DIGITALIZING PILOT'S TRAINING ON SAFETY PROCEDURES OR HOW TO DEAL WITH ABNORMAL SITUATIONS

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Abstract: *Flight safety is an extremely important parameter in pilots' training. Every pilot must know the aircraft, its limits, and how he/she will effectively deal with any in-flight contingencies. To this end, flight training includes real flight hours (whether with a flight instructor or solo flights), simulator hours, targeted presentations, and discussions of case studies. In the abovementioned training methods, the flight instructor must be with the trainee at a specific place and for a specific time, which sets practical restrictions. For example, the weather may not always allow for a flight, the simulation of critical situations or mechanical/engine failures during flight may present serious risks, the flight simulator may be off for certain periods for maintenance purposes and the flight instructor may not be constantly available to the trainee. In our paper, we will examine the use of virtual tools for the pilots' training on flight safety procedures and the relevant regulations of the aircraft.*

Keywords: *flight safety, electronic simulation, digitalization, distance education, T-6, escape room, educational game, experiential training*

1. INTRODUCTION

Educating cadets on emergency procedures and flight safety [1] [2] is deemed a very important parameter of flight training during all flight training stages [3]. Whether someone has just entered the Academy and is going for his/her first flight, or he/she is a third-year student with some prior flight training, the importance of following the protocols during any emergency is always and repetitively pointed out. Flight officers apart from enhancing the theoretical background with real flight hours, i.e. time spent in the sky on an aircraft, make use of the flight simulators [4] [5] that are available at the Air Training Wings. About the flight simulators and their VR training goals and procedures, there is an existing bibliography that discusses the pros and cons of their use; there are different types of flight simulators [6] to cover a variety of training needs [7] [8] and their use is deemed an invaluable training asset [9]. But there is a catch to this: cadets can only use the flight simulator when a flight officer is with them [10]; if they want to practice alone, they just cannot do it. Also, suppose they want to test their knowledge, ability, and preparedness to deal with a variety of critical cases and even rare real-life scenarios with different levels of difficulty, they cannot do it, unless they are on base with their supervisor. Given the limitations posed by using a single flight simulator for many trainees, each trainee has limited access to the simulator, especially during the winter months, when actual flights are limited because of the bad weather.

It is also true that due to technical inspections and maintenance of the flight simulator, but also due to other unforeseen situations, as well as personnel leaves, the flight simulator on the base is not always available.

Therefore, we tried to figure out a way, so that cadets can get a virtual, but close-to-real and meaningful flight experience without the need of being supervised by a flight officer. Our proposed digital solution is more economical since our platform needs no spare parts, machine maintenance, which can include regularly scheduled service, routine checks, and both scheduled and emergency repairs, and of course technicians' wages, all of which cost money and time. That said, the focus of our paper is to present the development of the virtual tools developed by Hellenic Air Force Academy for pilots' training [11] in in-flight safety procedures; the idea of using such tools, for training purposes, [12] is an entirely different educational approach. To the best of our knowledge, there is no other entirely digital, educational platform that supports and enhances remotely pilots' education on safety procedures and decision-making for dealing with incidents during flight.

2. VIRTUAL TOOLS DEVELOPED IN HAFA

When we come to think about how to effectively prepare flight trainees involved in potential crisis management in mid-air, the first thing that strikes our minds is to extensively train and educate them well and in-depth, so those who could find themselves in critical situations be able to understand and describe what is happening, and also to make decision or act or both. Therefore, given the differences between theoretical education and realist training, the second point needs to be effectively addressed. One thing is certain: we need to prepare flight trainees before the crisis comes around. We need to start discussing the safety issues early, which is something that usually happens on the theoretical level during the first semester of study at the air force academies. However, is the theoretical approach considered a successful means of training on safety procedures? Not, trainees need to study the theoretical background, but they also need to practice decision-making and taking action when there is no time to lose. Therefore, we need to provide flight trainees both with the theoretical background and hands-on training, if we want them to be able to effectively deal with emergencies. Given the aforementioned and the educational scope of our Academy, to evaluate cadets' knowledge of flight safety and emergency procedures, we thought it is extremely important to plan, design, and develop two interactive virtual tools a) a virtual reality (VR) escape room for training pilots on emergency procedures and b) a digital platform for training pilots against air disasters. These tools are designed to be used by the trainees remotely and working on a merely digital form, to provide them with a virtual, real-time experience in dealing with critical situations related to flight safety. The idea is that they will thus have the opportunity to exercise their theoretical knowledge and realize by themselves the difficulties of handling difficult situations in mid-air. Also, they will be able to feel and understand what it means to consider different options and think about their actions in risky situations when there is no time to lose.

2.1 Virtual Reality Escape Room for training pilots on emergency procedures

2.1.1 Methodology

In this paragraph, the methodology followed for developing the virtual reality escape room for training pilots on emergency procedures is presented. The first part of our research was carried out in two stages: (a) we studied the flight manual, the boldface

procedures, and the operating limitations of T-6A aircraft to write down the procedures set out to be followed in key incident categories (aircraft evacuation, regain control and landing) and (b) we selected the categories of incidents/emergencies to be used as part of our virtual escape room [electronic and mechanical malfunctions, multiple malfunctions (electronic and/or mechanical) immediately after take-off, during cruise and landing]; we also decided how to set up the difficulty level for each incident or emergency scenario and the time, which would be available to the pilots, to solve the case.

Subsequently, we constructed the scenarios that pilots would be asked to solve; for this part of our research, we mainly teamed up as an interdisciplinary research group and got help to test our ideas from focus groups, which consisted of pilots with different levels of experience. To evaluate our scenarios, we did run various tests too: (a) in the cockpit of the aircraft, (b) in the cockpit of the flight simulator, c) on a recreational digital flight simulator that was not intended for educational use, so, we could only test a limited part of our emergencies, and (d) in the form of time-tested scripts to compare methods for efficiency learning the safety procedures and the relevant regulations of the aircraft. To fully test our emergencies and their narratives, we also developed and used questionnaires, as well as holding interviews with both trainees (i.e., the players and our targeted population) and trainers to evaluate the realism of our scenarios. The last stage of our research work was the development of the actual virtual escape room. Given the novelty of our educational approach (training pilots for emergency procedures not in a flight simulator, but through a completely digital educational escape room accessed remotely on and off base).

2.1.2 About the Virtual Reality Escape Room

The four scenarios (emergencies) that a trainee has to deal with are a) generator Loss, b) smoke in the cockpit, c) engine stall/failure, and d) low hydraulic pressure and uncommanded propeller feather. The purpose of these scenarios is to evaluate the trainee's knowledge of flight safety regulations, as well as the safety regulations of the aircraft, to understand the parameters and in-flight critical situations, and train future pilots in a variety of situations of graduated difficulty with time constraints. The gameplay starts by displaying some cockpit readings to the trainee. The trainee has then to identify the problem and put hierarchically his/hers forthcoming actions. Then the order of these actions will be analyzed and examined for their correctness by the game. The trainee is evaluated by his/hers actions regarding the a) maintenance of the basic control of the aircraft, b) knowledge of boldface procedures, c) use of the checklist, d) use of the in-flight guide, and d) reporting the incident correctly. In the final part of the game, the trainee has to answer multiple-choice questions (checklist, boldface, in-flight guide, etc.) and his/hers final score is calculated and received as well as it is sent to the trainer

2.1.3 Evaluation

As far as the evaluation of the level of realism and difficulty of each scenario, the comments we received for our scenarios were overall positive (89%) because the problems posed demand both knowledge of the safety regulations and the aircraft's T-6A manual, as well as critical thinking to be solved. Flight officers expressed the view that "trainees, to deal with an emergency, must be able to think and combine different parameters, such as manoeuvre, configuration, mechanical failures, weather"; our parameters and narratives made scenarios realist enough to be part of flight training (82%). Also, the different parameters and their part in each scenario were deemed as rather important (92%). The level of difficulty made each scenario to be "appropriate for

different phases of flight training" and the gradation of difficulty was deemed appropriate and well estimated (78%).

Flight officers were also positive (84%) about the educational aspect of each scenario. When asked whether our scenarios are good enough to be part of flight safety training, they replied that "each scenario is educationally interesting, and it has a real story for the trainees to solve" (tested positive for 88% of the targeted population). Our scenarios serve their educational purpose (92%) because they deal with several cases related to different phases of flight, therefore cadets can understand that emergencies of any type can come up at any time.

2.2 Digital platform for training pilots against air disasters

2.2.1 Methodology

The developed platform, which is based on the serious game approach, is comprised of real-life unfortunate air disaster incidences caused by severe structural failures. The purpose of this digital platform is to deliver an innovative educational approach to teach and discuss why structural failures, in aircraft, happen and how they may lead to air disasters. It is also discussed what pilots can do to prevent air disasters and how to recover the aircraft from a dangerous situation. The developed approach combines academic elements and flight training, implemented in a serious game, allowing the trainees to visualize how the forces exerted on the aircraft at critical events or in critical phases of the flight (e.g., during take-off or landing).

Initially, a questionnaire is constructed, to identify the topics, of the subject of "Aircraft Structures", that trainees have difficulties understanding. Through this procedure, it is found that structural failures occurred due to a) material corrosion, b) Damage Tolerance Design, c) aircraft maintenance and d) fatigue failure are of major interest for this purpose. Consequently, four (4) incidences are carefully selected from a long list of accidents by examining the relevance of the type of structural failure that occurred, with the outline of the subject of Aircraft Structures and of course the topics that trainees must cover.

2.2.2 Platform Description

The platform will be fully introduced in the Aircraft Structures course to assist trainees to visualize the forces exerted on the aircraft in a selected scenario and analyzing the risks that may be posed for the flight. The demo version is currently tested and evaluated as educationally fit-for-purpose. The platform contains the following features a) folders for each scenario (type of failure), b) details, photos, animation/documentaries for each incidence, and c) interactive forms for analyzing the behavior of the aircraft after the failure occurred considering the forces exerted and educating materials for role-playing (pilot, investigator, design/structural engineer), d) the official releases of the investigations of each accident, e) a digital crash site museum that contains photos from the crash sites and the damaged parts of the aircraft, f) a digital library that contains a bibliography relevant to the structural failures discussed in each case and their effect on the flight and g) finally, quizzes true or false, and multiple-choice questions, for self-evaluation, are also included in the platform.

2.2.3 Evaluation

The demo version is tested and evaluated as educationally fit-for-purpose however, the platform is currently under development. The basic feature, among other, that we are working on for improving the trainee's experience is the educating material, the visual material, the available options as answers to certain questions, the digital environment, and the completeness of the accompanying material for all scenarios, etc.

3. CONCLUSIONS

The benefits of our proposed virtual tools will help Flight Officers and Professors to provide their trainees with well-rounded training. They can still use traditional techniques to provide effective training (briefing/debriefing, analysis of flight emergencies, role-playing, etc.) as far as the theoretical background is concerned, but they will also be able to use our virtual tools: a) to test the theoretical knowledge their trainees have, b) to check how stress and time limitations affect how knowledge is applied in practice and c) to provide their trainees with virtual hands-on training, and, the most complete possible education, in terms of theory and practice. Trainees will also get the best possible training, in terms of both theory and practice. They will also be able to test themselves individually, whenever they feel like using our VR tools on their personal computer (PC) or smartphone. Trainees' evaluation will be based on their choices, decisions, and actions within the simulated emergency. At the end of the game, trainees will be presented with the list of options they made and how they rated against the different flight parameters that determined their payoff. Finally, our virtual tools can also be used for evaluation purposes either by Flight Officers or Academic Professors.

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