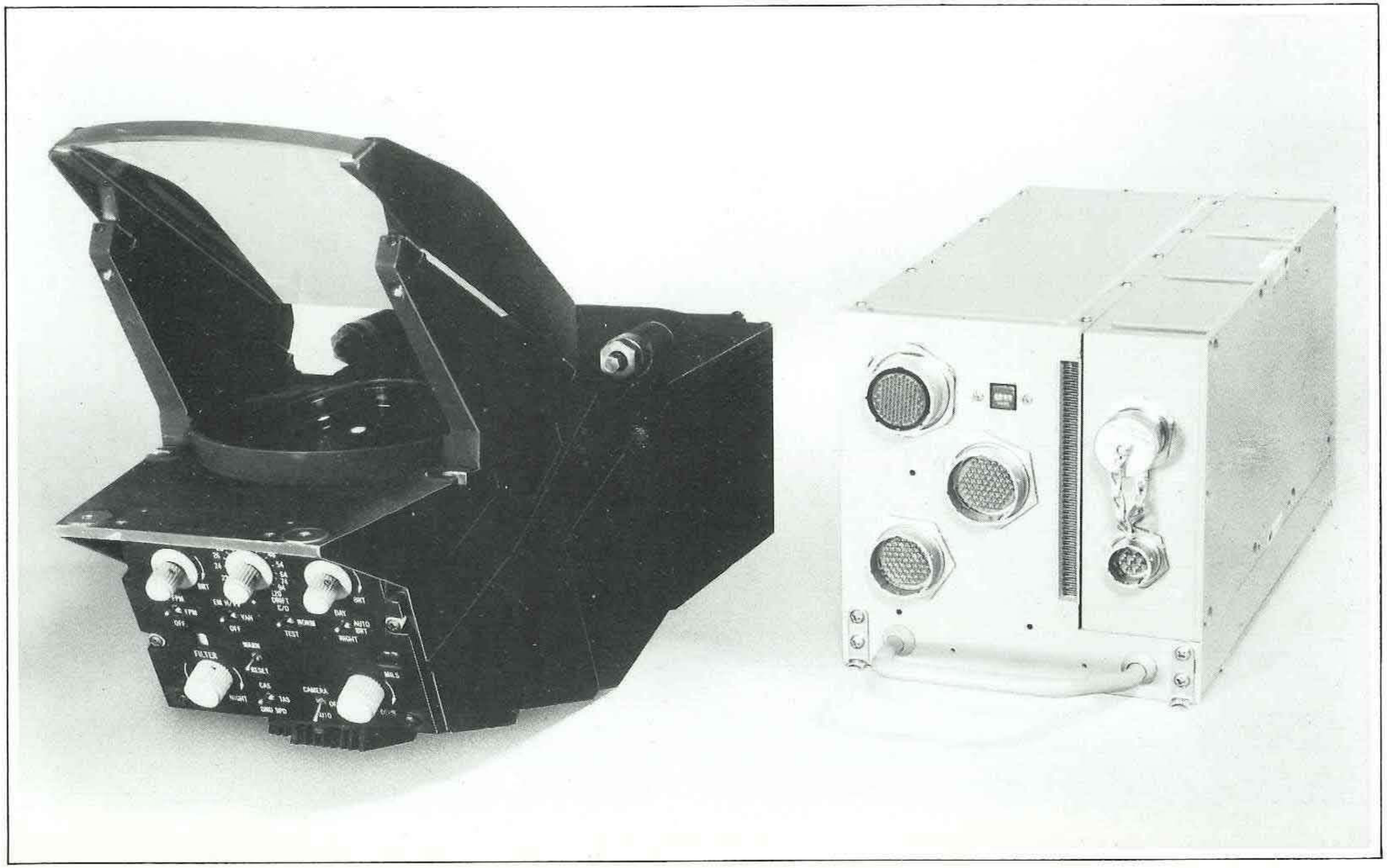
MARCONI
AVIONICS

HUDWAC

Head-Up Display Weapon Aiming Computer

For Successful Tactical Operations

Tactical air forces form a major part of a country's military capability. In recent years, however, developments in anti-aircraft systems have rendered tactical aircraft increasingly vulnerable to surface fire. To to be successful in a hostile tactical environment aircraft must operate at low altitudes where exposure to enemy radar is minimised and anti-aircraft weaponry rendered far less effective. To operate safely at these levels the pilot must maintain a constant look-out and cannot afford the distraction of having constantly to look down and scan his instrument panel.

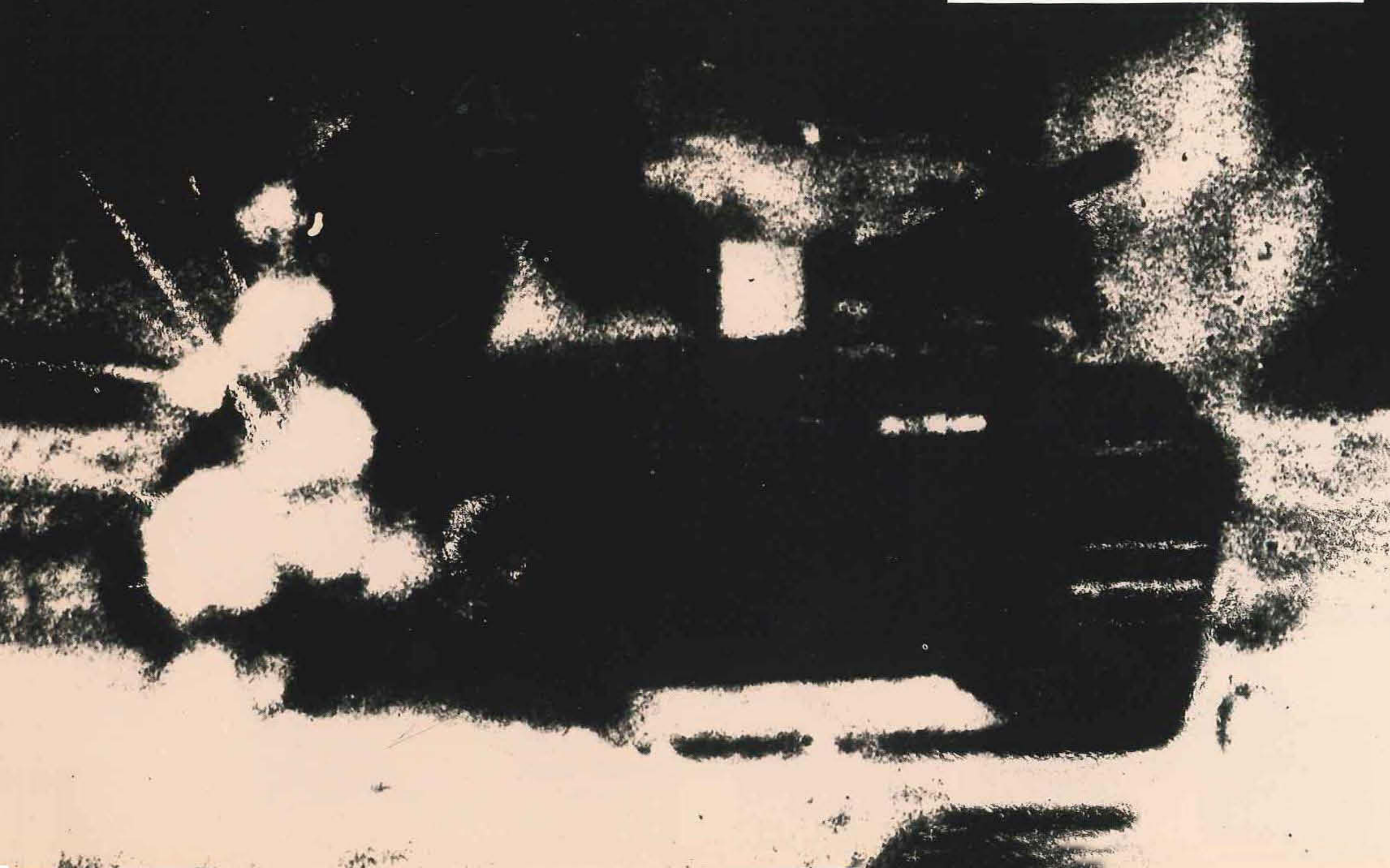


The Marconi Avionics Head-Up Display Weapon Aiming Computer (HUDWAC)

The HUDWAC provides a highly cost effective solution to the problem of successful low level operations. It presents flight parameters and continuously calculated weapon aiming solutions on a transparent screen immediately in front of the pilot. The symbols on this screen are focused at infinity and enable the pilot to concentrate his attention on the tactical situation while continually being made aware of vital flight and mission parameters by his display.

Advanced Capability

The HUDWAC contains a small but efficient digital computer which, in addition to generating the required display, can perform a variety of navigation and weapon aiming functions. Depending on user requirements, it can provide continuously computed impact points for bombs, guns and rockets for air to ground operations plus the most effective weapon solutions available today for air to air and, depending on the aircraft's sensor fit, a full range of navigation information.

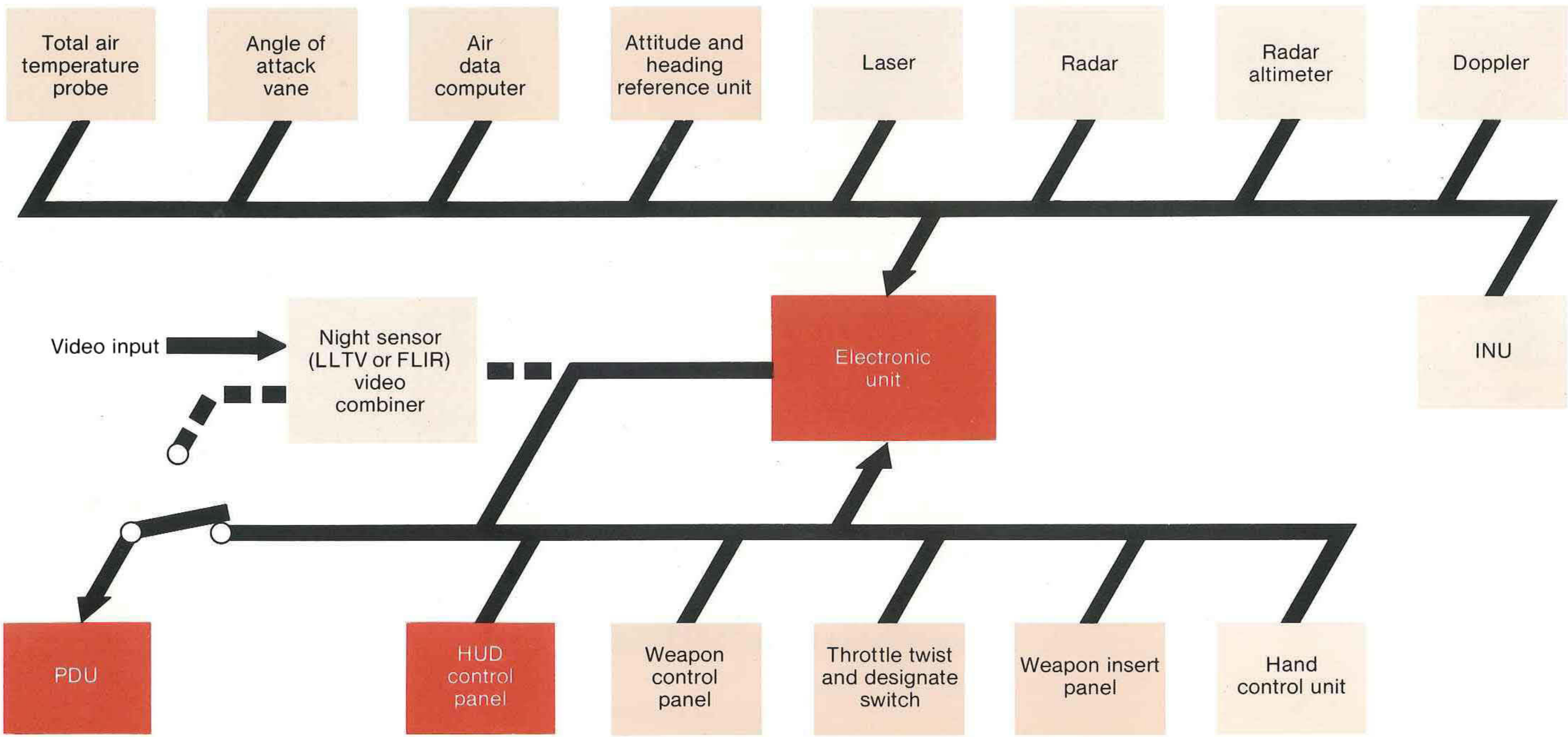


By providing continuous solutions for air to ground weapon release it not only improves accuracy in attacking targets of opportunity but also eliminates the requirement for pre-planned (and predictable) 'canned' attacks on fixed ground installations. Elimination of 'canned' parameters greatly increases the attacking aircraft's survivability in the face of hostile ground fire.

In the air combat arena the ability to remain Head Up and have flight information superimposed on the sector of sky containing the aggressor greatly increases successful manoeuvring potential, particularly in the close-in dogfight.

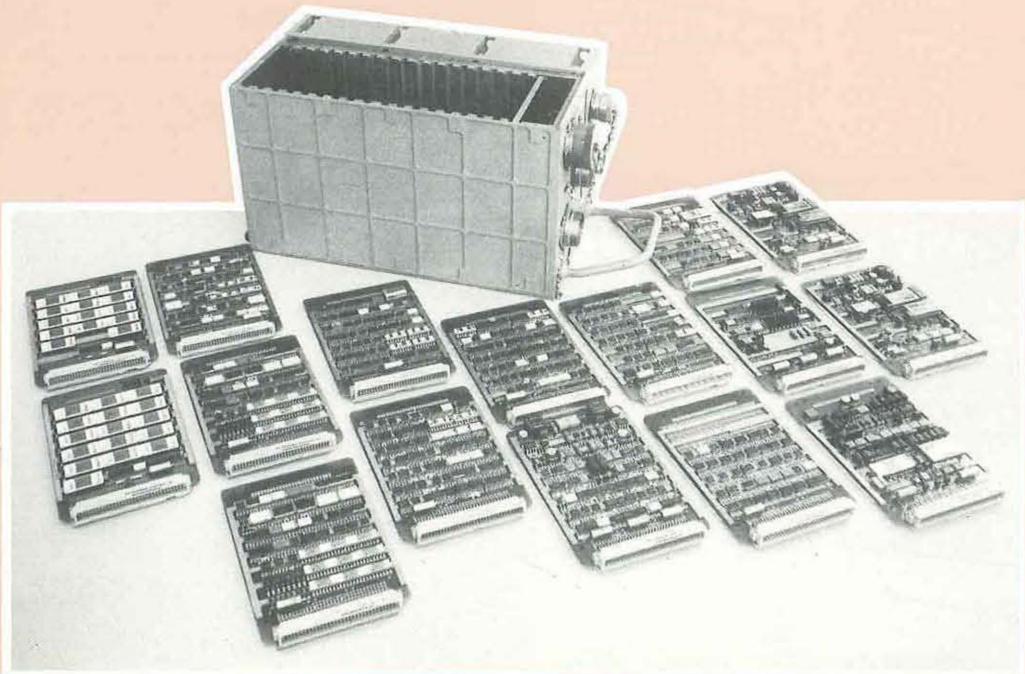
A Versatile System

The HUDWAC is compatible with a wide range of sensor and other aircraft system inputs. It can accept signals in synchro, analog, discrete or digital form. This versatility is made possible by the modular construction of the Electronic Unit which enables interface modules to be engineered to the individual aircraft's requirements.



The Electronic Unit

The Electronic Unit (EU) consists of three functional sections: the interface section, processor section and the symbol generation section. Inputs from the various aircraft systems and sensors are received in the interface section where they are converted into digital numbers acceptable to the processor. The processor uses these inputs and its stored program to instruct the symbol generator. The symbol generator in turn converts these demands into analog output signals which drive the deflection coils and bright up circuitry of the cathode ray tube (CRT) in the Pilot's Display Unit. To enhance night operational capability the EU can also contain a field store where the symbols to be transmitted are stored until the vertical retrace period of the raster scan. Cursive symbology is then written over the raster video.

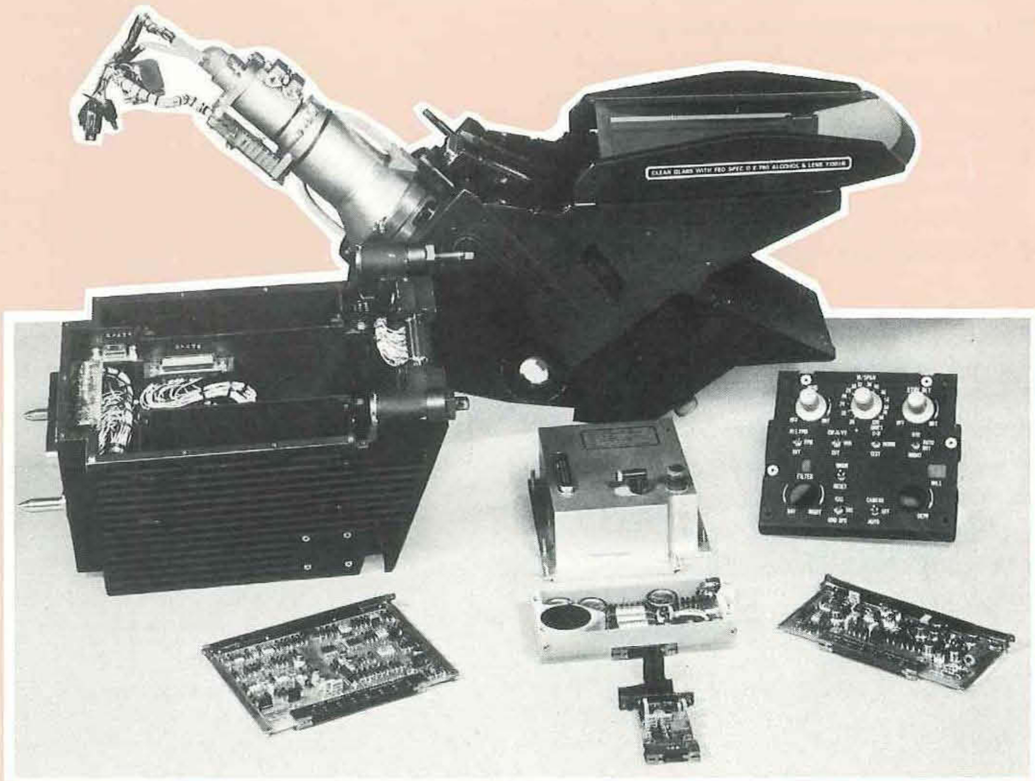


The Pilot's Display Unit

The Pilot's Display Unit (PDU) consists of a cathode ray tube on which the required symbology is drawn, an optical system which projects the symbology into the pilot's field of view and a control panel all mounted in a rigid chassis. Also contained within the chassis are the high voltage power supplies, video drive circuitry, video protect circuitry and automatic brilliance control.

Deflection voltages from the EU symbol generator are amplified by the video drive circuitry and position the CRT beam. At the same time bright up signals from the same source are fed to the CRT grid and enable the symbols to be seen. The optical unit then relays these symbols to the combiner glass where they are reflected to the pilot by a partially reflecting surface.

The Pilots control panel (PCP) is normally mounted on the optical module immediately in front of the pilot. The configuration of the PCP can be tailored to suit customer requirements.



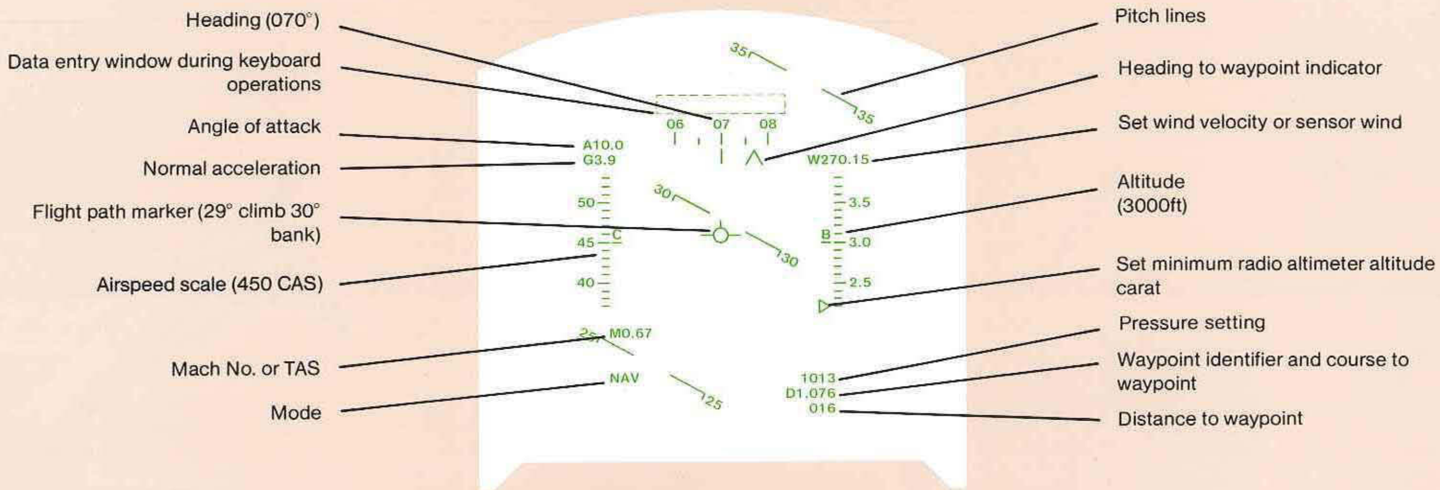
Symbology

The HUDWAC provides the pilot with displays for instrument flying, navigation and both air to air and air to ground weapon delivery. The symbology depicted is similar to that used on the extremely successful and versatile fighter the F-16 Fighting Falcon. This symbology has evolved over 3 generations of HUDs in service and is the result of exhaustive research.

The use of erasable programmable read only memory (EPROM) storage allows the symbology to be easily changed or supplemented when operational needs or extended capabilities dictate.

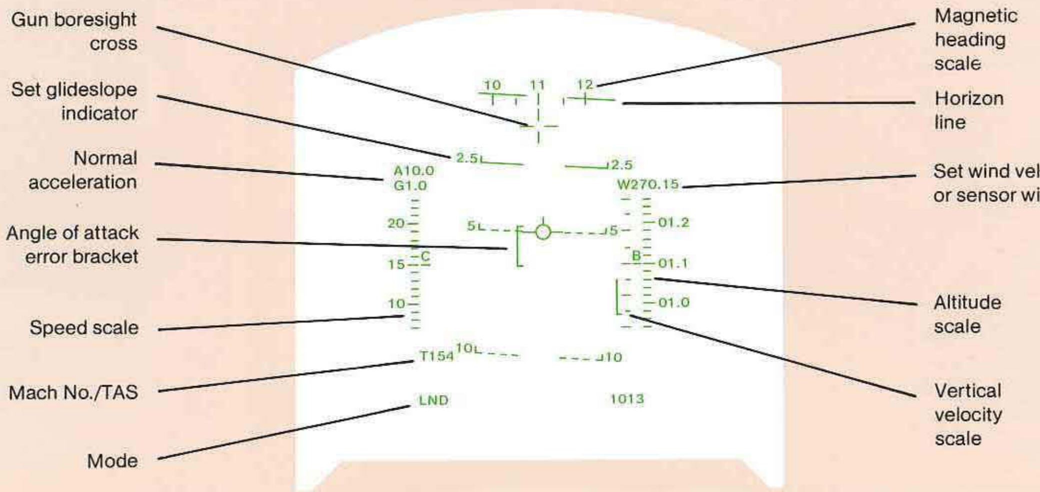
Navigation mode

- 10 selectable waypoints
- Moving tape speedscale (CAS) numerals represent tens of knots
- Digital readout of Mach or TAS
- Heading scale
- 1.1 geared pitch ladder, pitch bars displayed every 5° climb/dive
- Flight path marker
- Course and distance to selected waypoint
- Moving tape altitude scale. Radar or barometric height, pilot selectable, numerals in hundreds of feet
- Pilot selectable minimum altitude warning



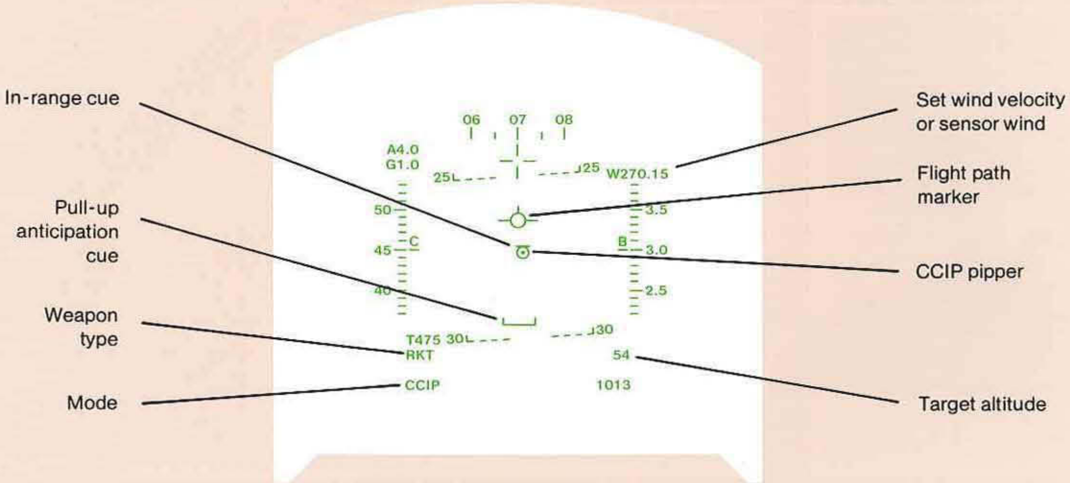
Landing sub-mode

- Automatic entry on gear down selection
- Expanded altitude tape scale
- Vertical speed indicator
- Pilot selectable desired glideslope indicator
- Digital angle of attack readout
- Angle of attack error bracket



All the ground attack modes free the pilot from constraints of dive angle, speed or height control. The Continuously Computed Impact Point (CCIP) marker position is updated 50 times a second, negating the requirement for target tracking.

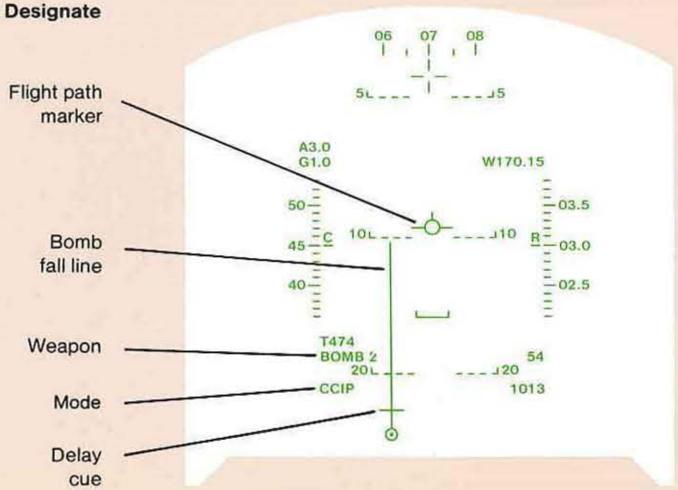
Comprehensive Ground Attack Modes



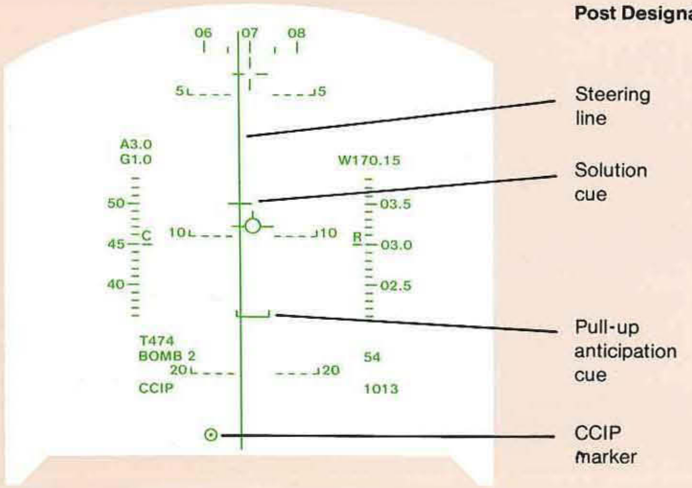
CCIP Rockets mode (Guns similar)

- Aiming symbol
- In range cue appearing at range desired by customer (typically 1.5 seconds time of flight for guns, 2.5 seconds for rockets)
- Pull up anticipation cue for ground and fragmentation avoidance
- Breakaway cross flashed at minimum firing range (not shown)

Pre Designate



Post Designate



CCIP Bombs mode

- Bomb fall line to aid alignment of CCIP marker with target
- CCIP provides centre stick aiming for stick bomb release
- Steering line and solution cue to enable targets below the aircraft nose at weapon release to be accurately attacked
- Pull up anticipation cue
- Breakaway cross for ground and fragmentation avoidance
- Flashing flight path marker as weapon release indication

An Adaptable System

1

With over twenty years of experience in fitting HUDs and HUDWACs to a wide variety of aircraft the company is the world leader in HUD technology. Over 5500 HUD systems have been produced and are employed in over twenty-five different aircraft types. Of these systems more than 1700 are HUDWACs and have been fitted to the A-4, Mirage, F-16, Draken, MiG 21 and F-5 among others.

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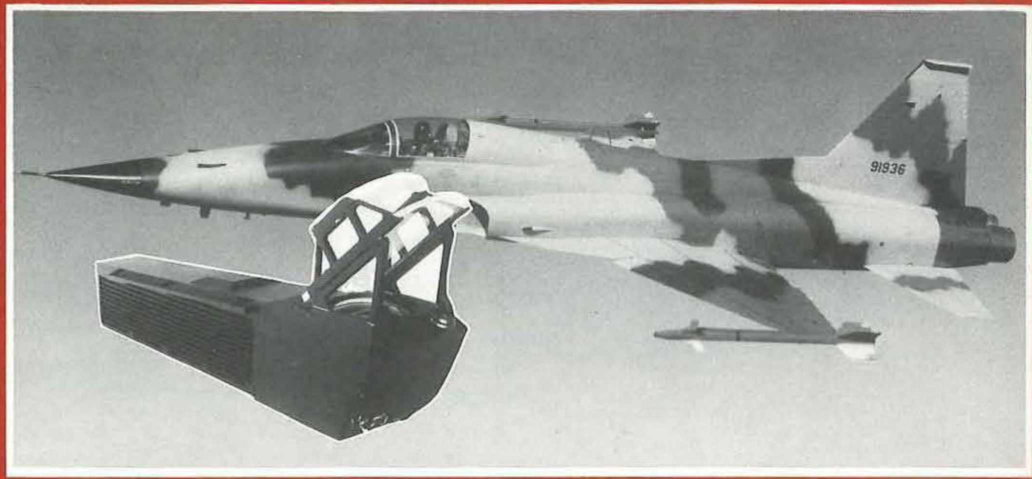

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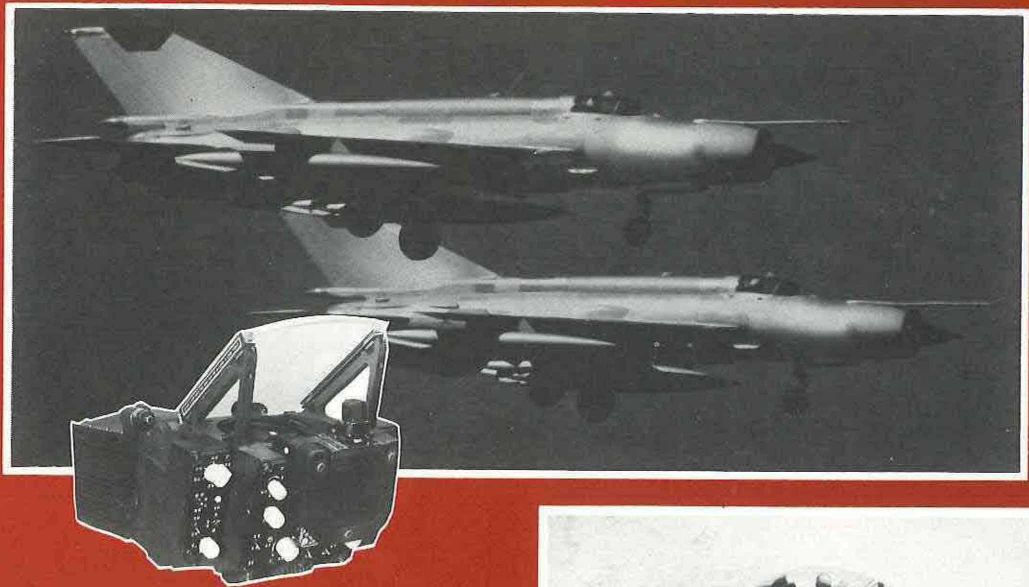

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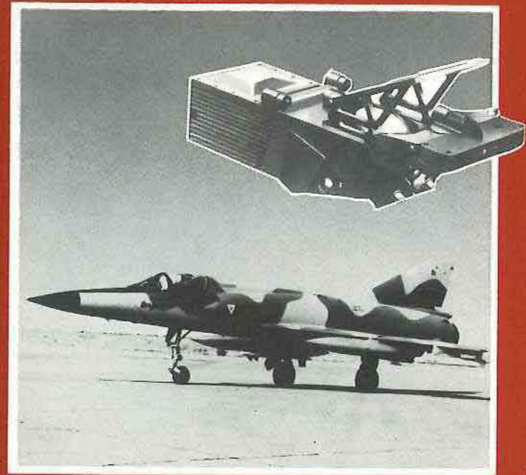

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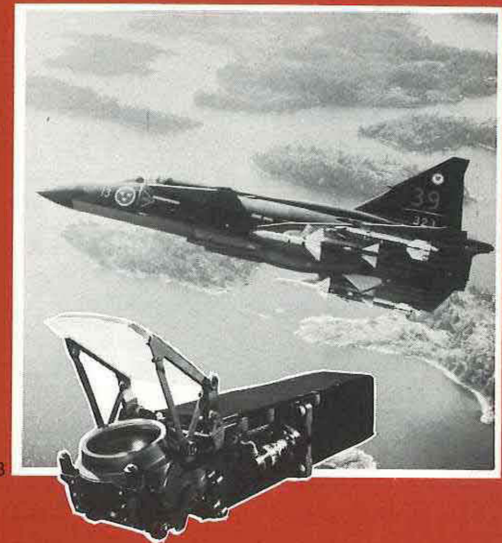

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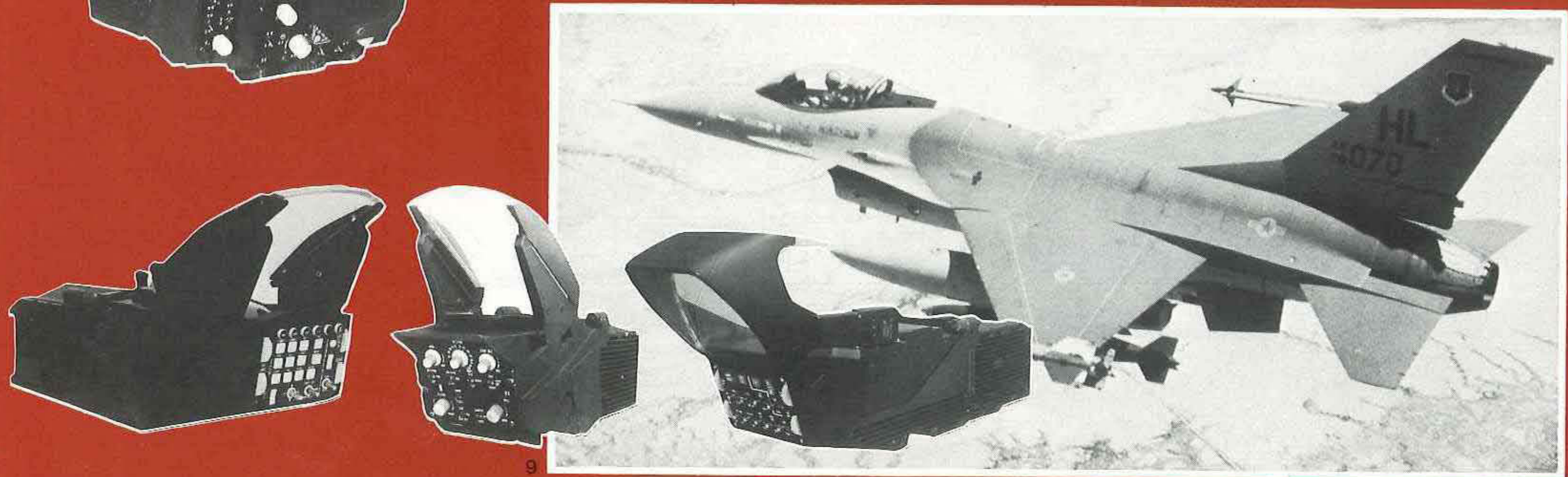

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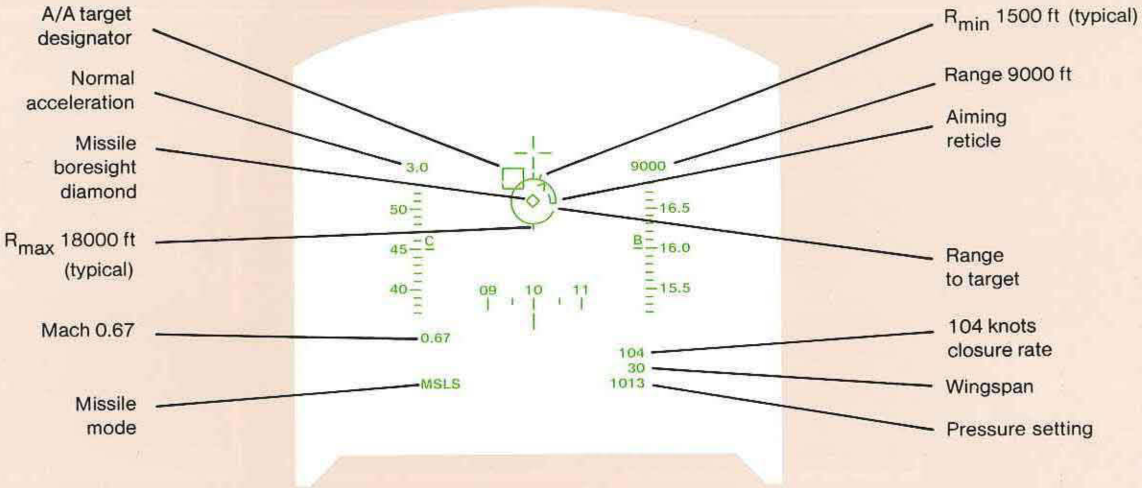
1 *A-7*
2 *Draken*
3 *F-5*
4 *A-4M*
5 *Buccaneer*
6 *MiG 21's*
7 *Mirage 50*
8 *Viggen*
9 *F-16*

Decisive Air to Air Modes

Air to air symbology is divided into four basic weapon delivery modes enabling both gun and missile firing.

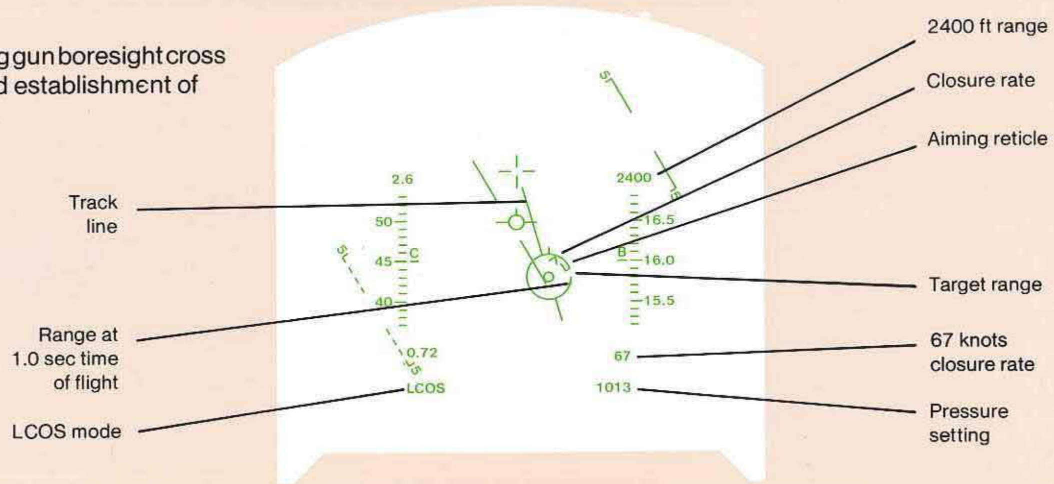
Air to Air Missiles mode

- Target box indicates position of target locked on to by aircraft radar
- Missile boresight diamond indicates missile seeker line of sight
- Aiming reticle size is a function of missile selected and whether or not it is uncaged
- Range and closure rate to target indicated on aiming circle and as digital readout
- Missile range boundaries displayed
- Missile launch opportunity cues provided by flashing aiming reticle when missile launch parameters satisified



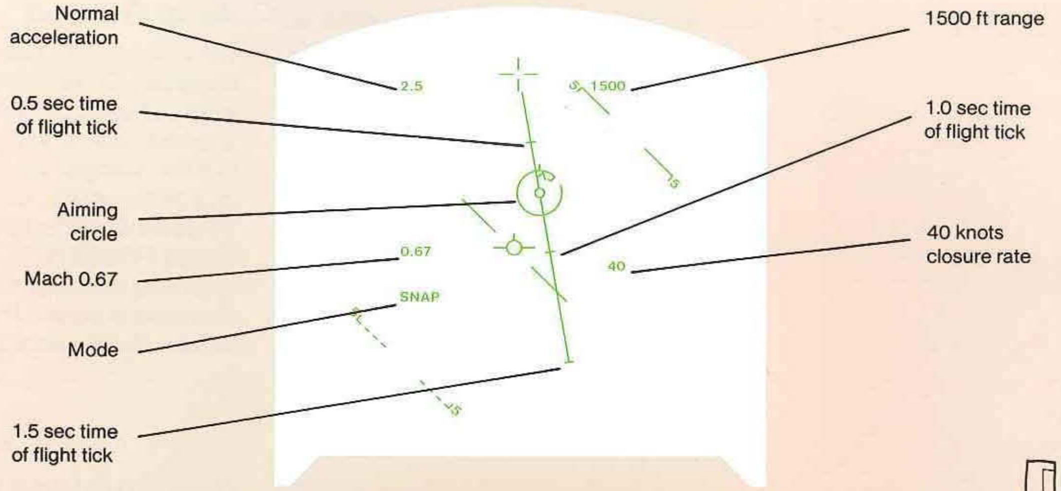
LCOS mode

- Provides a gunnery solution for smooth tracking of the target
- Aiming reticle surrounding the aiming pipper is a fixed size for radar ranging or computed from pilot selected wingspan for stadiametric ranging
- Range is indicated on aiming reticle and as a digital readout
- Range at 1 second time of flight provided as a tick moving round the aiming circle circumference
- Closure rate is indicated on aiming reticle and as a digital readout
- Provision of line joining gun boresight cross to aiming reticle to aid establishment of correct aiming plane



Snapshoot mode

- Provides the pilot with a gunnery solution optimised for transient firing opportunities using a continuously computed impact line (CCIL) derived from the lead angles computed for fixed bullet times of flight
- The aiming pipper is interpolated on to the CCIL at the time of flight derived from target range
- Bullet time of flight ticks displayed on the CCIL for 0.5, 1 and 1.5 seconds

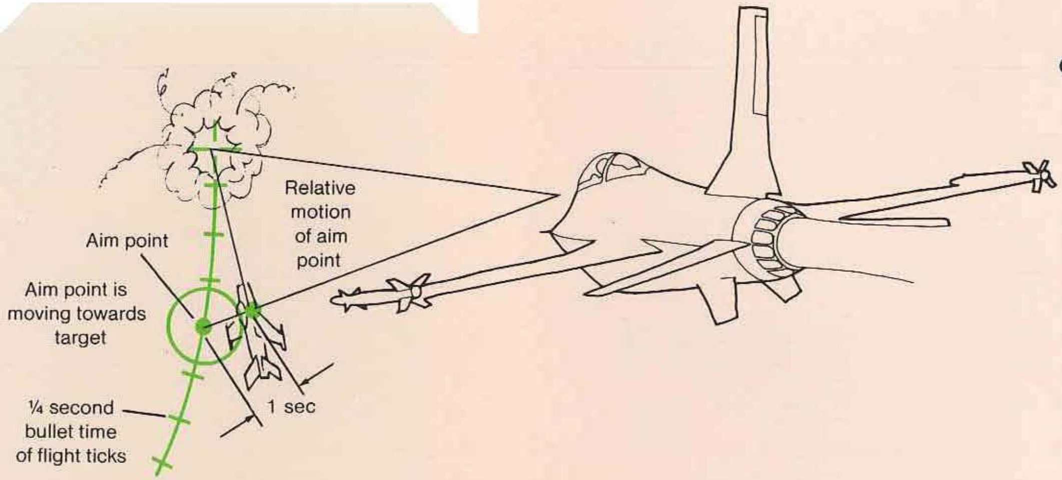


- Snapshoot Solution

  The gun cross symbol represents the gun boresight and the start of the bullet line

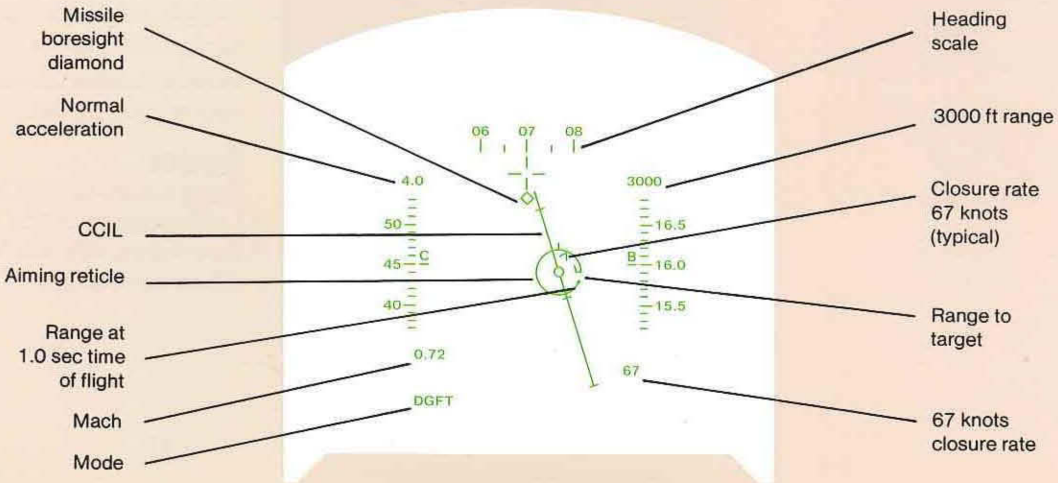
  Pilot manoeuvres to ensure target will fly through aim point

  Pilot estimates bullet time of flight



Dogfight mode

- This mode can be entered instantaneously on depression of a control column or throttle switch
- It represents an amalgamation of missile, LCOS and snapshoot modes with the following provisos
- Range indication is as for LCOS mode
- Missile boresight diamond only is portrayed
- LCOS track line not displayed
- Aiming reticle centred on LCOS solution



Flight Trials Results

Actual flight trials results illustrate the flexibility of the HUDWAC in the air to air scenario and clearly demonstrate the system capability both against a manoeuvring target and with a moving pipper.

Accuracy

The accuracy of a HUDWAC system is best illustrated by a performance comparison with a gyro gunsight (GGS) for air to air weaponry and a fixed depressible sight for air to ground weapon delivery.

Air to Air Guns

The graph shows the single shot probability of a kill with increasing air range. It shows clearly that the HUDWAC is 4 TIMES MORE EFFECTIVE THAN A/GGS in angle off situations at air ranges greater than 1500ft. In other words 4 times fewer bullets are required per kill.

Air to Air Firing trial

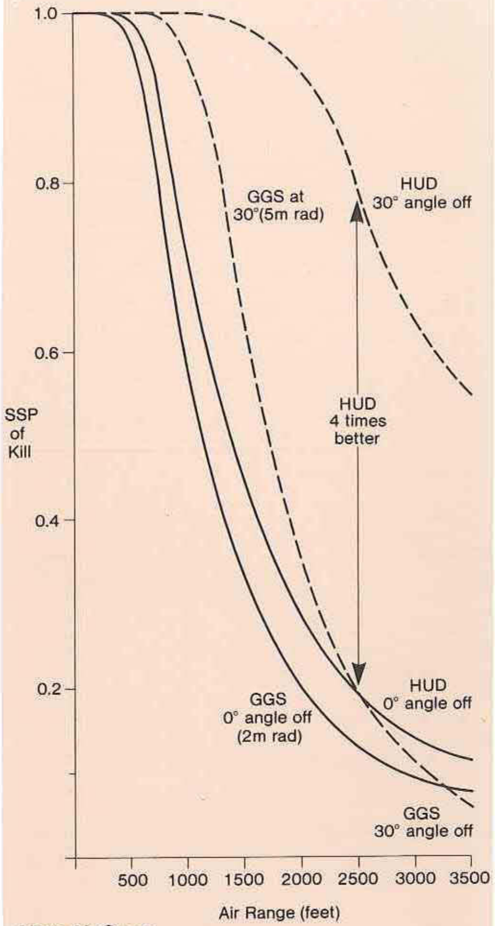
Dassault Mirage 50. Radar ranging. Firing ranges between 350m to 800m.

Air to Air Missiles

An air to air missile must be launched inside its air range and load factor envelopes. Failure to launch inside parameters is wasteful of missiles and an analysis of SE Asian combat statistics shows that 50% of missile launches occurred out of the launch envelope. The HUDWAC is programmed to provide a flashing Head-Up launch cue to indicate to a pilot that he is inside the missile envelope together with steering information to the best chance of success launch zone.

Air to Air Guns HUDWAC v GGS

Single shot kill probabilities



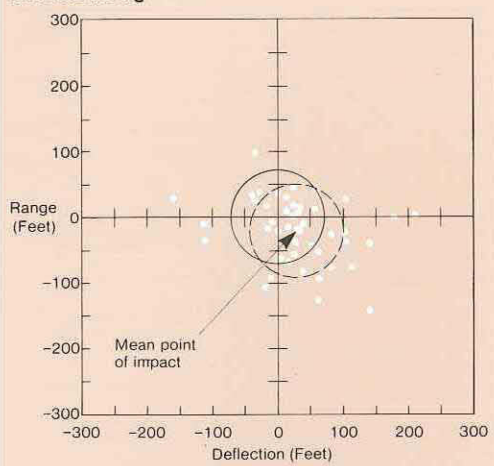
Air to Air Guns

Target manoeuvre	Stabilised flight	Butterfly	Pipper moving at 10 mils/sec relative to target
% Bullets inside 4m radius	15	15	10
Bullets inside 9m radius	41	42	31
% Frequency of at least 3 bullets inside 4m radius	34	35	24
% Frequency of at least 3 bullets inside 9m radius	53	63	54

Air to Ground

The accuracy of a fixed depression gunsight is typically 27 milliradians CEP in the bombs mode, whereas a HUDWAC demonstrates an accuracy of 7-10 milliradians. This means that the number of bombs required to be dropped for a 95% confidence level against a 10 metre diameter target will be NEARLY 4 TIMES FEWER WITH THE HUDWAC, representing a substantial weapons saving and decrease in the total number of aircraft required for the attack.

Dive Bombing



Dive Bombing trial

Aircraft A-4M 426
Type delivery CCIP cumulative
Weapon type Mk76
No. weapons 44
Mean point of impact deflection 34 feet
Mean point of impact range – 19 feet

Nominal release conditions
True airspeed 450 kts. approx.
Dive angle 30° to 45°
Slant range 5,000 feet to 6,400 feet
Altitude 3,000 feet to 5,000 feet

10.44 MILLIRADIANS CEP about the target

Rocketry

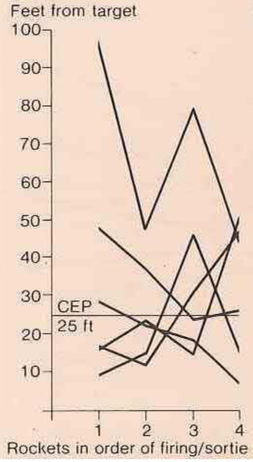
MiG 21 MF firing SNEB rockets, nominal release conditions: 500 kts, 15° dive, slant range 1000 metres.

Superimposition of results from 6 consecutive rocket firing sorties.

Strafe

Trials results MiG 21 MF over 5 consecutive sorties against a 15 x 15 ft target, nominal parameters: 450 kts, 15° dive, 1 second burst, 900m slant range.

Rocketry



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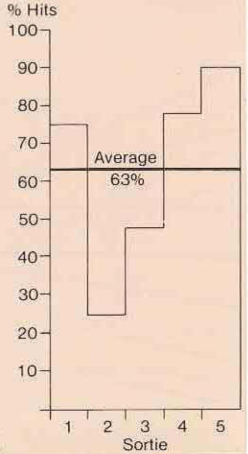
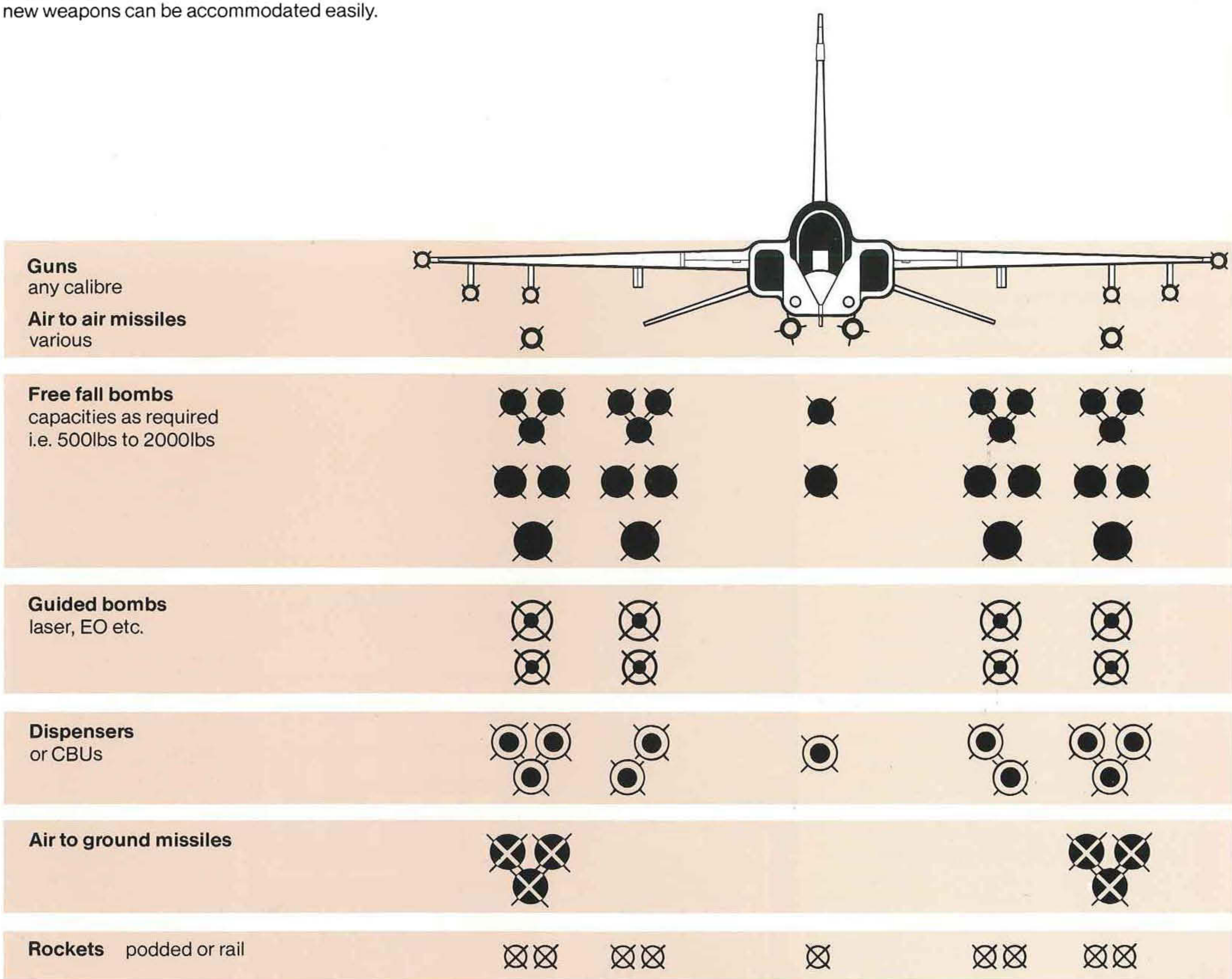


Exceptional Weapons Versatility

The exceptional versatility of the HUDWAC is graphically illustrated below. The modes of operation and weapon aiming capability of the system allow for a complete range of armament configurations. Any armament currently available can be catered for, whilst new weapons can be accommodated easily.



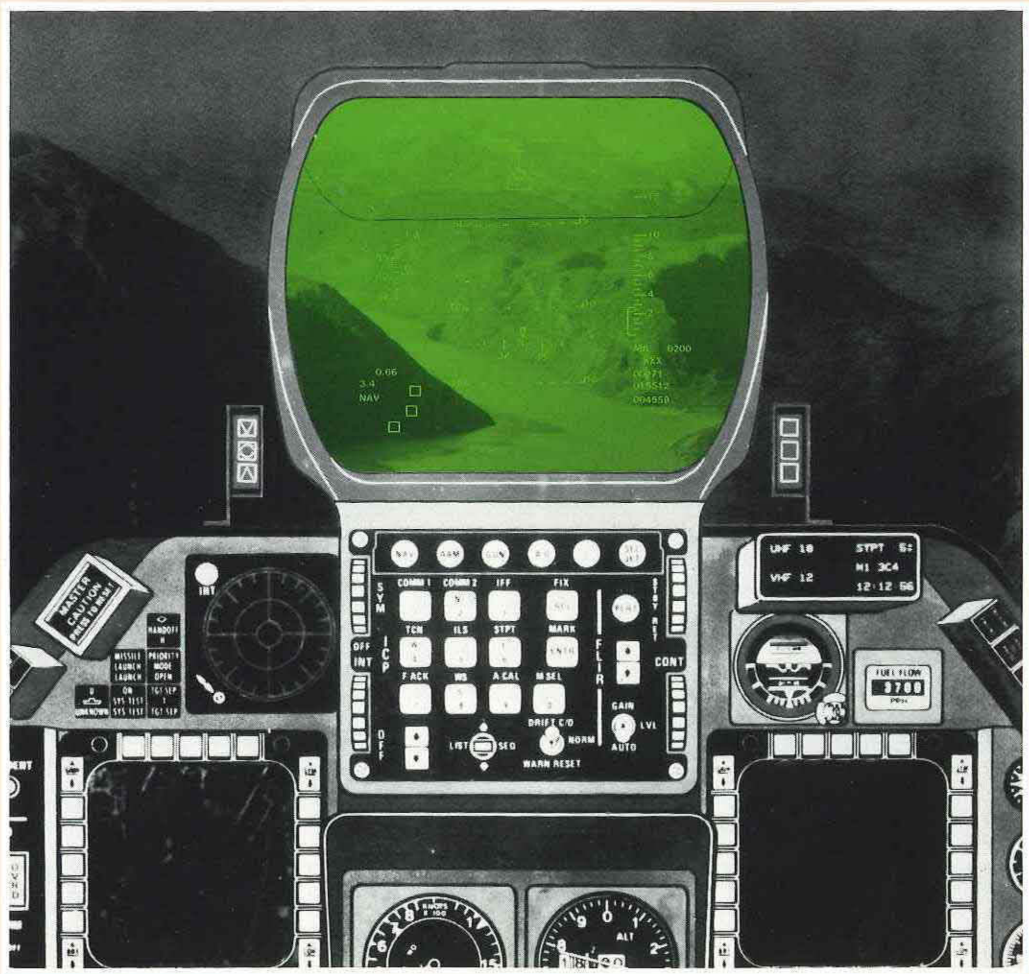
Training ordnance and dispensers as required

24 Hour Operation

When used in conjunction with a night vision sensor such as Low Light Television or Forward Looking Infra-Red a night vision version of the HUDWAC makes twenty-four hours a day tactical operations possible.

This is achieved by operating the HUDWAC in a raster scan mode compatible with the sensor output. The pilot then sees on his combiner glass a composite of his symbology and the sensor picture superimposed in one to one correspondence with the real world. This enables him to fly at low level at night using essentially the same visual cues that he would during the day. Enemy formations advancing under cover of darkness can be attacked with the same precision and effectiveness as during full daylight. At the same time visual identification of unlit air to air threats becomes possible and 'visual' night attacks using guns and missiles become a reality.

LLTV pod



FLIR pod

Cost of Ownership

Reliability and Maintainability are a major feature of the HUDWAC System. All systems are subject to RST and 'Burn In' before delivery giving a high confidence level of reliability and high MTBFs.

During the design and manufacture CADMAT (Computer Aided Design Manufacture and Test) principles are employed.

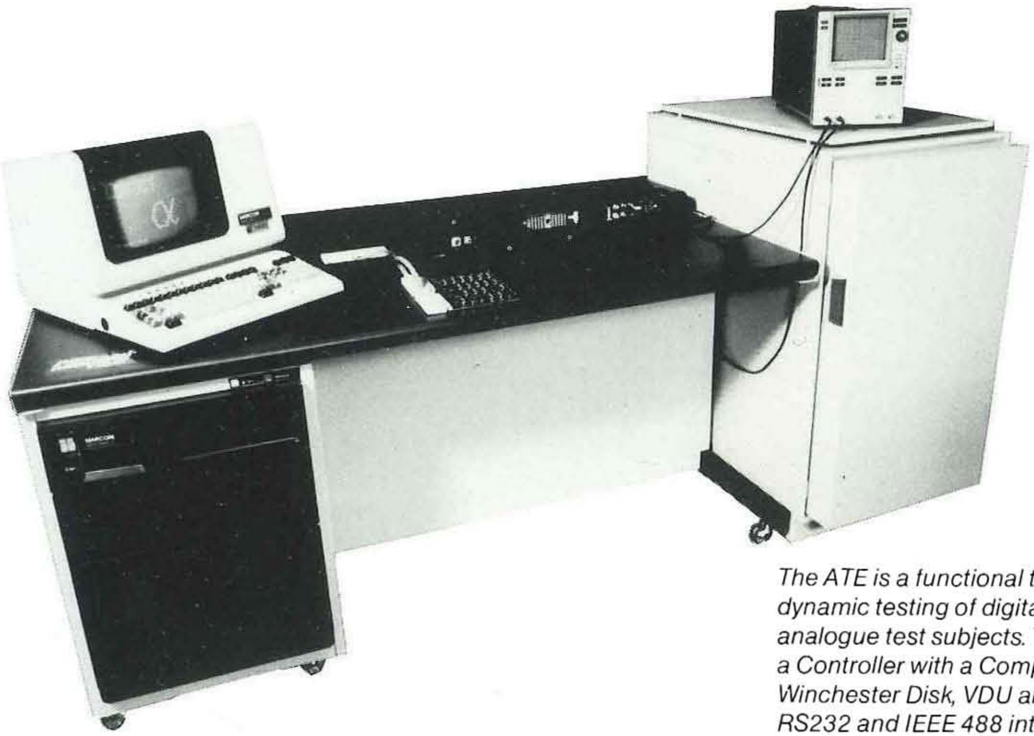
CADMAT is the basis of good design, ease of maintenance, 'Testability' and fast turn around times.

Reliability

High reliability is a feature of all our HUDWAC systems. This is achieved by careful control of the entire process from engineering design, through parts procurement, production and inspection to final delivery. A comprehensive quality control procedure ensures that each production system meets the high standard of reliability that is a hallmark of our HUD design.

This insistence on quality at every stage of the manufacturing process is exemplified by our HUD system for the General Dynamics F-16 which has consistently and easily exceeded the requirements of its Reliability Improvement Warranty.

Reliability is further ensured by application of RST procedures with temperature cycling and vibration over the 'burn in' period.



The ATE is a functional tester providing dynamic testing of digital hybrid and analogue test subjects. The ATE includes a Controller with a Computer, Winchester Disk, VDU and Keyboard, RS232 and IEEE 488 interfaces supporting digital and analogue instrumentation.

Maintainability

Testability at the design stage is a major contributary factor in ensuring ease of maintenance for the HUDWAC system. Comprehensive built-in test equipment (BITE) enables front line flight crews to check out the complete system, isolate and replace faulty line replaceable units (LRUs) and recheck the system as part of a normal pre-flight inspection without the use of any specialised ground equipment. Indeed, the low failure rate of individual electronic components and the modular design of the system make any form of scheduled maintenance unnecessary. The basic philosophy is therefore one of unscheduled removals as and when a failure occurs. The faulty LRU is replaced and despatched to an intermediate level workshop for test and repair.

The intermediate workshop is equipped with Automatic Test Equipment (ATE), similar to that illustrated below. The HUDWAC LRUs are designed to permit automatic dynamic functional testing on the ATE via the external connector. Diagnosis is to a sub assembly/module level, the faulty item is replaced and the LRU returned serviceable, typical turn around time is one hour.

The faulty module is returned to depot where the modules are tested on ATE with diagnosis to component level. Test Programs are prepared using ATPG (Automatic Test Programme Generation), an integral part of the CADMAT philosophy.

This maintenance philosophy removes the requirement for specialised skills on the flight line, ensures the most effective use of test equipment and considerably reduces the long term cost of equipment ownership by reducing logistic support costs.

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