RAeS Loughborough Branch

Lecture synopses - 2007/08 Season

16 October 2007 Operating the RAF C-17 Flt Lt J J Jackson, RAF Brize Norton

The C-17 is the RAF's new strategic heavy lift capability. One C-17 is equivalent to 17 Hercules. A Hercules can carry 30,000 lb and requires a 2360 ft runway whilst a C-17 170,900 lb and requires a 3,000 ft runway. 4 C-17 aircraft were originally procured on loan from Boeing to bridge the gap until the time the A400M comes into service. The C-17s have proved so useful that the original 4 are to be purchased together with 2 additional aircraft.

The squadron has a 4:1 crew to aircraft ratio because the aircraft are so heavily used and have been found to be indispensable. The aircraft represents a jump in experience compared with any other aircraft in RAF service. Training comprises 10 weeks in Oklahoma and this is all either computer based or using simulators. This is followed by 2 local sorties out of Brize Norton.

The aircraft are very manoeuvrable. They are in effect a ruggedised airliner, hence their technology is similar to that of a modern airliner. They incorporate HUD displays similar to those in the Hercules J.

One Loadmaster is able to reconfigure the aircraft in 5 minutes. 2 ground engineers can change tyres even in remote places by using the aircraft's own jacking facilities.

The aircraft is often used to fly into hostile areas such as Iraq and Afghanistan. This necessitates operation with night vision goggles. Sometimes it is necessary to fly into these areas during the daytime because no navigation aids are available. The aircraft incorporates a number of anti-missile countermeasures for use in such circumstances. These measures include flares and other laser based countermeasures to burn out the seeker heads of oncoming missiles.

At any one time it is normal to have 3 aircraft operational and one being serviced. Most operational sorties to Iraq and Afghanistan are via the Incirlik USAF base in Turkey were relief RAF crew are stationed. A typical load to Afghanistan includes 110,000 lbs of bullets and bombs. These loads are taken 2-3 times each week.

The aircraft are being used to support operations in the Falklands, especially by ferrying F3 fighter aircraft when these aircraft require major overhauls. They have also been used for:

a) The Asian tsunami relief effort when they flew into Banda Ache with Chinook helicopters, ground support equipment and relief supplies.
b) The Russian submarine rescue at Kamchatka.
c) Pakistan earthquake when they flew in Puma and Chinook helicopters.
d) VIP transport.
e) Queen's birthday fly past.

The aircraft can:

a) Carry one Challenger MBT or 6 Gazelle helicopters or 2 Puma helicopters.
b) Be used for humanitarian air drops (typically 40-45 tonnes).
c) Carry paratroops and/or passengers.
d) Be used for casualty evacuation (it can carry up to 36 stretchers and associated medical teams).

Other future roles include:

a) "Combat off-loads" in which the payload is on pallets which role out of the back of the aircraft as it accelerates forwards when its engines are powered up.
b) Providing support to UK special forces units. This will role will include tactical low flying and airdrops. This role is already practised by the US air force.
c) Launch low earth orbiters.

d) Air-to-Air refuelling including use as a Forward Air Refuelling Platform (FARP).

6 November 2007 - From VSTOL to Blind Landing by Wg Cdr Clive Rustin

Clive joined the RAF in the early 1950s as a National Service graduate entrant after gaining a first class degree in engineering. His first solo flight was in a two seat Vampire jet trainer. He was then posted to Germany where he flew Venom fighters. It was at this time he was granted a permanent commission with the RAF, with the eventual aim of using both his flying and engineering skills as a test pilot.

Later he became a member of the Black Arrows aerobatic team of No. 56 Squadron flying Hunters. This was followed by selection for the Empire Test Flying school (ETPS), where he flew wide range of aircraft under all conditions. On graduating from ETPS, Clive was posted to the Aerodynamics Research Flight, the last three years as OC, during which he flew many VSTOL R & D aircraft, including the Short SC1 and P1127 vertical take off and landing aircraft, a series of Lightning prototypes, the HP115 slow speed delta aircraft and the Fairey Delta 2. The latter incorporated Lightning wheels and a Gannet nose wheel.

The Short SC-1 was powered by 5 RB108 engines; four for lift and one for propulsion. The high fuel consumption permitted only 5 minutes flying after a vertical take-off and 40 minutes after a conventional take off. Vertical take-off stability was provided by nozzles fore and aft and at the wing tips. Later Clive flew the Kestrel V/STOL aircraft during trials of the aircraft on HMS Bulwark.

During the 1970s V/STOL airliners were also being considered. These included the Dornier 31 and the Breguet 951 STOL aircraft. The latter incorporated large propellers which produced high speed air flow over the entire wing surface. The resultant increase in lift at low speed allowed STOL at 50 knots and landing in less than 100 metres.

Clive performed trials on the HP126 jet flap aircraft which provided 30% direct thrust, 10% lift via nozzles and 60% enhanced flow over the wings. N.B. It was impractical to provide that degree of enhanced flow over the wings of an airliner.

His V-STOL work was followed by research into blind landing using first a Comet 4C and later a life expired Vulcan, both at RAE Bedford. He was then engaged in assessing the flying characteristics of a wide variety of aircraft for the development of appropriate flight simulators, including the Mirage 3B, Concorde, Hawk, Javelin, Tornado, Shorts SC-1 and various helicopters. He also became Officer Commanding the Fast Jet Squadron at A&AEE Boscombe Down which culminated in ejection from an irrecoverable spin in a Jaguar. His RAF career ended with a tour as CO of Handling Squadron, Boscombe Down.

His post RAF work included flying surveillance airships aimed at providing 30 days radar coverage at 10,000 ft over the US fleet. Other duties included flying in the Vampire formation team.

20 November 2007 - Tornado to Typhoon and Beyond by Billy Beggs, BAE Systems

The lecture was divided into two parts.

The first half consisted of an account of the way in which improvements in product design and manufacture had results in more rapid production of the Typhoon by comparison with the Tornado. This was principally due to the use of computer aided design and manufacture, with a "paper-less" approach throughout. Large composite panels with profiles controlled with high accuracy on computer controlled machines gave reduced manufacturing timer (by nearly and order of magnitude in some cases), and an associated reduction in the number of parts: in total the Typhoon has 16,000 compared with the Tornado's 36,000.

A further advantage of the use of computer controlled manufacturing was the ability to reproduce components to very low tolerances, giving complete interchangeability, with associated reduction in turn-round time.

The second half of the lecture was completely different, dealing with the range of unmanned vehicles now being introduced by BAE Systems. Six examples of unmanned air vehicles (UAVs) and one underwater vehicle (UUV) were discussed.

One of the points stressed here was the use of readily available parts from the modelling world, applied consistently during improvement of the product range of the UAVs. The UUV was unique in the world: the US had given up their own development to join the work which BAE Systems was doing.

Throughout the lecture, extensive illustration of the points made was supplemented by short video presentations, very well integrated with the subject matter.

4 December 2007 - The Story of Rolls-Royce Flying Test Beds by Barry Hocking, Nacelles Engineer, Rolls-Royce

Barry's lecture considered the definition of the flying test bed, its requirements and history. Finally he described the Trent 1000 test programme.

Flying test beds (FTBs) are usually modifications of existing production aircraft. As well as structural modifications it may be necessary to add other simulation features such as, in the case of the Trent 1000, electrical load simulators. This is in addition to all of the monitoring and test facilities which must be added.

FTBs are capable of providing altitude test facilities and are used to test all new engine installations, e.g. RR Merlin in the Mustang during WW2.

From 1908 up to the 1920s all altitude tests were carried out on FTBs. Subsequently more tests were carried out a sea level with altitude testing being carried out using engine tests beds, e.g. Pyestock and now Tullahoma, USA. More recently RR have reverted to the more extensive use of FTBs; the Trent 1000 FTB for instance is a converted Boeing 747-200. All RR FTBs fly out of Bristol. Earlier FTBs included; the RR Lincoln FTB with a Tyne engine; the RR Avro Ashton which was fitted with RR Nenes and used to test the RR Conway; the RR Wellington use to test Darts; RR VC10 used during 1968-9 to test RB211-22B conversion; Vulcan with RB199.

The challenges in using a Boeing 747-200 as an FTB for the Trent 1000 were:

1. The Trent 1000 is a fully digitally controlled engine whereas the aircraft is analogue;
2. Mechanical interface problems;
3. Provision of 3000-5000 psi hydro simulator;
4. Provision of electrical load banks to dissipate 500 KVA;
5. To demonstrate the Trent 1000 installation both structurally and aerodynamically.

The first flight for the Trent 1000 was on 18th June 2007 and RR have now completed the initial flight test programme. Tests have confirmed the excellent performance of the Trent 1000; there have been no hiccups.

The lecture concluded with a video of the Trent 1000 first test flight at RRs test facility at Waco, Texas, USA.

12 February 2008 - F-35 Lightning II Update by Ivor Evans, Director F-35 Business Development, Lockheed Martin (UK)

Up until now fighter aircraft have either been very manoeuvrable or stealthy but not both. This has changed with the advent of the F-35 Lightning II. This aircraft will be able to both pull 9g and carry weapons. It will also have a high sustainability capability in terms of ease of maintenance and servicing.

There will be three variants of the aircraft; the F35A which will be conventional take-off and landing, the F35B which will be Short Take-off and Vertical Landing (STOVL) and finally the F35CV of Carrier Variant. The US will be purchasing the F35A for land use and the F35CV for the US Navy. The UK will be purchasing the F35B for the UK Navy which will have carriers smaller than the US.

The CV variant has larger wings and horizontal tailerons to facilitate a slower landing speed.

The F35 will replace many aircraft. One example is the AV-8B with a fuel load of 7,758 lb and a max. thrust of 20,280 lb compared with 14,000 lb of fuel and a max. thrust of 40,600 lb for the F-35.

There are two engine variants; the Pratt & Witney F135 and the General Electric/Rolls-Royce F136. The latter is approx. 2-2.5 years behind the F-135 because its development programme was started later. The two engines will have identical characteristics and will be fully interchangeable. The engines will have curved inlet ducts and be mounted towards the rear of the aircraft. The use of such ducts is good for stealth but the mounting position is poor for vertical take-off. For this reason the F35B STOVL version of the aircraft will incorporate a two stage 19,000 lb thrust vertical lift fan mounted between the two inlet ducts and towards the front of the aircraft. This fan will be driven by a shaft from the main engine. Roll thrusters driven by gas bled from the main engine, will be mounted in each wing and provide a further 3,700 lb of vertical thrust. In addition a thrust director mounted on the rear of the engine will allow the main thrust to be redirected from rearwards to vertically downwards. The result will be a total of 40,600 of vertical thrust.

The main partners in the F-35 programme are the US and the UK. Other partners are The Netherlands, Turkey, Canada, Australia, Norway, Italy and Denmark. In addition there are a large number "interested countries", especially Israel and Singapore. The partners together with "interested countries" will result in sales of approx. 3,000 aircraft. Further sales throughout the life of the aircraft will raise this figure to a total of 4,000 aircraft. The principle industrial partners are Lockheed Martin, BAE Systems and Northrop Gumman.

AA1, the first prototype aircraft, first flew on 15th December 2006 and to date there have been 30 flights with this aircraft. Max. speed to date is Mach 0.8. BF1, the first prototype STVL aircraft, will fly in May 2008, CTL prototype in Jan-Mar 2009 and the CV prototype in Apr – Jun 2009. Much of the avionics flight testing is being carried out using the Boeing 737 Co-operative Avionics Flight Test Bed. This first flew in Jan. 2007. Its front fuselage section has been modified to resemble the front of an F-35, including the length of cable runs. An F-35 cockpit simulation has been built inside the aircraft although the aircraft also retains its original cockpit.

The F-35 Logistics and Sustainment Programme means that the F-35 will be supportable throughout the world. Spares will be provided via Fedex and DHL. Aircraft health management will be by based extensively on automatic prediction of the need for parts replacement, i.e. on condition maintenance.

Initial training will be in the US but in 2015 a training facility will be established at Lossiemouth, UK. 2015 is the year when there will be sufficient aircraft in the UK to warrant such a facility. Lossiemouth is also the airfield selected by the UK as the base for its four F-35 squadrons when they are not on carriers.

The aircraft will incorporate an Electro-Optical (EO) Targeting System, Network Connectivity Satellite Communications (SATCOM) and Radios as well as a radar based Distributed Aperture System (DAS) ground imaging system. All images will be displayed to the pilot on a helmet mounted display; there will be no head-up display. There will be an 8 inch x 20 inch LCD based head-down touch screen cockpit display which will incorporate a number of drop down display screens all activated by soft keys on the screen.

Weapons will be carried on 11 stations, 4,5,7 and 8 being internal. Only these internal stations will be used when the aircraft is required to operate in stealth mode. The STVL stealth weapon load will be 3,500 lb max.. The max. weapon load over all weapon stations will be 15,000 lb of which it will be possible to bring back 5,000 lb. The UK require this figure to be 7,000 lb. This will be achieved by landing at 50 – 70 knots instead of vertically.

The UK In Service Date (ISD) is 2016.

Joint lecture with I. Mech. E

26 February 2008 - Life and Times of Barnes Wallis by Peter Rix, Chairman Barnes Wallis Memorial Trust

Barnes Wallis was born in 1887 almost before the advent of aviation as we know it today. He was educated at Christ's Hospital School but left without matriculating to become an apprentice with a firm of shipbuilders. 1915 saw him join Vickers to work on airships and by the end of WW1 he was their chief airship designer.

In the early 1920s Vickers attempted to buy the German Zeppelin company but the negotiations were unsuccessful. The result was Vickers own design for an airship, the R100 which was completed in 1929 at a cost of £4M. The aim was to develop airships which could be used to transport passengers on long distance flights over several thousand miles as aircraft were thought at the time to be unable to be used over distances much exceeding 1000 miles.

The UK government started a national airship programme in 1924 which lead to the R101. The R100 completed a number of successful flights including visits to Canada and the USA. The R101 was less successful and crashed in France whilst on a flight to India. As a result the UK government cancelled all airship development in 1930 and the R100 was sold for £450 for scrap.

Wallis then moved to Weybridge to work on bombers and it was no coincidence that the same, highly successful geodetic structure used for airship girders was used in the construction of bomber fuselages. Aircraft constructed in this manner included the Wellesley and the Wellington.

During WW2 Wallis was responsible for the "bouncing bombs" used so successfully by 617 Bomber Squadron to attack the Mohne and Eder Dams in Germany. A sequel to this was the Highball bouncing bomb which was to have been used by aircraft such as the Mosquito to attack naval vessels. Here the aim was for the bomb to be detonated under rather than by the side of the target, i.e. below the heavily armed sides of the vessel.

Wallis concluded his WW2 work by designing the Tall Boy and Grand Slam "earthquake bombs". The former was used to sink the Tirpitz whilst the latter was used to destroy the Bielefeld Viaduct.

After WW2 he diverted his attentions to supersonic flight with the aim of developing a passenger aircraft capable of travelling at Mach 6 making possible a return trip to Australia and back in one day. Concorde did not impress him.

Throughout his life maintained an interest in education and to the establishment of a charitable foundation associated with his old school, Christ's Hospital. This charity still provides bursaries for the children of some RAF personnel attending the school. He was knighted in 1968 and died in 1979.

18 March 2008 - How do wings work? Overcoming popular misconceptions by Dr Holger Babinsky, Cambridge

According to Bernoulli's Theorem increasing the speed of an air flow will reduce the pressure associated with that airflow. An aircraft wing having suitably shaped aerofoil cross-section will result in an airflow which is faster over top of the wing than it is beneath. The result will be a reduced pressure on top of the wing compared with that beneath it, hence the wing will produce lift.

It is wrong to argue that, because an air flow is split in two by the wing, the two parts must reunite immediately behind the wing. Hence it is not the difference in distance travelled by the two part of the airflow that gives rise to the lift. A pulsed smoke flow test (shown in a video) confirms that the two parts do not reunite.

Assume a steady air flow at a low speed. The latter also means that the air flow must be taken as being incompressible and subsonic. The forces acting on a particle of air will then be gravity, friction and pressure. Both gravity and friction are relatively small forces. Hence, as a particle of air moves along in a streamline manner and experiences these forces, the predominant of these will be pressure.

Newton's 2nd Law says that, if there is a net pressure force on an element then that element will accelerate. This means that the pressure reduces in the direction of acceleration which agrees precisely with Bernoulli's Theorem.

A streamline flow over a downwardly curved surface will have a downwards component of acceleration and hence there will be a pressure reduction above that surface. The argument may be extended to a bunch of parallel streamlines all passing, one on top of the other, over the top of the curved surface. The result is a continuous pressure drop from some distance above the curved surface down to the curved surface. The Coanda Effect is a further example of this effect. Water falling on to the near top of a ball will pass round part of the surface of the ball and continue to "adhere" to the surface of the ball for some distance below the line passing through the centre of the ball. This "adherence" is due to the pressure drop across the curved streamlines. Teapots dribble for the same reason.

Increasing the angle of attack of a wing produces more lift provided that streamline flow is maintained. Stalling occurs when streamline flow ceases and vortices are produced above the wing. The onset of stall can be sudden as the speed of the wing through the air is reduced.

Aerobatic aircraft have symmetrical wings and rely on the angle of attack to produce lift. This means that they are well adapted to flying both in a normal orientation and upside down.

The Magnus Effect is yet another example of the effects of an increase in air flow rate across a surface. If an airflow is split by a rapidly rotating horizontal cylindrical section then a force will be produced which is perpendicular to the axis of rotation. The force will be upwards if the cylinder is spinning clockwise and downwards if it is spinning anticlockwise.

29 April 2008 - The History of Aviation in Leicestershire and Rutland by Francis Maccabee, RAeS Loughborough Branch Treasurer

This was a general survey of the development of aviation in the two counties, to celebrate the centenary of powered flight in Britain. It was based on the book by Roy Bonser. The following were the main elements of the lecture:

1. The "Circuit of Britain" flights in 1911;
2. Bleriot delivering newspapers to Loughborough in 1912;
3. WW1 – Aircraft production at the Brush works in Loughborough, development of small airfields, Zeppelin raids and the Loughborough Instructional Munitions Factory;
4. Inter-war years – Alan Cobham's Aerial Circuses, growth of Leicester Aero and Flying Clubs, preparations for WW2 (RAF Expansion Scheme at Cottesmore, opening of Ratcliffe aerodrome, Whittle's development of the jet engine, Taylorcraft production starts at Thurmaston and Rearsby);
5. Approach to WW2 – Taylorcraft C and D aircraft, Reid and Sigrist, Desford as a supplier of instruments and other accessories, Cottesmore becoming operational in April 1938, new airfield at Loughborough;
6. Airfield s opened during WW2, wartime aircraft and component production, bombing, training and other airborne operations during WW2 together with details of aircraft used;
7. Post-war military aviation including activities at North Luffenham, Cottesmore and Bruntingthorpe;
8. Manufacturing after WW2 – Armstrong Whitworth, Taylorcraft manufacture of the Beagle communications/navigational trainer;
9. Development of Castle Donnington into East Midlands Airport;
10. Professional institutions including RAeS in Loughborough;
11. Heritage and education facilites including Loughborough University;
12. Leasure flying.

The lecture was enthusiastically received and promoted considerable discussion.