RAeS Loughborough Branch

Lecture synopses - 2008/09 Season

14th Oct. 2008 - The British Aircraft Industry 1908 - 2008 by Dr RV Smith, BAE Systems, Farnborough

1. Introduction

This lecture described the 100 years of the British aircraft industry from 1908 to 2008. In essence the development of the industry may be divided into the following phases:

1. Pioneers 1908-1914
2. First World War Mass Production 1914-1918
3. Collapse & re-birth between the Wars 1919-1939
4. Second World War Mass Production 1939-1945
5. Post-War 1945-1960
6. Rationalisation - BAC and Hawker Siddeley 1960-1977
7. Modern Times 1977 to the present

2. The Pioneers

Cody flew his aircraft at Farnborough October 1908. This moment is often considered the starting point for UK aviation. Over the next five years pretty much every conceivable aircraft configuration was flown.

There were tremendous problems to solve with a limited knowledge base. Luck played its part; to succeed one needed to solve several difficult problems simultaneously. A problem in any one area could result in failure of an otherwise successful design. It should also be remembered that learning to fly was not at all easy.

One early comment was “There was no lift in the air”. This was they were attempting to take off down wind. As late as April 1914 there were fatalities due to pilots falling off the machine in flight.

There was the question of wing warping vs. ailerons. One can tell from the tone of the quote that *Flight* thought that wing warping was really the state of the art technique, e.g. *Flight* on the use of ailerons by the 1913 EAC Monoplane:

‘Although this is a departure from what has now become to be almost standard practice as regards monoplane construction, it is a system which works quite well in machines of the biplane type, and there is no reason why it should not be equally successful when applied to monoplanes.....’.

Some of the pioneers paid the ultimate price. From CS Rolls in 1911, the next 3 years saw 48 deaths.

Early 1909 Short Brothers contracted to build six Wright biplanes under licence. They set up their factory in Feb 1909 at Leysdown on the Isle of Sheppey and flew from nearby Shellbeach. At the time they lived in Mussel Manor at Shellbeach so that they could be next to the factory and flying ground. This was the first aircraft factory in Britain and by August 1909 it had eighty employees. The site became the focus of flying by the Aero Club (Royal Aero Club from 1910).

The entire operation moved to Eastchurch in 1910. From late 1913 onward, Shorts progressively moved their operation to Rochester and flying at the Isle of Sheppey ceased. Meanwhile, closer to London, other major centres had sprung up: Farnborough, Brooklands and Hendon

The DH no. 2 FE1 flew at Farnborough in January 1911, and the BE2 in Feb 1912. Farnborough’s enormous contribution to 1st World War included such notable types as FE2, RE8 & SE5A all of which were widely built by contractors across Britain.

Meanwhile, the two other major centres developed. These were Brooklands and Hendon

Brooklands, if not the birthplace, was the cradle of British Aviation. A selection of Pioneers and companies operating here included -

HJD Astley, AV Roe, Eardley Billing, Robert Blackburn, British & Colonial Aeroplane Co. School, Coventry Ordnance Works, L Howard Flanders, Handley Page Ltd School (briefly), Hewlett & Blondeau, Humber, Martin & Handasyde, Hammond, Lane, Neale, Parsons, Pashley, Sopwith, Spencer, Star, Vickers Ltd, Walton & Edwards, Howard Wright, etc. - A veritable *Who's Who* of pioneer aviation.

Brooklands had a long standing role in aircraft manufacture including Sopwith/Hawker and Vickers/Vickers-Armstrongs/BAC/BAe.

Hendon was established as "The London Aerodrome". It was set up by Grahame White in October 1910 and used for his factory and flying school. It was also used to publicise aviation with weekly Flying Meetings and by The Aircraft Co, later the Aircraft Manufacturing Co. (AIRCO) the progenitor of de Havilland. Other manufacturers at Hendon included WH Ewen/the British Caudron Co., Handley Page Ltd and Nieuport & General Aircraft Ltd.

British & Colonial Aeroplane Co set up at Filton in February 1910 with Schools at Larkhill & Brooklands. These were far & away the most important schools in England before the First World War. Trained 309 of 664 pilots to receive the Royal Aero Club certificate.

Larkhill (2284 acres) was used June 1910 to May 1914 and was also used for test flying. The Bristol Boxkite made its first flight here in July 1910. Some idea of the early success of British & Colonial as a manufacturer can be gauged by the fact that they built more than 100 aircraft in 1911.

As well as the well known airfield sites, the early pioneers made much use of lakes, beaches and large fields. These included.

- Windermere was used by The Lakes Flying Co, later Northern Aircraft Co. Ltd
- Portholme was the base for James Radley and later the Portholme Aerodrome Co. Ltd
- Camber Sands was used by Alec Ogilvie and Howard Wright
- Waterloo was the base for Mr Melly and the Liverpool Aviation School
- Freshfield - Planes Ltd/Mersey Aeroplane Co. & Compton Paterson
- Filey Sands was the early test site for Robert Blackburn
- Magilligan - Harry Ferguson; Red Wharf Bay - William Ellis Williams

Additional major centres were at Shoreham (mainly schools & seaplanes)

Thus the foundations of the British aircraft industry were laid before the First World War.

- A.V. Roe
- Short Brothers
- Robert Blackburn
- C.R. Fairey
- Frederick Handley Page
- Sir W.G. Armstrong, Whitworth & Co. Ltd
- Vickers Ltd
- T.O.M. Sopwith
- Harry Hawker
- Geoffrey de Havilland
- The British and Colonial Aeroplane Company (later to become The Bristol Aeroplane Co Ltd)

Other significant contributors to the Industry who were already active prior to 1914 include:

- Henry Folland (at Royal Aircraft Factory from 1912)
- George Carter (later of Gloster)
- Roy Fedden (Bristol engines)
- Frank Halford (learned to fly in 1913)
- JD North (later of Boulton Paul)
- Noel Pemberton Billing (company later to become Supermarine)
- J Lankester Parker (famous test pilot freelance, and then for Shorts)
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3. First World War Mass Production

The British Army Army's initial view was that aircraft were to be used mainly for reconnaissance. This was later extended to include the use of fighter aircraft to prevent reconnaissance operations and other aircraft for bombing operations, anti-submarine patrols (with seaplanes and flying boats), operations against airships and night fighting. This was coupled with a substantial requirement to train new pilots. Points to note are:

1. During WW1 the average life of an aeroplane at the battlefront is was more than two months. To keep 5,000 aircraft in active commission for one year it is necessary to furnish 30,000. Each machine in the period of its activity will use at least two motors, so that 60,000 motors will be required'. This rate of aircraft and engine production rate was actually achieved by 1918.
2. High losses were a major driver for industrial production and the supply of pilots.

First World War Aircraft Production

Period	Duration (months)	Aircraft built	Aircraft per month
August 1914 to May 1915	10	530	53
June 1915 to February 1917	21	7,137	340
March 1917 to December 1917	10	13,521	1,352
January 1918 to October 1918	10	26,685	2,669

Numbers of aircraft on charge (RFC/RAF and RNAS):

August 1914	272
January 1917	5,496
January 1918	11,091
October 1918 (RAF)	22,171

In four years, the aircraft establishment of the flying services increased more than eighty fold; the production rate increased more than fifty fold.

The types of company engaged in production included:

1. Car industry - Daimler, Wolseley, Standard Motors, Mann, Egerton & Co. Ltd, etc.
2. Furniture Industry - Waring & Gillow, Wm. Lawrence & Co, Highgate Aircraft Co.
3. Coachbuilders - Hooper & Co., Adam Grimaldi & Co.
4. Shipbuilders - Scottish Production Group

Examples of Contractors in Central & Eastern England are:

Morgan & Co.	Leighton Buzzard
Hewlett & Blondeau Ltd	Leagrave
The Brush Electrical Engineering Co. Ltd	Loughborough
Clayton & Shuttleworth Ltd	Lincoln
Ruston, Proctor & Co. Ltd	Lincoln
Boulton & Paul Ltd	Norwich
Mann, Egerton & Co. Ltd	Norwich
Ransomes, Sims & Jeffries Ltd	Ipswich
The Austin Motor Co. Ltd	Birmingham
Wolseley Motors Ltd	Birmingham
The Siddeley-Deasy Motor Car Co. Ltd	Coventry
The Coventry Ordnance Works Ltd	Coventry
The Daimler Co. Ltd	Coventry
Humber Motor Co. Ltd	Coventry
The Standard Motor Co. Ltd	Coventry

The main contracted aircraft types were:Trainers - DH6, Avro 504

Royal Aircraft Factory - BE2, RE8, FE2, SE5A

Fighters - Bristol F2b, Sopwith Pup, Sopwith Camel

Two-seaters - AIRCO DH4, AIRCO DH9, Sopwith, 1½ Strutter

Naval Machines- Short 184, Felixstowe F.3, F.5

4. Collapse & re-birth between the Wars

The Armistice had a devastating effect on the aircraft industry:

- No immediate requirement for aircraft, either military or civil;
- RAF manpower dropped by 90% in 15 months;
- Cancelled contracts - 25,000 aircraft on order at time of Armistice.

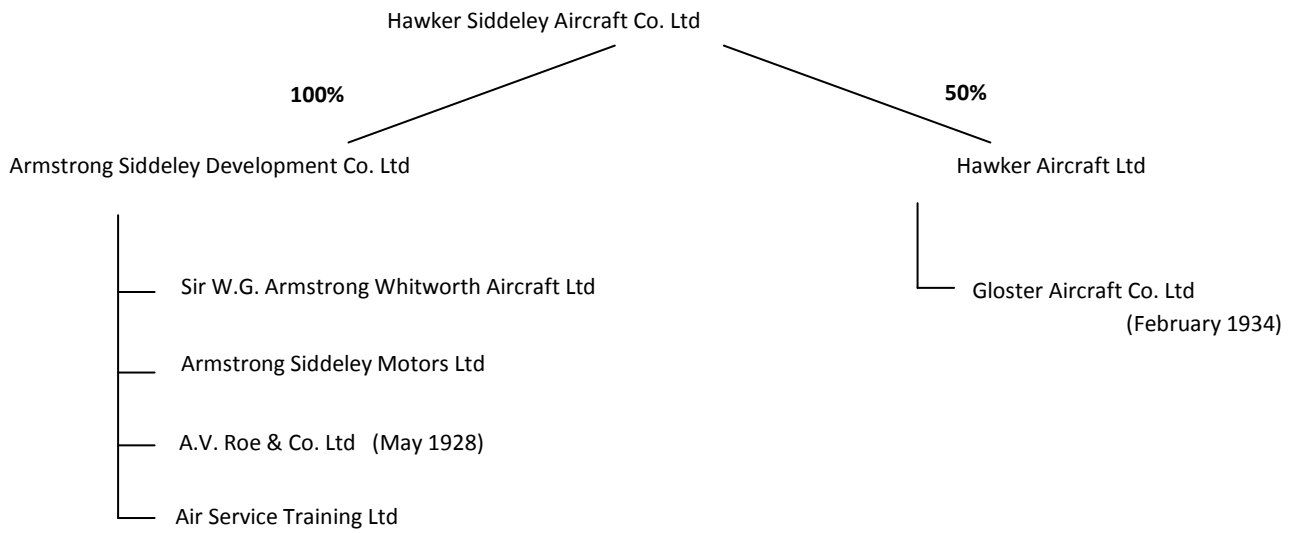
The Aircraft Disposal Company was formed in 1920. It purchased entire War surplus stock for £1m, for sale with half earnings returned to Government. This included 10,000 aircraft, 35,000 engines, 100,000 magnetos and 350,000 spark plugs.

Many companies diversified into other products, e.g.:

- AIRCO: manufacture of car bodies
- Bristol: bus and car bodies
- Grahame-White: car manufacture, furniture
- Shorts: aluminium bus bodies, barges and electric canoes

- Martinsyde: motorcycles
- Sopwith: ABC motorcycles, coachbuilding, furniture, kitchen utensils
- Westland: pianos, milk churns, light engineering
- Blackburn: car and bus bodies, nuts and bolts
- Fairey: Daimler car bodies built by Fairey and Charles Ltd

Re-structuring began in 1928 and Hawker Siddeley Aircraft was formed in 1935:



The critical decisions on re-armament were made in 1934 when Chamberlain as Chancellor of the Exchequer authorised expansion of the Metropolitan Air Force from 52 to 84 Squadrons, aiming for 1,252 aircraft by 1939. Schemes included the Shadow Factory Scheme (October 1936) Its initial focus engines, then light day bombers (Battle, Wellesley, Blenheim, Wellington) and finally fighters (Hurricane, Spitfire),

5. <u>Second World War Mass Production</u>

Second World War production effort was a layered effort with contributions from several distinct groups

1. The main design companies – all stemming from the First World War and companies that will be familiar names to anyone with a passing knowledge of British Aviation.
2. Dispersed & Shadow factories – the car industry and other contractors (Spitfires at Castle Bromwich)
3. Smaller companies – mainly second line types and repair, although also contracted for such types as the Mosquito (Airspeed and Percival), Seafire (Cunliffe Owen) and Firefly (General Aircraft Ltd). (Airspeed Oxford). (note light a/c movement link)
4. Companies within the CRO plus RAF Maintenance Units returning damaged aircraft to service. 500 aircraft per month at peak of activity. (Typhoon aircraft at Marshall of Cambridge in 1944).

One important difference from First World War was the degree of Standardisation. This increased production efficiency and was essential for a geographically dispersed industry and supply chain.

There was greater technical maturity (less easy for balance of power to be upset by the introduction of a new design on either side) – Undoubtedly, the apple cart would have been upset if German jet aircraft had been available earlier and in greater numbers.

6. <u>Post-War</u>

US produced transport aircraft in WWII, leading to C-47, C-54, Constellation

Brabazon Committee laid plans but initially Britain had to rely on converted bombers such as the Halton, Stirling V, York & Lancastrian and flying boats – Hythe, Sandringham & Solent.

A rush of new types followed. The Tudor, Brabazon, Princess, Marathon, Ambassador, & Hermes all failed or had limited success.

The Bristol Freighter, Viking and Dove found reasonably successful markets.

Britain's lead in gas turbines should have placed us at the forefront. In the event, the Viscount *was* an outstanding success *but* the long gestation of the Britannia and the structural failures suffered by the Comet ceded victory to America and the Boeing 707

On the military side, Britain during the Cold War produced a series of outstanding designs: Canberra; Valiant; Vulcan; Victor; Hunter. All were flown in the three and a half year period from May 1949 to December 1952 (with the English Electric P.1 flying in 1954). These were extraordinarily successful designs, but how much more extraordinary that the post-War economy could put all three V-Bombers and the Hunter and the Swift simultaneously into production and into service. This was not a sustainable position, however. Change was inevitable and was presaged by the Duncan Sandys Defence White Paper of 4 April 1957 '*Outline of Future Policy*'. It stated that in view of 'the good progress made towards the replacement of the manned aircraft of RAF Fighter Command with a ground to air missile system, the RAF are unlikely to have a requirement for fighter aircraft of types more advanced than the supersonic P.1, and work on such projects will stop'. The Saunders-Roe SR.177, Hawker P.1121 and Avro 730 were cancelled and later the TSR2.

7. Rationalisation - BAC and Hawker Siddeley

1960 saw whole scale rationalisation across the Industry (including Westland taking control of the helicopter interests of Fairey, Bristol & Saunders-Roe).

BAC came together for TSR.2 and its later products – Concorde, Jaguar, Tornado - introduced significant European collaboration.

Hawker Siddeley Aviation Ltd saw Folland, Blackburn and de Havilland joining the existing Hawker Siddeley Group (that which had come together in 1935).

HSAL had a mix of civil & military products and made the significant decision to participate in Airbus (and to remain in after the withdrawal of Government funding).

BAC and HSAL continued developing this product portfolio until nationalisation in the form of British Aerospace in 1977:

British Aircraft Corporation comprising: Bristol Aircraft Ltd, Vickers-Armstrongs (Aircraft) Ltd., English Electric Aviation Ltd., Hunting Aircraft Ltd..

and

Hawker Siddeley Aviation Ltd comprising: Hawker Siddeley Aircraft Co. Ltd., The de Havilland Aircraft Co. Ltd., Folland Aircraft Ltd. and Blackburn & General Aircraft Ltd..

Other Post War activities included:

Westland	Sikorsky machines under licence (S51, S55, S58 as the Wessex)
Bristol	Raoul Hafner produced the Sycamore & Belvedere
Saunders-Roe	Cierva legacy – Skeeter, P.531 – later Wasp & Scout
Fairey	Ultralight, Gyrodyne and Rotodyne

8. Modern Times

A common feature is the growing importance of international combines and collaborations and the impact of the ‘post-9/11 world’.From 1990 onward we have seen BAe/BAE SYSTEMS exit from

- Executive Jets
- Turbo-props
- Regional Aircraft

The Hawk remains the only all-British product in production at BAE SYSTEMS.

Joint lecture with Loughborough Students’ Flying Club (one of the societies attached to Loughborough University Students Union).

4th Nov 2008 - The Airbus A350 XWB by Rob Bray, Airbus UK

During 2008 Airbus will manufacture approximately 500 aircraft. Its main sites are located in the UK, Spain, France and Germany and it employs 56,000 people worldwide. Its UK factories are located at Broughton (all wing assembly except for A400M wing) and Filton, Bristol ((wing research and landing gear). The present product range is A320, A330, A340, A350 and A380 together with freighter variants.

The size of its aircraft has grown significantly over the years, e.g. A320 wing 14.5 m, A380 wing 36.3 m. The current market for passenger aircraft is 4 trillion passenger miles/pa. This is set to increase to 10 trillion passenger miles/pa by 2024. The annual growth rate is 4.9% pa. By aircraft numbers, 71% of this will be for single aisle aircraft., 5% for large aircraft and 24% for medium sized aircraft. The latter is the market area for the A350.

The A350 has a 32.4 m composite wing and as such it is the largest composite wing ever built. The aircraft is designed to take over from the A330/A340 type aircraft. The A350 design drivers were a growth in passenger comfort, environmental friendliness and giving the users a competitive advantage.

The aircraft will be wider than the A330/340 and have larger windows. It will use new Rolls-Royce Trent engines thrust rated at 74 Klbs to 93 Klbs over the three A50 variants, 800, 900 and 1,000 series. These variants will carry 270, 314 and 350 passengers respectively. The 1,000 series will compete with the Boeing 777 and the 800 and 900 series with the Boeing 787. The cabin width will be 220 inches compared with 215 inches for the Boeing 787. The A350-800 will carry 30 more passengers than the corresponding Boeing, be 6% more fuel efficient and save 8% on operating costs.

In terms of environmental friendliness, the A350 will consume 70% less fuel than the first jet passenger aircraft and exceed the most stringent air cleanliness limits. It will be 10dB quieter than current aircraft with the result that its takeoff footprint will be contained within most airports. N.B. This footprint is set at 85 dB where 65 dB is the threshold for not waking a sleeping person and 20 dB is the noise attenuation due to double glazing. This means that it will make half the noise of an existing Boeing 777 or an A330.

The use of composites in the A310 was confined to the fin, rudder and elevators. In the A350 the whole of the outer wing will be composite structure as will the fuselage. In all the A350 will be made of 53 % composites. The wing has been designed for Mach 0.85. The increased use of aerodynamic modelling has reduced the time necessary for wind tunnel testing. The wing will incorporate a droop nose device forming a variable camber leading edge. Adaptive dropped hinge flaps will be used at the back of the wing.

18th Nov 2008 - 1933 Flight over Mount Everest in a Westland Wallace by Rt Hon Lord Selkirk of Douglas QC LLB

In 1933 Flt Lt the Marquis of Clydesdale (later to become the Duke of Hamilton) and Flt Lt McIntyre flew a Westland Wallace over Mount Everest. Lord Selkirk of Douglas, the Duke's son, told the story of that historic flight. The lecture was illustrated by photographs and cine film taken from Lord Selkirk's collection.

In the summer of 1932 Clydesdale, encouraged by Colonel Stewart Blacker, recognised that aircraft technology had advanced sufficiently to achieve ever-increasing altitude records and could now fly above the highest point on earth. Lady Houston was approached to underwrite a geographic expedition to survey the Himalayas from the air, including a flight over the summit of Everest. Despite grave doubts about sending four young men to their deaths, Lady Houston reluctantly agreed. The team was assembled, led by Air Commodore Fellowes with Clydesdale as the lead pilot, and sailed for India in February 1933.

The aircraft chosen were the Houston-Westland PV3 and a PV6 (prototype for the Wallace) each powered by a single specially built, highly supercharged Bristol Pegasus IS3 engine. The capability of the aircraft to reach unprecedented altitudes was demonstrated by the Westland chief test pilot, Harold Penrose, when he achieved over 35,000ft at temperature as low as minus 79 degrees Fahrenheit. The aircraft, with their open cockpits, were extensively modified to include belly panel doors primarily to accommodate a Williamson Eagle III vertical air survey camera as well as still and cine cameras and the necessary crew survival equipment. Clydesdale was accompanied in the PV3 by Colonel Blacker as observer and Flt Lt David McIntyre, a Flight Commander in the Auxiliary Air Force squadron that Clydesdale commanded, piloted the PV6, accompanied by R.S. Bonnett from Gaumont as observer.

To survive the extremes of altitude each crew member was equipped with a primary and secondary oxygen system. Prior to departure from the UK training at RAE Farnborough had taught the men how to recognise the symptoms of hypoxia. This training proved vital. During the flight Clydesdale became aware of hypoxia and switched to his back-up system. Bonnett's oxygen supply line was ruptured, partially fixed using his handkerchief, and he spent much of the flight drifting in and out of consciousness. With no intercom, McIntyre was uncertain as to his health and had to hope that no long term ill-effects had been caused. Fortunately Bonnett revived during the descent.

Oxygen depravation was not the only environmental hazard being faced. At those altitudes, man and machine required additional heating. Not only were the men equipped with heated suits, gloves and goggles but also the cameras required to be kept at a temperature to keep them working.

Based at Purnea, some 160 miles south east of the summit of Everest, the team established their base on the plains. The topography required that the aircraft spent most of the flight out of gliding range of a safe landing strip. Given the remoteness and inhospitable terrain, there was no effective contingency for a forced landing. Even finding sufficient flat ground for a forced landing would have been difficult. The approach to Everest was far from straightforward with unpredictable currents off the peaks and insufficient space to turn around. At one stage the PV3 dropped 2,000ft in a severe down-draught and recovery looked unlikely, before being assisted by an unexpected but very welcome up-draught. Late morning the PV3 passed overhead of Mount Everest

and Clydesdale had achieved his amazing feat. The drama was not over as, immediately after the peak, the aircraft flew through an ice cloud.

Some three hours after take-off from Purnea the two aircraft returned to the relieved crews who had to endure an anxious wait. Letters were immediately dispatched to the King and Lady Houston.

The team felt that another flight would greatly enhance the photographic evidence. This was refused by Fellowes, who was concerned that fate should not be tempted. Shortly afterwards Fellowes fell ill and, in his absence, a successful second photographic flight was conducted. These flights provided detailed vertical air survey images from the Eagle III camera of this uncharted area, many of which provided Hillary's expedition with much needed data to conquer Everest on foot 20 years later.

Clydesdale and McIntyre were awarded the Air Force Cross in 1935 in recognition of their achievements and went on to establish Scottish Aviation at Prestwick. Clydesdale continued as Commanding Officer of 602 Squadron AAF until 1936. In 1937 he married Lady Elizabeth Percy, daughter of the Duke of Northumberland and raised a family of five sons, of which James, Lord Selkirk, was the third.

What became of the aircraft? PV3 (G-ACAZ) became a flying engine test-bed, first for the Bristol Engine Company, followed by RAE Farnborough where it ended its life. PV6 (G-ACBR) went on in a later incarnation to become the prototype Wallace.

2nd Dec 2008 - The UK Air Accidents Investigation Branch by Alan P. Simmons, Principal Inspector of Air Accidents, Air Accidents Investigation Branch, United Kingdom

1. Introduction

The Air Accident Investigation Branch (AAIB) is part of the UK Department of Transport. It was founded in 1915. It investigates a wide range of air accidents ranging from those involving microlights to the largest passenger aircraft.

The purpose of the AAIB is to improve air safety. Its investigations can include cases where there has been no actual accident. It can make recommendations but does not become involved in defining blame or liability; it is impartial.

Over the years the requirements, scope and number of investigations has increased dramatically. In parallel with this the technology used for investigations has also changed. Much of the modelling is now done on PCs. Specialist laboratories are required to analyse the data from modern flight recorders.

The need is to reduce the absolute number of accidents despite the significant growth in air travel in recent years. Note that there were fewer civil deaths due to air accidents in 2007 than in 1944.

The AAIB Chief Inspector reports directly to the UK Secretary of State for Transport.

The regulations governing the AAIB have been replicated in a number of Commonwealth countries and the AAIB also has responsibilities in these countries.

The AAIB is covered by the 1944 Chicago Convention which calls on countries to put in place mechanisms to investigate the causes of air accidents.

2. Staffing

The AAIB employs a total of 45 staff comprising:

a. Chief Inspector;
b. Deputy Chief Inspector;
c. Principal Inspectors;
d. Teams of Inspectors;
e. One Administrator.

Typical inspectors will be:

a. Qualified pilots with considerable civil flying experience;
b. Ex. Empire Test Pilots School.

In addition there are “engineer” inspectors who are experience chartered engineers. In this context “generalists” rather than specialists are required.

3. Powers

The AAIB has the authority to examine, remove, test and take measures for the preservation of an aircraft involved in an air accident. It needs cooperation and does not want to use legal powers.

If there has been a breach of regulations and the breech is severe, the CAA will be informed. If some minor breech of regulations has occurred which has not resulted in an accident then it is not the AAIB’s concern.

4. Examples of Accidents Investigated

4.1 Boeing 737 – Manchester Airport 1985

A typical example of an investigation occurred in 1985 when a British Airways Boeing 737 caught fire on take-off from Manchester airport. The fire was caused by an engine combuster becoming detached. Gases accumulated in the cabin and then there was a flash over. The cabin roof rapidly burnt through but there was still sufficient air near the cabin floor for survival for nearly 30 minutes. The passengers did not realise this and were incapacitated rapidly by gases emitted by burning furnishings. One of the recommendations from the AAIB investigation was that smoke hoods should carried on aircraft as only 60-120 sec is needed to get out of an aircraft.

4.2 Coastguard Helicopter

A helicopter was in flight when it lost power. It crash landed on a sports ground and burnt out.

The cause was a bearing failure on the low pressure turbine shaft one of the two engines. The investigation found that, in order to obtain a rapid take-off, that engine had always been overrun and the bearing subjected to 115% of normal max. engine torque. This torque level was permissible but only under normal flight conditions, not during take-off when the engine was subject to additional vibration.

20th Jan 2009 - Hawker Hunter – Britain's most successful post-war fighter? by Air Vice Marshal H A Merriman CB CBE AFC FRAeS

1. Initial Requirement

The operational need for this aircraft was based on the need to attack enemy bombers whilst they were approximately 100 miles off the UK coastline. The enemy bomber was assumed to have the same capability as the UK Canberra bomber, i.e. M0.85. Two separate requirements were defined to meet this need:

F43/46 Single seater, twin engined fighter

F44/46 Two seater, twin engined night fighter

The latter required its second seat for a radar operator. Key requirements were:

Time to 45,000 ft	6 min from start
Speed at 45,000 ft	0.95M
Endurance	1 hr inc. 10 min combat (at full power)
Airbrake	Essential to permit speedy recovery at base
Armament	Both aircraft were to use a minimum of 2 x 30 mm Aden guns or 4 x Hispano Suiza guns. The latter had been used throughout much of WW2 hence were considered low risk.

The engines available for use with the aircraft were:

Centrifugal engines	1. Derwent 5 (as on Meteor 4) 3,500 lb thrust 2. Nene 5,000 lb thrust
Axial Flow engines	1. RR AJ65 (Avon) – preliminary design 1945, entered service on Canberra as RA3 in 1951. 2. Metrovick Beryl (which became Armstrong Siddeley Sapphire)

2. Design and Development

The initial design was similar to an Me262 – two widely separated engines. This would have been difficult to fly on one engine. In essence it was an Avon powered Meteor. RAe Farnborough was in favour of swept wings to aid transonic flight. A swept wing has its own dihedral hence it is not necessary to incorporate it into the design. Dihedral with swept wings produces roll stability problems.

Design P1060 – two engines one on top of the other.

At the same time the prototype Sea Hawk P1040 was produced. Here the requirements were easier to meet - lighter, lower performance aircraft to be catapulted off the flight deck. Incorporated Nene engine with intakes in wing root. Straight wings. Suffered high rate of roll - 400°/sec.

Design P1052 – swept wing Sea Hawk, straight tail. Could not meet time to height requirement hence rocket motor to be considered.

Design P1062 – swept wing, delta tailplane. Debate on where to position tailplane such that it was clear of the jet blast.

Design P1081 – As P1062 but with jet pipe at rear.

Design P1065 – Single Avon engine + rocket motors. Began to move away from twin engined concept as Avon had begun to show promise.

Requirement F3/48(later OR228) issued in 1948. Required:

Time to 45,000 ft	6 min from press start
Speed at 45,000 ft	0.953M
Speed at 36,000 ft	0.945M
Speed in Dive	1.2M

Design Load	7.5 g
Endurance	1 hr 15 min inc. 10 min combat (at full power)
Airbrake	Essential to permit speedy recovery at base
Armament	4 x 30 mm Aden guns + rockets and bombs for ground attack.

Design 1067/1 – final design for the Hunter. Straight through exhaust, intake in nose. Later modified by Sydney Camm- intake in wing root which has advantage that bending moment from wing transferred to fuselage via top/bottom of fuselage. Tailplane on top of fin.

20/07/51 – first flight of prototype Hunter. Problems found were:

- Buffet/rudder vibration at high Mach No.
- Aileron controls too heavy, elevator controls too heavy and ineffective at high Mach No. Solution – increase hydraulic boost on ailerons and elevator controls. Eventually resorted to fully powered controls with spring "feel".
- Use of flaps as an airbrake was unacceptable despite flaps being stressed to be able to be lowered at any speed. Took 18 months to find an acceptable airbrake position – below rear fuselage.
- Use of guns produced violent nose down pitch. Solution – add gas deflectors to counter downward kick.
- Pitch up occurs on manoeuvring flight. Caused by downwash striking tailplane, hence lift behind c. of g. Solution – add leading edge extension to produce pitch down effect.
- Engine surge during manoeuvring and gun firing. Solution – add "bullet" fairing behind and at base of tailplane and use switch on gun trigger to cut back on fuel delivery. Blisters were later added below forward fuselage to collect spent links from the gun which were causing damage to the aircraft.

Fully loaded gun pack could be changed in 6 minutes.

Hunter Mk 6 incorporated the Avon 200 series engine – most of the problems with 100 series disappeared. Only residual problem – Dutch roll.

Mk 3 incorporated reheat in an attempt to improve time to height. Used so much fuel as to be unacceptable.

Other variants incorporated drop tanks which increased endurance to 2.5 hrs. Later a 2 seater variant was produced for training purposes.

Requirements for Hunter changed dramatically in 1960 when Gary Power shot down by Russian whilst flying a "spy plane" at 45,000 ft. Hunter now required mainly as a ground attack aircraft.

10th Feb 2009 - The Challenge of the Low-Cost Airlines, Dr Keith Mason, Senior Lecturer in Air Transport, Cranfield University

Low Cost Carriers (LCCs) have expanded by more than 250% during the last ten years and given access to cheap travel for most people. They have achieved this by changing the manner in which airlines do business, primarily by removing all unnecessary costs.

The top ten LCCs in the world carry 77% of the traffic. The largest LCC is Southwest airlines in the US. Ryanair and easyjet are also in the top ten and they are also the largest players in Europe. In terms of routes, Ryanair is the largest LCC in the world. Many of these routes are flown at a low frequency, generally a few times each week. LCCs are present in and in indeed dominate many markets.

An LCC's strategy is based on short haul flights, high aircraft utilisation, low levels of passenger comfort (which is acceptable on short sectors) and no interlinking connections (which means that aircraft do not have to be delayed in order to wait for other incoming flights). Turnarounds are kept short, hence more sectors can be flown in a day and more passengers can be carried. Secondary airports are often used, and this applies particularly to Ryanair, since these have lower airport charges, are less congested and hence allow a quick turnaround. They tend to operate a fleet of aircraft all of the same type, they do not offer free in-flight service and all their tickets are sold by direct distribution, generally over the internet. All the services they require are outsourced and this allows them to minimise ancillary costs.

60% of LCC traffic has been stimulated by the existence of the LCCs and 40% is derived from people switching from the main carriers. The people who fly are typically middle class. Some are second home owners. Some use LCCs for multiple holidays abroad each year.

The carbon emissions due to LCCs are low compared with the network short haul airlines; LCC 81gm CO_2 per passenger per mile v. Network Airline 153 gm. These emissions will become significant if the LCCs current growth rate continues.

All airlines use different business models and this also applies to LCCs. Of the two, easyjet flies much more to primary airports than Ryanair; easy jet is a "network supplanter" but Ryanair (and flybe) is a "network avoider". The later are more susceptible to an economic downturn. Ryanair has a much higher profit margin than easyjet even though its load factors are lower. It follows that, of all the LCCs, Ryanair has the biggest margin to play with at the start of an economic downturn.

The number of sectors flown in a day is extremely important to LCCs since this allows the number of passengers to be maximised. The number of sectors is significantly reduced in the case of long haul flights, which means that LCCs have less opportunity to compete against the network airlines in the case of long haul flights. This suggests that LCCs are unlikely to wish to penetrate the long haul market but will instead continue to make inroads into the short haul market.

Joint lecture with Institute of Logistics and Transport

24th Feb 2009 - Handley Page Victor as a Bomber in the Cold War by Air Commodore Norman Bonnor

The Handley Page Victor is well known as the RAF's tanker for over 25 years, but the 11 years it spent as a bomber tend to be forgotten. This lecture covered the initial development of the aircraft, the weapons it carried - with emphasis on the Blue Steel missile - crew training and equipment, QRA, readiness exercises and flight profiles.

Joint lecture with I. Mech. E

10th March 2009 - Marshall Aerospace by Martin Broadhurst, CEO, Marshall Aerospace

Marshall Aerospace was founded in 1929 and has operated from its current location at Cambridge Airport since 1937. In the early years its primary activity was pilot training, especially during WW2. Today there is a higher emphasis on aircraft servicing, including support at customers' own sites.

The company prides itself on the long service of its employees. Approximately 20 engineering graduates are taken on each year. Its total workforce at Cambridge is about 1800. In addition there are employees in Canada, Netherlands and at RAF Lyneham.

The UK MoD's Hercules Integrated Operational Support (HIOS) contract is the largest contract that the company has ever received. It involves maintaining 44 in-service Hercules J and K Series aircraft. The contract utilises a "transparent prime" contract format whereby Marshall Aerospace does not mark up the cost of support provided by suppliers such as Rolls-Royce.

Marshall's is also responsible for much of the fight testing of the new Europrop International (EPI) TP400-D6 turboprop engine for the A400M transport aircraft This is because the most suitable engine test bed aircraft for this testing is a Hercules rather than a jet aircraft as often used by jet engine manufacturers. The Hercules used is the ex. DERA meteorological research aircraft. The TP400-D6 produces twice the shaft horsepower of a normal Hercules engine and has a propeller blade diameter of 17.5 ft instead of the 13.5 ft of the normal Hercules propeller. The TP400-D6 test engine has been fitted in the port inboard position. This has necessitated stiffening the top and bottom airframe of the aircraft and installing a thrust comparator in the cockpit to allow the crew to compensate for the asymmetric thrust now provided by the aircraft 4 engines. The first flight with the TP400-D6 engine was on 6th Dec. 2008 and flight testing is continuing.

Marshall's are currently under contract to supplier two refurbished Hercules to Series J standard to the Netherlands air force. Both these aircraft were ex USAF aircraft and were salvaged from a mothballed condition at Tuxson, Texas USA.

The recent restoration of Vulcan XH558 is another refurbishment programme in which Marshall Aerospace has been heavily involved. This Vulcan last flew with the RAF in 1992. Restoration work started in December 2003 with a £2.4M grant from the Heritage Lottery Fund. This is believed to be the only restoration of an ex-military "complex" aircraft which will ever take place. The first flight since restoration took place in October 2007 under a CAA Permit to Fly.

Marshall Aerospace Business Aviation is another strand to Marshall Aerospace. It maintains and provides support services for private business jets. This activity saw a 100% expansion during 2008. This has included a major service contract from Netjets to service their European fleet of Cessna Citation aircraft. Recently a new facility providing services in support of business aircraft has been built at Cambridge airport. This includes catering, passenger management, flight planning, ramp services and refuelling.

In the future Marshalls intend to continue supporting the RAF's transport aircraft fleet including the A400M when it arrives at RAF Brize Norton. In addition it will build aerostructures for companies such as Airbus and continue with its business aviation operations.

24th March 2009 - Two Flights to Victory by David Styles

This lecture described two attacks on Japan during WW2; the Doolittle Raid of April 18th 1942 and the Hiroshima/ Nagasaki atom bombings of August 6th and 9th 1945.

The US naval base at Pearl Harbour, Hawaii was attacked by carrier borne Japanese aircraft on 7th December 1941. The surprise was such that the attack went off virtually unopposed. US President Roosevelt demanded retribution from his armed forces. A Captain Francis Low had the idea of using carrier borne bomber aircraft to mount a raid on Japan. Lt Colonel Jimmy Doolittle was tasked with putting the idea into practice.

The B-25 bomber was selected for the purpose and the aircraft carrier was to be the recently launched USS Hornet. The aircraft were obtained from the 17th, 95th and 89th squadrons of the 17yh Medium Bomb Group. These aircraft were detached to Owens Field in Columbia, South Carolina for a work-up programme. They were to be flown by volunteer crews.

Each aircraft was stripped of all items considered non-essential for the Raid and additional 160 gallon collapsible fuel tanks were added in the crew crawl space above the bomb bay. The sophisticated Norton bomb sight was removed (in case it feel into Japanese hands) and a rudimentary “Mark Twain” sight installed as a replacement. The engines were “mission tuned” for low speed economy andf high speed performance

The aircraft were then moved to Eglin Fields, Columbia to permit the use of the Gulf of Mexico as a training area. The aircraft left San Francisco Bay on 1st April 1942 on the USS Hornet. Take-off had been planned for 20th April but the fleet was spotted by a Japanese picket boat on 18th April, hence the decision was taken for the aircraft to take off early despite the 1500 mile range to the target. Fifteen of the sixteen bombers struck targets in Tokyo, Nagoya, Osaka, Kobe and Yokohama.

After the attack the aircraft flew on to China where they crash landed in a variety of locations. When Jimmy Doolittle arrived in Chungking, he was greeted by Madame Soong Mei-Li, the wife of General Chiang Kai Shek, and she awarded Colonel Doolittle the Order of Yung Hui First Class. On his return to the US, President Roosevelt decorated him with the Medal of Honor, the US highest decoration for gallantry. He was also promoted to Brigadier General and later, whilst in command of the US Army Airforce in North Africa, to Major General. During this time Jimmy suggested Colonel Paul W Tibbetts, his staff officer, to lead the team which was ultimately to drop the nuclear bombs on Nagasaki and Hiroshima.

The new B29 bomber was to be used to carry the bombs. The aircraft was fully pressurised for high altitude flying, and the nose section was built separately from the rest of the aircraft as a pressurised “cell”. A “Crawl Tube” was fitted for access over the bomb bay to the rear crew section and Tibbetts had a hatch fitted, with an air lock, to this tube so that one of his crew could safely go into the bomb bay and fit the detonating fuse to the bomb when it was required. The training for the attack was carried out a Wendover Fields, Utah.

The capture of the Pacific island of Tinian provided an airfield suitable as the starting point for the attack. There, the B-29 bomb bays were modified to carry a single bomb instead of the twenty the aircraft was designed to carry. The bomb doors had to open slightly wider to allow the bomb to be winched up into position from a pit, as both “Little Boy” and “Fat Man” bomb designs were too big to go under the aircraft from ground level.

The first attack was mounted by Colonel Tibbets in his aircraft “Enola Gay”. His bomb was “Little Boy”. The attack, on Hiroshima, was successful with the bomb being detonated at 1,900 ft. One minute after the explosion of “Little Boy”, the mushroom cloud rose to 50,000 feet. “Enola Gay” had managed to put nine miles between it and the impact point, but still felt a sledge hammer blow that almost put it out of the sky.

Forty eight hours after the first attack, no Japanese surrender had materialised. Major Charles Sweeney was briefed for a second drop using “Fat Man”. The Japanese surrender followed less than a week later.