Airframe

TORNADO has been designed to principles which will ensure a "safe life" of 16000 FH, factored by 4. This gives an in-service safe fatigue life of 4000 FH when flown to design spectra.

The airframe uses conventional metals and metallic honeycomb structure and is made up of modular components, comprising:

- Forward Fuselage
- Centre Fuselage
- Rear Fuselage
- Movable Wings incorporating Flaps, Slats and Spoilers
- Wing Root Glove including Root Fairing, Nib and Krueger Flap
- Fin including Rudder and Pre-Cooler Fairing
- Tailerons

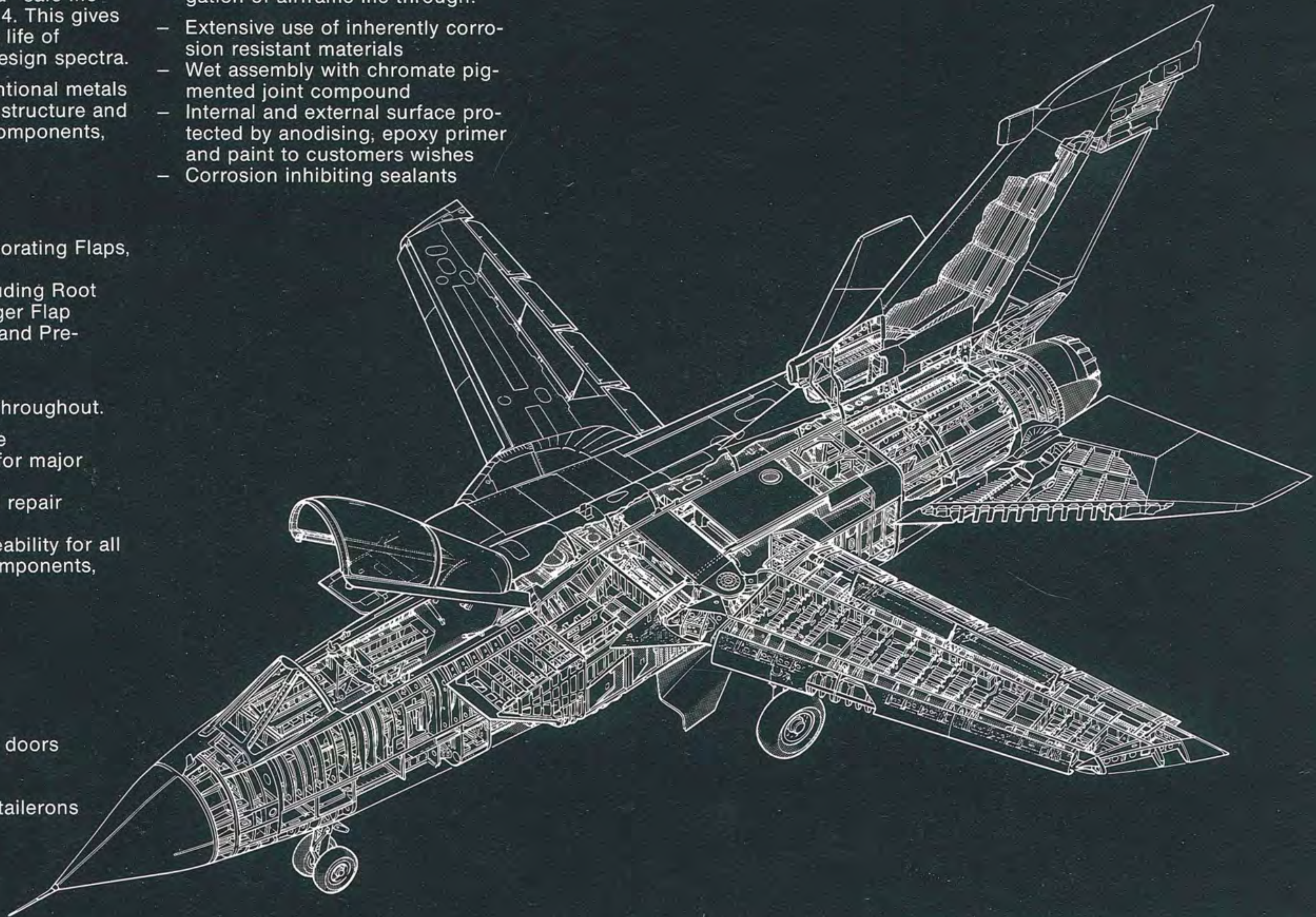
Prevention of corrosion throughout.

- Conventional structure
- Main sections unbolt for major repairs
- Extensive, established repair schemes
- Class "A" interchangeability for all important airframe components, including:

- Canopy
- Windscreen
- Radome
- Air intakes
- Landing gear doors
- Engine bay doors
- Secondary power bay doors
- Wing pivot fairings
- Spine hoods
- Flaps, slats, spoilers, tailerons
- Airbrakes
- Rudder

- Reduction in corrosion and prolongation of airframe life through:

- Extensive use of inherently corrosion resistant materials
- Wet assembly with chromate pigmented joint compound
- Internal and external surface protected by anodising, epoxy primer and paint to customers wishes
- Corrosion inhibiting sealants



Corrosion protection is carefully "built-in" during component and final assembly

Propulsion System

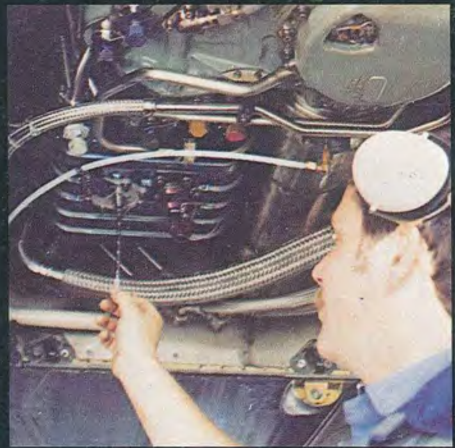
Engine

TORNADO is powered by 2 Turbo-Union RB 199 3 spool reheated turbofan engines. The engine was designed from the onset for TORNADO and the propulsion system and its air intake with movable ramps for supersonic flight are completely optimised for the aircraft.

Each RB 199 comprises a basic engine fitted with a fully modulating reheat, variable nozzle, thrust reverser and fully dressed gearbox. The complete assembly forms a Quick Engine Change Unit (QECU).

Emphasis is on Maintainability throughout. Engine accessories are readily accessible for inspection or quick replacement without engine removal. Numerous servicing points are incorporated and health monitoring features enable a full Condition Monitoring Maintenance concept to be followed, eliminating the need for overhauls of the complete engine on a Time Between Overhaul (TBO) basis. Engine change is simple and connecting points are minimal.

The construction of the engine with its nine maintenance assemblies breaking down to 16 modules as required allows replacement of assemblies and modules at operational wing maintenance level, avoiding the necessity to return engines to an overhaul base. The modules are functionally and mechanically interchangeable; rotating modules are pre-balanced and do not require re-balancing.



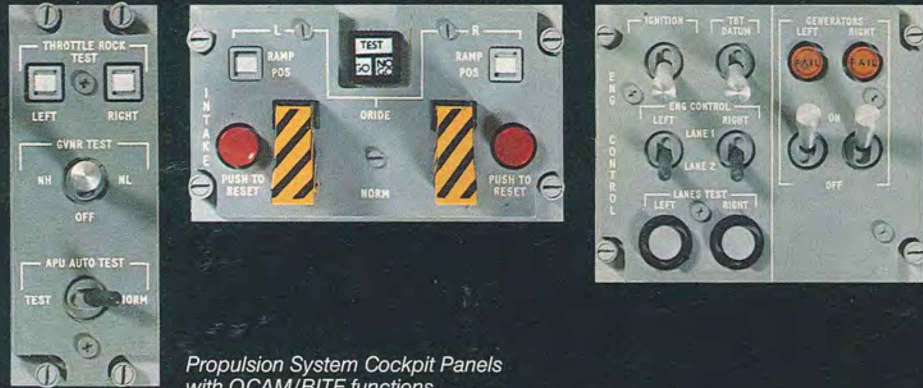
Taking an oil sample for analysis

Systems

The propulsion systems comprise:

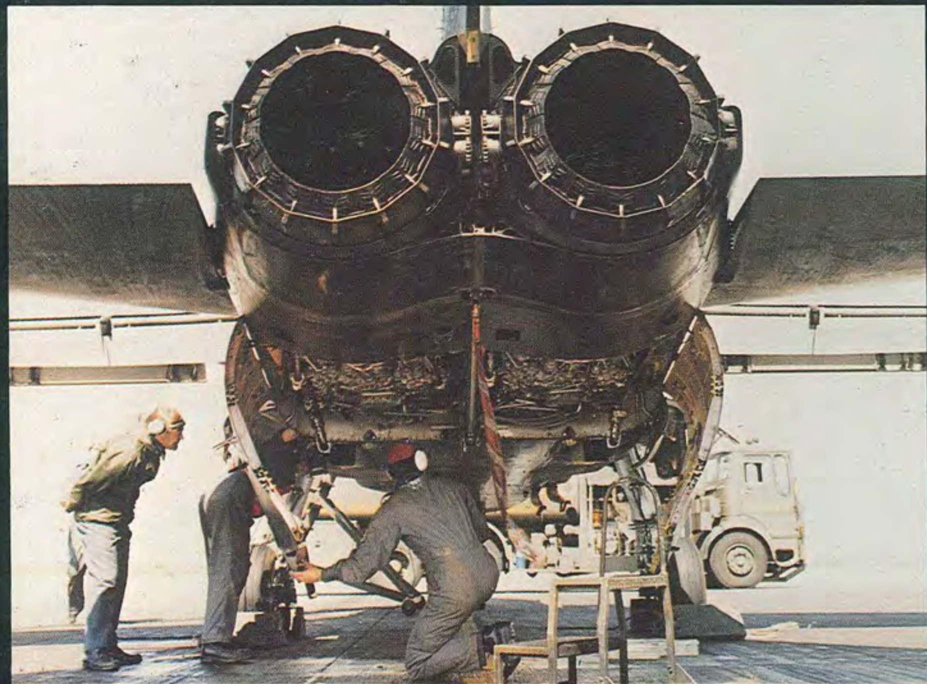
- Air System
- Engine Air Intake and Air Intake Control System (AICS)
- Engine Oil System
- Engine Fuel Control System
- Engine Reheat System
- Engine Ignition System
- Engine Starting System
- Engine Thrust Reversal System
- Throttle Box
- Engine Instruments
- Engine Overheat and Fire Detection System

The systems incorporate excellent maintainability features standard throughout TORNADO with emphasis on Condition Monitoring Maintenance, accessibility, LRU concept, repair by replacement and use of OCAM.



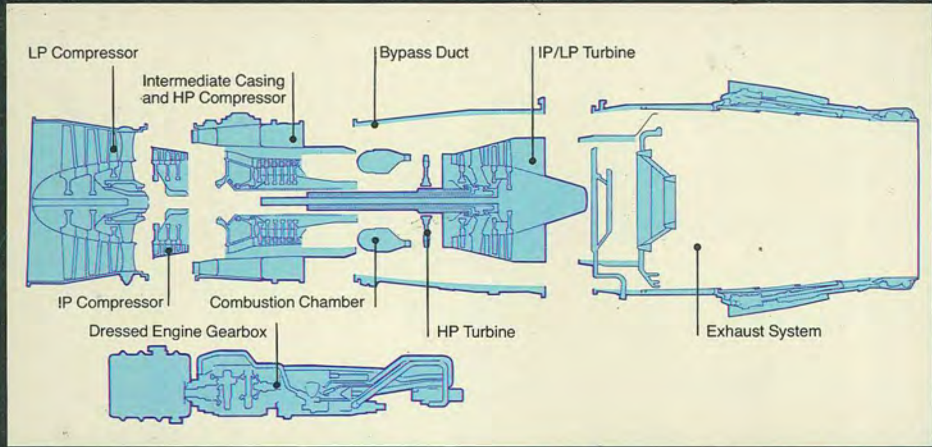
Propulsion System Cockpit Panels with OCAM/BITE functions

Access to all engine accessories through two large doors

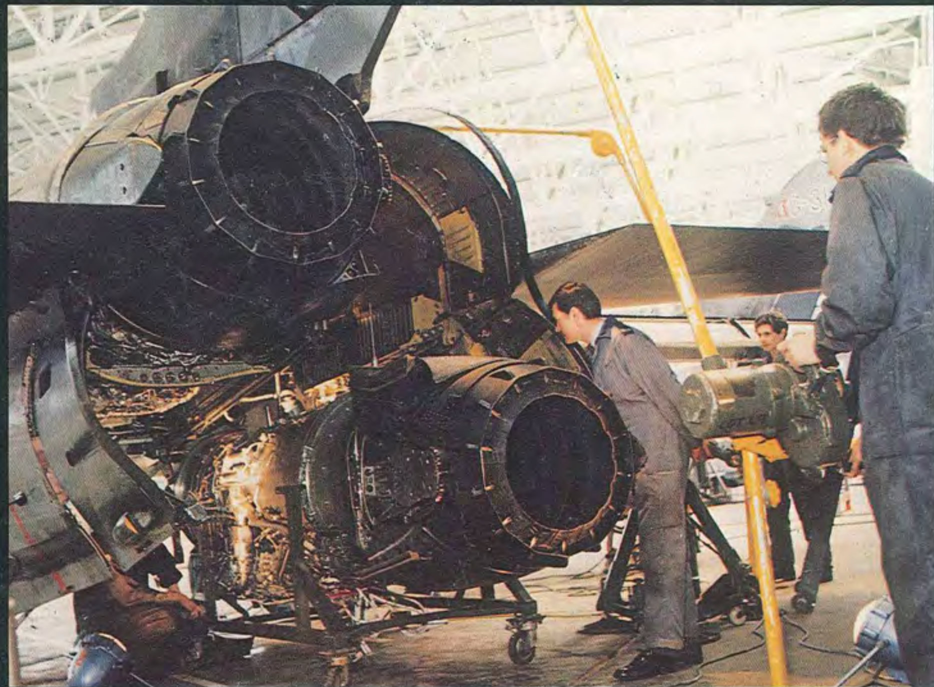


- Nine maintenance assemblies breaking down to 16 modules
- Assemblies/modules replaced at 2nd Level
- No re-balancing after assembly module exchange
- Corrosion resistant materials
- Absence of engine mounted aircraft accessories
- Engines completely interchangeable with only minimal dressing requirements
- Drop-out installation
- Minimal disconnect points
- Rapid engine change time – removal and replacement in less than 40 minutes
- Simple AGE requirements
- Health monitoring features enable Condition Monitoring of the engine:
  - Magnetic detector plugs
  - Spectrometric oil analysis
  - 13 Borescope inspection ports
  - Vibration monitoring
  - Time/Temperature cycle recording
- Large engine bay doors with shoot bolts allows easy access to engines and accessories
- Engine accessories are grouped around lower half of the engine – accessible for quick replacement without engine removal
- Servicing points provide ready access for checking magnetic plugs, pressure re-oiling, tank contents checking, filter inspection and oil sampling for spectrometric analysis

RB 199 Maintenance Assemblies



Rotor blades and the combustion chambers can be inspected visually



Rapid engine changes using the simple drop-out system

Secondary Power System

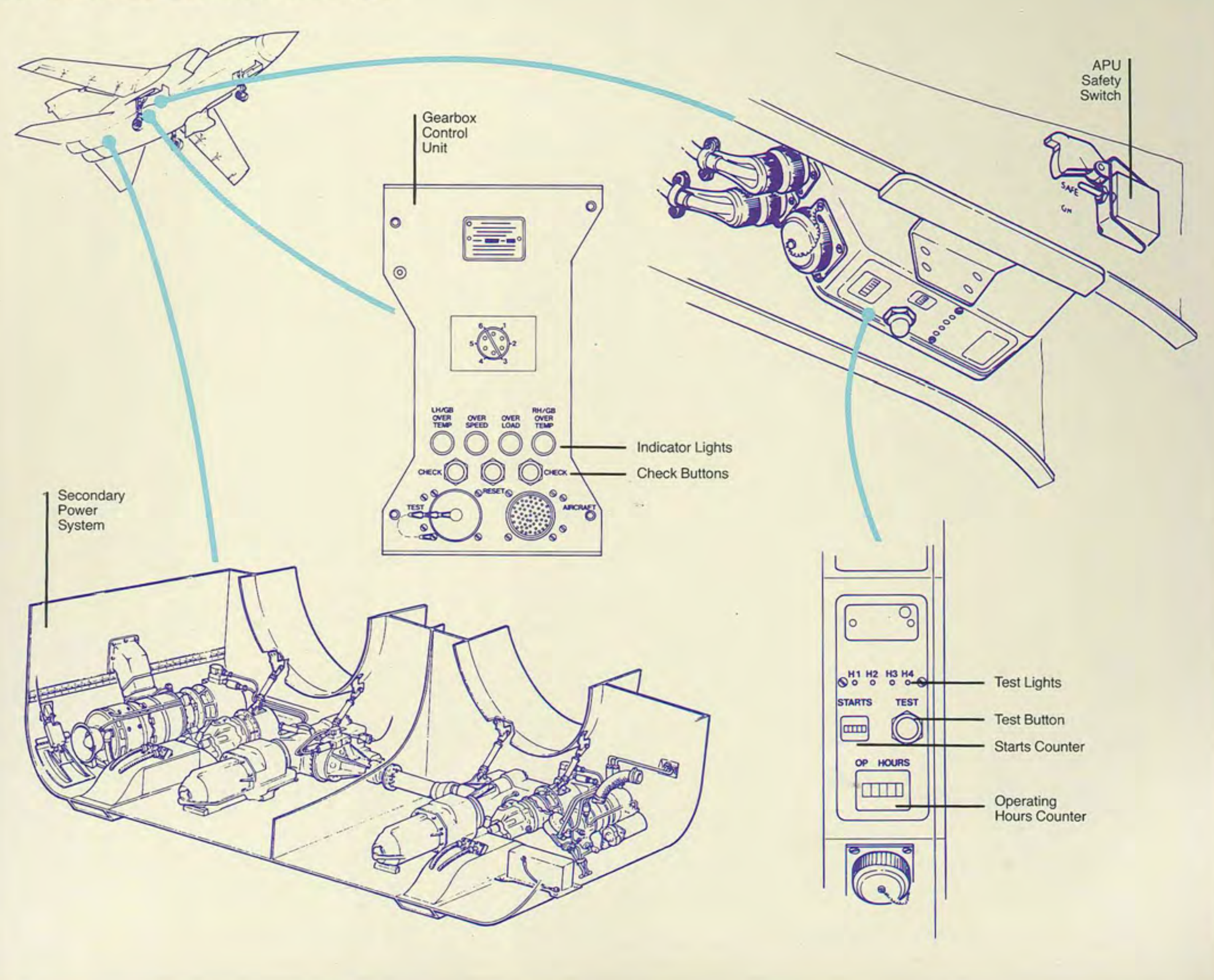
The Secondary Power System (SPS) on TORNADO comprises of two air-frame mounted main gearboxes each driven by its respective engine or the APU with a cross-drive shaft between them so that either engine can be started from the other (or from the APU) and in an emergency either engine can drive both gearboxes.

Each gearbox carries a hydraulic pump, an integrated constant-speed drive and electrical generator and a fuel pump. In addition, the starboard gearbox carries the Auxiliary Power Unit (APU) which is a gas turbine engine using aircraft fuel from the engine fuel supply system. The APU can be started from the aircraft battery for ground support purposes and to start the main engines.

The APU enables TORNADO to be independent of external power sources on the Flight Line; consequently it can be operated and serviced from dispersed airfields as it allows ground crew to carry out requisite system and avionic checkouts.

- Auxiliary Power Unit (APU) can be operated for up to 4 hours for maintenance purposes
- APU supplies ground electrical and hydraulic power and engine starting
- SPS Control Unit incorporates BITE and is easily accessible
- Gravity and pressure re-oiling points: optical fibre system for gearbox oil level checking
- All gearbox driven accessories utilise V-clamp attachments and are orientated by dowel pins
- Guard tubes on all drive shafts
- APU fuel from engine fuel supply

SPS Ground controls with OCAM/BITE functions



Fire Detection and Suppression

Because the by-pass flow through the engine substantially reduces the temperature of the engine external surfaces, the risk of engine bay fires is considerably diminished. There are no aircraft systems carrying combustible liquids through the engine bays other than hydraulic vents.

Detection

Fire and overheat detection in the engine bays and secondary power bay is provided by continuous sensing element systems.

The control units are mounted externally to the fire zones with the continuous sensing element forming loops around the engine (combustion chamber, engine accessories, vicinity of ventilating air outlet, and air conditioning engine bleed pipe) and secondary power bay (around the APU).

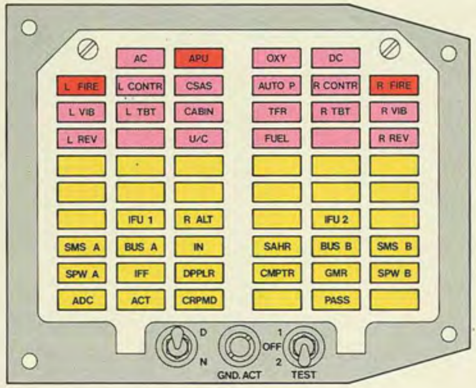
Suppression

The system is operated from the front cockpit by the selection of either a fire extinguisher push-button or a crash switch. It can discharge into either or both engine compartments.

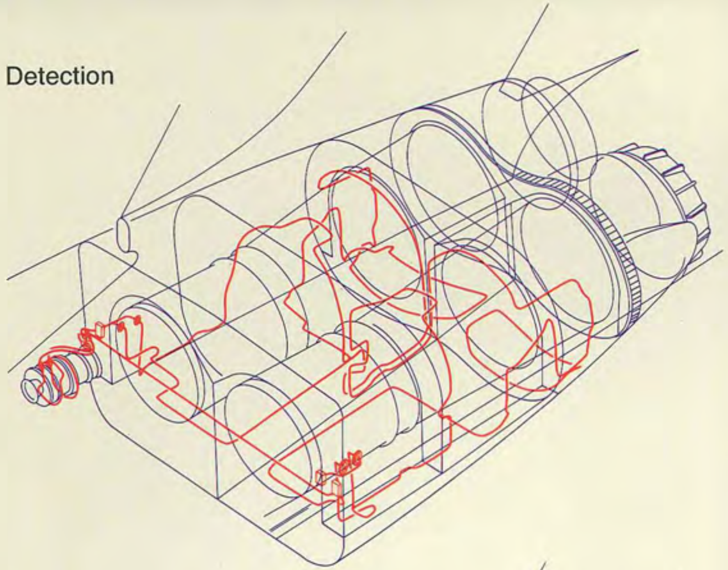
The fire extinguisher bottle is mounted on the interface between No. 2 engine compartment and the outer skin, and has a dual head, complete with two operating cartridge units.

- 2 gauges are mounted for indication of discharge
- All components readily accessible by panels or quick release doors
- Bottle easily removed without disturbing other components
- Post-flight BITE checks confirm serviceability of complete detection system (via CWS Test 2)
- Minimal post-discharge maintenance actions

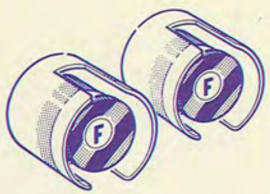
Fire detection loop and cockpit indications



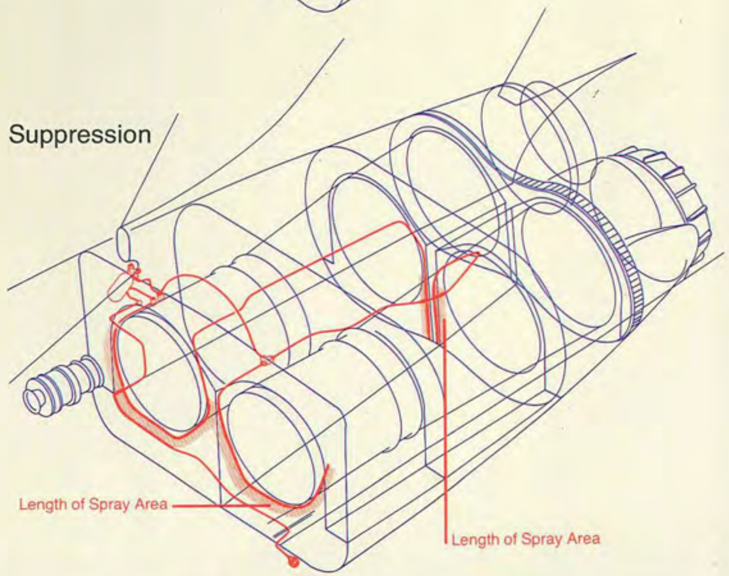
Detection



Engine fire extinguishing system



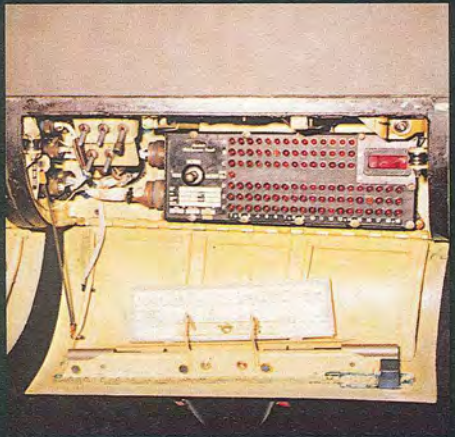
Suppression



Flight Control System

The TORNADO is the first military, production aircraft in the world to feature an all-electrical triplexed flight control system with an electrical reversionary mode and a mechanical reversionary mode in pitch and roll.

This technology, known as fly-by-wire, provides a number of advantages over a conventional mechanical/hydraulic system.

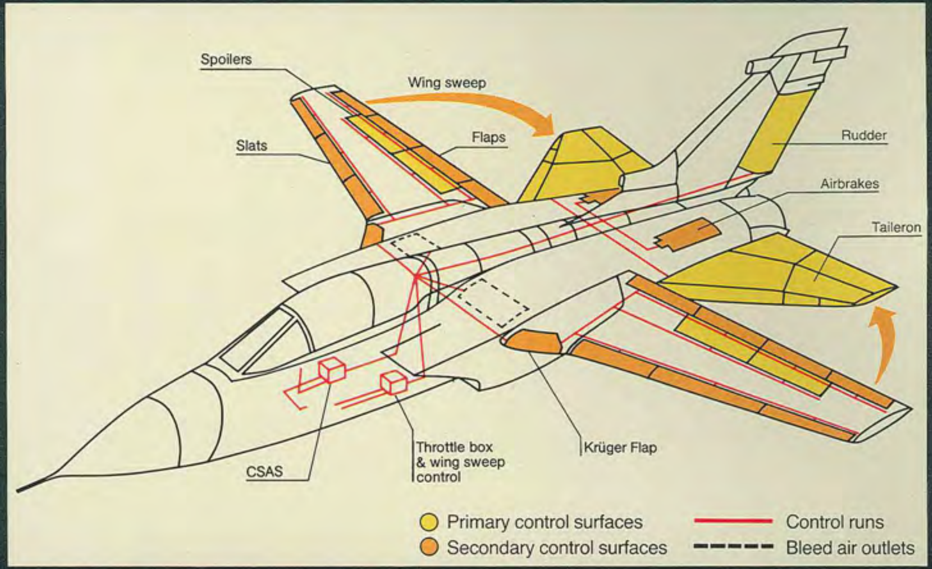


OCAM reports the status of LRU's to the Central Maintenance Panel

The Flight Control System (FCS) has two fully independent systems – Primary and Secondary

- Primary Flight Control System (PFCS)
  The PFCS operates the all moving tailerons for pitch control, differential tailerons for roll control plus two pairs of individually actuated spoilers for roll control (these can also be used together as lift dumpers) and a conventional rudder for yaw control. The taileron actuators are powered by the two hydraulic systems. The inboard and outboard spoilers are powered by left and right utility systems respectively. The rudder is powered by the right hydraulic system and left utility system. In the normal mode the PFCS operates via the Command Stability Augmentation System (CSAS) which is the heart of the PFCS.

- Secondary Flight Control System (SFCS)
  The SFCS operates the wing sweep, flaps, the full-span leading edge slats, Krueger flaps (located on the wing glove L.E.) and the airbrakes. A mechanical interlock prevents flap/fuselage interference at wing sweeps beyond 25 degrees, in which case the slats only are used. Wing sweep is mechanically controlled and hydro-mechanically operated. The wing sweep angle is adjusted by two screw actuators, one for each wing. The wing slats, flaps and Krueger flaps are electrically controlled and hydro-mechanically operated.



Flying controls

CSAS Cockpit panel with BITE functions and failure indications

- Fly-by-Wire control system
- LRU concept
- Extensive use of BITE
- Ready access to components
- Use of APU makes aircraft independent of external ground electrical/hydraulic power for testing FCS system
- All control surfaces are quickly detachable
- Most linkage bearings are sealed for life – others have quick access grease nipples
- LRU's are repairable by replacement of modules
- Built-in rigging index points at control surfaces
- Wing sweep actuator and flap/slat drive have oil level sight glasses for easy inspection

Electrical System

The electrical system consists of a 115/200 V AC three-phase, 400 Hz constant frequency subsystem and a 28 V DC sub-system.

Power is generated by two automatically controlled oil cooled brushless AC generators integrated with a constant speed drive unit and driven by the aircraft engines via accessory gearboxes. (Normally each engine drives its own accessory gearbox but provision is also made for either engine to drive the opposite gearbox through a cross drive system.) Following a generator failure the remaining unit is capable of supplying the total aircraft load.

When the aircraft is on the ground both gearboxes and thus both generators can be driven by the APU making the aircraft independent of external electrical supply.

The generators supply two main AC busbars and an AC essential busbar. DC power is provided from two fan-cooled transformer rectifier units (power being derived from the main AC system): these feed power to two main DC busbars, one essential DC busbar and a battery busbar. Either TRU is capable of supplying total aircraft DC load.

A fifth DC busbar is provided for maintenance purposes only.

The battery is a rechargeable nickel-cadmium type and provides power for basic flight line servicing functions and for starting the APU. In the unlikely event of a main electrical system failure or a double TRU failure, the battery is connected in a few microseconds to the essential services busbar utilising a thyristor switching circuit (fast action device), thereby supplying the essential electrical loads.

During operation the system is continuously monitored by control and protection circuits which control output levels and automatically switch off busbars and/or generation equipment in the event of fault conditions. Failure warning signals are fed to the front and rear CWS panels.

BITE is incorporated in:

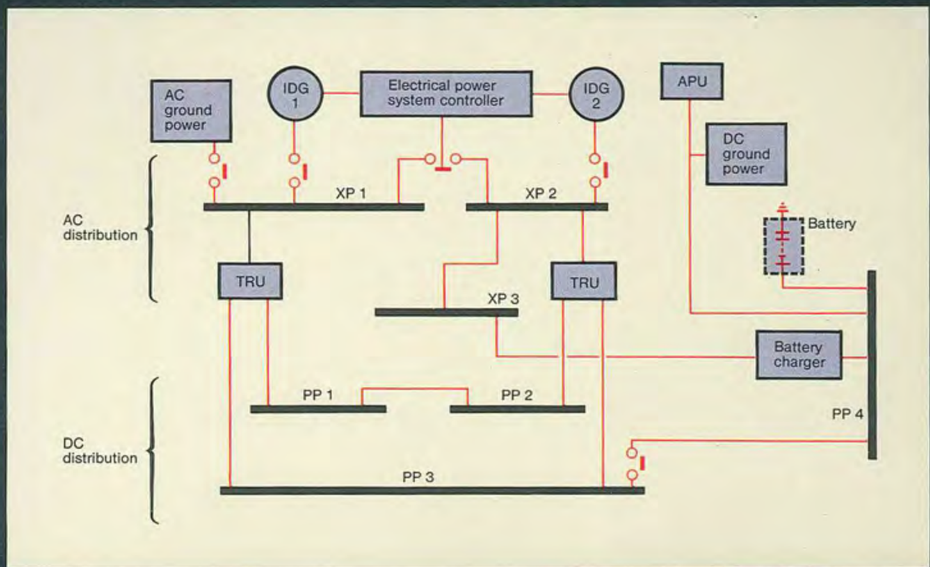
- Generator Control Unit
- Battery Charger
- Fast Action Device

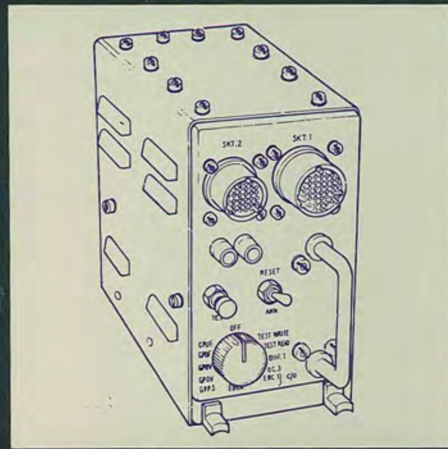
Electrical Power System Controller

The Electrical Power System Controller (EPSC) performs the following main functions:

- Acts in conjunction with the generator control unit to control the overall performance of the electrical power supply system during parallel operation
- Checks the status of external AC ground power supplies
- Checks, using built-in test equipment, the correct operation of the normally dormant protection circuits and records, on fault indicators, the operation of protection circuits.

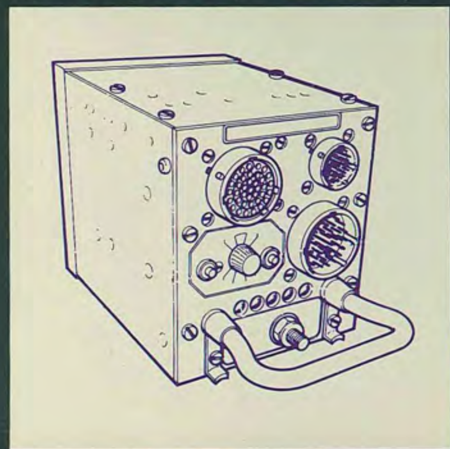
Electrical System
Block diagram

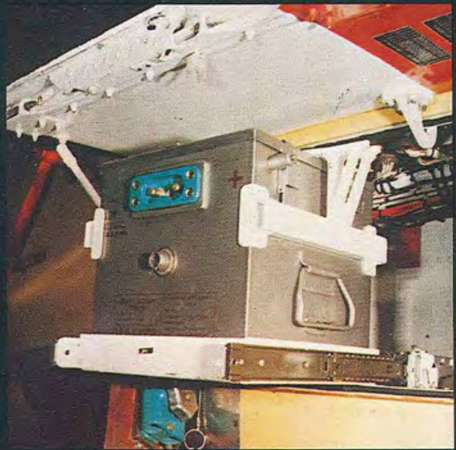




Generator Control Unit

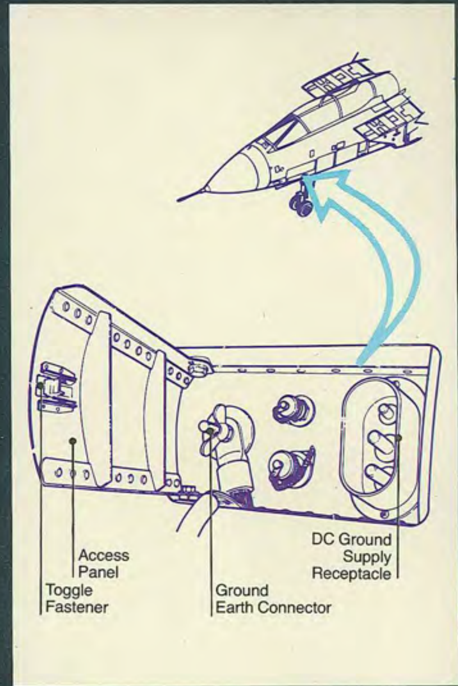
The GCU uses logic circuits to analyse information about the condition of the electrical power supply system. Outputs from the GCU logic are used to perform the GCU control and protection functions, to control the operation of BITE fault indicators and to provide inputs for the EPSC.





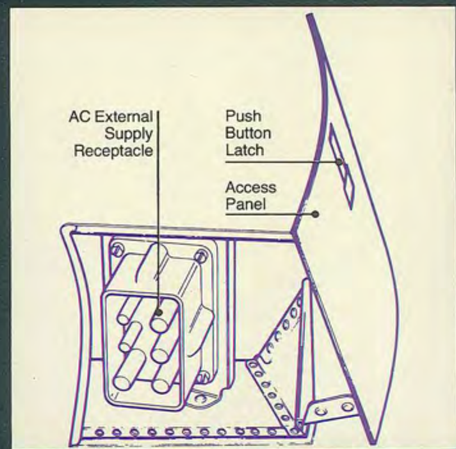
Battery installation on a sliding tray

DC Supply and earthing compartment



- Common oil supply which serves the constant speed drives and is the basic gearbox oil also
- Phase/voltage/frequency monitor for checking ground supply before connection to the main system
- AC ground supply plug to save APU life
- No electrical AGE required for "on-aircraft" routine servicing/maintenance
- APU can power all electrical ground running requirements
- Extensive use of BITE
- Electrical panels and components are built as LRU's
- Integrated Drive Generator (IDG) attached to gearbox via use of one V-clamp allows removal without disturbance to other components
- Relays are plug-in type
- Most components rack-mounted with quick release features
- Battery mounted on sliding tray to ease removal/refit
- Analysis of oil system via IDG magnetic chip detectors
- Regulated in-situ recharging of battery via battery charger
- DC ground supply plug for alternative to APU start facility

AC Ground supply to save APU life



Hydraulic System

Two separate hydraulic systems (left and right) are supplied from two separate independently driven hydraulic pumps, each mounted on an engine accessory gearbox. Each system is supplied with hydraulic fluid from a separate reservoir. On the ground, the accessory gearboxes may be driven by the APU or by the engines. Each engine normally drives its own accessory gearbox and hydraulic pump. A cross-drive mechanism between the gearbox can be selected so that the APU can drive the right or both, or either engine can drive either or both hydraulic pumps.

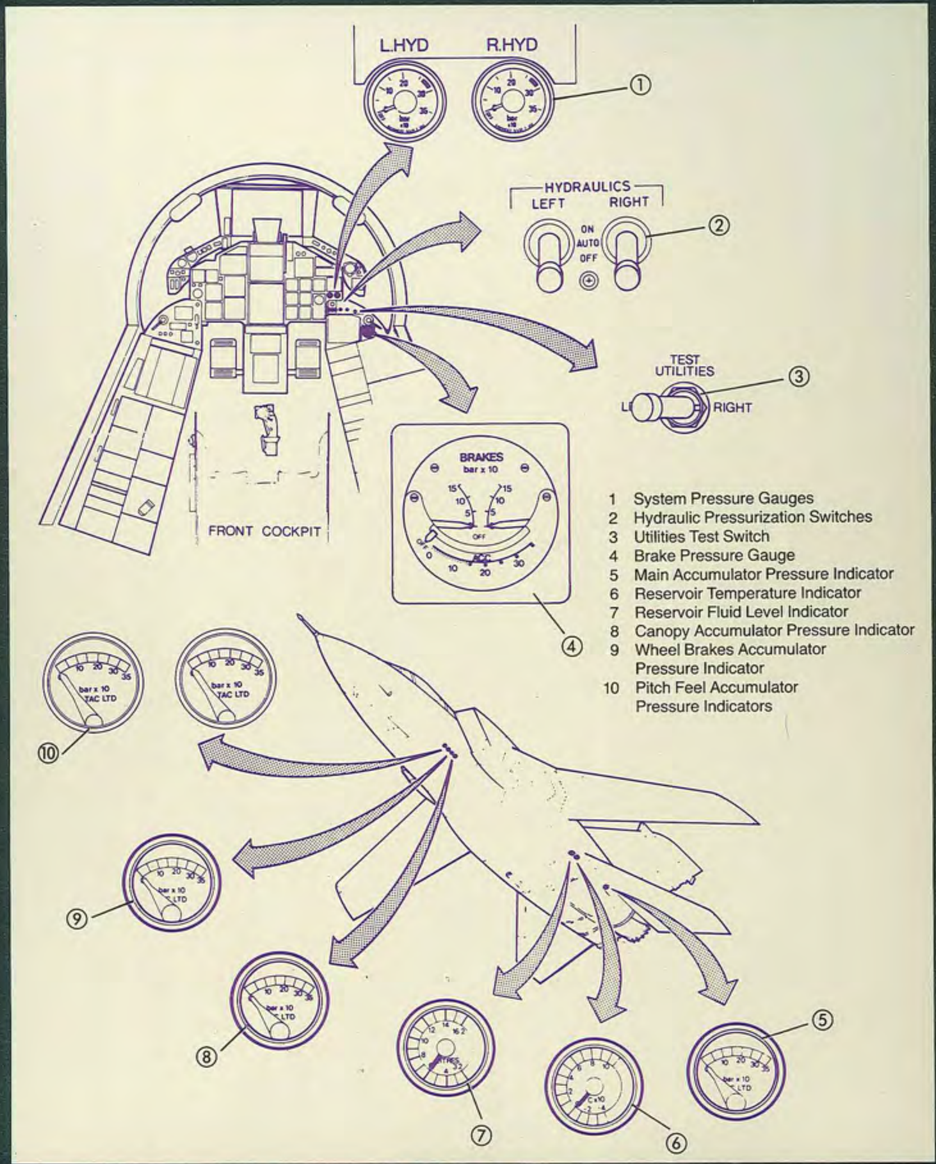
Each system is divided into a control and a utility system.

The primary flight controls are provided with hydraulic power from both systems.

Two reservoirs, one for each system, are located in the rear fuselage. Each reservoir has a hydraulic fluid capacity of 16.2 litres and is pressurized to approximately 8 bar.

The left system has a hand pump for pressurising the wheelbrake and canopy accumulators.

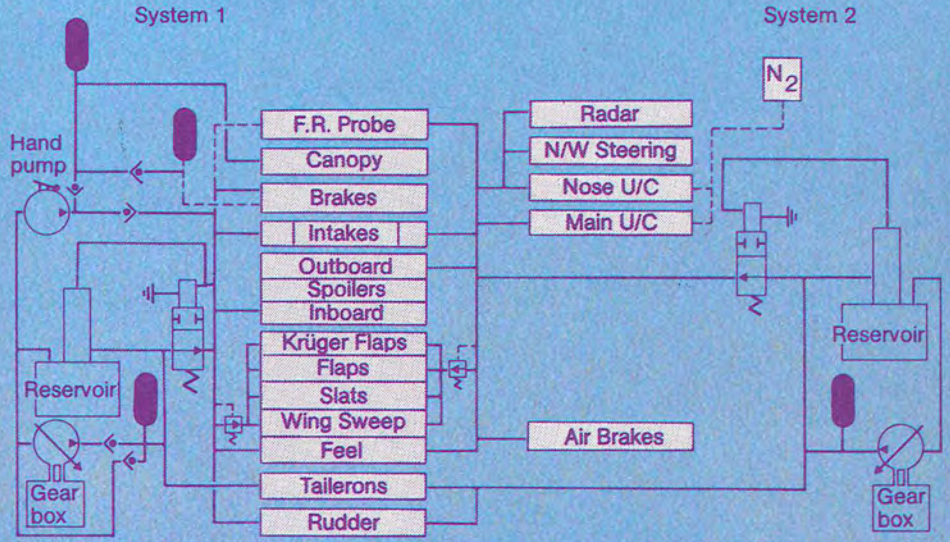
In the event of a double engine flame-out or double generator/TRU failure, an Emergency Power Supply System (EPS) provides hydraulic power for emergency operation of the taileron actuators.



Hydraulic System Controls and Indicators

Hydraulic Supply

Left System	*Right System*
Flight control system	Flight control system
Tailerons	Tailerons
	Rudder
Utility system:	Utility system:
Rudder	
Flaps and slats	Flaps and slats
Krueger flaps	
	Airbrakes
Inboard spoilers	Outboard spoilers
Wing sweep	Wing sweep
Left air intake ramps	Right air intake ramps
Pitch "Q-Feel" system	Pitch "Q-Feel" system
Canopy	
Wheelbrakes	
Air-to-air refuelling probe – emergency extension	Air-to-air refuelling probe – normal
	Landing gear
	Nosewheel steering
	Radar stabilisation and scanning



- High technology "state of the art" 4000 psi system
- Ready access to components throughout
- Hand pump for ground operation of canopy and wheel brakes
- APU for extended ground testing
- All charging points self-sealing
- Filters have pop-out indicators
- Filters are hand tightened with self-sealing connectors
- Skin mounted gauges for contents and pressures – all adjacent to relevant charging points
- Main components mounted in groups, reducing number of connections and shortening of pipe lines: for example hydraulic power packs
- Non-wire locking connections for all pipework
- Nimonic pipe lines
- Filter bowls can be pre-filled off-aircraft
- Speedy repairs to pipes and fittings can be done on-aircraft using Permaswage
- Priorities systems protected by low content switches which shut off the utilities system

Fuel System

Both bag and integral tanks are used to give TORNADO a high internal fuel capacity. The bag tanks are of tear- and damage-resistant material and maximum use is made of heavy structure for tank protection.

The wing tanks each have a single-ended AC booster pump which feeds back to the main tank groups.

External tanks can be carried on the two shoulder pylons, centre pylon and two inboard wing pylons.

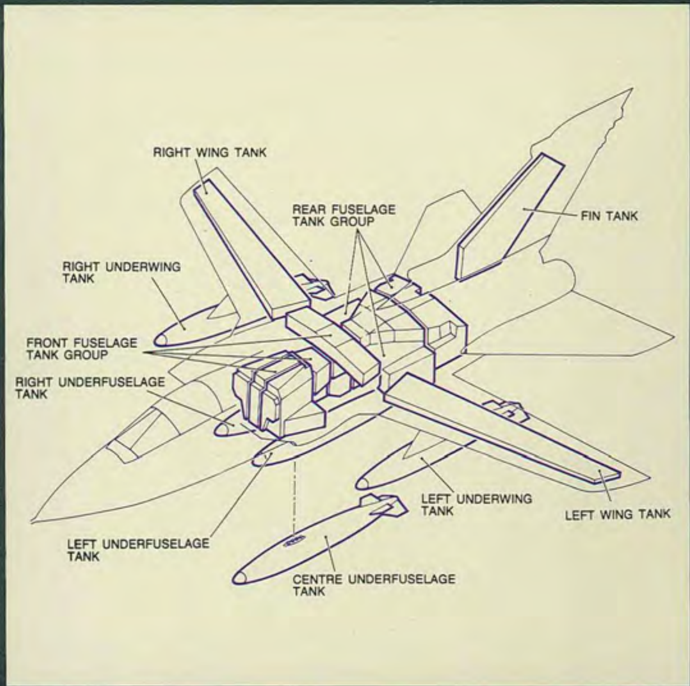
Ground refuelling is by means of a single NATO refuelling connector on the right-hand side of the fuselage. Each tank has a high level cut-off Thermistor: the refuelling process is fully automatic, but the individual tank group contents can be controlled manually, if required.

The CWP in the front cockpit gives system warning indications and BITE is incorporated.

A retractable air-to-air refuelling probe can be attached to the fuselage on the right upper side adjacent to the cockpit.

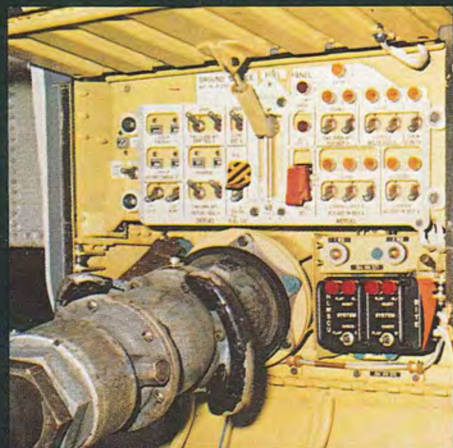
A buddy/buddy refuelling pod can be carried on the centreline pylon so that the aircraft can be used as a tanker.

- Single NATO standard refuelling/defuelling point – 2400 lbs/min and 50 PSI
- Centralised ground servicing fuel control panel adjacent to refuelling point
- External electrical power not required for refuel/defuel operations
- Gravity refuelling points in wings and fuselage for emergency use



Fuel tank layout

- Conventional tear-resistant bladders for fuselage tank cells
- Each of the 14 cells is in a sealed compartment with identified drain tube for swift leak diagnosis
- Simple push-in type water drain in all tanks
- Fuel content indicator system incorporates BITE
- Equipment failure location simplified by:
  - Air/Fuel system test switch
  - Caution lights for forward and aft boost pump: low level caution, vent caution, transfer functions



Single NATO standard fuel connector

Centralized ground servicing fuel control panel

- Fuel sampling at skin mounted water drain taps and at single refuel/defuel point
- Use of quick disconnect features throughout
- Valve actuators are exchangeable without removing valve
- Flight Refuel Probe (FRP) is a role change package installed on the right-hand side of aircraft
- FRP hydraulic system testing is via the aircraft hydraulic pump powered by APU

Air Conditioning and Pressurisation

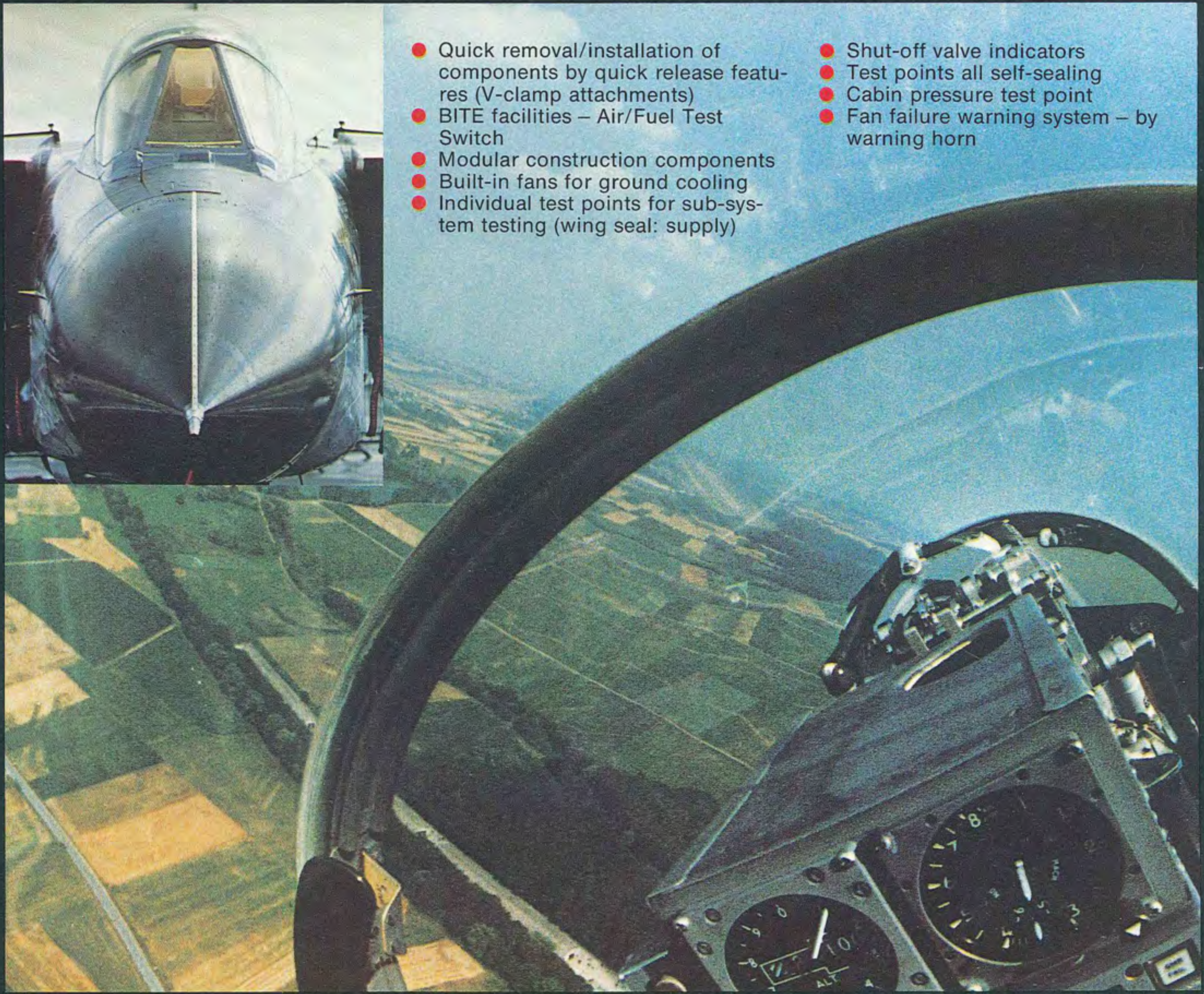
A conventional air cycle system (with "bootstrap" cold air unit) using engine tapped air from fourth stage HP compressor with ram air pre-cooler and inter-cooler heat exchanger, provides TORNADO's air conditioning. Cockpit temperature can be selected from +5° to +35° centigrade and is held automatically at this level. Cockpit pressurisation starts at 5,000 ft and varies linearly to 5.25 PSI at 40,000 ft.

The canopy is de-misted by hot air which is also used in emergency for the otherwise electrically de-misted/anti-iced windscreen.

The radar and forward avionic bays are cooled by cabin exhaust air while the remaining equipment is cooled by direct air system tapping. Cooling fans are provided for ground use, which can also be used in flight if the air system fails. There is an emergency ram air cooling system for the cabin in this case.

The air system supplies:

- Anti-g suits
- Wing slot seals (the rubberised bags sealing the fuselage slot into which the wings sweep back)
- Canopy and windscreen seals
- Windscreen washing
- Rain repellent
- Radar pressurisation and avionic cooling



- Quick removal/installation of components by quick release features (V-clamp attachments)
- BITE facilities – Air/Fuel Test Switch
- Modular construction components
- Built-in fans for ground cooling
- Individual test points for sub-system testing (wing seal: supply)
- Shut-off valve indicators
- Test points all self-sealing
- Cabin pressure test point
- Fan failure warning system – by warning horn

Oxygen System and Crew Escape System

Oxygen System

The main oxygen system is based on a 10 litre liquid oxygen converter which provides oxygen for both crew-members in excess of 10 hours (cruise conditions) via a demand-type regulator fitted on each seat.

The converter is located in a bay under the rear cockpit on the left-hand side which allows easy removal for replacement with a full converter or replenishment "in situ".

An emergency oxygen system is installed on each seat and provides oxygen from a 70 litre (NTP) cylinder for use in the event of a failure of the main system, or following ejection.

Crew Escape System

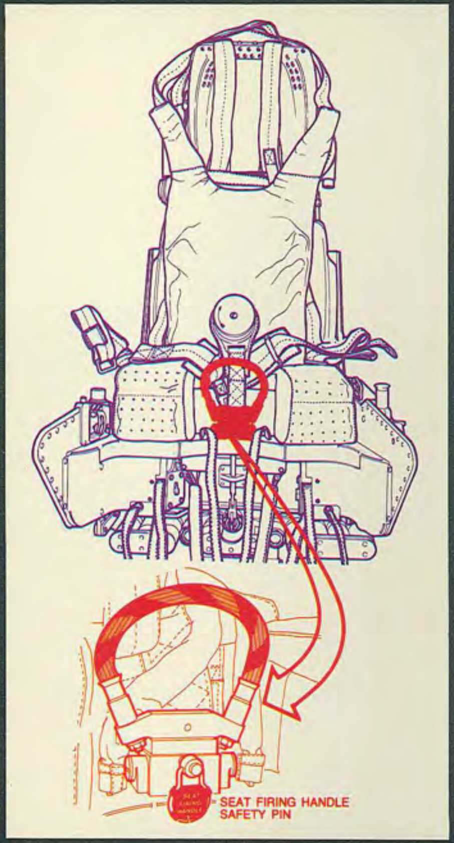
The system consists primarily of two Martin Baker MK.10A, fully automatic, rocket assisted ejection seats, interconnected and sequenced with each other and with the canopy jettison system providing a zero speed, zero altitude escape facility.

To minimise total escape times a command ejection facility is provided and a single canopy is used to cover both cockpits. This single canopy is jettisoned by means of two rocket motors, fitted at its forward end.

To provide an additional system to the canopy jettison system, and also providing a ground escape facility, a Miniature Detonating Cord (MDC) system is fitted to the canopy transparencies, over the front and rear cockpits to fragment the transparencies on operation of the ejection seat or external ground jettison handles.

- Oxygen flow indicators in each cockpit ("dolls eye type")
- Lox contents gauges in cockpit and on converter
- Lox converter (10 litres) swiftly replaced (2 minutes) or refilled in situ via trolley dispenser
- BITE on contents gauging system and pressure regulator
- Emergency oxygen bottle pressure gauge is attached to the ejection seat – easily readable by air and ground crews
- Easy access to components
- Components are modular construction
- Quick disconnect features and self-sealing couplings
- Conventional ejection seat and canopy jettison system
- One safety pin only required to make the seat safe

Easy replacement of LOX container



One pin only required for seat safety

- Five pins only required for total escape system safety
- Complete ejection seat assemblies removable from cockpit without canopy removal
- Seat pan readily removable in situ for accessibility
- Ejection seat safety equipment removable with seat in situ

Landing and Arrestor Gear

Landing Gear

Landing gear on TORNADO is tricycle-type forward retracting and hydraulically operated. Each Main Landing Gear (MLG) consists of an oleopneumatic leg with a single wheel. The Nose Landing Gear (NLG) has twin wheels. Normal extending and retracting of the landing gear is electrically controlled and hydraulically operated.

An emergency lowering system is incorporated which is mechanically controlled and is operated by nitrogen gas pressure.

Normal braking of the aircraft to low speed is achieved by use of the thrust reverser system thus minimising wear and maintenance on the wheel braking system.

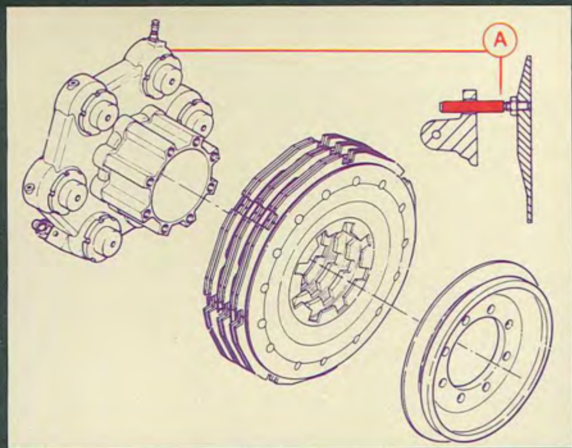
For taxiing, short landings or emergency use each MLG wheel is equipped with a hydraulically operated multiple disc brake. Normal braking is protected by an anti-skid control system.

Arrestor Gear

The arrestor hook system is installed to provide emergency arrestment of the aircraft on suitably equipped runways. The assembly is stowed manually and released electrically by operating the release button located in the front cockpit or manually for ground servicing purposes by a manual release lever. A ground safety pin and a safety device is provided to prevent inadvertent release of the assembly.

- BITE for ground use
- Easy access to all components
- Inherent corrosion resistant materials
- MLG wheel replacement without jacking whole aircraft
- Test points in landing gear control and indication system
- Built-in brake wear indicators
- No drag chute
- Simple cable release for arrestor hook
- Wheels, brakes, oleos, jacks, and locks are all interchangeable (left to right)

Maintenance free arrestor hook



Wheel brake assembly with wear indicators (A)

Avionic Systems

The TORNADO weapon system features a comprehensive, integrated avionic system whose performance is a very significant contribution to the overall capabilities of the aircraft.

The system breaks down into the following sub-systems:

- Navigation
- Flight Director and Terrain Following
- Weapon Aiming and Delivery
- Computing
- Communications
- Defensive Aids

The avionic system utilises digital signalling, which reduces EMC difficulties to a minimum and all equipment has been designed to perform in the most demanding low level environment. The centre of the system is the large capacity digital computer which draws upon information from the following major sensors:

- Ground Mapping Radar (GMR)
- Terrain Following Radar (TFR)
- Inertial Navigator (IN)
- Doppler Radar
- Secondary Attitude and Heading Reference (SAHR)
- Air Data Computer (ADC)
- Approach Aids
- Identification Friend or Foe (IFF)
- Passive Radar Warning
- Laser Range Finder and Marked Target Seeker (LRMTS)

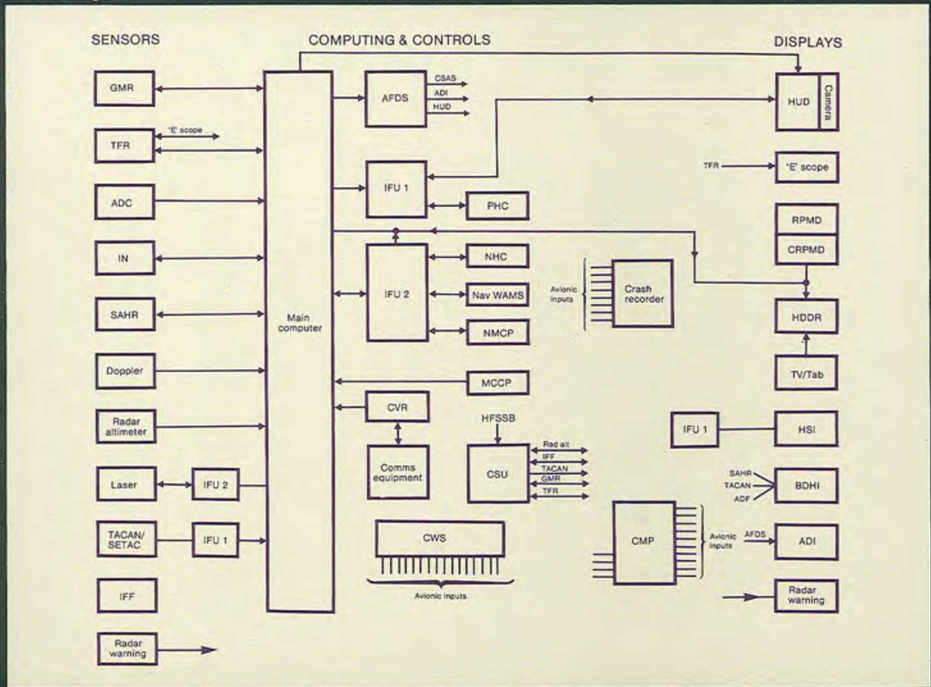
and utilises the following displays:

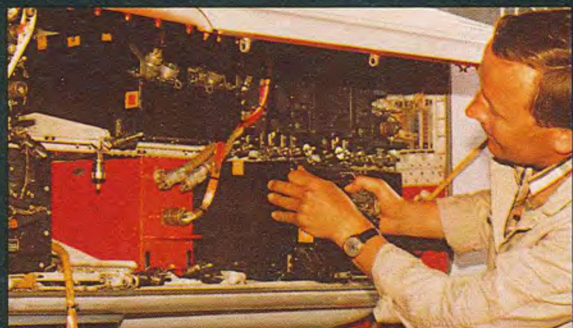
- Head-up Display (HUD)
- TV/Tabular Display (TV/Tab)
- Combined Radar Projected Map Display (CRPMD)

Several of the major sensors form parts of more than one sub-system.

Maintainability and reliability were regarded as of equal importance to performance in the design and development of the TORNADO avionic system.

TORNADO IDS Avionic Systems Block diagram





- Systems wholly on LRU basis
- Extensive use of OCAM with most equipment failures identified and located to single LRU
- Most LRU's feature BITE on continuous and interruptive basis
- Status of all prime LRU's indicated on CMP
- LRU's mounted on pull-out racks/housings for ready removal/refit
- No calibration/harmonisation required after LRU replacement
- Avionic LRU's can be tested off-aircraft using ATS or selected STTE
- External ground test programmes (EGTP) loaded into the main computer (MC) provide additional functional/diagnostic test facilities with read-out in plain language on TV/Tab Displays
- Ground Test Facility (GTF) co-resident in the MC with the OFP
- Power and cooling for ground testing via the APU
- Ready access to systems and LRU's throughout
- Radome is doubly hinged whereby opening the complete radome allows easy access to the forward avionic bay: opening the middle section allows ready access to front and rear of the radar
- Hinged windscreen enhances access to equipment in pilot's cockpit
- Mechanical and electrical interchangeability between equipment, LRU's, modules, sub-modules and components bearing the same part number, without resorting to selection, regardless of manufacturer or supplier
- HUD replaceable without bore sighting
- Stringent reliability features

Armament and Role Equipment

Armament

TORNADO'S stores compendium is extensive, ranging from conventional to advanced weapons.

Loading is uncomplicated with removal/refitting accomplished in minimal times using mostly NATO standard equipment and tools, rapidly restoring TORNADO to operational availability.

Carriage of all external stores is via pylons fitted to the fuselage (centreline and shoulders) and wings (inboard and outboard). Ejector release units (ERU's) fitted in the pylons provide means of releasing and jettisoning stores.

Two Mauser 27 mm guns are installed in compartments in the lower front fuselage left and right sides: a central container feeds both guns.

The armament control system comprises several integrated systems which control the release of armament stores and firing of missiles and guns. The main sub-system being the Stores Management System (SMS).

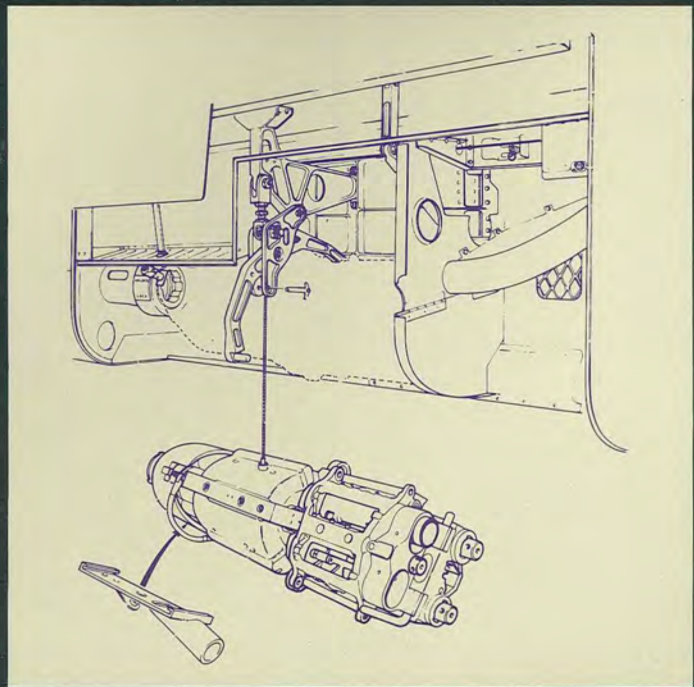
Basically, the SMS, in conjunction with external controls and interfacing units, provides overall control for selection, arming and operation of conventional bombs, rockets, guns, and guided missiles fitted to the aircraft.

SMS failures are detected, identified to LRU level and stored in the Weapon Programming Unit (WPU) which is readily accessible in the left rear avionics compartment.

Role Equipment

TORNADO as a multi-role aircraft weapon system is exceptionally diversified in its multi-role capacity and the equipment it carries. This capacity is fully enhanced by a comprehensive range of removable Role Equipment. This equipment which is almost entirely external to the aircraft is uncomplicated, readily handled and removed/refitted using mostly standard NATO equipment and tools: turn-around is quick thereby rapidly restoring TORNADO to operational availability.

Integral gun winching mechanism



Rapid bomb loading even in confined shelter space

- Wide variety of external store weapons with:
  - Minimal loading equipment
  - Rapid turn-arounds
  - Rapid change-of-role
  - Mostly standard tools and equipment
  - Rapid removal of pylons
  - Loading by either "push-up" or "mini-hoist" method
- 2 Mauser 27 mm guns internally mounted with integral winching system
- The built-in winching system facilitates rapid replenishment of gun ammunition container between sorties
- Boresighting effected at build
- Ready access to systems and components throughout
- LRU's used throughout SMS

Loading of MW-1 container

- LRU's employ slide-in, slide-out concept for quick removal/re-placement
- SMS failures are detected, identified to LRU level and stored in Weapon Programming Unit (WPU) for post-flight evaluation
- WPU readily accessible in left rear avionics compartment
- SMS utilises continuous BITE
- SMS interruptive BITE initiated by ground crew during pre-/post-flight checks

- LRU's can utilise ATS test and fault diagnosis at 2nd level
- Range of crutched and crutchless ERU's to suit national stores requirements
- Use of crutchless ERU (Minimum Area Crutchless Ejector – MACE) gives saving of 6 1/2 minutes loading time for 8 bombs
- ERU servicing at 300 hr or 40 firings (50 firings for MACE)
- ERU's on aircraft – 30 days without cartridge change
- Rapid removal/refit of ERU's

- Armed Turn Rounds – No software changes if same aircraft
- Armed Turn Rounds (1):
  - Configuration: 2 x guns + 2 x SRAAM + 4 x MK 82 bombs + 2 x ECM pod + external fuel tanks
  - Task:
    2 x guns rearm
    LH and RH SRAAM to wing pylons
    4 x bombs to fuselage stations
    Refuel
  - Time: 17 minutes

- Armed Turn Rounds (2)
  - Configuration: 2 x guns + 2 x SRAAM + 8 x MK 82 bombs + 2 x ECM pod + external fuel tanks
  - Task:
    2 x gun rearm
    LH and RH SRAAM to wing pylons
    8 x bombs to fuselage stations
    Refuel
  - Time: 24 minutes

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Tel. (0 89) 92 17-362
Telex 05–29 825

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