USE OF FLIGHT TRAINING DEVICES ON BRAZILIAN AIRLINE PILOTS RECURRENT TRAINING

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A Capstone Project Submitted to Embry-Riddle Aeronautical University in Partial Fulfillment of the Requirements for the Aviation Management Certificate Program

Embry-Riddle Aeronautical University
Sao Paulo, Brazil
October 2022

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This Capstone Project was prepared and approved under the direction of the
Group's Capstone Project Chair, Dr. Peter E. O'Reilly
It was submitted to Embry-Riddle Aeronautical
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for the Aviation Management
Certificate Program

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October 2022

Acknowledgements

The development of this work had the help of several people who were fundamental for the conclusion of this journey.

We appreciate the encouragement and patience of our family members, so that we did not give up, and our friends for our absence and temporary removal.

To all the professors at Embry-Riddle Aeronautical University who shared their knowledge and allowed us to complete this work.

To the dear professor Dr. Peter E. O'Reilly, who for months constantly accompanied us, giving all the necessary support with his precise and incisive scores for the elaboration and conclusion of this study.

Our thanks to ITL and SEST SENAT for the opportunity granted to participate in the aviation-focused course of the renowned Embry-Riddle Aeronautical that provides knowledge and development to professionals in the aeronautical industry.

To our leaders and airlines who provided the time and information necessary to contribute to the completion of this study.

And especially and not least to dear Mr. Israel Treptow, Mrs. Leticia Schmitz and Mr. Pedro Henrique Vilela for their full support throughout the course.

Abstract

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Title: Use of Flight Training Devices on Brazilian Airline Pilots Recurrent Training

Institution: Embry-Riddle Aeronautical University

Year: 2022

The result of this study showed that the migration of training of some maneuvers in the Full Flight Simulators to a Flight Training Device is economically viable and generates savings for companies that choose to use this equipment.

This research project studied the possibility of employing an alternative resource for Brazilian commercial operators while training its crews. We analyzed test cases by comparing the direct operational costs of an FTD against an FFS for a typical Brazilian airline. The use of FTDs was found to reduce the overall training costs without losing the basic premise of an aviation training program. Such training would deliver safe and proficient crews to the operations.

Flight simulators are undoubtedly a valuable and very important tool when training and/or assessing a pilot or crew performance. While a full flight simulator allows for a wide range of sensorial feedback, it may be substituted for a simpler and less

expensive device. It would be implemented where the non-technical skills are being evaluated with no loss of quality or measurable results.

The advancement in simulation technology made the training flights safer and more effective by allowing the crews to experience the reactions of the aircraft to a multitude of failures without having to leave the ground. The advances on aircraft technology however, made a human mistake or omission much more plausible on a real-world scenario than a technical failure. The training curricula had to follow through, focusing on the management of the available resources during an abnormal or emergency situation. The process included training a range of soft skills that involved situational awareness, communication, decision making and leadership, among others.

With a tailored approach, these skills can be taught and learned by using devices that present the needed scenarios for a crew to work on, without the need and cost of a full flight simulator. An advanced flight training device can adequately provide a rich and effective environment for non-technical skills training. Such a device can enhance the possibilities by not being constrained as a simulator, allowing for a more classroom-like approach, and emphasizing key aspects that are sometimes lost on a full flight training dynamic.

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Chapter I

Project Definition

The following project consists in the study of the potential benefits of the use of Flight Training Devices (FTDs) in the periodic training of pilots of Brazilian airlines.

The objective is to explore new guidelines for the use of flight training devices (FTDs) in the training of airline pilots. FTDs have the potential to train pilots in non-technical skills, task sharing, and normal operations. We intend to identify cost reductions and greater availability of full flight simulators without sacrificing safety. As a result, better quality training and strengthening of the safety culture may be achieved.

One of the distinctive characteristics of an FTD is the absence of a motion system. However, for training standard operating procedures, flows and aircraft systems familiarization, for example, it is not an essential system. The demonstrations and executions can be done with the added benefit of better interaction between the trainer and the trainees. This would allow for an environment closer to the classroom, with supporting material, like schematics or specific presentations.

The use of an FTD also makes clear to the trainees what the training session goals are. It allows them to concentrate on the basic comprehension and execution of fundamental tasks. These factors in an FFS are assumed to be sharp, but most of the time are not. Often, pilots show some wrong habits and deviations from the established procedures. In this case, the FTD also allows for a more productive session since those issues are treated beforehand.

Problem Statement

Currently, Brazilian regulations do not provide enough guidelines for the use of Flight Training Devices (FTDs) for pilot training in airlines and all tasks are performed in Full Flight Simulators (FFS). The following project provides for studying additions to ANAC RBAC 60, which addresses minimum requirements, acceptable devices, and initial and recurring training programs for pilots, and to IS 121-007B, which describes the maneuvers that could be done on FTDs.

This research project focuses on identifying potential new guidelines for the use of Flight Training Devices (FTD). An analysis here could provide the opportunity for airlines to improve training time, as well as achieve cost reductions.

The study also assesses which devices are available and their benefits. Some FTDs are capable of simulating some specific procedures from several aircraft types. With cockpit and hardware simulation, they provide flight path management, automation, and handling. They are proven to be useful for leadership and teamwork training, problem solving and decision making, situation awareness and workload management.

The FAA, on the Advisory Circular 120-45A, defined seven categories for the Flight Training Devices. Level 1 is currently reserved. Levels 2 and 3 are generic devices, in that they do not represent any specific type of aircraft. Levels 4 through 7 represent a specific cockpit and airplane. This research is focused on levels 4, 5 and 6. These were chosen because they must represent a specific aircraft type in order to achieve the desired training outcomes and the proposed cost reductions. These devices have the capability to deliver adequate training for tasks normally done on an FFS, such as RNP procedures and CAT II/III approaches, for example.

EASA adopts a different scale of categories. According to them, there are three FTD Levels (1,2 and 3). Level 1 is the most limited of them. It is used for RNAV procedures covered in the LOFT sessions, evidence-based training, and computer-based training (EBT/CBT). It is cost effective and can be used for IFR training.

Level 2 adds to the tasks of Level 1 in this FTD category. The tasks involved include Low Visibility procedures (Cat2/Cat3 and LVO approaches), landing incursions, and LOFT. Level 3 features higher fidelity to the aircraft type. It has a higher quality of details.

In addition, throughout the project, we examine possible skills, maneuvers, and operations involved in Full Flight Simulator (FFS) sessions that can be changed to an FTD. In this research project we intend to have discussions with various regulatory bodies to understand what the necessary rules and requirements are.

To prove the feasibility of this project, our research focuses on collecting data from other agencies that already have regulations for the use of FTDs, such as EASA and FAA. The research explores some global airlines. After comparing them, we analyze some already established Operational Training Programs.

This can lead to determining which skills or sessions can be switched from a Full Flight Simulator (FFS) to an FTD. Finally, the study provides suggestions on possible new guidelines. In addition, the study looks at the cost of purchasing and installing FTDs, maintenance requirements, and safety impacts.

Project Goals and Scope

This research assesses current regulations in other countries, evaluates sessions, maneuvers or skills that can be trained in an FTD, analyzing the quality of training and safety records that will be impacted using them. The intend of our research is to propose certain recommendations on the use of this type of equipment for initial and recurrent training programs for pilots. Also, we aim to estimate cost savings for airlines and training centers.

Contributions Expected

The importance of this subject relies on cost reductions for airlines and training centers with the use of simpler and less expensive equipment for training. It also aims to improve pilot training with the evolution of the quality standard, with a focus on evidence-based training (EBT). For an airline that wants to purchase the equipment, the benefits and gains are even more significant when compared to purchasing an FFS (Full Flight Simulator). Also, additional income from third-party training and optimization of simulator management could possibly be achieved.

Finally, the simplicity of installation and maintenance can be useful for the industry. Our research is following a worldwide trend in the industry regarding new pilot training techniques. In addition, the FTD environment can be compared at some degree to a classroom environment, allowing for better interaction between the pilots and the instructor through the benefit of a live demonstration of concepts and maneuvers.

Definition of Terms

Evidence-based training (EBT): Training and assessment based on operational data that is characterized by developing and assessing the overall capability of a trainee across a range of core competencies rather than by measuring the performance in individual events or maneuvers.

Full Flight Simulator (FFS): The FFS is a full-size replica of a specific type or make, model, and series airplane cockpit. It also includes the assemblage of equipment and computer software necessary to represent the airplane in ground and in-flight operations. There is a visual system providing an out-of-cockpit view, as well as a force (motion) cueing system that provides cues at least equivalent to that of a three degree of freedom motion system. It follows the minimum standards for a Level A simulator. (FAA AC 120-40B)

Flight Training Device (FTD): Is a full-scale replica of an airplane's instruments, equipment, panels, and controls in an open flight deck area or an enclosed airplane cockpit. FTD includes the assemblage of equipment and computer software programs necessary to represent the airplane in ground and in-flight conditions to the extent of the systems installed in the device. It does not require a force (motion) cueing or visual system. (FAA AC 120-45A)

Line-Oriented Flight Training: Training and assessment involving a realistic, "real time", full mission simulation of scenarios that are representative of line operations.

Non-Technical Skills: Those human performance skills that promote reliable and effective task performance in complex work systems. It encompasses attributes such as the ability to recognize and manage human performance limitations, make sound decisions, communicate effectively, lead and work as a team and mantain situational awareness.

List of Acronyms

ANAC-	Agência Nacional de Aviação Civil
AQP-	Advanced Qualification Program
CBT-	Computer-based Training
CRM-	Crew Resource Management
EASA-	European Aviation Safety Agency
EBT-	Evidence-based Training

FAA-	Federal Aviation Administration
FFS-	Full Flight Simulator
FSTD-	Flight Simulator Training Device
FTD-	Flight Training Device
IFR-	Instrument Flight Rules
IS-	Instrução Suplementar
LOFT-	Line Oriented Flight Training
LVO-	Low Visibility Operations
RBAC-	Regulamento Brasileiro de Aviação Civil
RNAV-	Area Navigation

Plan of Study

Chapter Two: Literature review on current legislation and available case studies for commercial operators. Also consult the equipment providers to verify the available devices and certifications.

Chapter Three: Research methodology to identify the types of training and/or maneuvers that are currently trained on an FFS and verify the feasibility of them being trained on an FTD, with the projection of cost reduction for the operator.

Chapter Four: Conclusions will be developed based on the various research methods to be utilized.

Chapter Five: Recommendations based on conclusions, limitations of the study, lessons learned, and future studies.

Chapter II

Literature Review

As the aviation industry evolved along with technology and ultra-modern aircraft, so it happened to the pilot training needs, methodologies, and devices available for this purpose. From the static computer-based courses to the most recent full flight simulators, the recreation of emergency scenarios of potential failures always aimed at manual handling (Hosman & Advani, 2016).

However, the advent of automation on operations, as well as several accidents and incidents over the last decades, taught the aviation industry different abilities that needed to be developed, such as non-technical and managing skills. For this matter, as training embraced more characteristics that needed to be achieved, full flight simulators became too complex and expensive environments, creating the opportunity for new devices to be deployed in simpler tasks (Warwick, 1990).

Dahlstroem (2008) mentions that the use of flight training devices and full flight simulators complement each other in highly specific contexts. One of his conclusions is that emergency training can be complemented with lower levels of simulation to train general skills for unexpected and escalating situations. It is then understood that simpler and less complex simulations can be trained and developed without the use of a completely full motion system.

The Contributions of an FTD

The use of flight training devices has been part of the aviation curriculums, in commercial and general aviation environments for some time. Several authors addressed the differences from a Full-Flight Simulator training to a Flight Training Device with no motion system. As stated in a study by Kirton (2002), the use of an FTD dramatically reduces the necessary in-flight training hours. It enables a higher skill and proficiency level before flying the airplane. This effect is also felt on pilots transitioning for a new type or category of airplane, with the maneuvers to be trained on the FTD being carefully selected for fidelity and validity (Weitzel & Lehrer, n.d.).

According to Beckman (2008), the FAA Advisory Circular 120-45A - Airplane Flight Training Device Qualification a level 7 FTD must also have the aerodynamic characteristics of the model/type being replicated, amplifying the usable range of the equipment for high altitude training, for example. According to the same study, another gain is from a higher frequency of training, since the device operation is cheaper and not constrained by meteorology or air traffic issues, for instance.

One of the most valuable gains of FTD use, and this is valid regardless the experience level, is on Scenario Based Training (SBT). The FAA Instructor Handbook defines SBT as a structured, scripted training mirroring real world scenarios and situations. This matter is cited by Thomas and Lee (n.d.) both from Embry-Riddle, in a paper about training scenarios development, according to whom the most valuable gain of this approach is that, compared to the traditional MBT (Maneuver Based Training), the scenario allows the application and evaluation of ADM (Aeronautical Decision Making) tools and techniques. The development of risk assessment skills and practical use of CRM/SRM is valuable for any pilot, in any aircraft, to develop the so called non-technical skills, and this can be successfully accomplished on an FTD (Kearns, 2009).

According to Business Insights (2022), companies also opt for FTDs on account of their low operational costs, modular approach, real-time aerodynamic flight model, and remote configuration as well as management. It is a clue that companies try to reduce their pilot training costs by balancing FFS and FTD methods.

The Effects of No Motion System on Training

Bürki-Coen and Go (2007) have used a newly developed simulator to evaluate pilots during maneuvers, such as continued takeoffs with engine failure and engine-out landing. The simulator used was Full-Flight Trainer FFT-X TM (FFT), which offers an alternative to the hexapod-motion systems that are standard in Full-Flight Simulators (FFS) and simulates motion via a high-level visual system and a dynamic seat with heave-motion and vibration cues only. The authors did not find operationally relevant differences in performance or behavior of pilots tested in the FFS with motion after having been trained in the same FFS with the motion system turned on or off - despite selection of maneuvers that require motion cues.

There were no differences between the flight precision of the FFS-trained and the FFT-trained groups for the takeoff maneuvers. For both the V1 cut and the V2 cut, pilots showed no statistically significant differences in heading standard deviation, yaw rate, airspeed exceedance, or pitch standard deviation (Bürki-Coen and Go, 2007). Similarly, for the engine-out instrument landing with quartering head and tail winds, there were no significant differences between the two groups with respect to localizer, glideslope, airspeed exceedance, or roll activity (Bürki-Coen and Go, 2007). This was the case for both the initial approach segment, from approach fix to decision height, as well as for the landing. There were also no differences between the two groups in touchdown speed or precision during quasi-transfer, and no differences in IAS at 50 ft AGL (Bürki-Coen and Go, 2007).

Regarding the opinion of pilots and instructors on this study, instructors and trainees perceived no differences in flight precision between the FFS- and FFT-trained groups once they transferred to the FFS**.** Also, according to Bürki-Coen and Go (2007), instructors believed that the two groups of trainees performed equally and as well as a typical pilot would. According to research, both instructors and trainees agreed that the pilots' control strategy and technique was equivalent between groups (Bürki-Coen and Go, 2007).

Based on the analysis, instructors believed that both groups achieved proficiency before transferring to the FFS, doing so with the same amount of ease as a typical pilot (Bürki-Coen and Go, 2007). The groups of trainees agreed with each other on the degree of ease with which they achieved proficiency during transfer testing (Bürki-Coen and Go, 2007). Hence, opinions from both instructors and trainees indicate that there were no differences in how either group performed once transferred to the FFS as a stand-in for the airplane.

The article by Bürki-Coen and Go (2007) also observes that no definitive conclusion can be drawn that would warrant modification of current qualification requirements for platform motion in full flight simulators. Some questions were raised during their initial work such as:

- Does the training conducted in a fixed-base simulator with a wide field-of-view (FOV) visual system produce a result equivalent to that which would be obtained in a like system having platform motion cuing?
- Specifically, regarding the sudden onset of asymmetrical thrust, does recurrent training accomplished in the absence of platform-motion cuing have any measurable effect on the pilot's capacity to respond in a timely and appropriate manner in the aircraft during maneuvers entailing power plant failure?
- And finally, from a regulatory perspective, do recurrent proficiency checks conducted in a visually equipped fixed-base simulator provide an equivalent

opportunity to verify the line-operational readiness of air-carrier pilots Bürki-Coen and Go (2007).

The authors provided an alternative viewpoint regarding the necessity of a motion system. Although it is certainly the case that there is no compelling evidence that platform motion cuing can safely be eliminated from present flight simulator qualification requirements, it can also be observed that the evidence in favor of the requirement is itself less than compelling and, therefore, warrants reexamination (Bürki-Cohen & Longridge, 1998).

After their research, the authors had not reached a clear conclusion. It is clear from a review of the pertinent literature that no definitive conclusion can be drawn that would warrant modification of current qualification requirements for platform motion in full flight simulators. The FAA believes that this situation will remain unchanged unless new research is undertaken, which considers the lessons learned from past research and the opportunities engendered by new technology (Bürki-Cohen & Longridge, 1998).

The use of FTDs: A Case Study

Daniel Meng, business developer of Lufthansa Aviation Training (LAT), developed three case studies regarding FTD use during pilots training in 2022. The first one was the introduction of Level 2 FTDs at Austrian Airlines. What made this case interesting is that this was the first FTD ever incorporated into regular recurrent training of one of LAT’s major airline customers. In contrast, LAT originally expected these devices to be used primarily for type ratings or ab-initio trainings. LAT expected that, with the decision to aim for the highest fidelity level possible on a non-motion FSTD. Over 80% of all training tasks of a typical type rating could be conducted on its new A320 Level 2 FTD (Meng, 2022).

Pilots were interviewed regarding their perceptions on FTD training. During this case study, it was also highlighted that there are differences within the group of pilots due to their different levels of flying experience. By this it was meant that more experienced pilots might be suitable for a higher number of non-motion FSTD training due to their extensive flight-hour experience in the real aircraft. (Meng, 2022). Therefore, motion effects are already anchored to a much larger extent than they are for newly appointed pilots (Meng, 2022). Because of this case study, several best practices were addressed which could be used in further FTD implementations (Meng, 2022).

The second case study was regarding the controversy of motion training versus non-motion training. While until late 20th century, training was increasingly only considered effective when conducted on an FFS. In one study, pilots conducting non-motion training reacted slightly slower, less than 0.5 seconds, on an engine-out event during take-off (Meng, 2022). Nevertheless, this barely measurable difference disappeared as soon as this training task was conducted on an FFS with motion switched on. This is in line with the fact that motion cues are perceived within approx. 0.15 seconds, while visual cues are perceived after approx. 0.5 seconds (Meng, 2022).

Finally, the authors addressed the FTD use inside evidence-based training (EBT). The challenge with EBT lies in using a non-FFS device as described in the latest revision of AMC1 ORO.FC.231(e): “Volume and FSTD:

- The EBT program has been developed to include a notional exemplar of 48 FSTD hours over a 3-year program for each flight crew member.
- b) Subject to ORO.GEN.120, the operator may reduce the number of FSTD hours provided that an equivalent level of safety is achieved. The program should not be less than 36 FSTD hours.

- c) Each EBT module should be conducted in an FSTD with a qualification level adequate to complete proficiency checks; therefore, it should be conducted in a full-flight simulator (FFS) level C or D." (Lufthansa Aviation Training, 2022)

As can be seen, Letter a and c together represent a very formal threshold for including Level 2 FTD or other emerging devices (Meng, 2022). The third case study of the paper is regarding the future of pilot training. In 2030 and beyond, it will presumably still look a lot like pilot training in 2021, meaning that FFSs will remain the backbone of professional pilot training (Meng, 2022).

Nevertheless, their dominance or market share across all training courses is expected to decrease over time. As already seen, and with EASA introducing a more flexible regulation that is specifically open towards technological innovations, the industry will experience a significant leap in how training will be delivered (Meng, 2022). Level 2 FTD are just the beginning and will be followed by training tools that serve other training needs and that do not even require the technical setup of such a fixed-base FSTD.

Effects on Cost

Homan (1996) conducted a study to determine whether training using a multimedia program versus training on an FAA-approved flight simulator would limit the cognitive performance of pilots. An instrument flight maneuver was chosen for assessment and testing. A computer scoring program was used for the test and a statistical methodology and a t test was used to evaluate the results.

Practical tests were carried out, and the analysis of the performance data of the tested pilots did not identify a significant difference in the cognitive performance between them. The conclusion of the study identified that multimedia trainers that have a much lower cost than FAA-approved devices can be an effective tool in learning flight training for pilots. They will be increasingly desired tools, due to the low investment compared to traditional simulators and studied so that the viability of these occurs in a short space of time.

Regarding this matter, Bürki-Cohen & Longridge (1998) addressed the problem faced by regional airlines in the U.S. electing to use flight simulators for training must establish contractual arrangements with training centers, or with other air carriers, who have the appropriate simulation equipment. As it turns out, the cost of such contractual arrangements, when coupled with the travel expenses for cockpit crew, can exceed the per-hour cost of conducting training in some regional aircraft. Moreover, for some regional aircraft operated in the United States, the worldwide availability of qualified flight simulators may be extremely limited. As a result, though most American regional airlines would clearly prefer to conduct all their training in flight simulators. Such carriers have found it necessary to either conduct all training in the aircraft or to limit the use of simulators to initial and transition training (Callender, 2008).

Summary

The controversy of motion training (FFS) versus non-motion training is not new (Baskin, 2006). A good number of researchers have been studying this subject in recent years. As seen in recent studies, companies are already using FTDs on their recurrent training upon aviation agency approval (Bürki-Cohen & Longridge, 1998). Also, studies have shown that differences regarding these two types of training do not impact on pilots' quality of training (Bürki-Coen and Go, 2007).

Chapter III

Methodology

This study was designed to be completed after four steps: historical analysis of flight training, comparison between the Brazilian RBAC 121 and existing legislations, assessment of Operational Training Programs of Brazilian airlines, and a costs review.

The methodology part of this project compared data from different sources. The data gathering and interpretation will be presented in the respective step description. The collection of data took into consideration important factors, such as, but not restricted to, confidentiality, official sources, and privacy.

Brief History of Flight Simulation

The first step of this project was a bibliographic review to show the history of simulation devices used in pilot training. It was shown that in the beginning, the training was carried out on the aircraft themselves. Afterward, due to cost and safety issues, the training started to be carried out on training devices.

Apart from the enormous cost savings so generated, training aircraft accidents were eliminated. Nowadays, the task of instilling in crewmembers the instinctive and correct reaction to failures as well as emergencies, has passed beyond the economic and practical use of the aircraft for training (Page, 2000).

Benchmark With Other Civil Aviation Agencies

This research compiled the current legislation from different agencies, FAA and EASA, to compare with ANAC RBACs 60 and 121, and IS 121-007B, in order to assess differences between them regarding the use of FTDs on pilot training. Data was collected through the respective official agencies' websites.

Regarding the legislation in the United States, we analyzed the 14 CFR, Subpart 121, which addresses the operational requirements for Domestic, Flag and Supplemental operations. In this document, Subpart N explains the Training Program and goes from articles 400 to 429. We found the definition of Flight Simulator Training Devices and its applicability on pilot training.

The Advisory Circular 120-35C contains guidelines for Line Oriented Flight Training. It explains the use of FTDs for recurrent and qualification LOFT. The FAA philosophy, also according to this same document, says that it is mandatory to use the most appropriate simulation device.

Appendix E of Part 121 has the Flight Training Requirements and defines which maneuvers or failures may be accomplished on an FTD for Initial, Transition, Upgrade or Conversion training. Table 3.1 shows which maneuvers may be conducted on FTDs. For sampling purposes, the table displays just a minor section of maneuvers.

Table. 3.1. FAA use of FTDs.

Maneuvers/procedures	Inflight	Static airplane	FFS	FTD
(d) Operation of systems and controls at the flight engineer station			I, T, U	
(e) Runaway and jammed stabilizer			I, T, U, C	
(f) Normal and abnormal or alternate operation of the following systems and procedures:				
(1) Pressurization				I, T, U, C.
(2) Pneumatic				I, T, U, C.
(3) Air conditioning				I, T, U, C.
(4) Fuel and oil		I, T, U, C		I, T, U, C.
(5) Electrical		I, T, U, C		I, T, U, C.
(6) Hydraulic		I, T, U, C		I, T, U, C.
(7) Flight control		I, T, U, C		I, T, U, C.

Source: FAA CFR 14 Part 121, Annex E.

Regarding the European agency, EASA, we analyzed the CS-FSTD(A) document. It has the definition of FTD, the requirements, acceptable means of compliance and standards. It also has the scenarios where an FTD can be used instead of an FFS, for both initial and recurrent training (EASA CS-FSTDA, 2018).

Table 3.2 shows a schematic of a set of maneuvers that can be performed on an FTD. Again, for sampling purposes, it shows a minor set of maneuvers.

Table 3.2. EASA Use of FTDs.

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS	FFS				FTD		FNPT			BITD
	A	B	C	D	1	2	I	II	MCC	
a PREPARATION FOR FLIGHT										
(1) Preflight. Accomplish a functions check of all switches, indicators, systems, and equipment at all crew members' and instructors' stations and determine that:										
(a) the flight deck design and functions are identical to that of the aeroplane or class of aeroplane simulated;	✓	✓	✓	✓	✓	✓	✓	✓	✓	
(b) design and functions represent those of the simulated class of aeroplane.										✓
b SURFACE OPERATIONS (PRE-TAKE-OFF)										
(1) Engine start										
(a) Normal start	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(b) Alternate start procedures	✓	✓	✓	✓	✓	✓				
(c) Abnormal starts and shutdowns (hot start, hung start, tail pipe fire, etc.)	✓	✓	✓	✓	✓	✓				
(2) Pushback/Powerback	✓	✓	✓	✓						
(3) Taxi										
(a) Thrust response	✓	✓	✓	✓			✓	✓	✓	
(b) Power lever friction	✓	✓	✓	✓			✓	✓	✓	
(c) Ground handling	✓	✓	✓	✓			✓	✓	✓	
(d) Nosewheel scuffing	✓	✓	✓	✓						
(e) Brake operation (normal and alternate/emergency)							✓	✓	✓	
A. Brake fade (if applicable)	✓	✓	✓	✓						
B. Other	✓	✓	✓	✓						

Source: EASA CS-FSTD (2018).

Finally, we compared both regulations with the one published by ANAC on its RBAC 121, for aerial public transportation with aircraft certified for more than 19 passengers. This is the regulation applicable for every airline in Brazil. The document just cites full flight simulators and other training devices. The Annex E, which covers Flight Training, describes the maneuvers and requirements for training only on Full Flight Simulators or training aircraft. We did not find any mention to the use of Flight Training Devices in pilot training. However, ANAC IS121-007B describes exactly which maneuvers can be done on FTDs level 4, 5, 6, and 7, separated by flight phases.

Actual Training Programs of Brazilian Airlines

The third step of the methodology used on this project was an analysis of the Operational Training Programs of three airlines in Brazil, designated as Airlines A, B, and C. The objective was to identify opportunities to suggest the use of an FTD instead of an FFS on certain sessions and maneuvers.

We began analyzing the Operational Training Program of Airline A. Its recurrent practical training is described for each fleet: ATR72-600, Embraer 195/195-E2, Airbus A320neo/A321neo and Airbus A330-200/900neo.

The recurrent training is completely performed in full flight simulators for all the four fleets, divided into five modules, from A to E. Each module lasts for six months. The module comprises several systems of the aircraft and the applicable failure maneuvers related to each system. In other words, on a time frame of two and half years, every system and failure of the aircraft is trained.

For license recertification purposes, the recurrent training consists of:

- LOFT session.
- Recurrent training session.
- ANAC proficiency check.

Six months later, for training purposes only, pilots perform:

- Recurrent training session.
- Company proficiency check.

The LOFT – Line Oriented Flight Training – session has the objective to train non-technical skills, such as teamwork, situational awareness, communication, and decision making. On Figure 3.1, there is the description of the session. The Embraer 195/195-E2 program was used as an example, but the same schematic is applicable to the other fleet.

Figure 3.1. Airline A LOFT Recurrent Training Sessions

MODULE / LESSON: RECURRENT LOFT - E-179					
PERFORMANCE PACKAGE	DEVICE	BRIEF TIME	SIM TIME	DEPT TIME	DEBRIEF TIME
N/A	FFS	00:30	04:00	N/A	01:30
ELEMENTS: CRM PRACTICE					
COCKPIT PREPARATION NORMAL CHECKLIST AIRBORNE AND GROUND FLOWS NORMAL TAKEOFF CLIMB DESCENT			APPROACH LANDING PARKING SECURING SCENARIOS WILL BE APPLIED ACCORDING TO INSTRUCTOR'S MANUAL **RIGHT SEAT QUALIFICATION**		

Source: Airline A Operational Training Program.

The figures from 2 to 6 represent the recurrent training sessions of the five modules, from A to E, that are part of the Recurrent Training Program of Airline A. Again, the Embraer195/195-E2 program was used for sampling purposes, but it is identically replicated for another fleet.

Figure 3.2. Airline A Module A Recurrent Training Module Schematic

MODULE / TRAINING: A - E-179					
SCENARIO	DEVICE	BRIEF TIME	SIM TIME	DEPT TIME	DEBRIEF TIME
4	FFS	01:30	04:00	N/A	00:30
ELEMENTS: ACCORDING TO IAC 121-1013 CGH SPECIAL AIRPORT OPERATION					
TRANSIT COCKPIT NORMAL PROCEDURES & GROUND FLOWS LOW VISIBILITY TAKEOFF ATA 70 ENGINE REJECTED TAKEOFF TCAS-RA / UPSET RECOVERY ATA26 - FIRE PROTECTION SEVERE WEATHER WINDSHEAR ATA28 - FUEL SYSTEM			ENGINE MALFUNCTION ABOVE V1 REJECTED LANDING MANEUVER (CGH) CABIN HI - PILOT INCAPACITATION ATA32 - LANDING GEAR EMERGENCY EVACUATION CAT II APPROACH NON PRECISION APPROACH		

Source: Airline A Operational Training Program

Figure 3.3. Airline A Module B Recurrent Training Module Schematic

***MODULE* / TRAINING: B - E-179**					
SCENARIO	**DEVICE**	**BRIEF TIME**	**SIM TIME**	**DEPT TIME**	**DEBRIEF TIME**
3-4	**FFS**	**01:30**	**04:00**	**N/A**	**00:30**
ELEMENTS: ACCORDING TO IAC 121-3130 SDU SPECIAL AIRPORT OPERATION					
TRANSIT COCKPIT			PRECISION APPROACH OR		
NORMAL PROCEDURES & GROUND FLOWS			NON-PRECISION APPROACH		
REJECTED TAKEOFF					
ATA52 - DOORS					
ATA70 - ENGINE MALFUNCTION			ATA29 - HYDRAULIC		
EGPWS LEADING TO STALL RECOVERY					
TCAS-RA / UPSET RECOVERY			ATA49 - APU		
ATA21 - AIR SYSTEM - PRESSURIZATION			EMERGENCY EVACUATION		
RAPID DESCENT PILOT ABSENCE					
ATA34 - NAVIGATION					

Source: Airline A Operational Training Program

Figure 3.4. Airline A Module C Recurrent Training Module Schematic

***MODULE* / TRAINING: C - E-179**					
SCENARIO	**DEVICE**	**BRIEF TIME**	**SIM TIME**	**DEPT TIME**	**DEBRIEF TIME**
3-4	**FFS**	**01:30**	**04:00**	**N/A**	**00:30**
ELEMENTS: ACCORDING TO IAC 121-1013 CGH SPECIAL AIRPORT OPERATION					
TRANSIT COCKPIT			TCAS-RA / UPSET RECOVERY		
NORMAL PROCEDURES & GROUND FLOWS			ATA35 - OXYGEN		
REJECTED TAKEOFF			CABIN HI - PILOT INCAPACITATION		
ATA70 - ENGINE MALFUNCTION			CAT II APPROACH		
CGH REJECTED LANDING MANEUVER			NON PRECISION APPROACH		
ATA 23 - COMM AUDIO PROBLEM			ONE ENGINE GO AROUND		
ONE ENGINE GO AROUND			ONE ENGINE LANDING		
ONE ENGINE LANDING			EMERGENCY EVACUATION		
SEVERE WEATHER WINDSHEAR					
ATA 22 - AUTO FLIGHT					

Source: Airline A Operational Training Program

Figure 3.5. Airline A Module D Recurrent Training Module Schematic

***MODULE* / TRAINING: D - E-179**					
SCENARIO	**DEVICE**	**BRIEF TIME**	**SIM TIME**	**DEPT TIME**	**DEBRIEF TIME**
3	**FFS**	**01:30**	**04:00**	**N/A**	**00:30**

ELEMENTS: ACCORDING TO IAC 121-3130 SDU SPECIAL AIRPORT OPERATION

TRANSIT COCKPIT NORMAL PROCEDURES & GROUND FLOWS ATA70 - ENGINE MALFUNCTION START / RTO / FAIL ABOVE V1 EGPWS LEADING TO APPROACH TO STALL RECOVERY TCAS-RA / UPSET RECOVERY ATA30 - ICE RAIN PROTECTION ATA36 - PNEUMATIC – DESCENT & PILOT ABSENCE PRECISION APPROACH OR NON-PRECISION APPROACH	ONE ENGINE GO AROUND ATA27 - FLIGHT CONTROLS JAMMED **VOLCANIC AREAS TRAINING** **IDENTIFICATION & SYSTEM PROBLEMS** **ASSOCIATED ENGINE PROBLEMS** ATA70- ENGINE FAIL ATA33 - LIGHTS EMERGENCY EVACUATION

Source: Airline A Operational Training Program

Figure 3.6. Airline A Module E Recurrent Training Module Schematic

***MODULE* / TRAINING: E - E-179**					
SCENARIO	**DEVICE**	**BRIEF TIME**	**SIM TIME**	**DEPT TIME**	**DEBRIEF TIME**
3-4	**FFS**	**01:30**	**04:00**	**N/A**	**00:30**

ELEMENTS: ACCORDING TO IAC 121-1013 CGH SPECIAL AIRPORT OPERATION - IAC 121-3130 SDU SPECIAL AIRPORT OPERATION

NORMAL PROCEDURES & GROUND FLOWS ATA31 – INDICATING – REJECTED TAKEOFF ATA70 – ENGINE MALFUNCTIONS ATA24 - ELECTRIC CAT II APPROACH NON PRECISION APPROACH REJECTED LANDING (CAPT) PRECISION APPROACHES TCAS-RA / UPSET RECOVERY CABIN HI – PILOT ABSENCE ATA46 - INFORMATION ONE ENGINE APPROACH & LANDING	EGPWS LEADING TO STALL RECOVERY SEVERE WEATHER - WINDSHEAR EMERGENCY EVACUATION

Source: Airline A Operational Training Program

Afterwards, an analysis of B's pilot training program was carried out. Since Airline B currently operates one type of aircraft, the Boeing 737 training program was analyzed. The following trainings are required in the periodic pilot training program (in Portuguese):

Figure 3.7. Airline B Recurrent Training Program

SEGMENTOS DE CURRÍCULO		REQUISITOS	CARGA HORÁRIA	PERIODICIDADE
[7]Solo (Presencial e não presencial)		RBAC 121.418RBAC 121.42(c)(iii) IS 121-007 (5.5.5.2) RBAC 121.433 (c)(1)(i) IS 121-006 Flight Technical & Safety (76-PT-P433)	25 horas	12 meses
CRM Gerenciamento de recursos de cabine (Presencial e Não Presencial)	CRM	RBAC 121.404 (5.3.2) IS 00-010A IS 121.006	O Treinamento de CRM é aplicado pela Academia de Águias de acordo com o DR-ORG-TC-001 - Programa de Treinamento de CRM	24 meses
	TEM LOFT	ISM FLT 2.2.14 IS 00-010A	8 horas	36 meses
[1]Emergências Gerais (Presencial e não presencial)	Teoria	RBAC 121.315 RBAC 121.417 RBAC 121.805 IS 121-006 ISARP FLT 2.2.8 e 2.2.9	4 horas	12 meses
	Exercícios práticos; [6]Eventos Médicos (Presencial e não presencial)			[7]12 meses
Treinamento Conjunto (Presencial e não presencial)		ISARP FLT 2.2.9	3 horas	36 meses
SGSO-Operacional (Presencial e não presencial)		RBAC 121.1205 RBAC 121.1231 IS 119-002D IS 121-006	02h30min	24 meses
Segurança da Aviação Civil (Security) (Presencial e Não Presencial)		RBAC 110 IS 121.006	04 horas	24 meses
[2]Artigos Perigosos (Presencial e Não Presencial)		RBAC 175 RBAC 121 Subparte Z RBAC 121.1001 Apêndice O IS 175-002 F IS 175-007 A (7.1.4.), (7.1.5.) e (7.1.6.) IS 121-006	04 horas	12 meses
[5]GRF- Gerenciamento de Risco da Fadiga Treinamento EaD - *e-Learning*		RBAC 117 IS 117-003 6.3.1.4 IS 121-006	02h30min	24 meses
Voo	[3]Simulador	RBAC 121.427, 121.433 (c)(1)(i) Apêndice F e H	02 sessões de 04 horas	12 meses
	[3]Exame de Proficiência	RBAC 121.441 IS 121-007 (5.10.7.1) Apêndice F e H /	01 sessão de avaliação com INSPAC/Examinador de 04 horas	12 meses
	LOFT	RBAC 121 Apêndice H	01 sessão de 04 horas	12 meses
	[4]Exame em Rota	RBAC 121.440, 121.441, Apêndice F	A critério do INSPAC/Examinador	12 meses

Source: Airline B Operational Training Program.

As seen on Figure 3.7, a 4-hour flight simulator session is required every 12 months in order to keep pilots recurrent and in compliance with Brazilian civil aviation agency.

The Airline C recurrent training program for the narrowbody fleet already has one session of the three being performed on an FTD. It is designed according to the AQP (Advanced Qualification Program) guidelines. ANAC has approved the program along with this substitution. The LOFT sessions still follow the same format as Airlines A and B. The sessions will be analyzed for the possibility of being performed on the FTD, as explained below.

Based on the data presented, we compared the Operational Training Program of Airline A to the other airlines in Brazil, Airlines B and C. What was benchmarked were the maneuvers, failures and the devices used to perform them. In the training program, the LOFT program was also detailed, which consisted of 4 hours of flight simulator with scenarios chosen by the instructor as shown in Figure 3.8 (in Portuguese). Unlike the recurrent training program aimed at training in-flight abnormalities, LOFT training does not have the maneuvers that must be trained in the simulator, nor if the training can be carried out in an FTD.

Figure 3.8. Airline B LOFT Training Program

6.2.11. SEGMENTO DE TREINAMENTO LOFT (TP02)

SEGMENTOS DE CURRÍCULO		REQUISITOS	CARGA HORÁRIA
Voo simulador	LOFT	RBAC 121 Apêndice H (a)(6) IS 121-007 5.6.5.5 ISARP FLT 2.2.31	01 sessão

1.	1 Sessões de Simulador	04:00
Carga Horária		**04:00**

Tal programa consiste de, pelo menos, 4 horas de voo para cada piloto. Deve conter, ainda, pelo menos 2 segmentos de voo representativos de linhas do operador. Um dos segmentos deve conter exclusivamente procedimentos normais, desde o "*push back*" em um aeródromo até a parada final em outro. O outro segmento deve conter o apropriado treinamento de operações anormais e de emergência em voo.

Esse treinamento deve correr em tempo real e em um cenário previamente preparado. O instrutor não deve intervir, seja verbalmente ou por meio da utilização de recursos de simulação como *freeze*, *speed up*, *reposition* etc. O instrutor deve fazer o papel de mecânico, comissário, controlador de tráfego aéreo etc., com o objetivo de tornar o cenário o mais real possível, permitindo uma melhor observação dos conceitos de CRM.

MÓDULO DE TREINAMENTO LOFT (TP02)

Módulo	**04:00**
MÓDULO 1: Um (1) voo em simulador, com cenários a escolha do facilitador	

Source: Airline B Operational Training Program

Business Plan of FTD and FFS Use

As mentioned in previous Chapters, it is known that replacing an FFS (Full Flight Simulator) device with an FTD (Flight Training Device) generates financial gains for airlines in the application of training their pilots and mechanics. After covering the previous steps, the final step of this study analyzed the cost to replace the FFS for FTD, as well as identifying the economic gains, such as cost reductions, that could be achieved.

The research analyzed the three Operational Training Programs. With that data in hand, evaluated the total hours of FFS to be replaced. Each company training curriculum consisted of different total hours trained in simulators. Therefore, each airline had a different percentage of replacements and consequently different financial gains.

Another option considered was the acquisition of FTDs by the airlines. In other words, due to the low complexity of having an FTD training device, companies, instead of having leasing contracts with approved training centers, could acquire the equipment. This equipment could be inserted into its feasibility studies. The return on investment could be added to ancillary revenue projections making sessions available to other players.

Reinforcing that the analyzed airlines have different programs, aircraft and simulator value per hour contracts, projected values were placed in the financial study.

Contract time to define the feasibility analysis.

- FFS flight hour cost (level D).
- FFS installation and maintenance cost.
- FTD Flight Hour Cost (level 7) and/or % gain vs FFS.
- FTD acquisition value (level 7).
- FTD installation and maintenance cost.
- NPV.
- Assumed WACC TAX.

The aforementioned information made it possible to demonstrate two possible scenarios with the replacement of training lessons from the approved programs of FFS companies for FTD:

- Scenario 1: Gain in value/hour, in the contract between the airline and the approved training center (owner of the equipment).
- Scenario 2: Acquisition of FTD equipment by the airline.

Chapter IV

Conclusions

In this chapter, three conclusions from this research project are presented. The conclusions were the result of analysis of market research, literature review, legislation benchmark, and financial viability of different formats of training programs. We studied the possible replacement of the simulation hours from FFS (Full Flight Simulator) for FTD (Flight Training Device). This research further included the addition to the viable scenarios for airlines in obtaining FTD equipment or a contract with an approved training facility.

As mentioned throughout the research, pilot training in FTD brings demonstrations and executions that can be done with the added benefit of better interaction between the instructor and students. Additional potential benefits included improving training, focusing on continuous improvement and with a closer to a classroom that sought better quality training and strengthening of the safety culture.

Pilot training is a significant part of airline costs. So, to achieve a more productive training, the research identified potential cost savings without impacting the quality addressed in the conclusions presented in this chapter.

The conclusions were described according to the supporting legislation in force in Brazil and in the world. The conclusions brought forward by this research included detailed analysis of the training programs of the main Brazilian airlines, as well as a study of market value/hours and financial viability with updated macroeconomic data that supported the details of the conclusions.

Conclusion 1 - There is opportunity for Brazilian airlines to replace one of the recurrent training sessions currently done in FFS to FTD to improve productivity and save money.

- **Data Gathering**

Data was collected from Instrução Suplementar 121-007B, appendix D. The Supplementary Instruction presents the guidelines to develop an operational training (PTO) acceptable by ANAC, ensuring adequate training of the flight crew member according to RBAC No. 121 subparts N, O, W, and X (ANAC, 2020).

We crosschecked the maneuvers that can be performed on an FTD presented on IS 121-007B (see Table 4.1) with the current operational training program of two Brazilian airlines. With this data, we verified the opportunity to switch one of the recurrent raining sessions currently done on FFS to FTD.

- **Results**

All the maneuvers listed in Appendix D of IS 121-007B that could be performed on an FTD are not currently trained on such a device by the analyzed airlines. Both of them train those maneuvers on FFS. So, there is opportunity to use an FTD instead of an FFS during recurrent pilot training in Brazil.

Also, it is possible to design a recurrent training session based on the maneuvers allowed to be performed on FTD, covering normal and abnormal operations on ground and in-flight. So, this research project concluded that one of the yearly recurrent training sessions of Brazilian airlines could be switched from an FFS to FTD.

- **Conclusion**

The research project concluded that some of the maneuvers described in table 4.1 (see Description of Conclusions) could be performed in an FTD training device during periodic training. Since the pilots who are receiving this type of training already have qualifications and are proficient, the lack of motion clues does not interfere on the performance of these pilots, who already know the environment, characteristics and real performance of the aircraft.

- **See Recommendation 1 in Chapter V.**

Conclusion 2: LOFT sessions could be performed in an FTD without loss of training quality.

- **Data Gathering**

This conclusion was based on literature review and legislation benchmark. The LOFT training is part of a specific type of recurrent training, the Line Oriented Simulation (LOS), described by the FAA on the AC 120-35D. The LOS training includes the LOFT (Line Oriented Flight Training), the SPOT (Special Purpose Operational Training) and the LOE (Line Operational Evaluation).

- **Results**

The goal of a LOS session is to train the non-technical skills of the pilots involved. These training sessions can be part of an initial or recurrent training, or even additional training after an event where a deficiency in CRM was detected by using a SPOT session.

Being so, an FTD could be used as an efficient device to evaluate those, since the scenarios are created to evaluate human behavior when handling complex situations, by observing the decision-making process, communication, leadership, workload management and teamwork, among others.

- **Conclusion**

The FTD allows, in many situations, a better assessment than an FFS, because it allows the instructor or evaluator to “isolate” some observable behaviors and its outcomes.

- **See Recommendation 2 in Chapter V.**

Conclusion 3 - The use of FTD creates an opportunity for airlines to optimize training costs.

- **Data Gathering**

The total financial feasibility analysis considers conclusions 1 and 2, with gain in value/hour, as a modality of contract between the airline and the approved training center (equipment owner) or the acquisition of FTD equipment by the airline. Therefore, for the study, two probable models were considered: the Rental Model (the most currently used by the companies) and the Purchase Model. Through this financial study, it is possible to conclude the economy of both models over the use of FFS on total of pilot training programs.

The conclusion of savings considered the replacement of training hours of an FFS simulator (Full Flight Simulator) for an FTD (Flight Training Device) level 5 to 7. The average unit value/hour of an FFS was considered for the study and for an FTD 60% lower than an FFS, the reference for these values was based on market research with simulator manufacturers such as L3Harris and CAE, as well as the purchase price of an FTD.

- **Results**

If the three Brazilian airlines decide to switch the LOFT session and one of the recurrent training sessions per year from an FFS to FTD, the total savings would be $18.752.879,00 per year. Airlines A and C will achieve better results if they decide to purchase or lease FTD equipment, while airline B should rent an FTD from a training center.

Besides the gains in cost reductions, the results also considered additional revenue from selling spare hours on these devices to third parties.

- **Conclusion**

After demonstrating the financial results of the three business cases carried out for the largest Brazilian airlines and considering the studies presented in conclusions 1 and 2, it was possible to conclude that the migration of these trainings from an FFS equipment to an FTD equipment generates economical savings for the airlines. It also maintains the quality of instruction for any of the airlines even with different training programs and number of pilots.

As for the decision to acquire an FTD as a lease or sign a contract with an approved training center, the results are not unanimous among the studied airlines due to the different training programs, the amount of equipment capacity utilization and the revenue potential that the study considers 100% transfer of excess capacity. Therefore, the conclusion regarding the acquisition of equipment should be an individual decision of each company.

- **See Recommendation 3 in Chapter V.**

Description of Conclusions

- **Conclusion 1**

On Table 4.1, there is the description of the maneuvers allowed by IS 121-007B, put in order of flight phase. They were crosschecked with the current operational training programs of airlines A and B. Both airlines train those maneuvers, but on FFS.

Also, we benchmarked the EASA regulations to ANAC. Based on the CS-FSTD (Certification Specifications for Airplane Flight Simulation Training Devices) document issued by EASA, the following maneuvers in table 4.1 could be added to IS 007B and could be performed on FTD training devices:

- Take-off – Normal;
- Cruise - High speed performance characteristics;
- Approach - 50% Loss of Thrust;
- Approach - Slats/Flaps Failure;
- Approach - Precision Approach (ILS CAT I / II / III);
- Approach - One Engine Inoperative - Non-Precision (Manual one engine out approach to DH and G/A;
- Missed Approaches – Precision;
- Missed Approaches - Non-Precision;
- One Engine Inoperative.

Table 4.1 – IS 121-007B training maneuvers comparison

Flight Phases	Training Events	FTD allowed	A	B	Observations
Preparation	Taxi	NO	X	X	
Take Off	Normal	NO	X	X	Airline A: Already done on FTD Level II for initial, differences, and requalification training.
	Crosswinds	NO	X	X	

	Engine Failure at V1	NO	X	X	
	Engine Failure on 2nd Segment	NO	X	X	
	Below Minimuns	NO	X	X	
Cruise	High speed performance characteristics	NO	X	X	
Approach	Visual Approach	NO	X	X	
	50% Loss of Thrust	NO	X	X	
	Slats/Flaps Failure	NO	X	X	
	Precision Approach	NO	X	X	Airline A: Already done on FTD Level II for initial, differences, and requalification training.
	One Engine Inoperative - ILS	NO	X	X	
	One Engine Inoperative - Non-Precision	NO	X	X	
Approach	Missed Approaches - Precision	NO	X	X	Airline A: Already done on FTD Level II for initial, differences, and requalification training.
	Missed Approaches - Non-Precision	NO	X	X	Airline A: Already done on FTD Level II for initial, differences, and requalification training.
	One Engine Inoperative	NO	X	X	Airline A: Already done on FTD Level II for initial, differences, and requalification training.
Landing	Normal	NO	X	X	
	Trim Runaway	NO	X	X	
	Following Precision IFR	NO	X	X	
	After precision IFR with Critical Engine Inoperative	NO	X	X	
	50% of reduced thrust	NO	X	X	
	Crosswinds	NO	X	X	
After Landing	Parking	NO	X	X	
Other	Windshear/microburst	NO	X	X	

- **Conclusion 2**

ANAC RBAC 121, Appendix H, states specifically that the LOFT training sessions must be performed on a level B, C or D FFS, not mentioning the possibility of using a level 6 or 7 FTD. The document does not mention the SPOT or LOE training possibility in the document, while the FAA allows an FTD usage for the entirely LOS training scope.

The FAA, according to the AC 120-35D (flight crew member operational simulations) already allows the use of flight training devices for the line-oriented training goals, such as stated on the afore mentioned document, learn and practice CRM by way of operator-developed behavioral markers that may include, but are not limited to, essential elements such as situational awareness, communication, decision making, workload management, and automation management skills.

The use of this kind of training device is also part of the training curriculum of many airlines using the AQP (Advanced Qualification Program) methodology, regulated by the CFR 14, part 121, subpart Y. This program was developed to provide realistic scenarios and consequently a more effective result for the crews. In Brazil, there is already a major airline using the AQP standards for its recurrent training and with one session already being performed on an FTD. On an almost parallel track from the AQP is the EBT (Evidence Based Training), that is more accessible to many operators because it uses a global database of possible scenarios. This type of training also aims to integrate the technical and non-technical skills on a “total assessment” of a pilot or a crew. This type of training has been the subject of a publication by the ICAO, Document 9995, published in 2013.

Many operators are transitioning from the traditional training to the EBT model, assessing competencies instead of the sole execution of a task or maneuver. Based on the core competencies and behaviors mentioned on the document, all of them can be trained using a flight training device, based on the fact that the training session is designed for such equipment. The scenario-based approach is basically the construction of an operation context and the available alternatives, much alike a role-playing game where the viable alternatives are presented and discussed, and that approach can be benefited by using an appropriate device such as the FTD.

- **Conclusion 3**

To get to the cost values, we analyzed the number of active pilots of three Brazilian airlines, gathered through the Seniority Lists of each company published on the website of the National Aeronauts Union, and the number of hours of simulator training for each company as well. This information is in accordance the current operational training program of each company.

Airline A

Pilots	1850
LOFT hours per year	4
Periodic Training possible hours per year	8
FFS Cost (US$ per hour)	340
FTD Cost (US$ per hour)	140
Discount rate	13,75%

Table 4.2 – Premises for feasibility analysis, Airline A.

Airline B

Pilots	1600
LOFT hours per year	4
Periodic Training possible hours per year	4
FFS Cost (US$ per hour)	340
FTD Cost (US$ per hour)	140
Discount rate	13,75%

Table 4.3 – Premises for feasibility analysis, Airline B.

Airline C

Pilots	1150
LOFT hours per year	4
Periodic Training possible hours per year	8

FFS Cost (US$ per hour)	340
FTD Cost (US$ per hour)	140
Discount rate	13,75%

Table 4.4 – Premises for feasibility analysis, Airline C.

Below are the descripted numbers of each airline for rent or purchase FTDs and the associated gains.

- **Airline A**

Business Case (Current rental model)

Company C Business Case (Current mode	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Pilot duo	925	925	925	925	925	925	925	925	925	925
LOFT hours per year	4	4	4	4	4	4	4	4	4	4
Periodic Training possible hours per year	8	8	8	8	8	8	8	8	8	8
Total Hours Year	11.100	11.100	11.100	11.100	11.100	11.100	11.100	11.100	11.100	11.100
FFS Cost (US$ per hour)	340	340	340	340	340	340	340	340	340	340
FTD Cost (US$ per hour)	140	140	140	140	140	140	140	140	140	140
Saving per hour	200	200	200	200	200	200	200	200	200	200
LOFT Potencial Savings	740.000	740.000	740.000	740.000	740.000	740.000	740.000	740.000	740.000	740.000
Periodic Potencial Savings	1.480.000	1.480.000	1.480.000	1.480.000	1.480.000	1.480.000	1.480.000	1.480.000	1.480.000	1.480.000
Cost Reduction	2.220.000	2.220.000	2.220.000	2.220.000	2.220.000	2.220.000	2.220.000	2.220.000	2.220.000	2.220.000
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
Cost Reduction PV =	1.951.648	1.715.735	1.508.338	1.326.012	1.165.725	1.024.813	900.934	792.030	696.290	612.123

Cost Reduction PV Amount (US$)	**11.693.649**

Business Case (Leasing FTD)

FTD Capacity	7.200

Company C Business Case (Leasing FTD)	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Pilot duo	925	925	925	925	925	925	925	925	925	925
LOFT hours per year	4	4	4	4	4	4	4	4	4	4
Periodic Training possible hours per year	8	8	8	8	8	8	8	8	8	8
Total Hours Year	11.100	11.100	11.100	11.100	11.100	11.100	11.100	11.100	11.100	11.100
FTD Capacity	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200
#FTDs	2	2	2	2	2	2	2	2	2	2
Operating Lease Cost	1.384.000	1.384.000	1.384.000	1.384.000	1.384.000	1.384.000	1.384.000	1.384.000	1.384.000	1.384.000
Service Contrat Cost	120.000	123.600	127.308	131.128	135.062	139.112	143.286	147.584	152.012	156.572
FTD Mid Life Upgrade Cost							700.000			
FTD Maintenance Cost	400.000	20.000	20.000	20.000	20.000	60.000	60.000	60.000	60.000	60.000
FTD Other Costs	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000
Total FTD Costs (US$)	**2.104.000**	**1.727.600**	**1.731.308**	**1.735.128**	**1.739.062**	**1.783.112**	**2.487.286**	**1.791.584**	**1.796.012**	**1.800.572**

Total External FFS (US$)	**3.774.000**	**3.774.000**	**3.774.000**	**3.774.000**	**3.774.000**	**3.774.000**	**3.774.000**	**3.774.000**	**3.774.000**	**3.774.000**

Cost Reduction	**1.670.000**	**2.046.400**	**2.042.692**	**2.038.872**	**2.034.938**	**1.990.888**	**1.286.714**	**1.982.416**	**1.977.988**	**1.973.428**
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
PV =	1.468.132	1.581.567	1.387.870	1.217.823	1.068.548	919.048	522.182	707.267	620.385	544.136

PV Amount 1 (US$)	**10.036.959**

Potencial Revenue Analysis

Hours available for rent	3.300	3.300	3.300	3.300	3.300	3.300	3.300	3.300	3.300	3.300
Hour price	140	140	140	140	140	140	140	140	140	140
Potential income from rent	462.000	462.000	462.000	462.000	462.000	462.000	462.000	462.000	462.000	462.000
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
PV =	406.154	357.058	313.897	275.954	242.597	213.272	187.492	164.828	144.904	127.388

PV Amount 2 (US$)	**2.433.543**

PV Amount 1 + 2 (US$)	**12.470.502**

Table 4.5 – Business Case, Airline A.

- Pilots: 1850, representing 925 pairs in training.
- Replacement of FFS Hours for FTD:
  - Recurrent Training: 7,400 hours.
  - LOFT: 3,700 hours.
- Rental Model:
  - Year Cost Reduction: $2,200,000.00.
  - Total Cost Reduction NPV (Net Present Value): $11,693,649.00.
- FTD Leasing:
  - # Equipment Capacity: 14,400 hours, 2 FTD.
  - Year Cost Reduction: $10,036,659.00.
  - Revenue Potential: $2,433,543.00.
  - Total Cost Reduction NPV (Net Present Value): $12,470,502.00.

Between the two analyses, the best option for Airline A would be to purchase a FTD but to be sure that 100% of the available hours to rent would be sold.

- **Airline B**

Business Case (Current rental model)

Company A Business Case (Current mode	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Pilot duo	800	800	800	800	800	800	800	800	800	800
LOFT hours per year	4	4	4	4	4	4	4	4	4	4
Periodic Training possible hours per year	4	4	4	4	4	4	4	4	4	4
Total Hours Year	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400
FFS Cost (US$ per hour)	340	340	340	340	340	340	340	340	340	340
FTD Cost (US$ per hour)	140	140	140	140	140	140	140	140	140	140
Saving per hour	200	200	200	200	200	200	200	200	200	200
LOFT Potencial Savings	640.000	640.000	640.000	640.000	640.000	640.000	640.000	640.000	640.000	640.000
Periodic Potencial Savings	640.000	640.000	640.000	640.000	640.000	640.000	640.000	640.000	640.000	640.000
Cost Reduction	1.280.000	1.280.000	1.280.000	1.280.000	1.280.000	1.280.000	1.280.000	1.280.000	1.280.000	1.280.000
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
Cost Reduction PV =	1.125.275	989.253	869.673	764.547	672.129	590.883	519.458	456.666	401.465	352.936

Cost Reduction PV Amount (US$)	**6.742.284**

Business Case (Leasing FTD)

FTD Capacity	7.200

Company A Business Case (Leasing FTD)	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Pilot duo	800	800	800	800	800	800	800	800	800	800
LOFT hours per year	4	4	4	4	4	4	4	4	4	4
Periodic Training possible hours per year	4	4	4	4	4	4	4	4	4	4
Total Hours Year	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400	6.400
FTD Capacity	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200
#FTDs	1	1	1	1	1	1	1	1	1	1
Operating Lease Cost	692.000	692.000	692.000	692.000	692.000	692.000	692.000	692.000	692.000	692.000
Service Contrat Cost	60.000	61.800	63.654	65.564	67.531	69.556	71.643	73.792	76.006	78.286
FTD Mid Life Upgrade Cost							350.000			
FTD Maintenance Cost	200.000	10.000	10.000	10.000	10.000	30.000	30.000	30.000	30.000	30.000
FTD Other Costs	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Total FTD Costs (US$)	**1.052.000**	**863.800**	**865.654**	**867.564**	**869.531**	**891.556**	**1.243.643**	**895.792**	**898.006**	**900.286**

Total External FFS (US$)	**2.176.000**	**2.176.000**	**2.176.000**	**2.176.000**	**2.176.000**	**2.176.000**	**2.176.000**	**2.176.000**	**2.176.000**	**2.176.000**

Cost Reduction	**1.124.000**	**1.312.200**	**1.310.346**	**1.308.436**	**1.306.469**	**1.284.444**	**932.357**	**1.280.208**	**1.277.994**	**1.275.714**
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
PV =	988.132	1.014.138	890.291	781.532	686.028	592.935	378.375	456.740	400.835	351.754

PV Amount 1 (US$)	**6.540.761**

Potencial Revenue Analysis

Hours available for rent	800	800	800	800	800	800	800	800	800	800
Hour price	140	140	140	140	140	140	140	140	140	140
Potential income from rent	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
PV =	98.462	86.560	76.096	66.898	58.811	51.702	45.453	39.958	35.128	30.882

PV Amount 2 (US$)	**589.950**

PV Amount 1 + 2 (US$)	**7.130.711**

Table 4.6 – Business Case, Airline B.

- Pilots: 1600, representing 800 pairs in training.
- Replacement of FFS Hours for FTD:
  - Recurrent Training: 3,200 hours.
  - LOFT: 3,200 hours.
- Rental Model:
  - Year Cost Reduction: $1,280,000.00.
  - Total Cost Reduction NPV (Net Present Value): $6,742,284.00.
- FTD Leasing:

- # Equipment Capacity: 7,200 hours, 1 FTD.
- Year Cost Reduction: $6,540,761.00.
- Revenue Potential: $589,950.00.
- Total Cost Reduction NPV (Net Present Value): $7,130,711.00.

Between the two analyses, the best option for Airline B would be not to purchase the FTD and continue paying the FTD rent by the hour.

- **Airline C**

Business Case (Current rental model)

Company B Business Case (Current mode	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Pilot duo	575	575	575	575	575	575	575	575	575	575
LOFT hours per year	4	4	4	4	4	4	4	4	4	4
Periodic Training possible hours per year	8	8	8	8	8	8	8	8	8	8
Total Hours Year	6.900	6.900	6.900	6.900	6.900	6.900	6.900	6.900	6.900	6.900
FFS Cost (US$ per hour)	340	340	340	340	340	340	340	340	340	340
FTD Cost (US$ per hour)	140	140	140	140	140	140	140	140	140	140
Saving per hour	200	200	200	200	200	200	200	200	200	200
LOFT Potencial Savings	460.000	460.000	460.000	460.000	460.000	460.000	460.000	460.000	460.000	460.000
Periodic Potencial Savings	920.000	920.000	920.000	920.000	920.000	920.000	920.000	920.000	920.000	920.000
Cost Reduction	1.380.000	1.380.000	1.380.000	1.380.000	1.380.000	1.380.000	1.380.000	1.380.000	1.380.000	1.380.000
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
Cost Reduction PV =	1.213.187	1.066.538	937.616	824.278	724.640	637.046	560.040	492.343	432.829	380.509

Cost Reduction PV Amount (US$)	**7.269.025**

Business Case (Leasing FTD)

FTD Capacity	7.200

Company B Business Case (Leasing FTD)	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Pilot duo	575	575	575	575	575	575	575	575	575	575
LOFT hours per year	4	4	4	4	4	4	4	4	4	4
Periodic Training possible hours per year	8	8	8	8	8	8	8	8	8	8
Total Hours Year	6.900	6.900	6.900	6.900	6.900	6.900	6.900	6.900	6.900	6.900
FTD Capacity	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200
#FTDs	1	1	1	1	1	1	1	1	1	1
Operating Lease Cost	692.000	692.000	692.000	692.000	692.000	692.000	692.000	692.000	692.000	692.000
Service Contrat Cost	60.000	61.800	63.654	65.564	67.531	69.556	71.643	73.792	76.006	78.286
FTD Mid Life Upgrade Cost							350.000			
FTD Maintenance Cost	200.000	10.000	10.000	10.000	10.000	30.000	30.000	30.000	30.000	30.000
FTD Other Costs	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Total FTD Costs (US$)	**1.052.000**	**863.800**	**865.654**	**867.564**	**869.531**	**891.556**	**1.243.643**	**895.792**	**898.006**	**900.286**

Total External FFS (US$)	**2.346.000**	**2.346.000**	**2.346.000**	**2.346.000**	**2.346.000**	**2.346.000**	**2.346.000**	**2.346.000**	**2.346.000**	**2.346.000**

Cost Reduction	**1.294.000**	**1.482.200**	**1.480.346**	**1.478.436**	**1.476.469**	**1.454.444**	**1.102.357**	**1.450.208**	**1.447.994**	**1.445.714**
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
PV =	1.137.582	1.145.523	1.005.794	883.074	775.296	671.411	447.365	517.391	454.155	398.628

PV Amount 1 (US$)	**7.436.220**

Potencial Revenue Analysis

Hours available for rent	300	300	300	300	300	300	300	300	300	300
Hour price	140	140	140	140	140	140	140	140	140	140
Potential income from rent	42.000	42.000	42.000	42.000	42.000	42.000	42.000	42.000	42.000	42.000
i =	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%	13,75%
N =	1	2	3	4	5	6	7	8	9	10
PV =	36.923	32.460	28.536	25.087	22.054	19.388	17.045	14.984	13.173	11.581

PV Amount 2 (US$)	**221.231**

PV Amount 1 + 2 (US$)	**7.657.452**

Table 4.7 – Business Case, Airline C.

- Pilots: 1,150, representing 575 pairs in training.
- Replacement of FFS Hours for FTD:
- Recurrent Training: 4,600 hours.
- LOFT: 2,300 hours.
- Rental Model:
- Year Cost Reduction: $1,380,000.00.
- Total Cost Reduction NPV (Net Present Value): $7,269,025.00.
- FTD Leasing:
  - # Equipment Capacity: 7,200 hours, 1 FTD.
  - Year Cost Reduction: $7,436,220.00.
  - Revenue Potential: $221,231.00.
  - Total Cost Reduction NPV (Net Present Value): $7,657,452.00.

Between the two analyses, the best option for Airline C would be to purchase a FTD but being sure that 100% of the available hours to rent would be sold.

Chapter V

Recommendations, Limitations of Study, Future Research, and Lessons Learned

The purpose of this research project was to analyze opportunities to use Flight Training Devices on recurrent pilot training in Brazil. The study concluded that FTDs can replace Full Flight Simulators in one recurrent session per year, as well as for LOFT session.

Along with the literature review and benchmark with current legislations in Brazil and other regions, some recommendations are important to back up the conclusions.

- **Recommendation 1**

The two largest Brazilian airlines could review their training programs in order to include the use of FTDs levels 6 and 7 for normal and abnormal operations during recurrent pilot training in maneuvers already approved by ANAC through IS 121-001

- **Recommendation 2**

ANAC could incorporate the practices currently adopted by EASA into its legislation.

- **Recommendation 3**

As demonstrated in the study, the migration of the training of some maneuvers in the FFS simulation equipment to an FTD equipment is economically viable, and our recommendation is that Brazilian companies work with the local aeronautical authority to approve the training program with FTD-trained maneuvers as demonstrated in this study.

Limitations of Study

To better achieve the feasibility of the implementation of FTDs, a next study should consider the number of active pilots by fleet for each airline. For the matter of this study, we considered only the number of pilots of narrowbody aircraft for airlines A, B, and C, disregarding different fleet.

Recommendation Details

- **Recommendation 1**

Two of the biggest airlines in Brazil, A and B, should incorporate the use of FTD for maneuvering training on their Operational Training Programs, for both normal and abnormal operations. To achieve that, those airlines should consider the maneuvers already approved by IS 121-007B.

Also, considering EASA document CS-FSTD, there is an opportunity to increase the number of maneuvers covered by FTD, which are still not applicable for ANAC. So, based on the example of Austrian Airlines and the European document, the use of FTD in Brazil can be increased, allowing airlines to switch one of the yearly recurrent training sessions from an FFS to FTD.

- **Recommendation 2**

ANAC could review current legislation, especially IS 121-001B, which sets out the maneuvers that are authorized to be trained in FTD. During this research, we glimpsed several maneuvers that are currently not authorized by ANAC to be performed in FTD but are authorized by EASA.

- **Recommendation 3**

As mentioned in Chapter IV, after demonstrating the financial results of the three business cases carried out for the largest Brazilian airlines, shown below, the recommendation is that the migration of training from FFS equipment to FTD brings savings for airlines, in addition to enable the same level of quality. For all companies, even with different values, due to the number of pilots and type of training program, in all studies with the equipment rental model, there were gains.

For the company's decision to acquire FTD equipment on a lease basis, the recommendation is that each company should assess the financial moment it is experiencing, if and if the revenue potential is feasible. In this study, 100% transfer of the simulator's excess capacity was measured and, according to the data presented, some companies showed very high potential for selling capacity, which can be a risk for the Business Case if this capacity cannot be transferred in full.

Airline A

- Rental Model:
  - Year Cost Reduction: $2,200,000.00.
  - Total Cost Reduction NPV (Net Present Value): $11,693,649.00.
- FTD Leasing:
  - # Equipment Capacity: 14,400 hours, 2 FTD.
  - Year Cost Reduction: $10,036,659.00.
  - Potential Revenue: $2,433,543.00.
  - Total Cost Reduction NPV (Net Present Value): $12,470,502.00.

Airline B

- Rental Model:
  - Year Cost Reduction: $1,280,000.00.
  - Total Cost Reduction NPV (Net Present Value): $6,742,284.00.

- FTD Leasing:
  - # Equipment Capacity: 7,200 hours, 1 FTD.
  - Year Cost Reduction: $6,540,761.00.
  - Revenue Potential: $589,950.00.
  - Total Cost Reduction NPV (Net Present Value): $7,130,711.00.

Airline C

- Rental Model:
  - Year Cost Reduction: $1,380,000.00.
  - Total Cost Reduction NPV (Net Present Value): $7,269,025.00.
- FTD Leasing:
  - # Equipment Capacity: 7,200 hours, 1 FTD.
  - Year Cost Reduction: $7,436,220.00.
  - Revenue Potential: $221,231.00.
  - Total Cost Reduction NPV (Net Present Value): $7,657,452.00.

Future Research

Prior to a possible addition of more maneuvers to IS 121-077B, enabling more maneuvers to be performed on FTDs, a study with the impact of the use of such a device on the performance of pilots could be conducted.

Lessons Learned

It was observed during the study that Brazil is still at an early stage in the use of FTD's, the view of professionals is that the FTD equipment is a very simple equipment and that it does not reflect the simulation of FFS equipment. However, the majority of Brazilian professionals with FTD contact with equipment with lower levels (1,2,3 or 4), that is, equipment of less complexity and that end up leaving the perception that training in FTD equipment is not a quality training.

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