# Chapter 1.

# Flight simulators.

## Flight simulators.

### Basic description of flight simulators.

A **flight simulator** is a device that artificially re-creates aircraft flight and the environment in which it flies, for pilot training, design, or other purposes. It includes replicating the equations that govern how aircraft fly, how they react to applications of flight controls, the effects of other aircraft systems, and how the aircraft reacts to external factors such as air density, turbulence, wind shear, cloud, precipitation, etc. Flight simulation is used for a variety of reasons, including flight training (mainly of pilots), the design and development of the aircraft itself, and research into aircraft characteristics and control handling qualities.

Flight simulators are commonly used to maintain level of pilot training. Several different devices are utilized in modern flight training. Cockpit Procedures Trainer (CPT) are used to practice basic cockpit procedures, such as processing emergency checklists, and for cockpit familiarization. Certain aircraft systems may or may not be simulated. The aerodynamic model is usually extremely generic if present at all.

The one of main goals of training on flight simulator is to increase highly automated skills and quality execution but non-standard solutions, which are characterized by flight activity during non-standard situations during flights, the load on intellectual pilot function while performing assigned tasks kinds of aircraft.

### Types of flight simulators.

All available aircraft simulators can be divided into two main types:

* software simulators;
* training complexes.

In modern terminology, aviation simulators with a fixed cabin belongs to flight simulators. Simulators significantly differ in design depending on the destination: from mechanics and electronic equipment from the dashboard and the front part of the fuselage, designed to train pilots to computer programs PCs. Many software simulation realism is characterized as low because it does not allow the use of all the senses and is used in gaming purposes for personal computers.

Software simulators divided into procedural and comprehensive. **Procedural** aircraft simulator designed for training flight crews. This technical teaching tool that allows you to shape the skills needed in the real world. It has the following main features: simulator imitation of individual fragments of conditions of real activity pilot; the possibility of practicing in certain operations and actions of real pilot with cab equipment; the possibility of objective monitoring results of all operations, practiced on the simulator and instructor’s actions.

The procedural simulators provide training of specific actions, such as control of the aircraft, engines and aviation systems, staff, management of electronic equipment, combat use and so on. Typically, this kind of simulators are composed of display boards and instrument simulators and simulators control levers, whose boundary movements, load characteristics and tactile sensations correspond to real at all stages and modes of flight. Some devices that are closest to the operation are real.

The procedural simulators designed for working crew procedures and training for the flight. Purpose consoles, instruments and controls are generally simulated using touch monitors. For the convenience of individual panels and controls can be presented as full-size models. Additionally, depending on the amount of realized tasks, training can be divided into the following types:

1. Functional (primary) cabins, which are modeled to display information controls. They make it possible to deepen the knowledge of students-pilots of aerodynamics and aviation equipment, off procedure during the pilot operation of aircraft. Primary aviation simulators are usually the simplest, often made by the aviation units and schools. Stands and models can be considered as functional simulators.
2. Specialized training designed to prepare cadets-pilots for doing specific activities, for development of certain psychological qualities and skills of action in special cases in flight.

A **comprehensive** aviation training simulator implements similar to procedural simulator, but on advanced level and has such basic features as approaching the maximum conditions of the pilot in the simulator to the real conditions of the flight. Providing practice on the simulator in general of all tasks of a real pilot, which he carries in flight; enable objective monitoring results of all tested tasks.

An integrated simulator - the highest level of technical training to prepare flight crews and effective means of maintaining trained skills of pilots. An integrated simulator recreates real cab interior also makes it possible to work out all modes of operation of the aircraft. Simulators of highest qualification level have complete set of tools that provide adequate performance in all channels of perception cadet.

### The Concept of Real-time Simulation

Typically, office operating systems provide acceptable control of the mouse and a mechanism for ensuring that the software is activating mouse 50 times a second part of the operating system, and is transparent to the user. The fact that the operating system does discretize this time, in a minor steps, so that the mouse control code is guaranteed to be performed 50 times per second. These time steps less than we can discern with our eyes (and hands and brain), giving the mouse that appears to be instantaneous and continuous movement, in fact implemented at discrete intervals.

Of course, we are all accustomed to such systems. The cameras at a football game capture frames every 1/25 second, which are transmitted to the TV in the house. Because the time step is so small, it seems that the players on the field are moving in the normal continuous mode, we would expect to see if we were sitting on the bench in the match.

The same situation occurs in the simulation flight. On the plane, the pilot moves a steering wheel. Assuming that a direct cable connection to the control surfaces (and not paying attention to the inertia of the control surface), the elevator moves at once, causing a disturbance to the plane, which is considered as a change in the pitch of the pilot, which reacts with the other control column movement for the correction of the pitch angle. In flight simulator, the position of the handle is digitized, elevator deflection is calculated, the new pitch ratio is computed and the image displayed on the screen via the visual system with a new pitch, allowing the pilot to adjust the attitude of the aircraft. The important point is that the total time for this calculation should be sufﬁciently short, so it seems the pilot instantly. In today's simulator, these calculations should be completed within 1/50-th of second or 20 milliseconds.

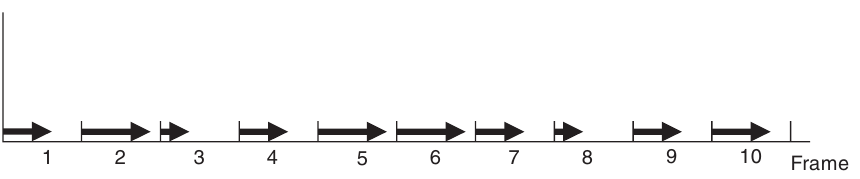
This concept is illustrated in Figure 1.1, which depicts 10 frames of a simulation. The arrow for each frame shows the proportions of the frame used in the calculation of the simulation. If the frame time is sufficiently small, say 1 / 50th of a second, and if any frame in the computation will never exceed the time frame, the real-time simulation.

Fig. 1.1. Real-time frames.

Note that there is an important distinction between the real-time calculations and fast computers. Although real-time simulations may need a fast computer, all calculations have to be completed within the time frame (Burns and Wellings, 2001), while for the fast computational problem, only metric is the overall time. Some simulation packages assume that the code generation in a compact form allows the real-time computation. While this may be true for certain applications, in all examples described in this book, the term real-time is used to indicate that all calculations are resolved within one frame for each simulation frame.

Another important factor has been affected. In addition to the basic modeling tasks, the processor may also be required to perform other background tasks. If this additional load calculation results in contradictory within a frame period to perform this task of modeling, simulation in real time cannot be sustained. Therefore, the operating system is an important part of any real-time simulator. The operating system must ensure that it will perform the task of simulating each frame and never introduce delays that cause the problem of modeling a frame exceed its limit.

The safety critical real-time environment, it is necessary to demonstrate that the frame rate in real time can never be broken beyond any reasonable level of doubt. Although the software for flight simulation is not critical for safety, real-time limit still to be performed mode. As a rule, it is the duty of the simulator of the designer. You can monitor the performance of real-time flight simulator and record any violations of the frame period. However, if the frame rate does fall, it is usually apparent to flight crew, as it is noticeable discontinuities in the visual system, or discernible lag in response to the aircraft or even changes in the frequency of the sound output system.

The simulator designer has, in fact, the time budget for the completion of all calculations in the frame and, therefore, trying to use as much of the frame time as possible, as it may leave a small margin for error in these estimates (or for future expansion), in particular as some calculation times data dependent. Taking into account all restrictions on the content of the visual system of the scene, processing flight model, engine model, the weather and so on. It is not uncommon for a frame period should be exceeded sometimes even for full flight simulator, in particular, as the simulator manufacturer cannot have full control over the behavior of the video card in all conditions of flight. However, providing real-time operation, especially for the worst conditions, it is an integral part of validation and acceptance testing system.

### Training versus Simulation

Flight simulators are used in flight training and is easy to assume that the two terms are synonymous and interchangeable. However, light training provided fulfil l education requirement. The equipment used for this preparation may also include a light simulator, but in this role, just equipment simulator. Simulator, together with an instructor and curriculum is a training package. Confusion has arisen because in some cases, the flight simulator is a pure replacement of the aircraft, and this may have led in the past to purchase flight simulators that were poorly adapted to the requirements of vocational training and is therefore provided a low education.

The first phase of purchases for any flight training program is an analysis of training needs. This establishes that the training program is required, and what is required. On one hand, if the training equipment low, it cannot provide effective training. On the other hand, if the inflated preparation equipment, cost simulation equipment may be excessive.

The often-quoted example of an effective coach is a "cardboard bomber". In the early stages of flight, pilots have to learn a series of checks, including checks before the flight, in-flight inspections, and emergency shutdown test. Sitting in a normal chair, in front of a cardboard facsimile of the cabin, with no moving parts whatsoever, the pilot can indicate on the tool, or press the switch that corresponds to each inspection. Photos used in such a way that each item physically resembles the actual equipment, and is located approximately in the same place as in an airplane. However, the requirement of training equipment just to help pilots remember checks. It is obvious that such equipment would be inappropriate in the later stages of learning, which need real tools aircraft or switches. Similarly, the actual use of aircraft equipment would be an unnecessary expense at the initial stage of training.

For the core curriculum, analysis of training will be conducted by a team of professionals with a good understanding of fl ying training, simulation technology, teaching methods and human factors. The team will not include flight instructors, which will give further training or simulator company that will produce the equipment. For the airline or military training, specific training will be ed in terms of the desired results (or output) training. For example, the tool for the coach, the requirement may declare "the completion of the training, the pilot must be able to demonstrate ILS approach with a cross wind to the maximum permissible value for the aircraft with one engine failed," as part of the training requirement. The purpose of this single statement is that the simulator requires ILS instrument, realistic model of an engine failure, the model forecast, which includes cross-winds and presumably a database of navigation aids including ILS beacons. Please note that the requirement does not include the elements of motor control, the details of weather patterns or the maximum number of ILS approaches must be provided.

Presumably, such information would be given elsewhere in the training requirement. The training needs analysis team will review the training syllabus, discuss the detailed requirement with the customer (possibly to modify or clarify the requirement), review the technical options (to establish any constraints or parameters) and discuss the training methods used by the instructors. For example, some of the questions to be asked about the ILS simulation might include the following:

* The need for aural cues;
* The accuracy of the simulated ILS;
* The range of the ILS;
* The failure modes of the ILS;
* The method of selecting an ILS frequency;
* The number of ILS channels;
* The failure modes that can be set by an instructor;
* The physical representation of the ILS.

This ﬁnal consideration might give the option of using a graphics display to represent the ILS instrument rather than a mechanical emulation, leading to the clariﬁcation of further issues, including

* The resolution of the ILS display;
* The need for anti-aliasing;
* The update rate of the display.

The important point to bear in mind is that the training requirement extends across the whole scope of the training programme, and even includes non-functional requirements, such as

* Access dimensions;
* Power requirements;
* Emergency lighting;
* Reliability and availability ﬁgures;
* Air-conditioning;
* Safety issues.

Once the training requirements are clearly deﬁned, these are passed to prospective manufacturers who will be invited to tender to supply the training equipment. There is often some variability in these requirements. For example, the requirement may simply state the tasks to be trained and the level of skill to be attained, and possibly the time available to attain it, using the training equipment. In this case, the simulator manufacturer can match their equipment to the training requirement, advocating one technology rather than another.

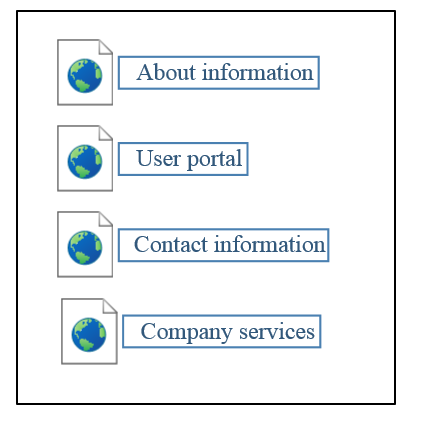
One further issue covered in a training requirement is the method of acceptance. For an airline, their senior pilots are likely to retain close links with the simulator company and go through a formal series of acceptance tests at the factory, prior to shipment and delivery of the simulator, followed by further acceptance tests following the installation.

## Existing working examples of aircraft and pilot portals

The idea of portals are to provide brief or full information of products and services that each company provides. Companies sites that have been investigated:

* Panam flight academy.
* Cardif aviation training center.
* FSC training company.

In some cases portals or sites provides full stack of services like user/pilot portal with user data stored and assigned to one. Custom approach is to make a sum of all possible services in one web application: contact information, company description, company services, user portal (Fig. 1.2, Fig. 1.3, Fig. 1.4).



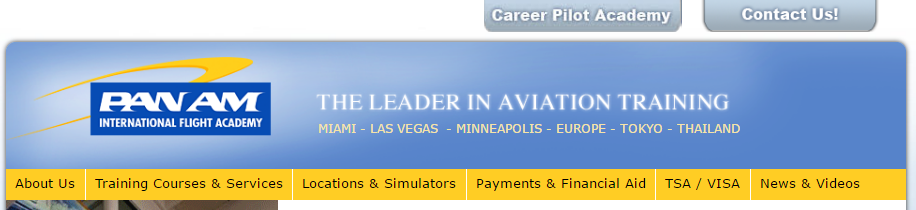
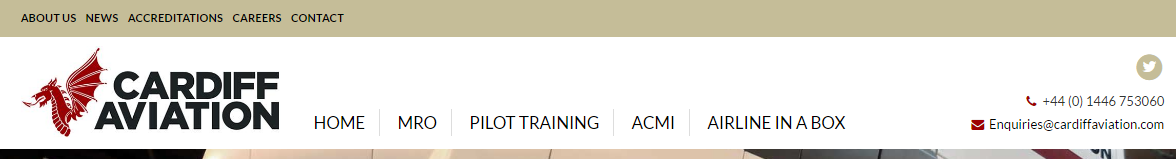


Fig. 1.4. Cardif aviation training center site.

Fig. 1.3. Panam flight academy site.

Fig. 1.2. Common company site map.

From other side, some company sites and portals provides only service for get-to-know and get familiar with products that company provides (Fig. 1.5). User cannot log in or register to become a member or get member rights on the site. The user/pilot portal is located on internal servers and provides functionality on closed basis.

Due to impossibility of getting access to closed part of user/pilot usability part, the investigation cannot be proceed and only theoretical and logical results is used.

## Service-oriented architecture.

Fig. 1.5. FSC site with log in functionality.