen to make the scenarios (such as emergencies, meteorological phenomena, operational conditions in which the latter take place, etc.) as well as the way in which they are combined are associated with the development of certain competencies. One of the main objectives of this simulator is that the user ends up learning how to combine these elements to work on the skills to be developed based on the specific profile of the pilot. Therefore, the simulator must have a knowledge base that associates the architecture of the scenarios and the competences they develop.

As will be seen in the next section, the player (the instructor to be trained by means of this simulator) will have the possibility at low levels of difficulty to have guidance about the events and conditions to choose from. However, at the high level of difficulty this guide is missed, and the instructor must demonstrate how to correctly choose all those elements.

4 Flight Instructors Simulator

The different phases that the player has to go through to complete a session are listed below:

- **Selection of a pilot**. In this part, a list will be shown with all the possible pilots where we can see the full name, an image and a reference of the difficulty of teaching said pilot. The difficulty will depend on the competences that the pilot has weak grades, with the exception of a 3-star difficulty that will mean that the instructor will not receive any type of recommendation.
- **Selection or creation of a scenario**. The instructor will be given the option to select from a set of scenarios or create a scenario from scratch. In case of choosing a preconstructed scenario the instructor will be able to modify the events belonging to the scenario making it more suitable for the pilot. If on the other hand the instructor what he does is build it from scratch, he will simply choose in each flight phase the event that best suits the pilot's needs.
- **Selection of trigger events**. They are a series of events that the instructor can select and that can be launched at will during the pilot evaluation at any flight phase (*Ground*, *Take-Off*, *Climb*, *Cruise*, *Descent*, *Approach*, *Landing*, and *Ground* again).
- **Evaluation of the pilot**. A "simulation" will be shown, which in our case is a static image of both the exterior and the cockpit of the aircraft representative of the event that would be running. The atmospheric and aircraft information will also be displayed. On the other hand, the instructor will be able to launch the different trigger events that he has previously selected, as long as he activates the phase to which they belong, as it can be seen in Figure 1. Once the phases are completed, the instructor must evaluate the

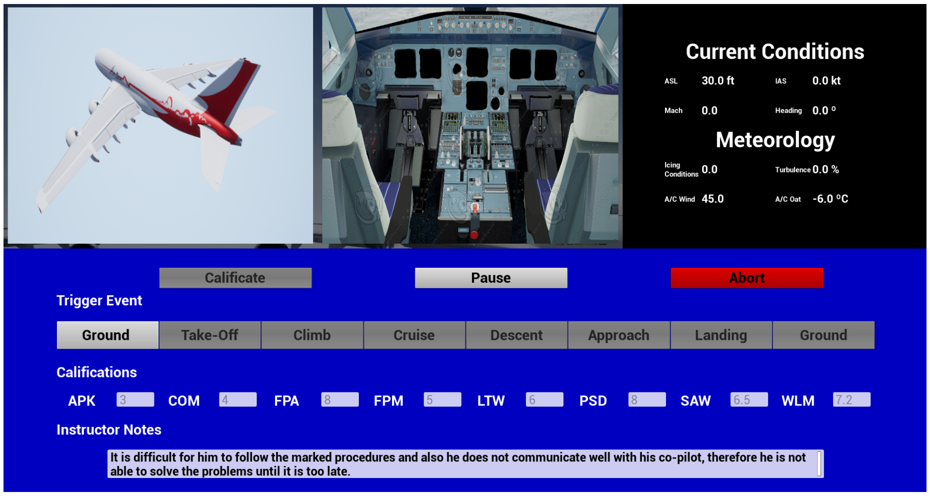

Fig. 1. Screenshot of the trainer evaluating a pilot in our prototype.

pilot in the different competitions and, possibly, making observations about his/her performance.

– **Final report**. This phase is in which the instructor himself is evaluated based on the choices made regarding the events on the stage in relation to the needs of the pilot. If the choices were those recommended by the simulator, you will be evaluated correctly and you will be evaluated erroneously if they are not recommended.

5 Proof of Concept

As a previous step before testing the simulator in person, a video was produced that served as a "proof of concept" showing the functionality of each part of the simulator. In this way the different specialists, although they could not use it, could get an idea of how it was used and the image was shown.

Once the video was made, it was shown to 13 different specialists within the aerospace field (pilots, flight instructors and members of different organizations within the Peruvian Air Force). After the video, a form was presented that they had to fill out. Among the questions we could distinguish three blocks:

First, to demonstrate that they are specialists related to the aerospace sector. Second, aimed at learning their opinions about the education received by both pilots and instructors. And the third one, destined to know the opinions about the simulator shown in the video and that they would improve or add.

Taking this into account, we will focus on the answers regarding the simulator that are the ones that interest us to evaluate its usefulness.

The specialists' responses (more than 90%) indicated that they understood the concept we were presenting with this flight instructor simulator.

Regarding the information from the pilot, a high percentage (more than 69%) of the responses indicated that the information displayed was sufficient. But when indicating what information they believed would be appropriate to add, two results were repeated among the responses, one was the pilot's flight hours and the other referred to the psychological profile of the pilots.

The responses regarding the information shown both in the scenarios and in the events were very similar, they agreed that the information was sufficient (more than 90%), but indicated that more detailed meteorological information than what we already gave would be recommended, and they also believe that it would be necessary to include information on air traffic.

Regarding the evaluation screen, they indicated that it was a screen that was understood (more than 90%), but that it would be necessary for a simulation to be shown instead of a static image of the event.

They agreed with the statement about clarity and ease when navigating between the different menus (100%).

And regarding errors, they indicated that the information they mentioned in previous questions would have to be added and also that both the way of qualifying and the ways of presenting the information would have to be adapted to those used by companies in the sector.

6 Conclusions

Considering the answers of the experts after watching the proof of concept video, it seems clear that the proposed work is considered novel, relevant and interesting for the field. However, this work is only a first approximation, and the feedback given by the experts will be an unvaluable resource for future developments.

According to the answers given, future steps should be directed mainly in two lines of work. First, the enrichment of the mission information available to create the scenarios, which should be used as an enriched input for an automatic scenario generator. Second, the representation of the possible reactions of the pilots by means of intelligent agents than can express both correct and wrong behaviors in a pedagogical proportion.

In both cases, the use of a knowledge base based on real simulation and operation data would be essential, such as the database at FAA's Aviation Safety Reporting System, so that the simulation of the virtual pilots would be as coherent and realistic as possible.

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