ROYAL AIR FORCE

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AIRCRAFT & WEAPONS

FOREWORD

Fundamental to everything the RAF tries to achieve is the equipment we have at our disposal, much of which relies on world-beating, cutting-edge high technology that has been tested in conflict. It is this equipment that when operated, maintained and supported by highly professional personnel, makes the RAF a truly potent deliverer of Air Power.

In defence of our airspace at home and abroad, the Tornado F3 maintains our Quick Reaction Alert with the ASRAAM missile, which is the most up-to-date and effective air-to-air missile deployed anywhere in the world. The next generation air-to-air missile, the Meteor, a fire-and-forget missile, will give the RAF a further significant advance in missile capability when it enters service early in the next decade. The combination of Typhoon and Meteor will defeat all current and projected air-to-air threats for the foreseeable future.

For expeditionary operations overseas, the backbone of the RAF's offensive aircraft is the recently upgraded ground-attack version of the Tornado, called the GR4, which carries a comprehensive suite of sophisticated weapons and equipment. Also in this role is one of the RAF's most versatile combat aircraft, the Harrier GR7. In time, the Harrier GR7 will be updated with new engines and avionics and will be redesignated the GR9. Looking even further ahead, the GR9 will be replaced with the Short Take-Off and Vertical Landing variant of the Lockheed Martin Joint Strike Fighter, which will incorporate stealth technology and is capable of carrying twice the payload of a Harrier, over twice the distance.

As well as upgrading aircraft, the RAF is buying a new range of offensive weapons, which combine pinpoint accuracy with a very high survivability rate. One such weapon is Storm Shadow, which was highly successful during the recent hostilities in Iraq. As well as providing improved operational capability, these precision weapons will reduce greatly the risk of collateral damage and civilian casualties.

Reconnaissance remains one of the most vital functions of the RAF. The reconnaissance versions of the Tornado GR4, the Jaguar GR3 and the Harrier GR7 are used in the tactical reconnaissance role. This capability has been further enhanced by the recent introduction into service of the Raptor pod for the Tornado GR4, which provides high-resolution imaging at an extremely long range and represents the most sophisticated dual-band reconnaissance system for tactical jets in the world. Operated together, Raptor and the Tornado GR4 are a truly world-beating combination. In the electronic intelligence gathering role, the introduction of the Sentinel R1 in 2005 will complete the third arm of the ISTAR triad of Sentinel R1, E-3D Sentry and Nimrod R1.

These capabilities are supported by Air Transport and Support Helicopter fleets, which are also enjoying enhancements with the recent arrival of the C-17 Globemaster for strategic heavy-lift operations and the introduction into service of the Hercules C-130J and the Merlin HC3 helicopter. Development work on the A400M is moving forward and work on other projects, such as the selection of the future strategic tanker aircraft, is underway.

The purpose of this publication is to detail the wide range of equipment that is used by today's RAF and to introduce the platforms and systems of the future. Overall, the RAF's current equipment programme is the most exciting it has ever had and it will ensure that the RAF can command air superiority and dominate the battlespace across land, sea and air. I hope that you enjoy reading it.

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AIRCRAFT & WEAPONS

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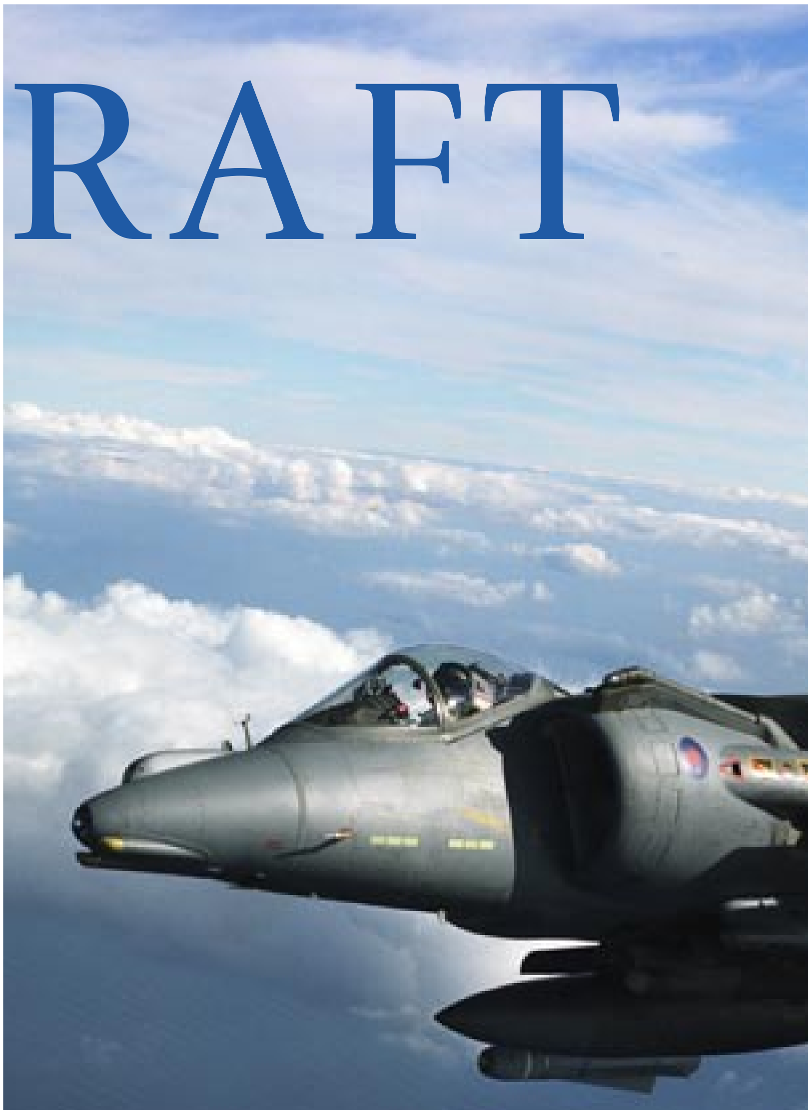


‘Fundamental to everything..........the equipment we have at our disposal, much of which relies on world-beating, cutting-edge high technology that has been tested in conflict.’

ROYAL AIR FORCE

Tornado F3

Air defence interceptor

- **Long-range air defence interceptor.**
- **Variable sweep wing for high supersonic speed or high loiter duration.**
- **All-weather day/night operation with beyond-visual-range engagement capability.**
- **Patrols for over 3 hours at 300nmls from base.**
- **Carries a full range of advanced air-to-air missiles.**

The Tornado F3 is the RAF's Counter-Air Operations Fighter. Originally a development from the Tornado GR1, the F3 was introduced as a long-range interceptor aircraft for defence of UK airspace. Changes in operational tasks, along with the experience gained during the Gulf War in 1991, led to a major Capability Sustainment Programme (CSP) of the aircraft. The F3 is capable of carrying four Skyflash semi-active missiles and four AIM-9L Sidewinder passive Infrared air-to-air missiles. After CSP modification, the aircraft is further capable of replacing Skyflash with Advanced Medium Range Air-to-Air Missiles (AMRAAM)

and Sidewinder with Advanced Short Range Air-to-Air Missiles (ASRAAM). The aircraft can also carry the Alarm missile and has a 27mm Mauser cannon on the starboard side of the airframe with a 180 round capacity. Either 1500 litre or 2250 litre external fuel tanks can be carried which, along with air refuelling, increases the aircraft's endurance.

The Tornado F3 uses the BAE Systems Foxhunter multi-mode, track-while-scan, pulse doppler air-intercept radar to detect and target hostile aircraft. It can engage multiple targets simultaneously, and has an Integrated IFF and ground-mapping mode. The front cockpit has a hands-on-throttle-and-stick capability, together with a head-up display and an electronic head-down and threat-warning display. In the rear cockpit the weapons systems officer has two multi-function display screens with a threat-warning display and a radar control panel. All aspects of both cockpits can be operated using night-vision goggles. The situational awareness of the aircrew is enhanced by a Joint Tactical Information Distribution System (JTIDS), which complements the command and control communications offered by one U/VHF radio, one Havequick radio, an HF system and a suite of IFF transponders and interrogators. JTIDS allows the F3 to interconnect with numerous sources and users of information; the UHF line-of-sight communications system can be supplemented by relay platforms and, in some cases, satellite communications. For defensive purposes, the aircraft's radar homing and warning receiver enhances threat detection and the F3 is equipped with chaff dispensers and infrared decoy flares.

There are four operational F3 squadrons and the Operational Conversion Unit. No 11(F) and No 25(F) Squadrons are based at RAF Leeming, while No 43(F) and No 111(F) Squadrons are based at RAF Leuchars, together with No 56(R) Squadron, which is the F3 Operational Conversion Unit. The Tornado F3 Operational Evaluation Unit (OEU) is currently hosted at RAF Waddington, but the OEU will return to RAF Coningsby in 2004. Four F3 aircraft are based in the Falkland Islands, where they form No 1435 Flight.

Specifications

Powerplant:	Two Turbo Union RB199 turbofans
Thrust:	16,410lbs each
Wingspan:	8.6 metres (28ft 2ins) to 13.91 metres (45ft 7ins)
Length:	18.62m (61ft 1ins)
Height:	5.95m (19ft 6ins)
Max T/O weight:	28,059kg (61,729lbs)
Max speed:	Mach 2.2
Max altitude:	70,000ft

Tornado GR4/A

All-weather strike or reconnaissance

- **Variable swept-wing, all-weather strike or reconnaissance aircraft.**
- **Terrain-following radar, forward-looking Infrared and night-vision goggles give it a full night capability.**
- **Laser target-marker allows self-designation of target for laser guided bomb operations.**
- **Full air-to-ground weapons capability including suppression of enemy air-defence systems.**
- **Infrared system enables the GR4A to conduct low-level, tactical reconnaissance missions.**

The Tornado GR4 is a variable-geometry, two-seat, day or night, all-weather attack aircraft, capable of delivering a wide variety of weapons. Powered by two Rolls Royce RB 199 Mk 103 turbofan engines, the GR4 is capable of low-level supersonic flight and can sustain a high subsonic cruise speed. The aircraft can fly automatically at low level using terrain-following radar when poor weather prevents visual flight. The aircraft is also equipped with forward-looking Infrared and is night-vision goggle compatible, making it a capable platform for passive night operations. For navigation purposes, the Tornado is equipped with an integrated global positioning inertial navigation system that can also be updated with visual or radar inputs. The GR4 is also equipped with a Laser Ranger and Marked Target Seeker system that can

be used for ground designation or can provide accurate range information on ground targets.

The GR4 can carry up to three Paveway II, two Paveway III or Enhanced Paveway Laser Guided Bombs (LGBs), and by using a Thermal Imaging Airborne Laser Designation (TIALD) pod it is able to self-designate targets for LGB delivery. The GR4 also has a ground-mapping radar to identify targets for the delivery of conventional 1000lb bombs and BL755 cluster bombs. All GR4 aircraft are capable of carrying the Air Launched Anti-Radiation Missile (ALARM), which homes on the emitted radiation of enemy radar systems and can be used for the suppression of enemy air defences. The GR4 is capable of carrying up to nine ALARM missiles or a mixed configuration of ALARM missiles and bombs. In the reconnaissance role the GR4 can carry the Joint Reconnaissance Pod to provide detailed reconnaissance imagery; this is currently being replaced with the RAPTOR pod, which provides an even greater day-and-night reconnaissance potential.

For self-protection, the GR4 is normally armed with two AIM-9L Sidewinder short-range, air-to-air missiles, a BOZ-107 Pod on the right wing to dispense chaff and flares and a Sky Shadow-2 electronic counter-measures pod on the left wing. The aircraft can also carry an integral 27mm Mauser cannon capable of firing 1700 rounds per minute.

The Tornado GR4 is now being equipped with the Storm Shadow missile and will soon be equipped with the new Brimstone missile. The Storm Shadow will allow the Tornado to make precision strikes in poor weather with a greatly increased stand-off range from the target area. Brimstone will provide the Tornado with an effective anti-armour weapon, also providing an enhanced stand-off range.

The Tornado GR4 is currently operated from two bases. Based at RAF Lossiemouth are the Operational Conversion Unit, No 15(R) Squadron, and Nos 12, 14 and 617 Squadrons. RAF Marham, the home of the GR4s of Nos 9(B) and 31 Squadrons, also houses the GR4As of Nos II(AC) and 13 Squadrons. The GR4A is equipped with the Tornado Infrared Reconnaissance system, which provides a low-level tactical reconnaissance capability.

Specifications

Powerplant:	Two Turbo Union RB199 turbofans
Thrust:	16,000lbs each
Wingspan:	8.6 metres (28ft 2ins) to 13.91 metres (45ft 7ins)
Length:	16.72m (54ft 10ins)
Height:	5.95m (19ft 6ins)
Max T/O weight:	28,059kg (61,729lbs)
Fuel internal:	5141kg (11,310lbs)
Fuel external:	1800kg (3960lbs) (under wing tanks)
Max speed:	Mach 1.3
Max altitude:	50,000ft

Harrier GR7

STOVL multi-role combat

- **Multi-role combat aircraft capable of vertical or short take-off and landing.**
- **Part of Joint Force Harrier (JFH), operating from land bases or aircraft carriers.**
- **Comprehensive weapons capability including bombs, rockets or missiles.**
- **Can operate at night, at low level, using night-vision goggles.**
- **Cockpit gives navigation and weapons information on multi-purpose colour displays.**

The Harrier GR7 is a single-seat, multi-role combat aircraft that can operate in extreme environments and from a wide selection of locations, including deployed air bases and aircraft carriers. The old GR3 model famously saw operation with the RN during the Falklands Campaign in 1982 and today's GR7 maintains the maritime link by working as part of the JFH. In its role as part of the JFH, the RAF's GR7 force remains ready to deploy anywhere in the world with the RN's Sea Harriers as part of a naval task force.

The Harrier's unique feature is its ability to vector the Pegasus-engine thrust. This vectored thrust enables it to operate from short landing surfaces and to take off

and land vertically. The jet efflux is directed out of four nozzles, which move in unison from a rearward-pointing position for conventional flight to a position where the nozzles point directly below the aircraft to allow it to hover. The single Pegasus engine produces 21,500lbs of thrust.

The flying controls work on the 'Hands-on-Throttle-and-Stick' system (HOTAS), enabling the most important weapons and avionics functions to be operated by the pilot without having to remove his hands from the controls. Information is displayed to the pilot through the Head-Up Display (HUD) and is also presented on two multi-purpose colour displays (MPCDs). The pilot can use the MPCDs to display almost any system information, including the aircraft's position on a moving map display, and the weapon load being carried. The MPCD's can also display target pictures obtained from the aircraft's sensors. The picture from the Dual Mode Tracker, a six times magnification television camera mounted on the nose, or from the Maverick missile seeker head, can also be displayed, together with a Thermal Imaging Airborne Laser Designator (TIALD) tracking-and-target picture if a TIALD pod is carried. During night operations, the Forward Looking Infrared picture is presented on a MPCD and is also overlaid onto the HUD. All the displays are compatible with night-vision goggles, which gives the Harrier its ability to operate by night, at low level.

The Harrier can carry a full range of air-to-ground weapons, including Paveway II and Paveway III laser guided bombs, BL 755 cluster bombs, CRV-7 rockets and Maverick missiles. For defensive purposes, the Harrier can also be armed with AIM-9L Sidewinder air-to-air missiles, and it is fitted with a radar warning receiver, an electronic jamming pod, a missile approach warning system and chaff and flare dispensers.

When flying at low level the Harrier cruises at 420kts (480mph) and then typically increases speed to 480kts (550mph) when delivering weapons. This gives it a low-level combat radius of approximately 250nmls. When operating at medium level the Harrier cruises at 0.75 Mach and has a combat radius of approximately 350nmls. These ranges vary upon the tasking requirement and weapon load being carried and can be increased by the use of in-flight refuelling.

The Harrier is a very capable aircraft and has proven to be a valuable asset over the past few years in many campaigns including those in Bosnia, Kosovo and Iraq. The GR7 will soon undergo a series of major improvements, with changes to both the avionics and to the engine, and will be redesignated the GR9.

Specifications

Powerplant:	RR Pegasus Mk 105 turbofan
Thrust:	21,750lbs
Wingspan:	9.25m (30ft 4ins)
Length:	14.36m (47ft 2ins)
Height:	3.55m (11ft 8ins)
Max STO weight:	14,091kg (31,000lbs)
Max VTO weight:	8614kg (18,950lbs)
Fuel internal:	3527kg (7,759lbs)
Fuel external:	3669kg (8071lbs) (four drop tanks)
Max speed:	575kts (661mph)
Max altitude:	43,000ft

Jaguar GR3/A

Offensive counter air, close air support and tactical reconnaissance

- **Operates in the offensive counter air, close air support and tactical reconnaissance roles.**
- **Recent major avionics, navigation and weapons systems upgrade.**
- **Full electro-optical reconnaissance capability at medium and low level.**
- **Carries laser target marking equipment for self-designation or cooperative designation.**
- **First RAF aircraft to be fitted with a helmet mounted missile sighting system.**

The RAF's GR1 Jaguar fleet has recently undergone a major upgrade programme and the aircraft has been redesignated the Jaguar GR3. The upgrade gave the aircraft improved avionics, including global-positioning and terrain-referenced navigation systems integrated into the aircraft's inertial navigation system, a military-standard 1553 databus, internal and external night-vision-goggle compatible lighting, and new head-up and head-down displays. The weapons upgrade included a helmet-mounted sight and an Advanced Short Range Air-to-Air Missile (ASRAAM) capability. The Rolls-Royce Turbomeca Adour Mk 104 turbofan engines are being upgraded to the Adour Mk 106 engines, which are more powerful

and economical than the Mk 104s, especially for high and hot operations. The aircraft can be deployed quickly anywhere in the world to conduct operations in the offensive counter air, air interdiction, close air support and tactical reconnaissance roles.

The RAF's Jaguars are all based at RAF Coltishall, which is home for the three operational squadrons, Nos 6 Squadron, 41(F) and 54(F) Squadrons, and the Jaguar Operational Conversion Unit, No 16(R) Squadron. All three operational squadrons are able to conduct attack and reconnaissance operations, although Nos 6 and 54(F) Squadrons are primarily attack squadrons, while No 41(F) Squadron is primarily a reconnaissance squadron.

The Jaguar is capable of carrying 1000lb retard and freefall bombs, BL755 and RBL755 cluster bombs, Paveway II and Paveway III laser guided bombs (LGB) and CRV-7 rocket pods. For self-defence it is equipped with a Skyguardian radar warning receiver, an electronic-countermeasures pod, and chaff and flare dispensers. It can also carry two 30mm Aden cannons and two over-wing mounted AIM-9L Sidewinder air-to-air missiles. The GR3 can be fitted with an external fuel tank on the centreline pylon, or two under-wing mounted tanks. In the reconnaissance role, the GR3A can carry the Joint Reconnaissance Pod, which contains various electronically scanned sensors, a number of electro-optical camera options and an Infrared Line Scanner. It can also carry the Thermal Imaging Airborne Laser Designation (TIALD) pod for self-designation or cooperative designation of targets during LGB operations.

RAF Jaguars participated extensively in the Gulf War in 1991, and have subsequently been involved in many operations in the Middle East and the Balkans. They deploy regularly for exercises to North America, Europe and the Middle East, where they operate in diverse conditions ranging from deserts to arctic tundra.

Specifications

Powerplant:	Two Rolls-Royce Turbomeca Adour turbofans
Thrust:	8249lbs each
Wingspan:	8.69m (28ft 6ins)
Length:	16.83m (55ft 2ins)
Height:	4.89m (16ft 1ins)
Max T/O weight:	15,733kg (34,612lbs)
Fuel internal:	3344kg (7357lbs)
Fuel external:	2850kg (6270lbs) (three drop tanks)
Max speed:	Mach 1.4
Max altitude:	46,000ft

Typhoon F2

High performance multi-role fighter

- **High performance, single seat, multi-role fighter aircraft.**
- **Optimised for air superiority, but with a full ground attack and reconnaissance capability.**
- **Carries a full range of air-to-air and air-to-ground weapons.**
- **Highly advanced avionics including Voice Throttle and Stick control system.**
- **Capable of automatically fusing all radar and weapons inputs for presentation to the pilot.**
- **World beating 4th generation aircraft capable of combating any perceived threat.**

Eurofighter Typhoon F2, is an agile, single seat, multi-role aircraft optimised for high altitude supersonic air superiority, but capable of operating throughout the complete range of air defence and ground attack roles. It is being built by a four-nation consortium comprised of European partner companies from the UK, Germany, Italy and Spain. The airframe, which is constructed mainly from carbon fibre composite materials and lightweight alloys, is powered by two EJ 200 engines each producing 20,000lbs of thrust in full afterburner. In full air-to-air configuration the engines provide a thrust-to-weight ratio of 1 to 1.3, which enables the Typhoon F2 to fly at Mach 2 at 65,000 feet, reach an altitude of 36,000 feet in less than two minutes and to accelerate from 200kts to 700kts in 30 seconds. The Typhoon F2 can carry the full current range of air-to-air and air-to-ground missiles, including

Paveway Laser Guided Bombs, Brimstone anti-armour missiles and the Storm Shadow stand-off cruise missile.

The Typhoon F2 is equipped with a highly advanced avionics suite with the main sensor being the ECR 90 multi-mode radar that incorporates Non Co-operative Target Recognition. The aircraft is also equipped with an Infrared Search and Track system, a Multi-function Information and Distribution System data link and a fully automatic Defensive Aids Sub-system. The aircraft has a wide-angle head-up display complemented by a helmet-mounted display which shows the flight reference data, weapon aiming and cueing and the forward looking infrared imagery. The cockpit also contains three multifunction, full mode selection and data entry using voice command, while the stick and throttle houses fingertip controls for sensor and weapon control, defence aids management and in-flight handling.

The Typhoon F2 will replace the Tornado F3 and Jaguar GR3. Current plans indicate that the Typhoon frontline will comprise seven squadrons, of which four will be primarily air defence, two will be multi-role squadrons and one will be a fighter bomber squadron. This combination will give the RAF a very wide range of ground attack and reconnaissance capabilities. Eurofighter Typhoon F2 gives the RAF a world beating 4th generation multi-role fighter aircraft capable of dominating the airspace against any currently perceived future threat.

colour, head-down displays and is fully night vision compatible with the use of night-vision goggles. The key to Typhoon's success will be the ability to fuse all of this data into a single usable format and present it quickly and effectively to the pilot; a process called sensor fusion.

The Typhoon F2 cockpit has been designed to minimise workload for the pilot by allowing all of the avionics to be controlled by direct voice input as part of the Voice Throttle and Stick system. This system allows all functions to be carried out by the pilot without the need to remove his hands from the aircraft controls. The direct voice input allows the pilot to carry out

Specifications

Powerplant:	Two Eurojet EJ200 turbofans
Thrust:	20,000lbs each
Wingspan:	10.95m (35ft 11ins)
Length:	15.96m (52ft 4ins)
Height:	5.28m (17ft 4ins)
Max T/O weight:	21,044kg (46,297lbs)
Max range:	1000nmls plus
Max speed:	Mach 2
Max altitude:	65,000ft

Joint Combat Aircraft

STOVL multi-role fighter/attack

- **Short Take-Off Vertical Landing (STOVL) multi-role fighter/attack aircraft.**
- **Planned in-service date of 2012 to replace Harrier GR7/GR9.**
- **Capable of all-weather, day and night air-support and reconnaissance operations.**
- **Embraces stealth design techniques producing a very low radar signature.**
- **Sophisticated avionics and weapon-targeting systems using advanced technology.**

The Joint Strike Fighter, which is being built by Lockheed Martin as the F35, will be known in UK service as the Joint Combat Aircraft (JCA) and will replace the RAF and RN's Harriers from 2012. Although Lockheed Martin is the prime contractor, the UK is a Level 1 partner with the US and a number of British companies, including BAE Systems and Rolls-Royce, will have extensive involvement in building and developing the aircraft. The UK version will be a multi-role fighter/attack aircraft designed to operate as a STOVL aircraft from land bases and from the next generation of aircraft carriers being built for the RN. This will give the UK a world-beating land-based and sea-based joint expeditionary air power capability well

into the middle of the Century. When the JCA enters service, it will be able to operate in all weathers, by day and by night, for defence of the fleet and for the offensive air support of ground forces. This support will range from close air support to long-range interdiction, as well as anti-surface warfare and tactical reconnaissance. The aircraft will offer several advantages over the Harrier: supersonic flight, improved survivability, internal and external weapons carriage, an increased range and easier supply and maintenance.

The JCA design applies stealth technology techniques and, to minimise its radar signature, the airframe has identical sweep angles for the leading and trailing edges of the wing and tail, and incorporates sloping sides for the fuselage and the canopy. As a further signature-reduction measure, the seam of the canopy and the weapon-bay doors are saw-toothed and the vertical tails are canted at an angle. To achieve the smallest signature possible the aircraft will have the ability to carry a range of weapons internally, rather than carried underneath the aircraft as in current fighters.

The main radar system will be a newly developed, electronically scanned array multi-function radar with synthetic aperture capabilities. Targeting information will be supplied by an electro-optical system, which will provide long-range detection and precision targeting by employing thermal imaging, laser tracking and marking, and a forward-looking Infrared system. The aircraft's systems will also provide navigation, missile warning and Infrared search and track capability.

Early production aircraft will be powered by a Pratt and Whitney F-135 turbofan engine, but there are plans for subsequent aircraft to be offered with a choice of an interchangeable F-136 engine being developed by General Electric. Vertical lift and hover will be achieved by means of a Rolls-Royce developed lift-fan system. Doors installed above and below the vertical fan open as the fan powers up to provide vertical lift. This vertical lift is used in conjunction with the main engine exhaust nozzle at the rear of the aircraft, which swivels down from the horizontal to provide the required lift.

The JCA will place the RAF at the forefront of aviation technology and will give it a multi-role aircraft that will surpass any aircraft or weapons system in production today, or envisaged in the foreseeable future. Coupled with the Typhoon F2, which is now entering service, it will give the RAF an air-power capability second to none.

Specifications

Powerplant:	Pratt & Whitney F-135 turbofan
Thrust:	37,000lbs
Wingspan:	10.67m (35ft 2ins)
Length:	15.52m (50ft 11ins)
Height:	4.6m (14ft 11ins)
Max T/O weight:	22,727kg (50,000lbs)
Max speed:	Mach 1.8
Max altitude:	50,000ft plus

E-3D Sentry AEW1

Surveillance and airborne command and control

- **Operates in air and sea surveillance and airborne command-and-control roles.**
- **Crew of 18, including an 11-man mission-control crew.**
- **Flying at 30,000ft it can scan 312 kms at ranges up to 280nmls.**
- **Multi-mode lookdown radar separates targets from ground and sea clutter.**
- **Transmits information to ground units or ships using digital data links.**

The RAF operates seven E-3D Sentry aircraft in the airborne surveillance and command-and-control role. The aircraft are based at RAF Waddington, where they are operated by Nos 8 and 23 Squadrons as the UK's contribution to the NATO Airborne Early Warning and Control Force. The E-3D also forms one arm of the UK Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) triad of Sentinel R1, E-3D and Nimrod R1 aircraft. Whilst primarily procured as an airborne early warning aircraft, the E-3D has been extensively employed in the Airborne Warning and Control System (AWACS) role. The E3-D Sentry, known to the RAF as the AEW Mk1, is based on the commercial Boeing 707-320B aircraft,

which has been extensively modified and updated to accommodate modern mission systems. Mission endurance is approximately 10 hours (over 5000nmls), although this can be extended by air refuelling. The E3-D is the only aircraft in the RAF's inventory capable of air refuelling by both the American 'flying-boom' system and the RAF's 'probe-and-drogue' method.

The normal crew complement of 18 comprises four flight-deck crew, three technicians and an 11-man mission crew. The mission crew comprises a tactical director (mission crew commander), a fighter allocator, three weapons controllers, a surveillance controller, two surveillance operators, a data-link manager, a communications operator and an electronic-support-measures operator. The Sentry's roles include air and sea surveillance, airborne command and control, weapons control and it can also operate as an extensive communications platform.

The aircraft cruises at 30,000ft and 400kts and its Northrop Grumman AN/APY-2 high-performance, multi-mode lookdown radar, housed in the black radome, is able to separate airborne and maritime targets from ground and sea clutter. One E-3D flying at 30,000ft can scan over 312 kms, it can detect low-flying targets or maritime surface contacts within 215nmls and it can detect medium-level airborne targets at ranges in excess of 280nmls. The multi-mode radar provides lookdown surveillance to the radar horizon and an electronic vertical scan of the radar beam provides target elevation and beyond-the-horizon operation for long-range surveillance of medium and high-altitude aircraft. These attributes allow it to determine the location, altitude, course and speed of large numbers of airborne targets. The aircraft's mission systems can separate, manage and display targets individually on situation displays within the aircraft, or it can transmit the information to ground-based and ship-based units using a wide variety of digital data links.

The communications systems provide the required internal and external communications to support the AWACS command-and-control mission. The aircraft has a multi UHF/VHF/HF radio fit to provide secure digital data links, secure-voice or clear-voice radio communications and secure satellite communications for extended-range operations. A planned upgrade programme will include new mission display-consoles, increased radio and satcom capacity and improvements to the AN/APY-2 radar.

Specifications

Powerplant:	Four CFM 56 2A-3 turbofans
Thrust:	24,0001bs each
Wingspan:	44.98m (147ft 7ins)
Length:	46.68m (153ft 3ins)
Height:	12.7m (41ft 7ins)
Max T/O weight:	151,136kg (332,500lbs)
Max endurance:	11 hours
Max speed:	460kts (530mph)
Max altitude:	35,000ft plus

Sentinel RMk1

Airborne stand-off radar

- **Long-range, battlefield-intelligence airborne radar aircraft for the RAF and the Army.**
- **Full day or night capability with a radar able to penetrate cloud, rain or smoke.**
- **Stand-off capability of several hundred kilometres, at altitudes up to 50,000ft.**
- **Provides high quality, radar ground images and tracks mobile targets.**
- **Near-real-time, secure data-link transmissions to mobile ground stations.**
- **Forms one arm of the ISTAR triad of Sentinel R1, E-3D Sentry and Nimrod R1.**

ASTOR (Airborne Stand-Off Radar) will provide a long-range, battlefield-intelligence, target-imaging and tracking radar for the RAF and the Army and will have surveillance applications in peacetime, wartime and in crisis operations. The prime contractor selected to provide the ASTOR system is Raytheon Systems Limited, using the Bombardier Global Express aircraft as the air platform. The system comprises three basic components, or segments. The first segment is the air platform, a modified twin-engined Global Express business jet, called the Sentinel RMk1 by the RAF, equipped with a radar system capable of both Synthetic Aperture Radar (SAR) and Moving Target Indicator (MTI) functions. The SAR will enable all-weather, day and night reconnaissance and surveillance to be carried out; the MTI will enable the operators to monitor the activity of mobile ground targets. The

second segment is the transportable and mobile ground stations that will process, analyse and exploit the information data-linked by the air platform and present it in a variety of formats to commanders, tacticians and weapons operators on the battlefield. Finally, the support segment provides important mission-support functionality such as mission-planning and mission-data reply at the main operating base at RAF Waddington or for subsequent deployment.

A two pilot flight-deck crew will operate the aircraft, with a mission controller and two air-imagery analysts forming the rear crew. The aircraft, currently in production as an ultra-long range business jet, will be modified to include a radome under the forward fuselage to house the radar and datalink antennas, and a radome on the upper fuselage to house the SATCOM antenna. The aircraft can operate at up to 50,000ft, with a ferry range in excess of 5000nmls and with a mission endurance of over 14 hours. The engines used by the ASTOR aircraft are the Rolls-Royce Deutschland (RRD) BR710 engines, which are the same as those used on the Nimrod MRA4 maritime patrol aircraft. Defensive aids will include a radar warning receiver, a missile warning system, a towed radar decoy and chaff and flare dispensers.

The radar is an upgraded version of the Raytheon ASARS-2 radar used on the U-2 aircraft and will be capable of providing high resolution images of the battlefield at ranges of several hundred kilometres and from altitudes as high as 47,000ft. The SAR aspect of the radar will provide high-quality images of the area surveyed, while the MTI aspect will simultaneously track moving vehicles operating in the area. The SAR can be operated in spot mode to identify and track the direction and speed of specific targets, or can be switched to swath mode to provide a large number of picture strips which join together to form a detailed image of the surveyed area. These images can be exploited by the airborne mission crew or transmitted in real time via secure data-links, satellite communications or ground networks to mobile or transportable ground-based processing stations, which display them as visual images for inclusion in reports transmitted to land force and/or air commanders.

ASTOR is due to enter RAF service in 2005 when it will become the most advanced long-range, airborne-surveillance system of its kind in the world. Five Sentinel RMk1 aircraft will be purchased and operated by No 5(AC) Squadron, based at RAF Waddington, where they will form one arm of the UK surveillance triad of Sentinel R1, E-3D Sentry and Nimrod R1.

Specifications

Powerplant:	Two RRD BR710 turbofans
Thrust:	14,9000lbs
Wingspan:	28.65m (94ft 3ins)
Length:	30.3m (99ft 5ins)
Height:	7.57m (24ft 10ins)
Max T/O weight:	42,500kg (93,500lbs)
Max endurance:	15hrs (internal fuel)
Max speed:	Mach 0.88
Max altitude:	51,000ft

Nimrod R1

Reconnaissance and electronic intelligence gathering

- **Jet-powered reconnaissance and electronic intelligence gathering aircraft.**
- **Carries a highly sophisticated and sensitive suite of systems.**
- **Able to transit at high speed and then loiter at lower speed for long periods.**
- **Endurance of 10 hours, which can be extended by air refuelling.**
- **Carries two inertial navigation systems and a global positioning system.**

The Nimrod R1 is a derivative of the Nimrod MR2 maritime patrol aircraft and is operated by No 51 Squadron, from RAF Waddington. The Nimrod R1 has a highly sophisticated and sensitive suite of systems used for reconnaissance and gathering electronic intelligence. The ability of the Nimrod to transit at high speed and then loiter in an operational area at lower speed for long periods makes it ideally suited to the task. Air refuelling can extend the Nimrod R1's endurance should the task demand.

The Nimrod R1 is operated by a four-man flight deck crew of two pilots, a flight engineer and a weapons systems officer, and an electronic reconnaissance crew of 24 reconnaissance-equipment operators commanded by a

mission supervisor. The aircraft is fitted with two inertial navigation systems and a satellite-based global positioning system to assist in the requirement for accurate navigation.

The Nimrod R1 can be distinguished from the maritime MR2 aircraft by the absence of the tail-mounted Magnetic Anomaly Detector boom.

Specifications

Powerplant:	Four Rolls-Royce Spey 251 turbofans
Thrust:	12,140lbs each
Wingspan:	35m (114ft 9ins)
Length:	35.86m (117ft 8ins)
Height:	9.14m (30ft 2ins)
Max T/O weight:	83,636kg (184,000lbs)
Internal Fuel:	38,182kg (84,000lbs)
Max endurance:	10hrs (internal fuel)
Max Speed:	360kts (420mph)
Max altitude:	44,000ft

Canberra PR9

Photographic and electro-optical reconnaissance

- **In service since 1962, but has received modern sensor updates.**
- **Used for photographic and electro-optical reconnaissance and aerial surveys.**
- **Provides medium-level, high-level and long-range oblique imagery in wartime.**
- **Sensors include survey, panoramic and long-range electro-optical cameras.**
- **Used only in the daytime reconnaissance role.**

Number 39 (1 PRU) Squadron is the only remaining Canberra squadron in service with the RAF and is based at RAF Marham, in Norfolk. Its role in peacetime is photographic and electro-optical reconnaissance, strategic air reconnaissance to meet overseas intelligence requirements, aerial surveys within the UK and overseas, and occasional low-level tasks. In transition to war, the role becomes medium-level, high-level and long-range oblique imagery capture in support of UK or Coalition Operations. To achieve its task, the Squadron operates four Canberra PR9 (Photographic Reconnaissance) aircraft. The PR9 was the final development of the Canberra

airframe and first entered service with No 39 Squadron in October 1962. Sensors and navigation equipment have since been updated, but the engines and airframe remain essentially the same.

Currently, the aircraft sensor-fit includes a survey camera, a panoramic camera and a long-range electro-optical camera. The survey camera is used mainly to produce vertical images on 9-inch square negatives for mapping purposes. The panoramic camera, which can be directed to any position from the horizon to the vertical, produces a swathe of negatives giving an oblique image of a target. The electro-optical camera can produce only oblique images, but the imagery can be highly magnified and transmitted to ground stations via an on-board datalink. In addition to the sensor platform updates, the PR9 has a much-enhanced navigation suite and, to improve survival in operational theatres, it has been fitted with a Skyguardian Radar Warning Receiver, and an Electronic Protective Measures suite, which dispenses chaff and Infrared decoy flares from packs mounted internally in the underside of the wings. During its earlier life, the PR9 had a low-level and medium-level night reconnaissance role using Infrared Line Scan equipment, but its current role is restricted to daytime reconnaissance.

With a pilot and weapons systems officer crew, the aircraft regularly operates at heights above 40,000ft and can remain airborne for up to 4$^1/_2$ hours, although it cannot be refuelled in the air. The Squadron recently saw operational service over Afghanistan and Iraq and has continued to provide surveillance and survey imagery of Kosovo and the Balkans over the last six years.

Specifications

Powerplant:	Two Rolls-Royce Avon Mk 206 turbofans
Thrust:	11,250lbs (each)
Wing span:	20.66m (67ft 10ins)
Length:	20.36m (66ft 10ins)
Height:	4.75m (15ft 7ins)
Max T/O weight:	24,227kg (53,300lbs)
Max speed:	450kts (520mph)
Max altitude:	48,000ft

Hercules C-130

Tactical support and transport

- **Total fleet of 50 aircraft in four designations.**
- **Each aircraft can carry up to 128 troops or 20 tonnes of freight over 2000nm.**
- **Provides tactical support to 16 Air Assault Brigade by day or by night.**
- **Long range, up to 4000nmls with air refuelling.**
- **Upgraded C-130Js replacing 25 CMk1 and CMk3 aircraft.**

The C-130 Hercules tactical transport aircraft is the workhorse of the RAF's Air Transport (AT) fleet and is based at RAF Lyneham, in Wiltshire, where it is operated by Nos 24, 30, 47 and 70 Squadrons. Also based at RAF Lyneham is No 57(R) Squadron, which is the Hercules Operational Conversion Unit. The fleet totals 50 aircraft and is a mixture of CMk1/CMk3 aircraft and the new C-130J aircraft, designated CMk4/CMk5.

CMk1/CMk3

The CMk1 and Mk3 aircraft are used primarily to carry troops, passengers or freight and are capable of carrying up to 128 passengers, or 20 tonnes of palletised freight or vehicles, for up to 2000nmls. The freight bay can accommodate a range of wheeled or tracked vehicles, or up to seven palettes of general freight. In the aeromedical evacuation role either 64 or 82 stretchers can be carried, depending on the mark of aircraft and the stretcher configuration. The maximum unrefuelled ferry range is 3500nmls, which can be extended to over 4000nmls by air refuelling. The other main role of the C-130 is Transport Support (TS), which is the airborne delivery of personnel or stores by airdrop. In this role the aircraft supports airborne operations conducted by 16 Air Assault Brigade by the aerial delivery of paratroops, stores and equipment. The aircraft is particularly valuable in its TS role as it can be operated from unprepared and semi-prepared surfaces by day or by night.

The majority of aircraft are fitted with defensive Infrared counter-measure equipment, whilst some aircraft used for special tasks have an additional, enhanced defensive-aids suite comprising a Skyguardian radar-warning receiver, a chaff and flare counter-measure dispensing system and a missile approach warning system. The CMk3 is also equipped with station-keeping equipment, which enables the aircraft to maintain its airborne position in a large formation in thick cloud or bad weather where the other formation members cannot be seen. The aircraft are receiving an ongoing avionics, electrical and structural upgrade, which will enable them to remain the workhorse of the AT fleet into the next decade.

CMk4/CMk 5

A total of 25 CMk1 and CMk3 aircraft are being replaced by the C-130J CMk4/CMk5 on a one-for-one basis. The CMk4 is almost the same size as the current CMk3 aircraft, but with a slightly longer fuselage, while the CMk5 is the same size as the CMk1. The C-130J has been modified and upgraded to include new Allison AE turboprop engines and Dowty Aerospace six-bladed composite propellers. The new engines and advanced propellers, coupled with a new digital engine-control system, give the C-130J increased take-off thrust and better fuel efficiency; thus the external fuel tanks have been omitted. The aircraft also has a revised flight deck with modern glass-cockpit and head-up displays, allowing two-pilot, flight deck operation. The cockpit is fully night-vision compatible with the use of night-vision goggles. A separate air loadmaster station has been established in the cargo hold. The aircraft is restricted to an AT role at the moment, pending military clearance for wider use in the tactical TS role.

The defensive-aids suite includes a missile warning system linked to the directional, Infrared counter-measure system, a radar warning receiver and a chaff or flare dispensing system. The defensive system helps protect the aircraft against surface-to-air and air-to-air Infrared seeking weapons that may be encountered during operations.

Specifications (C-130J)

Powerplant:	Four Allison AE 2100D3 turboprops
Thrust:	4591shp each
Propeller:	Dowty R39 six-blade variable pitch propeller
Wing span:	40.38m (132ft 7ins)
Tailplane span:	16.04m (52ft 8ins)
Length:	34.34m (ll2ft 9ins) (CMk4) 29.77m (97ft 9ins) (CMk5)
Range:	3000nmls
Max speed:	340kts (400mph)
Max altitude:	32,000ft

C-17A Globemaster III

Long range, strategic heavy-lift transport

- **Long-range, strategic heavy-lift transport aircraft.**
- **Capable of operating into austere strips with short runways and limited facilities.**
- **Basic crew of two pilots and one air loadmaster.**
- **Can carry 'outsize' loads up to 135,000lbs single-item weight.**
- **Self-supporting, needing little or no ground equipment for offload of cargo.**
- **Declared part of the UK's Joint Rapid Reaction Force.**

The C-17 Globemaster III is the latest addition to the RAF's inventory of transport cargo aircraft. It is capable of rapid, strategic delivery of troops and all types of cargo to main operating bases anywhere in the world or directly to more temporary forward operating bases owing to its short field capability. The design of the aircraft allows it to carry out high-angle, steep approaches at relatively slow speeds, thus allowing it to operate into small, austere airfields onto runways as short as 3,500 feet long and only 90 feet wide. The aircraft can operate into and out of problematic sites such as those surrounded by inhospitable terrain or made difficult by adverse weather conditions. The fully-integrated, electronic flight-deck and the advanced cargo-handling systems allow a basic crew of only two pilots and one air loadmaster to operate the aircraft. On the ground,

the aircraft can be turned in a very small radius and its four Pratt & Whitney engines are fully reversible, giving it the ability to manoeuvre into and out of restricted parking or freight-offload areas at undeveloped strips. This enables the C-17 to deliver cargo to small airfields with limited parking space in a shorter time, so increasing throughput where time on the ground is kept to a minimum. The C-17 can transport 100,000lbs of freight over 4,500 nautical miles whilst flying at heights in excess of 30,000 feet.

Cargo is loaded on to the C-17 through a large rear door that can accommodate military vehicles and palletised cargo. It can carry almost any of the Army's air-transportable, outsized combat equipment, ranging from a Challenger tank, to three Warrior armoured vehicles or 13 Landrovers, and can carry a Chinook helicopter or three Apache-sized helicopters. It carries all its own role-equipment and can fit centre-line seating, which increases the seating capacity from 54 side-wall seats to 102 seats. The aircraft can also be configured in the aeromedical evacuation role to carry a full stretcher fit. The C-17 needs little or no ground support equipment and if none is available it can perform a combat off-load where pallets are dropped from the aircraft ramp on to the taxiway or hardstanding.

The C-17 gives the RAF a long-range strategic heavy-lift transport aircraft that offers the ability to project and sustain an effective force close to a potential area of operations for combat, peacekeeping or humanitarian missions worldwide. The aircraft is a declared part of the UK's Joint Rapid Reaction Force and the RAF is currently the only European force which can offer 'outsize airlift' assets from within its own inventory.

Specifications

Powerplant:	Four Pratt and Whitney F117-PW-100 turbofans
Thrust:	40,400lbs each
Wingspan:	52m (170ft 8ins)
Length:	53m (174ft)
Height:	16.79m (55ft 2ins)
Max T/O weight:	265,909kg (585,000lbs)
Max range:	4,700nmls
Max speed:	Mach 0.875
Max altitude:	45,000ft

A400M

Tactical and strategic airlift

- **Tactical and strategic airlift capability from unprepared strips.**
- **Short-strip, low-speed capability allows support to front-line destinations.**
- **Four advanced turboprops offering reliability, economy and easy maintenance.**
- **Range, speed and height comparable to military jet transport aircraft.**
- **Can carry up to 116 troops or 32 tonnes of freight over 2300nmls.**
- **Two-pilot, flight-deck crew supported by one air loadmaster.**

The mainstay of the RAF's tactical and strategic airlift is the C-130 Hercules aircraft. A total of 25 C-130K aircraft have been replaced by the C-130J and future plans include the replacement of the remainder of the fleet by 25 A400M outsize, strategic-airlift aircraft in 2011. The aircraft, which is a collaborative venture involving the governments and industries of six European countries, will support the deployment of the Joint Rapid Reaction Force and will give the RAF a tactical and strategic-airlift aircraft capable of supporting all three Services in peace, crisis and wartime roles. The aircraft will be capable of carrying a load of 32 tonnes over a range of 2300nmls at speeds comparable with pure-jet military transports; furthermore, the range of the aircraft can be extended by the use of a removable, air refuelling probe mounted above the cockpit. The aircraft will be capable of

equipment and chaff/flare dispensers.

The cargo bay of the A400M will be controlled by one air loadmaster and can be configured for a number of roles: pure troop carrying, or a mixture of troops and support equipment; palletised cargo or military wheeled and tracked vehicles; two attack helicopters such as the Apache or Puma; or a mixture of light and heavy engineering equipment. Offloading equipment or stores after landing can be achieved using

operating either at low-level (down to 150ft agl) or at high-level altitudes up to 40,000ft, and it will be able to deploy troops or equipment between and within theatres of operation either by parachute (up to 116 paratroopers), or by landing on short, unprepared or semi-prepared strips. The aircraft will also offer significant improvements in reliability, maintenance and operating costs over the C-130K fleet.

The two-pilot flight-deck crew will have the benefit of an integrated, digital avionics system in the cockpit and a fly-by-wire control system. Additional systems will provide a night-vision-compatible glass cockpit complete with two head-up displays supported by at least five multi-function displays that will allow state-of-the-art avionics developments to be incorporated into the flight-deck design, so greatly reducing crew workload. The aircraft will be driven by four Europrop International (EPI) turboprop engines, which will be the most powerful turboprops developed to date in the western world, that will be light, easy to maintain and will consume 20% less fuel per mission relative to a similar turbofan engine. A modern defensive-aids suite will be fitted, incorporating radar and missile warning receivers, electronic-countermeasure conventional ground equipment, the aircraft's internal load-roller system, by airborne parachute or by gravity extraction from the aircraft's rear ramp.

The RAF sees the C-17 in the short term, combined with the A400M in the longer term, as the way ahead in providing the UK with a strategic airlift capability when and where it is required.

Specifications

Powerplant:	Four EPI TP400-D6 turboprops
Thrust:	11,000shp each
Propeller:	8-blade variable pitch fully feathering
Wing span:	42.4m (139ft 1ins)
Tailplane span:	19.65m (64ft 6ins)
Length:	42.2m (138ft 5ins)
Height:	14.7m (48ft 3ins)
Max range:	4100nmls
Max speed:	Mach 0.72
Max altitude:	40,000ft

VC10

Passenger/freight transport or air refuelling

- **Dual-role passenger/freight transport or air refuelling (AR) aircraft.**
- **Carries 137 passengers or 45,000lbs freight.**
- **Operates a two-station or three-station air refuelling pod.**
- **Capable of refuelling tactical fast-jet or heavy strategic aircraft.**
- **Able to dispense 68 or 78 tonnes of fuel depending on aircraft type.**

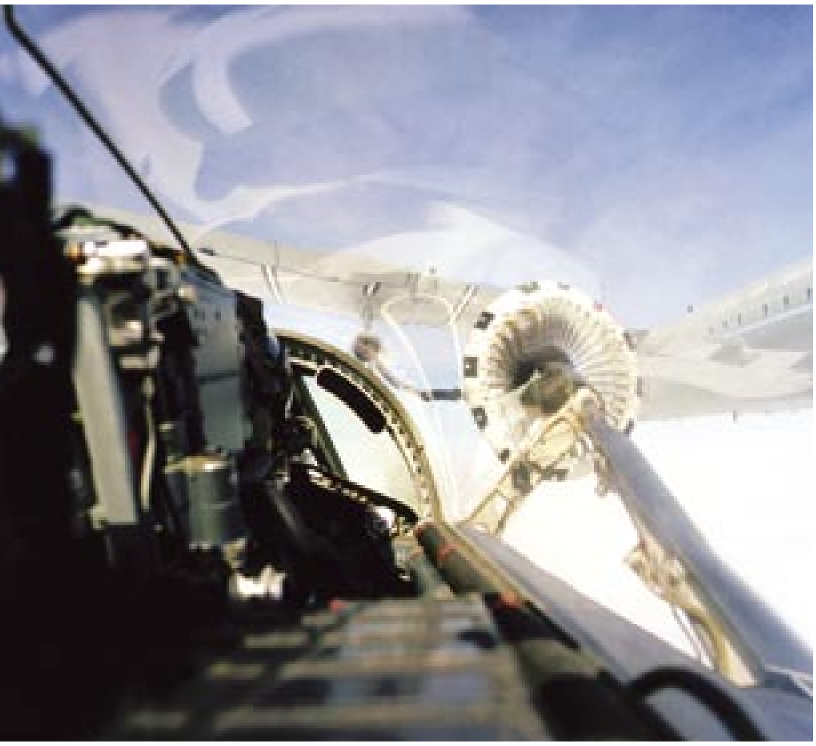
VC1O CMk1K

The VC10 CMk1K is a dual-role air transport (AT) and AR aircraft. In the AT role, the aircraft is used for troop carrying, with accommodation for 146 passengers and nine crew. Use of a large, cabin-freight door on the forward left side of the aircraft allows easy conversion of the aircraft into a dual-role passenger /freight or full-freight configuration. In its full-freight role, the cabin can hold up to 45,000lbs of palletised freight, ground equipment or vehicles, on its permanently strengthened floor. The aircraft can also be used for aero-medical evacuation, for which up to 68 stretchers may be fitted.

The CMK1K's were converted to the AR role in 1993 with the fitting of a Mk32 refuelling pod under the outboard section of each wing. The aircraft can carry up to 154,000lbs of fuel using its original eight fuel tanks; the fuel can be used to feed the aircraft itself or be dispensed to receiver aircraft that are equipped with a probe-and-drogue refuelling system. Capable of refuelling two aircraft simultaneously from the two under-wing pods, the VC10 CMk1K can itself be refuelled from a suitably equipped VC10K or Tristar AR aircraft by the use of an air refuelling probe, which is permanently attached to the aircraft nose. The aircraft is equipped with a modern flight-management system and the avionics required for full worldwide operations. The crew comprises two pilots, a weapons systems officer, a flight engineer, an air loadmaster and up to three air stewards.

VC10 MkK3/K4

The bulk of the RAF's single-role AR fleet comprises VC10s of two different variants, the K3 and K4. Each aircraft is a three-point tanker, with fuel being dispensed from the two wing-hoses or from the single fuselage-mounted Hose Drum Unit (HDU). The wing hoses can transfer fuel at up to 2200lbs per minute and are used to refuel tactical fast-jet aircraft. The HDU can transfer fuel up to 4400lbs per minute and is usually used to refuel 'heavy' strategic aircraft, although it can also be used by fast-jet aircraft.



Each tanker variant of VC10 carries a different fuel load. The K3 is equipped with fuselage fuel tanks, mounted in the passenger compartment, and can carry up to 78 tonnes of fuel. These internal tanks are missing from the K4, which has a maximum fuel load of 68 tonnes. For self defence, the aircraft's only counter measures are its recent change to a low Infrared paint scheme (grey), a radar-warning receiver and a Matador IRCM missile-protection system, which comprises two Infrared jammers mounted under the engines at the rear of the aircraft. The aircraft also has a very limited passenger-carrying capacity used almost exclusively to carry ground crew and other operational support personnel.

The VC10 is now reaching the end of its Service life, but continual modifications maintain the aircraft as a significant asset, enabling the rapid deployment of troops and their weaponry, and fast-jet fighter aircraft, to any theatre of operations around the world.

Specifications

Powerplant:	Four Rolls-Royce Conway turbojets
Thrust:	20,000lbs each
Wingspan:	44.55m (146ft 2ins)
Length:	48.36m (158ft 8ins)
Max T/O weight:	151,800kg (333,960lbs)
Range:	5000nmls
Max speed:	Mach 0.86
Max altitude:	43,000ft

Tristar

Long-range passenger/freight or air refuelling

- **Long-range passenger carrying, freight carrying and air refuelling aircraft.**
- **Capable of flying for up to 14 hours, with a range of 7000nmls.**
- **K1s and KC1s have a combined Air Transport (AT) and Air Refuelling (AR) capability.**
- **Centreline drogue refuelling equipment can transfer fuel at up to 4200lbs/min.**
- **Able to operate in the aeromedical casualty evacuation role with a full stretcher fit.**

The RAF has a mixed fleet of nine Lockheed L-1011 Tristar aircraft, which are operated by No 216 Squadron, based at RAF Brize Norton, Oxfordshire, in the AT and AR roles. The aircraft, which previously saw airline service when they were owned by British Airways and Pan-Am, were purchased by the RAF in the early 1980s. The six ex-British Airways aircraft were modified by Marshall of Cambridge (Engineering) between 1982 and 1984 into AR tanker aircraft, with a twin, centreline hose-and-drogue configuration. The installation included the addition of under-floor fuel tanks which increased the available fuel load by 96,800lbs. This allows a total fuel load of 308,000lbs to be carried, which can be used by the aircraft itself,

or given away to receivers. AR operations can be monitored by a CCTV system, which was added under the rear of the fuselage.

Although the aircraft has two hose-drum refuelling units, only one can be used at a time, thus restricting AR to single-point refuelling. On a typical AR flight from the UK to Cyprus, or Goose Bay (Canada), the KC1 can refuel up to four fast-jet aircraft and simultaneously carry up to 31 tonnes of passengers and/or freight. The addition of a large, fuselage freight-door and a roller-conveyor system allow outsized palletised cargo to be carried. Although the K1 model does not have the freight door, it retains a passenger-seat fit of 187 in the rear cabin, with baggage carried in the forward cabin.

The three ex-Pan Am aircraft are largely unchanged from their airline days and operate in the passenger role, carrying up to 266 passengers. These aircraft are designated C2 and C2A and are used extensively for transporting troops to world-wide destinations in support of exercises and operations. All versions of the Tristar aircraft can operate in the aeromedical evacuation role, including the option of installing a full stretcher fit if required for the repatriation of casualties.

All RAF Tristars have a comprehensive avionics suite, which is undergoing modernisation. As part of this programme the aircraft are being fitted with equipment which will enable them to operate as a JTIDS (Joint Tactical Information Distribution System) station and a radio relay station in areas of intensive military operations.

Specifications

Powerplant:	Three Rolls-Royce RB211 turbofans
Thrust:	50,000lbs each
Wing span:	50.09m (164ft 4ins)
Length:	50.05m (164ft 2ins)
Height:	16.87m (55ft 4ins)
Max T/O weight:	245,455kg (540,000lbs)
Internal fuel:	96,927kg (213,240lbs)
Max speed:	520kts (599mph)
Max altitude:	43,000ft

BAE 146 CC2

Royal or VVIP transport and communication

- **Operated in the Royal or VVIP transport and communication roles.**
- **Wide-bodied aircraft, equipped to promote space and comfort.**
- **A strong, rugged aircraft, able to operate from unprepared sites.**
- **Four high-bypass ratio turbofans, enabling short-field performance and quiet operation.**
- **Fitted with a defensive-aids suite to combat Infrared missile threats.**

The BAE 146 CC2 is operated by No 32 (The Royal) Squadron, at RAF Northolt. The Squadron operates two BAE 146s in the Royal or VVIP transport and communication roles. The standard operating crew for each aircraft consists of two pilots, two cabin crew and a ground engineer.

The BAE 146 CC2 is an all-metal, high-wing monoplane, with a wide-bodied fuselage and a slightly swept, anhedral wing. The fin is also slightly swept with a high T-tail. Ailerons and elevators are controlled through conventional wire-linked servo tabs, whereas the rudder is hydraulically operated. The secondary flight-controls are hydraulically powered and include a large airbrake on the rear fuselage, and single slotted

flaps and lift spoilers on the upper wing. The aircraft is powered by four Avco Lycoming ALF502R-5 turbofans that have a 6:1 bypass ratio. Numbers one and four engines supply the aircraft's electrical power, while numbers two and three engines drive the aircraft's hydraulic pumps. The aircraft has a trailing-axle main gear with a large damper unit, which allows the aircraft to operate from unprepared surfaces, including gravel and desert runways. The aircraft's excellent performance provides good short-field capability and allows it to operate from airfields located at up to 14,000ft above sea level. The aircraft is based on the civilian BAE 146 100 Series, but has additional fuel tanks and a Royal Suite cabin-fit; and the modern, electronic defensive-aids suite gives almost 360° protection against Infrared missiles.

The BAE 146 CC2 is fitted with three passenger compartments. Compartment A is situated at the front of the aircraft and accommodates the crew. Compartment B, in the centre of the fuselage, accommodates additional crew and extra passengers. Compartment C is situated at the rear of the aircraft and accommodates Royal or VVIP passengers. The layout of the compartments can be varied to meet task requirements, but the maximum seating capacity is 30 passengers.

The BAE 146 is a quiet, but rugged aircraft, with a high level of built-in redundancy. It can carry many of its own spares, allowing it to operate for long periods away from base, with little or no external support. The aircraft's excellent short-field performance, and its ability to operate from high or unprepared airfields in missile threat areas, mean that the aircraft is extremely versatile.

Specifications

Powerplant:	4 Avco Lycoming ALF502R-5 turbofans
Thrust:	6790lbs each
Wing span:	26.8m (86ft 5ins)
Length:	26.18m (85ft 10ins)
Height:	8.61m (28ft 3ins)
Max T/O weight:	37,308kg (82,078lbs)
Max fuel:	10,300kg (22,660lbs)
Max speed:	300kts (483mph at 24,000ft)
Max altitude:	30,000ft

HS125 CC3

Royal or VVIP transport and communication

- **Operates in the Royal or VIP transport and communication roles.**
- **Total of six aircraft, operated by No 32 (The Royal) Squadron, at RAF Northolt.**
- **Crew of two pilots, one cabin attendant and up to six passengers.**
- **Minimum ground time required to turn the aircraft around after landing.**
- **Fitted with a defensive-aids suite to combat Infrared missile threats.**

The HS125 CC3 is operated by No 32 (The Royal) Squadron, at RAF Northolt. The Squadron operates six Series 700B aircraft in the Royal or VIP transport and communication roles. The standard operating crew for each aircraft consists of two pilots and one cabin attendant.

The HS125 CC3 is an all-metal, low-wing monoplane with a semi-monocoque fuselage and a moderately swept, cantilever wing and stabilisers. It is certified as a transport category aircraft and can operate in all weather conditions, including adverse icing conditions. The aircraft is powered by two Garret TFE731-3-1H turbofans that are attached by pylons to the rear section of the aircraft. The lightweight TFE

series of engines are quiet and economical and their modular design allows easy maintenance and reduces the engine's unserviceability rate. In addition to providing power, the engines also drive an accessory gearbox, which, in turn, drives the aircraft's fuel, oil and hydraulic pumps and a generator for electrical power. As each engine has a separate gearbox, all aircraft systems can operate normally on a single engine. The HS125 CC3 is fitted with an electronic defensive-aids suite that gives the aircraft almost 360° protection against Infrared missiles.

The HS125 fuselage contains three main sections. The forward section of the fuselage contains a weather radar, the cockpit and the galley area; the centre section contains the passenger compartment, which can accommodate up to six passengers and their luggage; the rear section contains a large equipment bay and two additional fuel tanks for extended-range operations.

The HS125 CC3 regularly provides a passenger service to the Royal Family, Government ministers and senior military officers. Its robust engineering, flexibility of operation and rapid turn-around times have made it a very successful aircraft, operated throughout the world in the VIP role and, in its communications role, the HS125 CC3 has provided support for most RAF peacekeeping and humanitarian operations worldwide.

Specifications

Powerplant:	Two Garrett TFE731-3-1H turbofans
Thrust:	7400lbs total
Wing span:	14.33m (47ft)
Length:	15.46m (50ft 8ins)
Height:	5.49m (18ft)
Max T/O weight:	11,590kg (25,498lbs)
Max speed:	320kts (368mph)
Max altitude:	41,000ft

Nimrod MR2

Anti-submarine and anti-surface warfare and search and rescue

- **Only jet-powered maritime patrol aircraft in military service.**
- **Roles are anti-submarine and anti-surface warfare and search and rescue.**
- **Endurance of 10 hours, which can be extended by air refuelling.**
- **Crew of 13, which include 'wet' and 'dry' sensor coordination teams.**
- **Can carry Sting Ray torpedos, Harpoon anti-ship missiles, bombs and depth charges.**

The Nimrod MR1 entered service in 1969, but was upgraded to MR2 standard in the early 1980s. While the flight deck and general systems remained the same, the Mission System was given a significant upgrade. The Nimrod is the only jet-powered maritime patrol aircraft in military service and offers the advantages of speed and height in transit, while still capable of operating for long on-task periods. It also offers a stealth element in the anti-submarine warfare (ASW) role as most propeller driven aircraft make a discrete resonance that is easily detectable by submerged submarines, whereas the jet noise of the Nimrod is much less detectable.

The Nimrod is used in three main roles: ASW, Anti-Surface-Unit Warfare (ASUW) and Search and Rescue (SAR). It has an unrefuelled endurance of around 10 hours, which can be extended by the use of air refuelling. The operating crew comprises two pilots and a flight engineer, two weapons systems officers (WSO) (tactical and routine), and a WSO who is the sensor and communications coordinator. He is supported by a team of three 'wet' weapons systems operators (WSOps) and four 'dry' WSOps. The 'wet' team supervise the aircraft's acoustic processors, which monitor active and passive sonobuoys, whilst the 'dry' team manage a wide range of avionics and weapon systems which are essential to delivering Nimrod's full capability.

The Nimrod's offensive weapons include Sting Ray torpedos for use in the ASW role and Harpoon missiles for the ASUW role. For SAR purposes the aircraft has a selection of air deliverable, multi-seat dinghies and survival packs. For self-defence, the aircraft can be armed with four AIM-9L Sidewinder air-to-air missiles carried under the wings. The aircraft can carry in excess of 200 sonobuoys internally, of several different types, both active and passive, which are delivered via two unpressurised 6-buoy rotary launchers and two pressurised single-shot launchers.

The majority of the Nimrod's tasking comes from the Maritime Headquarters at Northwood. Peacetime work includes surface and sub-surface surveillance and the maintenance of a one-hour SAR standby in support of the Air Rescue Coordination Centre, collocated at RAF Kinloss. SAR tasks include long-range searches, assistance to SAR helicopters and coordination of search activities as an on-scene communication platform at major incidents. The aircraft routinely operates over the sea down to 200 feet, but is limited to 300 feet at night or in bad weather.

Nimrod aircraft are operated by Nos 120, 201 and 206 Squadrons, which are all based at RAF Kinloss, in Morayshire; RAF Kinloss is also the home of the Nimrod Operational Conversion Unit, No 42(R) Squadron. The Nimrod MR2 will continue in service until it is replaced by the MRA4, which is expected to enter service from 2007.

Specifications

Powerplant:	Four Rolls-Royce Spey 250 turbofans
Thrust:	12,500lbs each
Wingspan:	35m (114ft 9ins)
Length:	38.65m (126ft 9in)
Height:	9.14m (30ft 1ins)
Max T/O weight:	83,636kg (184,000lbs)
Internal fuel:	38,182kg (84,000lbs)
Max endurance:	9.5hrs (internal fuel)
Max speed:	360kts (420mph)
Max altitude:	44,000ft

Nimrod MRA4

Anti-submarine and anti-surface warfare and search and rescue

- **Only jet-powered maritime patrol aircraft in military service.**
- **Roles are anti-submarine and anti-surface warfare and search and rescue.**
- **Endurance of 15 hours, which can be extended by air refuelling.**
- **Crew of 10, which includes 'wet' and 'dry' sensor coordination teams.**
- **Completely new integrated Tactical Command Mission Control System.**
- **Weapons include Sting Ray torpedos, Harpoon anti-ship missiles and mines.**

The Nimrod MRA4 is expected to start entering service with the RAF in 2007 and a total of 18 aircraft will replace the present MR2, which first entered service in the early 1980s. Although the MRA4 looks similar to the MR2, only the basic fuselage shell is shared between the two aircraft and the MRA4 will have completely new systems and a new, longer wing carrying advanced Rolls-Royce Deutschland (RRD) BR710 turbofan engines. The engines are 30% more fuel-efficient and 25% more powerful than the Rolls-Royce Spey 250 engines they replace. The aircraft's maximum weight has increased from around 87 tonnes to approximately 104 tonnes and it can fly for longer periods than its predecessor with a bigger payload in both weapons and sensors. The Nimrod MRA4 will have a multi-tasking role, which will include its main roles of anti-submarine warfare,

anti-surface-unit warfare, maritime reconnaissance and search and rescue but, in addition, it will be used in law-enforcement tasks including anti-smuggling and anti-gun-running operations, fisheries protection and counter-terrorism duties.

The MRA4 operating crew will consist of two pilots and eight mission crew members operating new state-of-the-art radar, electronic and acoustic sensor systems. The new flight deck is an all-glass cockpit, which incorporates many of the systems, displays and integrated avionics developed for the Airbus series of civil airliners. There are a total of seven liquid-crystal, full-colour displays - the seventh display presents tactical information fed from the sensor bays for use by the pilots. The aircraft navigation system incorporates an interfaced navigation computer and flight management computer, which automatically controls the aircraft using a laser inertial navigation system and two global-positioning systems.

The heart of the mission system is the entirely new Tactical Command System, which is based around the seven reconfigurable, high-resolution, multi-function colour display workstations used by the mission crew, plus the pilots' tactical display. The primary sensor will be the Thales Searchwater 2000MR multi-mode search radar. This is a new, extremely high-performance radar designed for all-weather operation and optimised to have a high probability of tracking small targets in poor weather. It can automatically track over 100 surface contacts and can use a pulse-doppler mode for air contacts. Other sensors include electronic support measures, an acoustic detection system, magnetic anomaly detection equipment and an electro-optical surveillance and detection system. A new defensive-aids system will include a radar warning receiver, a missile approach receiver and integral chaff/flare dispensers.

The MRA4 will carry an extensive range of weapons both underwing and in the weapons bay. The range will include Harpoon anti-ship missiles, Sting Ray torpedos, mines and over 150 sonobuoys. Weapons management will be conducted via a stores management system, which carries out inventory tracking control, air-to-air and air-to-sea weapon control, and built-in test and fault diagnostic systems.

Specifications

Powerplant:	Four RRD BR710 turbofans
Thrust:	14,900lbs each
Wingspan:	38.71m (127ft)
Length:	38.63m (126ft 9in)
Height:	9.14m (30ft)
Max T/O weight:	105,075kg (231,165lbs)
Internal fuel:	38,182kg (84,000lbs)
Max endurance:	15hrs (internal fuel)
Max speed:	Mach 0.77
Max altitude:	42,000ft

Hawk TMk1/1A

Fast-jet pilot advanced flying training

- **TMk1 version is used as a fast-jet pilot advanced flying-training aircraft.**
- **TMk1A version is used as an air-to-air and air-to-ground weapons training aircraft.**
- **Can be equipped with bombs, rockets and missiles making it suitable for a war role.**
- **A strong and rugged aircraft, which has been designed to cut training and maintenance costs.**
- **Airframe refurbishment and replacement programme will extend its life into the next decade.**

The Hawk first entered service with the RAF in 1976, both as an advanced flying-training aircraft and a weapons-training aircraft. The Hawk TMk1 version is currently used at RAF Valley for fast-jet pilot advanced flying training with No 208 Squadron, and at RAF Scampton by the RAF Aerobatic Team, the Red Arrows. The TMk1A is used for weapons and tactical training on No 19(F) Squadron at RAF Valley, and by No 100 Squadron at RAF Leeming for advanced fast-jet weapons systems officer training and operational support-flying. In its weapons and tactical training role the Hawk is used to teach air combat, air-to-air firing, air-to-ground firing and low-flying techniques and operational procedures.

The Hawk is an all-metal, low-wing, tandem seat aircraft of conventional design. The wing has a moderate sweep with 2° dihedral and trailing edge slotted flaps. A one-piece all-moving tailplane is also swept back with 10° dihedral. The fuselage comprises three main parts. The front fuselage accommodates two equipment bays and a pressurised cabin containing two tandem cockpits. The centre fuselage contains the engine, a fuselage fuel tank, a gas turbine starting system and a ram air turbine; the ram air turbine provides emergency hydraulic power should the two normal hydraulic systems fail. The rear fuselage houses the jet pipe bay and an airbrake hinged to its under surface.

The Hawk is powered by a Rolls-Royce Turbomeca Adour Mk151 turbofan engine, which is an un-reheated version of the engine powering the Jaguar GR3 aircraft. The engine, which drives a gearbox providing power for the aircraft generator, both hydraulic pumps, an oil pump and a fuel pump, has proved to be economical in use and is ideally suited for a fast-jet training aircraft.

While the Hawk TMk1 is used solely in the advanced flying-training role, the Hawk TMk1A is equipped to an operational standard and is capable of undertaking a number of war roles. The TMk1A has two under-wing pylons cleared to carry BL755 cluster bombs or Sidewinder AIM-9L air-to-air missiles, and can carry a 30mm Aden cannon in a pod underneath the fuselage centre-line. The cannon can be fired at the same time as any of the pylon-mounted weapons are selected for release or firing. Aiming facilities for the aircraft's attack modes are provided by an integrated strike and interception system, while a Vinten video recording system is used to record the weapon sighting.

The next generation Hawk aircraft, the Hawk 128, will enter service in 2008 as a replacement for some of the current Hawk TMk1s. The Hawk 128 will introduce student pilots to the digital cockpit environment they will experience in front-line operational service and will provide a seamless transition between basic flying training on the Tucano, and operational conversion training onto advanced fighter aircraft such as the Typhoon F2 and the Joint Combat Aircraft.

Specifications

Powerplant:	Rolls-Royce Turbomeca Adour turbofan
Thrust:	5200lbs
Wing span:	9.39m (30ft 10ins)
Length:	11.9m (39ft 3ins)
Height:	3.99m (13ft 1ins)
Max T/O weight:	5700kg (12,540lbs)
Max speed:	550kts (633mph)
Max altitude:	48,000ft

Tucano TMk1

Pilot and weapons systems officer (WSO) basic flying training

- **All-metal, tandem seat aircraft used for pilot and WSO basic flying training.**
- **Handling is similar to a jet aircraft, making it an ideal replacement for the Jet Provost.**
- **Capable of 270kts at low level, and an initial 4000 feet per minute climb rate to 25,000ft.**
- **Turboprop engine, which gives it greater fuel economy and lower operating costs.**
- **All-weather capability, giving flexibility in flying-training operations.**

The Tucano TMk1 is a modified version of the Brazilian Embraer EMB-312 Tucano aircraft, and is built under licence by Shorts, of Belfast. The Tucano is operated primarily from No 1 Flying Training School, at RAF Linton-on-Ouse, to provide basic fast-jet flying training to RAF and RN student pilots, and basic WSO training to all potential RAF WSOs. Student pilots fly around 130 hours during their training course on the Tucano before progressing to the Hawk TMk1 aircraft at RAF Valley.

The aircraft is powered by an 1150shp Garret Turboprop engine, has a maximum speed of 300kts (345mph) and can maintain 270kts (310mph) at low level. It can operate at up to 25,000 feet and has an

initial climb rate of 4000 feet per minute. The Tucano replaced the Jet Provost in RAF service and its two-seat tandem cockpit makes it an ideal lead-in to the Hawk, which is flown at the next stage of training. The turboprop Tucano was chosen to replace the RAF's Jet Provosts because of its greater fuel efficiency and lower operating costs.

The aircraft handling is similar to that of a jet aircraft and it is fully aerobatic, thus providing an excellent workhorse for training fast-jet pilots in all aspects of military flying. It is used to develop students in a full range of skills, including general aircraft handling, formation flying and low-level navigation and, due to its comprehensive avionics and ice-protection packages,

it can be flown in all types of weather, by day and by night. The Tucano's all-weather flying capability, plus its excellent endurance, allows a great measure of flexibility in the training role. Should weather conditions be poor at their home base, crews operating from RAF Linton-on-Ouse can fly low-level sorties to locations as far away as Wales or the North of Scotland.

The Tucano has recently undergone a wing and fuselage strengthening programme to overcome aircraft stress problems and will remain as the RAF's primary fast-jet basic flying-training aircraft until later in the decade.

Specifications

Powerplant:	Garrett TPE331-12B turboprop
Thrust:	1150shp
Wing span:	11.28m (37ft 1ins)
Length:	9.86m (32ft 4ins)
Height:	3.4m (11ft 2ins)
Max T/O weight:	3182kg (7000lbs)
Max speed:	300kts (345mph)
Max altitude:	30,000ft

Tutor

Elementary flying training and air experience

- **Single-engined monoplane used for elementary flying training and air-experience flying.**
- **Constructed form carbonfibre reinforced plastic, giving high strength and light weight.**
- **Side-by-side seating, preferred for the elementary and basic flying-training role.**
- **Modern instrument and avionics suite, including a global positioning system.**
- **Docile handling and good performance makes it very suitable for elementary flying training.**

The Grob 115E, known by the RAF as the Tutor, is used for Elementary Flying Training by the 15 University Air Squadrons and 12 Air Experience Flights throughout the UK. It is also used by the Central Flying School and for elementary navigator training at the RAF College Cranwell. All of the Tutors in RAF service are entered on the UK Civil Aircraft Register and are provided by Vosper Thorneycroft Aviation.

The Tutor is constructed mainly from carbonfibre reinforced plastic, which combines high strength with light weight. Like its predecessor, the Bulldog, the Tutor has side-by-side seating but, unlike the Bulldog, the primary flight instruments are on the right-hand side of

the cockpit. This allows the student to fly the aircraft from the right-hand seat with a right-hand stick and a left-hand throttle so that future transition to fast-jet aircraft is made easier.

Unpressurised, and powered by a Textron-Lycoming 180hp piston engine driving a Hoffman three-bladed, constant-speed propeller, the Tutor can cruise at 130kts at sea level and climb to 5,000 ft in seven minutes. The aircraft has a very clean airframe and has a three-minute inverted-flight time limit, making it ideal for aerobatics where, unlike previous RAF light aircraft, it loses little or no height during a full aerobatic sequence. The aircraft has a very modern instrument and avionics suite, including a Differential Global Positioning System, which, apart from giving excellent navigational information, can also be used to generate a simulated Instrument Landing System (ILS) approach for training use at airfields where ILS ground equipment is not fitted for the runway in use.

The Tutor is a cost-effective, modern, elementary training aircraft. The combination of docile handling characteristics and good performance make it very suitable for its training role.

Specifications

Powerplant:	Textron Lycoming AE-360-B piston engine
Rating:	180hp
Wingspan:	10.00m (32ft 8ins)
Length:	7.79m (25ft 7ins)
Height:	2.82m (9ft 3ins)
Max T/O weight:	992kg (2183lbs)
Max speed:	135kts (155mph)
Max altitude:	10,000ft

Firefly T67

Initial pilot training, prior to multi-engine training

- **Excellent performance, handling and visibility, with full aerobatic capability.**
- **Side-by-side seating, preferred for the basic flying-training role.**
- **Durable long-life airframe with a rugged, wide-track, fixed undercarriage.**
- **Low maintenance costs and minimum routine-inspection requirements.**
- **Used for initial pilot training, prior to multi-engine advanced training.**

The Firefly, which entered RAF service in 1996, is a two-seat aircraft used at the RAF College Cranwell for training pilots who have completed elementary flying training and have been selected for multi-engine training on the Jetstream TMk1. The Firefly is used on a Multi-Engine Lead-In (MELIN) course, which is an integral part of the role of the Jetstream training squadron, No 45 (R) Squadron. The course gives student pilots an insight into more advanced flying than they encounter on the elementary course and comprises general handling, procedural instrument flying, low-level navigation, formation flying, night flying and an introduction to dual-crew operations.

The Firefly, made in glass fibre by Slingsby Aviation

in Yorkshire, is a single piston-engined aircraft with a 260hp Textron-Lycoming engine, which drives a three-blade, constant-speed, composite propeller. Its instrumentation and communications equipment allows it to be flown along airways and the aircraft is cleared for instrument flying and night flying. The Firefly is fitted with side-by-side dual controls, a fixed windscreen and a backward-tilting canopy incorporating direct ventilation windows and fresh-air scoops. The unpressurised aircraft is fully aerobatic and can easily maintain height during an aerobatic sequence. The aircraft also has fuel and oil systems capable of sustaining inverted flight.

The Firefly can carry two pilots for over three hours of training. This endurance, coupled with a rapid climb rate of less than 10 minutes to reach 10,000ft, make it an excellent training aircraft.

Specifications

Powerplant:	Textron Lycoming flat six-cylinder engine
Rating:	260hp
Wingspan:	10.72m (35ft 3ins)
Length:	7.48m (24ft 7ins)
Height:	2.29m (7ft 6ins)
Max T/O weight:	1159kg (2550lbs)
Max range:	650nmls
Max speed:	154kts (177mph) at sea level
Max altitude:	10,000 ft

Dominie TMk1

Multi-crew advanced flying training

- **Used to train weapons systems officers and operators, air engineers and air loadmasters.**
- **Military training version of the Hawker Siddeley 125 business jet.**
- **Major upgrade in 1996, incorporating modern avionics, new operating systems and cabin layout.**
- **Crew composition of one pilot captain and a total of five students/instructors.**
- **Mixed sorties of low, medium and high-level exercises dependent on training requirement.**

The Dominie TMk1, which has been in RAF Service since 1965, is the military training version of the Hawker Siddeley 125 twin-jet business aircraft. A total of nine aircraft are operated by No 55(R) Squadron at the RAF College Cranwell, where they are used to train weapons systems officers and operators, air engineers and air loadmasters in systems management, air leadership, decision making and teamwork to meet the operational demands of the RAF.

In 1996 the aircraft underwent a major upgrade programme, with the installation of a modern avionics suite and a new systems installation and cabin layout, completed under contract by Racal and Marshall Aerospace. The design features included installation of a Super Searcher Ground-mapping Radar, which

was fully integrated with the aircraft's associated radio equipment, avionics systems, multicolour displays and navigation mission-computer.

The Dominie T Mk1 has a maximum crew of six and is generally operated with one pilot captain, with the remaining aircrew comprising a balance of up to five students and instructors. Training sorties are usually of two to three hour's duration and are flown in a mixture of regimes dependent on the stage of training and the exercise requirements. These sorties include a mix of low-level flying, maritime operations, radar handling and targeting training. Medium level, high level and general-handling sorties are flown for other training requirements, including trials flights conducted for the Air Warfare Centre at RAF Waddington

Specifications

Powerplant:	Two Rolls-Royce Viper Mk 301 turbojets
Thrust:	3310lbs each
Wing span:	14.33m (47ft 1ins)
Length:	14.48m (47ft 5ins)
Height:	4.87m (16ft 0ins)
Max T/O weight:	21,000lbs
Max speed:	284kts (327mph)
Max altitude:	42,000ft

Jetstream TMk1

Multi-engined advance pilot training

- **Twin-engine turboprop used for pilot advanced flying training.**
- **Operated by a crew of two, with student pilot and instructor flight-deck crew.**
- **Used to teach multi-engine procedures and airways navigation.**
- **Can also be used to carry up to 12 passengers or freight.**
- **Current plans indicate it will be replaced in 2004.**

The Jetstream is a twin-engine, turbo-prop monoplane, which first entered RAF service in 1973. It is used as an advanced, multi-engine pilot trainer by No 45(R) Squadron, which is based at the RAF College Cranwell, in Lincolnshire. Prior to flying the Jetstream, elementary flying training students who have been selected to fly multi-engined aircraft receive an additional 30 hours training on the Firefly multi-engine lead-in (MELIN) course, which is also run by No 45(R) Squadron. During the MELIN course, students learn about crew cooperation and procedural flying to prepare them for their advanced flying training on the Jetstream.

A crew of two (student and instructor) operates the aircraft and students learn advanced skills such as twin-engine general handling, asymmetric flying, formation flying, low-level flying and airways navigation. On completion of the course students are awarded their pilot's wings, and then undertake their next flying phase at an operational conversion unit. A variety of courses are available using the Jetstream, based mainly on the student's previous flying experience. This experience can be as little as 100 hours for a student arriving straight from elementary flying training, to a few thousand hours for a qualified pilot transferring to the multi-engine role. In addition to its flying training role, the Jetstream can be used to carry up to 12 passengers or freight.

The Jetstream TMk1 has offered excellent service during its time in the RAF; however, it is now reaching the end of its active life. It is anticipated that it will be replaced in 2004 by the Beech King Air B200.

Specifications

Powerplant:	Two Turbomeca Astazou Mk16D turboprops
Rating:	968eshp each
Wingspan:	15.86m (52ft 1ins)
Length:	14.36m (47ft 2ins)
Height:	5.33m (17ft 6ins)
Max T/O weight:	6000kg (13,200lbs)
Max speed:	230kts (265mph)
Max altitude:	25,000ft

Vigilant TMk1

Single-engined motor glider

- **Self-launching single-engined, low-wing, monoplane motor glider.**
- **Used as a basic flying and gliding training aircraft for the Air Cadet Organisation.**
- **Side-by-side seating, preferred for the basic flying-training role.**
- **Constructed from glass-reinforced plastic, for lightweight and strength.**
- **Used to train air cadets to solo flying standard.**

The Grob 109B motor glider, known by the RAF as the Vigilant TMk1, is used by the Air Cadet Organisation to give basic flying and gliding training to air cadets. The aircraft is built in Germany, but it has been modified to meet the RAF's training requirements by the inclusion of an additional throttle in the cockpit and an increase in the maximum take-off weight. The Vigilant is currently used by 16 Volunteer Gliding Schools (VGSs), located at various sites around the UK. Their role is to train air cadets in basic flying techniques and to enable them to reach a standard where they are able to fly solo. Courses available to the air cadets are the gliding induction course, the gliding

scholarship course and the advanced gliding training course. The aircraft is also used at the Air Cadet Central Gliding School, at Syerston, in Nottinghamshire, where it is used to train the VGS instructors.

The Vigilant is powered by a Grob 2500E1 horizontally opposed, four-cylinder, air-cooled engine, which provides a direct drive to a Hoffman Ho-V62 R/L160BT variable-pitch, two-bladed propeller. The conventional landing gear, which is non-retractable, comprises two main wheels with fairings, and a tailwheel, which is steered through the rudder pedals. A retrofitted throttle is provided for use by the left-hand seat, giving the student the familiar military configuration of right-hand stick and left-hand throttle arrangement.

The Vigilant TMk1 is a cost-effective, modern aircraft. Its docile handling characteristics, combined with good fuel economy, make it an excellent training aircraft for cadets and instructors alike.

Specifications

Powerplant:	Grob 2500E1 horizontally opposed four-cylinder, air-cooled engine
Rating:	95hp
Length:	8.10m (26ft 6ins)
Height:	1.70m (5ft 6ins)
Wingspan:	17.40m (57ft 1ins)
Max T/O weight:	908kg (1998lbs)
Max speed:	130kts (149mph)
Max altitude:	8,000ft

Viking TMk1

Two-seat, high-performance glider

- **Two-seat sailplane, designed for basic training, high-performance flying and simple aerobatic flying.**
- **Tandem seating for a crew of two.**
- **Constructed using the latest techniques in industrial glass-reinforced plastic for lightweight and strength.**
- **Used to train air cadets to solo flying standard.**

The Grob G103A Twin II Acro, known by the RAF as the Viking TMk1, is used by the Air Cadet Organisation to give basic gliding training to air cadets. The aircraft is currently used by 11 Volunteer Gliding Schools (VGSs) located at various sites around the UK. Their role is to train air cadets to a standard that will allow them to fly solo. Courses available to the air cadets are the gliding induction course, the gliding scholarship course and the advanced gliding training course. The aircraft is also used at the Air Cadet Central Gliding School, at Syerston, in

Nottinghamshire, where it is used to train the VGS instructors.

The Viking TMk1 is a high performance sailplane, which can be winch launched or aero-towed. The aircraft is fitted with a non-retractable tandem undercarriage and upper surface airbrakes.

The Viking is a cost-effective, modern, high performance glider, ideally suited to its training role with the Air Cadet Organisation.

Specifications

Powerplant:	The aircraft can be winch launched or aero-towed
Length:	8.18m (26ft 9ins)
Height:	1.55m (5ft 1ins)
Wingspan:	17.50m (57ft 4ins)
Max T/O weight:	625kg (1375lbs)
Max speed:	135kts (155mph)
Max altitude:	8,000ft

Chinook HC2/2A/3

Troop and load carrying heavy-lift support

- **Used primarily for troop carrying or internal and underslung load carrying.**
- **Carries up to 55 troops or 10 tonnes of freight or vehicles.**
- **Equipped with modern avionics and an enhanced defensive-aids suite.**
- **Full night operation capability using night-vision goggles.**
- **Can be armed with six-barrelled M-134 Miniguns and an M60 machine gun.**

The RAF operates the largest fleet of Chinook Support Helicopters after the US Army, with a total of 34 HC2s, 6 HC2As and 8 HC3s (the HC3 has yet to enter operational service). The Chinook Wing, which forms the heavy-lift element of the Joint Helicopter Command (JHC), is based at RAF Odiham in Hampshire. Odiham supports three operational squadrons, No 7 Squadron, No 18 Squadron and No 27 Squadron, and the Operational Conversion Flight.

The HC2 and HC2A aircraft are used primarily for trooping and for carrying internal and/or underslung loads and can carry up to 55 troops or 10 tonnes of freight. The cabin is large enough to accommodate two Landrovers, while the three underslung load

hooks allow a huge flexibility in the type and number of loads that can be carried externally. Secondary roles include search and rescue and casualty evacuation, in which role a total of 24 stretchers can be carried. The crew consists of either two pilots, or a pilot and a weapons systems officer (WSO), and two air loadmasters. The pilot captain is responsible for the safe operation of the aircraft and completion of the mission, while the co-pilot or WSO operates the mission-management systems, navigation, communications and the self-defence suite. In the cabin are two air loadmasters who are responsible for passenger safety, load or cargo restraint, weapons operation and voice marshalling of the aircraft.

The aircraft are well equipped for their varied roles and are fitted with a satellite Global Positioning System, an Instrument Landing System, comprehensive avionics that enable them to fly in airways, and an extensive radio suite. The aircraft cockpit has a full night-time capability when operated with night-vision goggles, thus allowing low-level night operations in a hostile environment. The aircraft also carries dual-mode landing lights that can be switched between white and Infrared light, which are supported by Infrared searchlights operated by the two crewmen. The Chinook is well equipped with defensive aids and has a Radar Warning Receiver, an Ultraviolet and Doppler Missile Approach Warning System, Infrared Jammers and chaff and flare dispensers, which can be manually or automatically fired. The aircraft can be armed with two M134 six-barrelled Miniguns, one in each front side window, and an M60D machine gun on the ramp.

The Chinook is a very capable and versatile support helicopter that can be operated in many diverse environments ranging from cold weather 'arctic' conditions to desert warfare operations. It has been involved in most of the recent UK Operations such as the Falklands Conflict, Northern Ireland, the Gulf War, peace keeping in Bosnia, Kosovo operations, evacuation of Sierra Leone, operations in Afghanistan and, more recently, in Iraq.

Specifications

Powerplant:	Two Textron Lycoming T55-L712F turboshafts
Thrust:	3750shp each
Length:	30.18m (99ft)
Fuselage length:	15.54m (51ft)
Height:	5.78m (18ft 11ins)
Rotor diameter:	18.29m (60ft)
Endurance:	2¾hrs internal tanks
Max T/O weight:	24,500kg (53,900lbs)
Max airspeed:	160kts (185mph)
Max altitude:	15,000ft

Merlin HC3

Ground force tactical and strategic support

- **Ground force support helicopter operating in tactical and strategic roles.**
- **Carries up to 24 combat troops, or artillery, Landrovers or light strike-vehicles.**
- **Equipped with advanced navigation aids and a modern defensive-aids suite.**
- **Full night operation capability using night-vision goggles.**
- **Long range, which can be extended by air refuelling.**
- **Can be armed with two general purpose machine guns converted for the air role.**

The Merlin HC3 is operated by No 28(AC) Squadron at RAF Benson and is the first of a new generation of advanced, medium support-helicopters for the RAF. It is an all-weather, day and night, multi-role helicopter used in both tactical and strategic operational roles. The aircraft carries an impressive defensive-aids suite, which includes a Radar and Laser Warning Receiver, Missile Approach Warners and Directional Infrared Counter Measures equipment, all integrated with an automatic chaff and flare dispensing system. This is one of the most comprehensive defensive-aids suites fitted to any helicopter in the world.

To ensure accurate navigation anywhere on the globe, the aircraft's management computers take data from its laser-gyro, inertial-navigation platform and its doppler system and from air data sources, and combine

the information with precise position data received from Global Positioning System satellites. Navigation at night is enhanced by the crew's use of night-vision goggles and by the aircraft's multi-function turret, which can be fitted with forward-looking Infrared radar. To increase the aircraft's range, the Merlin is equipped with extended-range fuel tanks and is capable of air refuelling. Further range can be achieved by shutting down the third engine during the cruising phase of flight. It is also fitted with an active vibration-damping system, which reduces the level of noise and vibration inside the cabin to a level no greater than that of a turboprop aircraft. As a result, crew fatigue is much reduced during long transits and airframe life is increased.

The Merlin is able to carry a diverse range of bulky cargo, either internally or under-slung. Cargo can include artillery, Landrovers or light-strike vehicles and over five tonnes of freight. The spacious cabin can also accommodate up to 24 fully equipped combat troops and, when required, will convert to carry 16 stretchers for casualty evacuation or during humanitarian and disaster relief operations. Designed to operate away from base workshops and in difficult terrain, the Merlin has state-of-the-art support technology and incorporates aircraft health-and-usage diagnostics and a self-test capability for ease of maintenance.

The Merlin is armed with two general purpose machine guns converted for the air role, although there is provision for additional weaponry to be fitted at a later date.

Specifications

Powerplant:	Three Rolls-Royce Turbomeca
RTM 322 turbines	
Thrust:	2263shp each
Length:	22.8m (74ft 9ins)
Fuselage length:	19.43m (63ft 9ins)
Height:	6.62m (21ft 9ins)
Rotor diameter:	18.6m (61ft 1ins)
Max T/O weight:	14,600kg (32,120lbs)
Endurance:	4 hrs (600nmls) internal tanks.
Max airspeed:	l67kts (192mph)
Max altitude:	15,000ft

Puma HC1

Twin-engined battlefield tactical support

- **Twin-engined battlefield helicopter operated by Joint Helicopter Command.**
- **Capable of operating under temperate, desert or arctic conditions.**
- **Carries troops, freight or casualties in support of the front-line.**
- **Fitted with modern avionics and self-defence equipment.**
- **Full operations capability by day or by night.**

The Puma HC1 first entered service in 1971, and the RAF currently has a fleet of 33 aircraft available to the front-line Support Helicopter Force. The aircraft are operated by No 33 Squadron, which is based at RAF Benson, and by No 230 Squadron, which is based at RAF Aldergrove, in Northern Ireland. No 33 Squadron, which is divided into two flights and the operational conversion flight, offers flexibility in its role in that the aircraft of one of the flights are fitted with desert warfare specialist equipment, while the aircraft of the other flight are fitted with arctic warfare specialist equipment.

The Pumas are used as battlefield helicopters within the Joint Helicopter Command and provide tactical troop and load movement by day or by night. The aircraft can carry 16 fully-equipped troops, or up to two tonnes of freight carried either internally or as an underslung load. The other major role is that of casualty or medical evacuation support, for which up to six stretchers can be fitted.

Each aircraft is equipped with satellite-based global-positioning-system equipment and an instrument landing system, enabling the aircraft to be navigated accurately and to be landed at suitably equipped airfields in poor weather conditions. The normal crew of two pilots, or a pilot and a weapons systems officer, plus a crewman, is trained in procedural instrument flying and tactical low flying by day and by night using night-vision goggles. The aircrew and their supporting ground crew are also trained to operate from inhospitable areas in all conditions ranging from desert to arctic environments.

For self-defence, the Puma is being upgraded with a new defensive-aids suite. This suite includes an integrated radar warning receiver, an AAR47 missile-approach-warning system, an ALQ 144 Infrared jammer and automatic chaff and flare dispensing equipment. In addition, two cabin-mounted 7.62mm general purpose machine guns can be fitted for use by the crewmen.

Specifications

Powerplant:	Two Turbomeca Turmo 3-C4 turbines
Thrust:	1300shp each
Length:	14.08m (46ft 2ins)
Width:	3.00m (9ft 9ins)
Height:	4.54m (14ft 11ins)
Rotor span:	15.09m (49ft 7ins)
Max T/O weight:	7400kg (16,280lbs)
Max speed:	147kts (170mph)
Max altitude:	17,000ft

Sea King HAR 3/3A

Search and Rescue

- **Search and Rescue helicopter able to operate by day or by night in extremely poor weather conditions.**
- **Capacity of 17 passengers or up to six stretchers and four passengers.**
- **Crew of four, comprising two pilots, radar operator/winchman and paramedic/winchman.**
- **Carries medical equipment to deal with accident or aircraft-ejection trauma.**
- **Capable of long-range rescues with six hours endurance on internal fuel.**

The Westland Sea King HAR Mk3 entered RAF service in 1978 and the Mk3A in 1996; both marks of aircraft are used in the Search and Rescue (SAR) role. The aircraft are operated from six locations around the UK, with each location supporting two aircraft. There is also a detachment of two HAR3s providing SAR cover in the Falkland Islands. The SAR squadrons provide 24-hour cover around the UK and the Falkland Islands throughout each year. Each squadron maintains a 15-minutes readiness state during daylight hours and a 45-minutes readiness state during the hours of darkness.

For the search aspect of its role, the Sea King is able to operate to precise navigational standards and is fitted with a multi-band homing system, satellite navigation

systems, a search radar, a comprehensive avionics suite and a large selection of radios. For its rescue role, the aircraft is equipped with a hydraulically-operated main rescue hoist, an electrically-operated emergency rescue hoist and electrical connections suitable for powering medical equipment such as incubators. The SAR fleet of Sea Kings will shortly be fitted with a video/infrared detection pod, which is similar to the equipment used by police helicopters, to help search for casualties. All SAR crews are trained to operate using night-vision goggles over unfamiliar terrain. The standard SAR crew is made up of four members: two pilots, one of whom is the aircraft captain, a radar operator who acts as the winch operator at the rescue scene and a winchman, normally trained to paramedic standard, who will supply immediate first-aid and recovery services at the rescue site.

Specifications

Powerplant:	Two Rolls-Royce Gnome turboshaft
Thrust:	2778shp combined
Length:	22.15m (72ft 8ins)
Fuselage length:	14.4m (47ft 3ins)
Width:	4.98m (116ft 4ins)
Height:	5.13m (16ft l0ins)
Rotor span:	18.90m (62ft 2ins)
Max T/O weight:	9705kg (21,350lbs)
Max speed:	l25kts (144mph)
Max altitude:	10,000ft

Griffin HT1

Avanced multi-engined flying training

- **Military twin-engined helicopter based on the Bell Textron 412EP.**
- **Ideally suited for advanced multi-engined helicopter flying training for pilots.**
- **Also used for crewman training in multi-crew operations.**
- **Employed on both flying training and search-and-rescue duties.**
- **Incorporates an advanced, composite material, four-blade main rotor system.**

The Griffin HT1 is used as an advanced flying-training helicopter at the Defence Helicopter Flying School (DHFS) at RAF Shawbury, in Shropshire, and the Search and Rescue Training Unit (SARTU) at RAF Valley, in Anglesey. There are eleven aircraft in service; eight are based at RAF Shawbury and three are based at RAF Valley. The Griffin HT1 is a military twin-engined helicopter derived from the civilian Bell Textron 412EP helicopter and is powered by two Pratt and Whitney turboshafts rated at 1800shp. The aircraft has an advanced, composite material, four-blade main rotor system, and pendulum dampers on the rotor hub to reduce vibrations at higher cruise speeds. The composite main-blades can be

interchanged and folded easily for storage.

With a cruising speed of 120kts (138mph) and an endurance of 2 3/4 hours, the Griffin HT1 is ideally suited for Multi-engine Advanced Rotary Wing (MEARW) training, which is completed over a period of 34 weeks on No 60(R) Squadron at RAF Shawbury. The syllabus includes general-handling flying, underslung-load carrying, night-vision goggle training, procedural instrument flying, formation flying, low-flying navigation and an introduction to tactical employment, including operations from confined areas. A short SAR-procedures course, which includes elements of mountain flying and maritime rescue winching, is conducted at RAF Valley. However, students who are finally streamed for SAR flying duties on completion of their advanced helicopter training return to SARTU to complete an extended SAR course prior to joining the Sea King Operational Conversion Unit at RAF St Mawgan.

In addition to pilot training, the Griffin is used for crewman training: a very important and integral part of multi-crew operations. A Griffin simulator, with full motion capability and an advanced graphics suite, is also based at RAF Shawbury and is a fully integrated part of the MEARW course. It is especially useful for procedural instrument-flying training and practising complex emergency-handling techniques. The Griffin has now been in service with DHFS for five years and has been selected as a replacement aircraft for the No 84 Squadron Wessex on SAR duties in Cyprus.

Specifications

Powerplant:	Two Pratt & Whitney PT6T-3D turboshafts
Thrust:	1800shp combined
Length:	17.11 (56ft 2ins)
Fuselage length:	12.7m (41ft 8ins)
Height:	3.48m (11ft 5ins)
Rotor diameter:	14.02 (46ft 3ins)
Max T/O weight:	5409kg (11,900lbs)
Max airspeed:	l40kts (161mph)
Max altitude:	20,000ft

Twin Squirrel

VIP transport and communication

- **Multipurpose helicopter used for VIP transport and communication duties.**
- **Three aircraft are operated by No 32 (The Royal) Squadron, at RAF Northolt.**
- **Full instrumentation and navigation systems allow flight under UK instrument flight rules.**
- **Twin-engine design enables more flexible routing over urban areas.**
- **Operated by a single pilot, with accommodation for up to five passengers.**

Three AS 355 F1 Aerospatiale Twin Squirrel helicopters are operated by No 32 (The Royal) Squadron, at RAF Northolt, as replacements for the Gazelle in the VIP transport and communication roles. The Twin Squirrel is operated by a single pilot.

The aircraft is a twin-engined, six-seat helicopter with a skid undercarriage, and is derived from the single-engined AS 350B Single Squirrel design. The rotor system is made up of three main rotor blades of glass-resin laminate construction, a starflex semi-rigid main rotor-head, a two-bladed glass-resin laminate tail rotor, and main-rotor and tail-rotor gearboxes of conventional geared design. The Twin Squirrel has two independent hydraulic circuits: one for the upper body

of the main servo, and the other for the lower body of the main servo and the tail servo unit. The airframe comprises an aluminium centre fuselage and cabin floor, a monocoque tailboom, a fibreglass-laminated cabin ceiling and main cowlings, and polycarbonate windows. Built by Eurocopter France, and first certified by the UK Civil Aviation Authority in March 1984, the helicopter can be used by day and by night, in all weather conditions. It has full instrumentation and navigation systems, including a three-axis autopilot, an auto-coupled Instrument Landing System and a satellite-based Global Positioning System.

The Twin Squirrel is powered by two Allison 250 C20 turboshaft engines, installed in two independent fireproof bays. The well-proven, reliable engines drive fuel, oil and hydraulic pumps, and a generator for all electrical power. The twin-engine design gives the pilot more flexibility when planning routes over built-up areas, as the aircraft can operate at limited weight on a single engine; therefore, even if power from one engine is lost, the pilot can maintain level flight to clear the built-up area. The twin-engine design also increases safety margins when flying into and out of confined landing sites.

The Twin Squirrels of No 32 (The Royal) Squadron are leased to the RAF under a civilian-owned, military-regulated arrangement. This arrangement allows the RAF to provide Government ministers and senior military officers with a flexible, door-to-door service throughout the UK and to Europe.

Specifications:

Powerplant:	Two Allison 250 C20 turboshafts
Thrust:	420shp each
Length:	12.94m (42ft 5ins)
Height:	3.02m (9ft 11ins)
Rotor span:	10.69m (35ft 1ins)
Max T/O weight:	2400kg (5280lbs)
Max speed:	150kts (173mph)
Max altitude:	16,000ft

WEAPONS

Air-to-Air
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Sidewinder

Short-range air-to-air missile

The Sidewinder AIM-9 is a supersonic, heat-seeking, short-range, air-to-air missile capable of being launched from a vast array of aircraft types. The Sidewinder's main components are an Infrared (IR) homing guidance section, an active optical target-detector, a high-explosive warhead and a rocket motor. The in-built IR seeker allows the pilot to launch the missile, then leave the area, or take evasive action, while the missile guides itself to impact by homing on the engine exhaust of the target aircraft. IR homing allows the missile to be used by day or by night and in electronic countermeasure conditions. The Sidewinder is the most widely used air-to-air missile in the world and is one of the oldest, least expensive and most successful missiles ever produced.

The Sidewinder has been continually updated over the years and the AIM-9L version used by the RAF has enhanced guidance characteristics, which give it the ability to attack targets from all angles, including head-on. An improved active, optical fuse gave the missile a much-improved resistance to IR decoys, such as defensive flares or other pyrotechnics, and the installation of a conical scan-system increased the seeker's sensitivity and improved the tracking stability.

The Sidewinder is a within-visual-range missile, slaved onto a target either manually by the pilot, or by using one of the aircraft's sensors. It is a 'dogfight' missile and so launches and arms itself very quickly, thus allowing it to be employed at very short range. Once launched, the missile is guided to the target using IR homing and the annular blast-fragmentation warhead is detonated once the target is inside the missile's lethal radius. The Sidewinder is a fire-and-forget missile, allowing the pilot to fire several missiles at different targets.

Aircraft

Tornado F3
Tornado GR4
Harrier GR7
Jaguar GR3
Typhoon F2
Hawk TMk1A

Specifications

Primary function:	Air-to-air IR missile
Length:	2.87m (9ft 5ins)
Diameter:	0.13m (5ins)
Launch weight:	84.28kg (186lbs)
Range:	Over 6nmls
Speed:	Mach 3+
Guidance system:	IR reticule seeker

Skyflash

Medium-range air-to-air missile

The Skyflash is a supersonic, medium-range, air-to-air missile developed by the UK from the American AIM-7 Sparrow missile. The latest version of the missile has a boost-sustain, solid-fuel rocket motor giving it a greater range than previous versions. The missile can intercept and destroy enemy targets in all weather conditions, with the ability to 'snap-up' or 'snap-down' to engage targets at ultra-high or low level. The missile discriminates between separate target groups and can operate in a variety of countermeasure environments.

The Skyflash missiles on the F3 are recessed into the underside of the aircraft and are launched by large rams forcing them down into the airflow. The missile uses semi-active homing, where the launch aircraft illuminates the target and the missile uses its built-in radar receiver to home on the reflected energy. This semi-active guidance limits the launch aircraft's ability to manoeuvre until missile impact, as the launch aircraft must remain in relatively straight and level flight to maintain positive radar contact with the target. In a typical beyond-visual-range (BVR) engagement the missile is launched and semi-actively guided until the active-radar proximity fuse detonates the high-explosive fragmentation warhead near to the target.

Although Skyflash is primarily a BVR missile, it can also be employed at shorter ranges, where the missile is optimised to ensure quick reaction times and maximum manoeuvrability after it has been launched.

Aircraft

Tornado F3

Specifications

Primary function:	Air-to-air BVR missile
Wingspan:	1.02m (3ft 4ins)
Length:	3.66m (12ft 2ins)
Diameter:	0.203m (8ins)
Launch weight:	208kg (458lbs)
Range:	Over 20nmls
Speed:	Mach 2+
Guidance system:	Inertial mid-course/Active radar terminal

AMRAAM

Advanced Medium-Range Air-to-Air Missile

7he AIM-120B AMRAAM was initially procured for the RN's Sea Harrier; however, it was subsequently partially integrated onto the Tornado F3 as an enhancement to the aircraft's beyond-visual-range (BVR) capability. Full integration onto the Tornado F3 will be completed in mid-2004. AMRAAM will also equip the Typhoon F2 when it enters RAF service. AMRAAM can be used in all weathers and is scheduled to be operational with the RAF into the next decade.

AMRAAM is faster than Skyflash, which it replaces on the F3, and incorporates an active radar with an inertial reference unit and a datalink microcomputer system. This equipment makes the missile less dependent upon the fire-control radar of the firing aircraft. On the approach to a target, the missile's active radar guides it to interception, enabling the pilot to aim and fire several missiles simultaneously at different targets.

In a typical BVR engagement, the AMRAAM is launched from a range of 20 to 30nmls and is guided by its own inertial navigation system, while receiving command-guidance updates from the firing aircraft via the data link, until it reaches the target area. The missile then enters the final, or terminal phase, where its own mono-pulse radar detects the target and guides it to impact. The missile is equipped with a radar proximity fuse, which detonates the high- explosive fragmentation warhead at a pre-set distance from the target. In short-range mode, the missile can be launched 'active-off-the-rail', when the missile's radar detects the target immediately after launch.

Aircraft
Tornado F3
Typhoon F2

Specifications

Primary function:	Air-to-air BVR missile
Wingspan:	0.526m (1ft 9ins)
Length:	3.66m (12ft)
Diameter:	17.78cm (7ins)
Launch weight:	150kg (330lbs)
Range:	Over 20nmls
Speed:	Mach 2.5+
Guidance system:	Inertial mid-course/Active radar terminal

ASRAAM

Advanced Short-Range Air-to-Air Missile

The AIM-132 ASRAAM is a high speed, highly manoeuvrable, heat-seeking, air-to-air missile. Built by Matra-BAE Dynamics, the missile is designed as a fire-and-forget missile, able to counter intermittent target obscuration in cloud as well as sophisticated Infrared (IR) countermeasures. Although ASRAAM is predominantly intended for use in the within-visual-range (WVR) arena, it also has a capability in the beyond-visual-range arena.

The missile uses a new Raytheon Imaging IR Seeker Head and it is the world's first IR missile to enter service using a sapphire-domed staring array detector, which detects the whole target scene. When combined with digital signal-processing and imaging software, ASRAAM is able to see individual areas of its target, such as the engines, cockpit or wings. The picture is very similar to a monochrome TV picture, and gives the missile excellent long-range target acquisition, even against employed countermeasures such as flares or similar pyrotechnics. In addition to its ability to image targets, the seeker also allows the missile to be fired at very high off-boresight angles, in either lock-before, or lock-after launch modes. Because the missile has a fire-and-forget capability, the pilot can engage multiple targets with several missiles simultaneously. To increase its speed and its operating range, the missile has a low-drag design; only tail fins are provided for control purposes; and a new, low-signature, dual-burn, high impulse solid rocket motor provides the power. Compared to other similar missiles, this new motor improves both the missile's instantaneous acceleration and its maximum cruise velocity.

In a typical WVR engagement, the ASRAAM is slaved to the target either visually or by the launch aircraft's on-board sensors. Following release, the missile accelerates to speeds in excess of Mach 3 whilst being guided to the target using its IR seeker. Detonation of the high-explosive fragmentation warhead is achieved by the use of a laser proximity fuse, which can be set to detonate on impact or at a pre-determined distance from the target.

Aircraft
Tornado F3
Typhoon F2

Specifications

Primary Function:	Air-to-air IR missile
Length:	2.9m (9ft 6ins)
Diameter:	0.166m (6.5ins)
Launch weight:	87kg (192lbs)
Range:	15km (8nmls)
Speed:	Mach 3+
Guidance system:	IR staring array with inertial guidance


Meteor

Beyond-visual-range, air-to-air missile

Oeteor is a revolutionary beyond-visual-range, air-to-air missile (BVRAAM) and is planned to enter service with the Typhoon F2 early in the next decade. Built by an international consortium led by MBDA(UK), the Meteor is a highly flexible, agile, air-to-air weapon that will give the RAF a significant capability in the most complex air-combat scenarios. The missile will engage targets autonomously by using its internal, active radar-seeker by day or by night, in all weather conditions, and against hostile countermeasures.

In essence, Meteor is made up of four sections: the radome, the missile electronics and fuse system, the warhead and the ramjet rocket motor, all enclosed within a stealthy, low-drag, lightweight body. The radome encloses the active radar-seeker head, which will be developed from the French Mica and Aster family of radar seekers. The next section contains the missile's electronic systems and its radar proximity or impact fuse system; behind this lies the high-explosive fragmentation warhead. The final section contains the boost motor and the air-breathing ramjet rocket sustain motor, the datalink package and, on the rear of the missile, the datalink antenna. The missile has four rear-mounted fins, which provide flight control and a robust end-game manoeuvrability against agile targets. For mid-course navigation, the weapon can use its own inertial navigation system combined with information provided by the launch aircraft, or by any other friendly aircraft, via the two-way datalink. During the final, or terminal phase, the missile's active radar detects the target and guides it to impact. To ensure total destruction of the target, the missile is equipped with both proximity and impact fuses and a fragmentation warhead that is detonated at the optimum point to achieve maximum effect.

Even when the missile is launched from extreme stand-off ranges it remains under its own power right up to impact. Unlike conventional air-to-air missiles, which employ a short-duration boost motor to accelerate the missile to supersonic speed, but then coast to their target, the Meteor's ramjet motor sustains propulsion power throughout the missile's flight and gives it the energy to defeat fast, highly manoeuvrable targets.

Aircraft
Typhoon F2

Specifications

Primary function:	Air-to-air BVR missile
Length:	3.67m (12ft 2ins)
Speed:	Mach 4+
Guidance system:	Inertial mid-course/Active radar terminal

1000lb General Purpose Bomb

Freefall or retarded, unguided bomb

7he 1000lb general-purpose bomb has a simple and robust design, little changed from those weapons released in World War II, and has a unitary warhead, providing blast and fragmentation effects. An unguided 1000lb general-purpose bomb is sometimes referred to as a 'dumb' bomb and is fitted either with a freefall or a retarded tail. A freefall (or slick) tail allows the weapon to be delivered with a degree of stand-off from the target, whilst a retarded tail allows the weapon to be released at low level in close proximity to the target, so making the bomb more accurate. The retarded tail is used to reduce the bomb's speed during flight to permit the delivery aircraft to escape the effects of the bomb's blast.

The 1000lb general-purpose bomb can be detonated in one of three modes: airburst, impact or post-impact delay. In the airburst mode, the bomb is fused to detonate a short distance above the ground, to provide the maximum fragmentation effect, and is therefore most suited to attacking unprotected targets. In impact mode, the bomb is detonated as it hits the target, which optimises the weapon's blast effects against unprotected installations. In post-impact delay mode, the bomb fuse is set to detonate shortly after impact to allow the weapon to penetrate the target structure; the degree of delay is varied for each target to obtain maximum penetration before detonation.

The 1000lb general-purpose bomb is also used as the warhead for the UK's Paveway II laser guided bombs, and the recently introduced Enhanced Paveway II global positioning system satellite-guided bomb.

Aircraft
Tornado GR4
Harrier GR7
Jaguar GR3
Typhoon F2

Specifications	
Length:	2.48m (8ft 2ins)
Diameter:	0.42m (1ft 4ins)
Weight:	505kg (1112lbs)

540lb Bomb

Freefall or retarded, unguided bomb

7he 540lb bomb is similar to the 1000lb bomb but, has only about two-thirds the destructive power of the bigger bomb. It can be delivered as either a freefall or retarded bomb and can be set to function in the airburst, impact or post-impact delay mode.

Aircraft
Harrier GR7
Jaguar GR3

Specifications	
Length:	2.18m (7ft 2ins)
Diameter:	0.33m (1ft 1ins)
Weight:	312kg (687lbs)

Paveway II LGB

Precision laser guided bomb

Paveway II Laser Guided Bomb

7he original UK version of the Paveway II Laser Guided Bomb (LGB) comprises a 1000lb general-purpose bomb, a computer control group (CCG) fitted to the nose and a tail unit with fins that deploy after release from the aircraft. The CCG supports a seeker-head and movable guidance fins (canards). It is sometimes referred to as a 'smart' weapon as the precision-guidance package provides greatly improved accuracy over that achieved by an unguided bomb. A laser is used to designate the target and the bomb's guidance package then steers it to the source of the reflected laser energy. Laser designation may be provided from the air using the Thermal Imaging Airborne Laser Designator (TIALD) pod, or from forces on the ground using a laser target-designator. However, conditions over the target, such as cloud, smoke or mist, may obstruct or scatter the laser beam and prevent precise weapon guidance. The Paveway II can be delivered from either low-level or medium-level; therefore, the operational environment for the aircraft will dictate the release height of the bomb.

Aircraft
Tornado GR4
Harrier GR7
Jaguar GR3
Typhoon F2

Enhanced Paveway II (EPW II)

/essons learned during the Kosovo conflict identified the requirement for the RAF to obtain a precision bomb to satisfy all-weather, 24-hour tasking. The EPW II, which entered RAF service in 2001, incorporates a Global Positioning System Aided Inertial Navigation System (GAINS) into the CCG to give both a GPS and a laser guided capability to the weapon. The EPW II uses the same warhead, fuse and tail combinations as the original Paveway II version.

Target coordinates can be loaded into the weapon by the aircrew prior to the weapon's release from the delivery aircraft and, once released, the EPW II is fully autonomous where cloud or smoke over the target might obstruct the laser and prevent weapon guidance. In these circumstances, the EPWII is steered to the target using satellite-based GPS information and guidance from its on-board inertial navigation unit. Where good visibility permits, crews may still guide the weapon to the assigned target using the original laser guidance contained within the weapon. Laser designation may be provided from the air using the TIALD pod or, from forces on the ground using a laser target-designator. The performance of EPW II offers additional flexibility, and provides increased stand-off delivery range and improved launch-aircraft survival rates.

During the 2003 Iraq conflict, the RAF used an inert warhead variant of the EPW II to reduce the possibility of collateral damage. The bomb used its own mass and kinetic energy to destroy the target.

Aircraft
Tornado GR4
Harrier GR7

Specifications

Length:	3.68m (12ft 2ins)
Diameter:	0.42m (1ft 4ins)
Weight:	546kg (1233lbs)

Paveway III LGB

Precision laser guided bomb

Paveway III Laser Guided Bomb

The Paveway III is a Laser Guided Bomb (LGB) fitted with a 2000lb hardened-target-penetrator warhead, steered by an improved precision-guidance package compared to the Paveway II. The guidance control unit (GCU) fitted to the nose detects the laser energy reflected from a target; however, unlike the Paveway II, this bomb uses proportional guidance: the control canards on the front of the bomb move only that amount necessary to guide the weapon. This conserves the bomb's energy, improves its accuracy and increases the range of the weapon, thus allowing delivery aircraft to engage their targets from a greater stand-off range. When the bomb is released, it flies a pre-programmed profile into the target area, using the energy given to it by the releasing aircraft. These pre-programmed profiles are designed to provide the best attack conditions for the different types of target and to make maximum use of the increased stand-off capability of the weapon.

Computer-controlled trajectory-shaping during the final stage of the attack, coupled with its greater mass, enables the Paveway III to penetrate a greater depth of reinforced concrete than the Paveway II, which makes the Paveway III very effective against hardened targets.

Aircraft
Tornado GR4
Harrier GR7
Jaguar GR3
Typhoon F2

Enhanced Paveway III (EPW III)

The EPW III entered RAF service in late-2002. In a similar manner to the EPW II, the guidance section was modified to accommodate a Global Positioning System Aided Inertial Navigation System (GAINS). Target coordinates can also be loaded into the weapon by the aircrew, prior to its release from the delivery aircraft. Once released, the EPW III is fully autonomous where cloud or smoke over the target might obstruct the laser and prevent weapon guidance. In these circumstances, the EPW III is steered to the target using satellite-based GPS information and guidance from its on-board inertial navigation unit. Where good visibility permits, crews may still guide the weapon to the assigned target using the original laser guidance contained within the weapon. Laser designation may be provided from the air using the TIALD pod or, from forces on the ground using a laser target-designator. The performance of EPW III, like the EPW II, offers additional flexibility, and provides increased stand-off delivery range and improved launch-aircraft survival rates.

Aircraft
Tornado GR4

Specifications

Length:	4.45m (14ft 7ins)
Diameter:	0.92m (3ft 1ins)
Weight:	1141kg (2556lbs)

Cluster Bomb

BL755/IBL755/RBL755

The RAF's inventory of cluster bombs are carried and released in a similar manner to other bombs but, when released, the bombs break open in the airflow and release 147 high-explosive bomblets into the target area. This allows multiple targets to be attacked with one weapon, rather that a number of missions with single-warhead weapons. This is of great advantage in a high-threat environment, particularly when the targets are mobile. The BL755 bomb dispenses its bomblets into the airflow shortly after the weapon leaves the aircraft, and on impact with the ground, or a target, the bomblets detonate, producing a high-explosive velocity plasma jet that can penetrate armour up to 250mm thick. In addition, the bomblet casing breaks into shrapnel fragments that are capable of destroying soft-skinned vehicles and equipment. Recent improvements to the bomblets, designated IBL755, include better reliability and armour penetration. Both the BL755 and the IBL755 bombs are delivered from low-level attacks.

RBL755 is a modification of the original BL755 to give the cluster bomb an anti-armour capability from a medium-level attack. A radar-proximity, height-detecting sensor in the tail causes the bomblets to be dispensed after the weapon falls to a pre-determined height just above the target. This release system negates further aircraft involvement, and allows the aircraft to fly at a safer weapon-delivery level.

The BL/IBL/RBL755 cluster bombs are unguided. The bomblets are distributed in an approximately oval shape of some 150 metres by 60 metres around the target.

Aircraft

Tornado GR4
Harrier GR7
Jaguar GR3
Typhoon F2

CRV-7 Rocket

Multiple-function rocket weapon

The Bristol Aerospace CRV-7 is a multiple-function rocket weapon, which uses modular warheads fitted to a rocket motor. Each single-use operational launcher contains 19 rockets, which are ripple launched at the target. The rockets are fitted with a high-explosive, semi-armour-piercing warhead for attack on lightly protected installations and ships, or a kinetic energy penetrator, which contains no explosives, but relies on its kinetic energy to destroy armoured targets. The CRV-7 rockets have a very high impact speed and may be fired up to 3nmls from the target. A re-usable six-tube launcher and inert warheads are used during training.

Aircraft
Harrier GR7
Jaguar GR3

ALARM

Air Launched Anti-Radiation Missile

The ALARM, which first saw service during the 1991 Gulf War, is an autonomous missile designed to destroy or suppress enemy ground-based, air-defence radar systems. The ALARM operates by homing onto the radar energy emitted by a target radar, either in a direct attack or, if the targeted radar is quiet when the missile is launched, by loitering in the area until the radar starts transmitting.

The ALARM has four main operating modes. In Direct Mode, the missile is pre-programmed with a prioritised threat file and after launch it initiates a search for emitters within a box search area. The missile then locks onto the highest-priority emitter and homes to impact. In Dual Mode, the missile maximises the time available to detect an emitter. If the emitter is radiating, the ALARM will attack immediately. If the emitter shuts down before the ALARM has completed its attack, the missile will fly to a memorised point above the emitter where it deploys a parachute and loiters. If the emitter transmits again, the parachute is ejected and the missile dives onto the target. In Loiter Mode, the ALARM flys overhead the target's position and then loiters by deploying its parachute until the emitter is activated. In Area Suppression Mode, the missile is fired in the direction of emitters whose position may not be precisely known. The missile then autonomously selects the highest-priority target for attack.

Since its original entry into service, radars have become increasingly more sophisticated in their ability to avoid detection and attack by anti-radiation weapons such as ALARM; consequently, the missile is currently being upgraded. The improved ALARM employs a better radar-homing seeker-head, and is fitted with a pre-formed fragmentation warhead for maximum destructive effect.

Aircraft

Tornado GR4
Tornado F3
Typhoon F2

Specifications

Primary function:	Air-to-ground tactical missile
Length:	4.30m (14ft 2ins)
Diameter:	0.244m (9ins)
Launch weight:	265kg (583lbs)
Guidance system:	Passive radar homing

Storm Shadow

Long-range, stand-off, air-to-ground missile

6torm Shadow, built by Matra BAE Dynamics, is an air-launched, long-range, stand-off, precision-guided, air-to-ground cruise missile carrying a powerful conventional warhead. The missile can be launched from a stand off range of 250km and after following an entirely autonomous terrain-following flight at very low altitude it is able to destroy sensitive, highly protected and hardened targets with very great accuracy.

The initial track navigation of the weapon is based on TERPROM (Terrain Profile Matching) navigation and an integrated satellite GPS receiver. On approaching the target area, precise terminal guidance to the target is achieved by an Imaging Infrared sensor and an autonomous target-recognition system. On approaching the target the missile initiates a bunt manoeuvre, pre-selected during mission planning; as the missile climbs it jettisons its nose cover, thereby enabling the missile's high-resolution Imaging Infrared sensor to view the target area ahead. The missile's image processor compares the actual image features with a reference set of features, determined during mission planning. When a feature match is achieved, the target is acquired and as the missile closes on the target the acquisition process is repeated using a higher-resolution data set to refine the aim point. When engaging hard targets, such as hardened aircraft shelters or bunkers, the missile strikes the target at the estimated optimum dive angle, pre-selected during mission planning. On impact, the pre-cursor charge, mounted ahead of the main charge, perforates the target structure and the follow-through penetrator warhead continues to penetrate inside the target and is detonated after a pre-selected fuse delay. Should the mission be against a target which could result in high levels of collateral damage, the mission would be aborted if the target identification and acquisition process were unsuccessful. In such a case, the missile would fly to a predetermined crash site.

The Storm Shadow missile system gives the RAF's strike aircraft a long-range, stealthy, fire-and-forget capability, ensuring aircrews do not have to enter heavily defended enemy airspace to destroy high value targets.

Aircraft
Tornado GR4
Typhoon F2

Specifications

Length:	5.1m (16ft 8ins)
Weight:	1300kg (2860lbs)

Maverick

Anti-armour, fire-and-forget missile

The Raytheon AGM-65 Maverick missile, used by the Harrier GR7 as an anti-armour weapon, entered service in early 2001 and is one of the latest additions to the RAF's weapons inventory. The missile is an air-launched, precision-guided, fire-and-forget weapon, which enhances the RAF's day and night offensive role, especially in close air support and battlefield air-interdiction. The Maverick enables a stand-off launch to be made with a high probability of strike against a wide range of tactical targets, including armour, ships and transportation, and fuel-storage facilities.

The missile's seeker-head carries an Imaging Infrared (IIR) system, which allows the missile to be employed by day and by night and in poor atmospheric conditions. The system tracks heat generated by a target at night or in bad weather and provides the pilot with a pictorial target display in the cockpit. The picture from the IIR seeker head is displayed on a multi-purpose colour display, thus enabling the pilot to identify the target, lock the missile onto it and fire the missile once the target is within range. The Maverick then homes onto the target while the delivery aircraft attacks another target or carries out escape manoeuvres, so minimising the aircraft's exposure to enemy air-defence systems. The Maverick can hit targets ranging in distance from a few thousand feet when launched from low level or up to 13nmls when released at medium level.

The Maverick missile will complement the Brimstone missile when the Brimstone enters service, and give the RAF a complete 24-hour all-weather capability for air-to-ground operations against a wide variety of targets.

Aircraft
Harrier GR7

Specifications	
Length:	2.59m (8ft 6ins)
Weight:	218kg (480lbs)

Brimstone

Fully autonomous, fire-and-forget, anti-armour missile

Brimstone is a fully autonomous, fire-and-forget, anti-armour weapon, effective against all known and projected armoured threats. Its millimetric wave (mmW) radar-seeker ensures target searching and identification can be effected by day and by night, in all-weathers, and it is not susceptible to battlefield obscurants such as smoke, dust, flares or chaff.

Brimstone can be launched in Indirect and Direct modes. Indirect Mode is used when the targets and their position are known but are out of sight of the attacking aircraft. The launch aircraft releases Brimstone from a safe position, thus ensuring aircrews do not have to enter defended enemy airspace to destroy their targets. In Direct Mode, the pilot selects the target by using an on-board sighting system prior to weapon release. In both modes, Brimstone supports off-bore-sight operation so that the aircraft does not have to carry out any special manoeuvre prior to launch. Once launched, Brimstone operates autonomously. When the target is a group of armoured vehicles, missiles can be fired in a salvo of up to the entire platform load to cover the largest area.

Brimstone's advanced mmW seeker allows it to avoid terrain, and when launched from medium or high altitude, the missile goes into a steep dive until it detects the ground below before pulling out to level at the cruise height. Mid-course guidance is controlled by a digital autopilot and a highly accurate digital inertial-measurement unit, giving the necessary high-performance navigation required to locate targets at long range and in off-boresight operations. During the search phase of the engagement, Brimstone's mmW seeker searches for targets in its path, comparing them to a known target signature in its memory. The missile automatically rejects returns which do not match (such as cars, buses, buildings) and continues searching and comparing until it identifies a valid target. The missiles can be programmed not to search for targets until they reach a given point, allowing them to safely overfly friendly forces, or only to accept targets in a designated box area, thus avoiding collateral damage.

The Brimstone warhead is a dual, tandem-configured, high-explosive anti-tank warhead. The front charge breaks through the initial armour on a main battle tank and clears the path for the main charge immediately behind. The warhead is capable of defeating all known and projected armoured threats.

Aircraft
Tornado GR4
Harrier GR7
Typhoon F2

Specifications

Primary function:	Anti-tank armour piercing
Wingspan:	0.3m (1ft 0ins)
Length:	1.81m (5ft 11ins)
Launch weight:	49kg (108lbs)
Range:	Over 20nmls
Speed:	Boost to supersonic
Guidance system:	Inertial mid-course/Active

Harpoon

Autonomous, over-the-horizon, all-weather, anti-ship missile

The Harpoon AGM-84D, produced by McDonnell Aircraft and Missile Systems, a subsidiary of the Boeing Company, is a fully autonomous, over-the-horizon, all-weather, anti-ship missile, designed as a high-subsonic, sea-skimming weapon. Operated by the Nimrod MR2 and MRA4, the missile is pre-programmed with targeting information and then launched from the aircraft to fly to the target using its integral turbojet motor. To operate autonomously, the Harpoon is equipped with an active Phase J-band radar for terminal acquisition of the target, combined with a radar altimeter and a digital mid-course guidance system. The Harpoon can be launched at long range from its intended target, thereby minimising the danger of counter-detection and subsequent attack against the launch aircraft.

The missile is made up of four main components: the guidance section, the warhead, the sustainer section and the boat-tail assembly. The guidance section contains the radar seeker and radar altimeter, which are integrated with the missile guidance unit to maintain the missile on its programmed flight profile and guide it to its target. The sustainer section contains the jet engine to power the missile during sustained flight. The boat-tail assembly contains four electro-mechanical actuators, which operate four external fins at the rear of the missile to control the missile's direction during flight. The missile also carries mid-line fins, which are attached to the sustainer section, but these are used solely to provide lift during flight. The warhead, weighing some 222kg (489lbs), is a high-explosive unit capable of surviving the initial impact with the target's hull, enabling the missile to detonate inside the ship, so increasing its destructive effectiveness.

The Harpoon has proved to be both exceptionally reliable and extremely effective. Its low-level, high-speed attack profile, coupled with its high resistance to countermeasures, make it an excellent anti-ship weapon. Operational use in the Gulf War showed that, once the missile's terminal radar-seeker had acquired its target, the missile achieved a 100% success rate and caused maximum damage to the target ships.

Aircraft
Nimrod MR2
Nimrod MRA4

Specifications

Primary function:	Anti-ship missile
Length:	3.8m (12ft 6ins)
Weight:	527kg (1160lbs)
Range:	125km (67nm)
Guidance:	Inertial mid-course/Terminal active radar

Sting Ray

Lightweight, electrically-powered, homing torpedo

The Sting Ray is a lightweight, air-launched, electrically-powered, homing torpedo carried by the Nimrod MR2 and MRA4 for use against either deep ocean or coastal water submarine targets. It is powered by a seawater battery, and combines low-noise and excellent manoeuvrability with a high-speed attack capability. The Sting Ray is an autonomous weapon which, having received pre-launch, search pattern information from the launch aircraft, uses its active sonar and tactical software to search for, localise and attack its submarine target. The Sting Ray's in-built, tactical software enables it to deal with complex countermeasure defence scenarios used by its target.

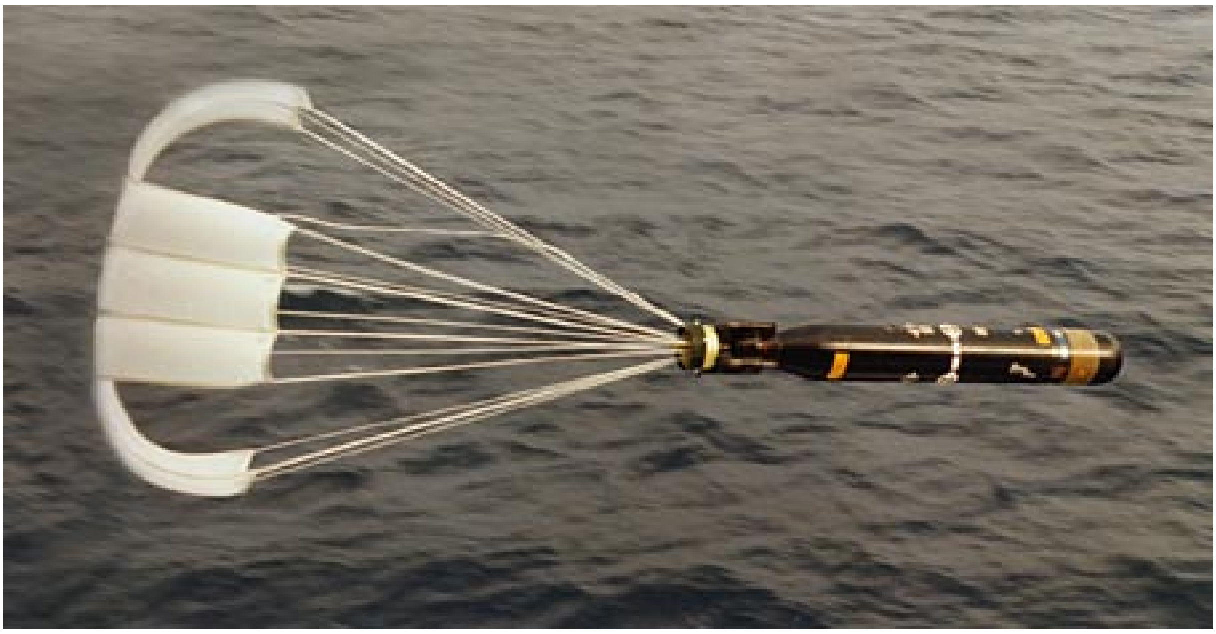
After being launched, the torpedo descends by parachute until it enters the water. The torpedo then activates its propulsion system, which discards the parachute and carries out an immediate check to determine the water depth. If the water is shallow, the torpedo runs at a fixed height following the contours of the sea bed. The torpedo's on-board computer, which controls the acoustics and the homing and attack profile, carries out a search pattern based upon the pre-launch inputs of safety ceiling, initial search depth, magnetic variation and torpedo heading, until the target has been acquired. The target is classified and identified from the return signals and, once acquired, the torpedo starts homing onto it. The torpedo is able to determine the target's speed, heading and depth, thus enabling the weapon to select the best attack-profile and optimum impact angle to ensure the torpedo's shaped charge works to maximum effect when penetrating a submarine's hull. Should the Sting Ray miss its target, it has the ability to turn and home in again for another attack. The current version of the Sting Ray torpedo, designated Mod 0, is receiving a major performance upgrade. The new version will enter service with the RAF as Mod 1.

Aircraft

Nimrod MR2
Nimrod MRA4

Specifications

Length:	2.6m (8ft 7ins)
Diameter:	0.354m (1ft 1ins)
Weight:	265kg (583lbs)
Max depth:	Below 760 metres
Speed:	Over 40kts (46mph)
Warhead:	29kg (64lbs) shaped charge



Mauser BK-27 Cannon

Fitted to Tornado F3 and GR4 aircraft

The Mauser BK-27 is a 27mm cannon fitted to the Tornado F3 and the Tornado GR4 aircraft for air-to-air or air-to-ground firing. The cannon is a single-barrel, high performance, breech-cylinder gun operated by a fully automatic gas-operated system at a selective rate of 1000 or 1700 rounds per minute. The belted-link ammunition box is positioned to the side of the gun-feed mechanism and a floating buffer system imposes a very small recoil and vibration load on the airframe of the aircraft. Spent cartridge cases and empty links are ducted from the rear of the gun into a collection bay immediately behind the gun. Automatic ram air purges the gun compartment and spent cases bay during and after firing.

The weapon has a very good hit-accuracy and one of its main strengths is the cannon's ability to achieve a full 1700-rounds-per-minute rate of fire almost from the first round. This is an important asset, particularly if the cannon is being used against a fast-moving target. Targeting of the cannon is done through the aircraft's head-up-display (HUD). When the cannon is selected in the cockpit, a firing predictor is projected onto the HUD; this depicts a moving line (continuously compacted impact line), or snake, that predicts where the next few rounds of cannon fire will go. The cannon can be aimed by using either a prediction sight or, in the case of the F3, a radar-designated sight.

The cannon has a very high muzzle velocity and its high rate of fire, coupled with its ability to fire several different types of high-explosive shells, make it equally suitable for both interceptor-type aircraft and ground-attack aircraft alike. The system is relatively compact, extremely robust and its simple, rugged design makes it highly reliable.

Aircraft
Tornado F3
Tornado GR4

Aden 30mm Cannon

Fitted to Jaguar GR3 and Hawk TMk1A aircraft

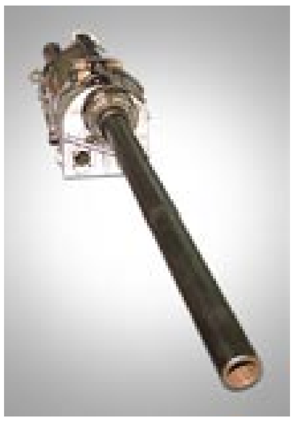
The Aden Cannon is a fully automatic, single-barrelled, five-chambered rotating cylinder gun, which is fitted to the Jaguar GR3 and the Hawk TMk1A. It is electrically fired and gas operated with a rate of fire of between 1200 and 1400 rounds per minute.

The Jaguar GR3 has two cannons housed in port and starboard gun bays in the lower centre fuselage. The cannon's 30mm ammunition is contained in two boxes mounted in compartments above the gun bays, with each box holding 150 rounds formed into a belt by metal links. During firing, the spent cartridge cases are ejected overboard and the empty links are retained in a compartment inboard and below the gun bays. The guns are harmonised in the aircraft by aligning the aircraft on the ground with a pre-positioned sighting board and adjusting the guns onto aligning marks on the board. Aiming of the guns is done through the aircraft's head up display, which depicts a gun-aiming symbol with a centre dot. The aircraft is flown to maintain the centre dot over the marked target cross.

The single Aden Cannon operated by the Hawk TMk1A is housed in an external gun-pod assembly bolted to the underside of the fuselage on the centre-line of the aircraft. The pod contains the cannon and a close-packed ammunition drum containing 100 rounds; it is possible to load a further 30 rounds into the system by using the feed chute. The ammunition ejection sequence follows the same pattern as the system on the Jaguar, with the empty cartridges ejected overboard and the links retained in a compartment at the rear of the pod. The cannon can be harmonised with the aircraft's HUD to give a firing imagery display, which the pilot aligns onto the target.

The cannon is able to fire ball ammunition or high-explosive-tipped rounds and is used by the Hawk for air-to-air and air-to-ground training and by the Jaguar in the air-to-ground role. The cannon has proved to be a very reliable weapon for many years in both its operational and training roles.

Aircraft
Jaguar GR3
Hawk TMk1A



M134 Minigun

7.62mm multi-barrelled rotary gun

7he M134 Minigun is a 7.62mm air-cooled, percussion-fired, multi-barrelled rotary gun, which is mounted on the Chinook helicopter. The gun is electrically driven from the aircraft's 115V AC supply and is mounted on either the port or starboard side of the aircraft in the escape hatch or the cabin door respectively. The gun is fired manually, using belt-fed ammunition at up to 4000 rounds per minute.

Aircraft
Chinook

M60D Machine Gun

7.62mm automatic machine gun

7he M60D machine gun is a 7.62mm calibre automatic, gas operated machine gun that is mounted on the Chinook helicopter and can be fired from either side of the cabin, or from the aircraft's rear ramp. The gun is attached to a mount fixed to the aircraft that permits it to swivel freely between mechanical stops, which prevent damage to the aircraft during firing. An ammunition-can assembly, and an ejection-control bag to collect spent cartridge cases, are supplied to each mount and are fitted directly to the gun. The gun is fired manually at up to 550 rounds per minute.

Aircraft
Chinook

TIALD

Thermal Imaging Airborne Laser Designator

TIALD is a second-generation laser designator pod, which initially entered service in the 1991 Gulf War when it was fitted to RAF Buccaneers to allow them to act as laser designators for the bombs carried by Tornado GR1s. The pods are designed to be operated 24-hours a day and comprise a high-resolution FLIR (forward looking Infrared), a laser designator and a tracking system. Most previous designation systems required the pilot or weapons systems officer (WSO) to keep the target tracked manually; however, TIALD allows automatic tracking once the target is locked. Initially, the TIALD pod is pointed at the target by the aircraft's navigation system; once the pilot or WSO has identified the target on his cockpit display the aiming cross is positioned over the target and the pod is switched into automatic-tracking mode. At the appropriate moment during the attack, the TIALD laser is turned on, which provides the bomb's guidance system with the required information to complete the attack. The whole process is recorded and can be replayed after landing to assess the success of the mission.

The TIALD pod was modified to provide a TV sensor in addition to the Infrared sensor and, following a number of other upgrades, the current 400-Series pod is now flown on the Tornado, Harrier and Jaguar ground-attack aircraft. A further upgrade is planned to the pod sensors and electronics, after which it will be re-designated as the 500-Series pod.

Aircraft
Harrier GR7
Tornado GR4
Jaguar GR3

Specifications

Length:	2.9m (9ft 6ins)
Diameter:	0.3m (12ins)
Weight:	230kg (507lbs)

RAPTOR

Reconnaissance Airborne Pod for Tornado

5APTOR, which is built by BF Goodrich Aerospace, is a new stand-off electro-optical and Infrared (IR), long-range oblique-photography pod fitted to the Tornado GR4. The images received by the pod can be transmitted via a real-time data-link system to image analysts at a ground station, or can be displayed in the cockpit during flight. The imagery can also be recorded for post-flight analysis. The RAPTOR system can create images of hundreds of separate targets in one sortie; it is capable of autonomous operation against pre-planned targets, or it can be re-tasked manually for targets of opportunity or to select a different route to the target. The stand-off range of the sensors allows the aircraft to remain outside heavily-defended areas, to minimise the aircraft's exposure to enemy air-defence systems.

The RAPTOR pod contains a dual-band (visible and IR) sensor, which is capable of detecting and identifying small targets from either short range or long range and from medium or high altitudes, by day or by night. The optical sensors gather high-resolution, motion-free images of extraordinary detail. The optical images are supported by IR imagery that can reveal differences in the shape, composition or content of objects from their thermal signatures. Daytime IR also offers superior haze-penetration in poor weather conditions, while the night time imagery can reveal details such as the fuel levels in storage tanks. The aircraft weapons systems officer controls the RAPTOR system using a real-time cockpit video display, enabling verification of target acquisition, and the conduct of tasks such as battle-damage assessment, or recording the images on digital tape for further in-depth, post-operation analysis.

Aircraft
Tornado GR4

Specifications	
Length:	5.8m (19ft 2ins)
Width:	0.8m (2ft 7ins)
Height:	0.75m (2ft 6ins)
Weight:	1000kg (2200lbs)

Joint Reconnaissance Pod

Provides high-resolution images of a target area

The Joint Reconnaissance Pod (JRP), sometimes referred to as the GP1 Electro-optical (EO) pod, is mounted on the centre-line pylon of the Jaguar GR3A, the Harrier GR7 and the Tornado GR4A aircraft. The JRP contains various electronically-scanned sensors, a number of electro-optical camera options and an Infrared Line Scanner (IRLS). All sensors record to analogue SVHS tapes that provide high-resolution still or moving images of the target area to a software-based Ground Imagery Exploitation System. The various EO camera options that can be fitted to the JRP enable it to be operated either at medium level or at low level. For medium-level operation, one camera is mounted in the nose of the pod and can be rotated through 180°, from horizon-to-horizon. In the low-level mode, two fixed-depression EO cameras are mounted on either side of the pod, giving left-hand and right-hand coverage of the aircraft's track. The IRLS is common to all camera fits and is mounted in the rear of the pod, where it gives a slightly forward-looking, almost vertical, horizon-to-horizon coverage.

When mounted on the Jaguar GR3A, the pod is designed to be used in a fully-automated mode against known targets, pre-planned on the Jaguar Mission Planner. To achieve a greater measure of mission flexibility, however, the pod can also be manually controlled by the pilot against targets of opportunity. After taking target images in manual mode, the pod can be switched back to automatic mode to continue with the pre-planned mission. Whilst medium-level operations are conducted by all three front-line Jaguar squadrons, only 41(F) Squadron operates the JRP in the low-level, tactical reconnaissance role. The Harrier GR7 and the Tornado GR4 operate the pod in manual mode only, in both medium and low-level operations.

Aircraft

Jaguar GR3A
Tornado GR4A
Harrier GR7

Specifications

Length:	2.81m (9ft 3ins)
Diameter:	1.4m (4ft 6ins)
Weight:	254kg (559lbs)

RAF Regiment

Ground defence of deployed air assets

5AF Regiment front-line units are grouped as Field Squadrons or Ground Based Air Defence Squadrons. The role of a Field Squadron is to carry out the ground defence of deployed air assets worldwide. To achieve this, Field Squadrons are highly mobile and equipped with a high scaling of mortars, machine guns and surveillance devices. Ground Based Air Defence Squadrons are equipped with the Rapier Field Standard C (FSC) system and the Squadrons' role is to provide anti-aircraft air defence of UK or coalition air forces deployed anywhere in the world.

GPMG

The GPMG is a 7.62mm calibre tripod-mounted weapon that can fire ball, tracer or armour piercing ammunition out to approximately 2000 metres with lethal effect. The GPMG can also be fired from the ground, using the weapon's built-in bipod. In either configuration the GPMG provides rapid and heavy fire by day or by night when used either as a single weapon or as part of a multiple-gun line. In a sustained fire mode the GPMG is normally operated by a two-man team and can achieve a 750rpm rate of fire when the ammunition is belt-fed by the support operator. The weapon's powerful effect can be combined with the 81mm Mortar to bring maximum firepower onto an enemy.

LAW

The 94mm LAW has an effective battle-range of approximately 300 metres and is able to penetrate over 700mm of armour plating. It has a built-in 9mm spotting rifle that allows the operator to confirm target lead and range before firing. The sighting system also uses a series of optical prisms and is manually operated by the weapon firer. The LAW is expendable once the missile has been fired.

L94 Sniper Rifle

The Field Squadrons' sniper teams are equipped with the L94 sniper rifle. This highly accurate, telescopically sighted, bolt-action rifle fires specialised 7.62mm calibre ammunition that enables a sniper to engage targets at over 1000 metres. In addition to the L94 sniper rifle, sniper teams carry a light support weapon and 9mm pistols. Snipers can operate as pairs or as individuals on observation, reconnaissance and offensive operations.

Common Weapons

Light personal weapons

L85 A2 Rifle

The L85 A2 rifle is manufactured by Heckler and Koch (UK) and is the standard infantry weapon of the UK's armed forces. The modified A2 version has overcome earlier serviceability problems and it is now recognised as one of the most powerful, accurate and versatile light support weapons in the world. The L85 A2 is fitted with an optical sight for daylight use which can be removed easily and replaced with a night-vision sight, and so provide the versatility for 24-hour use. The rifle uses a standard 5.56mm NATO round and can fire a 30 round magazine in single-shot or automatic-burst modes. The rifle has an effective range of 500 metres and the optical sight enhances the lethal effect of the weapon by providing a four-times magnification.

9mm Pistol

The standard pistol in RAF Regiment service is the Browning 9mm. With a magazine capacity of 13 rounds, this semi-automatic pistol is used for short-range firing at targets up to 45 metres distant. Each squadron holds a central store of pistols, which are issued to individuals when close protection is considered necessary.

ROYAL AIR FORCE

AIRCRAFT & WEAPONS

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