Flight Simulator Day

The Institution of Mechanical Engineers Aerospace North West held another successful flight simulator day at Alteon Training, Cheadle, Stockport, similar to the one they had hosted over two days on 18-19 June 2005.

Capt. Hugh Dibley, Chairman of the RAeS Toulouse Branch and a member of the RAeS Council and Flight Simulation Group Committee, presented a lecture on Development of Aircraft Simulation – an Essential Part of Training and Aircraft Design. Hugh is an Airbus A320, A330 and A340 pilot instructor and previously flew aircraft including the Boeing 707 and 747 for the British Overseas Airways Corporation (BOAC), later British Airways, before becoming a technical pilot at Airbus Training, Toulouse.

Leonardo da Vinci (1452-1519) envisioned some amazing concepts of flying machines, but it was about four centuries later when Otto Lilienthal (1848-1896) and Sir George Cayley (1773-1857) transmuted such visions into the first real gliders. Orville and Wilbur Wright learnt from the theories of Cayley and Lilienthal when they proceeded to develop the first powered flying machines. They used wind tunnels and tethered gliders to support their research in designing flight controls and improving stability and control, as well as flying in gliders to cultivate their flying skills. Thus, the Wrights learnt that, for example, they needed a canard at the front of their Flyer for control and safety.

Flight simulation began with the 1909 Antoinette Flight Trainer. However, simulation is not only applied to flying training, but also to engineering design: engineering simulators include flying test beds for aeroplanes and for engines, as well as specific ground simulators, for testing things such as tyres. One could even say that wind tunnel testing is a form of simulation – of aerodynamic simulation. On structural simulation, Hugh showed a video of a Boeing 777 wing being tested to destruction. The wing was required to withstand 150% of the highest load it would be expected to encounter in flight, and this test would demonstrate its resilience to extreme gusts or bad handling. Cables were attached to the wing and pulled until it broke – at 154%, with 24 ft (7.3 m) of deflection at the tips. The successful test result was applauded in the control room with cheering and jubilation of the inimitable American kind.

Aircraft themselves have been used as simulators, such as when NASA used a Boeing 737 in the 1980s as a flying laboratory, with a second, completely separate cockpit at the rear to test fly-by-wire systems; and when SpaceShipOne and White Knight were recently used as trainers for sub-orbital flight.

In 1928, Edward Link, having learnt to fly, left his father’s organ building business to begin working on a pilot trainer. Driven by organ bellsows, this machine could provide training at $\sqrt{150}$ of the cost of aircraft training. Ed Link’s blue box, which Hugh trained on when he was in the Navy, was used to determine the suitability of student pilots before they started instrument training.

However, the Link Trainer was not specific to any particular aircraft type, so Curtis-Wright were amongst the first to make type-dedicated flight simulators, such as for the B-25 bomber, which later used a real aircraft cockpit. In the 1950s, this was also applied to civil aircraft, with a Boeing Stratocruiser simulator used by BOAC.

When even large aircraft still had mechanical controls and simulators still used valve computers, aircraft handling relied largely on the subjective and often varied judgement of simulator test pilots, as well as on engineers’ patience. Modern computing systems, however, can capably fulfill the growing training requirements, including realistic aircraft handling; all kinds of weather, and its effects, in the air and on the ground; avoidance of terrain and buildings; increasing numbers of navigational and other systems; instant repositioning of the aircraft and flight management system; and procedures for identifying and rectifying any system failures. From the 1960s, flight simulators had already advanced so far that it became difficult to tell whether a cockpit photo was from a simulator or a real aircraft.

Early simulators were run by an instructor or radiotelephony expert in an operating station outside the cockpit, where there was no visibility of what the pilot was doing. Nowadays, the instructor operating station is inside the cockpit, permitting immediate interaction and facilitating multi-crew training. Making selections in the operating station is, understandably, secondary to the instructor’s prime task of overseeing the training, and it is recongized that clear layout and content of the control screens is essential, as is the appropriate description and positioning of pre-set buttons. Hugh illustrated one scenario of misleading button descriptions: the pilot is too high on an approach, so the instructor, wishing to hold the simulation in that position for a discussion, presses HOLD POS – then the aircraft suddenly appears back on the runway at the threshold, because this represented HOLDING POSITION and the instructor should have selected POS FREEZE instead.

Hugh also described the operation and capabilities of the latest visual and motion systems, which can be applied not only to aircraft simulators but to ground vehicle and ship simulators.

The cost of a full flight simulator for a Boeing 747 is 40 times cheaper than the aircraft, and using the simulator instead for training means that the aircraft remains available for revenue service, burns less fuel, produces less pollution and noise and suffers less wear and tear. Training is also improved, with a safe environment for practising system failures, abnormal weather, traffic and terrain avoidance, and virtual operation at any airfield in the world. Alongside this, there is less burden on air traffic control, and less risk of training accidents. Hugh showed some video clips of some bad landings and crashes in flight training.

Maintenance and flight training devices, such as the CAE Simfinity Integrated Procedures Trainer, are used for flight crew training before the crew move on to full flight simulator training. MFTDs have the same integrity as the full simulator and contain identical software, but they are cheaper to operate and are more effective for flight management and cockpit setup training. Use of MFTDs also allows time in the full, moving simulator to be concentrated more on handling training.

Airbus aircraft software and system development begins with the ‘iron bird’ systems integration and test bench. Validation and integration of the systems at aircraft level continues through various stages until it is put onto the aircraft itself, where virtual becomes reality but is linked forever to the iron bird. Hugh showed a video of the first flight of the A380, ‘Reality on 27 April 2005’, and then concluded with a video of the X-15 being launched from a B-52 – another example of a flying test bed, this time for hypersonic research.

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Visitors were shown the cabin crew training facility, where fuselage mock-ups, fitted with various Airbus and Boeing doors and escape slides, are used for cabin evacuation training. To represent real emergency conditions more realistically, it is possible to fill the cabin with smoke, apply faults to the doors and add heave, pitch and roll motion, setting scenarios such as a burst tyre, rejected takeoff or rapid deceleration.

For flight training, there is an A320 MFTD as well as full moving simulators for the Embraer EMB-145, Airbus A320, Boeing 757/767 and Airbus A330/A340.

On our visit, we were taken onto the Airbus A340 simulator, in groups of about five people per session, and each group member was allowed to take the controls for a short time.

The simulation was set up on the threshold of Runway 24R at Manchester International Airport, and to begin the exercise, we practised a few takeoffs, rotating at approximately 140 kts.

Next, we practised some approaches and landings, and I was allowed an attempt at this. On my previous attempt, in 2005, I had performed poorly on the landing, so I appreciated another opportunity to try to do it better. This time, it indeed started much better; I anticipated the aircraft response more effectively and avoided overcorrecting, and so I made an accurate approach, followed by a gentle touchdown. Unfortunately, however, my performance deteriorated from that point. I failed to lower the nose after touchdown, and the aircraft lifted off again. Trying to come back down as quickly as possible to avoid overshooting, I pushed the nose forward too sharply and crashed into the runway. Suddenly, the view of Manchester Airport through the windows was replaced with a blazing red glow, the speakers emitted a rumbling noise, and the simulator bumped and juddered and swung around for a prolonged period as if it was about to buckaroo from its stilts. (How many million pounds would I have had to pay for that damage?). Then the computerized cockpit voice called, “Retard!”, and the machine finally went still.

The last part of the exercise was on ground handling, which involved taxiing from the runway exit to the boarding gate, pushing back from the gate under reverse thrust (not the normal method!), and then having another attempt at drawing up to the gate.

Brian Taylor, Alteon Engineering Manager, presented a lecture on Alteon – Boeing’s Training Company, beginning with a corporate description of Alteon’s background. The Boeing Company and FlightSafety International launched FlightSafety Boeing Training International in 1997, as an independent company under a 50:50 joint venture agreement. FSB were formed in response to the increasing demand for high-quality, reliable and standardized airline training, delivered closer to the customer. Boeing later bought out FlightSafety’s interest and re-introduced the company in 2002 as Alteon, a wholly-owned Boeing subsidiary.

As well as the UK, Alteon have sites in the USA, Mexico, Brazil, Spain, Morocco, Singapore, China, Korea, South Africa and Australia, and they are establishing two further ones in Russia and Poland. They provide simulator training for 27 aircraft types, their training programmes are accepted by 90 governments/regulatory authorities, and they offer nearly 400 distinct courses. Their portfolio also covers maintenance training, and new courses are starting for the Boeing 787, mainly specializing in composite aircraft. Their mission remains, “To enhance aviation safety by supporting the industry’s training needs.”

The remainder of Brian’s presentation addressed the history of flight simulation. On training requirements, he began with the mythological story of Icarus and Daedalus: with their lack of training, they didn’t understand the machine they were operating – and the effects of flying too high.

Before powered flight, people would learn to fly gliders by sitting inside one while facing into a strong wind, thereby learning the feel of the controls. Training in powered aeroplanes began as a graded sequence of exercises on the real aircraft, starting with a lower powered version and progressing, as the student gained a feel for the different controls, to more powerful versions, with high-speed taxis and short hops, and then finally onto flying. Training aircraft were often suspended from balloons or overhead gantries or tethered to railway bogies.

The first synthetic flight training device was the French Antionette Trainer. This consisted of a barrel with a horizontal bar, and the student would have to move the controls to align the bar with a fixed reference on a facing wall while people moved the barrel.

During World War I, the new discipline of aviation psychology had formed, and the need for aptitude tests – with a system to measure and record reaction times – had been identified. ‘Automatic devices’ evolved with the replacement of human operators on the Antionette ‘Trainer’, and by 1917, Lender & Heidelberg had invented a range of devices.

Between the wars, the requirement focused on ‘blind’ instrument flying, and trainers were divided into the two categories of ‘moving trainers’ and ‘non-movable devices’. Non-movable devices, such as that of Jenkins & Beryl in 1932, were very rudimentary – the most complex part being the compass, driven by a magnet underneath. Meanwhile, a selection of moving trainers emerged, the most popularly known one being the Link Trainer of 1930. This consisted of a complete model »
aeroplane, sat on gimbals able to rotate through 360°. The lid could be closed to provide darkness inside, and an operator outside could perform radiotelephony tuition. Vacuum turbines, pumps, bellows and mechanical linkages drove the instruments, and the altimeter was controlled via a pressurized tank, which could be pumped up and deflated.

During the Second World War, there was a sudden requirement to train large numbers of student pilots and to deal with new aircraft systems, such as variable pitch propellers and retractable undercarriages, as well as training for flight at higher speeds. The Link Trainer remained widely used, while the Celestial Navigation Trainer was used in astronavigation training for very northerly areas, where a compass would not work properly and a sextant had to be used. The Silloth Trainer could be used for training on any aircraft with two or four engines, and simulated faults could be put into the system for full crew training.

The major advance during World War II was the analogue computer, providing the ability to solve the flight equations of an aircraft. This led by 1941 to the US Navy receiving arguably the first operational flight trainer that attempted to simulate a specific aircraft.

By the arrival of the jet age, the digital computer had dawned, and manufacturers were able to provide more complete data for simulation models. Simulators could now be used as an instrument in flight development programmes, to evaluate future aircraft handling rather than just to provide training for handling aircraft. The digital computer also solved the growing requirement to drive more complex motion and visual systems.

Redifon built a full Comet IV simulator for BOAC in 1958, which had a pitch motion system. However, the introduction of wide-bodied aircraft such as the Boeing 747 required lateral acceleration cues as well, and so four- and six-degree-of-freedom motion systems promptly followed. Meanwhile, visual equipment developed through model/camera/monitor systems, projector/mirror systems and digitally generated plots. In 1978, Redifon built the B747-200 full flight simulator, mounted on top of a six-axis motion system, with a digital computer behind. A version for the B727-200 followed in 1979.

On finishing, Brian discussed aspects of the modern flight simulator, including real-time digital computer systems, 6-degree-of-freedom motion systems, day/dusk/night digital visual display systems, aerodynamic models built and tested against aircraft data, and pilot training with zero flight time.

The Aerospace North West Team, including Ivan Dean, Don Oates, Becky Tomkins, Dr Thurai Rahulan and their colleagues, made this day’s programme a commendable success, as they had also done in 2005, this time with the additional welcome support of Hugh Dibley.

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