Motion in Flight Simulators
A story of Evolution

Author:
Peter John Davison, B.Sc., Ph.D.
Vice President.
peter@aviationfocus.aero

Aviation Focus
Suite D, 6/F., Ho Lee Commercial Building
38-44 D'Aguilar Street, Central
Hong Kong
+852 2251 8382
info@aviationfocus.aero

Contents

1. Early Simulators

Ever since Man developed flying machines, he has endeavored to pass on flying skills to successive generations of pilots. Over time, devices were invented which substituted for the real aeroplane. This is just as well as, prior to this, the aspiring pilot merely listened to a briefing, read some notes, jumped in and set off on what often turned out to be a one-way flight with a drastic and sometimes fatal ending.

As this picture shows, the first training devices were rudimentary to say the least. However, they were useful in at least demonstrating to the student pilot the range of inputs to the flight controls which would result in the desired outcome. These devices typically had a basic representation of the arrangement and range of movement of the controls that he or she would encounter in the actual flying machine. Moving these controls would result in visible deflection of flight controls on a structure resembling a wing, rudder or aileron. The student could look around and observe these movements. They would therefore gain a valuable insight and awareness of the likely outcome of control movement that they would experience in the actual aircraft.

Even these earliest machines, the so-called "barrel simulators" shown in the above picture could approximate the motion resulting from control deflection simply by the outriders moving the barrels over one another to result in roll, pitch and yaw.

Even this rudimentary and basic experience would or could be a life saver and must have alerted the flying community to the benefits of learning to fly with feet planted on "terra firma".

The appearance of these early simulators was sometimes reminiscent of an aircraft and sometimes looked more like a shopping trolley or bedstead, (a term later used to describe a simulator of the 60s used to test vertical take-off at landing concepts).

Whatever the size and shape, all these devices had common goals and served early pilots well in preparing them for early aeroplanes. They could at least see the flight control surfaces moving in the natural sense rather than to try and explain it on a blackboard (although this was also surely attempted).

Even the earliest machines, the so-called "barrel simulators" shown in the above picture could approximate the motion resulting from control deflection simply by the outriders moving the barrels over one another to result in roll, pitch and yaw. Only heave and surge were missing.

The student would already have been introduced to words like "roll" and "pitch" as these are movements familiar in maritime usage being the natural movements of a sailing vessel. The concept of "yaw" although being easy enough in concept, was instead referred to as "port" and "starboard".

Further approximation of motion was attempted by mounting the device on some sort of moveable equipment. As the picture below shows, the result could be quite hair raising.

More often than not the motion achieved was more of an indication of motion rather than motion itself. The picture below shows a device demonstrating such a quality but it is easy to see that, in this case, the motion achieved would not be exactly convincing.

2. Acceleration in Flight Simulation

2.1 How acceleration is sensed Introduction

However, on first flying in a real aircraft, the student pilot was exposed to a new sensation which had no counterpart in the (new fangled) simulator and which could not be fully experienced except during actual flight conditions. This sensation was (and remains to this day), "acceleration". It is not exactly true to say that we do not experience the sensation of acceleration everyday because we do. For instance, we all know (or think we know) the rather familiar feeling of gravity. We also experience accelerations whenever we change our direction or rate of motion. Isaac Newton was able to describe these accelerations mathematically in his three laws of motion.

Happily, the student pilot does not have to have a deep understanding of Newton's Laws in order to fly an aircraft but when it comes to trying to recreate the motion of an aircraft in the simulator environment, these laws dictate and direct the design of the device so that the sensation of motion, is simulated in at least a convincing manner.

2.2 Anatomy of Acceleration.

The human body senses accelerations using the Vestibular Apparatus within the Inner Ear. The vestibular apparatus senses two kinds of acceleration, Rotational and Linear. Rotational acceleration is that produced by movement of the head in any of the planes so familiar to us. Up/down (nodding), left/right, (shaking) and tilting, (leaning). Linear (which includes vertical) accelerations are sensed by the Otoliths which are located at the base of the vestibular apparatus. Otoliths sense translation of movement (accelerations) in vertical and lateral planes, including gravity.

The vestibular system therefore detects accelerations in all world planes and translates them into nerve signals that are sent to the brain for integration. The brain then reaches a solution, which we experience as our position and motion in space. It is worthwhile mentioning that the exact mechanism by which these computations are made by the brain are not fully understood. However, our experience leads us to suspect that the neural pathways which process these signals are not absolutely discreet and there is evidence that interaction between them occurs, a process called parallel processing and we shall return to this later.

We may take this for granted until we suffer an injury or sickness which damages this delicate apparatus. The result is that we can feel "giddy" or have difficulties maintaining our balance. In severe cases, we may not be unable to stand up straight (or at all).

3. Acceleration in Flight Simulation II

3.1 Motion in Flight

When flying an aircraft, the human brain is constantly receiving information of changing accelerations and interpreting it in terms of flight conditions. Smooth flight is a condition where the acceleration in all planes is constant or nearly constant. Turbulent flight is experienced when there are multiple changes of accelerations of varying magnitude. When the aircraft enters a turn, or a climb or a descent, or increases or decreases its speed, this results in accelerations which we can interpret and which influence our control input. For instance, pulling hard back on the control column results in a rapid change in the direction of motion and we feel this as "G". The intensity of this feeling may well induce us to relax or cease that control input in order to reduce the rate of change (or acceleration) and hence the "G" of this maneuver and return the aircraft to a steady flight condition.

It should be apparent from the above introduction that changes in acceleration are very important in determining the state of flight. This was realized by engineers who reasoned that a device capable of measuring these accelerations could derive enough information to direct the progress of a flight. The resulting equipment is known today as an Inertial Reference System and will be familiar to many pilots. At the beginning of a flight, the IRS is given a reference in the real world from which to compute all subsequent accelerations. This process is called Initialization and is the first thing that happens when the IRS is switched on during cockpit preparation.

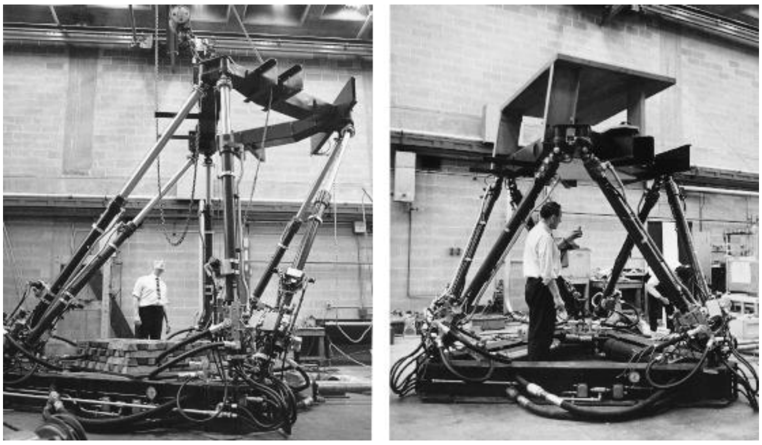
When initialization is complete, the IRS can be selected to NAV mode and is now ready for flight. When the aircraft accelerates in any direction (including up and down) the IRS is able to integrate these accelerations into information useful to the pilot such as Groundspeed, direction of movement and hence, change of position. It is remarkable straightforward for the IRS to determine rates of change of position etc and, when combined with suitable instrument interfaces, a complete navigation picture is available to the pilot.

4. Motion within a Flight Simulator

4.1 Achieving motion simulation. A game of deception.

But what does this have to do with motion in flight simulators? If accelerations can give so much information about position and motion, then surely by recreating these accelerations in a simulator, the pilots may experience a similar environment as they would in an actual aircraft in flight.

Considerable progress in producing accelerations in a tethered device was made in the 60s by the development of Gough-Stewart Platforms one of which is shown in below.

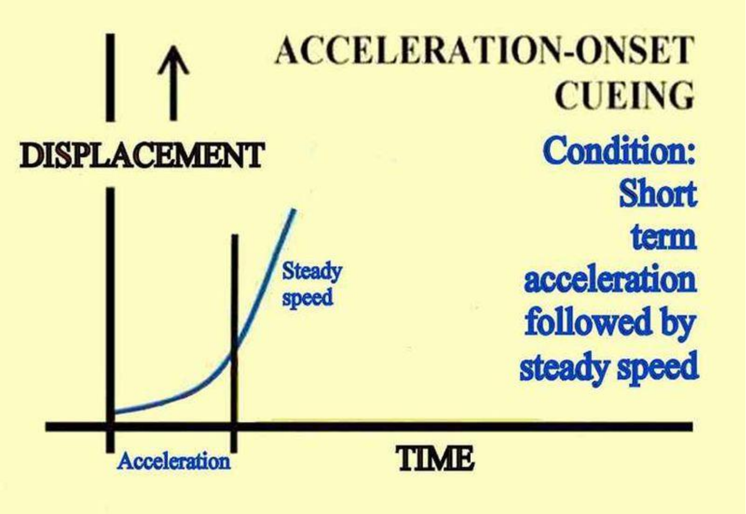


The design basics are still the same today and it is only really the software driving these platforms that has evolved significantly.

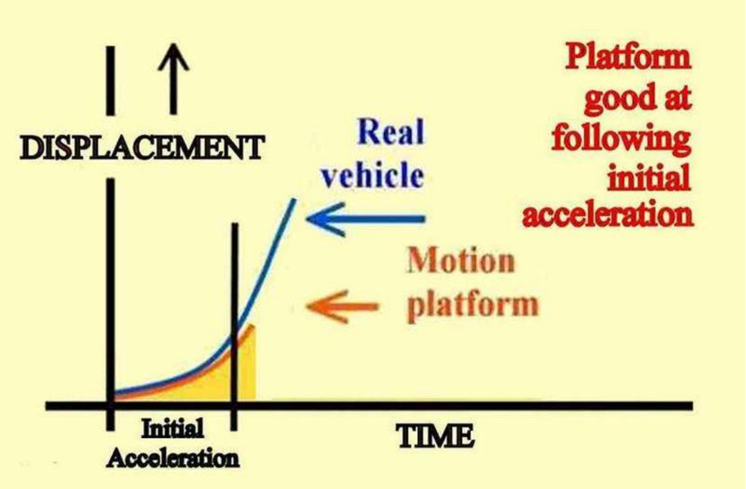
However, the problem is that, since the simulator is tethered to the earth, only transient accelerations can be produced by moving the motion platform a limited amount in one direction or another.

That movement is accomplished by jacks (either hydraulic or electrically actuated) whose length of travel (or throw) is limited. The process of Acceleration Onset Cueing attempts to compensate this problem.

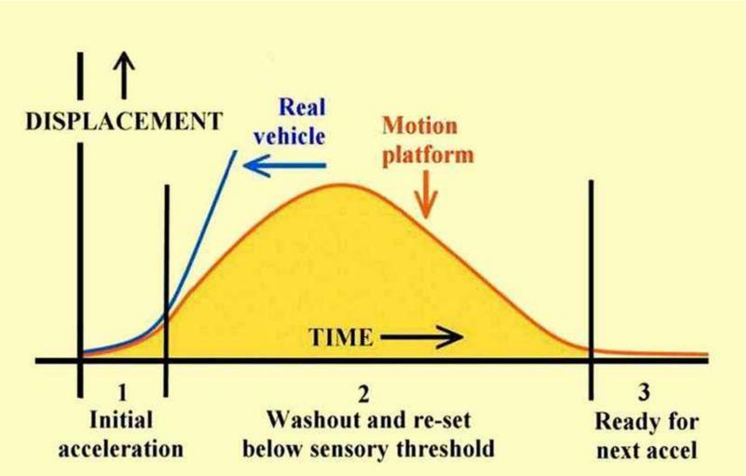
Initial acceleration is produced by the movement of the jacks in a given direction, the so-called Initial Displacement phase.



As the jacks reach the limit of travel, the rate of displacement is reduced to zero at a rate which is below the threshold of human sensory system, the so-called washout phase.



The jacks are then returned to the null position once again at a rate below the human sensory threshold, the so-called reset phase.



The problem with such a system is that, although initial accelerations may be quite convincing to the body sitting in the simulator, the washout and reset phases are “dead” periods during which further accelerations (which may be present in an aircraft in flight) are not possible. These discontinuities can in give rise to a perception of “wrong movement” and sometimes can lead to simulator sickness which could detract from the simulation experience or even require the training to stop in order to prevent further sickness.

The software used to drive Acceleration Onset Cueing has improved a lot recently and so have visual systems, to the extent that simulator sickness is much more uncommon than before. The image below shows the deployment an acceleration platform on a modern Full Flight Simulator (FFS).

[It should be noted at this point that, the human body is unable to sense zero rate accelerations and so cannot determine if such a condition is as a result of being at relative rest, or moving with constant velocity (either condition being characterized by lack of acceleration.) This is unlike an Inertial Reference System, which quantifies the rate of change of momentum (acceleration) and can determine the steady state resultant as either rest or constant velocity.]

However the simulation of acceleration in flight simulators remains limited and, in fighter aircraft whose accelerations are typically large and sustained, motion simulation is not used.

There is one simulator called Desdemona in the Netherlands in which sustained accelerations can be produced by mounting the simulator vehicle in a gimbal which is free to rotate thus producing centrifugal forces which are equivalent to sustained G forces. The problem with this device is that it is experimental and comes with a colossal price tag. Also the cockpit section within the simulator vehicle is a generic single seat flight deck. The cost of mounting a replicated airliner flight deck in such a vehicle would be so high as to be economically impossible for even a large airline. The resulting vehicle would be very large and the associated gimbal mountings and machinery could be more expensive than an airliner.

Therefore the problem remains that the simulation of accelerations in flight simulators is difficult and limited by the laws of motion relating to a tethered device.

5. Acceleration in Flight Simulation III

5.1 Sensing of motion within a Flight Simulator - Overview

There are ways other than through acceleration by which the human body can perceive motion. If you have ever sat in an IMAX theatre, you will have enjoyed the feeling of motion as you sit in the Space Shuttle and blast off into orbit, or plummet like a meteor down a fantastic spiral on the latest adventure ride at a new wonderland park.

You may have noticed that the experience may even make you feel unsteady in your (fixed) seat or even a little sick. This is because the brain interprets the visual stimulation as part of the equation of motion. What do we mean by the equation of motion?

In the real world, medium and large magnitude accelerations are usually accompanied by large spatial displacements and we would see these as a shifting visual field or optic flow. The combination of spatial displacement (acceleration) and visual progression (optic flow) is sensed and interpreted as motion. Therefore;

Equation of motion

Acceleration + visual = (perceived) motion.

If we take away the acceleration yet leave the accompanying visual, the brain (being a very remarkable and adaptive organ) will attempt to complete the equation with a (false) sensation of motion. Pilots may experience this in a simulator when the instructor asks them to “look away” or “close your eyes” when re-positioning the visuals for the next exercise. If they choose not to do so, they may experience the type of perception described above, and feel sick as a result. The repositioning is not accompanied by any acceleration of the motion platform in this case so the false acceleration is due to signal processing within the central nervous system.

There are some other senses such as proprioception and pressure sensors in the muscles skin and bones which make a contribution to the equation.

To summarise, the equation of motion as experienced by the human body, is derived by collecting many stimuli, integrating the signals in the brain and then interpreting the result as our perception of motion. The major components of this equation are Acceleration and optic flow (visual).

5.2 Neural Parallel Processing.

The neurophysiology of the above processes is under constant investigation by medical research teams around the world (along with many other brain pathways no doubt) and the data so gained, apart from being fascinating in it's own right gives us clues about how we can "deceive" the brain into reaching the conclusion of "real motion" in a simulator.

If the brain's solution of motion is derived from equations of acceleration and visual input, then, when only the visual quantity is present, the brain attempts to solve the equation by substitution of a value equivalent to the acceleration component. Where can it derive this value? The answer is, from previous experience. Our expectations of the future are often derived from our experience of the past, the learning experience. The human brain is especially adept at these substitutions and some examples exist.

In a famous experiment of the 60s, a special pair of glasses was constructed in which the image of the world was inverted using prisms. The wearer of these glasses would at first be entirely confused by his upside down world and yet in a short time, the brain would simply resolve the data and the subject would now "see" the image of the world in the correct sense. Of course, the real fun would start when the experiment was over and the subject removed the glasses only to find himself once again in his topsy-turvey world! Happily, this situation was once again short lived and normal vision would return as the brain once again recomputed the visual signal. The visual cortex of the brain is therefore very adaptive to changes in visual stimuli and can make sense of many confusing sensory inputs.

Similarly, the Vestibular Cortex is adept at integrating signals from the Vestibular Apparatus into information of self motion and it has been shown that visual signals are summed with vestibular signals to achieve this. It will probably be many years before researchers can map the brain in enough detail to provide a complete picture of this process but **parallel processing** of visual and vestibular signals is certainly involved in determining our perception of motion. It is the relative importance of each that we are concerned with when deciding how to provide the most convincing experience of motion within an airplane flight simulator.

We have determined that motion is determined by visual stimuli and by vestibular stimuli. How can a simulator supply this information to our brain in a convincing fashion?

6. Acceleration in flight Simulation IV

6.1 Motion dynamic in a flight simulator

Which is the most important contributor to the motion dynamic in a flight simulator, visual or vestibular stimulation? Before looking at this, it is useful to refresh our understanding of these stimuli in a real airplane.

Many of you will have heard of air accidents that resulted when the pilots “thought” they were in level flight when the airplane was actually in a so called “death spiral”. This can occur when, in the absence of visual confirmation, the pilots miss interpret the flight instruments and rely instead on vestibular signals which “tell” them to go in the wrong direction, the so called “leans”. In some cases, the pilots regained visual contact with the outside world with enough time to quickly correct the situation. It is evident from this that the visual signals quickly over ruled the vestibular signal. Another way of putting this is in the old adage “seeing is believing”.

The vestibular signals in an airplane in flight can, when taken in isolation, prove to be notoriously unreliable but the visual signals are easily interpreted and usually correct (we discount for a moment the obvious visual artifacts such as “goldfish bowl”, “whiteout” etc). We expect therefore that the same may apply in a flight simulator. Let’s look at each in more detail.

6.2 The vestibular signal in flight simulation

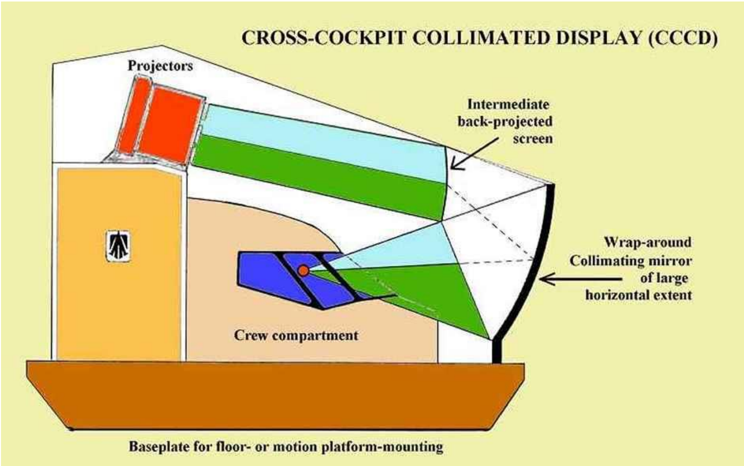
How is this signal supplied in a flight simulator? The motion platform accelerates the simulator using a Gough-Stewart six-axis platform controlled by a motion cueing program. This results in a stimulus to the vestibular system. However, in the simulator due to the constraints of earth tethering, these stimuli can only be short lived and incomplete. At best therefore, they can only approximate to the vestibular signal present in an airplane in flight (which have been shown to be unreliable in isolation as discussed above.)

6.3 The visual signal in a flight simulation

When visual systems were first incorporated into flight simulators, they were derived by tracking a camera over a large model of the terrain (complete with little model sheep, houses and human beings) and projecting the picture onto a screen in front of the pilots in the simulator vehicle. The result was good enough to add a certain degree of reality to the TSE but was never going to be a long term solution for many reasons.

Firstly, such a system could not model day or night, or changes of weather to any useful degree. Also, it was clumsy and liable to frequent mechanical breakages. It was very expensive and required a large space to accommodate the model landscape and the gantry housing the camera tracking apparatus. The use of such a system also alerted the manufacturers to the problem of parallax error in which the visual aspect for each crew station was different. This problem was still apparent when the first digital visuals were produced and projected onto the simulator screen.

This problem was solved using collimation. Collimation is the process of straightening light beams so that they are parallel. This results in an image which appears to originate from a source at infinity. It may thus be viewed in the natural sense from all stations within the simulator vehicle (in much the same way as a distant object such as the Sun looks the same to observers on the opposite sides of the street).



Digital imaging improved more or less in parallel with increases in computing power and continues to improve. These advances have lead to the production of so-called wrap around visuals in flight simulators and has transformed the industry. With such a visual, it is possible to fly a “visual” circuit around a runway observing the landing area in the correct sense from all points in the circuit.

Indeed, so convincing is this, that take offs and landings incorporating many visual circuits can be flown in a simulator rather than in an aircraft in flight and, for pilots with certain previous experience, can lead to the so-called “Zero Flight Time Qualification” in which a Type Rating can be issued without flying the aircraft concerned.

Such a qualification could not be achieved without these visual systems. The pace of improvement in computer processing powers shows no sign of slowing and it is likely that visuals will continue to evolve to a point where they differ little from that experienced in the aircraft itself.

Indeed, the motion picture industry has used similar advances to great effect in the last ten years and entire blockbusters have been produced using only so-called CGE, or Computer Generated Effects.

By contrast, due mostly to limits imposed by simple physics, improvements in the simulation of accelerations (vestibular) have been rather pedestrian and it is unlikely that significant advances will take place.

6.4 Visuals and the motion dynamic.

Where does this leave us when we consider the motion dynamic in a flight simulator?

It is apparent from the above considerations that motion is perceived by a complex interaction of vestibular (acceleration based) and visual stimuli according to the equation of motion. In a flight simulator, the vestibular signal is provide by the acceleration platform and the visual signal by a moving digital image. The vestibular dynamic is limited because the device is tethered to the earth whereas the visual dynamic is evolving rapidly.

The quality of the visuals has reached a point where it is contributing the lion's share of the motion equation in the flight simulator. One could challenge that, when practicing simulated maneuvers in IMC, since the visual is lacking, it is up to the vestibular (acceleration platform) to provide the only motion dynamic. However, in an airplane in flight we have already seen how unreliable this dynamic can be so is it really necessary to mimic this during simulation of non-visual (IMC) maneuvers?

A quite convincing sensation of continuous motion could be achieved if a "sweeping" visual was provided at the peripheral field. In an airplane in flight in IMC, this is apparent to pilots as the airplane penetrates cloud. The idea of motion perceived in this way is established in pschycology and is called Optic Flow (ref).

7. Future concepts

7.1 Time to redefine motion?

In the context of flight simulation, motion has always been taken to refer to the dynamic provided by the so-called Motion Platform. In the light of the discussion above, we believe this is a misnomer as it is plain that the perception of motion is the result of vestibular and visual processing. It is more accurate in our view to rename the motion platform as the Acceleration Platform since this is plainly what it does.

Motion in a flight simulator is derived from the Acceleration Platform and the Visual System and it is arguable that the Visual System is contributing the greater share of the motion dynamic.

7.2 Time to re-evaluate Flight Simulator categories?

We also believe that, for the reasons outlined in this paper, it is a good time for certification authorities to look again at the categorization of flight simulators and align the new categories with advances in visual simulation. Such re-evaluation is all the more appropriate now that a new pilots licence has been introduced that is obtained mostly in simulators rather than aircraft.

The Multi Pilots Licence (MPL) is a qualification built upon experience gained in the environment of a modern jet airplane rather than in a light. The logic that lead to the MPL was that, in airline employment, little relevance could be attached to the hours of flying which the student might have achieved in light aircraft except to learn the basic maneuvers of flight such as taking off and landing. It is considered that experience gained in (jet airliner) simulators was much more relevant to the final qualification as a co pilot of such an airplane.

The MPL will place a huge burden upon operators to source simulator time in a market where such time is mostly assigned to recurrent training and licence recency.

7.3 The total simulation experience (TSE)

When considering the overall training of an airline pilot, we are concerned at all stages of training where simulators are used, with the “total simulation experience” or TSE. This is a term that describes:

1. *The quality of simulation achieved by the given device.*
2. *The continuity of the simulation experience as the student moves from one device to another*
3. *The cost at which these devices deliver the training.*

The regulatory authorities can contribute to the TSE available by looking again at the qualification levels of flight simulation devices and ensuring that credit is given where appropriate, for the considerable advances in technologies embodied in their design.

(FFS can then consolidate and concentrate their role in the examination and assessment phases of a simulator-based course such as the MPL.)

In this way, continuity of quality of training will be maintained across the range of simulators at all phases of training.

For a given training course that leads to the grant of a pilot licence valid on a particular aircraft type, the TSE has a profound effect upon

1. The time taken to complete the qualification
2. The success rate of the students on the course
3. The cost of the course, either to the airline or TRTO paying for the training, or to the self-funded the student.

More and more these days, the cost aspect is being addressed as a higher priority. This is partly for obvious economic reasons but also partly because of the complexity of the airliners in service and of those which will enter service in the near future.

Gone are the days when a cardboard cut-out could be used to help the student understand the systems of a modern jet airliner. Instead the student expects to interact with a training device which is a faithful representation of the working environment where he/she will spend a good proportion of their professional life. This is a reasonable expectation because the operation of such an airliner is largely a matter of systems operation in both normal and abnormal configurations.

The flying aspects of the airliner are important of course, but largely taken care of by automation. Automation of the actual flying task is now highly evolved and very reliable and safe. The efficient (which equates with economical) operation of the airliner is largely a matter of correct system configuration and usage.

Given these considerations, we have concluded that motion simulation, is of less importance than system and visual simulation. A well-designed fixed base simulator can achieve a TSE which is complementary to a FFS, whilst delivering the TSE at a reasonable price.

It should be borne in mind that efficiency and economy of flight simulation in a given airliner is part of the total efficiency of operation of the airliner itself, a fact often overlooked by airline operators when constructing their budgets.

Airliner manufacturers also need to bear this in mind when bringing a new airliner to the market as it will undoubtedly influence the airline operator.

This is one of the reasons why the simulation division of an airline manufacturer should stand firmly in the role of support to the core product, which is, of course, the airliner itself. That role may be better served by ensuring that a wide range of simulators are available and (most important) supported by the airplane manufacturer. These simulators will range from classroom devices which showcase the systems such as description and operation, the alerting system (ECAM, EICAS etc), to so-called FFS (Full Flight Simulators).

8. The way ahead is Multifunction.

8.1 A range of devices

If one looks at this range of simulation devices (and lets just call them all simulators) one can see that the student pilot will encounter many types and grades of simulator as he/she progresses through, firstly, the pilots course, and then the Type Rating course. It is logical that, if we consider the economics of a typical training course, a training provider (FTO, TRTO, Airline etc) will want to maximize the efficiency of the training. One way of doing this is to use simulators which are multi functional.

8.1.1 CBT

A typical Type Rating course of ten years ago (say) would consist of around three to four weeks of classroom studies during which the general and system-specific properties of the airplane would be explained in an environment familiar to the student from school and college days. This type of training served many a pilot well for decades and was only superceded in the mid to late 80s by the arrival of Computer Based Training or CBT.

The advantage of CBT was that it saved on manpower (no lecturers needed) and time. The most important advantage however was that it ensured that the delivery of system knowledge was uniform and not influenced by the skill (or lack of skill) of the lecturer.

Also CBT enabled the student to go back and forth within the material at will without holding up the rest of the class, (the brilliant student could leap forward and complete the studies at a rate according to his/her capacity).

8.1.2 Systems simulation

Typically, a modern airliner has many complex systems. This is not simply to show off how complex the airliner is, but more to do with how much the design of such systems has evolved in recent years. The complexity is partly because, by varying many parameters in a continuous and accurate range, efficiency and hence economy of system operation is achieved.

For instance, the operation of the jet engine in a modern airplane is monitored by many parameters (EGT, Fuel Flow, Vibration, Inlet/Outlet Guide Vane position, Turbine/Fan clearance, Oil Temp Pressure, to name a few). In some cases, this reporting will generate in flight warnings or advisories which should or must be acted upon by the pilots (no Flight Engineers these days).

If this principle is repeated for many other airplane systems, (Hydraulics, Electrics, Pneumatics, Air Conditioning, Flight Controls etc) it is easy to see that pilots could become saturated with information which is of little value during a flight. However in a flight emergency or other occurrence, operational consequences could arise, which must be considered by the crew and it is here that good simulation can assist in preparing and informing the student pilot in a setting as close as possible to the environment that would exist in the airplane itself.

8.2 Multi Function CBT/IPT/Flight Simulator.

8.2.1 Multi functional FTD

If we could integrate the function of classroom device, procedures trainer and flight simulator, we would have a **multi functional** device which would combine this training into a more cost efficient model.

Currently, this is the realm of Fixed Base Simulators or FTDs (Flight Training Device). In airline flight training it describes a range of airplane simulators which feature a flight deck environment (generic or replica) with or without a visual system.

FTDs are graded according to the flight deck arrangement, the control handling qualities and the visual system. FTDs with a control loading system which based upon the real airplane allow flight skills to be realistically practiced. These skills may be carried over into the FFS so that time may be saved in that device (typically the last training device used before flight in the actual airplane).

[Earlier in this article, the balance of motion and visuals in the determination of the TSE was discussed and it was noted that motion may be regarded as a flight character simulation whereas visual simulation may be regarded more as an operational simulation (although it contributes a lot to the perception of flight) and the relative contributions of each to the TSE was briefly discussed.]

If we set aside the acceleration input (which is the case for a Fixed Base Device) we have, in the FTD, a device in which we may look at system operation as seen in the airplane and also combine this with system instruction.

For example, each system may be configured as required and the student may see this in the context of the flight deck presentation but, crucially, this presentation may be augmented by integrating system informatics and diagnostics. For instance, if the training detail is concerned with Hydraulics, the student may look at system diagrams, schematics and textual explanations at the same time as he/she manipulates the controls and/or indicators in the airplane flight deck.

These presentations may be viewed by using the visuals. Flight maneuvers may then be practiced and if the FTD has a control loading set, the control feedback and responses will be the same as in the airplane.

The FTD therefore can serve three functions, Classroom device, Integrated Procedures Trainer and Flight Simulator. FTDs can be equipped with the same level D visuals as a Full Flight Simulator but since they lack an acceleration platform, they can be accommodated in a much smaller space than a FFS (which typically needs a three story housing in its operational configuration.)

This is a huge benefit to the student as he/she can experience and learn in an environment that is as familiar on the device as it is on the airplane itself. These presentations can be reinforced when the student can "fly" the simulator and experience the changes in flight control response which may result from changes in system performance during normal and abnormal operation.

It is not really practicable to integrate these functions into a FFS as time spent on this device is much more expensive than time spent on a fixed base device. It would not make economic sense to fly a "classroom" on an acceleration platform fifteen or twenty feet in the air.

Aviation authorities now are in good position to assess the best way to incorporate some of the technological advances in fixed base devices into an improved qualification program. This is fair to operators who are seeking to improve the quality of training whilst ensuring that it can be delivered at a price affordable to training providers.

What about the future of flight simulation?

The Role of Airplane Manufacturers

The Role of Simulator Manufacturers

The Role of Airlines and Operators

The Role of Aviation Authorities

The Role of Training Providers

Content to follow.