FAST

FARNBOROUGH AIR SCIENCES TRUST

Samuel F Cody made the first recognised flight in the United Kingdom at Farnborough in 1908

Museum Guide

ACCREDITED MUSEUM

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The Queen's Award for Voluntary Service

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Replica of British Army Aeroplane No 1A in which Samuel Cody made the first recognised flight in the UK in 1908. This full size replica was built by FAST volunteers in 2008

Hawker Hunter T.7 WV383, now preserved at FAST, prepares for a night sortie

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Introduction to FAST

Farnborough Air Sciences Trust (FAST) was set up in 1993 to campaign against the threatened total destruction of Britain's premier historic aviation research site and the dispersal, or loss, of priceless artefacts recording the history of almost a century of continuous aviation research and development at Farnborough. There were two distinct aspects of the Royal Aircraft Establishment (RAE) heritage that initially concerned FAST as a newly formed registered charity:

i. the protection of key historic buildings, and
ii. the conservation of historic documents and artefacts.

By 1994 the Trust had formed the FAST Association (FASTA), a body created to help raise funds and provide a team of volunteers and supporters to assist the then four Trustees with their work.

The eventual purchasers of the site, Slough Estates plc, offered the refurbished Gl building as the FAST headquarters. Two of the wind tunnels (R133 and Q121) were listed at Grade I status - an outstanding achievement which made the RAE site, at a stroke, the most highly protected 20th Century heritage site in the country!

With the closure of the National Gas Turbine Establishment (NGTE) Pyestock site, FAST were asked by the Museum of London Archeological Services – who were contracted to record the history of this site – to review and save the historically significant drawings from the 100,000 or so stored technical drawings of the site, the four main engine test cells and the supporting laboratories.

Recently FAST initiated and supported English Heritage and the local council in the successful listing of the Royal Air Force Institute of Aviation Medicine's (IAM) Man Rated Centrifuge whose building retains all of its originality.

G1 building (left in 1914) is a Grade 2* listed building and was the HQ of the Balloon School in 1906 and later the early HQ of the Royal Flying Corps (RFC). On being given tenure FAST set up a public Museum and a working environment for the cataloguing and preservation of, and public access to, the heritage collection.

The 'heritage collection' consists of the physical scientific, technical and engineering artefacts (from experimental space systems to flying clothing), the photographic collection, the technical reports, books, aeronautical proceedings and aeronautical magazines, aircraft and systems concerned with the RAE research and development from Farnborough and its associated R&D establishments. The Archive has around 500,000 objects in its stores.

The Museum itself is above all, a Farnborough Air ***Sciences*** Museum, and one of the many aims is to provide an educational facility for the many schools and universities (and public) that arrange visits to the Museum.

For the Centenary of the first powered, controlled and sustained flight in Great Britain, flown from the airfield site by Samuel Cody on the 16th October 1908, FAST raised the funds and constructed a true replica of the original aircraft – British Army Aeroplane No 1A – and constructed an appropriate building, the Cody Pavilion, to display this unique exhibit. For the Centenary of Cody's death in 1913 the Trust raised the money to enable a statue to be commissioned and erected on a site overlooking Farnborough Road and RAE Road (a road which Cody would have used regularly during his work).

Since its inception FAST has worked hard to achieve Museum Accreditation, achieving that National Standard in 2013. In 2014 FAST were further honoured to receive the Queen's Award for Voluntary Service – generally recognised as the MBE for volunteer groups – a singular recognition of all of the work put in by the volunteer workforce.

Aviation at Farnborough

Airship and balloon construction effectively started at Farnborough in 1906, when the Army Balloon Factory moved from Aldershot to the north side of Farnborough Common (which is now the airfield). By 1907 the first airship had been constructed (first flight September 1907) and the first aircraft (Army Aeroplane No.1A) was completed and flown in 1908. In 1910 work on aircraft research and construction had officially commenced, and by 1912 aircraft production was well underway. Due to the fact that this was the government's centre for aircraft development and production it began its role as a world centre for aeronautical research, specialising in areas such as aerodynamics, materials, structures and engines. Activities at the Royal Aircraft Factory were stepped up dramatically during WW1. However, on the cessation of hostilities in 1918, aircraft production ceased and work was concentrated on research. Also in 1918 the Royal Aircraft Factory was re-named the Royal Aircraft Establishment (RAE) to avoid confusion with the newly formed Royal Air Force.

Research activity at the RAE continued over the succeeding decades, with the workforce expanding during WW2. However, with the advent of the Cold War, extensive research continued and expanded into areas such as avionics, guided weapons and space. To cater for the wider range of activities a number of additional sites and outstations were set up as part of the overall RAE. In 1954 RAE Bedford came on stream to provide extensive flight test facilities, as well as housing a large suite of wind tunnels, the Blind Landing Experimental Unit and the Naval Air Department. The archive for RAE Bedford is held by the Bedford "wing" of FAST, the Bedford Aeronautical Heritage Group (BAHG), and more information can be obtained from their website www.bahg.org.uk. Weapon testing took place from the ranges at Larkhill, Aberporth and West Freugh, with drone aircraft flown from Llanbedr used as targets for the Aberporth Range. In addition, satellite ground stations were established at Lasham in Hampshire and West Freugh in Scotland. The station at RAF Oakhanger was also transferred to RAE Space Dept for some years. A number of "lodger" units were sited within RAE Farnborough at various times, including the Empire Test Pilots' School (ETPS), the Institute of Aviation Medicine (IAM), the Air Accident Investigation Branch (AAIB), and the Meteorological Research Flight (MRF), which included the C-130 Hercules (left)

In 1983 the National Gas Turbine Establishment, adjacent to the RAE at Pyestock, was absorbed within the Establishment. In 1988 RAE was renamed the Royal Aerospace Establishment, partly to recognise the work performed by RAE Space Dept which played a leading role in

the UK and European space programmes for over 30 years.

In 1991 the four principal defence research establishments were merged to form the Defence Research Agency (DRA). All research flying was transferred to Boscombe Down in 1994. In 1995 other research establishments were absorbed into DRA to form the Defence Evaluation and Research Agency (DERA). In 2001 a large part of DERA was privatised as QinetiQ, the remaining part being set up as the Defence Scientific and Technology Laboratory. Today aerospace activities still continue at Farnborough, with QinetiQ being housed in their complex on the north west side of the airfield. In addition BAE Systems have their headquarters on the south of the airfield, as do AAIB. The airfield now belongs to TAG aviation and is extensively used by business aviation. The world famous Airshow is still held here on alternate years, operated by Farnborough International Limited.

The building which houses the **FAST** Museum (known as G1) was completed in 1906. It was designed to accommodate the Balloon School and store of the Royal Engineers and, later, the Air Battalion. The single storey extension at the northern end of the building housed the "Balloon Mobilisation Store" and it contained the balloons (stored in tins) with baskets, nets and cordage stowed on top.

In May 1912 G1 became the Headquarters of the newly formed Royal Flying Corps, with many of the earliest squadrons being formed here. In 1914 the senior officer was Hugh Trenchard (later Marshal of the Royal Air Force Viscount Trenchard) whose office was located on the first floor. The "Black Sheds" between G1 and the airfield were erected at this time as RFC hangars. No1 RAF Officers Mess stood on the site now occupied by the Aviator Hotel to the south of the Museum.

The RFC Headquarters was transferred to London in 1915, but an RFC presence continued at Farnborough. Many years later G1 eventually housed the RAE Museum until it was closed by DRA in 1993 and the contents moved to the Science Museum.

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The FAST Museum

The Aircraft Collection

Puma S.A.330 XW241 – This aircraft[1] arrived at FAST on 29th August 2007. It was based at Farnborough for many years as an Electro Magnetic Compatibility test vehicle within Flight Systems Department.

Hunter T.7 WV383 – This aircraft[1] was donated to FAST in 1999 and was disassembled and transported by road from Boscombe Down to Farnborough on 13 April 2000 and stored in M shed. On 14th June 2002 it was brought to G1 and reassembled. It is fitted with a full set of under wing pods comprising 2 x 100 gallon

fuel tanks and 2 x experimental pods. The cockpit is fully equipped with experimental displays and original ejection seats. The nose tip retains provision for a Forward Looking Infrared sensor looking through a germanium window. This aircraft carried out most of the RAE ground breaking research into low level flight at night and in poor weather, initially using low light television and then infrared imaging systems.

Jindivik (Target Aircraft) – This remotely piloted target aircraft[1] operated from Llanbedr for many years. It was used for both air to air and surface to air weapons training and trials. It was retired from QinetiQ operations during 2006 and after a period of storage arrived at FAST in July 2007.

Gnat T Mk1 XP516 – This aircraft[1] arrived at FAST on 8th June 2004. It was used at RAE as a ground experimental test bed within Structures Department.

Canberra B/DS WT309 (Nose) – This aircraft was used for trials at RAE. The nose was purchased by a group led by majority shareholder Peter Cooper. After storage in 'M' Shed at Farnborough it was moved to the museum for display on 14th June 2002.

Trident 3B-101 G-AWZI (Nose) – Trident "Zulu India" was purchased by FAST enthusiast Andrew Lee in June 2003 and restored at Lasham. On 16th December 2003 the cockpit was transported to the FAST Museum for display and is open to the public most weekends generously manned by Andrew and his team of volunteers.

Harrier T Mk4 XW934 – This ex RAF aircraft[1] arrived at FAST on 29th August 2007. It came to Farnborough in 1990 and was used as an Electro Magnetic Compatibility test vehicle within Flight Systems Department.

Jaguar B.08 XW566[1] – This was the first development aircraft B08 (last prototype). It arrived at FAST on 8th June 2004. In 1982 it was used by RAE to evaluate the first wide field of view (30 degrees) diffractive optic head up display (HUD), made by Hughes. The HUD used a curved combiner that was the fore-runner of the type used in the Typhoon today. The aircraft was then used for many years as an Electro Magnetic Compatibility test vehicle within Flight Systems Department.

Lightning T5 XS420 – This privately owned aircraft is the FAST Museum Gate Guardian. It arrived at the Museum on 3rd September 2003.

Beagle B206 G-ARRM – This was the first prototype and first flew on 15th August 1961 from Shoreham Airport. Last flight was in December 1964. Manufactured by British Executive and General Aviation Limited (trading as BEAGLE). It is currently on loan from the Brooklands Museum.

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[1] These aircraft were generously donated to FAST by QinetiQ.

Aerospatiale SA.341C Gazelle HT2 XW863 (left) – Arrived on loan in June 2013. Originally with 705 Squadron, Fleet Air Arm, it was part of "The Sharks" naval display team. It then moved to Middle Wallop as an instructional airframe, and then to the School of Electronic and Aeronautical Engineering at Arborfield and later to Cranfield. It was then stored at Fairoaks before moving to FAST.

Concorde fuselage section– This fuselage section was part of airframe 006 tested at RAE to identify possible structural failure modes that might develop during the aircraft's lifetime. After testing finished this section was used by British Airways to train Concorde cabin staff in emergency evacuation procedures.

Hunter XL563 Restoration – This was the first production T7 Hunter and for many years operated as a trials aircraft for IAM. It arrived at FAST in December 2014 in pieces and the FAST volunteer aircraft team are setting about identifying any missing parts and making preparations to rebuild it. A "sponsor a panel" scheme is being set up to raise the necessary funding by public sponsorship.

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Foyer – Photo Interpretation

It is believed that the cupboard under the stairs in G1's entrance foyer contained the RFC's first dark room for developing aerial reconnaissance photographs. This technique was developed by Lt Col Moore-Brabazon (later Lord Brabazon) and Corporal (later Group Captain) Laws.

Model Aircraft Room

Leading off the foyer is the model room, which contains an extensive collection of scale models of many British military aircraft. The collection concentrates mainly, but not exclusively, on aircraft used at RAE for both research and trials work. Some of these aircraft were built specifically for research, whilst others were production aircraft attached to RAE for trials work.

Located on the north wall of this room are photographs of trials work carried out by Naval Air Department at both Farnborough and Bedford. The display shows the range of this work, especially that connected with the problems in operating off aircraft carriers. The "rubber deck" landing trials pioncered at Farnborough are also covered.

Stairs left to Coffee Room

Hall 1 Please proceed clockwise:

RAE Artefacts Cases and Associated Displays

As a major government research establishment RAE employed many talented people, and the display cases arranged around the walls contain artefacts reflecting the diversity of the establishment's work and the achievements of its staff, together with memorabilia from their many clubs and societies. The Test Pilot's Memorial commemorates all British test pilots and aircrew observers killed in the course of their work. Whilst it might be supposed that many died in the early years of British aviation, sadly a large number were also lost in the 1940s and 1950s.

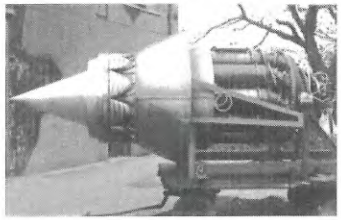
Small displays cover many areas of RAE's work. These include: A case covering the development of the automatic blind landing system first fitted to the Trident airliner, which was the first passenger aircraft in the world to be certified for blind landings. Flying clothing and an ejection seat reflect the development and testing of such vital equipment at Farnborough. A case containing slide rules and mechanical calculators shows how calculations were effected before the days of electronic calculators and personal computers. The RAE's internal railway system, which had a connection to the goods yard at Farnborough Station, is described. Suspended from the ceiling is X-RAE1, one of the RAE's many experimental unpiloted drones. Associated with this room, but located at the far end of Hall 2 (owing to its size), is the map board. This terrain map is a small part of a scale model of part of Salisbury Plain, created as one of the first flight simulators developed by RAE. A remote camera tracked over the model to give a "pilot's eye" view of the terrain by day, or by night using an infrared camera.

Jet Engine Display - Part 1: The Early Years

Whilst Sir Frank Whittle is renowned as "the Father of the Jet Engine", other pioneers were also working on the development of gas turbines, including the RAE Engine Department under Dr. A.A. Griffiths. Many of the early developers were looking to use the turbines to drive propellers rather than using them to provide a propelling jet like Whittle. A good selection of historically important artefacts connected with these early developments is displayed in Hall 1, whilst the later research and development work is contained in a separate exhibit in Hall 2.

Whittle's company, Power Jets Limited, was formed in 1936. Much development was needed to achieve the temperatures and pressures required in a workable engine, and there were many setbacks. However, by 1939 Power Jets received a contract to provide the engine (the W1) for Britain's first jet, the experimental Gloster E28/39, which flew in 1941. By 1940 the Air Ministry realised the potential of the jet engine and Power Jets received a contract to produce the W2 engine for the RAF's first production jet fighter, the Gloster Meteor, which entered service in 1944. An original

version of the Whittle W2 (the W2/700) is displayed here alongside a combustion chamber, impellor and other artefacts from early engines.



Next to the W2/700 is the Augmentor for the proposed Miles M52 supersonic research aircraft under development towards the end of WW2. This very advanced aircraft was to perform supersonic research at up to 1,000 mph at 36,000 ft. It had a cylindrical fuselage, thin straight wings and an all moving tailplane. The modified W2/700 engine (shown above with part of the Augmentor) was housed in the fuselage with the Augmentor (basically a compressor, additional combustion chambers and a form of afterburner) installed behind it. The project was terminated in 1946 despite the aircraft being well under construction.

Whittle's engines used a centrifugal compressor, in which the air is sucked in and compressed by being thrown outwards by the impellor before entering the combustion chambers. RAE had been working on axial flow compressors, in which air is compressed as it passes through a series of rotors and stators, as illustrated by the RAE/Metropolitan-Vickers F2 compressor included towards the end of the display. RAE Engine Department's work expanded considerably in the mid 1940s, and a purpose-built jet research and development facility was constructed at Pyestock on the north west side of the Farnborough airfield. This became NGTE, and Power Jets was merged into it in 1946. The work of NGTE and the development of the jet engine continue in a separate display in Hall 2.

Carbon Fibre Display

It is now more than half a century since the pioneering research at RAE led to the invention of high strength, high stiffness, carbon fibres. The inventors – Bill Watt, Bill Johnson and Leslie Phillips – were aware that fibres with a lower density than glass were needed to reinforce plastics for application in aerospace structures. In 1963 they decided that the best approach was to carbonise organic fibres, especially the textile fibre polyacrylonitrile (PAN) because heating in air oxidised it to produce a high yield of carbon without melting. Their unique experiments showed that it was all important to overcome the shrinkage of the PAN fibres during the low temperature stages of oxidation before subsequent heat treatment up to 2500 degrees Centigrade. During the next five years the RAE process was optimised and licenced to UK companies interested in supplying commercial carbon fibre for the manufacture and evaluation of reinforced plastics, initially for sports and leisure equipment and later for aerospace components. The FAST museum exhibit includes a concise description of the RAE invention, with a biographical note on the inventors, and the Queen's Award in 1988 for Technological Achievement, which is reflected in the displays of carbon fibre and its diverse range of applications.

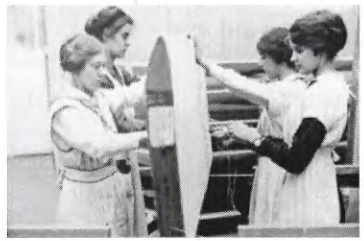
Avionic Systems Display

The exhibit shows a range of technologies used over the years to assist pilots to both fly and navigate their aircraft. The unique properties of the gyroscope enable it to be used to provide aircraft attitude, heading and rate of turn information. More advanced technologies such as the ring laser and fibre-optic gyros on display provide accurate aircraft angular rate information. The accelerometer is also an important sensor and, with the gyroscope, forms the basis of an inertial navigation system (INS). The INS provides accurate flight control and navigation signals and is independent of ground-based sensors. An ex-TSR2 INS is on show.

Another important cockpit system is the head-up display (HUD). This presents information to the pilot on a semi-reflective glass plate positioned between him and the windscreen. Symbology is overlaid on his line of sight to allow him to control the aircraft and carry out his mission. A slideshow describes the evolution of the HUD, which is found in all military combat aircraft. Examples of hardware and typical symbology are presented. Finally, a WW2 bombsight computer is on display. Nowadays, this function is performed within the HUD system with appropriate symbology presented to the pilot.

Royal Aircraft Factory 1914—1918

During the period of 1914/18 the Royal Aircraft Factory experienced a rapid expansion, with the number of staff rising from around 1000 to over 5000. Whilst the primary role was to develop and test aircraft designs and their associated supportive technologies, a degree of aeroplane manufacture was also managed with over 500 aeroplanes being produced.

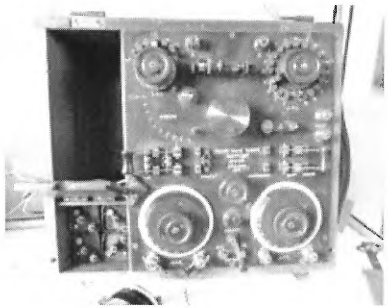


To illustrate some of the activities and achievements our display starts with a brief overview of the factory, followed by descriptions of how the many women workers may have been employed at the factory, with extracts from diaries kept at the time giving a worker's view of everyday life.

A time line showing the factory's achievements during this period is supported by a collection of original photographs of factory work and some of the resultant aeroplanes and engines. A life size female mannequin (left), dressed in typical factory clothing of the period, is working the fabric of a section of airframe beside an

original factory sewing machine, which is displayed with some of the test and production tools used at the time.

To take you back in time, two screens continuously play a collection of period films showing aeroplanes, men, women and some of the many activities in which they were involved, including footage of Farnborough and the museum building during WW1.



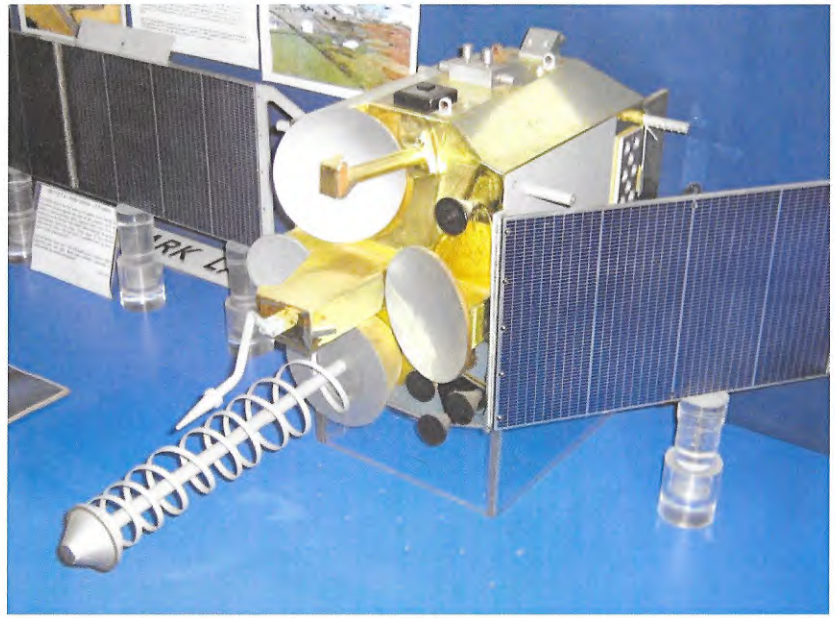
Across the room are shown some of the supporting technologies, such as the development of aerial photography and wireless. On display is an original 1917 wireless receiver (left) as used by the RFC, together with headsets; also a device called a Gosport Tube used for inter-cockpit communication, which greatly improved the safety of flight instruction.

Scientific work on the development and evaluation of materials, aerodynamics, ordnance, fabrics and dopes were just some of the important contributions made to military aviation by the factory. To aid these activities the use of wind tunnels and a whirling arm were of great importance, and these are illustrated by photographs and extracts from original documents.

Understanding meteorology is important within the world of aviation and, to this end, an advanced meteorology section was developed at Farnborough. This is fully described and illustrated with time lines and personalities.

Due to the many companies manufacturing aeroplanes, engines and components a system of test and inspection was instigated to ensure the quality and acceptability of materials. The final part of the display shows how this was achieved, from its start at Farnborough with the establishment of the Aeronautical Inspection Department, to its rapid expansion to additional sites across the UK.

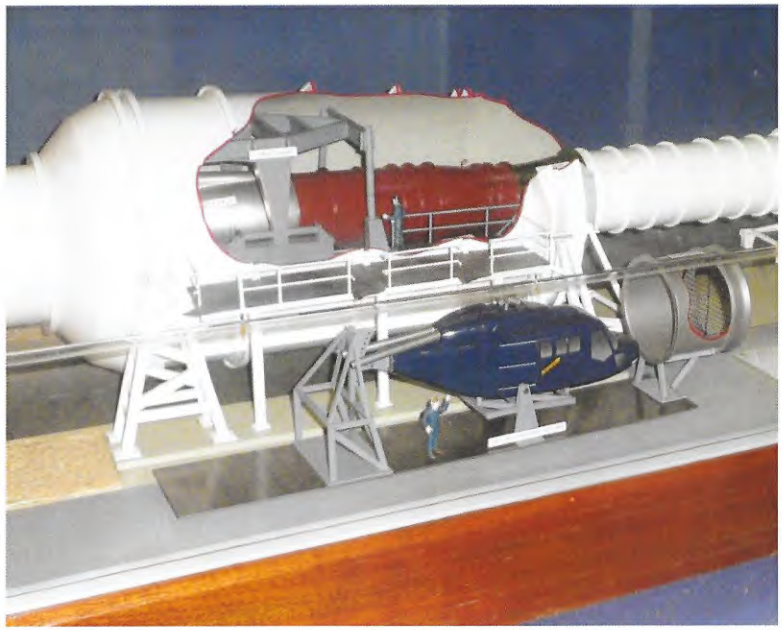
Use of carbon fibre in the construction of experimental wings for a Jaguar aircraft



Part of the RAE Space display showing a model of the British SKYNET 5 military communications satellite with right hand solar panel folded to show deployment

Two RAE Space Department designed Black Knight rockets on the launch pad at the Woomera Test Range

Concorde airframe 006 in the RAE Structures test rig
(The FAST Concorde fuselage section (arrowed) was part of this airframe)



Model of Engine Test Cell 3 West at NGTE Pyestock

Reserve Collection: Sectioned Rolls Royce Derwent engine

Hawker Hunter T7 XL563 awaiting restoration

Wind tunnel model of BAe Harrier fitted with an "W" wing and tested at Farnborough

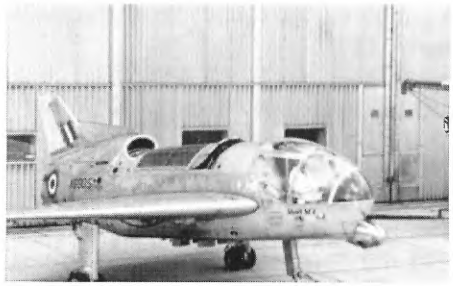
Hall 2 Please proceed clockwise:

Jet Engine Display - Part 2: Engine Development and NGTE Pyestock

In the early years work at the National Gas Turbine Establishment (NGTE) was concentrated mainly on the development of axial flow compressors, combustion chambers and turbines for use in jet engines, as well as in marine and industrial gas turbines. NGTE itself was charged with providing a research and testing centre for the British gas turbine industry as a whole, with much information sharing to ensure that Britain held the lead in this technology.

During the 1950s it became apparent that much larger facilities were required for engine development and testing, so a new site was constructed to the north west of the old one. The establishment eventually had six test cells, along with associated air supply houses, laboratories, workshops, an anechoic chamber and offices. The larger test cells could accommodate RB211 turbofans, as well as the engines used in supersonic combat aircraft and Concorde. The tests could simulate speeds up to Mach 3.5 at 100,000ft. The NGTE were responsible for producing engine design codes, investigating advanced turbine materials, conducting research into the chemistry of combustion and examining methods of noise reduction amongst their many tasks. Part of this section of the display covers this work and includes models of turbine blades, engine intakes and silencers used in the test rigs at NGTE. To illustrate the workings of a gas turbine the display includes a sectioned Gem engine from a Lynx helicopter and a Conway bypass engine. The development of the jet engine from the pure jet to the turbofan is explained so that the evolution of the engine from the 1940s to the present day can be appreciated.

Another British success in engine development is covered by the inclusion of a section on vertical/short take-off and landing (V/STOL). In the late 1950s thoughts turned to the possibility of V/STOL operations, firstly to avoid the problem of runways being destroyed by enemy action and secondly to provide the opportunity for city centre to city centre flights. At the centre of the display there is an RB108 lift engine, used to power research aircraft, including the Shorts SC1 (left) tested at RAE Bedford. There are also photographs and diagrams of a number of V/STOL proposals and prototype aircraft, generally powered by the RB108 (or the larger RB162). Despite much effort none of these schemes were developed further due to defence spending cuts. However, the Bristol Pegasus engine, with its swivelling nozzles, was successfully used to power the Hawker P1127, which was developed into the Harrier



and Sea Harrier 'Jump Jets'. The display includes model engine pods and exhaust nozzles used at NGTE during the development of the Bristol Pegasus (and similar Rolls-Royce Medway) vectored thrust engines.

Bombs, Missiles and Target Drones

The display covers a number of missiles, target drones and wind tunnel models, reflecting the RAE's involvement in the development of such systems.

Guided weapons development commenced in WW2, with much work being undertaken by the Germans and less by the allies. Following WW2, and with the Cold War in progress, it was recognised that guided weapons were the solution to the problem of shooting down fast moving and high flying Soviet combat aircraft. As the technology matured increasingly sophisticated weapons emerged, with guidance systems ranging from radar to inertial navigation to a pre-programmed target. The RAE was at the centre of missile research, development and testing, with a number of test ranges and aircraft dedicated to weapons trials.

When missiles were test fired on the Aberporth range, their target was often a heat or radar source trailed behind a Jindivik target drone launched from the nearby RAE airfield at Llanbedr. A Jindivik drone is on display outside the museum and Firestreak and Redtop air-to-air missiles are located alongside the Lightning. The FAST museum has a number of target drones and a Stiletto drone is dramatically displayed within the main exhibition. Stilletto was designed as a high-speed target to work up Royal Navy warships in anti-aircraft and anti-missile defence. In the Reserve Collection is a Chukar II target used by the Fleet Target Group and launched from the flight deck of Royal Fleet Auxiliary ships.

The RAE was also responsible for the development of bombs, especially the design of the aerodynamics of the casing and the aircraft interface. A number of the models on display were used to check that the weapon would release cleanly from the aircraft rather than flying up and striking its underside.

RAE and the UK Nuclear Deterrent

A highly classified programme of work at RAE, only now starting to be revealed, was the RAE involvement in aspects of the design and launch systems for the UK nuclear deterrent. This began in 1948, two years before the Atomic Weapons Research Establishment (AWRE) at Aldermaston was opened. One launch system was the Blue Streak intercontinental ballistic missile designed by Space Department. The first weapon was the Blue Danube bomb, for which RAE designed the bomb casing and modelled the ballistics of the weapon. By 1952 the weapons work was moved into an enclosed site to the south of the airfield, commonly referred to as "ARL". This site

was large enough to accommodate not only the buildings and research facilities required but also bomber aircraft such as the Valiant, seen right entering ARL.

RAE became the design authority for the non nuclear aspects of the work, including the blast and thermal impact of weapon detonation, aircraft paint schemes and aircraft structural design, as well as taking part in weapons tests in Australia and elsewhere. The warhead R&D was done at AWRE.

The final UK air launched nuclear weapon was the WE177 bomb. Two inert weapons, used for ground handling trials at RAE, can be seen outside the building (left) as you leave to visit the Cody Pavilion. They are mounted on the special trailer designed to stand up to rough handling over uneven terrain.

The UK submarine borne deterrent used the Polaris missile, and RAE became responsible for an upgrade programme named Chevaline. This was a British developed re-entry platform carried as the payload of the Polaris missile. The key to the system was the use of decoys in addition to the warheads themselves. The platform carried two warheads and, once they had been released, it had a degree of manoeuvrability so that warheads and decoys could be deployed over a large area at high altitude. This would confuse and saturate Soviet defence systems to ensure that the warheads reached their targets. A complete Chevaline platform is on display in the museum. Elements of Chevaline were tested on the last British rocket, Falstaff, a model of which is in the Space Exhibition.

RAE Space Department

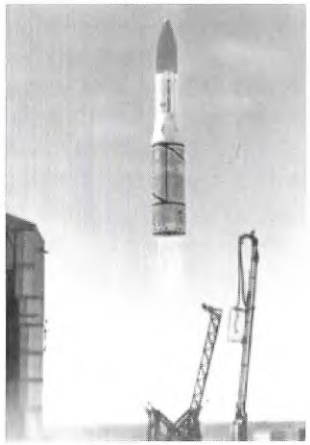
In the 21st century Space is taken for granted, yet the World runs on it and millions of people depend on space applications. Utilisation of space began in 1946 with the German V2 rocket which offered the first opportunity to fly instruments into the upper atmosphere, up to 500km, and make meaningful measurements of atmospheric properties. In 1946 RAE Controlled Weapons Department was formed, later renamed Guided Weapons Department. Over the next decade R&D concentrated on the Blue Streak intercontinental ballistic missile. The USA supplied the engines from their Atlas rocket, and the inertial guidance system, in a programme of USA/UK co-operation. Sputniks 1 and 2 were launched in October and November 1957, showing that the USSR could place satellites in orbit and also successfully launch ICBMs and

navigate them to their targets. This raised UK awareness of the potential of space in general. The main UK driver was initially military.

In 1960 the Government ordered the US Skybolt missile and cancelled Blue Streak. Skybolt was cancelled in 1962 and the submarine launched Polaris missile purchased instead. Much of GW Department's work was still needed for Polaris, for example, understanding of upper atmosphere properties, the physics of re-entry and sensor design, along with precise navigation and the understanding of the shape of the Earth and its impact on bodies in the upper atmosphere and in orbit.

On 1st January 1962 RAE Space Department was formed, largely from GW Department. At this time there were no plans for a UK satellite project and space technology could only be tested on the Skylark sounding rocket (right) which provided five minutes in a zero gravity environment. Space Department comprised five Divisions: Satellite Launching Vehicles, Ballistic Research Vehicles, Satellite Engineering, Instrument Research and Dynamics.

The main programmes of work were the design and build (in industry) of the Black Knight, Black Arrow, Skylark and Falstaff rockets, the "X" series of UK technology satellites and the "UK" series of science satellites for the Science Research Council. The main programmes represented are:



The successful launch of the technology satellite Prospero on the Black Arrow rocket (left) on 28th October 1971. This launch of an all British satellite on an all British rocket, both designed in RAE, made the UK the sixth nation to achieve this capability. Following the launch the Government cancelled the Black Arrow programme.

Half scale models of the science satellites UK2, UK4 and UK5, all launched on US rockets.

The UK SKYNET series of military communication satellites, giving HM Forces the ability to communicate around the world.

In the late 1970s, Space Department, with funding from the Department of Trade and Industry, became the UK leader and innovator in satellite remote sensing. The National Remote Sensing Centre (NRSC) was set up in R190 Building, unique in that it was outside the security fence and open to the public. Space Department was a leader in the field until the privatisation of NRSC in 1991.

Concorde Display and Simulator

RAE began investigations into a supersonic transport (SST) in the early 1950s and reported in 1955 that such an aircraft was possible. The reference shape proposed had thin straight wings with engines mounted at the wing tips and a long slender fuselage. A wind tunnel model of this proposal is included in the display.

RAE chaired a major committee, the Supersonic Transport Aircraft Committee (STAC), which reported in 1959. During the course of this work many aircraft shapes were examined, including, straight, swept, W- and delta wing configurations. Models and photographs of a number of these are included in both the Concorde and wind tunnel displays.

A delta shape was the preferred configuration for an SST. However, when the Concorde agreement was signed in 1962, the challenges of developing and testing such an aircraft required very considerable input from RAE in many areas. These included aerodynamics and many delta shapes were tested in the wind tunnels at RAE Bedford. A number of these are included in this display. Despite all this testing there were still concerns about the high and low speed handling of the proposed delta shape, and two research aircraft were built for testing at RAE Bedford, the BAC221 and the HP115. FAST possess wind tunnel models of both aircraft and it is hoped to include these in the display in the future.

Due to the kinetic heating of the airframe, it was decided that a Concorde structures test rig would be erected at Farnborough, so that a complete airframe could be tested using representative flight and pressurisation loads, as well as the effects of heating and cooling. Photographs and an architect's drawing of this facility are included in the display. A section of the test fuselage is displayed outside, next to the Canberra nose.

Cell 4 at NGTE Pyestock was built to test engines at supersonic speeds, including a complete Concorde engine and intake assembly. It was one of the most advanced test facilities in the World when completed. A major issue with the engine intake design for an SST was the ability to slow the supersonic air down to subsonic speed before it enters the engine. The solution to this problem, and how the engine produces sufficient thrust in the cruise without using reheat, is explained in the display.

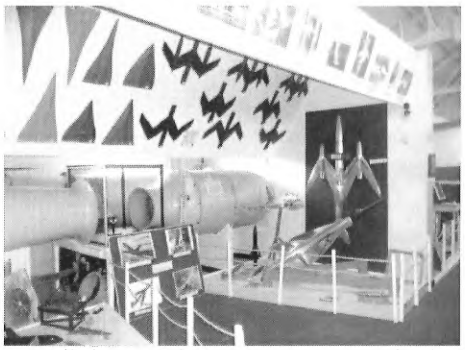
Completing this section is the Concorde simulator, which has been built by two FAST volunteers. Museum visitors can "fly" a Concorde, which makes a fitting conclusion to this section of the display which shows the huge contribution that the RAE made to the Concorde programme.

Wind Tunnels

Wind tunnels have been used to measure aerodynamic forces on models since before the days of powered flight. Since then most aircraft research and design organisations have built suites of wind tunnels to investigate and visualise airflows around aircraft and many other structures subject to wind loading. Both Farnborough and Bedford possessed several tunnels, ranging from large and small low speed facilities up to large supersonic tunnels.

As you enter the wind tunnel display you pass a case on your right containing a number of the smaller models tested. These include missile and space re-entry bodies, high speed deltas, swept wings and wave riders. To your left, at the other end of the scale, there is a large half model of a Tornado swing wing combat aircraft, which would have been bolted to the floor of the wind tunnel so that the airflows could be measured as the wings were moved.

Moving to the main part of the display, on the boards to your right the Principles of Flight are explained, along with an explanation of how wind tunnels are used and why aircraft shapes vary to suit the purpose for which they are designed. This section concludes with photographs from the museum's collection showing various aspects of the models and their uses.



At the centre of the main display is our low speed wind tunnel (left), which was used at Gottingen University in Germany. It was moved to the RAE Apprentices Training School after WW2 and then used at Farnborough College of Technology before coming to FAST. The tunnel is still used, both to demonstrate lift over an aerofoil and by students undertaking projects. To the left side of the tunnel the display is arranged to show how different wing shapes are required for increasing speed, moving from a wooden straight wing model, through the swept wing, delta and swing wings to the high speed deltas and space vehicles. To the right of the tunnel the display concentrates on the development of the delta wing working from the Fairy Delta 2 and Eurofighter Typhoon models, currently on display, through to F-35 concept models tested by the RAE, which we plan to add in the near future.

Arranged around the wind tunnel there are additional photos of other wind tunnels, as well as a number of other models of interest, including swept, delta and W-wing concepts.

Structural Testing and the Comet Failures

The display currently starts with a photographic display illustrating the means by which RAE tested the strength of aircraft. This work ranged from the use of lead shot bags to load the wings in the early days, through to the Concorde test rig. As the museum layout evolves it is planned to transform this area into an extension of the wind tunnel display. However, the Comet display will remain.

The Structures Department at RAE was on occasions called upon to assist AAIB, who are also located at Farnborough. RAE's most famous investigation was that of the de Havilland Comet accidents. A number of contemporary photographs mounted within a Comet rear fuselage cover the investigation and its findings. The investigation centred on testing the complete aircraft over repeated flight cycles until failure occurred. During these tests the fuselage was immersed in a water tank with the wings projecting (above). After repeated application of the flight loads the fuselage ruptured due to fatigue failure, which occurred after a very much shorter fatigue life than that expected by the designers.

Helicopter Rotors and Propellors

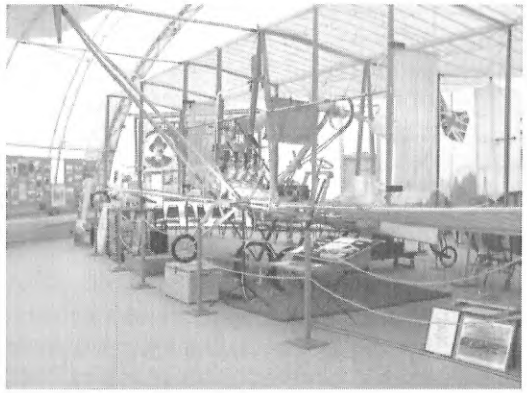
The exhibits in this area show the way in which the shape of propeller blades has developed over the years, in particular with the introduction of complex curves and shapes to maximise efficiency. The display also shows the materials used in blade construction, including carbon fibre, developed at the RAE to give a very good strength/weight ratio. A propeller works by accelerating a mass of air backwards so generating a forward thrust and the display explains how the pitch of the more complex propellers can be varied in the air to improve efficiency.

A helicopter rotor (a horizontal propeller) achieves lift by accelerating a mass of air downwards. Ever since American built helicopters first arrived at Farnborough in 1945 the RAE has been involved in rotor research. This has ranged from using coloured smoke to investigate flow patterns to using rotor rigs, such as the one displayed here, to develop advanced rotor blades and rotor heads. Press the switch on the rotor rig to demonstrate the "Swash Plate" mechanism, which adjusts the pitch of the individual blades as they rotate in order to control the helicopter. A full description of the working of the rotor and "Swash Plate" is included in the display. The blades

fitted to the rig are part of the British Experimental Rotor Programme (BERP), which has produced one of the most advanced rotor blades in the world.

Please leave by the west door and proceed to the Cody Pavilion opposite

The Cody Pavilion



The permanent exhibition in the Cody Pavilion covers the life and times of Samuel Franklin Cody, Britain's first pilot. The dominant feature is the replica of British Army Aeroplane Number 1A (right), built in the Balloon Factory by Cody and flown by him at Farnborough on 16th October, 1908, this being the first recognised powered, heavier than air, controlled and sustained flight in Great Britain

To the left of the replica aircraft is a series of picture boards representing a time line of Cody's life from his early days to his kite and aircraft developments and his death at Farnborough following a flying accident.

The picture boards on the right show the build of the replica and of the pavilion. Also on the right, behind the replica aircraft, is a Flight Simulator set up to replicate the flight characteristics of Cody's first aircraft.

Hanging above the viewing area is a modern replica of a Cody Kite, representing the first attempts by Cody to improve the flight characteristics of the basic double box (Hargrave) kite. This was the basis of all Cody's subsequent activities.

The Royal Engineers Corps of the British Army was commissioned in the late 1870s to build and operate hydrogen filled balloons, to be used as a means of improving the observational capabilities of the Army. This work started in Woolwich, moved later to Chatham and, in 1890, to Aldershot. Such balloons were ineffective if the wind strength exceeded 20 mph because of instability.

In 1902, having developed a man carrying kite system at his own expense, S F Cody attempted to interest the British Army in his invention which he believed would supplement the balloons in windy conditions. It took Cody, an American "showman" at the time, until 1904 before he captured the interest of the British Army when he was

immediately taken on as the Army's Chief Kiting Instructor. The Royal Engineers were still located in Aldershot at this time.

In 1906, wishing to expand their activities into the development of dirigibles (airships), more room was needed than was available on the Aldershot site for the building of airship sheds. After a search of possible sites it was decided to move two miles up the road to Farnborough Common, Cove Common and "Laffan's Plain" (now Farnborough Airfield). The Balloon School was built (now the Museum) and the Balloon Factory was built where the BMW Garage now stands and to the west.

Cody moved to Farnborough at this time and was engaged in installing the engine in the airship (called "Nulli Secundus", "Second to None") which flew from Farnborough to London in October 1907 with Cody on board.

Cody continued to develop his kites, progressing through large kites capable of carrying him aloft and including one with an engine, though not big enough for a pilot. This led progressively to the build of British Army Aeroplane Number 1, itself a kite, which flew, under its own power for 27 seconds and covered 1390 feet (426 metres) and which counts as the UK's first flight. The large aircraft in the pavilion is a replica of that aircraft. The replica was unveiled to the public on the centenary of that first flight, 16th October, 2008.

Cody went on to build seven more aircraft, including a second version of British Army Aeroplane No. 1, shown on boards on the left.

On 7 August, 1913, whilst giving a pleasure flight to a Mr W H B Evans, a recently retired Hampshire cricketer, something on his aircraft broke, causing a manoeuvre so violent that Cody and his passenger fell from the aircraft whilst at 300 feet (100 metres) and both were killed instantly. Cody was given a full military funeral and was buried in the Aldershot Military Cemetery where his grave can still be seen

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Behind the Scenes at FAST

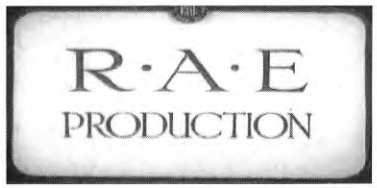
The Reserve Collection

To the north west of the Cody Pavilion are the Jaguar Building and a stack of large shipping containers. These house the Museum's reserve collection of some 500,000 artefacts relating to the research work carried out at the RAE and its lodger units. Among the artefacts are the forward fuselage sections of Westland Wasp and Westland Lynx helicopters, aero engines, a wide range of weapons, test rigs, wind tunnel models and an extensive and comprehensive range of engineering drawings, including original plans of RAE facilities.

The Photographic Archive

The Museum houses a major photographic archive from the RAE illustrating research work carried out over 100 years. In addition to a large collection of 47,000 glass plates there are 73,000 colour and monochrome prints and over 5,000 slides. Work is in hand to digitise and catalogue the collection.

The Film Archive



Cine film was introduced into the RAE in the 1940s for recording scientific, aircraft and other related trials and experiments. It was replaced by video in the 1980s. The FAST archive holds some 4,000 films which are being catalogued. In 1999 FAST started to work with Amity Productions Ltd (now FAST Archives) to commercially exploit the archive to raise funds for FAST. Clips from the films have been used in productions by many major television channels. DVDs featuring film extracts may be purchased from the Museum shop.

The Library

Open by appointment for research. It holds over 2,500 books and in excess of 30,000 technical reports, dating from 1915, produced by RAE, NGTE, the National Physical Laboratory and the Aeronautical Research Council. There is an ongoing programme to scan these into digital format to make them more readily available.

Museum Opening Hours: 10:00am to 4:00pm Saturdays, Sundays and Bank Holiday Mondays. Groups, including school parties, can visit by prior arrangement **only** on Tuesdays and Thursdays. Call 01252 375050 or email:

manager@airsciences.org.uk

Finally: Whilst every effort has been made to ensure the accuracy of the information contained in this guide, the Editors would be pleased to receive comments that may be used to improve future editions. Please email:

manager@airsciences.org.uk

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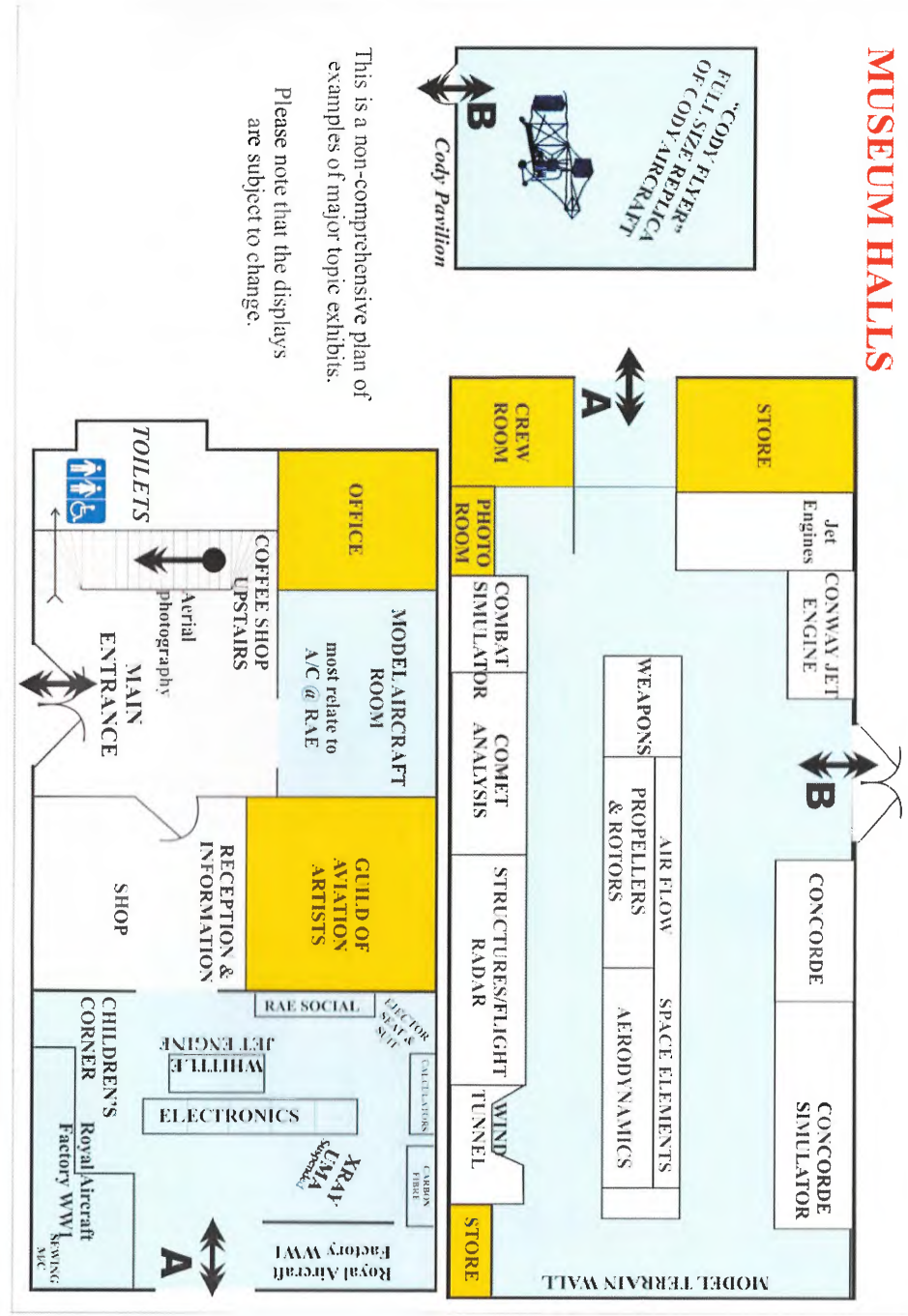

SITE LAYOUT & EXTERNAL EXHIBITS