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## **FLIGHT SIMULATION DEVICES IN PILOT AIR TRAINING**

**Summary.** This article deals with issues related to the use of flight simulation devices in pilot training. It also discusses the regulations included in the legislation defining the scope of simulator use in flight training processes for particular aviation ratings. In addition, the methods for using flight simulation devices in pilot training and practical training processes are presented, taking into consideration civil and military aviation applications.

**Keywords:** flight simulation devices, flight simulator, instrument training device, training device

### **1. INTRODUCTION**

Training devices used in air training can perform many functions. Depending on their ability to simulate flight conditions, they may be used in screening candidates and, most of all, during various stages of pilot instruction and training. The type of training device used will be dependent on the type of flight elements to be trained on. It will also be dependent on aviation regulations that define the rules for the use of aircraft simulators in the process of practical aviation training, i.e., specify which part of the training performed on the aircraft may actually be carried out using a training device. Moreover, aviation regulations specify

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technical requirements that aviation simulators must meet in order to meet the eligible criteria for their use in the implementation of training.

It is also worth noting that the conditions affecting the use of training devices in aviation training and instruction differ significantly, depending on the aviation type. As such, it is sufficient to compare the rules and the level of their application in commercial aviation, general aviation and military aviation.

## 2. TRAINING DEVICES USED IN AVIATION

### 2.1. Simulator types

The classification of flight simulators and the requirements for training devices used for the instruction, training and verification of the correctness of flight crew operations have been set and defined in relevant regulations issued by international aviation authorities. In Poland, the document setting out these principles, as approved by the President of the Civil Aviation Authority, is JAR-FSTD A<sup>3</sup>, which covers the provisions for introducing European aviation safety requirements that are concerned with aircraft flight simulation training devices.

Depending on their capabilities for simulating flight conditions, training devices have been divided into categories. Based on the JAR-FSTD A document, the categorization can be presented as follows. The most technologically advanced type of flight simulator falls into the *full flight simulator* (FFS) category. A simulator belonging to this category must be equipped with a complete cockpit of a given aircraft type, model or series, and have an appropriate computer system to simulate, with optimal realism, aircraft manoeuvres on the ground and during the flight. Furthermore, such a simulator is required to visualize the manoeuvres performed by the aircraft, as well as to provide the sensation of flight dynamics by imitating the motion sensations through the use of a system of actuators moving the simulator cockpit.

Another category of flight simulators are *flight training devices* (FTDs). Simulators of this type must have a complete, full-size and functional replica of instruments, equipment and control panels of a given aircraft type, managed by a suitable computer system necessary for optimal rendering of the manoeuvres of the aircraft on the ground and in flight. These devices are not equipped with visualization and motion imitation systems.

The next category of flight simulators covers *flight and navigation procedures trainers* (FNPTs). For these types of simulator, the cockpit is connected with a suitable computer system necessary to represent a particular type, or group of types, of aircraft during in-flight operations. Devices of this type are used, e.g., in training for IFR flights and radionavigation.

The simplest types of flight simulators that enable training for at least the flight procedures of IFR flights are *basic instrument training devices* (BITDs). These devices only imitate the instruments of an aircraft.

### 2.2. Conditions for utilizing training devices in aviation

One of the most important reasons for using training devices in aviation is the necessity to limit the possibility of dangerous events during the instruction and training of flight crews. At different stages of flight training, a trainee pilot can make more or less serious mistakes in aircraft handling. Some elements of flight training may carry a high risk of an air accident. To

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<sup>3</sup> JAR-FSTD A refers to “Joint Aviation Requirements – Flight Simulation Training Devices A”, i.e., the European aviation regulations concerning flight simulators.

avoid this, part of the practical training should be conducted using flight simulators. A good example of this may be multi-engine (ME) aircraft handling training in simulated single-engine flights and in-flight engine restarts. Due to the risk associated with this drill, the regulations recommend the engine to be turned off and on at a safe altitude, but also give the opportunity to perform this exercise on the flight simulation training device.

When training qualified pilots, safety considerations also determine the necessity of using flight simulators. It is difficult to imagine the safe performance of crew training in some emergency situations in a real flight, e.g., belly landing, on-board fire or dangerous weather phenomena threatening flight safety.

An important reason for using training devices is also the economic factor. The utilization of training devices significantly reduces the costs of pilot training. This is most evident in the case of comparing air training costs for the instrument rating (IR)<sup>4</sup>. In accordance with the provisions contained in the Part-Flight Crew Licensing (Part-FCL)<sup>5</sup>, 70% of this training may be done using the flight simulation training device. As a result, the training costs to obtain the IR are reduced by half, compared to the costs of this training if performed entirely on the aircraft.

There are numerous benefits of using flight simulation devices<sup>6</sup>, but one of them should be particularly emphasized: i.e., the instructor is able to break the student's flight at any time and discuss errors just after they have been committed. The trainee pilot has time to analyse and resume a given flight sequence, without having to repeat the whole flight, trying not to commit the error again. In turn, the instructor has more time to practise the flight elements that cause the trainee the most difficulties, without repeating those that the trainee handles well. This reflects an effective use of time allocated for aviation training.

### 3. UTILIZATION OF TRAINING EQUIPMENT IN FLIGHT TRAINING

#### 3.1. Civil aviation

When analysing the use of training devices in civil aviation, it should be noted that, at the stage of obtaining licences and aviation ratings, pilots follow a similar path. If there are some differences, they result from the fact that some training centres do not possess certified flight trainers.

Regulations specify the possibilities of using training devices in air training. In the integrated Airline Transport Pilot Licence (ATPL) airplane training, 40 h out of a 150 h minimum provided for in the training syllabus may involve the use of an FFS/NPT II or FFS simulator. This constitutes approximately 26% of the total flying time. The situation is similar in integrated commercial pilot licence (CPL)/IR aircraft training.

Training devices in helicopter training are used at a similar level. In the integrated ATPL helicopter (ATPL(H))/IR training, 65 out of 195 h, as provided for in the training syllabus, may involve the use of an FFS (approximately 33% of the total flying time), or 60 h using an FTD 2/3 (approximately 30% of the total flying time), or 55 h using an FNPT II/III (approximately 28% of the total flying time) (Figure 1). In the integrated CPL(H)/IR training, 50 h out of 180, as provided for in the training syllabus, may involve the use of an FFS

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<sup>4</sup> The IR gives the authorization to perform IFR flights.

<sup>5</sup> Part-FCL concerns the licensing of flight crews

<sup>6</sup> J. Kozuba. 2011. "Czynnik ludzki - rola symulatora lotniczego w szkoleniu lotniczym". *Logistyka*. [In Polish: "Human factor – the role of an air simulator in aviation training".]

(approximately 28% of the total flying time), or 45 h using an FTD 2/3 (approximately 25% of the total flying time), or 40 h using an FNPT II/III (approximately 22% of the total flying time) (Figure 2).

Further use of flight simulation equipment in pilot training and practical training will then vary, depending on where a pilot will be performing flights. If a pilot ends up in so-called general aviation, training devices may be used in training to obtain additional ratings, but not for any other form of systematic training. The situation is different if a pilot starts working, for example, with an aviation organization dealing with air transport. A pilot coming to an airline, after completing an academic training course for a new aircraft type commences practical training on a flight simulator. Before entering the real aircraft cockpit, the pilot then has to master the operation of on-board equipment, procedures for start-up, taxi, take-off, en route, and landing, as well as emergency procedures using a simulator. Only upon the successful completion of an examination session on a simulator will s/he be allowed to commence practical air training.

That is not the end of his/her “adventure” with flight simulators. Airline pilots have to participate in simulator training on a regular basis. As part of the session, they rehearse the crew’s conduct in emergency situations. Very frequently, scenarios of individual training sessions are based on emergency situations that have actually occurred on a given aircraft type, with simulator training used to teach crews how to act properly and efficiently.

<b>Integrated ATPL(H)/IR training</b>					<b>FSTD credits</b>
	<b>Flight with an instructor</b>	<b>Solo flight</b>	<b>Student pilot-in-command (SPIC)</b>	<b>Total</b>	<b>FFS; FTD; FNPT</b>
<b>Visual, including ME T/R training</b>	<b>75 instruction hours</b>	<b>15 instruction hours</b>	<b>40 instruction hours</b>	<b>130 instruction hours</b>	<b>30 h C/D level or 25 h FTD 2/3 or 20 h FNPT II/III</b>
<b>Basic IFR</b>	<b>10 instruction hours</b>	-	-	<b>10 instruction hours</b>	<b>20 h FFS or 25 h FTD 2/3 or FNPT II/III or 10 h at least FNPT I</b>
<b>IR training</b>	<b>40 instruction hours</b>	-	-	<b>40 instruction hours</b>	
<b>MCC</b>	<b>15 instruction hours</b>	-	-	<b>15 instruction hours</b>	<b>15 hours FFS or FTD 2/3 (MCC) or FNPT II/III (MCC)</b>
<b>Total</b>	<b>140 instruction hours</b>	<b>55 instruction hours</b>		<b>195 instruction hours</b>	

Fig. 1. Integrated ATPL(H)/IR training – successful completion of flight simulation training device training for helicopter flights with an instructor

Source: GM1 to Annex 3; Annex 6; FCL.735.H

<b>Integrated CPL(H)/IR training</b>					<b>FSTD credits</b>
	<b>Flight with an instructor</b>	<b>Solo flight</b>	<b>SPIC</b>	<b>Total</b>	<b>FFS; FTD; FNPT</b>
<b>Visual, including ME T/R training</b>	<b>75 instruction hours</b>	<b>15 instruction hours</b>	<b>40 instruction hours</b>	<b>130 instruction hours</b>	<b>30 h C/D level or 25 h FTD 2/3 or 20 h FNPT II/III</b>
<b>Basic IFR</b>	<b>10 instruction hours</b>	-	-	<b>10 instruction hours</b>	<b>20 h FFS or 25 h FTD 2/3 or FNPT II/III or 10 h at least FNPT I</b>
<b>IR training</b>	<b>40 instruction hours</b>	-	-	<b>40 instruction hours</b>	
<b>Total</b>	<b>125 instruction hours</b>	<b>55 instruction hours</b>		<b>180 instruction hours</b>	<b>50 h FFS level C/D or 45 h FTD 2/3 or 40 h FNPT II/III or 10 h at least FNPT I</b>

Fig. 2. Integrated CPL(H)/IR training – successful completion of flight simulation training device training for helicopter flights with an instructor  
Source: GM1 to Annex 3; Annex 6; FCL.735.H

### 3.2. Military aviation

Flight training devices play a vital role in the training of air force pilots. At the beginning, in order to become a military pilot student at the Polish Air Force Academy (PAFA) in Dęblin, a candidate for a military pilot must pass, among other tests, a test on the “Selekcjoner” (Screener) training device, checking his/her predisposition to the profession of a pilot. If s/he passes all the tests and examinations successfully and is admitted to school, s/he will also train on flight simulators during the five years of study. Simulator training includes basic training, i.e., learning and training in operating on-board equipment, learning to start up the power plant, taxi, take-off, traffic patterns, flights to the training zone and basic flight manoeuvres, landing on ice, radiotelephony communication, and responses to emergency situations. In the subsequent phases, the trainee participates in advanced training, in which s/he also carries out flights to the training zone and intermediate flight manoeuvres. During the training at the academy, s/he will perform about 100 h of flying time on flight simulation devices.

Some differences between the simulation training of civilian and military pilots are worth stressing. In the training of air force pilots, conducting 100 h of simulated flights does not “replace” the flying time achieved on a real aircraft; it merely complements it. This means that, if the training programme for a given type of aircraft sets a specific amount of flying time necessary for a pilot to achieve the intended level of flight training, it should be attained in a real aircraft, not simulated flight.

It may be assumed that this is beneficial for the pilot, because increased training means more experience in aviation. But some drawbacks to this solution may also be noticed. First

of all, there is the economic factor: the application of flight simulators in air training does not reduce the number of hours of practical training in the air.

Stage 1	Basic training	PZL-130 "Orlik" aircraft simulator	30 instruction hours
Stage 2	Basic training	TS-11 "Iskra" aircraft simulator	30 instruction hours
Stage 3	Advanced training	TS-11 "Iskra" aircraft simulator	20 instruction hours
	Tactical training	TS-11 "Iskra" aircraft simulator	20 instruction hours

Fig. 3. Flying time summary for simulator training of a PAFA officer cadet seeking to become a jet pilot

Along with technological progress, a new potential for using air simulators has appeared. Consequently, the documentation of a tender for the purchase of new aircraft for military aviation also includes provisions regarding the requirements for flight simulators to be delivered, together with the aircraft ordered.

There is also the possibility to change the methodology for using flight simulation devices in the process of instructing and training pilots. The experience gained by pilots trained on the F-16 aircraft in the US led to the introduction of a new training system in air force units operating F-16 aircraft in Poland. Flight training on the aircraft has been integrated with flight simulator training. Before being allowed to enter the cockpit of the aircraft, the pilot has to complete appropriate training on the flight simulator. Before the commencement of training in the air on the two-seat F-16, s/he must complete basic training on the flight simulator. Only when s/he has mastered basic procedures, such as engine start-up, checking onboard systems, taxi, take-off, conducting radiotelephony communication and performing emergency procedures on the ground, i.e., on a flight simulator, can s/he commence training on the F-16 in the air.

We should state that flight trainers have been and are still used anyway. The difference in their use is that flight training on flight simulators, and at a later stage on the aircraft, is carried out separately, as part of separate training programmes, and at different times. This means that the trainee pilot has performed the required procedures on the flight simulator, but their implementation on the aircraft could be carried out after a considerable period of time.

A cadet officer studying to become a *jet aircraft pilot* commences his/her simulator training with basic training on a PZL-130 "Orlik" aircraft simulator. The training is based on a simulator training syllabus covering 24 flights in 30 h. In order to successfully complete the simulator training, the trainee must successfully complete all the exercises included in the programme (i.e., familiarization flights, basic manoeuvre flights to the training area, traffic patterns, en route flights, and flights with the instrument approach procedures), and then pass the final examination by performing an examination flight.

The system implemented in the F-16 training, however, assumes the need for training on individual missions on the simulator, directly before they are conducted on the aircraft. The successful completion of the simulated exercise is the condition for continuing the training on the aircraft.

When purchasing the M-346 "Master" aircraft, which is intended to replace the TS-11 "Iskra", flight simulators have not been overlooked, and their use will be based on the

principles used in the F-16 pilot training. Additionally, an integrated M-346 aircraft training system, AJT M-346, has been purchased, which provides the opportunity to simulate the use of weapons during flights, as well as engagement in combat missions involving the simulated participation of other aircraft.

#### 4. CONCLUSION

The legitimacy in using training devices in air training is obvious. First of all, they increase the level of safety in air training by providing flight crews with the opportunity to practise procedures in the event of dangerous emergency situations, as well as reduce flight training costs. They also allow instructors to react to errors that have occurred by stopping the student's mission and discussing the errors on an ongoing basis, and then repeating the selected flight sequence.

Differences in the use of flight simulators in civil and military aviation result primarily from the different specifics of aviation tasks performed. Differences also arise from the fact that flight training for civilian pilots is "dispersed" across many small air training centres, whereas flight training for military pilots is carried out by the PAFA in Dęblin, which is the home of the *Flight Simulation Equipment Team*.

Despite the many benefits of using flight simulators, the main obstacle for air training centres interested in using them in flight training is the very high purchase cost involved. Only a few air training centres can afford to have their own certified flight simulators. Owing to technological progress and the arrival of new innovative solutions, one can expect that, in the future, simulators will become increasingly precise and more accurately reflect actual flight conditions. However, it will be difficult to obtain a significant reduction in the purchasing cost of professional simulators, which would allow their use in aviation training to be more commonplace.

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