AIRCRAFT RECOGNITION
ADVANCED

Australian
Air Force Cadets

Cadet / Instructor Notes

Rewrite Edition, 1st Jan 2007

AIRCRAFT RECOGNITION ADVANCED (ARA)
(12 PERIODS)

Serial No	Title and Objective.	Attain Level	Periods
ARA 1	**Stealth Technology**	**B**	**1**

a. Describe 'stealth technology'.

b. Identify using WETFUS, current stealth Technology aircraft, and their salient features:

(1) F-117A
(2) B-2
(3) F-22A.

c. Describe the need for stealth technology aircraft in high risk environments.

d. Outline the implications of OTH radar on stealth technology aircraft.

ARA 2	**Stealth Technology- Application**	**B**	**2**

a. Analyse the application of stealth technology aircraft in the 2003 Gulf War or 1999 NATO Kosovar Air Bombardment.

ARA 3	**C3 Aircraft**	**B**	**3**

a. Describe the role of aircraft dedicated to the Command, Control and Co-ordination (C3) function, specifically:

(1) Wedgetail (AEWACS)
(2) E-8 (JSTARS)

b. Outline the data-linking process between C3 aircraft and air interdiction and/or Ground support aircraft on combat air patrol (CAP).

ARA 4	**Airborne Target Acquisition Systems.**	**B**	**2**

a. Describe the characteristics of Airborne Target Acquisition Systems (ATAS) with Respect to targets acquired by:

(1) Laser
(2) Microwave
(3) Infra-red
(4) Television/optical

b. Describe the practical application of Precision Guided Munitions (PGMs)

ARA 5 Case Study B 2

Select a topic from ARA 1, ARA 2 or ARA 3 and prepare a case study presentation focusing on an aspect of interest. The case study should be at least 500 words.

ARA 6 Examination 1

ARA 7 Examination Review 1

Note: Presentation of ARA 5 constitutes 50% of the assessment of ARA with the examination (ARA 6) contributing to the remaining 50%.

AIRCRAFT RECOGNITION ADVANCED (ARA)
ARA 1 - STEALTH TECHNOLOGY FEATURES
1 PERIOD

Objectives

1001. a. Describe “stealth technology”.

b. Identify using WETFUS current stealth technology aircraft and their Salient features

(1) F-117A

(2) B-2

(3) F-22A

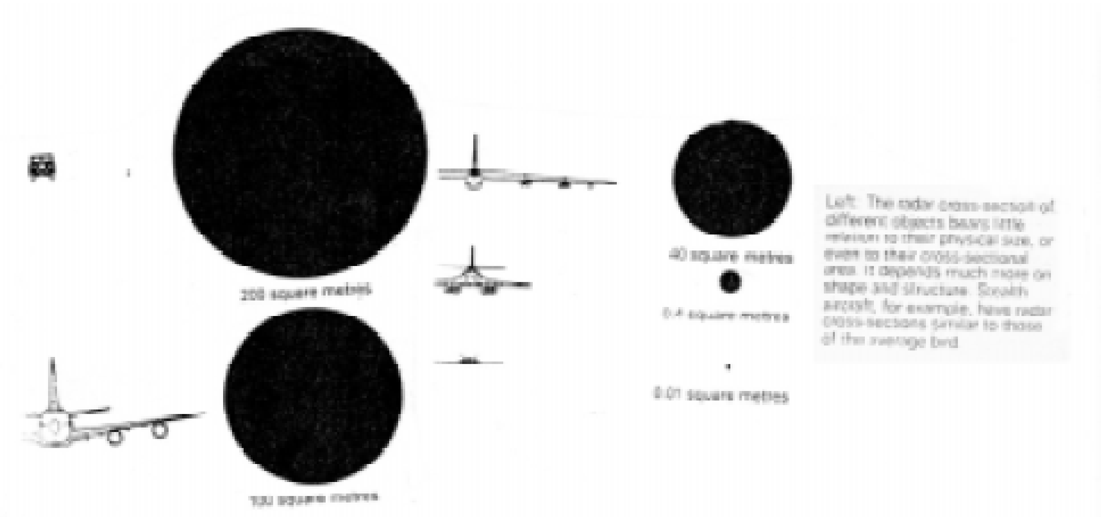
c. Describe the need for stealth technology aircraft in high risk Environments.

d. Outline the implications of OTH radar on stealth technology aircraft.

e. Analyse the implication of stealth technology aircraft in the 1991 Gulf War.

STEALTH TECHNOLOGY

1002. Ever since the first combat aircraft took to the skies, pilots have attempted to conceal their Aircraft from eyes, both on the ground, as well as the sky. The most obvious of these was the painting of camouflage, but methods such as clear covering were also attempted. However as radar and tracking technology increased more ingenious methods become necessary.



1003. It was soon discovered that there was more to lowering radar cross section than just size (see previous figure).

1004. Stealth technology is a broad term used to describe features and equipment of an aircraft which assist it in minimising its radar signature, or to avoid detection by radar all together, and reduce the Thermal Energy emissions from an aircraft, primarily in the Infra-Red range.

1005. Encompassed in this term are the following methods to reduce the Radar Cross Section (RCS) of an aircraft.

Radar Absorbent Material (RAM)

1006. RAM consists of composite materials used for airframe construction and the use of special paints. These materials have the ability to absorb a quantity of transmitted radar waves, thus preventing them from being received at a receiver station.

1007. RAM materials comprise:

a. rubber compounds

b. silicones

c. polyurethanes

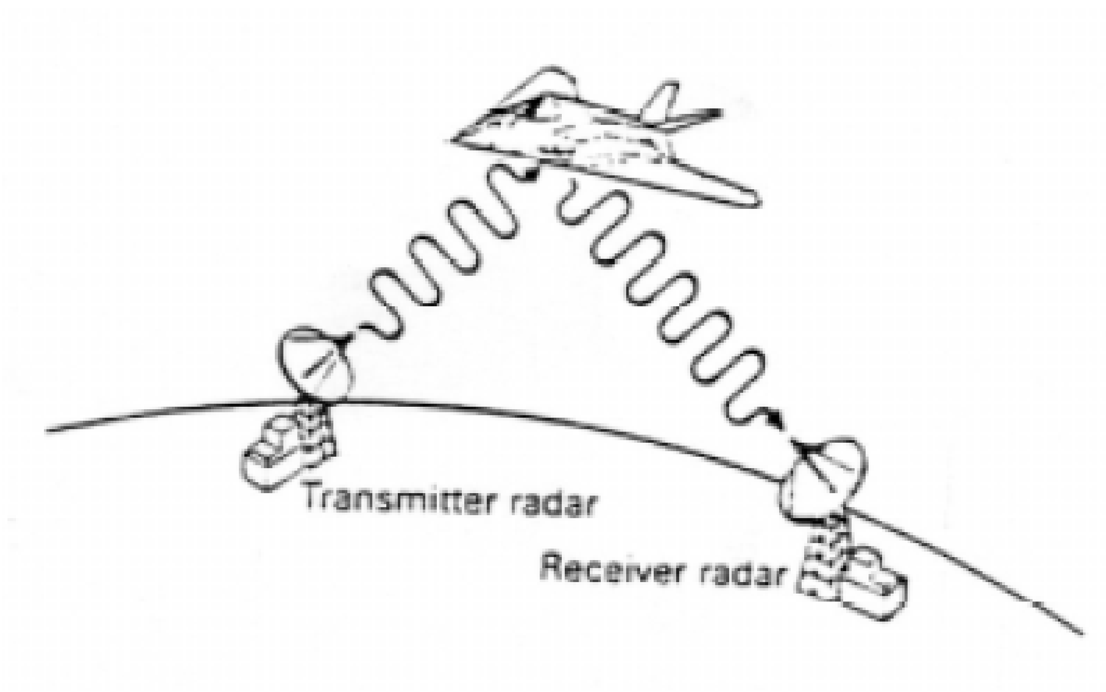
d. dielectric foam

e. wire mesh, and

f. carbon composites

Faceting

1008. This technique rather than absorb the radar, utilizes angles and sharp corners, which reflect the radar away in a number of directions from the transmitting station. This method is quite effective but falls down when used against Biostatic radar which uses a separate receiving station. (see figure below).



Sharp Wing Configuration

1009. Giving the wing a highly swept back leading edge, as well as a "saw toothed" trailing edge, causes the radar when striking these surfaces to be deflected at angles away from the radar station.

Engine Intakes and Exhausts

1010. Engine compressor faces are one of the biggest radar reflectors on most aircraft. They have to be carefully redesigned for Stealth, to reduce RCS:

a. inlet and exhaust ducts are placed above the wings

b. inlets are covered by mesh screens, or serpentine in shape (S ducts), this prevents radar signals leaving the ducts

c. exhausts angled slightly upwards

d. outer edges of all ducts must be ‘saw toothed’.

Profile

1011. Another way to lower radar signature is by simply minimizing the aircraft’s cross section. This involves the use of sleek lines and the blending of wing and fuselage. A thin profile with no slab sided tails or appendages, no external weapons, fuel or electronic sensor carriage.

Cockpits, Cavities and Control Surfaces

Cockpits

1012. These are the second largest radar deflectors. Transparencies must be small and covered in a conductive film to prevent radar transmissions entering the cockpit.

Cavities and Control Surfaces

1013. Any straight join between two separate surfaces will produce a strong radar return. Weapon bay and wheel doors, cockpit edges must all have ‘saw toothed’ edges to prevent this. Control surfaces are at an angle on the swept wings to achieve the same result.

Summary

1014. To have a low RCS, a design must have:

a. the elimination of slab sided tails, fuselages and appendages

b. the use of compound curvature or a multi-faceted shape

c. reshaping of cavities and control surfaces

d. no exterior weapons or fuel tanks

e. the redesign of engine inlet and outlet geometries to eliminate reflections

f. the elimination of stepped cockpit contours.

Infra Red Emissions

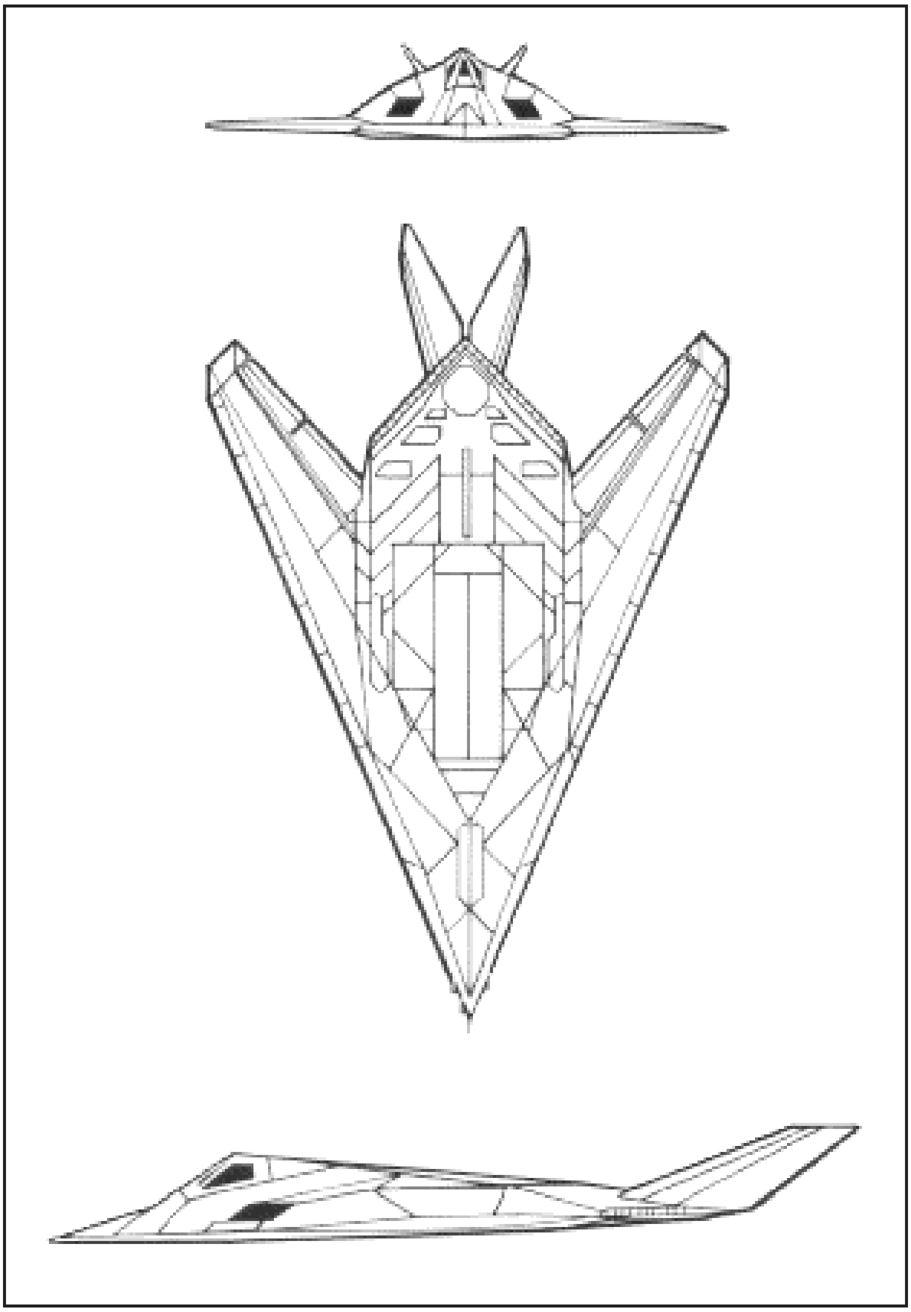
1015. Nearly all the Infra Red (IR) emissions come from the exhaust and in a conventional aircraft forms a conical pattern behind the aircraft, with an intensely hot core.

1016. For Stealth the exhaust duct is shaped to produce a thin flattened exhaust pattern, that is angled up slightly, and allows the hot gasses to mix rapidly with the surrounding and quickly cool. Baffles in the ducts shield the IR emissions and confine them to a small area directly behind the aircraft.

Stealth Technology Aircraft

Lockheed F-117A Nighthawk

1017.	ORIGIN:	USA
	ROLE:	Single seat, low-altitude low-observable interdictor, precision night attack aircraft
	CREW:	1
	POWERPLANT:	Two General Electric F404-GE-400 turbofans
	SQN:	USAF 37th Tactical Fighter Wing (formally 4450th Tactical Group)



Recognition Features

1018. W. swept back leading edge with no fuselage protruding forward, gives the wing an arrowhead plan form

E. two non-afterburning turbofans, above wing either side of fuselage.

Intakes covered with wire mesh screens

T. saw toothed trailing edge, twin outward canting vertical stabilizers (V-tail) no horizontal stabilizer

F. triangular fuselage cross section. Pyramid appearance. Faceted tapered shape.

U. tricycle retractable undercarriage

S. black colour scheme, Weapons in internal bay. Attack sensors housed internally in nose.

Stealth Techniques Utilised

1019. a. faceting

b. highly swept wings (62 degrees)

c. mesh inlet covers

d. passive radar

e. inlet and exhaust above wing, with exhaust directed up vertical stabilizers

f. conductive film on cockpit transparencies

g. radar absorbent materials

h. armament in internal weapons bay, and sawtooth edges to all bay and wheel doors.

Armament

1020. 2270kg of ordinance which may comprise of laser-guided or IR air to surface missiles.

Dimensions

1021. Span: 13.2 m

Length: 20.08 m

Height: 3.78 m

General

1022. Although the F-117A is given the fighter designated (F), it is not suited to the fighter role, more for strike and reconnaissance. Announced officially on 10 Dec 88, it is believed the aircraft first flew during June 1981 and achieved operational capability in October of 1983. With a Max speed of Mach = 0.92 at 1525m. The F-117A has an empty weight of 6804kg and a capable takeoff weight of 12608kg. The USAF has 59 aircraft in service.

Northrop B-2A Bomber

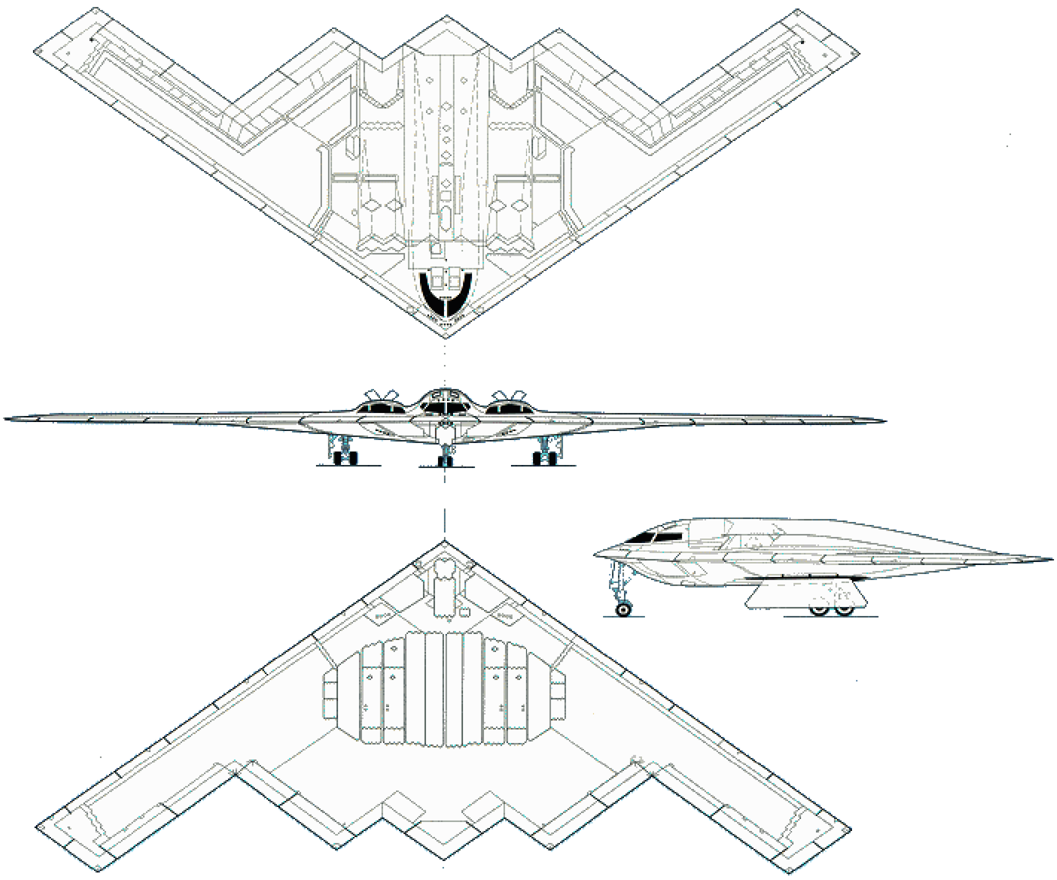
1023. ORIGIN: USA

CREW: 2 seated side by side (with provision for third behind)

ROLE: Low-observable, long range strategic bomber

POWER PLANT: Four 1900lb thrust General Electric F118-GE-110 turbofans

SQN: USAF Strategic Air Command (509th Bomb Wing)



Recognition Features

1024. **W.** delta wing, swept back leading edge, saw toothed trailing edge

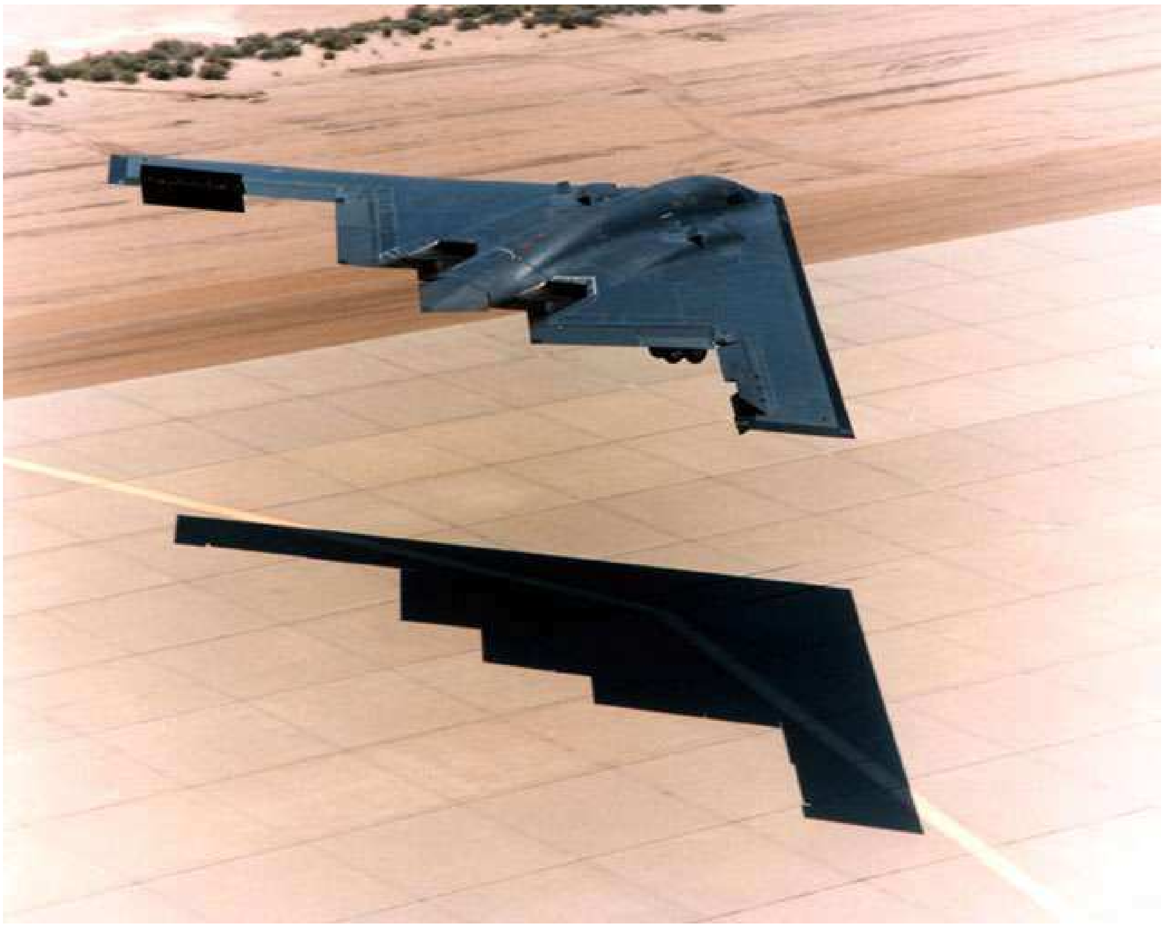
E. two turbo-fan engines above each wing

T. no vertical or horizontal stabilisers

F. fuselage blended in wing

U. tricycle undercarriage

S. black colour scheme



Stealth Techniques Utilized

1025. a. RAM on whole surface. Wing leading edges fitted with RAM honeycomb

b. low front and side profile

c. swept back leading edge and saw toothed trailing edge

d. S ducts

e. exhaust and inlet above wing, with exhaust gases distributed over a large area of the wings surface to enhance cooling

f. passive radar

g. no extended appendages

Armament

1026. Rotary launcher in each of two weapons bays with a possibility of up to 16 SRAMs (Short range attack missiles).

1027. Up to 20 x B61 or 16 x B83 free fall nuclear bombs, or a wide range of conventional air-to surface weapons to a max load of 22,680kgs.

Dimensions

1028.	Span:	52.43m
	Length	21.03m
	Height:	5.18m

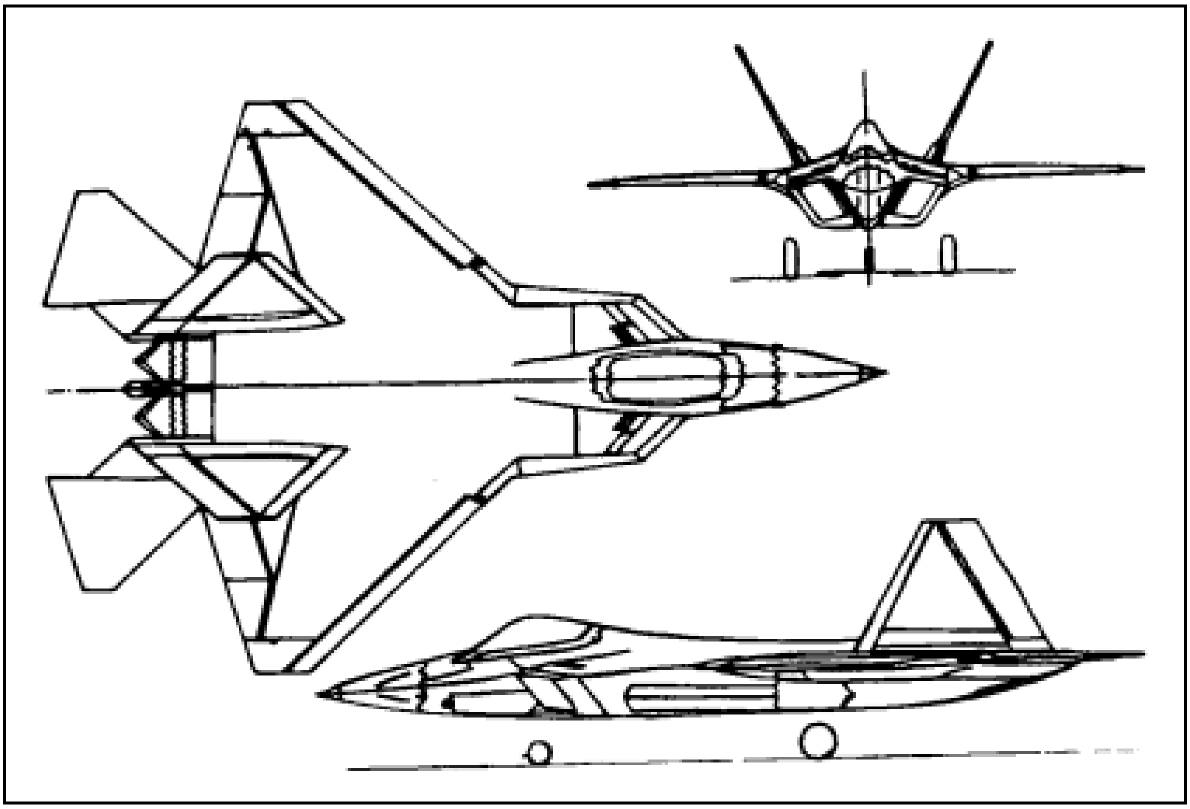
General

1029. With the first B-2 being flown on 17 Jul 89 and the second on 19 Oct 90, production is well under way. Originally 133 aircraft ordered, how-ever Congress has only approved 15 to be built.

1030. The B-2 has an empty weight of 49900kg and a Max take-off weight of 168433kg. It has an estimated max speed of 955-1010 km/hr at 50000ft and an active range of 11675km without refuelling.

Lockheed / General Dynamics / Boeing F-22A

1031.	ORIGIN:	USA
	ROLE:	Single seat, Air Superiority Fighter
	CREW:	1
	POWERPLANT:	Two Pratt & Whitney F119-PW-100, augmented turbofans, with vectoring thrust.



Recognition Features

1032. **W.** Delta wing with swept back leading edge, swept forward trailing edge.

E. Internal turbofans either side of the fuselage, intakes below cockpit

T. Twin outward canting stabilisers, full flying horizontal stabiliser with a swept back leading edge and swept forward trailing edge

F. Compound fuselage. Diamond section nose, and almost rectangular Plan

U. Tricycle, retractable undercarriage

S. Two-dimensional thrust-vectoring engine nozzles to enhance manoeuvrability.

Stealth Techniques Used

1033. a. Low frontal profile

b. Sharply angled wings & fuselage to deflect hostile signals

c. long inlet ducting

d. Sawtooth edges to all doors & cockpit edges

e. Outward sloping fins

f. Internal weapons

g. Radar absorbent materials

Armament

1034. One 20mm M61 rotary cannon and four short range AIM-9 Air- to Air missiles (AAMs) in the centre of the three in line weapons bays with two AIM-120 medium range AAMs in each of the outboard bays.

Dimensions

1035.	Span:	13.10m
	Length:	19.56m
	Height:	5.40m

General

1036. Developed by Lockheed and teamed with General Dynamics and Boeing, the YF-22 was competing at the beginning of 1991 with the Northrop/McDonald Douglas YF-23.

1037. Of the two prototypes, the first flew on 29 Sep 90, the second following on 30 Oct 90. If selected to meet the USAF's ATF (Advanced Tactical Fighter) requirement, 76 aircraft are expected to be built by the year 2000, when it is anticipated that operational capability will be achieved.

1038. The aircraft having a top speed of Mach 1.2 at low altitude, and Mach 1.8 above 10975m. It has a normal loaded weight of 24950kg (empty 14970kg).

The Need For Stealth Technology

1039. The need for Stealth aircraft evolved during the “Cold War” arms race between the USA and USSR. In spite of building a vast stock of Intercontinental Ballistic Missiles, successive American Administrations did not wish to rely on weapons of mass destruction for national security. Nuclear missiles are essentially ‘first strike’ weapons and the manned bomber is less threatening and more controllable. The manned bomber allows a limited strike capability rather than the threat of ‘mutually assured destruction’ of the ICBM.

1040. Consequently, the manned bomber has been included in defence planning for many years but it was recognised that it would have to be capable of penetrating Soviet Air Defences and reaching targets deep into Siberia.

1041. The vulnerability of manned aircraft to the expanding Soviet air defence network was demonstrated in May 1960, when Francis Garry Powers was shot down while flying a Lockheed U-2 spy plane over the USSR.

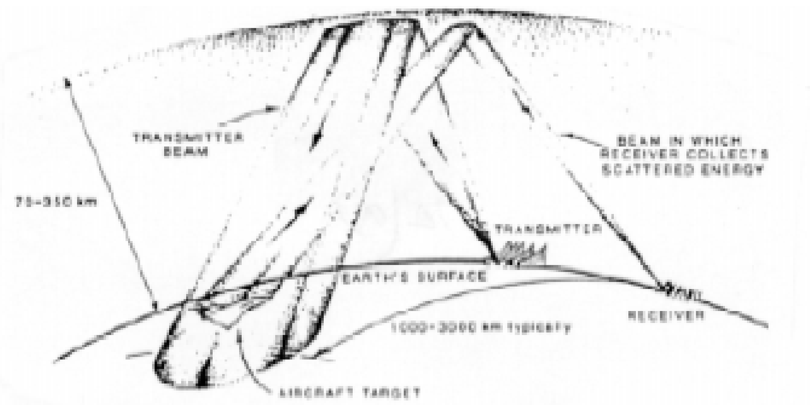
1042. The B-70 Valkyrie bomber was cancelled in 1961 by President Kennedy, as being unable to carry out its assigned mission. It was designed to fly very fast and at high altitude to evade supersonic interceptors and ground based SAMs. However, advancements in SAM technology left it just as vulnerable as the B-52s it was designed to replace.

1043. The accuracy of modern SAM and AAM weapons is one reason why airborne targets are so vulnerable. When they are coupled with very effective target acquisition and tracking radars, they become an awesome Air Defence System that is difficult to breach with acceptable losses by conventional aircraft. Stealth is the only way to penetrate these defences efficiently and at low cost, opening the way for non-stealth aircraft.

1044. It is no longer accurate to judge the cost of a mission simply by the price of the hardware. A relatively expensive Stealth weapon can save many times its procurement cost by eliminating the need for other conventional weapons systems and support aircraft. The truth of this statement will be proven later when Stealth in the Gulf War will be examined in greater detail.

Implications Of Over The Horizon Radar On Stealth Aircraft

1045. An Over the Horizon Radar such as Jindalee is designed to provide a wide area, long distance, surveillance assessed as a PRIMARY detection device to alert other units: Aircraft of Surface vessels: whose role it is to intercept and engage the surface or air targets detected by the OTHR.



Principle of Over-the-Horizon Radar

1046. On its own, a radar such as Jindalee cannot provide both long range detection and intercept control. Being a long distance system it can only act as a first line of defence - a “trip-wire” – that activates a coordinated defence response by other assets.

1047. Jindalee, and other systems like it, consists of a High Power, remote, High Frequency transmitter which refracts a signal down from the ionosphere to illuminate a target. The return echo travels by a similar path back to a receiver located about 100 kilometres from the transmitter. Unlike traditional microwave radars that can only see as far as the horizon Jindalee is expected to detect ships and aircraft at ranges of 2000-3000 kilometres.

1048. The United States Air Force has openly conceded that the B-2 is detectable by high power low band VHR Surveillance radars, and it therefore follows that the less sophisticated F-117A will also be detectable by such systems.

1049. HF radar like Jindalee or VHF systems such as many ‘geriatric’ Soviet systems use wavelengths comparable to the size of stealth aircraft, hence the scattering mechanisms which occurs is different and a solid return is seen. Faceting is totally ineffective. VHR radars are, however, generally considered to be inaccurate and very poor performers against low altitude targets of any kind - therefore the sanctuary of low altitude is clearly available to stealth aircraft. Jindalee should perform quite well against targets at all levels. 1050. In practical terms the ability of a low band radar to detect an inbound stealth aircraft may be of little real value, as the radar cannot be accurate enough to target anything but a nuclear armed SAM. Precision SAM, AAM and fighter radars all operate in the upper G-J bands, where they are effectively defeated by stealth aircraft’s unique capabilities.

AIRCRAFT RECOGNITION ADVANCED (ARA)
ARA 2 - STEALTH TECHNOLOGY - APPLICATION
2 PERIODS

The Application Of Stealth Aircraft In The Gulf War

2001. The F-117A Stealth Fighter saw its first real combat in the Gulf War and it performed to expectations - penetrating the most heavily defended areas without being detected and suffering zero attrition. The ability of stealth aircraft to attack targets without any other support that tankers offers tremendous economies.

2002. To demonstrate this fact the following case study should be considered. It is the comparison of a pair of raids by the USAF, against a nuclear reactor facility south of Bagdad. The first raid was a classical strike by a conventional force of aircraft that was made up of the following units:-

32 F-16's as bombers

16 F-15Cs as the combat air patrol

4 EF-111 Electronic warfare aircraft - jamming Iraqi radar

8 F-4G suppression aircraft

15 Tankers

2003. While damage was inflicted, the facility remained functional and the strike force was unable to loiter to intensive fire, requiring re-attack at a later date.

2004. The second raid which successfully destroyed three of the four reactors involved:-

6 F-117A

2 Tankers.

2005. To further re-reinforce the point, the raid could have been flown by two B-2s without tankers.

2006. Support radar jamming was provided for penetrating F-117A during the Gulf War, because stealth aircraft are not totally invisible to radar - they are merely less detectable - and do benefit from jamming. A jammer offers such a reduction in defending radar sensitivity as to render a detectable inbound aircraft effectively invisible by burying its return in 'noise'. This tactic was used successfully on a number of F-117A raids but was discontinued when the Iraqi's commenced firing a blind barrage AAA once support jamming was detected.

2007. The F-117A is only a first generation Stealth Strike Aircraft - with an unspectacular payload radius performance and limited sensor suite - that produced spectacular results. Its role was critical. It represented a mere 2.5% of the total strike aircraft available but successfully attacked 31% of the total targets destroyed by the coalition forces during the war. It was a clear demonstration of the benefits of stealth in future conflicts.

AIRCRAFT RECOGNITION ADVANCED
ARA 3 - C3 AIRCRAFT
1 PERIOD

Objective

3001. a. Describe the role of aircraft dedicated to the Command, Control and Co-ordination (C3) function, specifically:

(1) E3A - Sentry (AWACS)

(2) E-8 (JSTARS)

b. Outline the data-linking process between C3 aircraft and interdiction and/or ground support aircraft on combat air patrol (CAP).

The Role of Aircraft Dedicated to COMMAND, CONTROL & COORDINATION

3002. In an age in which the source of electromagnetic transmission can be readily identified and swiftly targeted, the airborne command post offers the comparative security of mobility in friendly airspace, together with the advantages of height for communications at all ranges.

3003. The rapid acceleration in micro-miniaturised, secure communications greatly enhances the airborne command post, which greatly reduces the traditional threat of paralysis by attack on a force's nervous system - its command and control. This threat of paralysis became reality during the Gulf War, when coalition forces systematically destroyed Iraqi C3 assets.

3004. The modern C3 aircraft is comprised of three major elements:

a. An Airborne Early Warning Radar system (AEW)

b. Airborne Command facilities

c. Coordination & Communication system.

3005. AEW was developed during the Second World War to provide warning of the presence of hostile aircraft and surface vessels in the naval environment. It was put to extensive use in the Battle of the Atlantic and during the great naval battles of the Pacific and it continues to this day to be an essential facet of naval warfare.

3006. During the 1970's the USA extended this concept to the airborne control of Air Defence fighters with the development of the E-3A Sentry AWACS aircraft.

BOEING E-3A SENTRY.

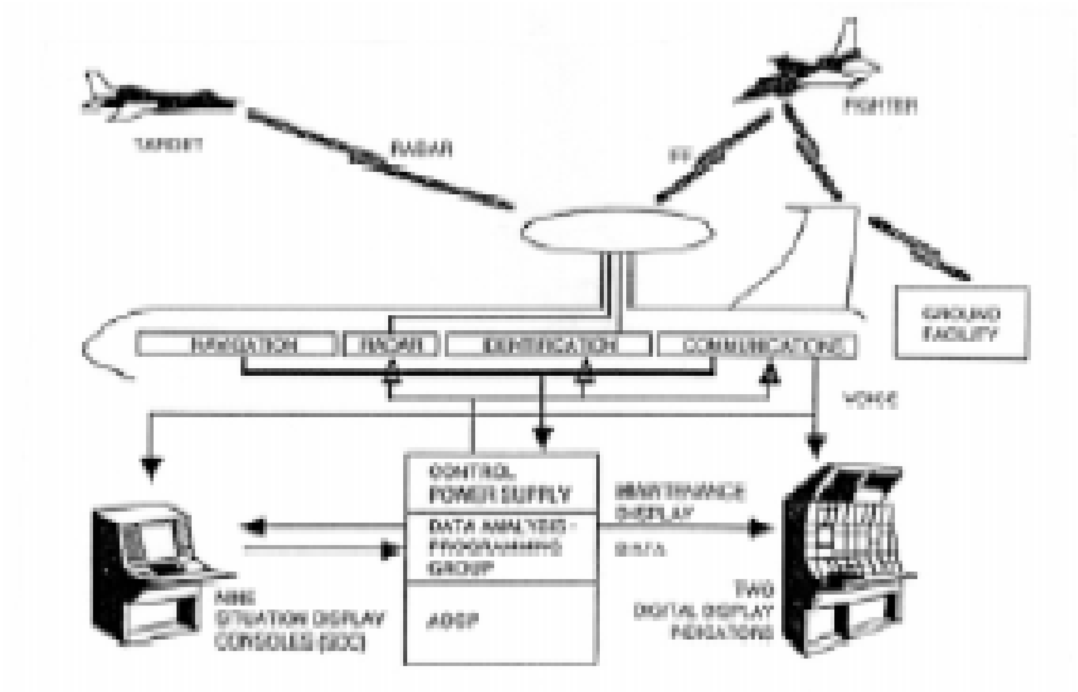
Airborne Early Warning and Control System (AEWACS)

3007. The Wedgetail is an airborne command, control and communications (C3) platform consisting of five basic avionics sub-systems built into a modified B737 airframe:-

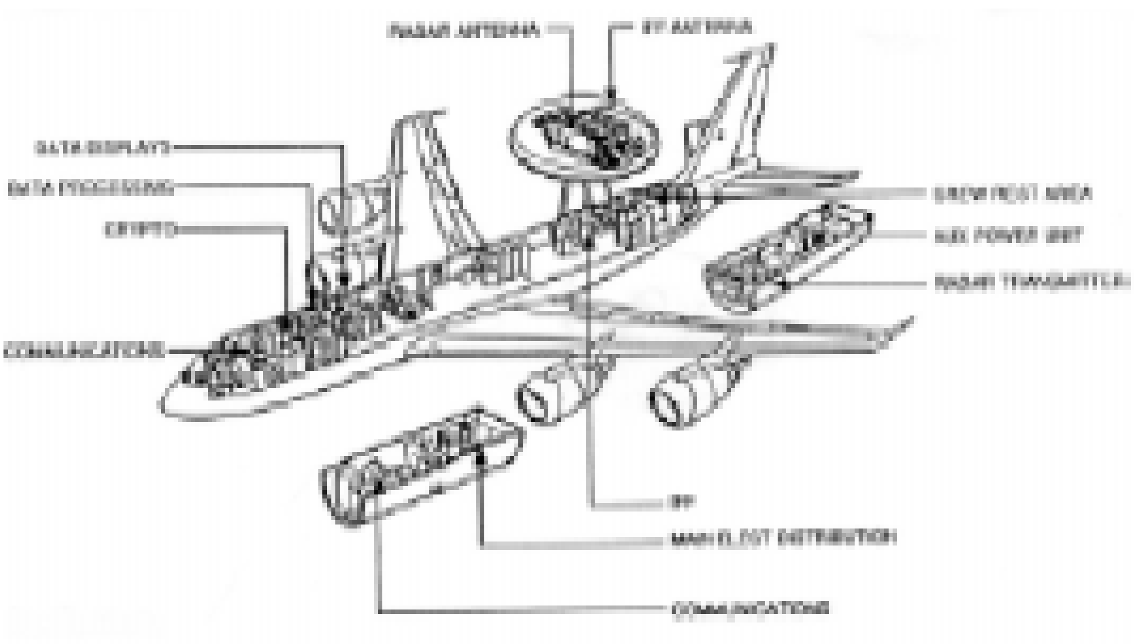
a. radar
b. identification friend or foe (IFF)
c. communications
d. navigation
e. data processing & display

3008. The major modifications to the basic B737 aeroplane are the addition of Pratt & Whitney engines and the addition of the rotodome along the fuselage. In flight refuelling is used to extend the range of the mission or time on station.

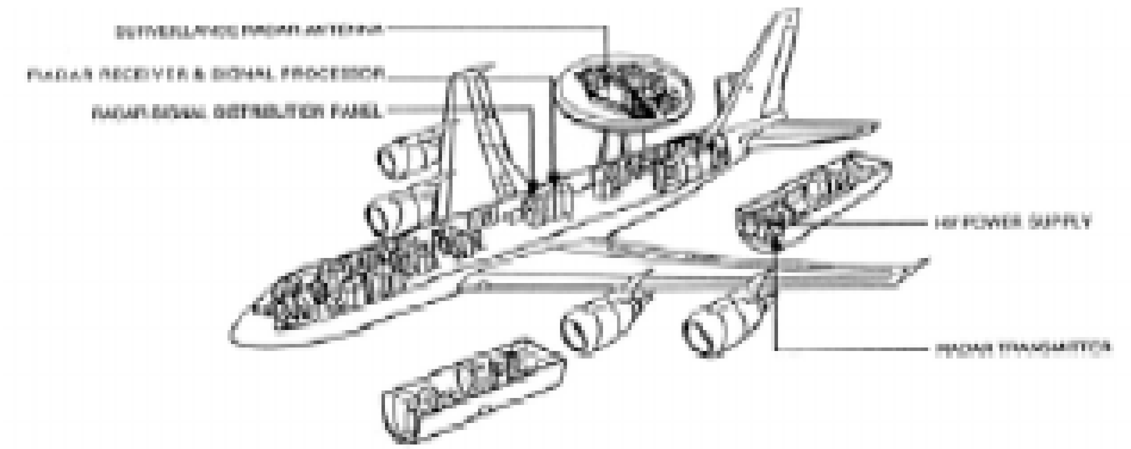
3009. Large radar and IFF antennas are housed on either side of a 'strongback' in the rotodome. All sensor information is passed via the Control Power Supply (CPS) to the Data Analysis & Programme Group (DAPG) and thence to colour Situation Display Consoles (SDC's).



3010. Figure below shows the disposition of the C3 hardware within the B737 airframe. The galley, resting areas and general roominess of the interior contribute to crew comfort and fatigue reduction during long missions - up to 18 hours at a 600 nautical mile station radius with one refuelling.



Radar System

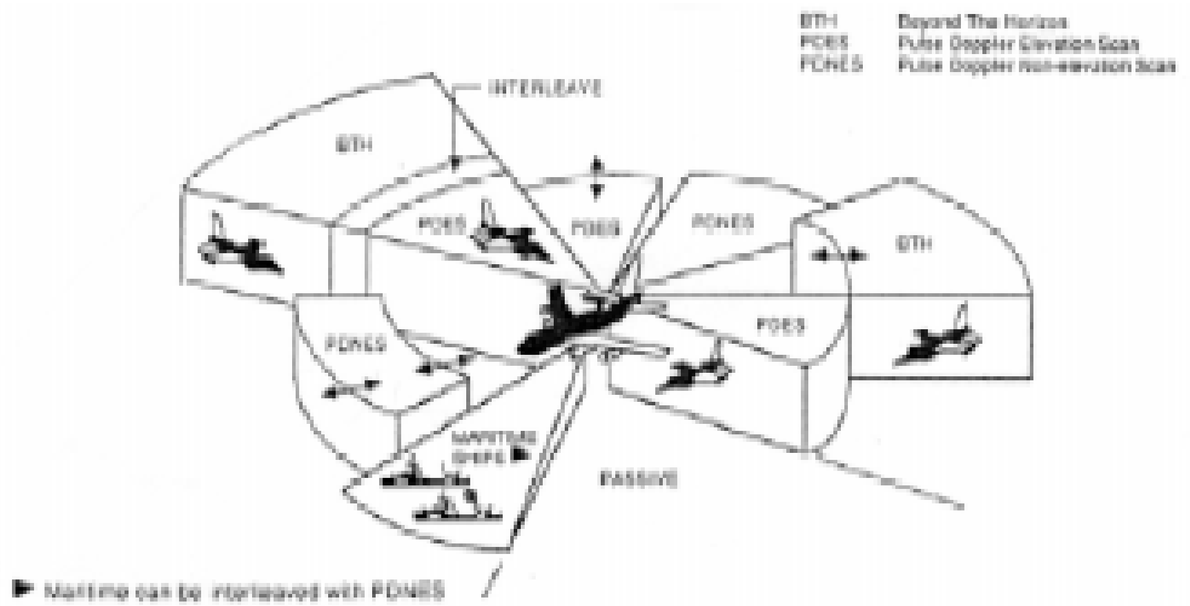


3011. The transmitter signal is carried by waveguide through the antenna pedestal strut to the antenna where it uses a waveguide rotary joint to pass between the stationery strut to the moving antenna.

3012. The antenna is an array of slotted waveguides, which provides proper signal distribution across the array for low side lobes. It also allows a broad operating bandwidth which minimises the effects of clutter and jamming. There is a height finding function and it is space stabilised, which maintains the beam position as the aircraft rolls and pitches.

3013. Energy reflected from targets is sensed by the antenna and passed through electronic phases shifters and passed through the waveguide to the Beyond - the -Horizon, Maritime and Pulse Doppler receivers. Reports from all three receivers are passed to the Radar Data Correlator.

3014. The Radar Data Correlator is a high speed, programmable computer that operates in conjunction with the Surveillance Computer to perform overall radar management.



3015. The figure shows radar made combinations:-

a. The Pulse Doppler (DP) mode for detecting targets against a clutter background

b. The Pulse, or Beyond the Horizon mode, for detecting targets against a non-clutter or benign background

c. The Maritime narrow pulse mode for detecting moving or stationary maritime targets

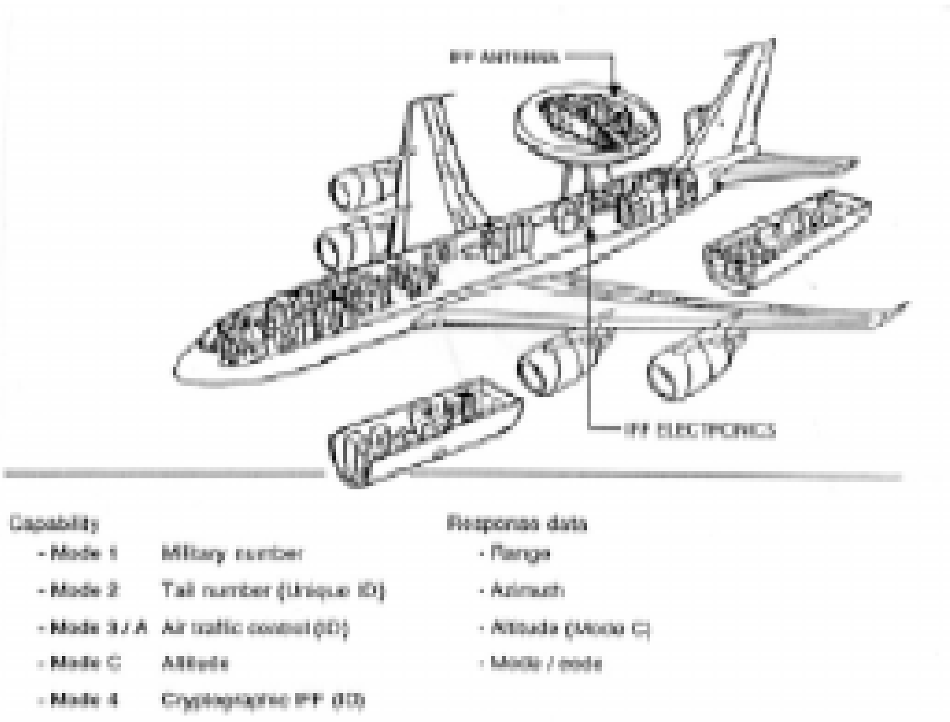
d. The Passive mode for detecting and tracking in-band jammers.

3016. These various modes can be interleaved to accomplish simultaneous surveillance and tracking of many different targets.

IFF System

3017. The MARK 12 IFF system consists of an interrogator set and an antenna. The IFF Interrogator set has redundant switchable receiver/transmitters, redundant power supplies, redundant crypto units, target data processor and radio frequency switch.

3018. The antenna of this system is mounted in the rotodome facing 180 degrees from the face of the radar array. It is a 48 element log-periodic array.



Communications System

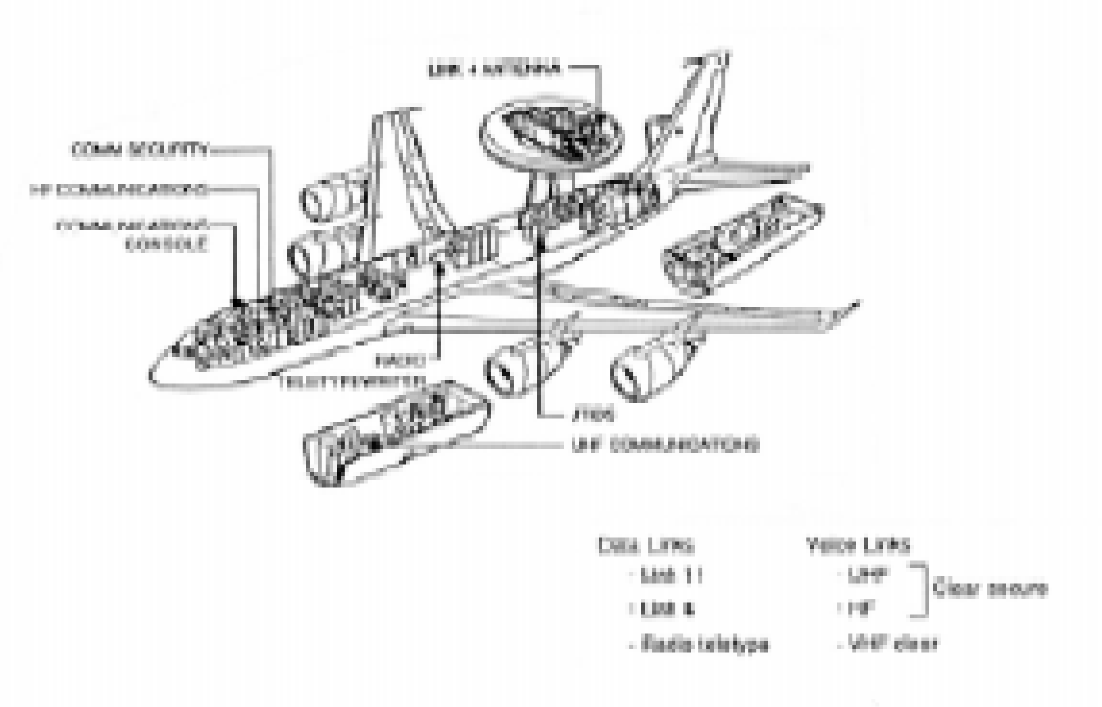
3019. The communications sub-system comprises various types of antennas, avionics equipment, control panels and transmission lines. The major elements are:-

a. audio distribution system

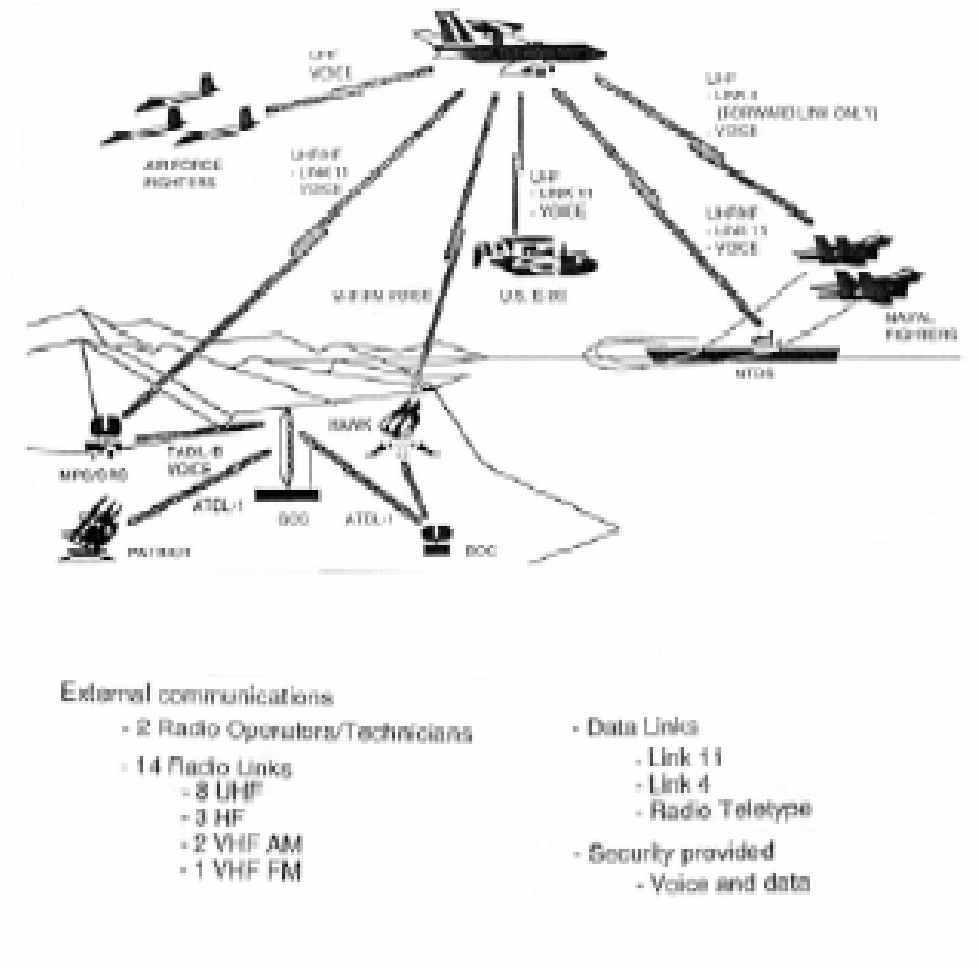
b. baseband switching system

c. LINK-11 Modem

d. UHF communication system
e. VHF-AM communications system
f. VHF-FM communications system
g. HF communications system
h. Radio teletypewriter communications system
i. UHF communication relay system
j. communication console
k. cryptographic systems



3020. The figure above shows a typical communications inter-operability scenario where the various links to the ground, air and naval resources are identified.



Navigation

3021. Navigation is achieved by the use of Dual Inertial navigation, Doppler navigation and Omega navigation systems. This determines the AEWACS position, sensor beam steering and alignment, sensor report and track location. Navigation update rate is once every 25 milliseconds.

Data Processing and Display

3022. Data processing is accomplished by the Airborne Operational Computer Program section of the data Analysis Programming Group Computer, which performs the major computational tasks for on-board command, control and communication operations, such as:-

a. inputting, converting and correlating surveillance sensor data

b. calculating tracking data, guidance paths, weapons availabilities, threat assessments, and other mission critical parameters databases

c. updating display databases

d. storing and recording mission data

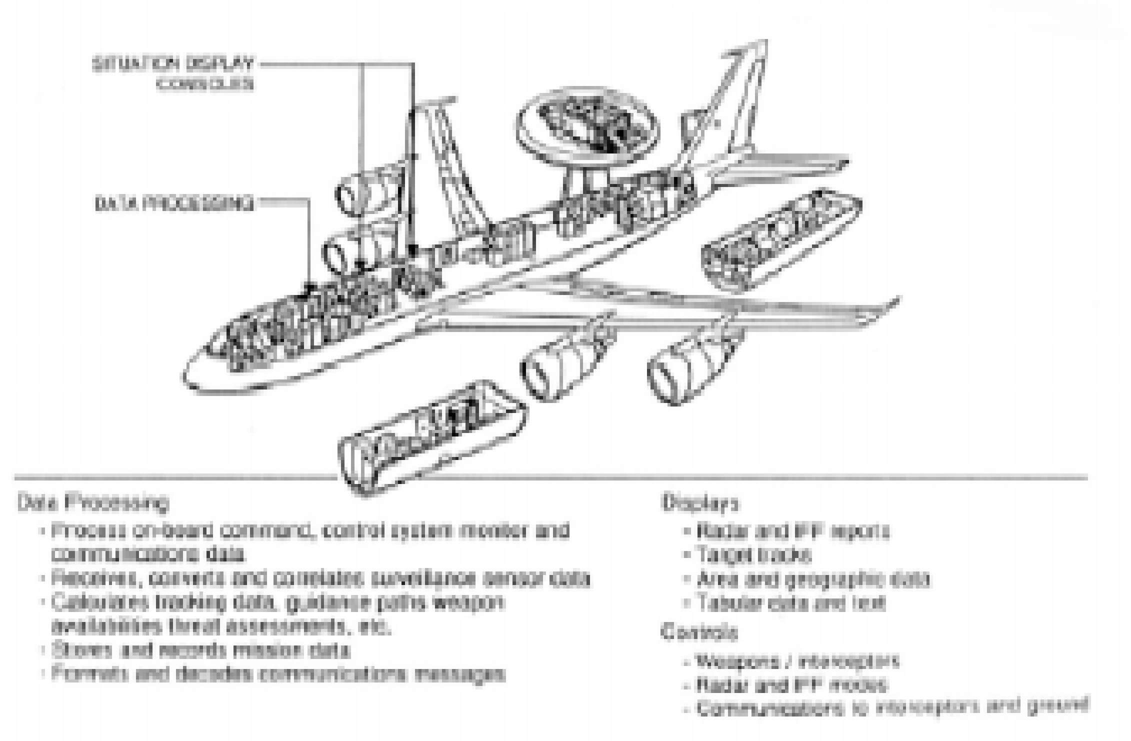
e. formatting and decoding communication messages

f. responding to operator inputs

g. processing system monitor data reporting failures, and re-figuring the computer

h. simulating missions and generating training stimuli.

3023. The data generated is displayed on 9 colour situation display consoles which provide the man- machine interface of the Wedgetail system. The figure shown on the next page illustrates the data processing and display sub-system.



Wedgetail Operators

3024. The Wedgetail is currently in service with USAF, coming on with RAAF in the late 2008.

GRUMMAN E-8

JSTARS - Joint Standoff Target Acquisition Radar System.

3025. Having proven the value of the E-3A Sentry, the E-6a Mercury (which provides the President of the United States with the means to communicate with submerged nuclear powered ballistic submarines) and the E-4B (a Boeing 747 used as an Advanced Airborne National Command Post that becomes the seat of Government of the USA in time of crisis), the US Defence Dept. decided to apply this formula to the ground battle. The Grumman E-8 was conceived during the "Cold War" with extensive armoured battles in Europe in mind, had war erupted between the two superpowers.

3026. The E-8 system consists of a B707 airframe fitted with a sophisticated long range, moving target indicator/synthetic aperture radar in a radome under the fuselage; the Data processing systems to analyse the information received from the radars; and the communication facilities to transmit the information gained to command HQ as well as provide airborne control of ground and air forces.

3027. This system was still under development when the Gulf conflict began and the two prototype units were hastily rushed into service, with civilian workers to help support the largely untried aircraft. The two aircraft flew 49 missions totalling 535 flying hours, between them, probing deep inside Iraqi territory with their radar. They were searching for vehicles, supply dumps, scud missiles and armoured fighting vehicles, and the abilities of these "ground AWACS 'impressed all participants.

3028. As is mentioned above, their sensors are designed to detect moving targets and during the initial phase of the Gulf war they were not very effective for the simple reason that the Iraqi forces were dug in and static. Once the ground fighting developed into a war of manoeuvre the JSTARS came into their own. The moving target indicators easily detected vehicles moving on the ground. The data processing equipment was then able to plot and display any patterns to the movements and the synthetic aperture radar provides a picture of areas of particular interest. Scud batteries were located in this way, as well as columns of Iraqi armour, all of which became targets for allied forces. An Iraqi counter attack was located by JSTARS and subsequently destroyed before it reached its intended area of operation.

3029. JSTARS is able to display information to the airborne crew and transmit it to ground commanders simultaneously. This ability to provide a comprehensive picture of enemy strength, hundreds of miles beyond the battlefront, under all weather conditions, day and night, is a fundamental advantage, particularly in a manoeuvre scenario, which some commentators have even called 'ungentlemanly" because of the advantages it gives to one side in battle.

Data-linking Process

3030. As was mentioned in the section describing the E-3A Sentry aircraft, an essential part of any C3 aircraft system is communications. This is mentioned several times in the 'Gulf Technology Video'. The Iraqi command was "rendered blind, deaf and dumb" by the systematic destruction of their command structure in the first days of the air war. Another reference is to the air ground links in the JSTARS aircraft that allows ground commanders to have first hand access to the gathered information.

3031. Data links from these aircraft can be split into two parts:

a. Radio communication, and

b. Electronic Data Transmission.

Radio Communications

3032. Radio is the simplest method for command and control of aircraft either in the air defence or the strike role and it primarily utilises radio in the UHF band, but these frequencies can also be used for coordination with ground missile batteries, naval vessels and other C3 aircraft.

3033. VHF (either AM or FM) and HF radio are also used for communications with naval task forces, air defence missile batteries and ground radar units. UHF and VHF are relatively short range, line of sight radios whereas HF has a much longer range by using ionospheic skipping.

3034. These radio communications must remain secure from enemy jamming, interference and eavesdropping. Transmission security is maintained by frequent frequency changes, and by electronic shielding.

Data Transmission

3035. All data within these aircraft is converted to digital format for internal display and transmission to other units. The modem microprocessor makes this a simple task and similarly modem technology is used to transmit it where it is needed. UHF radio is the most common method of transmission but for longer range HF and Satellites is used.

3036. As with the Fighter direction channels all data links are secured from enemy interference by methods which are not openly published.

3037. The E-8 JSTARS makes extensive use of data down links to ground command posts for obvious reasons, as is shown in the video.

AIRCRAFT RECOGNITION ADVANCED (ARA)
AVA 4 - AIRBORNE TARGET ACQUISITION SYSTEMS
2 PERIODS

Objectives

4001. a. Describe the characteristics of Airborne Target Acquisition Systems (ATAS) with respect to targets acquired by:

(1) Laser

(2) Microwave

(3) Infra-red, and

(4) Television/optical

b. Describe the practical application of Precision Guided Munitions (PGMs)

Introduction

4002. For either an air interception or ground attack, it is vital for the attacker to locate the target in time for a first pass attack; the second time around is simply not good enough, an abortive first pass will only alert the defenders. Another factor is fuel; in many cases there will be insufficient for feints or other deceptive measures if the first pass fails.

4003. Rapid target acquisition is essential. The most basic means is visual, while successive steps in sophistication lead on to Forward Looking Infra Red (FLIR); Tele-visual; to Ground mapping, Synthetic aperture, or Air intercept Radars.

4004. Visual detection needs daylight and clear weather. A low flying fast jet has little chance of visually acquiring anything other than a large area target unless it appears straight ahead. Visual acquisition depends on aircraft leaving the shelter of the ground briefly, for a quick pop-up, to have a look around. The tactical wisdom of such a manoeuvre will depend on the strength of the defences in the area, in some cases it will be feasible, in others suicidal.

4005. Forward Looking Infra Red (FLIR) gives a picture made up from heat imagery; ideally it is displayed at the exact size a pilot would see visually, while the focus can be adjusted for a close up view. The picture is black and white, and definition in clear air is very good, turning night into day, but only along the line of sight. While generally reckoned to give a night attack capability, FLIR can also be used to penetrate smoke and dust over the battlefield.

4006. Tele-visual acquisition uses an optical camera to give a picture of the target either from the nose of a missile or from a multi-sensor. Most have the ability to record data for post strike analysis through a strike camera.

4007. Ground mapping radar scans terrain ahead and presents a picture in the cockpit from which targets may be identified. As slant look angles cause a fair amount of distortion, a computer processes the returns and displays the picture in plain view so that it is more easily identified.

4008. Synthetic Aperture Radar (SAR) was developed for reconnaissance in the 1960's, but advances in processing have allowed the definition improvements to the level of low grade photography. The improvements will be good enough to give targeting data and detect and identify previously unknown targets on either side of the flight path.

4009. Finally, fighter radars, using micro-processor technology, are compact powerful units capable of performing many different tasks simultaneously.

4010. In practice Laser, Microwave, IR and TV/optical systems are rarely used alone. The modern Target Acquisition System utilises more than one type in combination.

Laser

4011. Laser systems are only target marking devices, that must be used in conjunction with another method of acquisition, and consist of two separate components.

a. a laser designator that marks & illuminates the target, and

b. a sensor unit that guides the weapon to the illuminated target.

4012. The designator can be carried by either the attacking aircraft, another or by forward ground troops. When pointed at a target the laser produces a cone of infra-red light that reflects from the surface. The designator signal is pulse coded to give positive target identification to the weapon.

Ground-based laser designation can be of great help to a pilot carrying out a close-support mission. This is the Ferranti Battlefield Operations Laser Designator used by British troops to designate targets for laser-guided bombs during the Falklands War of 1982.

4013. The sensor unit has silicon detectors under a glass lens on the nose, which focuses the light into a spot on the detectors. Electrical impulses from the detectors are fed to the guidance computer, which, in turn, sends a signal to the flying controls to adjust the aim of the weapon.

4014. Laser target marking is used with the PAVEWAY laser guided bomb, and air to surface missiles such as MAVERICK and HELLFIRE.

Microwave

4015. Two systems are covered:

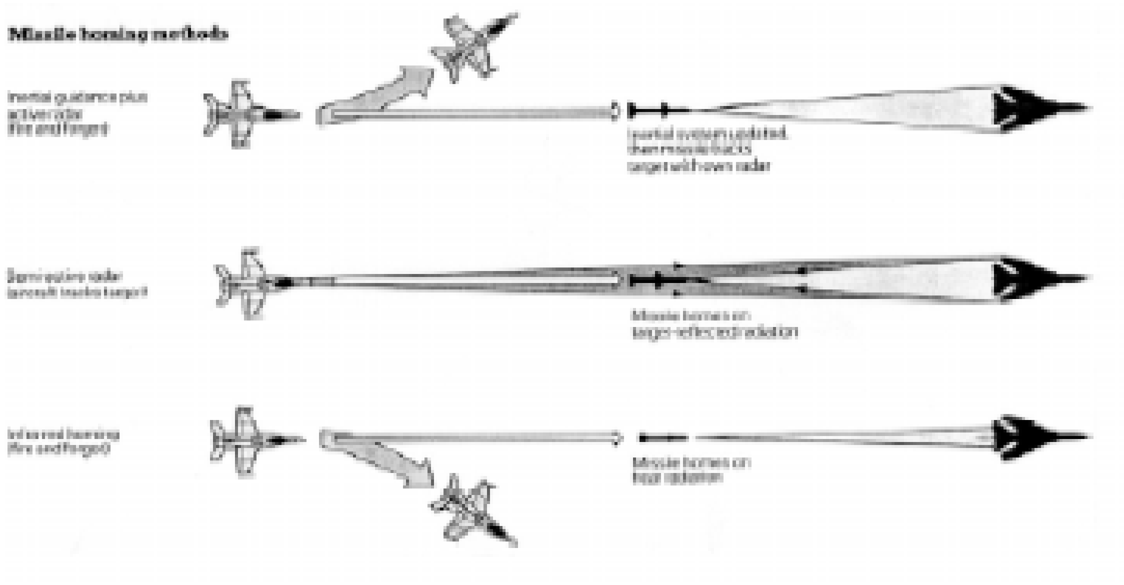
a. Air to Air, and

b. Attack.

Air to Air

4016. The modern air interception radar uses multiple frequencies and varying pulse repetition rates for very long range, medium and short range target search. Single target tracking and computation of missile firing solution is displayed on the Head UP display (HUD) while target illumination is provided for radar guided missiles. For close-in fighting a gun director mode is usually available which makes all the necessary computations and gives the pilot a firing solution on the HUD. Radar is backed up by air INFRA RED TRACKER to assist proper target identification.

4017. Missile guidance can be ACTIVE RADAR HOMING (ARH), SEMI ACTIVE RADAR HOMING (SARH) or PASSIVE HOMING.



4018. The ARH missile is a ‘fire and forget’ system, the fighter acquires the target on its radar and this information is fed to the missile’s electronics. Inertial guidance and an autopilot guides the missile to the target until its own active radar locks on for final homing.

4019. The SARH missile is only fitted with a passive radar receiver to detect returns from the target transmitted by the fighter’s radar. Using these returns guidance commands keep the missile on course to the target. The only disadvantage with this type of missile is that the fighter must keep moving towards the target allowing it to be seen by the target.

4020. PASSIVE radar guidance are used in the SUPPRESSION of ENEMY AIR DEFENCE (SEAD) and are designed to home onto the transmissions from an enemy air defence radar. The best known missile of this type is the AGM-88a HARM (High Speed Anti-radiation Missile).

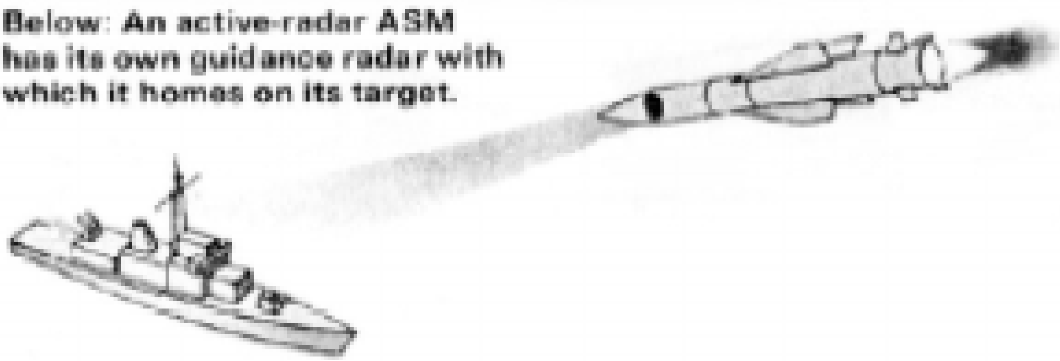
4021. Radar guided missiles are not the only air to air weapons available to the fighter. Gun systems, such as the M61A1 Sidewinder, are carried for close range action.

Attack

4022. The Norden APQ-148 Radar fitted to the A-6E Intruder is a good example of the capabilities of a dedicated attack radar. It is a multi-mode type that combines terrain avoidance, ground mapping, detection, tracking, and identification of fixed or moving targets.

The A-6E coordinates the radar with the Target Recognition Attack Multi sensor (TRAM), contained in a small pod under the nose, for final attack solutions and weapon guidance.

4023. The AGM-84A Harpoon is an anti shipping missile that gets initial guidance from the parent aircraft's radar, fed into its inertial guidance. In the terminal phase it uses active radar homing to pop up and dive on the target.

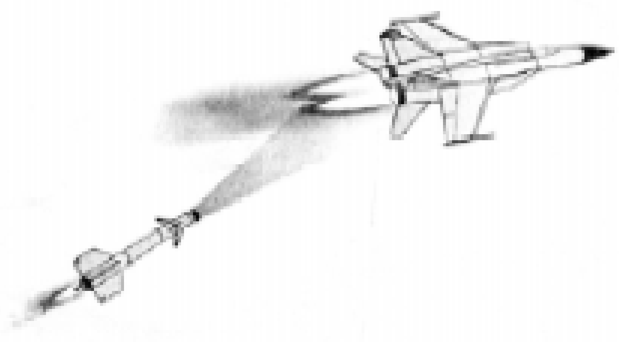


Below: An active-radar ASM has its own guidance radar with which it homes on its target.

Infra Red

4024. There are two distinct uses for Infra Red (IR); weapon guidance and target acquisition.

4025. Both use electro-magnetic waves from the spectrum that also includes radar, radio and light waves. The most important aspect of Infra Red is that the target generates its own IR radiation and this can be detected as a 'hot spot' against a basically 'cold' background, by day and night and through rain cloud and smoke.



Above: IR homing. Most short range AAMs have IR (infra-red) guidance: they home automatically on to hot objects emitting IR (heat) radiation within a chosen band of wavelengths. Spurious sources, such as sunlight, are if possible excluded from these wavelengths.

4026. The IR homing system is passive and creates no detectable emissions of its own. Air to air missiles with this guidance have a fairly short range and home onto the hottest source of IR; the engines and tail pipes. In the early stages of development these missiles sometimes tended to home on the sun or its reflection and it was necessary to fire rear of the target to detect the greatest radiation.

4027. With advances in technology sensors have become much more sensitive and have allowed missiles to achieve a lock on from any aspect including front on and at longer ranges.

4028. IR is also used for ground attack weapons but as target identification and tracking rather than homing. IMAGING INFRA RED (IIR) is the most commonly used system today. It processes infra red emissions and presents them on a small cockpit screen as a black and white picture. The definition and clarity is exceptionally good allowing the aircrew to place a target designator on a precise spot. Once the system is locked on to the spot it will continue to automatically track the target. The unit is often pod mounted as on the FA-18.

Television/Optical

4029. Tele-visual sensors and guidance are limited to ground attack weapons and they all suffer from the need to clearly see the target. Clear weather by day is needed for these systems.

4030. Missile guidance can be one of two types:

a. Command guidance, by data link, from the attack aircraft or

b. Lock on and ‘fire and forget’.

4031. Command guidance receives visual signals from the missile of the target by data link and the aircrew continually flies the weapon to the target right up to the time of impact, using a small joystick similar to a video game. Control can be retained by the aircraft that fired the weapon or transferred to another depending on circumstances.

4032. The fire and forget system has a camera in the nose of the missile which allows a pilot to lock on the missile using brightness contrast (light against dark of vice versa). Unfortunately, a high level of contrast is needed, clear weather is essential plus an attack direction where the angle of the sun gives the greatest amount of contrast. This limitation is why the latest version of Maverick uses Imaging Infra Red (IIR) for homing and contrast.

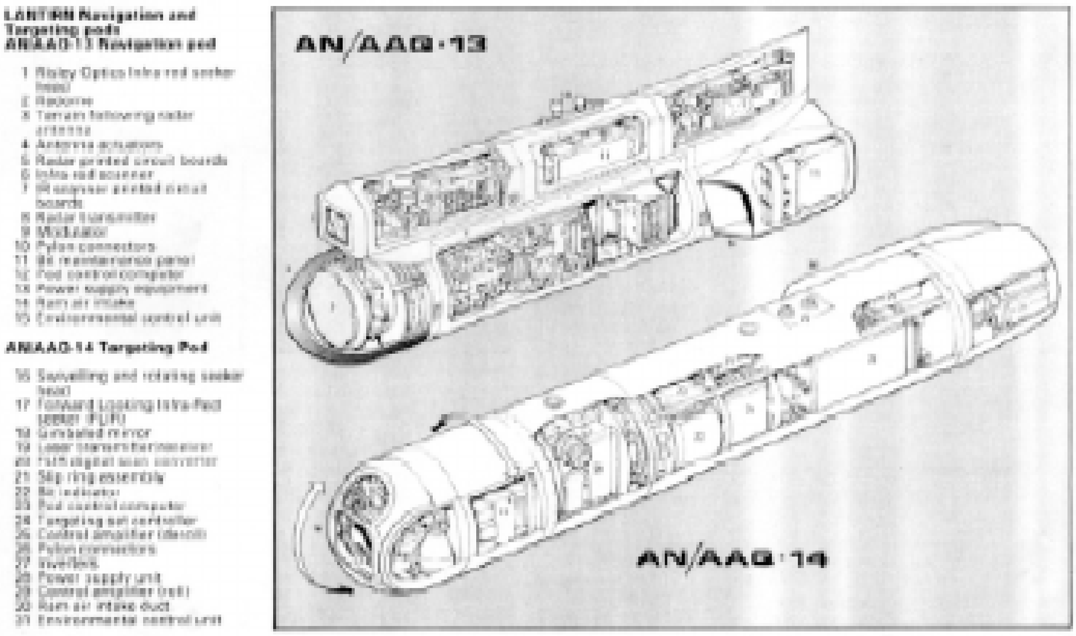
Below: The Rockwell GBU-15 is a glide bomb which uses electro-optical guidance with a data link to the controlling aircraft.

4033. Televisual sensors are integrated into many sensor suites of attack aircraft to give the crew a picture of their target. The Apache helicopter has a nose mounted turret that has FLIR, LOW LIGHT TV (LLTV) and DIRECT OPTICS which is the heart of its attack system.

The Practical Application of PRECISION GUIDED MUNITIONS (PGMs)

LANTIRN Low Altitude Navigation Targeting Infra-Red for Night

4034. Fitted to the F-15E it allows this aircraft to fly and fight by day and night, in all weathers, and to deliver its weapons with surgical precision. It consists of two separate pods; an AN/AAQ-13 navigation pod; and, an AN/AAQ-14 targeting pod.



4035. The navigation pod contains FLIR and TERRAIN FOLLOWING RADAR (TFR). The FLIR image is displayed on the heads up display, with holographic imaging, while the TFR is fed into the aircraft automatic flight control system in the ‘hands off’ mode. This allows the aircraft to fly at 200 feet (60 metres), in all weathers at speeds up to 520 knots (960kph).

4036. The targeting pod has a high resolution stabilised FLIR with a laser designator boresighted to it, both housed in a steerable turret at the front of the pod. The FLIR has a range of over 8 miles (18 km) and is used for target acquisition and tracking. The Laser is for designation of individual targets for precision guided weapons.

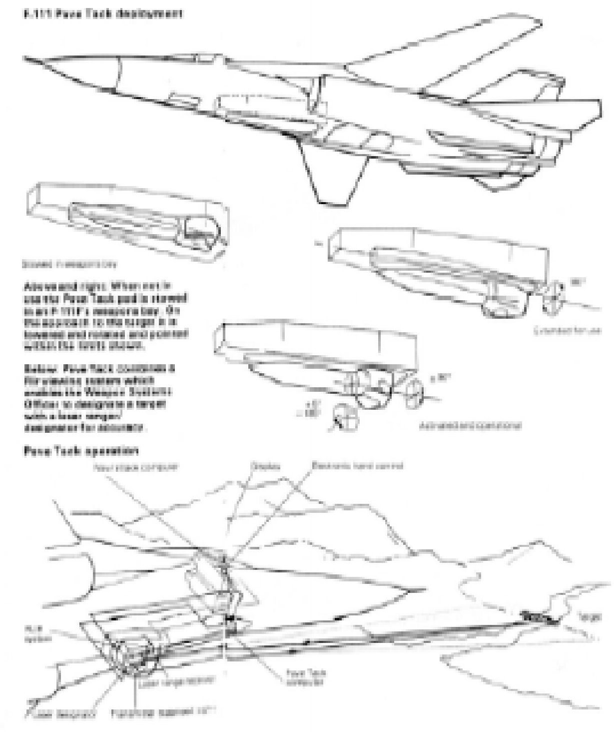
3037. LANTIRN was first used during Desert Storm and the USAF claimed 99% reliability for the nav pod and 88% for the newer targeting pod.

PAVE TACK DESIGNATOR POD

4038. This is the principal attack system of the F-111 and is in service with the RAAF. It is carried as a retractable pod in the weapons bay and comprises of a FLIR, a Laser ranger and Laser target designator all boresighted in the same turret.

4039. During a typical attack the F-111 approaches the target at low level, and after passing an Initial Point, for navigation update, it would pop up for bomb release using radar aiming.

Immediately after release, while the aircraft is turning away from the target, the Weapon Systems Operator (WSO) acquires the target with the Pack Tack sensor. The target is marked with the laser designator allowing the bombs to acquire the laser reflections and track to them.



4040. The process is difficult and needs a lot of practice to achieve a perfect result.

The pilot has to fly a carefully calculated manoeuvre manually in the dark, while the WSO has to operate Pace Tack while being flung about the sky.

TIALD THERMAL IMAGING AIRBORNE LASER DESIGNATOR

4041. This British system was also used first in the Gulf War and was more experimental than LANTIRN. Only two units were available for Tornado's, which had been carrying out daylight strikes on targets marked by Buccaneers with PAVE SPIKE -TV/Laser designator pods.

4042. Once in service these pods worked overtime complimenting the Tornado's in-built ability to operate at very low level and at high speed. The principle weapon used with TIALD, on these missions was the 1000 lb (450kg) Mk 82 PAVEWAY LGB and the conflict ended before the larger 2000 lb (907 kg) Mk 84 could be used.

AIM - 120 - AMRAAM Advanced Medium-range Air-to-Air Missile.

4043. Propulsion: Advanced internal rocket motor.

4044. Dimensions:

Length:	3.7m
Diameter:	178mm
Weight:	152kgs (at launch)

4045. Performance:

Speed:	approx Mach 4
Range:	40 NM (74KM)

4046. Guidance System:

a. Launched with Initial Target Guidance from aircraft radar.

b. Inertial navigation mid-course guidance, which can be updated during flight by the launching aircraft by data-link.

c. Active radar homing by missile in terminal phase of flight

Above: One of the 94 test AMRAAMs ready for firing from a Navy F-14A.

AIM-54 PHOENIX

4047. Propulsion: Aerojet Mk60 or Rocketdyne Flexadyne long-burn solid motors.

4048. Dimensions:

Length:	4.01m
Diameter:	380mm
Span:	925mm
Weight:	447kg

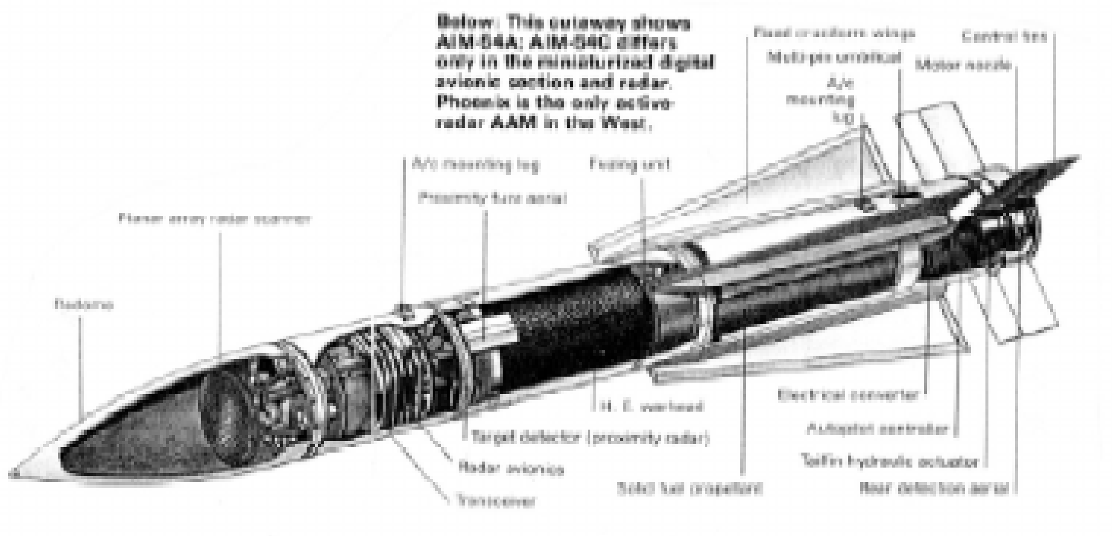
4049. Warhead: Continuous-rod 60kg with proximity and impact fuses.

4050. Performance:

Speed:	Mach 5 at motor burnout.
Max Range:	80NM (148km)

4051. Guidance: Initial targeting guidance from aircraft radar mid-course inertial navigation guidance update and missile ACTIVE RADAR HOMING in the terminal phase.

4052. This is by far the most sophisticated and costly AAM in the world. This missile provides air defence over an area of 31,000km, from near sea level to the limits of altitude attained by aircraft. But it cost half a million dollars each, and can only be used with the F-14 Tomcat which can fire up to 6 missiles (almost simultaneously at 6 different targets).



AIM-9 SIDEWINDER.

4053. Propulsion: Solid Motor

4054. Dimensions:

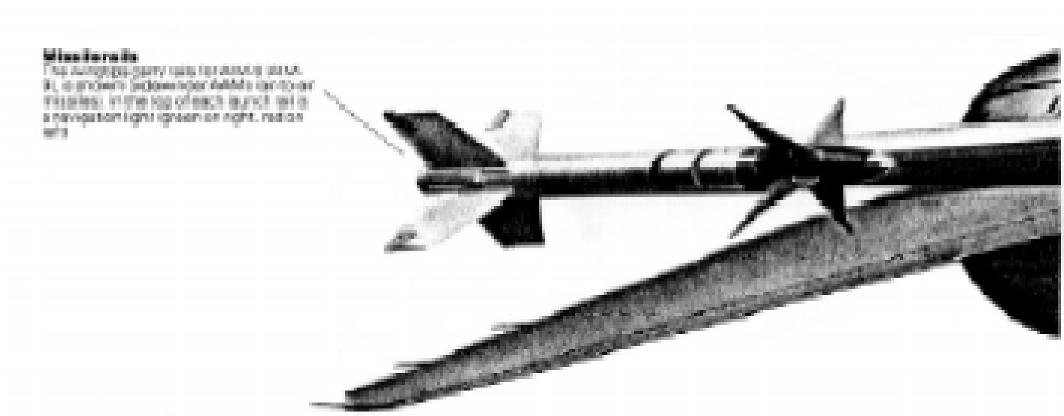
Length:	2850mm
Diameter:	125mm
Weight:	86kg

4055. Guidance System: Infra-Red.

4056. Warhead: 11.4kg advance annular blast/fragmentation charge.

4057. The Sidewinder's is a simple weapon, said to have less components than an average radio. Its compatibility with many aircraft makes it a cheap and reliable missile. With improved performance now it is an all aspect missile but still works best when fired from 6 o'clock.

ARA - 38



AIM-7 SPARROW

4058. Propulsion: Solid motor.

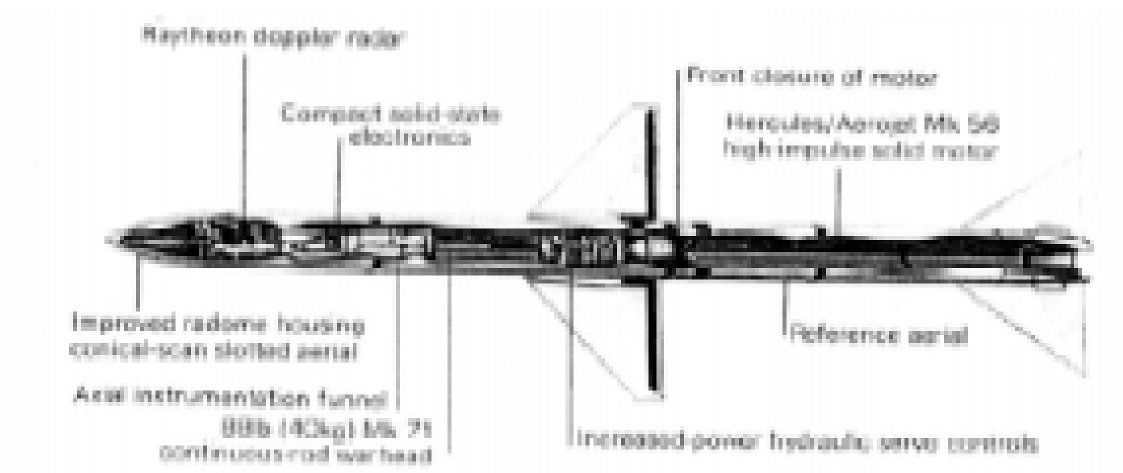
4059. Dimensions:

Length:	3660mm
Diameter:	203mm
Span:	1020mm
Weight:	205kg

4060. Performance:

Speed:	Approx Mach 4
Range:	100 km

4061. Guidance System: Semi active radar. Homing on current models. Active radar on A & B models only.



AGM-88A - HARM (High-speed anti-radiation missile)

4062. Propulsion: Reduced-smoke boost/sustain motor

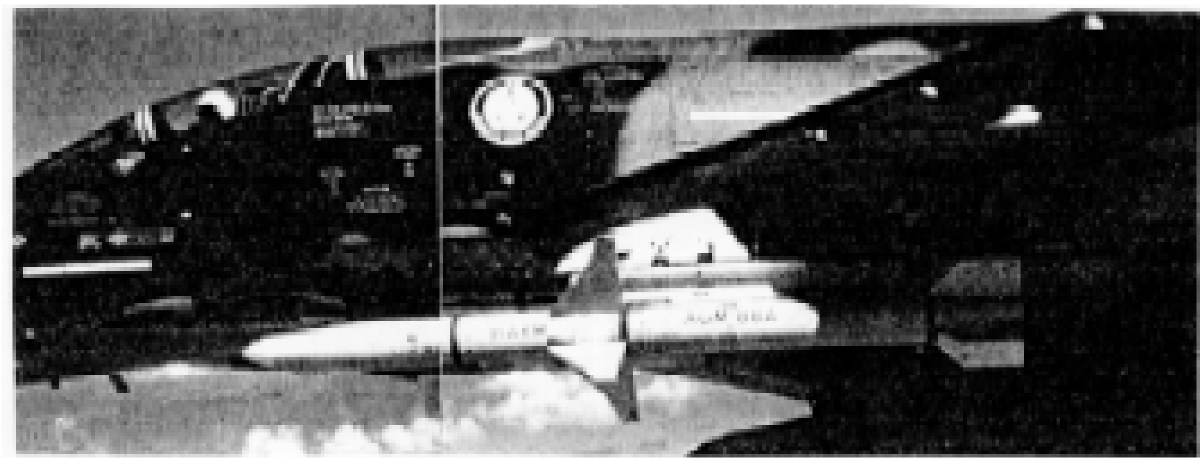
4063. Dimensions:

Length:	4.17m
Diameter:	254mm
Span:	1.12m
Weight:	361kg

4064. Performance:

Speed:	Mach 2
Range:	18 km

4065. Containing proximity and impact fuses the HARM is equipped with a low cost autopilot and an optical target detector.



MAVERICK AGM-65

4066. Propulsion: Reduced smoke boost/sustain solid rocket.

4067. Dimensions:

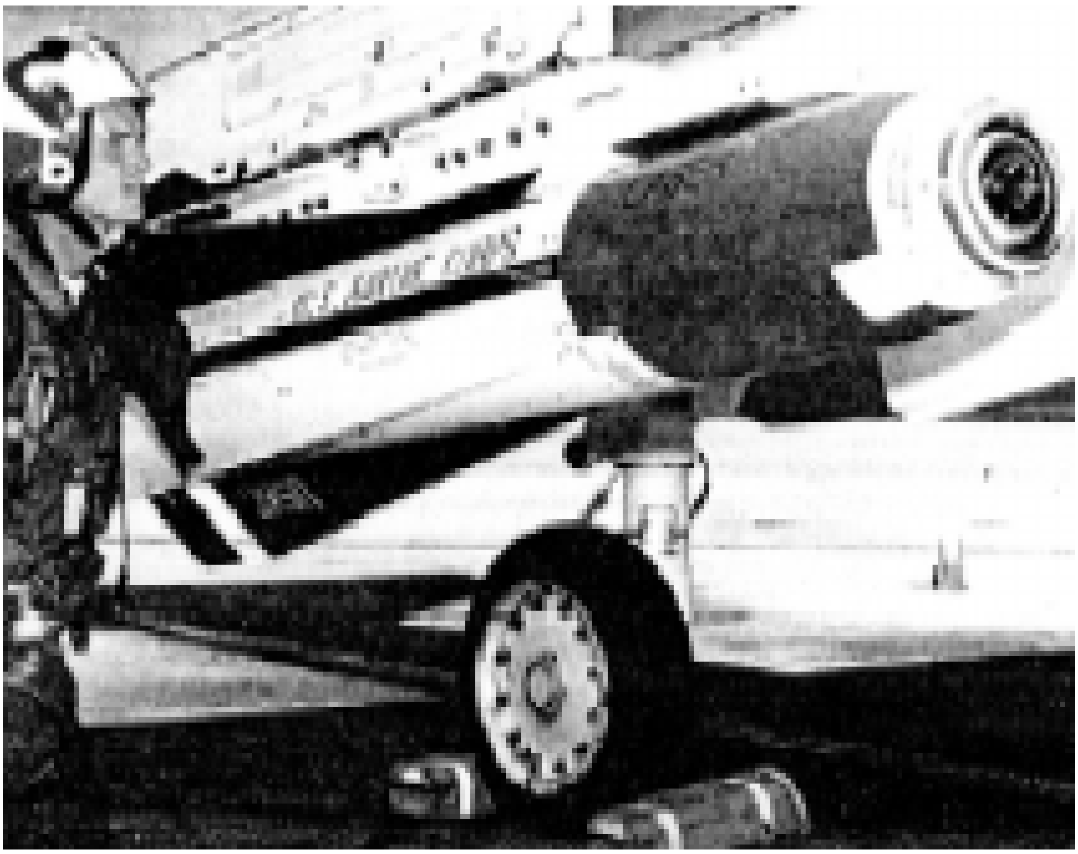
Length:	2.49m
Diameter:	305mm
Span:	720mm
Weight:	210kg

4068. Performance:

Speed:	classified but supersonic
Range:	40km from high altitude.

4069. Guidance System: Optical, laser, or imaging Infra-red.

4070. Smallest of the AGM's, the Maverick is a 'fire and forget' lock-on-before-launch guided missile. With optical guidance before firing, the camera in the missile is activated, which transmits an image to a monitor in the cockpit where the pilot flies the cross hairs onto the target's image. The missile is then fired and homing is automatic, but there is an option of joystick control.



PAVEWAY LASER GUIDED BOMBS

4071. The Paveway Laser Guided Bomb series were first used in the Vietnam War to give a precision delivery of standard 500 lb (225Kg), and 2000lb (900kg) dumb bombs. The bomb is a standard free fall weapon fitted with a Paveway tail and nose guidance unit. It can accept laser designation from the parent aircraft, another aircraft, low lying helicopters or forward troops, as was used by British troops during the Falklands War.

Below: A direct hit scored by a Paveway LGB. Laser guidance gives superb accuracy in the right operational conditions.

4072. The Paveway II has three sizes, which are designated:

a. GBU-10 Mk 84 2000lb

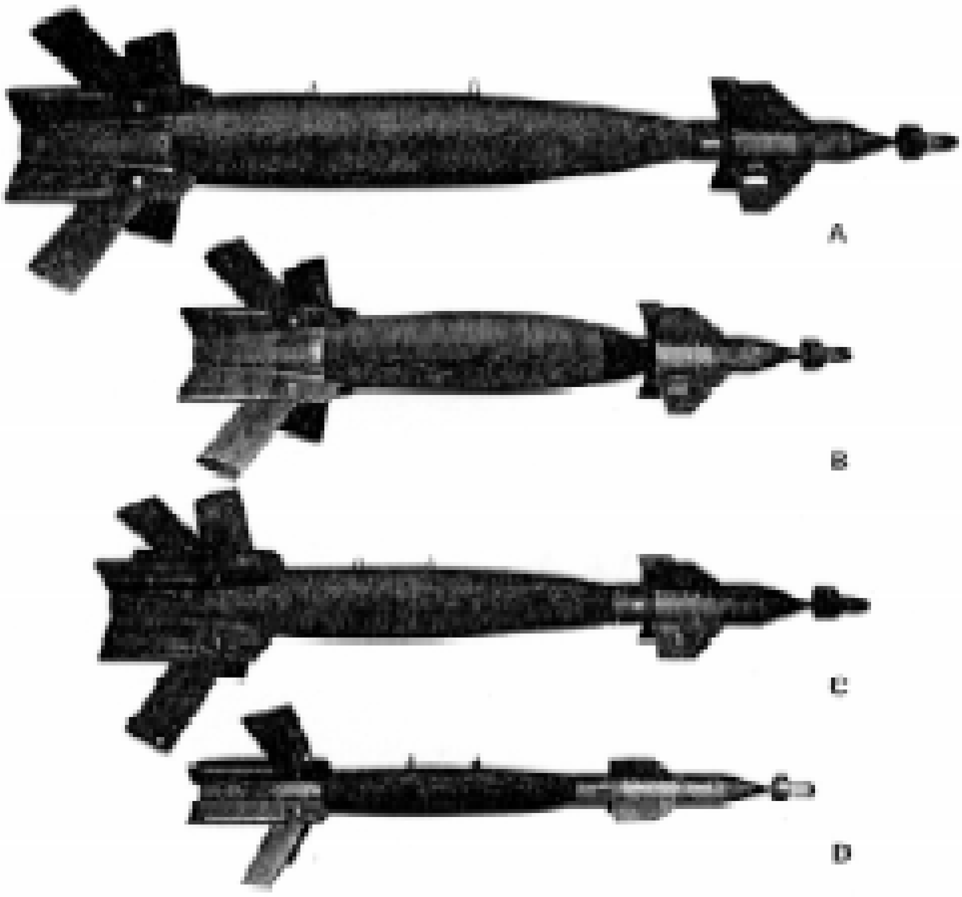
b. GBU-12 Mk 82 500lb

c. GBU-16 Mk 82 1000lb

and were the most used weapons during the Gulf War, with more than 8000 rounds expended.

4073. The Paveway II is a very cheap delivery guidance system with a Circular Error of Probability (CEP) of less than 6 metres. It has two drawbacks: it has a limited trajectory envelope: and if released too low a height it will be unable to reach a target and fall short. It must have clear skies. If the target laser reflections become obscured by cloud the bomb will lose lock and free fall.

4074. The latest version is the Paveway III. The guidance unit has an optical head with better sensitivity and a digital auto-pilot that produce an optimal mid flight trajectory, and a more accurate terminal phase. It can be released at a lower height and has a CEP of one metre or less.



Above: Today the production at Texas Instruments is centred on the Paveway II family, which feature several important changes which improve performance and reduce cost. A, the GBU-10E/B, based on the 2,000lb Mk 84 bomb (replaces KMU-351A/B). B, Mk 13/18 is fitted to the British 1,000lb GP bomb. C, GBU-16B/B is based on the Mk 83 1,000lb GP bomb (replacing KMU-421B). D, GBU-12D/B is based on the Mk 82 GP bomb of nominal 500lb size. In turn these will progressively switch to Paveway III weapons.

AIRCRAFT RECOGNITION ADVANCED (ARA)
ARA 5 - CASE STUDY
2 PERIODS

5001. Select a topic from ARA 1, ARA 2, or ARA 3 and prepare a case study presentation focusing on an aspect of interest. The case study should be 500 words or more.