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Credits

Project managers, Tim Taylor and David Brice would like to thank the following people for their invaluable contribution to this project.

- **Raymond Rotmans**, for some fantastic textures, flight model updates and in depth testing.
- **Jivko “J.R.” Rusev** for some truly inspirational work on the F-15E Head up Display and targeting systems.
- **John Blum** of Vertical Reality Simulations ([www.vrsimulations.com](http://www.vrsimulations.com)) for the lighting techniques and ‘Ferris wheel’ compass concept used in this IRIS Mudhen Driver.
- **Scott Gentile** of A2A Simulations ([www.a2asimulations.com](http://www.a2asimulations.com)) for the use of the A2A Landing Lights.
- **Szabolcs Serflek** (Sabc) from ([www.f-15e.info](http://www.f-15e.info)) for his invaluable support and assistance.
- **Herve Etienne, Jason Norment**, and resident F-15 Driver, **William Pope** along with the team at Simulated Air Force ([www.simairforce.org](http://www.simairforce.org)) for their fantastic testing efforts, and for providing a sizable chunk of the documentation.
- To **Mr X.**, for providing the avionics and weapons delivery code for our wonderful product. You know who you are... 😊
- **Jeff Andersen**, USAF F-15E Avionics Tech for his assistance.
Dedication

Both Tim and I would like to dedicate this product to Tim’s mum, Carol on her birthday this year.

‘Carol, Tim has been an inspiration to me, a constant source of amusement and for the most part a rather large pain in my rear! His work ethic is nothing short of astounding, and his passion for his work is plain to see in the quality of the work he provides.

Both I and my wife Karen would like to congratulate you on raising a wonderfully generous, hard-working and supportive person in Tim. He’s the reason why this product is as good as it is! His driving influence has often been seen in my household over the last 6 months by me sitting at my desk at some ungodly hour of the morning trying to do ‘just that little bit extra’ in order to make his vision for this product a reality.

Quite simply, this product is his hard work and labour… I just punched in some numbers here and there. :-)

Happy Birthday from us all…

David, Karen and the team at IRIS Development Studios.’
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About this Guide

This guide has been written to familiarize new users to the systems, operations and handling of the IRIS Platinum Series F-15E Mudhen Driver product.

It is essential that users have a working knowledge of Microsoft Flight Simulator and the theory of flight PRIOR to running this product.

By reading and learning the Pilot Manual prior to flying and keeping it to hand during your flight for reference, you will gain the most enjoyment from this product.

Tactile usage of switches and knobs in this product

In general, LEFT mouse-click places a switch AWAY from the pilot and a rotary selector COUNTER CLOCKWISE.

A RIGHT mouse-click places a switch TOWARDS the pilot and a rotary selector CLOCKWISE.

In some circumstances this does not apply, but the majority of switches and knobs operate in this fashion.
The Origins…

The United States Air Force commissioned the F-15 in 1967, after the Soviets Union revealed the powerful Mikoyan Gurevich MiG-25 fighter. The MiG-25, also known as the ‘Foxbat,’ was far superior to the Air force’s primary fighter jet, the F-4 Phantom II.

In order to keep a firm stance during the Cold War, the U.S. military needed a new fighter jet to rival the Foxbat.

Unbeknown to the U.S., the MiG-25 was a high-speed interceptor. Nevertheless the appearance of the MiG-25, with its larger tail planes and tail fins, spurred on the U.S. military to commission a heavily armed fighter jet with unmatchable manoeuvrability.

Four companies, General Dynamics, Fairchild Republic, North American Rockwell, and McDonnell Douglas, were selected to submit proposals for the new fighter in 1968.

In June 1969, McDonnell Douglas won the contract to develop USAF’s next premier fighter, the F15 Eagle. The maiden flight of the first F-15 took place in July 1972.

The DRF (Dual-Role Fighter) Program

After the development of the F-15 for air combat missions, the USAF still needed a replacement for the aging F-111. The Air Force sought a dual-role fighter (DRF)—one that could not only be a superior air-to-air combat fighter, but could also be a highly accomplished long range interdiction fighter capable of carrying a substantial bomb load in day or night and in all weather. Ironically, the very characteristics that made the F-15 an excellent fighter also made it a contender for the DRF program.

Multistage improvement programs began for both the F-15 and its then competitor the F-16 XL. Modifying the F-16 to perform this dual role required a new wing design, while F-15 modifications were made more in the area of avionics and airframe strengthening. Based on the cost of the programs, the F-15 was chosen, and on 24 February 1984, the Air Force Chief of Staff approved a $1.5 billion bill to upgrade 392 F-15s to perform the dual-role fighter mission. The F-15 DRF was designated the Strike Eagle. The F-15E Strike Eagle was born.
Characteristics
Compared to an average fighter, the F-15E is a very large aircraft, 70 feet long and 42 feet wide. It is more or less the same size as a B-25 bomber from World War II. It’s a twin-engine, twin-tails construction; it has fixed-geometry, swept wings which are shoulder-mounted. The wing surface is exceptionally large, resulting in a very low wing loading, which is a key factor for good turning performance.

The structure of the aircraft is stronger compared to other F-15 models (A to D), it can safely operate at takeoff weights as great as 81,000 pounds, can withstand 9G load when turning and is cleared for 16,000 hours, double the lifetime of earlier F-15’s.

**General characteristics**

Crew: 2 (1 Pilot and 1 WSO)
Length: 63.8 ft. (19.43 m)
Wingspan: 42.8 ft. (13.05 m)
Height: 18.5 ft. (5.63 m)
Wing area: 608 ft² (56.5 m²)
Empty weight: 31,700 lb. (14,300 kg)
Max takeoff weight: 81,000 lb. (36,700 kg)
Power plant: 2 × Pratt & Whitney F100-229 afterburning turbofans, 29,160 lbf. each
Or 2 × Pratt & Whitney F100-220 afterburning turbofans, 27,700 lbf. each

**Performance**

Maximum speed: Mach 2.5+ (1,650+ mph, 2,660+ km/h)
Ferry range: 2,400 mi (2,100 nmi, 3,900 km) with conformal fuel tank and three external fuel tanks
Service ceiling: 60,000 ft. (18,200 m)
Rate of climb: 50,000+ ft/min (254+ m/s)
Thrust/weight: 0.93

**Armament**

Guns: 1× 20 mm (0.787 in) M61 Vulcan 6-barreled gatling cannon, 510 rounds of either M-56 or PGU-28 ammunition
Hardpoints: 2 wing pylons, fuselage pylons, bomb racks on CFTs with a capacity of 23,000 lb (10,400 kg) of external fuel and ordnance

**Avionics**

Radar: Raytheon AN/APG-70

**Targeting pods**

AN/AAQ-14 Sharpshooter or Lockheed Martin Sniper XR or AN/AAQ-28(V) LITENING targeting pods.
Getting to know your new desk

Getting to know the F15E, its weapon system, its avionics, its engines, cockpit, functions and switches is the key to your full enjoyment of the Iris F15E Strike Eagle. We made every effort to reproduce the system as it is in real life based on its technical order. Once you step onboard this F15E, you will be capable of enjoying the same sensation a real F15E pilot and his/her WSO experience enjoy, as they hop onto their cockpit, strap themselves up and get ready for their assigned mission of the day.

Cockpit Overview

Pilot instruments and controls are divided into three main sections: one is the main instrument panel and the other two are the left and right consoles, located on each side of the pilot's seat. A huge effort has been made to reproduce the myriad of displays, switches and other controls with as much fidelity as possible...
Descriptions of the numbered controls displayed above:

(1) Mirrors - Three canopy frame mounted rear view mirrors (left, middle, right) which help increase pilot's Situation Awareness by being able to monitor part of the airspace behind the aircraft.

(2) Lock/Shoot Lights - Two orange signal lights built into the canopy frame blinking when a missile lock is achieved (in A/A mode).

(3) Air Refuelling Ready Light - Illuminates when the aircraft is ready for refuelling boom engagement (after the air refuelling process has been initiated by the pilot).

(4) Chart Light - A small directional reading light.
(5) **Head-Up Display** - The HUD is used to project useful flight related information right into the pilot’s forward vision. For more details please refer to the Head-Up Display section in the avionics chapter.

(6) **Standby Magnetic Compass** - Although an electronic compass strip is constantly displayed on top of the HUD, the Strike Eagle also uses a completely conventional magnetic compass built into the canopy frame.

(7) **Up-Front Control** - The UFC is a control panel which houses functions such as radio and navigation control & autopilot control.

(8) **Warning Lights** – A set of red warning lights provide indication of system malfunctions that require immediate crew attention.

(9) **Multipurpose Displays or Multi-Function Displays** - Two large LCD displays used to present multiple information to the pilot (A/A radar picture; A/G radar picture; FLIR picture, HSI etc.). Both of them are green monochrome (MPD's).

(10) **Cautions Lights** – Yellow lights are cautions lights, and are classified as major category caution lights.

(11) **Hydraulic Pressure Indicators** - Conventional gauges to display pressures of critical hydraulic systems.

(12) **Clock** - A conventional analog clock.

(13) **Data Transfer Module Receptacle** - The DTM is used to enter pre-designed mission information to the aircraft’s onboard computers. The DTM cartridge is prepared on mission planning computers during the mission planning phase and should be inserted into this receptacle before the mission.

(14) **Cockpit Pressure Altimeter** - A traditional gauge showing cockpit pressure on an altitude scale between 0 and 50,000 feet.

(15) **Engine Monitor Display** - A digital display to present information about the engines of the aircraft. For further details please refer to the Engines chapter.

(16) **Fuel Quantity Indicator** - A combined indicator to display different fuel quantities.

(17) **Caution Lights Panel** – Another set of caution lights each responsible for one specific system. They illuminate to indicate the occurrence of a caution condition.

(18) **Emergency Vent Handle** - When turned 45° CCW, electrically dumps cabin pressure. Extension of the handle shuts off ECS air to the cockpit and allows ram air to enter the cockpit (the amount is controlled by how far the handle is extended).

(19) **Holding Brake Switch** - Switch to engage the holding brake.
(20) Jet Fuel Starter Control - A control handle to start the JFS. For more details please refer to the Jet Fuel Starter section.

(21) Multipurpose Color Display - A large LCD display are used to present the same information as on the other two MFD’s. To the contrary of the other two MFD’s this one is a color one.

(22) Rudder Pedal Adjust Knob - Knob used to adjust the rudder pedals to the pilot’s personal preferences. The knob should be pulled out to adjust the rudder pedals (pushing feet against a spring pressure) and pushed back in to fix them in their adjusted position.

(23) Circuit Breaker Panel - Panel containing an array of circuit breakers.

(24) Cockpit Cooling & Pressurization Outlet - Outlet for cockpit air exchange and cooling/heating.

(25) Emergency Stores Jettison Switch - Switch used to quickly jettison ordnance and/or external fuel tanks.

(26) Vertical Speed Indicator - Conventional gauge to indicate vertical speed. Since vertical speed is displayed on the HUD, this instrument serves as a backup.

(27) Angle-of-Attack Indicator - Conventional gauge that indicates the aircraft’s Angle of Attack. Since the AoA is displayed on the HUD, this instrument serves as a backup.

(28) Emergency Brake/Steering - A handle to be pulled out for emergency braking/steering.

(29) Pitch Ratio Indicator - Conventional gauge to show the ratio of symmetrical stabiliser motion to longitudinal stick motion (value between 1 and 0, the bigger the value, the bigger the stabiliser motion for a given stick motion). Naturally, the higher the aircraft speed is, the lower ratio value is needed to pitch the aircraft.

(30) Pitch Ratio Select Switch - A two-way switch. When AUTO, normal pitch control functions are maintained. When EMERG, hydraulic pressure is removed from the hydro-mechanical pitch control system, which results the pitch ratio to move to a mid-range value (between 0.3 and 0.5) and lock there.

(31) Landing Gear Handle/Indicator Panel - A panel to operate landing gear and to display its status.

(32) Radio Call Panel - A panel to indicate radio calls.

(33) Emergency Landing Gear Handle - A handle used to emergency-rollover the landing gear (the gear doors open and the gear lowers by forces of gravity and drag).

(34) Arresting Hook Control Switch - A switch used to lower/raise the tail hook designed to catch the runway arresting cable in case of emergency.
(35) **Canopy Jettison Handle** - A handle used to emergency-jettison the canopy. Canopy is blown off by pyrotechnic charges.

(36) **Armament Control Panel** - A panel used to manipulate different armament settings.

(37) **Standby Airspeed Indicator** - A conventional gauge to indicate airspeed. Since airspeed is displayed on the HUD, this instrument serves as a backup.

(38) **Standby Attitude Indicator** - Gauge that indicates the aircraft attitude (also called as artificial horizon). It’s a completely mechanical backup indicator.

(39) **Standby Altimeter** – Altitude gauge. Since altitude is displayed on the HUD, this instrument serves as a backup.

(40) **Fire Warning/Extinguishing Panel** - A panel used to display and/or extinguish engine fire. For further details refer to the Fire Warning System section.

(41) **Caution Indicator (EMIS)** - An orange light which illuminates if the aircraft emits detectable electromagnetic energy (i.e. radar is emitting).

(42) **Master Caution Switch/Indicator** - An indicator to display and acknowledge a new caution status.
**Front Left Panel**

**- Front Miscellaneous Control Panel**

### Misc Control Panel

- **ROLL RATIO:** A two-way switch. When on AUTO mode, normal roll control functions are maintained. When on EMERG mode, the hydraulic pressure is removed from the hydro-mechanical roll control system, which results in the roll ratio to move to a mid-range value (between 0.3 and 0.5) and lock there.

- **INLET RAMP:** Controls engine air intake ramps. When on AUTO, the ramps are moved automatically. When on EMERG, the ramps are fully up.

- **ANTI SKID:** Controls the operation of the landing gear anti-skid system. When on NORM it operates normally. When on PULSER it always performs pulsing braking. When in the OFF position it does not operate.

- **LDG LIGHT/TAXI LIGHT:** Controls landing and taxi lights. When on LDG LIGHT, landing lights are turned on. When on TAXI LIGHT, taxi lights are turned on. When on OFF, both lights are turned off.
- **FUEL CONTROL SWITCHES (TOP ROW):** Controls fuel flow of wing drop tanks (WING), centerline drop tank (CTR) and conformal fuel tanks (CONF TANK). When on NORM, fuel transfers normally. When on STOP TRANS, no fuel is transferred at all. When on STOP REFUEL, no refuelling is allowed.

- **FUEL DUMP SWITCH (MIDDLE ROW):** Spring loaded and lever locked to its NORM position. When set to DUMP, fuel is dumped from board.

- **CONF TANK EMERG TRANS:** Used to emergency-transfer CFT fuel. When on NORM, no emergency-transfer takes place. When on L or R, center compartment transfer pumps are activated.

- **EXT TRANS:** Sets the transfer sequence of external fuel. WNG CTR refers to external drop tanks, CONF TANK refers to CFT's. The unselected tanks stops transferring fuel.

- **SLIPWAY:** Controls air refuelling receptacle door. When on CLOSE, the door is closed. When on OPEN, the receptacle door is opened. When on ORIDE, the door is opened, and additional functions are activated.
- **Front VMAX Arm Switch** - Temporarily adds approximately 4% engine performance increase. For further details please refer to the Engines section.

- **Front NCTR Switch** - Engages radar Non Cooperative Target Recognition mode. For further details refer to Radar System section.

- **Front Blank Panel** - Blank panel reserved for future developments.

- **Front Fly Up Enable Switch** - Enables fly-up with the terrain following system.

- **Front Seat Adjust Switch** - Used to electrically adjust the seat upward/downward.

- **Front EWWS Enable Switch** – Enables EWWS system.

- **Front Intercom Control Panel** and **Front IFF Antenna Select Switch** - Controls the intercom and IFF systems.

---

**Intercom Control Panel and IFF Select Switch**

- **IFF ANT SEL**: Selects which IFF antenna to use. UPPER for upper antenna, LOWER for lower antenna, BOTH for both antennas.

- **VOLUME KNOBS (TOP ROW)**: Knobs for setting different volumes. TEWS CAUTION and LAUNCH knobs are for TEWS caution and missile launch warning tones. ICS stands for internal communications system (that is intercom), WPN stands for weapon related tones,
ILS stands for instrument landing system localizer identification tone, and TACAN stands for tactical aid for navigation station identification tones.

- **CRYPTO**: A lever locked switch to set the storage of IFF Mode 4 crypto codes. When on NORM, codes are stored when aircraft power is on. When on HOLD, codes are stored after power down. When on ZERO, codes are zeroed. For further details refer to the IFF System section.

- **MIC**: Intercom function selector switch. When ON, it provides direct communication from the pilot’s cockpit. When OFF, the microphone cannot be used for intercom purposes. When on RAD ORIDE, it attenuates radio communications in favour of intercom communication. VW/TONE SILENCE: Button to silence voice warning (VW) tones.

- **UHF ANT**: Controls which UHF antenna to use for the UHF1 radio, UPPER or LOWER. When on AUTO, the radio selects the antenna with the best signal.

- **VHF ANT**: Controls which VHF antenna to use: UPPER or LOWER. When on AUTO, the radio selects the antenna with the best signal.

- **TONE**: Selects tone between UHF1 and UHF2 radios.

- **CIPHER TEXT**: Radio communication encoding switch. When on NORM, the radio can receive both coded and clear text communication. When in the ONLY position, the radio can receive only coded text communication.

- **MODE**: Lever locked switch to set IFF replies. B for Mode 4/B replies, A for Mode 4/A replies, OUT for no Mode 4 replies at all. For further details refer to the IFF System section.

- **REPLY light and switch**: The switch sets what feedback should be given once a Mode 4 IFF interrogation is received. When on LIGHT, the REPLY light illuminates. When on AUDIO REC, an audio tone is played. When on OFF, no feedback is given. For further details refer to the IFF System section.

- **MASTER**: Sets IFF system mode. When on LOW, low sensitivity is set. When on NORM, normal mode of operation is set. When on EMERG, emergency sensitivity is set. For more details see: IFF System.

- **Front Emergency Air Refuelling Control** - Opens air refuelling door by use of pyrotechnic devices. Process is irreversible and used in emergency only.

- **Front Armament Safety Override Switch** - Allows the landing gear handle safety interlock to be bypassed for armament circuit checkout. When on SAFE, normal circuitry is used. When on OVERRIDE, the switch is solenoid-held until electrical power is removed, the landing gear handle is placed UP, or the switch is put back to SAFE manually.
- Front Ground Power Panel

**Front Ground Power Panel**

- **1, 2, 3, 4:** For powering several aircraft systems. Each of these switches is responsible for a set of systems. When ON, systems are powered from a ground source. When on AUTO, systems are powered from the aircraft generator. The difference between A ON and B ON (switch 1) is that with on A ON, the automatic flight control system (AFCS) is not powered from the aircraft generator.

- **PACS:** Switch to power the programmable armament control set (PACS). ON for ground power, AUTO for aircraft generator power, OFF for no power.

- **CC:** Switch to power the central computer (CC). ON for ground power, AUTO for aircraft generator power, OFF for no power.

- **MPDP/AIU:** Switch to power the multi-purpose display processor (MPDP) and avionics interface unit (AIU). ON for ground power, AUTO for aircraft generator power, OFF for no power.
- **Front Control Augmentation Panel**

![CAS Control Panel](image)

- **YAW, ROLL, PITCH:** Enable/disable CAS control in the yaw, roll and pitch axis, respectively. ON for normal operation (after CAS control for respective axis is engaged). OFF to disengage axis. RESET to re-engage axis (after a fault).

- **BIT:** Button to activate built-in test of the CAS system.

- **TF:** Couples the TF system to the autopilot. When COUPLE, the TF system is coupled to the autopilot. When OFF, TF system is deactivated.

- **T/O TRIM:** Take-off trim button and light. When pressed the stick and rudder pedals move to the takeoff position (which in turn moves the control surfaces). Once there the light goes on and a warning tone sounds, which stops after the button is released.

- **Front Throttle Quadrant** - For further details refer to the Pilot Throttle section.
- **FORMATION**: Knob to set the brightness of formation lights. Settings are from 1 to 5, OFF to turn off formation lights.

- **ANTI-COLLISION**: Turns ON or OFF anti-collision lights.

- **VERT TAIL FLOOD**: Switch to set the brightness of vertical tail flood lights. BRT for bright, DIM for dim setting, OFF to turn them off completely.

- **POSITION**: Knob to set the brightness of position lights. Settings are from 1 to 5, OFF to turn off position lights.
- **TF RDR**: Controls the terrain following (TF) radar. When ON/OFF it turns the TF radar on/off. When on STBY it puts the TF radar in standby mode.

- **RDR ALT**: Controls the radar altimeter. When ON/OFF, the radar altimeter is activated/deactivated.

- **RADAR**: Controls the radar. The knob needs to be pulled before turning. When on OFF, the radar is completely turned off. When on STBY, the radar is put in SNIFF mode. When ON, the radar is turned on. The EMERG setting should be used in case of emergency only. For more details see: Radar System section.

- **INS**: Controls the inertial navigation system (INS). When on OFF, power is removed from the INS. When on STORE, the INS performs a stored heading (SH) alignment procedure. When on GC, the INS performs a gyrocompass (GC) alignment procedure. For normal navigation the INS knob should be turned to NAV setting.

- **NAV FLIR**: Controls the navigation FLIR. The GAIN LEVEL knob sets gain level. Switch ON/OFF turns the navigation FLIR ON/OFF, while switch STBY puts the navigation FLIR into standby mode.
- **JTIDS**: Controls the JTIDS. The knob needs to be pulled before turning. When on OFF, the system is turned completely off. When on POLL, the system sends out poll signals. When on NORM, normal operation is maintained. When on SIL, the system works without emitting (silent mode).

- **CC RESET**: Pushbutton to perform a central computer (CC) reset.
Front Right Panel

- Front Oxygen Regulator Panel

**Oxygen Regulator Control Panel**

- **FLOW**: Oxygen flow indicator. White for flow, black for no-flow. It changes with each breath.

- **Oxygen Pressure Gauge**: A round gauge to show oxygen pressure.

- **Emergency Lever**: Three-position lever. When on EMERGENCY, continuous positive pressure oxygen is delivered to the mask. When on NORMAL, normal operation is provided. When on TEST MASK, positive oxygen pressure is supplied.

- **Diluter Lever**: Two-position lever. When on 100%, pure oxygen is supplied. When on NORMAL OXYGEN, a mixture of air and oxygen is supplied.

- **SUPPLY**: Two-position lever. When ON, the proper mix of cockpit air and oxygen is supplied to the mask. When OFF, breathing is not possible with the mask on.
- **GEN L, R**: Lever locked switches to turn left and right generators on/off. For more details refer to the Engines section.

- **EMERG GEN**: Emergency generator switch. AUTO for automatic activation, MAN for manual activation, ISOLATE for powering critical systems only. For more details refer to the Engines section.

- **ENG CONTR**: ON to place engines in PRI control mode, OFF to place them in SEC control mode. For more details refer to the Engines section.

- **ENG MASTER L, R**: Guarded engine master switches to turn engines on/off. For more details see: Engines.

- **EXT PWR**: External power switch. NORM for allowing external power, OFF to disallow external power, RESET for establishing external power if it's not on the line (switch spring loads back to NORM). For more details refer to the Engines section.

- **STARTER**: JFS controls. The READY light indicates if the JFS is ready to be engaged. ON allows JFS to be engaged, OFF immediately disengages JFS. Actual JFS engagement is done by the JFS control handle (see main instrument panel (20), above). For more details see the Jet Fuel Starter section.
- **RCD/EOT**: RCD light illuminates green when a recording is in progress. EOT light illuminates white when the end of the tape is reached (or if not tape).

- **MIN REMAIN**: Counter to indicate the remaining minutes of recording on the tape.

- **RESET**: Push-and-turn button to reset the MIN REMAIN counter.

- **RECORD**: A two-way switch. When on ENABLE, enables VTRS recording (the INS should be activated). When on UNTHREAD, it unthreads the video tape (deactivating the INS also unthreads the video tape).
- **Front Compass Panel**

  - **Sync indicator meter:** Indicates the direction (plus or minus) between the AHRS directional gyro and the magnetic azimuth detector (MAD) in the slaved mode (see below).

  - **PUSH TO SYNC:** When pushed it synchronizes the gyro-magnetic compass to the MAD in the slaved mode.

  - **FAST ERECT:** Pushing this button re-erects the gyro for correct attitude sensing. Should be used in straight and level, un-accelerated flight only.

  - **N-S switch:** Select hemisphere. N for northern, S for southern hemisphere.

  - **LAT:** Latitude control knob. Used to manually insert present position latitude in DG and slaved mode.

  - **Mode selector knob:** When on SLAVED, directional gyro sensed heading is corrected to the MAD heading. When on COMP, only MAD directional information is used (emergency mode). When DG, only directional gyro sensed heading information is used (over areas where the Earth's magnetic field is appreciably distorted).
- **OXY TEST**: A button on the top left to initiate a built-in test (BIT) of the OBOGS system.

- **ANTI-FOG**: Controls the anti-fog system. HOT for hot air, NORM for normal temperature air and COLD for manually tempered air.

- **WINDSHIELD**: Turns on/off windshield heating for anti-icing.

- **PITOT HEAT**: Turns on/off pitot tube heating for anti-icing.

- **ENG HEAT**: Turns on/off the engine anti-icing system. When on TEST it performs a system test and turns on the INLET ICE caution.
- **TEMP switch**: A three-way switch to manage cockpit temperature. When on AUTO, cockpit temperature is automatically maintained at the temperature selected on the TEMP knob. When on MANUAL, cockpit temperature may be changed with the knob, but not maintained automatically. When on OFF, it shuts down off ECS air.

- **TEMP knob**: A rotary knob to set the cockpit temperature.

- **FLOW switch**: A three-way switch to select the air flow. MIN, MAX and NORM settings are available for minimum/maximum/normal air flow, respectively.

- **FLOW knob**: A four-position knob to set the air source. When BOTH, bleed air is supplied from both engines. When L ENG or R ENG, bleed air is supplied from the left/right engine only. When OFF, no bleed air is supplied.
- **CONSOLE**: Knob to set the brightness of the console instrument backlighting. OFF to turn it off completely.

- **INST PNL**: Knob to set the brightness of the forward instrument panel backlighting. OFF to turn it off completely.

- **LT TEST**: Switch spring loaded to its OFF position. When switched to ON, performs an interior lighting test.

- **UFC**: Knob to set the brightness of the up-front controller (UFC). OFF to turn it off completely.

- **STBY COMP**: Used to turn on/off the lighting of the standby magnetic compass on the canopy frame. When ON, lighting brightness is regulated by the INST PNL knob.

- **CHART LT**: Knob to set the brightness of the chart light on the canopy frame. OFF to turn it off completely.

- **DISPLAY**: Switch to set the display backlighting into DAY (no backlighting) or NIGHT (backlighting) mode.
**WARNING CAUTION:** Knob to set the brightness of the warning/caution lights. OFF to turn them off completely. For safety reasons, the knob must be placed momentarily to the RESET position to enable itself to set warning/caution lights' brightness.

**STORM FLOOD:** Knob to set the brightness of the storm/flood lights which provide secondary lighting in the cockpit. OFF to turn them off completely.

**Rear Panel**

Descriptions of the numbered controls displayed above are as follows:

1. **Up-Front Control** - The UFC is a control panel which houses functions such as radio setting, navaid setting etc...

2. **Multipurpose Displays** - Two large Monochrome LCD displays and two smaller colour LCD displays are used to present multiple information to the WSO. (A/A radar picture; A/G radar picture; FLIR picture, HSI etc).
(3) **Warning & Caution Lights** – A set of red warning lights and amber caution lights provide indication of system malfunctions that require immediate crew attention.

(4) **Clock** - A conventional analog clock.

(5) **Cockpit Pressure Altimeter** - A traditional gauge showing cockpit pressure on an altitude scale between 0 and 50,000 feet.

(6) **Rudder Pedal Adjust Knob** - Knob used to adjust the rudder pedals to the pilot's personal preferences. The knob should be pulled out to adjust the rudder pedals (pushing feet against a spring pressure) and pushed back in to fix them in their adjusted position.

(7) **Cockpit Cooling & Pressurization Outlet** - Outlet for cockpit air exchange and cooling/heating.

(8) **Vertical Speed Indicator** - Conventional gauge to indicate vertical speed. Since vertical speed is displayed on the HUD, this instrument serves as a backup.

(9) **Angle-of-Attack Indicator** - Conventional gauge that indicates the aircraft’s Angle of Attack. Since the AoA is displayed on the HUD, this instrument serves as a backup.

(10) **Landing Gear Handle/Indicator Panel** - A panel to operate landing gear and to display its status.

(11) **Emergency Landing Gear Handle** - A handle used to emergency-rollover the landing gear (the gear doors open and the gear lowers by forces of gravity and drag).

(12) **Arresting Hook Control Switch** - A switch used to lower/raise the tail hook designed to catch the runway arresting cable in case of emergency.

(13) **Canopy Jettison Handle** - A handle used to emergency-jettison the canopy. Canopy is blown off by pyrotechnic charges.

(14) **Standby Airspeed Indicator** - A conventional gauge to indicate airspeed. Since airspeed is displayed on the HUD, this instrument serves as a backup.

(15) **Standby Attitude Indicator** - Gauge that indicates the aircraft attitude (also called as artificial horizon). It's a completely mechanical backup indicator.

(16) **Standby Altimeter** – Altitude gauge. Since altitude is displayed on the HUD, this instrument serves as a backup.
Rear Left Panel

- Rear Early Warning Control Panel

- **RWR/ICS**: A two-way switch. When in TRNG, the Radar Warning Receiver (RWR) and Integrated Communication Set (ICS) default to standard warnings and audio. When in COMBAT, the RWR and ICS switch to their standard combat based audio/warnings.

- **PODS**: Controls the actions of onboard early warning pods fitted to the aircraft.

- **ICS**: Controls the operation of the Integrated Communication Set (ICS). For the purposes of the *IRIS Mudhen Driver* product, all VMS audio is inhibited when the switch is in the **STBY** position.
**- Rear Intercommunications Set Control Panel**

**VOLUME KNOBS (TOP ROW):** Knobs for setting different volumes. TEWS CAUTION and LAUNCH knobs are for TEWS caution and missile launch warning tones. ICS stands for internal communications system (that is intercom), WPN stands for weapon related tones, ILS stands for instrument landing system localizer identification tone, and TACAN stands for tactical aid for navigation station identification tones.

**CRYPTO:** A lever locked switch to set the storage of IFF Mode 4 crypto codes. When on NORM, codes are stored when aircraft power is on. When on HOLD, codes are stored after power down. When on ZERO, codes are zeroed. For further details refer to the IFF System section.

**MIC:** Intercom function selector switch. When ON, it provides direct communication from the pilot’s cockpit. When OFF, the microphone cannot be used for intercom purposes. When on RAD ORIDE, it attenuates radio communications in favour of intercom communication.

**VW/TONE SILENCE:** Button to silence voice warning (VW) tones for up to 60 seconds.

**TONE:** Selects tone between UHF1 and UHF2 radios.

**CIPHER TEXT:** Radio communication encoding switch. When on NORM, the radio can receive both coded and clear text communication. When in the ONLY position, the radio can receive only coded text communication.
**Rear SENSOR Control Panel**

**TGT FLIR/Laser - Sensor Control Panel**

**TGT FLIR**: Controls the TGT FLIR. The GAIN LEVEL knob sets gain level. Switch ON/OFF turns the TGT FLIR ON/OFF, while switch STBY puts the TGT FLIR into standby mode.

**LASER**: A switch which controls the status of the LASER targeting feature of the LANTIRN system. The SAFE position indicates a standby operation of the unit, whereas ARM connects the unit to the onboard weapons systems.
Rear Right Panel

- Rear Oxygen Regulator Control Panel

**Oxygen Regulator Control Panel**

- **FLOW**: Oxygen flow indicator. White for flow, black for no-flow. It changes with each breath.

- **Oxygen Pressure Gauge**: A round gauge to show oxygen pressure.

- **Emergency Lever**: Three-position lever. When on EMERGENCY, continuous positive pressure oxygen is delivered to the mask. When on NORMAL, normal operation is provided. When on TEST MASK, positive oxygen pressure is supplied.

- **Diluter Lever**: Two-position lever. When on 100%, pure oxygen is supplied. When on NORMAL OXYGEN, a mixture of air and oxygen is supplied.

- **Supply**: Two-position lever. When ON, the proper mix of cockpit air and oxygen is supplied to the mask. When OFF, breathing is not possible with the mask on.
**- Rear TEWS Control Panel**

- **ICS Switch** – A two position switch which controls if the TEWS audio feedback is on or off. For the purposes of the **IRIS Mudhen Driver** product, this switch when used in conjunction with the TEWS volume knob, activates various TEWS audio elements based on proximity to NAV waypoints.

- **TEWS SET-1 thru 3**: Two position switches which turn TEWS SET-1 thru 3 between automatic and manual modes of operation.

- **RWR switch**: A master two position switch which turns the Radar Warning Receiver (RWR) functions within the aircraft on or off.

- **Electronic Warfare Warning Set Power and Tone Switches**: Two-position switches which control the use and audio of the EWWS system.
- **Rear Interior Lights Panel** - Manages the rear cockpit interior lighting.

- **CONSOLE**: Knob to set the brightness of the console instrument backlighting. OFF to turn it off completely.

- **INST PNL**: Knob to set the brightness of the forward instrument panel backlighting. OFF to turn it off completely.

- **LT TEST**: Switch spring loaded to its OFF position. When switched to ON, performs an interior lighting test.

- **UFC**: Knob to set the brightness of the up-front controller (UFC). OFF to turn it off completely.

- **STBY COMP**: Used to turn on/off the lighting of the standby magnetic compass on the canopy frame. When ON, lighting brightness is regulated by the INST PNL knob.

- **CHART LT**: Knob to set the brightness of the chart light on the canopy frame. OFF to turn it off completely.

- **DISPLAY**: Switch to set the display backlighting into DAY (no backlighting) or NIGHT (backlighting) mode.
- **WARNING CAUTION:** Knob to set the brightness of the warning/caution lights. OFF to turn them off completely. For safety reasons, the knob must be placed momentarily to the RESET position to enable itself to set warning/caution lights' brightness.

- **STORM FLOOD:** Knob to set the brightness of the storm/flood lights which provide secondary lighting in the cockpit. OFF to turn them off completely.

**- Rear Countermeasures Dispenser Panel**

- **DISP SEL switch:** Three position switch which controls if chaff, flare or both are dispensed by the CMD system.

- **MODE knob:** Knob to set the mode of operation for the CMD system. For the purposes of the IRIS Mudhen Driver product, In Semi-Auto mode, the CMD system will launch flares for a short time after release of onboard air to ground weaponry as a precautionary measure.
HUD

The F-15E HUD (Kaiser IR-2394/A) is much larger than the HUD in previous F-15 versions (A, B, C, D), thus letting the system display more information. It provides a 21° x 28° field of view. Note that although the HUD glass is more or less rectangular, the limits of the maximal projected area are rounded thus no image can be projected to the very edges of the HUD. Symbology projected to the HUD appear in green, its appearance can be controlled by the pilot, using the HUD controls under the UFC (Up-Front Controls).

The HUD control rack is located in the middle of the pilot's dashboard, right below the UFC. The rack contains all the control switches and knobs necessary for managing the appearance of the HUD symbology. Note that this rack houses the master mode selector buttons as well, which too have effect on the information displayed on the HUD.

**Brightness Knob** controls the brightness of the stroke symbology. Note that due to its nature, stroke symbology is always displayed at a 'maximum contrast setting'.

**Symbol De-clutter Switch** serves as a de-clutter switch for the HUD. When set to 'NORM', all stroke symbology appears on the HUD. When set to 'REJ1' or 'REJ2' some or all of the stroke symbology is removed from the HUD. Note that the pilot can program which symbology should be removed and which should remain in any of these settings. Brightness Knob #1 and Symbol De-clutter Switch together are labelled as ‘SYM’, since they control the appearance of stroke symbology on the HUD.
**Day/Night/Auto Switch** sets the HUD display mode. When set to 'DAY', HUD symbology illumination goes to max power so information displayed on the HUD should be visible even in bright daylight. When set to 'NIGHT', symbology illumination is low, but still clearly visible against the dark sky. When set to 'AUTO', symbology illumination varies depending on ambient lighting. Note that oddly enough, in 'AUTO' mode, the HUD does not provide enough illumination in the dark.

**BIT Button and BIT Indicator** are used during maintenance when the HUD's built-in test function should be engaged.

**Video Brightness Knob** controls the brightness of the raster (video) symbology.

**Contrast Knob** controls the contrast of the raster symbology. Video Brightness Knob and Contrast Knob together are labelled as 'VID', since they control the appearance of video imagery on the HUD.

HUD symbology largely depends on which master mode the aircraft is on. However, here is some of the basic symbology present on an F-15E HUD.
FLIGHT CONTROL SYSTEMS

The F-15E uses a semi-fly-by-wire flight control system, inputs from the stick and rudders are fed to the FCS (Flight Control System) electronically and the system (in cooperation with other systems of course) decides how to move the control surfaces in response of the pilot's hand and feet movements.

Being a two-seat fighter, the F-15E has its flight controls doubled: both the pilot and WSO do have their own flight controls. The both of these can control the jet at any given moment, thus making crew coordination absolutely necessary to prevent both aviators to steer the jet at the same time (in opposite directions as a worst case scenario). As a default, it is the pilot who has full control and responsibility over the jet, however he may choose to transfer this to his WSO.

Pilot Flight Stick

As the F-15E uses a semi-fly-by-wire flight control system, stick input is fed to the system electronically. Therefore no mechanical links exists between the stick and the flight control surfaces. The stick moves the control surfaces in a traditional way, i.e. longitudinal stick movement results in horizontal stabilator deflection (from a level flight, pulling the stick back makes the aircraft raise its nose and climb, pushing the stick forward makes the aircraft lower its nose and descend), while lateral stick movement results in adverse aileron deflection (pushing the stick left makes the aircraft roll left, pushing the stick right makes the aircraft roll right).

Directly underneath the stick grip, the stick force sensor box, which senses the force the pilot deflects the stick with and feeds this input to the AFCS (Automatic Flight Control System). It does not mean that the stick senses only deflection force and does not move in itself (like in an F-16) - it can be moved around in the space available between the knees of the pilot. Stick deflection translates to electrical signals for the AFCS and by moving the stick the pilot mechanically moves parts (linkages, rods, cables, etc.) which lead to the control surfaces as well. By the same token, the F-15E has double steering control: if the AFCS fails, the jet still can be steered mechanically and vice versa, if the mechanical steering system fails, the AFCS is still there to control the jet. In normal operation they work together for a smooth, fully optimized flying experience.
1 - **Castle Switch**: This switch has lots of functions. Tipping it in a direction scrolls the image on the MPD (or MPCD) in command to the given direction. The castle switch can also be used to put an MPD (MPCD) in command: to do this the castle switch should be pressed down first momentarily, then it must be tipped in the direction of the MPD (MPCD) to be put in command: tip left for left MPD, tip right for right MPD, tip aft for MPCD.

When tipped in conjunction with the coolie hat on the throttle (the coolie hat must be tipped down simultaneously) it can make the NAV FLIR snap look: tip forward to snap look down, tip aft to snap look up, tip left to snap look left, tip right to snap look right.

When tipped in conjunction with the master caution light it can be used to display the caution control screens on one of the MPD's (MPCD): while keeping the master caution light pressed, tip left for left MPD, tip right for right MPD, tip aft for MPCD.

2 - **Trim Switch**: This is what its name tells: it is used to make steering trims during flight. Tipping it forward makes the aircraft lower its nose, tipping it backward makes the aircraft raising its nose, while tipping it sideways makes the aircraft lower its respective wing. If pressed down it engages the manual 1 program of the CMD (i.e. releases chaff).

3 - **Auto Acquisition Switch**: This switch handles most of the functions on the pilot stick, which is logical, since it is the switch which can be handled by the thumb of the pilot the most easily while grasping the stick. Besides the ability to be pressed, the auto acquisition switch can be tipped
forward and aft as well. The exact function triggered by pushing and tipping it depends on which 'mode' the aircraft is currently in. Here is a list of the different 'modes' and functions available:

- During in-flight refuelling, pressing the switch down disengages the refuelling probe (if connected).

- When TSD is displayed on the MPD/MPCD in command, tipping the switch forward and aft creates smaller and larger target cue footprints (i.e. the area around the target which will appear on a HRM), respectively, while pressing the switch down returns to the present position map.

- When viewing a HRM or an RBM, tipping the switch forward sets a smaller window, tipping the switch aft sets a larger window, while pressing the switch down rejects current mode (or performs an MN reset if the cursor function is MN update). In addition to these tipping the switch aft when viewing a HRM enables/disables pattern steering line if cursor function is target.

- When using the targeting FLIR in manual mode, tipping the switch forward alternates between narrow and wide FOV's, tipping the switch aft returns to cueing mode, while pressing the switch down alternates between track and untrack modes (or performs an MN reset if the cursor function is MN update).

- When a guided A/G weapon view is displayed, tipping the switch forward cages/uncages the weapon's seeker head. Pushing the switch down enables slewing, while releasing the switch issues a track command.

- In connection with the A/G HUD, tipping the switch aft toggles between some A/G bombing modes (AUTO/CDIP, CDIP/DIRECT).

- When A/A radar screen is displayed on the MPD/MPCD in command, tipping the switch forward toggles between some A/A radar search modes (SS/BST, HDTWS/RAM), tipping the switch aft toggles between other A/A radar search modes (vertical scan, normal TWS), while pressing the switch down rejects current mode.

4 - Paddle Switch: This switch can be pressed (pulled back) momentarily and continuously. If pressed momentarily during flight it disengages autopilot. If pressed momentarily on the ground (WOW is sensed) it terminates AFCS BIT. If pressed and held during flight it can be used (with conjunction to stick movement) to override the terrain following system with manual stick steering. If pressed and held on the ground it disengages nose wheel steering (done by rudder pedals when WOW is sensed).

5 – Nose wheel Steering Button: If pressed and held on the ground (WOW is sensed) it puts nose wheel steering in manoeuvre mode, that is extreme wheel turns can be achieved - this is useful when making sharp turns during taxiing. If pressed in A/A master mode it cages the seeker head of the missile and uncages it when released. If pressed in A/G master mode it does the same (cage/uncage) with a guided weapon's seeker head.
6 - **Gun Trigger:** This trigger has two detents. Pressing it to the first detent starts camera video, pressing it to the second detent fires the gun (provided that the master arm switch is 'ON'). Releasing the trigger stops camera/gunfire.

7 - **Weapon Release Button:** When pressed momentarily, this button lets loose whatever weapon is set for release (drop A/G ordnance, launch A/A missile, etc. Pressing this button when not in weapon release mode enables programmed recording with VTRS (on-board video recorder).

**Pilot Throttle**

Being a twin-engine fighter the F-15E’s throttle is split into two halves, each controlling its respective engine.

1 - **Boat Switch:** This is a 2-way switch. Tipping the switch aft always un-designates the current target. Tipping the switch forward in A/A radar mode or in A/G guided weapon mode rejects current missile.

2 - **Speed Brake Switch:** This is a 3-way switch. When tipped forward it retracts the speed-brake, when tipped aft it extends the speed-brake. Left in the center it holds the speed-brake in its current position.

3 - **Microphone Switch:** This is a 2-way switch. When tipped forward the pilot can transmit on radio channel 1, when tipped aft the pilot can transmit on radio channel 2. Channels 3 (forward tip) and 4 (aft tip) will be available in the future.
4 - Right Multi-Function Switch (Coolie Hat): The 4-way coolie switch is again a multi-functional switch, which earned its name by being similar in shape to the typical, wide hat of rice-plant workers in the Far East. The exact functions performed by tipping the switch in a direction depend on what the pilot is doing at the moment.

-When the targeting FLIR is used, tipping the switch up selects the next sequence point.

-When any of the following is viewed: HRM, RBM, BCN, SET, PVJ, TSD, tipping the switch up selects the next sequence point, tipping it down invokes one from the following functions (depending on the type of screen viewed): missile bore-sight, gun-sight stiffen, look into turn. When tipped inboard it activates EWWS/NCTR and when tipped outboard it performs an IFF interrogate.

-In A/A radar mode, tipping the switch up performs a quick step, tipping it down invokes missile bore-sight/gun-sight stiffen /look into turn. When tipped inboard it activates EWWS/NCTR and when tipped outboard it performs an IFF interrogate.

-When controlling an A/G guided weapon, tipping the switch down invokes weapon bore-sight. When tipped inboard it activates EWWS/NCTR and when tipped outboard it performs an IFF interrogate.

5 - Target Designator / LOS Slew Control: The TDC switch is a 4-way switch which can be depressed as well (TDC stands for Target Designation Control). A typical use of the switch is to press it, select something by tipping it to directions while keeping it pressed (move a cursor, for example) and then invoke a function to the selected point with releasing the switch. Note that the switch senses the force it is tipped to a direction - the stronger it is tipped, the faster the cursor moves. As with many HOTAS controls, the exact functions performed depend on what the pilot is doing at the moment.

-When the targeting FLIR is used, pressing the switch enables LOS control, tipping the switch moves LOS and releasing the switch designates the point selected by LOS.

-When a HRM or RBM is viewed on an MPD/ MPCD, pressing the switch enables cursor control, tipping the switch moves the cursor and releasing the switch designates the point marked by the cursor.

-In A/A radar mode the TDC switch can be used to control the acquisition symbol. Pressing the switch puts the A/A radar in mini-raster search mode, tipping the switch moves the target designator cursor and releasing the switch designates selected target.

-When viewing the TSD display on an MPD/ MPCD, pressing the switch invokes range/bearing line control mode, tipping the switch moves the line and releasing the switch issues a cue command with the selected range/bearing line setting.

-When controlling an A/G guided weapon the TSD switch moves the LOS of the weapon.
-When the HUD is in command (either in NAV, A/A or A/G master mode) the switch controls the HUD TD circle or TD diamond. Pressing the switch enables LOS control, tipping the switch moves the TD circle or diamond and releasing the switch designates the selected target.

-When the navigation FLIR is viewed on an MPD/MPCD, the TDC switch handles the electrical bore sight slewing.

6 - Left Multi-Function Switch: It is a simple pushbutton which can invoke multiple functions, depending on the ‘mode’ the jet is currently in.

-When the targeting FLIR is used, pushing the button fires the targeting laser, releasing the button stops lasing.

-When a HRM or RBM is viewed on an MPD/MPCD, pushing the button freezes the map, releasing the button unfreezes it again.

-When the HUD is in command (either in NAV or INST master mode), pushing the button cages the velocity vector, releasing the button un-cages it again.

-When viewing the TSD display on an MPD/MPCD, pushing the button engages track mode, releasing the button exits track mode.

7 - Antenna Elevation Control: This wheel can be rotated up or down and it controls the elevation of the A/A radar antenna.

8 - CMD Dispenser Switch (Pinky Switch): This is a 2-way switch. When tipped up it engages CMD manual 2 program (semiautomatic countermeasure dispensing), and when tipped down it engages CMD manual 1 program (dropping chaff).

9 - Finger Lifts: These levers can be pulled up. When pulled up each one starts its respective (left or right) engine, provided that JFS is running.

10 - Flap Switch: This switch engages/disengages flaps. Note that flaps can be placed only in full up or full down position - no intermediate position is available.

11 - Rudder Trim Switch: This is a 2-way switch which is used to trim the rudders. When tipped left or right it deflects the rudder thus yawing the jet in the respective direction.

12 - Weapon/Mode Switch: This is a 3-way switch. When tipped forward it places MRM (if any) in priority, when tipped aft it places the gun in priority. Put in center selects SRM (if any) in priority. Default setting is MRM.

Friction Adjusting Lever: This is a lever at the base of the throttle quadrant, in front of the rudder trim switch. This lever is used to adjust the force that must be exerted to move the throttle. Moving the lever forward increases the force, moving it aft decreases it.

Avionics
Radar

The heart of the F-15E's electronics suite is the AN/APG-70 radar developed by Hughes Aircraft Co. The AN/APG-70 is a highly reliable pulse doppler I/J band (8-20 GHz) multi-mode radar with improved maintenance features. It has both air-to-air and air-to-surface capabilities. It had been developed as part of the F-15E MSIP II programme (Multi-Stage Improvement Programme). It is sometimes called as an upgrade of the AN/APG-63 but in reality it is a brand new radar which has a couple of things common with the AN/APG-63. The AN/APG-70 was designed for greater reliability and easier maintenance.

The new AN/APG-70 unit has multiple bandwidths for high-resolution ground mapping using SAR technology. Several new radar modes were added, such as TWS (track-while-scan), which makes it possible to launch BVR missiles at separate targets simultaneously. Gate array technology enabled the AN/APG-70 to incorporate modes not available in earlier radars while providing greatly enhanced operational capabilities in other modes.

The increased processing power made it possible to implement Non-Cooperative Target Recognition (NCTR) technology, which provides the ability to distinguish more reliably between friendly and hostile aircraft.

The AN/APG-70 radar also had a Low Probability of Intercept (LPI) capability, which makes it able to detect and direct attacks on enemy aircraft without its emissions being easily seen by the
enemy. This means that the radar can be quickly switched on to obtain a single-sweep synthetic aperture image of a target area, then rapidly switched off seconds later (or by another words, put in SNIFF mode), making it difficult for an enemy to pick up the emissions and track the F-15E's location and flight path. Putting the radar in SNIFF mode is absolutely essential during aerial refuelling - otherwise the powerful microwave radiation emitted from the radar would cause severe injuries to the boom operator from such a short distance. For this reason a special security measure is installed into the radar which prohibits emitting radar energy when the aircraft is on the ground.

**Air-to-Air Features**

The AN/APG-70's can be put in A/A mode by taking command of an A/A radar display of one of the MPD's, in this mode its A/A features become available. In A/A mode, AN/APG-70 has several search modes of which only one can be active at a time. These modes can be selected by using the push buttons on the lower edge of the MPD/MPCD where the A/A radar screen is.

Targets picked up by the AN/APG-70 in either mode are displayed as "blips" on the A/A radar screen on the MPD/MPCD the aircrew had selected. The radar's software incorporates a special algorithm to filter out returns from ground moving objects. It has three sensitivity settings to filter out returns from objects moving slower than 45, 63 or 87 knots. This algorithm comes also handy when returns from dropped chaffs (which slow down rapidly after dropping) should be filtered out - however the AN/APG-70 has other algorithms to filter out false chaff returns.

The radar beam operates by periodic scanning (at a normal scan rate of around 70 degrees per second), which means that it detects and re-detects the same target from time to time, so some time elapses between two consecutive detections of the same target. The target (especially fast moving targets) can move considerably within this time between successive detections, which means that the target blip displayed on the screen can lose its 'actuality' quite fast. This phenomenon is called target aging. Since the radar beam - due to the time it requires to take a full scan - cannot provide movie-like display of the aerial situation, target aging is handled by the MPD processor. The 'older' the target, the less bright its blip is on the A/A radar screen. If the pilot wishes so, the result of the past few scans can be displayed simultaneously on the screen (as a series of blips with ever decreasing brightness as the target ages), thus depicting the movement of the target.

In A/A mode five different radar frequencies can be selected manually to avoid interference with the radars of other F-15E's of the same flight.
The AN/APG-70 features a ‘mode’ called NCTR (Non-Cooperative Target Recognition). Using NCTR the radar analyzes returns from the target and tries to identify the type and model of the target from certain tell-tale signs (returns from turbine and fan blades if the target flies at such aspect that the radar can ‘have a look’ at engines). NCTR utilizes a massive and continuously updated database of radar returns of different aircraft types and models - returns received from the actual target are searched in and compared to this database to have an ID of the target. NCTR is activated either automatically or manually and NCTR data are displayed on the radar screen. Since this is a highly advanced feature of the AN/APG-70, most of it is classified.

**AN/APG-70 has the following A/A modes:**

**Range While Scan (RWS) modes:** The RWS mode provides all-aspect (nose-on, tail-on) and all-altitude (look-up, look-down) target detection. This is the most commonly used mode upon nearing a hostile environment. It is a good balance of wide volume, and fairly rapid scan. This mode is used to resolve (detect) multiple targets separated by less than the antenna beam-width, at long range. There are three RWS modes, depending on what pulse repetition frequency (PRF) is used for emitting radar energy. In RWSH mode high PRF is used, while in RWSM mode medium PRF is used. High PRF’s are better to detect distant contacts with high closure rates with the risk of low or no-closure contact not showing up on the radar screen. Medium PRF’s are not very good on long ranges since they are subject to clutter when receiving returns from long ranges, but they are useful for detecting medium-range low closure targets or targets which are below the radar water line. A good mixture of high and medium PRF’s is realized in RWSI mode (interleaved RWS) when the radar emits energy alternating between high and medium PRF’s as it scans through bars.

**Range Gated High (RGH) mode:** This mode uses a single PRF somewhere between those used in RWSH and RWSM modes. Returns are processed electronically to find low and high closure targets. This mode may not be as accurate as RWSI, but can find certain targets more quickly. Note that this mode can detect targets up to a 160 nm range, but it is sensitive to altitude, it can be confused by ground clutter below 4000 feet.

**Velocity Search (VS) mode:** This mode is specifically for detecting medium and high closure targets, with the cost of not detecting low and no-closure targets at all. This mode displays targets on the radar screen by azimuth and velocity instead of by azimuth and range. Note that sometimes a fast moving part of the target (a turbine blade for example) can make VS mode detect a speed much higher than the actual speed of the target itself. This phenomenon is called Jet Engine Modulation (JEM).

**Vector (VCTR) mode:** The scan rate for this mode is half as normal, about 35 degrees per second. This means that a full scan takes twice the time, but the computer uses this time to make extra work, thus enhancing the detection of objects which have a low radar cross section (RCS). Lower RCS contacts are picked up from greater distances by using VCTR mode. This mode uses high PRF’s only.

**Track While Scan (TWS) modes:** Track-while-scan means that the radar does its normal right-to-left, left-to-right scanning while it is actively tracking a couple of targets. TWS uses either high or medium PRF’s. In TWS mode the radar beam covers an area much smaller than the maximal 120 degrees, but this way the target updates are much quicker. In takes around 2 seconds for the...
radar to complete a full scan. The arc and number of bars covered by TWS scan can be set to different settings: ‘wide’ (60 degrees with 2 bars), ‘medium’ (30 degrees with 4 bars) and ‘narrow’ (15 degrees with 6 bars).

Since the radar normally can cover a 120 degree arc in front of the jet, it can be manually slewed in TWS mode, which means that the actually scanned area (15, 30 or 60 degrees) can be placed anywhere within the 120 degree limits.

The AN/APG-70 stores tracking information of up to 10 targets in TWS mode. This track record serves as a defence against losing radar contact - if a target disappears from the screen, the system extrapolates from its track records and tries to predict where the target should be next and then tries to re-acquire the target at the predicted spot. Additionally TWS provides speed and heading information to targets. Screen symbology of speed and heading information are small ‘vector sticks’ to point from the dot representing the target. The vector stick points to the heading of the target (the top of the screen meaning a heading of north) while the length of the stick illustrates the speed of the target. This is very useful for the aircrew to get a quick overall impression of the tactical situation. In TWS mode it is possible to put the designation cursor over a target to get important data of it (altitude, range, closure rate, heading, aspect angle, true airspeed) without locking up the target - this way triggering the target’s RWR systems can be avoided.

There is a sub-mode in TWS which is called High Data Rate TWS (HDTWS). This mode halves the 2 second time needed for a full scan to 1 second at the price of halving the number of bars scanned. In HDTWS mode the radar scans either a 30 degree arc with 2 bars (called ‘high data’ TWS) or a 15 degree arc with 3 bars (called ‘three-bar HD’ TWS). Slewing is also possible in both HDTWS sub-modes.

The AN/APG-70 provides another sub-mode within TWS, other than HDTWS sub-modes. This sub-mode is designed to help target sorting, that is to make a difference between two or more targets that are flying very close to each other.

**Single Target Track (STT) mode:** If the pilot marks a single target for tracking, then the radar enters STT mode and begins tracking that specific target. This tracking uses a 3 degree mini-raster of radar energy centered on the target with very quick scans thus rapid target updates. If STT mode is entered from any of RWSI, RWSH, RWSM, RGH, VS or VCTR modes, then all other contacts disappear from the screen. If STT mode is entered from TWS or from HDTWS mode, all other targets remain on the screen. In STT mode exact data of this single target are immediately available, such as altitude, range, closure rate, heading, aspect angle and true airspeed.

STT mode gives special aids to AIM-7 Sparrow usage (considered now obsolete). The AIM-7 Sparrow is a SARH (Semi-Active Radar Homing) missile, which means it has no radar of its own, but instead uses returns of radar signals originating from the launching F-15E for homing. Normally by entering into STT mode, the radar tries to switch to a medium PRF if it used a high PRF before. If the pilot places the AIM-7 Sparrow in priority, the radar tries to switch back to high PRF when the target enters into missile range. The AIM-7 Sparrow needs the high PRF for homing, since high PRF provides a more intensive signal exchange between the jet and the missile, hence makes homing easier. Since the SARH Sparrow requires continuous radar lock until impact, a numerical value is
also displayed for the pilot giving the maximum angle (in degrees) that is allowed to steer without reaching radar gimbal limits, thus breaking lock for the Sparrow.

**Dual Target Track (DTT) mode:** This is the same as STT mode, but it tracks two targets simultaneously. This mode supports the AIM-120 AMRAAM only (it is able to receive guidance from the F-15E in its non-active phase of flight) and provides no support for the AIM-7 Sparrow. DTT mode is rarely used since TWS mode is much better from practically every aspect.

**Auto Acquisition modes:** All the modes above are for detecting targets while target designation is done manually by the pilot. Sometimes the situation dictates otherwise. To aid the pilot in snap-locking a target, there are five modes of the AN/APG-70, all of which are designed to acquire and designate the target automatically, within the limits of the given mode. These modes are the following:

**Super Search (SS) mode:** SS mode projects a 20 degree circle onto the center of the Head-up Display (HUD). The radar locks up the first target within 500 feet and 10 nm that enters this circle.

**Bore-sight (BST) mode:** BST mode projects a 4 degree circle onto the center of the HUD. The radar locks up the first target within 500 feet and 10 nm that enters this circle.

**Long Range Bore-sight (LRBST) mode:** LRBST mode projects a 4 degree circle onto the center of the HUD. The radar locks up the first target within 3000 feet and 40 nm that enters this circle.

**Vertical Scan (VTS) mode:** In VTS mode the radar beam covers a vertical area of about 75 degrees azimuth and of an elevation between 5 degrees and 55 degrees above the nose of the F-15E. The radar locks up the first target within 500 feet and 10 nm that enters this area. This mode is useful for targeting enemy aircraft in a turning fight.

**Guns (GUNS) mode:** Despite its name GUNS mode has nothing to do with the built-in gun of the F-15E. It is just a moderate range and wide scan auto ACQ mode of the radar. In GUNS mode the radar scans a 60 degree azimuth and a 20 degree elevation area (that is 30-30 degrees to the left and right and 10-10 degrees up and down). The radar locks up the first target within 3000 feet and 15 nm that enters this area.

**Electronic Attack (EA) modes:** In EA modes, the radar automatically reconfigures itself when inevitable signs of enemy jamming activity are detected. Facing enemy ECM activity, the radar tries to select special search and tracking modes which are the least sensitive to enemy jamming.
Air-to-Ground Features
AN/APG-70’s A/G features are available for the aircrew when the radar is in A/G mode, which can be evoked by taking command of an A/G radar screen on one of the MPD’s. In A/G mode, AN/APG-70 utilizes SAR technology to map the targeted area to produce a bird’s eye view of it, where different ground features (as small as tanks, trucks, etc.) can be clearly distinguished. SAR (Synthetic Aperture Radar) technology requires to paint the target with radar energy from different ranges and azimuths. As a rule of thumb, the greater the size of the radar antenna, the better the resolution of the created map, which is often called as ‘patch map’ by fighter speak, or more officially a HRM - High Resolution Map. The size of the F-15E radar antenna is much too small to produce a useable patch map, therefore creating a SAR image requires the jet to fly offset to the direction of the targeted area and make a couple of ‘snapshots’ from different azimuths and ranges. This way (aided by a powerful computer) a large sized radar antenna can be simulated by the jets movement and great resolutions can be achieved.

The AN/APG-70 also has a feature called PVU (Precision Velocity Update). By doing PVU the radar scans 8 sectors of terrain in front of the jet quickly in order to update/validate the velocity values used by the Inertial Navigation System (INS) to keep position. This simple technique makes it possible for the aircrew to designate the target from the generated SAR radar image.

The AN/APG-70 has the following A/G modes:

Real Beam Map (RBM) mode: RBM mode displays radar returns from different terrain elements in front of the jet as an arc projected onto one of the MPD/ MPCD’s. On the image the F-15E is on the bottom of the display. The radar scans the terrain at a rate of 95 degrees per second. The range of the scan can be selected by the aircrew by choosing from the following values: 4.7 nm, 10 nm, 20 nm, 40 nm, 80 nm (this is a theoretical range of course, real ranges scanned depend on the LOS of the radar). Azimuth limits for the scan can also be set, available values are 50, 25 and 12.5 degrees to both sides of the F-15E (scanning 100, 50 and 25 degrees in azimuth, respectively). Having an RBM displayed the WSO can select a point within the displayed arc to be the center point of a HRM to create. Then HRM can be created (see HRM mode, below) of the terrain section represented by the selected point.

The RBM image can be frozen by pressing the laser fire button on the Throttle Quadrant (either pilot or WSO). With the image frozen the results of successive radar scans will not be shown of course, giving reason for the aircrew to put the radar in ‘SNIFF’ mode during this time, that is prohibiting any radar emissions to leave the AN/APG-70. This not just reduces the chances of detection by enemy, but lets the WSO place his cursor more easily on the RBM image to produce a HRM (note, that many WSO’s just don’t freeze the RBM at all).

High Resolution Map (HRM) mode: A HRM can be produced practically from any area that is scanned and is displayed on the RBM image. There are some limitations however. Because of the reasons mentioned above, while producing a HRM image the F-15E should NOT fly directly towards the target. The greater the azimuth to the target, the less time it will take for the computer to produce a HRM (which is generally around 4-10 seconds) and the better the quality of the HRM will be - so the quicker the better. Flight level is also a factor. If the jet flies too low, the range to create a good HRM might not be enough. If the jet flies too high, the HRM might loose important details.
The HRM image covers a rectangular area with equal sides. The size of this area (called DW - Display Window) can be selected by the aircrew before letting the computer generate the HRM. Available DW sizes are 0.67 nm, 1.3 nm, 3.3 nm, 4.7 nm, 10 nm, 20 nm, 40 nm.

Ground Moving Target (GMT) mode: Although the vehicles usually targeted (SAM's, trucks, tanks, etc.) do show up on the finest resolution HRM's, but they are still very difficult to pick up on a static HRM, especially if they are moving. To pick up moving ground objects the AN/APG-70 features a specific radar mode called GMT. GMT utilizes Doppler shifts of ground returns to detect ground movements. Note that it does NOT detect the moving objects themselves (nor does it identify them), it just pinpoint a geographical area where movement is detected from. Movement detection is not possible beyond 32 nm, regardless of the radar range settings. GMT provides the same ‘radar sweep’ display as in RBM mode, but non-moving ground objects and terrain is filtered out, only moving objects are shown as small, bright crosshairs. This way they are easy to designate thus pass their position on to other targeting systems such as the targeting pod or the video seeker of a AGM-65 Maverick missile for example.

Interleaved Ground Moving Target (IGMT) mode: IGMT is the same as GMT with respect to detecting moving ground objects. It however superimposes target crosses over the usual RBM image, thus giving the WSO the added advantage of seeing the targets in their surroundings. Detection limits and designation methods are the same as in GMT mode.

**IFF**

The Northrop Grumman AN/APX-101(V) Mark XII Diversity Transponder is the standard IFF Transponder on USAF F-16, F-15, A-10, KC-10A, E3A and F5E/F jets. The APX-101 contains two separate receiver and video processing channels, one for the upper antenna and one for the lower antenna. Normally the transmitter on the lower antenna is selected for transmission, since the lower antenna is usually seen by ground interrogators. The video processing circuitry measures the strength of the received messages, processes the stronger signal and directs the transmitter to reply using the antenna which received the stronger signal.

As for interrogator side, a BAE Systems (formerly Hazeltine) AN/APX-76 IFF interrogator informs the F-15E pilot if an aircraft seen visually or on radar is friendly or not. A Litton reply evaluator for the IFF system operates in conjunction with the AN/APX-76.

Ten T-shaped dipoles are placed all over the surface of the AN/APG-70 planar array. These dipoles working together are actually conforming the IFF main beam (sigma channel) as well as the omni-directional beam (diff channel). Embedded into the radar antenna dish the IFF antennae can take advantage of the scanning movement of the planar. The AN/APX-76 Interrogator is able to generate 2-8 kW pulse power at a frequency of 1.03 GHz.

**Working with the AN/APG-70 Radar**

The IFF Interrogator usually supports two modes of operation. When the radar operates in TWS (Track-While-Scan) mode the Interrogator can be continuously interrogating to detect the codes of all platforms carrying an operative Transponder, since the IFF also has the capacity of locating targets in distance and azimuth, the echo detected by the radar and the plot detected by the IFF can be integrated in a single target and presented to the pilot as a cooperative platform. Due to
this mode of operation a picture of all collaborative platforms in the airspace can be obtained. However this mode is seldom used in a battle environment since the interrogating platform constitutes a source of continuous high power radio emission that can be easily detected by an RWR (Radar Warning) system which immediately classifies it as a military platform.

The other mode of operation is when the radar is operating in STT (Single Target Track) mode in a battle environment and a particular target is locked by the radar. Then a last chance of identification is performed by sending a burst on Mode 4 interrogation ("squawk ID" request) to the platform locked up in order to obtain a friendly response. If no feedback response (an audio signal informs the pilot about target friendship) is obtained and no voice-radio contact is obtained, then usually the platform is classified as hostile and treated accordingly.

The Transponder is a fully asynchronous system. The pilot manually enters the codes of all modes of operation (Modes 1, 2, 3/A or 4) before taking off and activates the Transponder. When the platform is interrogated by a ground station (Air Traffic Control Tower using only modes 3/A and C) the Transponder automatically sends the reply without the pilot being aware of this. If the mission requires EMCON (Emission Control, which means, no electromagnetic signals should be transmitted) the Transponder is automatically switched to standby mode.

Note that the pilot has ways of knowing when his platform is interrogated in Mode 4 (cryptographic). If a Mode 4 interrogation is received and a FRIEND response is transmitted, then the REPLY light illuminates and/or an audio tone sounds, depending on the pilot's preferences (see below). On the other hand, if a Mode 4 interrogation is received and the Transponder is not able to send a FRIEND reply, this generates an IFF Mode 4 caution on the MPD/ MPCD and the Master Caution light illuminates, thus letting the pilot know that he is treated as enemy by the interrogating platform.
Pilot Controls

The codes for modes 1 and 3/A can be set in the cockpit. Mode 2 is set using the control box in door 3R. Mode 4 is keyed in door 3R by maintenance personnel using the KIK. Mode 2 cannot be changed in flight. Mode 4 can be changed between 4A and 4B during flight and the codes can be zeroed.

The Interrogator control panel contains the controls providing A/A target identification (AAI). Controls for the IFF Transponder are located on the remote intercom panel in the front cockpit and the UFC. The following figure illustrates the placement of the IFF Transponder controls:

![Intercom Control Panel and IFF Select Switch](image)

The functions of these controls are the following:

**Mode 4 Selector Switch:** This is a lever-lock switch with the following positions:

'B' Enables Mode 4/B reply
'A' Enables Mode 4/A reply
'OUT' Disables all Mode 4 replies

**Mode 4 Reply Switch:** This switch has the following positions:

- **LIGHT:** When the Mode 4 system replies to valid interrogation being transmitted above a minimum threshold rate, the REPLY light illuminates.
- **AUDIO REC**: Allows audio tone when valid interrogations are received. The light operation works as described in 'LIGHT' above.
- **OFF**: Disables the Mode 4 'LIGHT' and 'AUDIO REC' functions.

**Master Switch**: This switch has the following positions:

- **LOW**: System operates with reduced sensitivity. Mode reception is reduced; however Mode 4 response to a valid interrogation is normal.
- **NORM**: System operates at full sensitivity.
- **EMERG**: Selects normal sensitivity IFF operation. Allows the system to respond to interrogation in Modes 1, 2, 3A, C and 4.

**IFF Antenna Selector Switch**: The Antenna Selector Switch is located on the pilot's left console next to the ICCP. This switch has the following positions:

- **UPPER**: Selects upper antenna.
- **LOWER**: Selects lower antenna.
- **BOTH**: Provides automatic antenna selection.

**Mode 4 Crypto Switch**: This is a lever-lock switch with the following positions:

- **HOLD**: In this position Mode 4 crypto codes are stored when power is removed from the aircraft.
- **NORM**: Permits normal operation of the crypto codes with power on the aircraft.
- **ZERO**: Sets the code settings back to zero. Seat ejection also zeroes the codes.

Upon ejection from the cockpit the IFF emergency mode automatically becomes active if Mode 1, 2, 3/A or C is enabled.
Engines

The F-15E Strike Eagle can be equipped with two different types of engines, one is the F100-PW-220 and the other is the F100-PW-229, this latter being the newer, more powerful and more reliable version. Today’s F-15E jets are running on these two types of engines.

**PW-220/229 Comparison**

Its predecessor was the Pratt & Whitney F100-PW-100, an engine developed especially for F-15A and B models. When it was introduced, PW-100 represented a quantum leap in modern turbofan engine design over the previous engines. It introduced computer technology (it was an analogue computer) the first time in jet engine design - previous engines used mechanical linkages to control the fuel flow. However it's service life was not without problems, to say the least. It often suffered stagnations and compressor blade stalls, not mentioning afterburner fires, this latter posing a considerable risk of losing the entire airframe.

Needless to say, USAF was not happy with the reliability of the engines, they even seriously considered switching to General Electric engines in their F-15 jets. Pratt & Whitney realized the risk of losing a well-paying customer, so they pushed on with developmental work and the result was the PW-220, the first jet engine featuring Digital Electronic Engine Control (DEEC). The PW-220 proved to be more reliable and needed less maintenance. From October 1986, all F-15E's were equipped with this engine (and later C and D models got it too).

PW-220 produced slightly less thrust than PW-100 (23,450 lbs against 23,830 lbs), but the DEEC system reduced fuel consumption and wear and tear on engine components as well. DEEC automatically trims to maintain performance as the engine deteriorates, and produces much quicker reactions to pilot's input than the previous analogue control system.

The most visible difference between PW-220 and PW-229 is the color of the flame coming out from them in afterburner mode. PW-220 produces a yellowish flame, while PW-229’s afterburner flame is bluish.

The PW-229 variant was introduced in 1992, the first jet to be equipped with it was 90-0233. Many people say that the PW-229 was not as reliable as the PW-220, but these criticisms are often dismissed in the light of the sheer power of PW-229. In fact the power of the 229 engine is such that an F-15E flying in a clean configuration (i.e. no external ordnance and pods) can even reach supersonic speed without using afterburner. This is called ‘supercruise’ ability, a term that was introduced with reference to the ultramodern F-22 Raptor!

PW-229 features an Improved DEEC (IDEEC) and 22% more take-off thrust than its predecessor. It reacts more quickly to pilot inputs (only 4 seconds from minimum power to maximum power, compared to 7 seconds of PW-220). Its greater power and quicker reactions make the PW-229 the engine of choice among Strike Eagle pilots - especially when they are talking about missions flown with heavy weapons loads.
The PW-229 has bigger cooling requirements, hence CFT’s had to be redesigned to equip with cooling scoops that reached further than the relatively slower CFT boundary layer airflow. The PW-229 was also capable of powering an increased capacity generator.

Another big difference between these two engine types is the presence of ATDPS (Asymmetric Thrust Departure Prevention System). Only PW-229’s are equipped with this. You can read more about this further below in this article.

**Implementation in the F-15E**

The engine system in the F-15E is made up of a collection of elements, namely the following:

- Engine induction and air inlet system
- Jet Fuel Starter (JFS)
- Engine oil system
- Ignition system
- Engine control system (ECS)
- Engine monitoring system (EMS)
- Afterburner system
- Variable area exhaust nozzles
- Engine anti-ice system
- Asymmetric thrust departure prevention system (ATDPS)
- Engine monitoring display (EMD)
- Fire warning/extinguishing system
- Engine caution system
- Secondary power system

How engines are built in the F-15E airframe is illustrated in the figure below. Numbered parts in the cutaway drawing will be discussed and referred by their number in the following text.

Engines are mounted to the airframe by standard mounting links resting on all-titanium mounting frames. This way engine mounting and engine change is a relatively simple event, which can be done by front-line maintainers as well. Engine mounting links were design to incorporate not only the Pratt & Whitney F100-PW-220/229 engines, but the General Electric F-110- GE-129 engine as well, this latter engine being a realistic alternative to the P&W engines, which however never made it to the F-15E in operational service.

Engine induction and air inlet system and the Jet Fuel Starter (JFS) are covered in other articles.

Each engine is equipped with a completely self-contained engine oil system. Oil is supplied to the main pump element by gravity feed. Return of the engine oil to the pump reservoir is severely limited during 0 or negative G flight, that’s why the duration of these kinds of flights is limited.

The ignition system is a capacitor-discharge type and contains an independent engine mounted generator and four igniters plugs (two for the engine combustor, two for the afterburner). During engine start (it is discussed in detail in the JFS article - see ‘Engines’ section in the left menu) moving the throttle from OFF to IDLE causes the engine igniter plugs to discharge. Ignition is then
continuous during engine operation. When the throttle is moved into afterburner, afterburner ignition is activated for approximately 1 - 1.5 seconds in co-operation with the LOD system (see further below).

The engine control system (ECS) comprises a primary (PRI) digital control and a secondary (SEC) hydro-mechanical control mode. PRI offers all the advantages of DEEC/IDEEC and runs the engine scheduling across the full range of throttle positions. SEC is a backup mode and will be discussed later on. Since the PW-229 is more powerful than the PW-220, IDEEC incorporates a ground idle thrust (GIT) setting to mimic the PW-220 performance when taxiing on the ground. IDEEC also incorporates a transient idle control logic that gives the pilot freedom to snap the throttles to idle whilst the engines maintain about 79% rpm. Thrust is reduced in accordance with requested throttle settings, but the engines maintain core rpm momentum for 20 seconds - after this they return to idle if no further throttle commands are given. This elongates engine life and improves subsequent throttle response times. The pilot has override authority on the operating mode of the ECS via engine control switches, so the pilot can re-enter PRI mode and enter SEC mode if he desires so. This is achieved by the engine control switches: ON is for PRI mode, OFF is for SEC mode.

The DEEC schedules engine and afterburner fuel flows, compressor inlet variable vanes (CIVV), rear compressor variable vanes (RCVV), start bleed position, anti-ice and nozzle position. The DEEC controls engine performance by scheduling engine fuel flow to control airflow and nozzle position to control engine pressure ratio (EPR), this latter being a ratio between exhaust and inlet pressures. By controlling airflow and EPR, the engine performance remains consistent for a new or deteriorated engine until the FTIT limit is reached.

If a fault is detected by in the PRI mode software, then SEC mode is entered automatically. Note that SEC mode can be entered manually by placing the engine control switch to OFF position. SEC mode inhibits afterburner use and limits MIL power to 70-80% of its normal value. The CIVV are in a fully closed position, the nozzle is closed near to its minimum area (below 5%). In the meantime L or R ENG CONTR caution is displayed. RCVV, start bleeds and engine fuel flow are scheduled by the MFC. The engine remains in SEC mode until the fault is cleared or the engine control switch is put back to ON position.

Note that engine start can be accomplished with the engine control switches in either ON or OFF position, but after engine start they should be left in their position for at least 1 minute, otherwise DEEC will switch to SEC mode. If the engine is started with its engine control switch in OFF position then SEC mode will be entered immediately of course - this way ground starting time will be longer.

The F100-PW-220/229 incorporates a built-in engine monitoring system (EMS) which consists of DEEC/IDEEC software and the EDU (Engine Diagnostics Unit). This continuously monitors engine parameters and system states to detect engine operating failures. Engine operation failures (along with engine and aircraft data) are detected and logged in memory for further analysis by maintenance personnel. The EDU also maintains engine life-cycle information.
The afterburner has 5 concentric fuel spray rings in the flow coming out from the core engine (see image below: only 4 are visible, 1 is hidden), plus 2 more rings further outwards in the fan bypass airflow (see image below: these rings have a shiny, metallic color).

The afterburner is equipped with a high-energy ignition system which allows a modulated light-up. A light-up detector (LOD) is attached to the system which senses afterburner ignition and along with the DEEC permits faster throttle transients. If the LOD does not sense a light-up, it automatically retards the throttles to MIL, terminates fuel flow to the afterburner and checks all systems. If everything checks well, the LOD will automatically attempt two additional relights. If these are also unsuccessful, the LOD is disabled by the DEEC and one additional relight is attempted, using tailpipe pressure values for sensing afterburner light-up.

In PW-220 engines the afterburner has 5 stages which are progressively selected as the throttle moves from MIL to MAX. PW-229 engines have 11 afterburner stages for MIL to MAX. During snap accelerations (when the pilot aggressively snaps the throttle forward) the first afterburner segment may be lit just above IDLE rpm and more segments may be lit advancing towards MIL setting, depending on flight conditions.

All major afterburner assemblies are made of titanium, while the interior liner is coated with Haynes-188. There is a small fuel drain on the bottom of the afterburner, this is to gather unburnt fuel (for example after an unsuccessful light-up) thus avoiding fuel accumulation and probable flame-out.

The exhaust nozzles (12) are axially symmetrical and they follow a convergent-divergent profile. They give a wide range both in area and in profile. The nozzles can be moved pneumatically by utilizing engine bleed air. The nozzles themselves are moved by titanium rods (11) driven by actuators (9). On the ground (when WOW is sensed) and the engine is in IDLE, the nozzles are 80% open with PW-220 engines and 90-100% open with PW-229 engines (provided that DEEC/IDEEC is on). As the throttles advance toward MIL, the nozzles are moving to their fully closed position.

During flight the nozzles are at their minimum area at all times, except at MIL power or on afterburner. At MIL nozzles are 5-10% open with PW-220 engines and 6-20% open with PW-229 engines. The nozzles reach their fully open state only in full afterburner to compensate for increasing afterburner fuel flow.

The Asymmetric Thrust Departure Prevention System (ATDPS) is present only in the F100-PW-229 engine. ATDPS’s main purpose is to reduce the possibility of a directional departure following loss of a single engine at high airspeeds (that is 500+ KCAS or Mach 1.1+). When activated ATDPS puts both engines into their secondary hydromechanical control mode (thus disabling DEEC/IDEEC) and tries to equalize thrust between the two (enabling DEEC/IDEEC again once it returns back to a state that it considers to be ‘normal’). The system reacts very quickly and in the majority of cases it prevents loss of control of the aircraft due to a sudden dramatic increase of yaw rate. Sudden and big sideslips can be dangerous, since air would be coming from the side of the intakes, thus not letting enough air into the engines, resulting in a possible flameout (not mentioning the structural stress the aircraft faces).
The engines are controlled by direct linkage between two sets (one for the pilot and one for the WSO) of split throttles, mounted on the left hand console in both cockpits. The throttle can be freely moved and be put to any setting in between the two limits, OFF and full afterburner (MAX). For OFF setting the throttle must be pulled fully backward, afterburner is reached when the pilot pushes the throttle fully forward. There are two detents in between the two limits, one for IDLE power (minimal thrust possible with the engines running) and one for MIL military power (maximum thrust available without afterburner). The friction of throttle movement can be adjusted manually by a small lever at the base of the quadrant. Control is electronic, moving the throttle provides input to DEEC/IDEEC, which controls engines based on its software (for more detailed description of the throttle quadrants see section 'Cockpit' in the left menu).

The secondary power system is discussed in detail in another article.

**Engine Displays and Cautions**

Both the pilot and the WSO can monitor engine status in the engine display called up on one of the MPD/MPCDs. The pilot also has a smaller display called the Engine Monitor Display (EMD) near his right knee. This constantly provides essential engine information as follows:

- **RPM%** - Compressor rpm from 0 to 110%, displayed in 1% increments
- **TEMP °C** - FTIT from 100 to 1375 Celsius in 1 Celsius increments
- **FF/PPH** - Main engine fuel flow from 0 to 150,000 pph in 10 pph increments
- **NOZ POS%** - Exhaust nozzle position from 0 to 100% open in 1% increments
- **OIL PSI** - Oil pressure from 0 to 100 PSI in 1 PSI increments

The same engine information can also be displayed by any of the MPDs/MPCDs by pressing the ENG pushbutton.

If a parameter exceeds its minimum or maximum value then the min/max value will be displayed and the parameter will be displayed in yellow (on an MPCD) and boxed. Yellow color is not possible on an MPD, so a greater intensity will be used instead. If any of the data is invalid or cannot be acquired then an 'OFF' text is displayed.

On airframes 90-0233 and up an additional test is available for the ATDPS. It can be tested only during low speed ground operation. When ATDPS test is selected, switching one engine control to OFF will result in both engines transferring to SEC mode. The engines will return to PRI mode only after engine control switches are set to ON and ATDPS test is deselected.

Engine start and shutdown is a fairly simple process, which is described in the article on the Jet Fuel Starter (JFS).

The engine caution system captures and displays engine caution situations. In case a caution situation occurs, the master caution light will be illuminated together with the engine caution light both in the front and the rear cockpits. The exact cause of the caution can be determined by invoking the caution display on any of the MPD/MPCDs. The following cautions may be displayed:
- **L INLET, R INLET** - Failure with the left or right engine inlet controller.
- **L ENG CONTR, R ENG CONTR** - Left or right DEEC/IDEEC failure, loss of Mach number signal, afterburner inhibit (either the last 3 segments or total afterburner inhibit) or switch off.
- **L OIL PRESS, R OIL PRESS** - Left or right oil pressure is too low (not more than 8 PSI).
- **FUEL HOT** - Engine fuel inlet temperature is too high.
- **L BST PMP, R BST PMP** - Left or right main boost pump pressure is too low.
- **L BLEED AIR, R BLEED AIR** - There is a left or right bleed air leak or an over temperature situation.
- **ATDP** - System operating mode is other than commanded or air data is invalid.

### Pilot Controls

The engine control panel contains the necessary switches and lights for the pilot to control the engine and its accessories. The engine control panel is located on the pilot’s right console, near his right knee. See the illustration below.

The generator switches turn generators ON and OFF. These are lever-locked switches which must be raised before they are moved to a new position. Generators are discussed in more details in another article under the 'Power Systems' section in the left menu.
The external power control switch controls application of external power to the aircraft's electrical buses. It has three positions: NORM allows aircraft electrical buses to be energized by external power, RESET established external power if it's not on the line (this position is spring loaded back to NORM), OFF disconnects external electrical power from the aircraft. This topic is discussed in more details in another article under the 'Power Systems' section in the left menu.

The emergency generator switch controls the emergency generator, a utility hydraulic motor driven AC/DC generator. The switch has three positions: AUTO provides automatic activation of the emergency generator, MAN provides manual activation, while ISOLATE restricts the emergency generator to powering to a couple of critical systems only. This is discussed in more details in another article under the 'Power Systems' section in the left menu.

The engine control switches are used to place the engines (left and right) either in PRI or in SEC mode. More detailed descriptions on these modes can be found above where the engine control system (ECS) is discussed. Note that afterburner usage is inhibited with the switch in OFF position.

The engine master switches are guarded. They are to allow/deny the operation of their respective (left/right) engine. The engine can be operated only if its master switch is ON. Placing the switch to ON opens the airframe mounted engine fuel shutoff valve of its respective engine and directs power to the fuel transfer pumps. Placing the switch to OFF decouples the engine from the JFS and closes the airframe mounted fuel shutoff valve (provided that engine control/essential power is available).

The STARTER switch and light (also on this console) are for the Jet Fuel Starter (JFS), hence they are discussed in another article. See the JFS article in the 'Engines' section in the left menu.

PW-220 engines have another switch (not visible on the illustration above since it is located below the front cockpit left canopy sill), this is called the VMAX arm switch. It has a wired down guard and its use is prohibited in peace time. With the VMAX system armed, the throttle in MAX afterburner and airspeed above Mach 1.1, the engine control schedules a 22 Celsius increase in FTIT and a 2% increase in rpm. Main engine and afterburner fuel flow is increased by approx. 4% and thrust is increased by approx. 4% as well. Not more than 6 minutes is allowed to stay in VMAX mode. Each VMAX use is logged and a hot section bore-scope inspection may be performed after flight. Maximum total VMAX time is 60 minutes until engine overhaul. Note that PW-229 engines do not respond to the VMAX switch.
Technical Data (PW-229)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Thrust</td>
<td>17,800 lbs</td>
</tr>
<tr>
<td>Afterburning Thrust</td>
<td>29,160 lbs</td>
</tr>
<tr>
<td>Weight</td>
<td>3,740 lbs</td>
</tr>
<tr>
<td>Length</td>
<td>208&quot;</td>
</tr>
<tr>
<td>Inlet Diameter</td>
<td>34.8&quot;</td>
</tr>
<tr>
<td>Maximum Diameter</td>
<td>46.5&quot;</td>
</tr>
<tr>
<td>Bypass Ratio</td>
<td>0.36</td>
</tr>
<tr>
<td>Overall Pressure Ratio</td>
<td>32 to 1</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>8,000 cycles</td>
</tr>
<tr>
<td>(for first inspection)</td>
<td>4,000 cycles (9 years)</td>
</tr>
<tr>
<td>Exhaust Gas Temperature</td>
<td>over 1,000 degrees</td>
</tr>
<tr>
<td>Exhaust Gas Speed</td>
<td>over 1,000 mph</td>
</tr>
</tbody>
</table>

Jet Fuel Starter

The Jet Fuel Starter (JFS) is a simple, scaled down jet engine (often called as APU - Auxiliary Power Unit - in civilian aviation) fitted centrally between the two engines. It is used to start the two engines (in fact it's the only way of starting them).

The JFS can start either engine, but not both simultaneously. The JFS itself is started by accumulated hydraulic pressure. There are two hydraulic accumulators which are automatically charged during flight by the utility hydraulic system or manually by a hand pump. Fuel is provided by the aircraft's main fuel system, ignition and electrical power are provided by the JFS generator (permanent magnet). The JFS has its exhaust on the bottom fuselage of the aircraft, behind the central external hard-point (SUU-73/A pylon).

Pilot Controls

The JFS is activated via a handle and a switch on the pilot's right hand console. See the illustration below.
The JFS starter switch (1) has positions of ON and OFF. For the JFS to be engaged this switch has to be put into ON position. Although the JFS shuts itself down automatically, it can be manually shut down by placing the switch to OFF position at any time during operation.

The JFS control handle (2) is used to discharge the hydraulic accumulator(s) to actually start the JFS. Pulling the handle straight out discharges one accumulator. Rotating the handle 45 degrees counter-clockwise and pulling discharges both accumulators (or the remaining one if one has been already discharged). The handle is spring loaded to return to its normal position.

The JFS ready light (3) indicates if the JFS is ready to be engaged. The light goes out when the JFS is shut down.

A 'JFS LOW' caution appears on the caution display on MPD/ MPCD if either JFS accumulator pressure is too low.
JFS Limitations

There are certain limitations regarding JFS usage. These can be summarized as follows:

- Maximum 10 seconds (15 seconds if temperature is below 0 Fahrenheit) between JFS start initiation and ready light.
- Starter engagement time shall not exceed 90 seconds, except if a hot-start occurs, when this time may be extended to 150 seconds.

Minimum 10 seconds between first engine at idle speed and engagement for second engine start. If the engine engagement time exceeds 90 seconds, wait 20 seconds before again engaging or shutting down the JFS.

Fire Warning System

The Fire Warning/Extinguishing System is included with the Pratt & Whitney F100-PW-220/229 engine integration to the F-15E.

The Fire Warning/Extinguishing System is controlled from a dash-mounted panel in the top left side of the front cockpit (see illustration below).
The system features three illuminated pushbuttons, one for each engine and one for AMAD.

The rear cockpit has lights only for the two engines. In case of engine/AMAD fire or afterburner/engine overheat occurs, the appropriate pushbutton illuminates and a "fire sensor" caution appears on the caution display on the MPD/MPCD while the master caution light and engine caution light illuminates as well. In the meantime the pilot gets appropriate audio warning from 'Bitching Betty' as well. The voice warning will state the cause of problem, pauses and repeats it again. Possible audio warning messages are the following:

- "WARNING, OVERTEMP LEFT"
- "WARNING, OVERTEMP RIGHT"
- "WARNING, ENGINE FIRE LEFT"
- "WARNING, ENGINE FIRE RIGHT"
- "WARNING, AMAD FIRE"
- "WARNING, AB BURN THRU LEFT"
- "WARNING, AB BURN THRU RIGHT"

Overheat occurs when temperature in the afterburner or in the engine's turbine section exceeds design limits. These limits are 1,000 and 1,107 Celsius FTIT (Fan Turbine Inlet Temperature) for PW-220 and PW-229 engines, respectively.

Pushing the button illuminated (after lifting a spring loaded metal guard) immediately removes power from the appropriate engine, shuts off bleed air, removes fuel flow from the engine and arms the extinguisher for discharge. After button push the engine decelerates but may continue running at sub-idle rpm for up to 120 seconds until the fuel is consumed downstream of the airframe mounted fuel shutoff valve. Pushing the AMAD button (guarded too by a spring loaded metal cover) will not prevent normal JFS operation.

When arm is selected, the black-yellow stripes around the discharge switch become visible. The fire light buttons must be pressed again to disarm the extinguisher and restore the selected system to normal operation. Once armed (the appropriate pushbuttons pushed) it can be discharged by a switch located above the pushbuttons (see illustration above). The switch is spring loaded to the middle, normal position. Extinguisher gas discharge cannot be initiated from the rear cockpit.

A test feature (to test the system without actually discharging the extinguisher gas) is also included. Switching to test mode the three fire warning lights illuminate (only the AMAD light illuminates during JFS operation) indicating the fire sensors are operational. Rear cockpit lights are also illuminated. Each fire light consists of four quarters (see illustration above), each of them capable of illuminate independently. The top two quarters of the AMAD light are associated with the AMAD fire sensor loop, while the two bottom quarters with the JFS fire sensor loop. In case of the engine fire lights, the top two quarters are associated with the forward transponder loop, the bottom two quarters with the aft transponder loop. If any of the quarter-pair are not illuminate, this means there is a problem with their corresponding sensor loops.

Note that from aircraft serial number 87-0201 and up the front cockpit warning/extinguisher panel contains left and right "afterburner burn thru" warning lights.
READY TO STRAP IN AND TAKE OFF?

PRE-FLIGHT

The pilot will brief the ground crew as required. Prior to starting, the pilot will get an okay signal from the rear cockpit occupant. Use operational headsets to the maximum extent possible during all engine start and pre-taxi checks as well as when technicians are performing tasks on the aircraft.

FRONT COCKPIT INTERIOR CHECK

A thorough cockpit interior pre-flight shall be accomplished before each flight. The design features of the aircraft greatly simplify this task. Switch positions designated AS DESIRED allow pilot preference in switch/control positioning. AS REQUIRED indicates those switches that will differ with mission requirements. If no specific requirement exists, those avionics switches designed AS DESIRED or AS REQUIRED should be OFF for start.

- Left Console Equipment – CHECK/SET
  1. Ground power panel – ALL SWITCHES AUTO
  2. Armament safety switch – SAFE
  3. Emergency air refueling switch guard – DOWN
  4. Communications controls – AS DESIRED
     a. Volume knobs – AS DESIRED
     b. UHF antenna switch – AUTO
     c. Tone switch – AS DESIRED
     d. IFF master switch – AS REQUIRED
  5. EWWS enable switch – OFF, GUARD DOWN
  6. IFF antenna switch – BOTH
  7. Sensor control panel – OFF
  8. Exterior lights panel – AS REQUIRED
9. Flyup enable switch – **OFF, GUARD DOWN**
10. NCTR enable switch – **AS REQUIRED**
11. V-MAX switch – **COVER CLOSED AND SAFETY WIRED**
12. Flap switch – **UP**
13. Throttles – **OFF**
14. Fuel control panel – **SET**
   a. Fuel dump switch – **NORM**
   b. Wing switch – **AS REQUIRED**
   c. Center switch – **AS REQUIRED**
   d. Conformal tank switch – **STOP TRANS**
   e. Slipway switch – **CLOSE**
   f. Conformal tank emergency transfer switch – **NORM**
   g. External transfer switch **WING/CTR**
15. Nuclear consent switch – **COVER CLOSED**
16. CAS switches – **ON**
17. TF COUPLE switch – **OFF**
18. Miscellaneous control panel – **SET**
   a. Anti-skid switch – **NORM**
   b. Inlet ramp switches – **AUTO**
   c. Roll ratio switch – **AUTO**
   d. Landing/taxi light switch – **OFF**
19. Canopy jettison handle – **FORWARD**
20. Emergency landing gear handle – **IN**
21. Arresting hook switch – **UP**
• Instrument Panel – CHECK/SET
  a. Landing gear handle – DOWN
  b. Pitch ratio switch – AUTO
  c. Master arm switch – SAFE
  d. Select jettison knob – OFF, BUTTON NOT PRESSED
  e. Fire lights – NOT PRESSED
  f. Fire test/extinguisher switch – OFF
  g. HUD control panel – AS REQUIRED
  h. Emergency jettison button – NOT PRESSED
  i. Circuit breakers – IN
  j. JFS handle – IN
  k. Holding brake switch – OFF

• Right Console Equipment – CHECK/SET
  1. Emergency vent handle – IN AND VERTICAL
  2. Oxygen system – CHECK AND SET
     a. Oxygen supply lever – FULLY ON
     b. Emergency lever – NORMAL
     c. Indicator – CHECK
     d. Diluter lever – 100%
     e. Emergency lever – EMERGENCY
     f. Oxygen flow – CHECK
     g. Emergency lever – NORM
     h. Diluter lever – NORM
  3. Anti-ice switches – SET
4. Engine control panel – SET
   a. Generator switches – ON
   b. Emergency generator switch – AUTO
   c. ENG CONTR switches – ON
   d. JFS starter switch – ON
   e. Engine master switches – ON
   f. EXT PWR switch – AS REQUIRED

5. Air conditioning control panel – SET
   a. Temperature control switch – AUTO
   b. Air source knob – NORM
   c. Air flow selector switch – BOTH

6. Interior lights controls – AS DESIRED

7. Compass control panel – AS REQUIRED
   a. Latitude – SET
   b. Hemisphere – SET

Normal engine start procedure does not use external power. With the JFS running, power is available to operate the AMAD fire warning system, the intercom system between the aircrew and ground personnel, and the cockpit utility light. Engine RPM and FTIT indications on the EMD are inoperative until the emergency generator comes on the line at 15-17% RPM during engine start. The rest of the engine instruments are inoperative until a main generator comes on the line at 56-58% RPM during the first engine start.

The ENGINE category light will come on and remain on until the second engine starts and no engine faults exist. It will come on again momentarily, between 15-29% RPM, indicating that the IDEEC is automatically performing a self-test. If engine is started with the ENG CONTR switch in OFF, the ENGINE category stays on throughout the start cycle, indicating the engine is in SEC mode. During engine starts, the engine anti-ice switch will be placed in the ON position for all starts, to provide additional starting stall margin. Test cell data has shown a hot start may occur on
warm engine restarts if the engine is started without anti-ice flow. The engine anti-ice switch should be set as required for ambient conditions.

Because a JFS accumulator was discharged to start the JFS, the **JFS LOW** caution light will come on when power is available to display the caution. It will go out when accumulators are recharged by a running engine.

When the finger-lift is raised, the JFS will engage and accelerate the engine. JFS engagement is indicated by an audible decrease in JFS whine when the JFS clutch engages. JFS whine decrease is followed immediately by an increase to a higher pitch than before engagement. Engine rotation is apparent within approximately 5 seconds. If electrical power is not available, rotation can not be felt and heard. If electrical power is available, rotation can be felt and heard. If electrical power is available, RPM increase can be seen on the EMD. The JFS will continue to smoothly accelerate engine rotation without hesitation until light-off occurs or steady-state windmill (23-30%) is reached. A normal start is indicated by RPM acceleration occurring before initial FTIT movement.

Monitor engine indications on the EMD and compare against the operating limitations listed in Section 5 of this POH. After first engine start, the JFS automatically decouples from that engine and is ready for the second engine start. After second engine start, the JFS shuts down automatically.

The following procedure is applicable to either engine. The right engine is normally started first to permit checking utility hydraulic pressure with only the right pump operating.

**STARTING ENGINE PROCEDURE (BASED ON TECHNICAL ORDER FOR THE F-15E)**

1. Set Parking Brake - **ON**
2. JFS Starter Switch - **ON**
3. JFS Control Handle – **PULL AND RELEASE**

**NOTE**

If JFS does not start, starter switch should be set OFF. Wait 30 seconds after cycling switch to OFF before trying second start so JFS can decelerate, and start sequence relay de-energize. Failure to wait 30 seconds may result in a JFS no start.

4. Starter READY light – **CHECK ON**
5. Fire extinguisher switch – **TEST (observe the fire warning lights on with voice)**

6. Engage the Right Engine by pulling its finger lift on the throttle. As a standard operating procedure, the right engine should be started first so that a hydraulic pump operated by the right engine can be checked. The finger lift on the front of the throttle engages the JFS connection to the engines.

7. Wait until the JFS spins the right engine to 20% rpm. Engine rpm can be monitored on the Engine Monitoring Display (EMD) on the front dashboard above the right knee of the pilot (see article on the engines in the 'Engines' section in the left menu).

8. Push the throttle forward out of NULL and into IDLE. The digital electronic engine control (DEEC) takes over from there.

9. Monitor the rpm and FTIT (Fan Turbine Inlet Temperature) on the EMD during the process to ensure there is not a hot start or other malfunction. PW-220 hot-start FTIT limit is 680 Celsius, while the same limit for PW-229 is 800 Celsius.

10. As the engine spins up past 56% rpm the right generator comes on-line and the right engine intake ramp, which has been locked into the full-up position, slams to the full down position (this scares a lot of first-time passengers in the back seat!)

11. Since the JFS is a jet engine in itself, extra care should be taken not to be within the reach of its air intake and its hot exhaust gases when the JFS is running. The ‘danger’ zone is a 4 feet circle around the intake and two 20 degree cones from the JFS exhausts to the engine tail cones (see illustration below).

12. The JFS automatically shuts down when the second engine reaches approx. 50% rpm.

13. The JFS may be used during flight to perform a JFS assisted restart (special operating procedures apply to this).

14. Warnings and caution lights – **TEST**

15. VHF #2 – **ON**

16. EMER BST ON caution – **OBSERVE ON**
NOTE

If automatic avionics shutdown occurs due to low ECS cooling airflow only VHF #2 will be available. All major caution lights will be inoperable. In addition, the right engine ramp may move to the full up position. Start other engine as soon as possible to obtain sufficient ECS airflow. If two engine operation is not possible, single engine operation at 71-73% RPM will provide sufficient ECS airflow.

17. Total fuel quantity – CHECK

18. Hydraulic caution light – CHECK

NOTE

At idle RPM the left engine fuel flows displayed on the EMD and MPD]MPCD may oscillate between 200 and 1,600 PPH, may momentarily drop to zero, and may differ between EMD and MPD/MPCD displays. The fuel flow displays should all stabilize when the left engine RPM is increased above idle.

19. Engine instruments – CHECK

20. JFS – CONFIRM OFF; JFS SWITCH ON

21. ECS – CHECK (ensure ECS caution off and airflow present)

22. Inlet ramp switches – CHECK AUTO (observe ramps down)

23. Engine anti-ice switch – AS REQUIRED

BEFORE TAXIING (FRONT COCKPIT)

1. Canopy – CLOSE IF DESIRED (wait 10 sec before locking)

2. MPDs/MPCDs – ON
3. HUD – **ON**

4. Brakes – **CHECK**

5. Holding Brake – **ON**

6. Sensor control panel – **SET**
   a. NAV FLIR power switch – **STBY**
   b. Radar power switch – **STBY**
   c. Radar altimeter power switch – **ON**
   d. INS – **ALIGN**

7. Flight Controls – **CHECK (CAS OFF)**
   a. AFCS BIT – **NOT IN TEST**
   b. CAS PITCH, CAS ROLL, CAS YAW – **OFF**
   c. Anti-skid – **CHECK NORM**
   d. Stick full aft and left – **OBSERVE CONTROLS**
   e. Stick full left and forward – **OBSERVE CONTROLS**
   f. Stick full right and forward – **OBSERVE CONTROLS**
   g. Stick full right and aft – **OBSERVE CONTROLS**

8. Trim – **CHECK AND SET**
   a. Trim pitch, roll, and yaw off neutral
   b. T/O TRIM button – **PUSH (to set normal takeoff trim)**
   c. T/O trim light – **ON**
   d. T/O trim button – **RELEASE**

9. AFCS preflight BIT – **INITIATE**

10. Engine control switches – **CHECK**

11. Avionics – **AS REQUIRED (AAI, IFF, ILS/TACAN)**
12. Slipway door – **CHECK (if AAR is planned)**

13. Oxygen – **CHECK**
   a. Emergency lever – **NORMAL**
   b. Pressure – **10 to 60 psi**
   c. Indicator – **CHECK**
   d. Connection – **CHECK**
   e. Emergency Oxygen – **CHECKED AND SET NORMAL**

14. Fuel quantity gauge – **CHECK**

15. Bleed air – **CHECK**

16. Radar STBY BIT – **INITIATE**
   a. GND indication – **CONFIRM**
   b. Previous matrix – **CHECK**

17. Radar power switch – **ON**

18. Auto BIT – **INITIATE**

19. Radar Track Test and Operate BIT – **INITIATE**

20. Flaps – **DOWN**

21. Speed brake – **CYCLE**

22. JFS LOW caution – **OUT**

23. INS mode knob – **NAV (when aligned)**

24. MPD – **BIT CHECK**

25. AAI BIT – **INITIATE**

26. Avionics/BIT – **CHECK BIT FOR CODES**

27. Cautions/Warnings – **CHECK OFF**

28. Standby attitude indicator – **CAGED THEN UNCAGED**
29. Altimeter – **SET AND CHECK (should be within 75 feet of known field elevation)**

30. Radar – **SET STBY**

31. MPDs/MPCDs – **SET AS DESIRED**

32. UFC – **SET AS DESIRED**

**REAR COCKPIT INTERIOR CHECK**

A thorough cockpit interior pre-flight shall be accomplished before each flight. Switch positions in response to **AS DESIRED** and/or **AS REQUIRED** actions are the same as for the front cockpit.

1. Left Console Equipment – **CHECK/SET**
   
   a. Intercom set control panel – **SET**
      
      1) Volume knobs – **AS DESIRED**
      
      2) Tone switch – **OFF**
   
   b. EW control panel – **SET AS REQUIRED**
   
   c. Sensor control panel – **SET**
   
   d. Nuclear consent switch – **SAFE (cover closed)**

2. Instrument Panel Equipment – **CHECK/SET**
   
   a. Emergency landing gear handle – **IN**
   
   b. Arresting hook switch – **UP**
   
   c. Emergency brake/steer handle – **IN**

3. Right Console Equipment – **CHECK/SET**
   
   a. Command selector valve – **NORM (vertical)**
   
   b. Oxygen system – **CHECK AND SET**
      
      1) Oxygen supply lever – **FULLY ON**
      
      2) Emergency lever – **NORMAL**
      
      3) Indicator – **CHECK**
      
      4) Connections – **CHECK**
5) Emergency oxygen – CHECKED AND NORMAL

c. TEWS control panel – SET
   1) ICS switch – OFF
   2) RWR switch – OFF
   3) EWWS switch – OFF

d. Countermeasure dispenser control panel – SET
   1) Mode switch – OFF
   2) Flare switch – OFF

e. Circuit breakers – IN

f. Interior lights controls – AS DESIRED

BEFORE TAXIING (REAR COCKPIT)

1. Warning and caution lights – TEST

2. MPD’s/MPCDs – ON

3. INS – CONFIRM ALIGN

4. Avionics – AS REQUIRED (AAI, ILS, VHF, TACAN, TEWS, CMD)

5. Sensor control panel – SET
   a. TGT FLIR – STBY
   b. LASER switch – SAFE

6. Avionics systems – CHECK and SET

7. Radar – STBY

8. PACS – SET AS REQUIRED

9. Oxygen – CHECK

10. Standby attitude indicator – CAGE THEN UNCAGE

11. Altimeter – SET AND CHECK
NOTE

If the altimeter is not within tolerances, the aircraft may be flown provided that the altimeter checks within plus/minus 75 feet of field elevation. The plus/minus 75 feet of field elevation is an operational restriction and does not necessarily reflect instrument tolerance.

TAXIING

As the throttles are moved out of idle, confirm that the holding brake is released. As aircraft starts to roll, apply brakes to check operation. When clear, actuate nose gear steering in both directions to ensure proper operation. During taxi, check all flight instruments. At high gross weights, make all turns at minimum practicable speed and maximum practicable radius. At low gross weight, taxi speed requires continual attention due to excess thrust at IDLE.

CAUTION

Nose gear damage can result during turns at high gross weight when using asymmetric thrust and/or asymmetric braking. At heavy gross weights, avoid abrupt nose gear steering inputs. Make turns at minimum practical speed and maximum practical radius, and avoid operations on rough and uneven taxiways or runways. Failure to do so may result in tire damage.

1. Holding brake – OFF
2. Brakes – CHECK
3. Nose gear steering – CHECK
4. Flight instruments – CHECK

If taxiing is required before INS alignment is complete and the aircraft is stationary again before takeoff, place the holding brake ON to continue the alignment.

CAUTION

To prevent a skid and possible tire failure, the aircraft must be completely stopped before placing the holding brake ON.
ENGINE SHUTDOWN

Complete engine shutdown can be accomplished from the front cockpit only. However if over the left wing access door is used for engine shutdown, the engines can be positioned to IDLE from the rear cockpit as well to reduce danger of intake suction. The engine shutdown procedure is the following:

- Depress the left and right engine fire extinguisher buttons. This action closes the engine fuel shutoff and bleed air. Note, that the JFS should be running to provide 28 volt DC power for operation of the AMAD fire extinguisher system.
- If the JFS is running, push the AMAD fire button to close the JFS fuel shut-off relay.
- Raise finger-lifts on throttle and pull back throttles to below IDLE.
- Release finger-lifts and pull throttle back to OFF.
EMERGENCY PROCEDURES

STARTING

AMAD FIRE DURING START

AMAD fire may be recognized by illumination of the AMAD fire light, voice warning “Warning, AMAD Fire,” or by ground crew notification. Extinguisher actuation will discharge the fire extinguisher into the AMAD compartment and automatically shut down the JFS. If this action does not suffice, ground fire extinguishers may be required. If fire light is on (steady light):

1. AMAD light – PUSH
2. Fire extinguisher – DISCHARGE
3. Throttles – OFF

JFS READY LIGHT DOES NOT COME ON

If the JFS ready light does not come on within 10 seconds, and –

a. The JFS sounds normal.
b. The AMAD fire light tests normally, then the JFS light is inoperative, and the start may be continued (the JFS READY light is required to monitor inflight JFS air start).

If the above cues are not present or JFS did not start on the first accumulator:

a. JFS switch – CYCLE
b. Have ground crew check JFS system.

If no abnormality is found and 30 seconds have elapsed, another JFS start may be attempted.

JFS FAILS TO ENGAGE OR ABNORMAL ENGAGEMENT/DISENGAGEMENT.

Failure to engage is indication by no decrease in JFS whine after the fingerlift is raised. This may be caused by the throttle not being full off, master switch not on or an electrical malfunction. If the normal starting sequence has been interrupted (one engine shut down for some reason), it may be necessary to cycle the engine master switch to reset the control circuits. Once the JFS has engaged (JFS whine decreased), any abnormal sound or other indication requires immediate JFS shutdown. These can include no JFS whine increase, no engine rotation, RPM hangup, or JFS disengagement. If the JFS fails to decelerate after either engine start, shut down the JFS and both engines.

If JFS fails to engage –

1. Throttle – ENSURE FULL OFF
2. Engine master switch – CYCLE
3. Fingerlift – RAISE AND RELEASE

If still no engagement –

4. Engine master switch – OFF
5. Do not attempt another start

If engagement/disengagement is abnormal –

1. Throttle – OFF
2. Engine master switch – OFF
3. JFS switch – OFF
4. Do not attempt another start

EMERGENCY GENERATOR NOT ON LINE ON START

On internal power starts, the emergency generator should come on line within 30 seconds after raising fingerlift for first engine start. This is indicated by an increasing RPM indication on the engine monitor display. The emergency generator does not power the emergency boost pump during the first engine start. Therefore, the EMER BST ON caution will not illuminate until the first main generator comes on line. The emergency generator should remain on line for 30 seconds after the first main generator is on line. There is a remote possibility of the emergency generator dropping off line prematurely. If this occurs before a main generator come on line, the RPM and FTIT indications go blank. Regard a BST SYS MAL caution less than 30 seconds after the first main generator comes on line as an indication that the emergency generator has dropped off line prematurely.

If emergency generator not on line 30 seconds after raising fingerlift –

1. Emergency generator switch – CYCLE THRU ISOLATE

If emergency generator still does not come on line –

2. Engine master switches – OFF
3. JFS – OFF
4. Abort

If emergency generator prematurely drops off line –

1. Throttle – OFF
2. Engine master switch(es) – OFF (Have maintenance investigate malfunction).
ABNORMAL ENGINE START

ENGINE FAILS TO START

If no indication of light – off 20 seconds after throttle advanced to IDLE –

1. Throttle – OFF

If another start attempt desired –

2. Engine master switch – OFF
3. Throttle – IDLE

If another start attempt is not desired –

2. Engine master switch – OFF
3. JFS – OFF
4. Complete engine shutdown procedure

ENGINE FAILS TO ACCELERATE NORMALLY

If both RPM and FTIT appear to stop increasing during the start sequence –

1. Throttle – OFF
2. Engine master switch – OFF
3. JFS switch – OFF
4. Complete engine shutdown procedure

AUTO-ACCELERATION ABOVE IDLE

If auto-acceleration occurs, place the throttle to OFF, press the ENG FIRE PUSH light, and place the engine master switch to OFF.

HOT START

If one of the following conditions occurs during engine start, the starting FTIT limit of 680 Celsius may be exceeded:

- RPM acceleration simultaneous with or after initial FTIT movement.
- FTIT above 500 C with RPM before 40%.
- FTIT rises rapidly through 580 C.
- RPM stops increasing then decreases while FTIT is stable or increases.

If starting FTIT is exceeded, allowing the engine to windmill after shutdown will assist cooling.

1. Throttle – OFF

If FTIT starting limit not exceeded –
2. Engine – WINDMILL (10 seconds after FTIT indicates 200 C) (The JFS can be engaged when RPM is below 30%).
3. Air source knob – SELECT ENGINE TO BE STARTED
4. Throttle IDLE
5. Air source knob – BOTH (idle RPM)

If FTIT exceeded starting limit –

2. Engine – WINDMILL (if practical)
3. Engine master switch – OFF
4. JFS switch – OFF
5. Complete engine shutdown procedure

ENGINE FIRE DURING START

1. Fire warning light – PUSH

If warning light remains on –

2. Throttle – OFF
3. Fire extinguisher – DISCHARGE
4. JFS switch – OFF
GROUND OPERATIONS

ECS (Engine Control System) MALFUNCTIONS

DUAL ENGINE OPERATION (ECS CAUTION ON)

An ECS caution during engine ground operation is an abnormal condition. Make sure that the cockpit temperature control switch is in the AUTO position and that the air source knob is at BOTH. If the caution remains on, the ECS is not operating properly and avionics may suffer heat damage. Shutting down either engine will provide automatic avionics shutdown to protect the avionics equipment from overheating. In the event the automatic avionics shutdown does not occur, turning off all avionics except VHF will protect this equipment.

1. Temperature Control Switch – AUTO
2. Air Source Knob – BOTH

If the ECS caution remains on after 2 minutes –

3. Either throttle – OFF

Automatic avionics shutdown will occur at this time –

4. Abort Mission

If automatic avionics shutdown does not occur –

5. Avionics (except VHF) – OFF
6. Remaining engine – SHUTDOWN (as soon as practical)

SINGLE ENGINE OPERATION (AUTOMATIC AVIONICS SHUTDOWN)

During single engine operation inadequate avionics cooling airflow is possible. When inadequate cooling is detected, an immediate automatic avionics shutdown occurs. The only indication of this condition will be blank displays.

Automatic avionics shutdown disables the following avionics:

- HUD
- RMR
- MPDP
- RADAR
- ADC
- JTIDS (when available)
- EWWS
- AIU #1
- AFCS Flight Control Computer
• ILS
• CC
• IBS
• PACS
• RWR Low Band Receiver/Processor
• RWR Power Supply
• AHRS
• Left and Right Air Inlet Controller
• VTRS
• VHF #1
• MDPs
• MPCDs

The MASTER CAUTION light and major category lights are shutdown as a result of the automatic avionics shutdown of AIU #1.

Advancing the throttle to increase single engine RPM to 73% should provide adequate airflow to avionics and normal avionics operation will resume in two minutes. If normal operation does not resume, it may be necessary to start the second engine.

1. Single engine RPM – INCREASE (to 73%)

If avionics remain shut down after two minutes –

2. Abort mission

DISPLAY FLOW LOW CAUTION

During dual engine operation, a Display Flow Low caution is an abnormal condition and indicates low cooling air flow to the cockpit displays. Turning off all non-essential displays will help protect them from heat damage.

During single engine operations, a slight increase in RPM above idle (to 73%) may be required to extinguish the light with ECS operating normally.

1. Non-essential displays – OFF
2. Abort Mission

INS PROBLEMS

EXCESSIVE GROUNDSPEED/POSITION ERROR

If groundspeed and present position/update errors are excessive prior to take-off, another alignment may be attempted. Generally, groundspeed error of 6 knots or more, and/or positional error of 2 miles or more, are considered excessive for normal operations. Lesser errors may be considered excessive for certain missions. The INS should be off for at least 5 seconds prior to
another alignment. Allow the INS to remain in the GC mode as long as possible. If possible, monitor the ground speed and present position for at least one minute to assess accuracy.

**TAKEOFF**

**ABORT**

The decision to abort or continue takeoff depends on many factors, most of which relate to a specific takeoff situation. Considerations should include, but are not limited to, the following:

- **Runway factors:** Runway remaining, surface condition (wet, dry, etc.), type and/or number of arresting gear available, obstructions alongside or at the departure end, wind direction and velocity, weather and visibility.
- **Aircraft factors:** Weight, stores aboard, nature of the emergency, velocity at decision point, and importance of getting airborne.
- **Stopping factors:** Maximum braking, speed brake, hook, jettisoning stores, engine shutdown.

Consider aborting after airborne where sufficient runway is available. Normally, with the short takeoff distances of the aircraft, abort is not a problem, but early decision will provide the most favourable circumstances.

1. Throttles – IDLE
2. Brakes – APPLY (If aborting with a blown tire or if a main tire blows during abort, place the anti-skid switch to PULSER and use braking on the good tire).
3. Hook – AS REQUIRED

**EXTERNAL STORES JETTISON**

Two means exist to jettison external stores: the emergency jettison button on the center of the front instrument panel, or the select jettison knob/button on the armament control panel in the front cockpit.

- The emergency jettison button jettisons pylons on stations 2, 5, and 8 plus also all CFT stores (air-
to-air and air-to-ground). When airborne, the possibility exists of wing station stores colliding with CFT mounted stores and subsequent collision with the aircraft. Ground jettisoning may result in the stores striking the ground before pylon aft pivots release. Under these conditions, the wing mounted pylon stores will probably rotate horizontally, and will strike the landing gear if the rotation is in that direction. The centerline pylon will almost certainly strike the landing gear.

- Air-to-ground stores on CFT stations must be jettisoned before air-to-ground stores on wing stations to ensure safe separation.

**CAUTION**

If centerline or inboard release is required with the landing gear down, damage may occur to the aircraft.

Do not use emergency jettison on the ground, or with AIM-7 missiles onboard, except as a last resort or in extreme emergency. For complete selective jettison procedures, refer to stores jettison systems, Section 1 of this POH.

**ENGINE FAILURE ON TAKEOFF**

Depending on the type of failure and aircraft condition, MIL power may be sufficient to sustain flight. The aircraft accelerates better at a reduced AOA. If afterburner is required, use only that necessary to maintain safe flight.

If the decision is made to continue takeoff, input one-half aft stick at the rotation speed for continued takeoff found in figure A3-10 (with CFTs) or figure A3-11 (without CFTs), and rotate to a 10 degree pitch attitude. Delaying rotation in this way results in increased single engine rate of climb at takeoff. With CFTs, figures A3-12 through A3-16 should also be checked to determine if adequate single engine rate of climb is available at this takeoff speed. If available runway permits, the takeoff speed may be increased somewhat by delaying rotation until either runway limitations or tire limit speeds dictate rotation. This will result in correspondingly increased ground roll distance.

**If takeoff is continued –**

1. Throttle(s) – AS REQUIRED
2. Climb to a safe altitude and investigate
ASYMMETRIC THRUST DEPARTURE PREVENTION SYSTEM (ATDPS) FAILURE

When the ATDP caution is ON, loss of augmentor or transfers to secondary mode on one engine can result in a sudden loss of thrust on both engines. Refer to Engine Control Malfunction.

AFTERBURNER FAILURE

The engine has an automatic afterburner recycle capability using the light-off detector. If the afterburner does not light satisfactorily or a blowout occurs, the DEEC will automatically resequence the afterburner ignition systems a maximum of three times in approximately 12 seconds providing the throttle remains above MIL. If the afterburner does not light during these attempts, the throttles must be retarded to MIL or below before further attempting to light the afterburner.

If the ENG CONTR caution is on, afterburner operation may be prevented or may be limited to only the first and second segment. If the DEEC has transferred to secondary mode, afterburner operation is prevented and approximately 80 to 85% of MIL thrust is available. Cycling the engine control switch may return the engines to normal operation. The engine control switch may be cycled ON-OFF-ON at MIL or below. If the ENG CONTR caution goes off, the engine will operate normally. However, if there is a malfunction in the afterburner control, the ENG CONTR caution may come on again when afterburner is re-selected. Refer to Engine Control Malfunction, page 3-13 of his section.

ENGINE FIRE ON TAKEOFF

If you decide to abort –

1. Fire warning light – PUSH

If warning light remains on –

2. Throttle – OFF
3. Fire extinguisher – DISCHARGE

If you decide to continue –

1. Climb to safe altitude and follow Engine Fire Inflight procedures

PITCH RATIO FAILURE

If takeoff is made with the CAS ON, it is unlikely that pitch ratio failure will cause any control difficulty, and takeoff may be continued. The PITCH RATIO caution may be the only noticeable indication of failure. However, if the failure occurs with CAS OFF, longitudinal stick forces may be considerably higher than normal, and the late nosewheel liftoff will likely result. In this case, aborting the takeoff is preferred if conditions permit. If takeoff is continued with CAS OFF, manoeuvre conservatively since the ARI is inoperative.
LANDING GEAR FAILS TO RETRACT

If the warning light in the landing gear handle stays on after the handle is placed up, or it comes on in flight, the gear or the gear doors are not correctly sequenced. Reduce airspeed below 250 KCAS, check landing gear circuit breakers in, and lower the gear. If the gear comes down normally, attempt a second retraction. If the light is still illuminated, lower the gear, reduce weight, and land.

INFLIGHT

OUT-OF-CONTROL RECOVERY

The aircraft is out of control when it does not properly respond to aircrew flight control inputs. An example of this is attempting to perform a slow speed, nose high reversal in one direction and the aircraft will not roll in that direction. An out-of-control situation will progress to a departure if the situation is not corrected by smoothly neutralizing controls to reduce AOA or yaw rate.

A departure is characterized by an uncommanded flight path change such as a nose slice, roll away from a lateral input, or excessive yaw rates. The departure warning tone may sound indicating high yaw rate and is the best indication of an impending spin. If a continuous warning tone is heard and the controls are not neutral, it is imperative that the controls be neutralized immediately in a smooth manner. This action should recover the aircraft from all departures.

Abrupt neutralization of longitudinal controls while out-of-control or in a departure, where high yaw rates are present, may aggravate the situation and induce a spin. Releasing all rudder and stick pressure (hands off) once the controls are at or near neutral will result in neutral controls if trimmed near 1G.

If the controls are not neutralized at the first indication of departure, or when the departure warning tone begins, a spin may develop. Spins are typified by a high yaw rate accompanied by a high rate departure warning tone. The turn needle will be steady and full deflected in the direction of the spin. For recovery from a positive G spin, maintain neutral longitudinal stick and apply full lateral stick with the yaw the same direction as the turn needle. Rudder is not needed, but if used, must be against the yaw, opposite the direction of the turn needle. Neutralize all controls when the aircraft recovers from the spin and allow large residual motion to subside. Spin recovery is indicated by departure warning tone stopping, sustained nose low attitude, increasing airspeed, and AOA decreasing from greater than 45 units.

An auto-roll is a rudder roll caused by rudder deflections with neutral cockpit controls. The aircraft may slowly self-recover. However, for a rapid recovery from a positive-G auto-roll, apply full rudder against the roll. Do not use ailerons to stop the roll as this input may induce a spin. If unsure
of the roll direction, use the ADI to determine roll direction. Do not use the turn needle as it oscillates during rolls. The departure warning tone may not sound.

Neutral controls will recover the aircraft from all negative G conditions including spins and auto-rolls. However, rudder with the roll will produce a faster recovery from a negative G auto-roll.

Do not move the throttles unless in afterburner. If in afterburner, reduce power to MIL.

1. Controls – SMOOTHLY NEUTRALIZE AND RELEASE
   If aircraft is not recovering, an auto-roll is possible –
   2. Rudder – OPPOSITE ROLL
   3. Aileron against the roll can induce a spin.

If aircraft is still not recovering, an upright spin is most probable –

4. Longitudinal stick – CENTERED
5. Lateral stick – FULL IN DIRECTION OF YAW (turn needle)
6. Aircraft recovers (tone ceases) – CONTROLS NEUTRAL

If the departure warning tone malfunctions (i.e., yaw rate gyro failure) and stops prior to 30 degrees per second, neutralizing controls may result in yaw acceleration and a redeveloped spin. Use other indications of spin recovery in conjunction with the departure warning tone.

If recovery is not apparent by 10,000 feet AGL –

7. Eject

EJECTION

Ejection sequences are not modeled in the Iris’ F-15E. All emergency and abnormal checklist procedures that reference ejecting should be referenced as the equivalent of ending the flight through the normal FSX methods.
ENGINE STALL/STAGNATION

Engine stalls are the result of a disruption of airflow across one or more fan/compressor blades. Although many conditions affect compressor airflow (i.e., aircraft manoeuvring, ice, DEEC, afterburner backpressure, etc.) most will not exceed the design stall margin of the engine. The IDEC includes logic to detect and automatically recover most engine stalls without pilot action.

The fan bypass duct provides a convenient passage from pressure disturbances created in the afterburner section to travel directly forward to the fan/compressor. If the engine nozzle does not position properly when operating the afterburner, pressure pulses can be transmitted forward to the fan/compressor causing the blade to exceed the stall limit. Hence, most stalls will be associated with use of the afterburner. High altitude/slow flight and manoeuvring all increase the sensitivity to stall because they increase airflow disturbances to the face of the engine. Cycling the control mode switch (PRI to SEC or SEC to PRI), particularly during throttle transients or high altitude/idle power operation, may cause stalls.

If the fan/compressor stall does not self-clear, the disturbed airflow will propagate through the compressor, resulting in engine stagnation. Unstable burning then occurs in the combustion chamber causing higher than normal temperatures and RPM decreasing to sub-idle (less than 60%). To clear this condition, the engine must be shutdown and restarted.

Stalls normally produce an audible pop, bang, or thud, but may occur without audible warning. Engine instruments may not indicate anything unusual, but RPM rollback, increased FTIT, and nozzle opening may be noted for more severe stalls at MIL and above.

Generally, the stall will be self-clearing. However, quickly retarding the throttle to MIL (IDLE if non-afterburner stall) will aid recovery. If stagnation develops, it will be characterized by rising FTIT and decreasing RPM with no change in throttle position. FTIT may exceed 1,070 C or stabilize at some lower level. FTIT above 1,070 C will result in engine damage.

To prevent catastrophic engine damage, immediate corrective action should be taken. It is possible that a stagnated engine may also display a fire plume trailing the aircraft if the throttle is not placed to OFF. This plume may persist until the throttle is placed to OFF and the stagnation cleared.

A GEN OUT caution and EMER BST ON caution may be the first indication of engine stagnation. With a single engine stagnation and no other anomaly, the GEN OUT caution and EMER BST ON should be the only cautions on before engine shutdown. If altitude permits, immediately lower the nose to maintain 350 KCAS.

Post stagnation engine operation is keyed to FTIT. If 1,107 C was not exceeded, normal engine operating limits apply. If 1,000 C was exceeded, the engine may be started to provide redundant hydraulic and electric power, but should be left at IDLE unless additional thrust is required to
ensure safe recovery. After stagnation has cleared, engine parameters at MIL will initially be lower until the DEEC can return.

**SINGLE ENGINE STALL/STAGNATION**

1. Throttle – CHOP TO IDLE (MIL if in AB)- (If afterburner stall does not clear at MIL, chop the throttle to IDLE).

If RPM is less than 60% with no response to throttle movement, or if FTIT continues to rise –

2. Throttle – OFF
3. Perform restart

**If engine overtemp warning activated (1107 C)** –

4. Throttle – SET AT 80% RMP OR LESS (if practical)

**SINGLE ENGINE OPERATION**

If the engine will not start, best cruise may be approximated by a climb at 250 KCAS until rate of climb stops. Accelerate to 0.7 Mach in MIL. Cruise climb as fuel weight decreases.

**DOUBLE ENGINE STALL/STAGNATION/FAILURE**

Three conditions can cause double engine flameout: all boost pumps inoperative or empty feed tanks (Mechanical failure is not reproduced in FSX). If both main boost pumps and the emergency boost pumps are not operating, restart is possible only within a severely restricted flight envelope. If altitude permits, immediately lower the nose to maintain 350 KCAS. Check RPM and FTIT to determine whether the engines are flamed out or stagnated. If the flameouts were caused by temporary fuel starvation, they may restart. If the engines are stagnated, they must be shut down and restarted.

Shut down the right engine first unless the engine overtemp warning is activated. If this occurs, shut down the engine with the lower FTIT.

During a double engine out situation, regardless of airspeed, altitude or cause, attempt a spool down restart. However, the primary task is to maintain enough hydraulic power for aircraft control while getting at least one engine producing normal power. A single engine at about 18% RPM, or both engines at 12% RPM, will provide enough hydraulic power for flight control and emergency generator operation. An airspeed of 350 KCAS will normally maintain 12% RPM or greater.

At low speed, a momentary steep dive may be required to rapidly attain 350 KCAS. However, a shallow dive (10 degrees or less) will maintain 350 KCAS and 12% RPM. Once steady state RPM is established, excessive airspeed/dive angle reduces time available for restart.
If sufficient RPM is not maintained to fully power the emergency generator system, the emergency generator output may degrade to powering only the ISOLATE functions. In this case, RPM and FTIT will still be available. If this occurs, increase airspeed to increase engine RPM and cycle the emergency generator switch to ISOLATE and back to MAN to restore full emergency power. The JFS, when engaged, will provide sufficient hydraulic power for flight control and emergency generator operation, permitting a minimum rate of descent glide at 210 KCAS.

During a double engine stagnation, allow one engine to remain in stagnation while commencing a restart on the other engine. Prolonged overtemperature increases damage and reduces the probability of successful restart of that engine. Therefore, shut down the second engine and commence a restart as soon as a restart is indicated on the first engine.

Eject before losing flight control. Imminent loss of control is indicated by loss of the emergency generator and/or control transients as the first PC system drops to 0.

DOUBLE ENGINE STALL/STAGNATION

1. Both throttles – CHOP TO IDLE (MIL if in AB)  (If afterburner stall does not clear at MIL, chop throttle(s) to IDLE).

If RPM on both engines is less than 60% with no response to throttle movement, or FTIT on both engines continues to rise –

2. Throttle (right engine) – OFF WHILE ESTABLISHING 350 KCAS   (If FTIT exceeds 1,107 C, shut down engine with lower FTIT).

3. Perform Restart procedure   (If optimum restart parameters are not met by the time RPM decreases through 30%, place the throttle to midrange regardless of FTIT, airspeed, or altitude).

4. At RPM increase on engine being restarted or if restart unsuccessful, shut down other engine

5. Other engine – RESTART

RESTART

Ignition and fuel are continuously supplied when the throttles are at IDLE or above. If an engine does flameout and the auto start does not occur, it is unlikely that a start can be accomplished as cycling the throttles through OFF does not recycle either ignition circuits or fuel flow. Therefore, restarts are generally required only because an engine has been shut down for some reason. Restarts may be made with RPM as low as 12% (fuel flow and/or ignition may not be available below approximately 12%). However, for optimum restart capability, place the throttle in midrange when the following conditions are met:

- RPM between 30% and 50%.
• FTIT below 800 C.

Normally the fastest restart is accomplished by placing the throttle to midrange as RPM unwinds rather than waiting for RPM to stabilize, or by attempting a JFS assisted restart. Advancing the throttle at a minimum 30% when RPM is decreasing should allow time for a relight before RPM drops to 12% RPM. There is a high probability of hot starts, hung starts, or no lights below 275 KCAS, as well as increased chances for these problems at altitudes at or above 30,000 feet. If airspeed is insufficient and RPM drops below 12%, airspeeds up to 450 KCAS may be required to regain 12% RPM.

**CAUTION**

If the engine RPM is allowed to drop to 0%, it may thermally seize. If this occurs, the engine will not rotate even with high airspeeds or engagement of the JFS. If a restart is planned, maintain engine RPM above 0%.

During restart, there will be no response to throttle movement above IDLE and the IDEEC will inhibit pilot inputs until a stabilized flight idle has been established.

Stabilizing or increasing RPM is normally the first indication of light-off during restart. The fuel manifold drain port on the pressurization and dump valve is capped, resulting in normal light-off time of 5 seconds or less after advancing throttle to mid-range. However, RPM and FTIT turn around are slow, making light-off subtle and difficult to detect. This condition should not be confused with a hung start. For PRI restarts below 30,000 feet MSL, if light-off is not indicated in 20 seconds, place the throttle in OFF and attempt a restart in SEC.

IDEEC over-temperature protection logic attempts to limit FTIT during start to 870 C, which may result in decreasing, hung, or slowly increasing RPM. If a hung start occurs below 30,000 feet MSL (stabilized FTIT 870 C or less, RPM hung, and definitely stabilized below 60% RPM), increase airspeed to a maximum of 400 KCAS/0.9 Mach. If the hung start persists, attempt a restart in SEC.

Above 30,000 feet MSL, the restart should be initiated by moving the throttle to midrange at 50% RPM regardless of FTIT or airspeed to increase the probability of light-off. If unable to move the throttle to midrange at 50%, do so at as high an RPM as possible and always by 30%. Obtain 400 KCAS/0.9 Mach by diving or using the good engine to minimize RPM spool down rate, and quickly decrease altitude to less than 30,000 feet MSL. If light-off indications are not noted within 20 seconds after advancing the throttle, or if FTIT exceeds 870 C (hot start), move the throttle to OFF and reinitiate a PRI restart. If a hung start occurs (RPM stable with FTIT stable at 870 C or less), keep the throttle at midrange until below 30,000 feet MSL, then reinitiate a PRI restart.

If the control system senses a condition which could prevent safe operation in the primary mode, an automatic transfer to SEC mode will occur and a SEC start may result regardless of the ENG
CONTR switch position. The start procedure for either a primary or secondary start is the same. However, a higher airspeed is required for SEC start.

Windmill restarts at 25,000 feet MSL and above with alternate fuels may result in no lights. If light-off indications are not noted within 20 seconds, move the throttle to OFF, descend and hold airspeed to maintain 12% RPM, and reinitiate the restart when below 25,000 feet MSL.

During a SEC start, 60 to 70 seconds are required for light-off and acceleration to midrange from the time the throttle is advanced from OFF. If a SEC spool down restart is initiated below 20,000 feet with RPM in the 40 to 50% range, as much as 30 seconds may be required to see positive RPM response. Do not confuse this slow response with a no-light. Higher altitude or lower RPM (30-40%) SEC spool down restarts will show normal positive RPM indications within 20 seconds. Restarts initiated at higher RPM in general will typically accelerate slowly in the 40-50% RPM range.

**JFS ASSISTED RESTART**

JFS airstart capability has been incorporated for assistance in engine restarting. This capability is intended for use when encountering engine stall or stagnations after all other restart options have been attempted or rejected as being impractical. The probability of a successful JFS airstart and engine engagement will be enhanced if the aircraft is within the envelope depicted in Figure 3-1. Additionally, the centerline pylon should be jettisoned if at all possible. If the centerline pylon will not jettison, it may be necessary to descend to lower altitudes to achieve a JFS airstart.

In all cases, proper considerations to the safe ejection envelope should be made prior to attempting the JFS airstart procedure. During restart attempts, ensure that at least one engine is rotating (even in stagnation) at or above 18% RPM to provide sufficient hydraulic power for the emergency generator and flight controls.

**WARNING**

When doing a JFS assisted restart, the engine display format on the MPD/MPCD may freeze if power is lost to the IDEEC. The EMD will continue to correctly display engine parameters and should be used in this case.

If a JFS assisted restart is desired:

1. Throttle – OFF
2. Centerline pylon – JETTISON (if required)  (If both engines are below minimum RPM for generators (approximately 56%) or both main generators are inoperative, the centerline pylon can only be jettisoned by pressing the emergency jettison button.

3. JFS switch – CHECK ON

After at least one engine is below 40% RPM –

4. JFS handle – PULL AND RELEASE  (Use single accumulator for inflight JFS starts.  If both accumulators are discharged simultaneously the JFS may accelerate too rapidly and fail to start.

**WARNING**

If the JFS does not start, the starter switch should be placed to OFF. Wait 30 seconds after cycling the switch to allow the start sequence relay to disengage and the JFS to decelerate before trying a second start. Failure to wait 30 seconds may result in a JFS no start.

5. JFS ready light – CHECK ON (within 10 seconds)

After engine is below 30% RPM –

**CAUTION**

To preclude a possible CGB shear section failure, do NOT move the engine control switch until the engine achieves idle.

6. Finger lift – RAISE AND RELEASE  (Attempts to engage the JFS above 30% RPM may shear the CGB shaft. Once the JFS is engaged, sufficient hydraulic pressure to the flight controls should be available to permit a controlled minimum rate of descent glide – approximately 210 KCAS).

7. Throttle – MID RANGE  (after engine reaches steady state motoring speed of 26 to 29% RPM)

**CAUTION**

When shutting down an engine with the JFS running, releasing the finger lift before reaching the cutoff position to prevent immediate JFS reengagement and
possible CGB shear section failure.

8. Other engine – START (if applicable)
9. JFS – CONFIRM OFF

AIR INLET SYSTEM MALFUNCTION

INLET LIGHT ON

An illuminated caution light indicates either an AIC failure, ramp position error, or a diffuser ramp that did not lock or unlock at the appropriate Mach number. Airspeed should be reduced below Mach 1.0 and if above Mach 0.95 accelerations are limited to +4.0 G to -1.0 G.

1. Inlet ramp switch – EMERG
2. Throttle – MIL (if above Mach 1.0)
3. Limit aircraft loads to +4.0 G to -1.0 G

ROLL RATIO and RUDR LMTR CAUTION ON –

If the engine RPM does not decrease as the throttle is moved to idle, and ROLL RATIO (and possibly RUDR LMTR) caution is displayed, and AIC malfunction has probably occurred resulting in a false high Mach signal to the engine.

1. Determine if engine RPM responds to throttle movement

If RPM does not respond to throttle movement –

2. Engine control switch – OFF
3. Refer to Engine Control Malfunction procedures

If RPM does respond to throttle movement –

2. Refer to Engine Control Malfunction procedures

ENGINE CONTROL MALFUNCTION

The ENG CONTR caution will come on as a result of a failure of an electrical signal used for afterburner control, or if the IDEEC has transferred from the primary to the secondary mode due to the IDEEC failure detection. If the ENG CONTR caution and corresponding INLET caution are ON, a Mach number failure is most likely the cause. If the ENG CONTR caution is ON, and the corresponding nozzle position is greater than 5%, then the engine is probably in secondary mode. When the engine control is in secondary mode, the nozzle is closed, afterburner operations is
prevented, only 70-80% RPM at MIL thrust is produced, and both ground idle and approach idle thrust are disabled. This will increase taxi speed. Cycling the ENG CONTR switch may return the engine to normal operation.

If supersonic –

1. Throttles – MIL
2. Slow to subsonic

If above 30,000 feet –

1. Throttle – MINIMIZE MOVEMENT
2. Descend below 30,000 feet

If subsonic and below 30,000 feet –

1. Throttle – 80% to 85% RPM
2. ENG CONTR switch – CYCLE ON – OFF – ON

NOTE

Cycling the ENG CONTR switch from OFF to ON above 30,000 feet may cause an engine stall.

If engine operation abnormal or ENGINE category light and ENG CONTR caution message still on –

3. ENG CONTR switch – OFF
4. Land as soon as practical (Gear down idle thrust will be greater than normal)

After landing –

5. Shutdown the engine to reduce taxi speed (if required)

NOZZLE FAILURE

The cockpit nozzle indication is nozzle control unit commands, not actual nozzle position. It is possible for the nozzle to fail open or closed and still have normal cockpit indications. Engine stall when selecting afterburner may be an indication of a nozzle failed closed. A loss of thrust and lower than normal FTIT at MIL may be an indication of a nozzle failed open. If nozzle malfunction is indicated, leave the ENG CONTR switch ON. Do not use MIL or afterburner unless required to maintain flight. Gear down idle thrust will be greater than normal with the nozzle full closed.
ENGINE FIRE INFLIGHT

If a fire light comes on, or a voice warning “Warning, Engine Fire, Left (or Right)” is heard, or indications of an engine/aft fuselage fire are observed, perform this procedure. A fire in the afterburner section or in the vicinity of the nozzle will not cause a FIRE light to come on, the L BURN THRU or R BURN THRU light will come on and the “AB Burn Thru, Left (Right)” voice warning will be heard. If an afterburner/nozzle burn through occurs, reducing the throttle to IDLE should extinguish the fire within 30 seconds. If the initial throttle reduction causes the light to go out or fire indications to cease and the fire detection system tests good, restrict thrust on the affected engine. If a fire light is accompanied by other indications of a fire (e.g., smoke, control difficulties, bleed air light, hydraulic or electrical anomalies), complete the procedure.

With indications of explosion or catastrophic failure, do not delay completing engine shutdown steps. This may terminate fuel to the fire before it becomes self sustaining. Once the light has been pushed and the fuel shut off, do not depress the light again unless engine restart is necessary. If the fire extinguisher is used successfully, do not consider restarting the engine unless absolutely necessary.

1. Throttle – IDLE

If warning light goes off or fire out –

2. Fire warning system – TEST
3. Monitor other fire indications closely

If warning light remains on or fire persists –

2. Fire warning light – PUSH
3. Throttle – OFF
4. Fire extinguisher – DISCHARGE

If fire persists –

5. Eject

AFTERBURNER BURN THRU

If a fire occurs in the afterburner section, the left or right afterburner burn through lights will come on and the voice warning will be heard.

1. Throttles – RETARD TO MIL OR BELOW
AMAD FIRE INFLIGHT

The most likely cause of an AMAD fire light in flight is the generators. If indications of a fire (AMAD Fire Light and “Warning, AMAD Fire” voice warning) exist, check electrical indications as well. Turning off a generator may remedy the situation.

1. Throttles – REDUCE

If fire warning light goes out –

2. Fire warning system – TEST
3. Monitor other fire indications closely
4. Discontinue mission

If fire warning light remains on –

2. AMAD light – PUSH
3. Fire extinguisher – DISCHARGE

If fire warning light still remains on –

4. Emergency generator switch – MANUAL (The EMER BST ON caution light should come on and the BST SYS MAL caution light should remain off. If the BST SYS MAL caution is on when both generator switches are turned OFF, double engine flameout may occur due to lack of boost pump pressure).
5. Affected generator switch – OFF

If unable to determine which generator is affected –

6. Both generator switches – OFF (one at a time to isolate source)

If fire persists –

7. Eject

CANOPY UNLOCKED INFLIGHT/LOSS OF CANOPY

CANOPY UNLOCKED

The CANOPY UNLOCKED caution indicates that either the canopy locking mechanism has moved to the unlocked position or the canopy actuated initiator lanyard has become disconnected. The following procedures are recommended:
• Slow to below 250 KCAS.
• Emergency vent handle – TURN (below 25,000 feet).
• Canopy control handle – FULL FORWARD

BLEED AIR CAUTION

Bleed air malfunctions have the potential for developing into serious situations. Depending on the location of the hot air leak, various indications can result, causing pilot confusion and misinterpretation. Therefore, prompt action is required by the pilot.

If left or right bleed air caution comes on –

1. Air source knob – OPPOSITE SOURCE

If caution remains on –

2. Throttle – IDLE

If both cautions come on –

3. Air source knob – OFF (below 25,000 feet)

ECS CAUTION

An ECS caution indicates low airflow or over-temperature of the avionics cooling air. In either case, avionics damage due to heat is the primary concern. Very low or high engine RPM can degrade ECS operation. Therefore, maintain moderate airspeeds and RPM if the ECS caution is on. Shut down the radar first as it is very heat sensitive and reduces the cooling air available for other systems. Turn off non-essential avionics for their own protection. Avionics that cannot be turned off, (AHRS, transformer rectifiers, IFF, AIC, ADC, signal data recorder, etc.) will continue to be heat damaged.

Turning the emergency vent handle dumps cockpit pressurization. Pulling the handle diverts ECS cockpit air to the avionics and allows ram flow to enter the cockpit as a function of handle extension. Turning the cockpit temperature control switch OFF will switch avionics cooling to ram air. The ECS caution will continue to monitor avionics cooling air flow and temperature. Optimum ram air cooling is obtained at 400 KCAS and 15,000 feet.

ECS turbine bearing disintegration and failure generally causes a high pitched whine that increases in pitch as engine RPM rises (starting about 80%). It can be accompanied by vibration in the floor area, an ECS light, and/or smoke and fumes. The only way to shut the ECS turbine down is by placing the cabin temperature control switch or air source knob to OFF.
NOTE

When landing with an illuminated ECS light, an automatic avionics shutdown may occur upon touchdown or during landing rollout. If so, the HUD and cockpit displays will blank out and VHF 1 will be inoperative. Aerobrake using backup visual references.

If ECS caution illuminates –

1. Maintain 250 to 450 KCAS (75% to 85% RPM)

If caution remains on –

2. Non-essential avionics – OFF
3. Emergency vent handle – TURN AND PULL (below 25,000 feet)

If caution still remains on –

4. Cabin temperature control switch – OFF

ASYMMETRIC THRUST DEPARTURE PREVENTION (ATDP) SYSTEM CAUTION

When ATDP caution is ON, the aircraft is unprotected from asymmetric thrust induced yaw departures and may also be susceptible to dual secondary mode transfers. When operating in afterburner at high dynamic pressures, the yaw moment can be large enough to cause permanent structural aircraft damage or even aircraft loss.

The caution indicates either system operating mode is other than commanded or air data is invalid. With the caution present, the aircraft flight envelope is restricted based on airframe configuration.

WARNING

When configured without CFT, do not fly above 650 KCAS when Mach is greater than 1.3 and altitude is less than 35,000 feet. When configured with CFT, do not fly above 525 KCAS when Mach is greater than 1.35 and altitude is less than 35,000 feet, or fly above 600 KCAS when Mach is between 1.25 and 1.35 and altitude is less than 35,000 feet.

Refer to Engine Control Malfunctions.
OIL SYSTEM MALFUNCTION

Engine oil system malfunctions include over or under pressure, and excessive fluctuations. If the oil pressure stays below 8 PSI but above 0 PSI and appreciable time at altitude is expected, consider engine shutdown. If oil pressure stays at 0 PSI or above 100 PSI and the other engine is operating normally, the engine should be shut down without delay to limit damage. If the engine is left running and vibration or other indications of possible engine seizure occur, shut down the engine and make a single-engine landing.

If oil pressure is out of normal range –

1. Throttle – IDLE

If oil pressure below 8 PSI or pegged at 100 PSI –

1. Throttle – OFF (conditions permitting)
2.

EMER BST ON AND/OR BST SYS MAL CAUTION

The EMER BST ON and BST SYS MAL cautions provide indication of the status of both the emergency fuel boost pump system and the emergency generator system. A single caution, or combination of cautions, requires the following aircrew actions:

<table>
<thead>
<tr>
<th>EMER BST ON</th>
<th>BST SYS MAL</th>
<th>AIRCREW ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>OFF</td>
<td>Refer to generator failure or boost pump failure as applicable. Follow applicable boost pump failure procedure. Do not turn main generators OFF or place emergency switch to ISOLATE as this may fail the emergency boost pump.</td>
</tr>
<tr>
<td>OFF</td>
<td>ON</td>
<td>Refer to generator failure or boost pump failure as applicable. Follow applicable boost pump failure procedure. Do not turn main generators OFF or place emergency switch to ISOLATE as this may fail the emergency boost pump.</td>
</tr>
<tr>
<td>ON</td>
<td>ON</td>
<td>Refer to generator failure or boost pump failure as applicable. Follow applicable boost pump failure procedure. Do not turn main generators OFF or place emergency switch to ISOLATE as this may fail the emergency boost pump.</td>
</tr>
</tbody>
</table>

FUEL BOOST PUMPS INOPERATIVE

There are various combinations of indications to warn of a single or multiple fuel boost pump failure. A single boost pump failure is indicated by a L or R BST PUMP caution on, or a BST SYS MAL caution on, or even a BST SYS MAL caution light on without an associated illumination of the EMER BST ON caution light. Emergency procedures are different depending upon whether one or both of the cautions are displayed.

SINGLE OR DOUBLE (ANY TWO) FUEL BOOST PUMP FAILURE(S)

With only one boost pump operating, prudence dictates that the aircraft be operated at the lowest practical altitude below 30,000 feet and at a higher (but not afterburner) power setting.
1. Land as soon as practical

**BOTH MAIN FUEL BOOST PUMPS AND EMERGENCY BOOST PUMP INOPERATIVE (TOTAL BOOST PUMP FAILURE)**

1. Descend to minimum practical altitude using maximum practical power on at least one engine (not afterburner)

**NOTE**

If the situation permits, maintain high power settings for at least 3 minutes to cool the fuel, and descend with both throttles at military power. As the descent becomes more restricted by weather, airspeed, etc., maintain one throttle at MIL while retarding the other as necessary toward IDLE. If the retarded engine operates at IDLE and additional power reduction is required, you can then retard the advanced throttle as required. Use of the speed brake should be considered.

2. Reduce electrical load to the minimum practical

3. Maintain split throttles until established in traffic pattern

**NOTE**

Maintain one engine at as high a power setting as possible until the throttle must be retarded to permit landing.

**FUEL TRANSFER SYSTEM MALFUNCTION**

The primary indication of a fuel transfer system malfunction is the fuel gauge. Other indications include premature FUEL LOW caution, BINGO caution, wing low tendency and appropriate voice warnings.

**INTERNAL TANK(S) FAIL TO TRANSFER**

If tank 1 transfer pump has failed, a differential greater than 750 pounds between tank 1 and the internal wing tanks will be observed. If this occurs, the fuel in tank 1 should be considered trapped, and as the wing tanks empty the aircraft CG will shift forward.
If feed tank fuel quantity begins to drop with fuel remaining in either of the internal wing tanks, a wing transfer fuel pump failure is likely. If any or all of the transfer pumps fail, the fuel in the affected tanks will gravity transfer to the feed tanks when tanks with operating transfer pumps are empty and the fuel level in the feed tanks drop below the level of fuel in the affected tank(s). Gravity transfer can be confirmed by observing the simultaneous decrease of fuel levels in the affected tank(s) and associated increase in fuel level in the feed tanks. Gravity transfer may not occur until after the FUEL LOW caution warning illuminates and very low feed tank fuel level is reached (300 to 400 pounds in each tank). Gravity transfer will not completely refill the feed tanks, and may not keep up with feed tank usage.

**WARNING**

Fuel flow rates above 3,500 pounds per hour per engine will exceed the gravity feed transfer rate and if not corrected will result in fuel starvation to the engines.

### If transfer pump failure is suspected –

1. Throttles – RETARD (less than 3,500 PPH per engine)

### For tank 1 transfer failure –

2. Slipway switch – CHECK CLOSED

**NOTE**

Open slipway will prevent fuel feed from tank 1.

### If slipway switch closed –

3. Stay below 30 units AOA
4. Maintain approximately 250 KCAS for cruise and plan for a minimum fuel descent
5. Land as soon as practical

**EXTERNAL TANK FAILS TO TRANSFER**

With external wing tanks installed, if the external fuel tanks fail to transfer completely or if STOP TRANS is selected due to an emergency and any external tank, including the centerline, is partially
full, the aircraft may exceed the aft CG limit as internal fuel decreases due to fuel moving aft in the external tanks. Cycling the external tank switch or slipway door may restore transfer. If the landing gear is cycled under these conditions, it may fail to retract due to weight-on-wheels (WOW) switch malfunction. Ensure fuel on board will allow flight to a suitable landing base with the gear down if transfer is not restored. If not, it may be necessary to jettison the tanks to restore CG within acceptable control ranges.

If external tank transfer failure is suspected –

1. External transfer switch – WING/CTR
2. External tank fuel control switches – CYCLE
3. Landing gear circuit breaker – IN
4. Slipway switch – CYCLE
5. Throttle(s) – MIL

If external tank still fails to transfer or STOP TRANS is selected –

6. Maintain minimum 250 KCAS
7. Use minimum pitch angle for manoeuvring
8. Jettison external tanks (if required)

If partially full external tanks are retained –

9. Maintain 18 units AOA on final

CFT FAILS TO TRANSFER

CFT fuel transfer failure is indicated by voice warning, “WARNING, TRANSFER PUMP” and by the FUEL PUMP caution light illuminating. This condition can be verified by referencing the fuel quantity indicator and noting reductions in feed tank fuel levels with lack of reductions in CFT fuel levels.

If CFT transfer pumps on one side of the aircraft, it may be necessary to discontinue all CFT fuel transfer to preserve safe aircraft CG. If both main generators fail, all CFT transfer pumps automatically shut off.

If fuel is not critical, do not transfer CFT fuel. However, if fuel condition is critical, then CFT fuel can be transferred using the CFT emergency transfer switch. The landing gear handle must be up to prevent fuel from transferring to the other CFT vice the intended feed tanks. Wait until internal fuel decreases to 1,000 pounds then select L or R. When internal tanks are full, place the switch to NORM. Wait until internal fuel again decreases to 1,000 pounds before repeating the same emergency fuel transfer procedure. Repeat this procedure until the CFT’s are empty or until the fuel condition is no longer critical.
If both generators fail and fuel critical –

1. Landing gear handle – UP

After internal fuel decreases to 1,000 pounds or less –

2. Conformal tank emergency transfer switch – L or R (select desired CFT side to transfer from)

When internal tanks full –

3. Conformal tank emergency transfer switch – NORM
4. Repeat steps 1 through 3 for opposite CFT

EMERGENCY FUEL TRANSFER/DUMP (EXTERNAL TANKS), GEAR DOWN

Fuel in external tanks cannot be transferred and/or dumped unless the landing gear handle is up or the fuel low level system is activated. If it is necessary to transfer or dump fuel with the gear down, the following procedures will permit external fuel transfer/dump without raising the landing gear.

1. Emergency landing gear handle – PULL
2. Landing gear handle – UP
3. Fuel gauge – MONITOR
4. Fuel dump switch – DUMP (if required)
5. Landing gear handle – DOWN (when dumping complete)

If UTL A pressure zero –

6. Emergency landing gear handle – RESET

UNCOMMANDED FUEL VENTING

Fuel flowing uncommanded from the dump mast(s) in flight is, in all probability, due to abnormal venting caused by fuel transfer system and/or fuel pressurization/vent system failures. The probability of spontaneous dump system failure is extremely rare.

**CAUTION**

If fuel dump is selected during abnormal venting, the internal fuel tanks could over-pressurize and rupture.
If uncommanded fuel venting is observed –

1. Fuel dump switch – NORM
2. External tank/conformal tank fuel control switches – STOP TRANSFER

**WARNING**

If any external tank is partially full, the aircraft may exceed the aft CG limit at light internal fuel weights due to fuel moving aft in the external tanks. In this case, it may be necessary to jettison the external tanks.

3. Slipway switch – OPEN
4. Air source knob – OFF (below 25,000 feet) (Except a possible ECS light once the air source knob is turned off).

If fuel venting continues and flight to an emergency landing site is not within range of feed tank fuel quantity –

5. Emergency generator switch – MAN (The EMER BST ON caution should come on and the BST SYS MAL caution should remain off).
6. Main generator switches – OFF (If the BST SYS MAL caution is on when both generator switches are turned OFF, double engine flameout may occur due to lack of boost pump pressure).
7. Fuel gauge – MONITOR FEED TANK (Feed tanks may be refilled by turning on a main generator thus activating transfer pumps, or by allowing fuel to gravity feed from internal wing tanks).

When feed tank fuel is sufficient for flight to an emergency landing site –

8. Main generator switches – ON

**GENERATOR FAILURE**

A generator failure is indicated by an L GEN OUT or an R GEN OUT caution light. The emergency generator will come on and power the emergency boost pump and the EMER BST ON caution will come on. If the BST SYS MAL caution comes on, the emergency generator has probably failed. Normal flight electrical loads (except TEWS pods) can be handled by one generator. Check hydraulic warning lights and gauges for indications of AMAD failure. Check engine instruments for indication of stall/stagnation or flameout.
Upon indication of generator failure –

1. Generator switch – CYCLE

If generator still failed –

2. Generator switch – OFF

DOUBLE GENERATOR FAILURE

If both generators fail, the emergency generator will automatically power the essential buses providing the emergency generator is not in ISOLATE. The HYDRAULIC caution and the landing gear warning light will come on and the landing gear warning tone will sound. Operation of the landing gear warning light/tone is due to the loss of the ADC. The gear should operate normally. Hydraulic system operation can be verified only by proper operation of hydraulically powered systems.

Refer to Emergency Power Distribution Chart (Figure 3-5) for equipment that will be operative/inoperative when the emergency generator is on line. If either generator can be reset, the electrical system will revert to normal operation.

The following indicators/instruments will fail immediately and, except for the fuel flow, oil pressure, and exhaust nozzle indications (which all go blank), will tend to remain at the last valid reading:

- Vertical velocity indicator
- AOA indicator
- Exhaust nozzle position indications
- Oil pressure indications
- Fuel flow indications
- Oxygen quantity indicator
- PC1 hydraulic pressure indicator
- PC2 hydraulic pressure indicator
- Utility hydraulic pressure indicator

The only display powered by the emergency generator is the front MPCD which will display ADI format and cautions. Dual generator failure may also degrade quality of power to surviving displays, making them unreliable. Therefore, reference to the standby ADI and other standby instruments becomes essential.

NOTE

All standby instruments remain operational and reliable during dual generator failure.
Upon indication of dual generator failure –

1. EMER BSO ON caution – CHECK ON (If the EMER BST ON caution is not on, cycle the emergency generator switch to ISOLATE and back to MAN).

   NOTE

   In ISOLATE mode, rear cockpit power and intercom are lost. WSO should be notified prior to initializing ISOLATE mode.

2. Main generator switches – CYCLE
3. Implement “Both Main Fuel Boost Pumps and Emergency Boost Pump Inoperative” procedures

   WARNING

   With both main generators inoperative the nozzles will stay fully closed with the landing gear down and idle thrust will be substantially higher than normal.

   NOTE

   Feed tank fuel cannot be monitored. Flameout due to fuel starvation may occur with prolonged use of high power settings. With total electrical failure, the standby attitude indicator will display an OFF flag but is reliable for 9 minutes after loss of electrical power.

AMAD FAILURE

AMAD failure is indicated by the simultaneous loss of the PC system, the utility pump, and the generator on the same side. If this occurs:

1. Throttle – IDLE
2. Refer to Electrical and Hydraulic Failures

If double AMAD failure occurs –
1. Eject (If double AMAD failure occurs, total hydraulic and electrical power are lost and aircraft control is impossible).

RUNAWAY TRIM

Sufficient control is available to land the aircraft from a runaway trim in any direction. Unless other flight control malfunctions are evident, leave pitch and roll ratio switches in AUTO. If a runaway trim condition cannot be controlled with the normal trim controls, use of the takeoff trim button may be effective in returning the trim to a near neutral position. Pulling the AFCS ESS AC circuit breaker removes power from the trim actuators while leaving the rest of the flight control system operational (upper AFCS ESS AC circuit breaker is for pitch trim, and the lower AFCS ESS AC circuit breaker is for both roll and yaw trim).

FLIGHT CONTROL SYSTEM MALFUNCTION

The CAS is a highly reliable three channel system that continuously self-checks its operation. If the system senses two channels, of the same CAS axis failure, it will drop itself off line. Nevertheless, if flight control failure is noted, immediately perform the following step:

1. Eject

ADC FAILURE

Operation of the Air Data Computer (ADC) is entirely automatic, and no control over the system is available to the pilot. Primary indications of ADC failure are freezing or failure of the vertical velocity indication, warning light in the landing gear handle, and when airborne, landing gear warning tone. The ADC provides inputs to most flight instruments as well as to the inlet controller to each engine intake.

Reference to standby instruments is the only effective pilot action. Flight should be continued to the first available emergency airport.

INS FAILURE

If the INS fails, the ATTITUDE caution is displayed. If the ISN is the selected data source, OFF is displayed next to INS and an X is displayed on the ADI attitude ball. Master caution and the AV BIT caution will also come on. Select the attitude source that is still valid and monitor the standby attitude indicator.

Flight without the INS can still be made using either visual pilotage or by dead reckoning methods as well as by use of TACAN navigation systems.

In the event of INS failure inflight, the pilot or WSO may elect to perform an inflight alignment (IFA) by inputting a known position and heading, and having the pilot remain on a constant heading.
unaccelerated vector during the duration of the alignment period. Navigational errors of 8 knots may be experienced after a successful IFA.

MULTIPURPOSE DISPLAY PROCESSOR (MPDP) FAILURE

The MPDP is powered by four power supplies. These supplies are labelled A through D. Each of these four power supplies control dedicated displays and modes, and therefore a failure of any of the four supplies will cause performance and display degradations. The systems lost through supply failures are:

Power Supply A Failure

- FWD MPCD
- Right Aft MPD
- Displays off 1553 Bus A
- GP I/O (backup mode capability)
- 1553 avionics bus
- SGP Bus A
- JTIDS 1553
- Radar

Power Supply B Failure

- Aft right MPCD
- Fwd right MPD
- EWWS, OWS, RWR
- Displays off 1553 Bus B
- SGP Bus B

Power Supply C Failure

- Aft left MPCD
- HUD backup mode
- Displays off 1553 Bus B
- Radar
- Fwd left MPD

Power Supply D Failure

- Displays off 1553 Bus A
- VTR
- Aft left MPD
- HUD (primary)
- TEST PATTERN (on initiated BIT)
NOTE

In the event of a power supply C or D failure, removing power from the CC will result in six display backup mode of operation.

If a total MPDP failure occurs, all systems which require an MPD/MPCD or HUD to be displayed (i.e. radar, INS, PACS) are lost. The EMDs and the standby instruments are still functional.

NOTE

If several front and rear cockpit displays go blank or display STANDBY, a recycle of power to MPDP should return the system to normal operation.

LANDING

CONTROLLABILITY CHECK

If handling characteristics for recovery are suspect, perform a controllability check. If recovery is possible, plan to fly the final approach at the AOA determined in the controllability check, and delay reducing power until well into the flare.

1. Attain a safe altitude
2. Reduce gross weight to minimum practicable
3. Establish landing configuration (Use of flaps is not recommended if structural damage to the wing is suspected).
4. Slow aircraft to no less than on-speed AOA (20-22 units)
If recovery is possible –

5. Maintain landing configuration and fly straight-in approach no slower than AOA determined in step 4
6. Delay reducing power until well into the flare

If recovery is not possible –

5. Eject (Eject over ideal location for optimal chance of successful recovery).

SINGLE-ENGINE OPERATION

Single-engine operation provides adequate power for flight. Since loss of electric and hydraulic redundancy is the major concern, make every attempt, consistent with safety and prudence, to have the ailing engine running, even at idle. Otherwise, normal procedures should be followed, making appropriate allowance for reduced thrust. Reduce gross weight as practicable. Plan ahead to avoid situations requiring high thrust levels. A windmilling engine can cause repeated flight control transients, reduced control sensitivity, momentary split flaps, and CAS disengagements as the hydraulic switchover valves operate. After PC pressure has decreased to near zero, these anomalies will cease.

Approaches to landing should be made on a straight-in final with a normal glidepath and ideally flown under visual conditions.

**WARNING**

Failure of the surviving engine while on final approach is a very critical issue and unless already established in the flare, should lead to immediate ejection. Ejection at very low altitude and with an established sink rate can cause increased risk of injury during the ejection sequence.

FLAP MALFUNCTIONS

If a split-flap situation occurs and the flaps cannot be retracted, fly a wider than normal pattern using normal AOA and airspeeds. Sufficient control will be available either CAS-ON or CAS-OFF under most configurations. A controllability check should be performed. With CAS-ON, only a slight rolling tendency will be noticed. With CAS-OFF, the tendency for roll is more pronounced but still not severe.

LANDING GEAR UNSAFE

If one or both main gear indicate unsafe, but all gear are visually confirmed to have extended and appear to be locked, leave the gear handle down and perform a normal approach and
landing with minimum touchdown force and minimum braking action. Runway length should be factored in to account for additional float and increased stopping distances. Use of nosewheel steering should be minimized and applied in a smooth manner.

If all three gear extend without any of the three gear down indicator lights on, and a gear down condition is visually confirmed (either by tower controller or wingman), then a circuit breaker is likely popped.

If unable to visually confirm the landing gear down condition, or if visual confirmation is made that one or more gear has failed to extend, refer to Landing Gear Emergency Extension procedures.

**If landing gear failure is indicated** –

1. Obtain visual confirmation of gear status (if practical)

**If gear visually confirmed down** –

2. Anti-skid – OFF/PULSER

**If one or both main gear indicate unsafe** –

3. If conditions warrant, conduct a normal approach with softest possible touchdown and minimum braking and nosewheel steering inputs (if one main gear is unsafe, land on the good gear and keep full aileron input to keep the failed gear off the ground as long as possible).

**If nose gear indicates unsafe** –

3. Make normal landing (use maximum aft stick force as necessary to keep nose gear off the ground as long as possible, or to keep nose radome off the ground as long as possible).

**If gear not visually confirmed down** –

2. Use Landing Gear Emergency Extension procedure

**LANDING GEAR EMERGENCY EXTENSION**

Failure of the gear to extend may be caused by loss of UTL A hydraulic pressure, mechanical or electrical failure of a system component, or physical jamming of the gear. Pulling the emergency landing gear handle (far enough out to lock) bypasses the normal electrical and hydraulic controls and port JFS accumulator pressure to open the gear doors and unlock the landing gear. The landing gear, aided by air loads, then free falls to down and locked. Providing no component or UTL A failure exists, resetting the emergency landing gear handle with the normal handle DOWN will restore pressure to the extend side of the gear actuator, close the landing gear doors, and allow JFS accumulator to recharge.
If failure to extend is due to a mechanical jam, repeated cycling with the normal system may be the only method to dislodge the object causing the jam. If normal hydraulic and electrical power are available and completion of the following steps does not successfully extend the gear, restore normal system operation by pushing the emergency landing gear handle in and ensuring the circuit breaker is in. Attempt to extend the landing gear normally several times. Pause 10 seconds between each attempt and pull positive G during the extension cycle. If this fails, refer to Landing With Abnormal Gear Configuration.

1. Airspeed – BELOW 250 KCAS
2. Landing gear handle – DOWN
3. Emergency landing gear handle – PULL UNTIL LOCKED (Yawing the aircraft and slowing to below 200 KCAS may aid in obtaining gear down indications).

With UTL A pressure zero –

4. Emergency landing gear handle – RESET

If any gear fails to extend –

5. Landing gear control circuit breaker – PULL, WAIT AT LEAST 30 SECONDS
6. EMERGENCY LANDING GEAR HANDLE – PULL

If gear extend –

7. Landing gear control circuit breaker – RESET

If gear still fails to extend or cannot be visually confirmed down –

8. Refer to Landing Gear Emergency – Landing, Figure 3-4

If any gear retracts –

5. Emergency landing gear handle – PULL (DO NOT RESET)

LANDING WITH ABNORMAL GEAR CONFIGURATION

There are essentially three types of abnormal gear indications for landing:

- All gear retracted (or not locked down)
- Nose gear retracted (or not locked down)
- One or both main gear retracted (or not locked down)

All three conditions call for a normal approach glidepath on normal approach speeds. The only differences are various techniques employed during the flare, touchdown, and initial landing rollout. In all such landings, crash-fire rescue (CFR) should be notified and standing by at the runway environment to provide immediate response. Runway of optimal length should also be selected.
LANDING WITH ALL GEAR RETRACTED OR NOT LOCKED DOWN

When all three landing gear are jammed in the retracted position, or are not indicating extended and locked, all the gear should be assumed unreliable. Effort should be made to make a normal stabilized approach on speed until crossing runway threshold. At the point of flare, slightly more power should be maintained so as to ensure a soft touchdown with minimal descent velocity. Rudder should be used to maintain runway centerline orientation. Below 70 KCAS, rudder effectiveness will reduce and the pilot will lose ability to ensure runway centerline alignment.

A runway environment with a minimum of side obstructions should be used. Additionally, if possible, select a runway with sufficient distance remaining to skid to a stop.

If optimal runway conditions are not possible, consider ejecting over the airport environment with the aircraft pointed away from populated areas.

LANDING WITH NOSE GEAR RETRACTED OR NOT LOCKED DOWN

Landing with both main gear fully extended and locked but nose gear retracted or not locked down is not considered a critical emergency. Use of normal approach, flare, and touchdown technique should allow the pilot to use the rudder after touchdown to maintain runway centerline. Strong consideration should be given to select a runway oriented as close as possible into the wind, but should not come at the expense of inadequate runway distance to facilitate the longer than expected stopping distance.

After touchdown, the pilot should use all available elevator authority to keep the nose gear off the ground, or if the nose gear is jammed in the retracted position, to keep the nose radome off the ground as long as possible. Contact of either should only be made at the minimum airspeed possible. However, the pilot should ensure enough elevator authority is retained to facilitate a soft touchdown of the nose gear of radome.

After the nose gear or radome touches the ground, rudder should be avoided if the nose gear is partially extended as any nose wheel movements could cause ground looping. If the nose gear is confirmed to be fully retracted, then rudder can be used after nose radome contact on the ground to help avoid ground looping, but control inputs must be smooth and steady so as to avoid inducing a ground loop.

LANDING WITH ONE OR MORE MAIN GEAR RETRACTED OR NOT LOCKED DOWN

The most critical situation is landing with the nose gear extended, with one of the two main gear extended but the second either jammed in the retract configuration, or partially extended but not locked. Visual inspections should be made to try to determine whether the main gear with faulty indication is likely suffering a false indication. If the main gear is merely a false indication, then a normal landing may be performed, but special caution observed to anticipate a gear collapse at any time during the landing gear rollout.
If the suspect main gear is confirmed visually to be jammed, then runway selection becomes a critical component of successful landing. If a runway of sufficient length is available that is oriented directly into the wind, it should be selected. Crosswind landings should be avoided if possible, but runway length should be prioritized over crosswind considerations.

If a crosswind landing is necessary, the approach should be made so as to have the good main gear on the upwind side of the aircraft. This will allow the pilot to ensure that gear makes first contact with the ground. Regardless, the pilot must make every effort to bank the aircraft as necessary to ensure only the good main gear contacts the runway, and aileron and rudder should be used to keep the bad gear off the runway as long as possible while using rudder to keep the nose pointed down the runway centerline.

The pilot should also retain enough aileron authority to softly fly the bad gear side down to the runway while also having rudder authority to attempt to counter the expected yaw toward the side of the aircraft with the bad landing gear. The pilot and WSO should anticipate a ground loop as well as the aircraft veering off the side of the runway. CFR should therefore be immediately available and lined up on the side of the runway facing the good main gear side of the aircraft. CFR should also follow the aircraft as it rolls/slides down the runway.

**NOTE**

If single main landing gear failure is noted, it should be considered preferable to retract all landing gear and implementing the Landing With All Gear Retracted procedures.
## Warning/Caution/Advisories

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>CAUSE</th>
<th>CORRECTIVE ACTION/REMARKS</th>
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</thead>
<tbody>
<tr>
<td><strong>RED WARNING LIGHTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AI</strong></td>
<td>Air intercept threat</td>
<td>Information</td>
</tr>
<tr>
<td><strong>AMAD FIRE</strong></td>
<td>Fire condition</td>
<td>Refer to emergency procedure (front cockpit only)</td>
</tr>
<tr>
<td><strong>L BURN THRU R BURN THRU</strong></td>
<td>Abrupt temperature change in the AB section</td>
<td>Retard throttles out of AB range (front cockpit only)</td>
</tr>
</tbody>
</table>
| **CANOPY UNLOCKED** | Canopy unlocked or canopy actuated initiator lanyard disconnected | **GROUND:** Relock canopy or connect lanyard.  
**AIR:** Airspeed – 200 KNOTS  
Cockpit Pressure – DUMP  
Canopy – LOCK |
<p>| <strong>FIRE</strong> | Excessive temperature in indicated area | Refer to emergency procedures |
| <strong>Landing Gear Handle</strong> | Gear up and aircraft in landing regime. Gear not in selected position, or ADC failed. | Climb or Refer to emergency procedure. |
| <strong>LOW ALT</strong> | Aircraft has descended below LAW altitude selected in UFC Menu 1 | Climb above LAW. |
| <strong>OBST</strong> | Obstacle in flight path. | Climb or Turn |
| <strong>SAM</strong> | Missile threat | Information |
| <strong>TF FAIL</strong> | Terrain following failed | Do not rely on any terrain following indications |
| <strong>UNSAFE</strong> | Gear up and aircraft in landing regime. Gear not in selected position, or ADC failed. | Information (Rear cockpit only) |</p>
<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>CAUSE</th>
<th>CORRECTIVE ACTION/REMARKS</th>
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</thead>
<tbody>
<tr>
<td><strong>YELLOW CAUTION LIGHTS</strong>&lt;br&gt;<strong>(CAUTION LIGHT PANEL)</strong></td>
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<tr>
<td><strong>AV BIT</strong></td>
<td>Avionics BIT failure</td>
<td>Check BIT display on MPD/MPCD if FLT CONTR caution also on – Refer to LAT STK LMT caution</td>
</tr>
<tr>
<td><strong>BST SYS MAL</strong></td>
<td>Emergency boost pump logic malfunction</td>
<td>Refer to emergency procedure</td>
</tr>
<tr>
<td><strong>CHAFF</strong></td>
<td>Flashing: Dispensing chaff&lt;br&gt;Steady: Chaff dispenser empty</td>
<td>Information</td>
</tr>
<tr>
<td><strong>DISPL FLO LO</strong></td>
<td>Inadequate cooling air flow to cockpit displays</td>
<td>Refer to emergency procedure</td>
</tr>
<tr>
<td><strong>EMER BST ON</strong></td>
<td>Emergency boost pump supplying pressure</td>
<td>Check BST SYS LIGHT MAL caution out/off</td>
</tr>
<tr>
<td><strong>ENGINE</strong></td>
<td>Engine systems failure</td>
<td>Information</td>
</tr>
<tr>
<td><strong>FLARE</strong></td>
<td>Flashing: Dispensing flare&lt;br&gt;Steady: Flare dispenser empty</td>
<td>Information</td>
</tr>
<tr>
<td><strong>FLYUP ARM</strong></td>
<td>Flyup enable switch ON</td>
<td>Information (Rear cockpit only)</td>
</tr>
<tr>
<td><strong>FLT CONTR</strong></td>
<td>Flight control system failure</td>
<td>Information</td>
</tr>
<tr>
<td><strong>FUEL LOW</strong></td>
<td>Left feed tank below 540 lbs and/or Right feed table below 960 lbs</td>
<td>Use minimum power – Check all tanks</td>
</tr>
<tr>
<td><strong>L GEN R GEN</strong></td>
<td>Left/right generator failure</td>
<td>Refer to emergency procedure.</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Action</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>HYD</td>
<td>Hydraulic systems failure</td>
<td>Information</td>
</tr>
<tr>
<td>MINIMUM</td>
<td>Dispensable stores at a predetermined level</td>
<td>Information</td>
</tr>
<tr>
<td>NUCLEAR</td>
<td>Nuclear armament malfunction</td>
<td>Check armament display</td>
</tr>
<tr>
<td>OXYGEN</td>
<td>Oxygen concentration is below acceptable limits</td>
<td>Refer to emergency procedures</td>
</tr>
<tr>
<td>EMIS LMT</td>
<td>EMIS LMT switch ON</td>
<td>Information</td>
</tr>
<tr>
<td>FLAPS</td>
<td>Flaps in transit</td>
<td>Information</td>
</tr>
<tr>
<td>LASER ARMED</td>
<td>Target Pod laser armed</td>
<td>Information (Front Cockpit only)</td>
</tr>
<tr>
<td>LOCK/SHOOT</td>
<td>Steady: Radar locked on Flashing: Shoot cute</td>
<td>Information (Canopy Bow)</td>
</tr>
<tr>
<td>MASTER CAUTION</td>
<td>One or more cautions displayed</td>
<td>Check caution lights and MPD/MPCD</td>
</tr>
</tbody>
</table>
UPFRONT CONTROLS

The upfront controls in the front and rear cockpit are the major interface units for control of avionics subsystems. The UFC consists of 10 function buttons, six 20-character rows of display, four radio volume controls, two rotary switches, a 20 key data entry keyboard, a rotary brightness control knob, and an EMIS LMT pushbutton.

The UFC provides control of the following systems:

- Inertial Navigation System (INS) – data entry and display
- TACAN
- Auto pilot – attitude hold, altitude hold, radar preset altitude, and steer modes
- Terrain Following (TF)
- IFF/SIF
- AAI
- UHF radios – including ADF and KY-58.
- ILS
- NAV FLIR
- JMC and JVC
- A/G stores delivery bias

The UFC multifunction buttons are used as the options indicate except buttons 5 and 6 which are dedicated to radios/submenu displays.

Buttons are numbered 1 thru 10 beginning at the top left.

PB1 thru PB5 are top to bottom on the left.
PB6 thru PB10 are top to bottom on the right.

Since a large number of system functions have been integrated into the UFC, several menus or display formats were developed. These displays are called data displays, menus, and submenus. There are 2 data displays (DATA 1 and DATA 2), 2 menus (MENU 1, MENU 2), and 19 submenus. Regardless of the data or submenu displayed, the radio communication information is always retained (5th row).
UFC OVERVIEW

1. UHF-1 preset channel knob – Turn to increment or decrement preset UHF-1 channel when in preset channel mode.

2. UHF-1 (Inner) volume knob – Turn to increase or decrease UHF-1 IDENT volume.

3. UFC brightness knob – Turn to increase or decrease UFC display brightness. Used in conjunction with the UFC lighting knob on the Pilot or WSO interior lighting panels.

4. UFC keypad – The keys on the UFC panel alphanumeric keypad have the following functions:
   - A/P – Autopilot page and engage/disengage key.
   - MENU - Menu 1 and 2 cycle.
   - DATA - Data 1 and 2 cycle.
   - CLR – Clear.
   - MARK – Switch to LAT/LONG point data screen.
   - GREC C/M - Enables/disables guard receiver on appropriate radio and toggles between preset and manual UHF channels.
When making an entry requiring a decimal point, the decimal point is not required to be entered.

The **CLR** (clear) key has two functions on successive pushes:

- 1st push – removes last character entered; 2nd push – clears all scratchpad.

**5. EMIS LMT** - Limits electronic emissions from the aircraft.

**6. UHF-2 (Inner) volume knob** – Turn to increase or decrease UHF-2 IDENT volume.

**7. UHF-2 preset channel knob** – Turn to increment or decrement preset UHF-2 channel when in preset channel mode.
DATA 1 Display

This displays current aircraft information. It is selected by pressing the DATA pushbutton on the UFC keyboard. On this format, pressing PB1 shows LOS bearing and range to current steer point and ETE/ETA. The selection will initially power up to display steer point bearing and range. The PB may be pressed and released to toggle through the three selections. PB 2, 3, and 4 display calibrated, true, and ground speeds respectively. Additionally, PB 3 and 4 control the display of true airspeed and groundspeed on the HUD and ADI formats (an asterisk is displayed on the UFC when the display is enabled). PB7 displays either winds or the CC clock time.

The display will initially power-up to display time at PB7. Radar and baro-corrected altitudes are displayed by PB8 and PB9 respectively. In addition, PB8 controls the display of radar altitude on the HUD and EADI formats (as asterisk is displayed on the UFC when display is enabled). PB10 shows the current steer point. Steering can be changed by typing the new point in the scratchpad and entering it by pressing PB10. Pressing PB10 with a blank scratchpad calls up the point data submenu.
DATA 2 Display

Pressing the DATA pushbutton a second time displays the DATA 2 display. This display provides time, groundspeed, and fuel information pertaining to two selected points in the navigation route sequence (the origin and destination waypoints for the current steering pathway).

On the data 2 display, the sequence points are indicated by SP followed by the point number identifier; only steer and target points may be identified as sequence points (SP) on the data 2 display. Target 01, route alpha is the current line of sight point selected. As a result, the 19,850 pounds readout represents the amount of fuel remaining when the aircraft reaches the SP if the aircraft travels at the current aircraft ground speed displayed, 356kts, from the aircraft present position direct to SP01.A. Also shown is the calculated ETA to reach SP01.A. Pressing the pushbutton next to the ETA will provide the ETE. If range and bearing to SP01.A is desired, pressing the pushbutton next to the fuel remaining (19,850 pounds) will display the information.

Within the same format a second sequence point, SP02.A, is displayed automatically with the data relating to it because it is the next point after the line-of-sight point with a time-on-target (TOT) assigned to it. The 20185 pounds readout is total fuel remaining. When command airspeed (CS) is selected (asterisk) it will be displayed on the MPD instead of AOA.
MENU 1 Display

Pressing the MENU pushbutton on the keyboard calls up the MENU 1 format. This is a basic avionic system status display. It can be used to change steer points, to access the point data submenu, to access the TACAN, FLIR, AAI, IFF, and A/P submenus, or change the LAW altitude. The information displayed and controlled from MENU 1 is described in the following paragraphs:

**LAW** - The LAW (400' AGL) with the asterisk displayed indicates the system has been enabled with the adjacent pushbutton and the low altitude voice warning and light will be activated if the aircraft first climbs above and then descends below the altitude (AGL) displayed. The LAW altitude is changed by keyboard entry into the scratchpad and pressing the pushbutton next to LAW (based on radar alt).

**TACAN** - The current TACAN channel selected and operating is channel 084 mode X. The colon indicates power is on. TACAN channels are changed by first pressing PB2 to enter the TACAN page, then pressing PB1 to enable keyboard entry of the new channel number into the scratchpad and pressing PB1 next to TCN. Turning the TACAN ON/OFF, changing between mode X or Y, and changing operating modes (A/A, TR/ or REC) is done from the TACAN submenu. Pressing PB1 on the MENU1 page displays the TACAN submenu.

**AAI** - Indicates the current air-to-air interrogation (AAI) mode and code.
**N-F NORM** - Indicates the current NORM mode/power status of the LATIRN navigation FLIR.

**A/P NAV** - Indicates autopilot is engaged and current steer mode if any. In this case NAV steer mode. Pressing with a blank scratchpad displays the autopilot submenu.

**IFF** - This IFF format indicates that 1/2/3 modes 1, 2, and 3 have been selected for operation. A colon indicates power is on. Modes are selected/deselected from the IFF submenu.
MENU 2 Display

MENU 2 display is selected by a second pressing of the menu pushbutton. The display contains control features for the secure speech system and the ILS. It also allows access to the DIRECT/MANUAL bombing mode HUD reticle setting, present position source submenu and the update submenu. The information displayed is described in the following paragraphs:

**JVC** - JTIDS voice code (JVC)

**JMC** - JTIDS mission code (JMC). For entry of JITDS data.

**A/G DLVRY** - Pressing this pushbutton displays the Air-to-Ground Delivery sub-menu which is currently not supported.

**ILS 110.60** - Indicates current instrument landing system (ILS) localizer frequency selected, with the colon indicating it is being powered. The localizer frequency range is 108.10 to 111.95 MHz.

**PP-INS** - Pressing the pushbutton displays the PP keeping submenu (either INS, MN, TCN, or A/D; current selection is mission navigator).

**KY-58** - Pressing this pushbutton displays a KY-58 submenu which is currently not supported.
**UPDT SEL** - Pressing this pushbutton displays an update select submenu.

**BOTH TX** - Pressing the pushbutton displays an asterisk which permits transmission on both radio transmitters, either on the same or different frequencies, provided neither radio is in a red mode (secure).

**Submenus**

MENU 1 and MENU 2 provide access to the following submenus:

- Point data latitude and longitude
• Point data range and bearing
• IFF
• AAI
• NAV FLIR
• Autopilot
• TACAN
• Position keeping
• KY-58
• Update

Submenus can be selected when the scratchpad is blank by pressing the pushbutton next to the system of interest. For example, to select the IFF submenu, press the pushbutton next to IFF on the menu 1 display. Once displayed, system changes can be selected and made using keyboard entry. To return to either a menu or data display, press either the MENU or DATA pushbutton.

Note: For the purposes of the IRIS Mudhen Driver product and unless indicated otherwise, any UFC option with a submenu or cycleable feature will be indicated by a ‘:’ at the far right or far left of the UFC line.

In addition, any item which can be interacted with for the purposes of entering in a scratchpad value via the keypad will be indicated by a ‘*’ at the far right or far left of the UFC line.
DATA 1: Point Data Submenus

The point data latitude/longitude submenu is accessed by pressing the button adjacent to the current steer point number. For each point, the sequence point type, lat/long, elevation, minimum enroute altitude (MEA), and time-on-target (TOT) may be changed.

The RNG/BRG submenu is available from the lat/long submenu only if there are offsets stored for a target or target offset point. Press RNG/BRG to enter the range/bearing submenu.
LOW ALTITUDE WARNING (LAW)

When LAW is enabled on the UFC MENU 1, audio and visual warnings are activated when the aircraft descends below the selected LAW altitude. The warnings are removed when the aircraft climbs 20 feet above the selected LAW altitude, the LAW function is disabled on the UFC menu 1, or the LAW altitude is changed to below the present radar altitude. If LAW is enabled and the radar altimeter fails, the LAW warnings are activated. If LAW is enabled, radar altitude is less than 5,000 feet, aircraft attitude is less than 50° of roll and less than 20° of pitch, and the radar altimeter breaks track, the LAW warnings will be activated. The warnings are removed for these cases when either the fail condition corrects itself or the LAW function is disabled on the UFC menu 1.

Low Altitude Voice Warning
The “LOW ALTITUDE” voice warning repeats twice when the aircraft descends below the selected LAW altitude and resets when the LAW condition is removed. This voice warning is a function of LAW only.

Low Altitude Warning Light
A red low altitude warning light, labelled LOW ALT, is located on the upper instrument panel in both cockpits. The LOW ALT light comes on when a LAW condition is encountered and remains on until the LAW condition is removed.

Up-Front Control
The UFC is used to set the LAW altitude, to enable the LAW function, and the select radar altitude for display on the HUD and ADI. Baro altitude is always displayed boxed in the upper right corner of the HUD and ADI and also at PB 9 on UFC Data 1. The present LAW altitude, in feet, is displayed at PB 1 on the UFC menu 1. To set a different LAW altitude, the desired altitude value is entered in the UFC scratchpad using the UFC keyboard. After verifying the correct altitude in the scratchpad, the upper left pushbutton adjacent to the LAW readout is pressed to change the LAW altitude to what is displayed in the scratchpad. The LAW function is enabled if an asterisk appears on the upper left adjacent to the LAW readout. Alternatively pressing the upper left pushbutton with the scratchpad blank enables and disables the LAW readout. Selecting “B” (asterisk) on UFC Data 1 displays radar altitude on the HUD and ADI in addition to baro. When selected, an “R” with the radalt readout will be displayed below the baro altitude on the HUD and ADI.
MENU 2: Present Position Source Submenu

To select the PP source submenu, press the button next to PP-INS. The display appears as shown. Either the pilot or WSO may select the desired PP source and change the aircraft present position latitude and longitude.
**UFC NAVIGATION DISPLAYS**

Navigation displays consisting of sequence point coordinates, elevation, range and bearing, offset data, and INS update data are contained on several submenus on the UFC, and are accessed from the menu and data displays on the UFC. These submenus are used to verify data loaded into the aircraft via the DTM, provide steering and timing data for route navigation and target attack, and to enter or change data for navigation and target attack. In order to enter or change a specific item on the UFC, the appropriate submenu must be accessed.

**SEQUENCE POINTS**

Sequence points are a set of geographical points which can be overflown or used for sensor cuing during a mission. All points are stored at latitude/longitude and converted for display as lat/long. These points are divided into the following categories:

**LIST** - DTM loaded points which are used to generate steer, aim, target, and target offset points. The system can store a total of 99 list points.

**STEER** - Points which comprise the basic route to be flown. Combined steer and target points cannot exceed 100 (all routes, A, B, and C). Displayed as the point number and route letter (17A).

**AIM** - Always associated with a steer point, up to seven aim points per steer point. Displayed as the steer point number plus a decimal, tenth, and route letter (17.1A). The system can store up to 100 combined aim and offset points in all three routes.

**TARGET** - Displayed as a point number followed by a decimal and route letter (18.B). Combined target and steer points cannot exceed 100.

**OFFSET** - Always associated with a target point, displayed as the target number, decimal, hundredths, and route letter (18.01B). The system can store up to seven offsets per target, maximum of 100 combined offset and aim points in all three routes.

**MARK** - Mark points are entered by an overfly mark, radar mark, or an automatic overfly mark at weapon release. Data displayed includes time of day. They are displayed as the mark sequence number preceded by M (M2) up to 10 such mark points.

**BASE** - The base point is normally the unit home station, is displayed as B and should agree with the PP coordinates during INS alignment.

**TACAN CONTROLS**

The controls for TACAN operation are on the intercommunications set control panel, the remote intercommunications control panel, and the UFC. The TACAN volume control on the ICSCP/RICP adjusts the volume level on the TACAN station identification audio tone. Operation of the TACAN system is done using the upfront control (UFC).
**MENU 1: TACAN Submenu**

The TACAN submenu on the UFC is selected and displayed from MENU 1. When displayed, all the TACAN functions are presented as shown in Figure 9. For example, TACAN channel 101 is shown as the current channel selected and the system is being powered as indicated by the colon symbol adjacent to TCN. The asterisk symbol indicates the system currently has the transmit/receive (T-R) mode selected.

To change the TACAN channel number, type the new number on the keyboard and check it in the scratchpad, then enter it by pressing the pushbutton next to TCN display. To select a TACAN mode (A/A, T-R, REC), press the pushbutton next to the respective display. An asterisk appears next to the selected mode. To change the channel mode from Y to X or X to Y, press the pushbutton next to the X or Y currently being displayed. Return to menu 1 by pressing the MENU key on the keyboard. As noted in the figure, TACAN has a program sub-menu that permits indexing of 12 TACAN stations for navigation updating and present position keeping purposes.
Operation of UHF Radios

The UHF communications system provides an air-to-air and air-to-ground communications, automatic direction finding (ADF), and monitoring of guard (emergency frequency). The system consists of two separate receiver-transmitters (UHF 1 and UHF 2), which operate on manually selected frequencies or on 20 preset frequencies within the 225.000 to 399.975 MHz range.

Note: For the purposes of the IRIS Mudhen Driver product, UHF-1 and UHF-2 operate on COM1 and COM2 frequencies of between 118.000 to 136.992Mhz.

The asterisk symbol displayed next to the preset channel number or the manual frequency indicates the radio is turned on. A separate submenu display is provided for UHF 1 and UHF 2.

Selection of UHF 1 submenu is accomplished by pressing the pushbutton adjacent to the UHF 1 frequency shown in MENU 1 with a blank scratchpad. When selected, the appropriate UHF submenu will appear. UHF 2 submenu is selected in a similar manner.
Keying In A Manual Frequency

When in the UHF-1 or UHF-2 submenu, press PB10 so that the scratchpad becomes active. Next key in your desired frequency without the decimal point and then press PB10 again to lock in the desired frequency.

The change in frequency should show in both Line 1 and Line 5.
The autopilot in the pitch axis provides attitude control, barometric altitude hold, radar altitude hold or radar altitude select, and in the roll axis provides attitude hold, heading hold, TACAN steering, navigation steering, or ground track steering.

The UFC is the primary autopilot mode selection and engagement controller. The basic autopilot mode is selected and engaged using the UFC but before any autopilot mode can be engaged using the UFC, all three CAS axes, pitch, roll, and yaw, must be on.

The UFC menus involved in autopilot engagement and display of system and mode status are MENU 1 and the autopilot submenu (Figure 12). MENU 1 provides current autopilot status information such as the engagement mode, and whether it has been coupled with the existing steering mode.

The autopilot submenu provides the means of coupling the current aircraft steer mode and selecting either the baro or radar altitude hold mode. When the autopilot is engaged the autopilot status (same as MENU 1) is displayed centred on the top line. If the A/P is not engaged, A/P is displayed centred on this line.
**Autopilot Preselection**
Autopilot modes of operation may be preselected on the autopilot submenu prior to coupling of the basic autopilot. Any option with an asterisk (steer mode, altitude hold, radar altitude select) will be coupled when the UFC keyboard A/P button is pressed.

**Autopilot Engagement – Basic A/P Mode**
The basic autopilot is engaged by pressing the A/P key on the UFC keyboard. The autopilot automatically engages pitch attitude hold if pitch is within 0 ±45°, and heading hold if the bank angle is 0 ±7°. If the bank angle is greater than ±7° and less than ±60° roll, attitude hold is engaged until the bank angle is decreased to ±7° and then automatically reverts to heading hold. When the autopilot key is pressed, the UFC autopilot submenu replaces the current display to facilitate steer mode and/or altitude hold engagement selections. If attitude hold is engaged it appears on menu 1 in the current autopilot mode display as A/P ATT. If heading hold is engaged it is displayed as A/P HDG.

**Autopilot Disengagement**
The autopilot modes are disengaged from the UFC by deselecting the mode or engaging a higher priority mode.

**Autopilot Coupled With Steer Modes**
The autopilot can be coupled with any one of three steer modes, navigation (NAV), ground track (GT), or TACAN (TCN). The UFC autopilot sub-menu, line 2, will show the steer mode currently selected on the HSI and is used to couple the autopilot to the displayed steer mode. If ILST or ILSN is selected on the HSI, the coupling to the steer mode is inhibited since the autopilot cannot fly an ILS approach. With the autopilot coupled, ILST and ILSN are removed from the HSI display.

**NOTE:** If either ILS mode is selected on the HSI when the autopilot is coupled, the appropriate steer mode (TCN or NAV) is automatically selected and displayed on both the HSI and the UFC autopilot submenu. For example, if ILSN was selected, the NAV steer mode is automatically selected on the HSI (boxed) when autopilot is coupled.

Assuming that the basic A/P is already engaged, coupling of the selected steer mode is done from the autopilot submenu. Pressing the pushbutton next to the steer mode legend on the UFC displays an asterisk symbol next to the steer mode legend, couples the autopilot to the steer mode displayed, and displays an A/P symbol on the EHSI format. If NAV steer mode has been coupled, the autopilot status is displayed on menu 1 as A/P NAV indicating that the autopilot is in the NAV steering mode.

The two remaining steer modes, TACAN and ground track, are selected and coupled with the autopilot in the same manner. When coupled to a steer mode, and ‘A’ is displayed on the HUD to the left of the steer mode.
Altitude Hold
Altitude hold is selected and engaged from the autopilot submenu where it is displayed as ALT HOLD. One of two altitude hold modes are available, either radar (RDR) or barometric (BARO). To change the altitude source, press the pushbutton next to the displayed source. Assuming basic autopilot mode is engaged, the mode itself is selected by pressing the pushbutton next to the ALT HOLD. An asterisk symbol appears next to the ALT HOLD legend when selected.

BARO - With the BARO altitude source displayed on the autopilot submenu display, press the pushbutton next to the ALT HOLD legend to select the mode. ALT HOLD maintains baro altitude at selection. When selected an asterisk symbol appears next to the mode. The mode can be engaged if the vertical velocity is less than 2000 ft/min and disengages at 2000 ft/min or greater. The current altitude is held but not displayed on the A/P submenu in baro altitude hold.

RADAR - With radar (RDR) selected as the altitude source, two options are selectable, radar altitude select and radar altitude hold. The primary difference between the two is that a specific altitude is selected via the keyboard for radar altitude select whereas radar altitude hold maintains the altitude at selection. Each is described in the following:

a. Radar altitude select. First enter the desired holding radar altitude using the UFC keyboard.
   The selected altitude can be any value between 1,000 and 50,000 feet in increments of 10 feet. Once displayed on the scratchpad and confirmed as the desired altitude, the selection is transferred to the UFC display, opposite the ALT HOLD legend, by pressing the pushbutton next to the previously selected altitude (PB 8). Pressing the pushbutton next to the altitude digital readout a second time displays an asterisk to indicate the digital altitude value has been selected. The actual mode is selected by pressing the pushbutton next to ALT HOLD. An asterisk next to it indicates the mode is selected.

b. Radar altitude hold. This mode is selected to maintain the existing aircraft radar altitude. The engagement limit is defined as a radar altitude of 400 to 50,000 feet. Selection is accomplished by first noting that the radar altitude select (PB 8) displayed has no asterisk, then press the pushbutton next to ALT HOLD.

The autopilot status on MENU 1 with altitude hold or altitude select engaged and NAV steering selected (on the EHSI) and asterisk (on autopilot submenu) is displayed as A/P NAV/ALT.

Autopilot Caution Displays
Caution displays relating to the autopilot system are indicated by illumination of the MASTER CAUTION light, the flight control caution light (FLT CONTR), and the specific caution displayed on the appropriate MPD/MPCD in each cockpit. The caution cues will be triggered as a result of crew action (unsuccessful selection of autopilot mode or unsuccessful coupling) or autopilot disengagement not initiated by the crew. In either case all three visual indications will remain on indefinitely until reset by the cockpit MASTER CAUTION reset function.
Multi-Purpose Display (MPD) and Multi-Purpose Colour Display (MPCD) Overview

**Display Information**

The MPD/MPCD main menu controls access to the various data pages required for safe and efficient operation of the aircraft.
Display Information
The engine status page shows all required information for the effective running and management of the aircraft engines. If any value goes out of normal operating parameters, this is indicated by a highlighted value and immediate action should be taken by the pilot.
MPD/MCPD AIR TO AIR RADAR PAGE

Display Information
The Air to Air Radar page shows FSX AI Traffic within the specified radar range on the screen. The display of aircraft is from the top to the bottom of the screen in furthest to nearest distance.

Display range is adjusted by the radar range increase and decrease buttons as shown above, and the display is overlaid by an attitude indicator showing both pitch and roll.

The air to air radar will only operate when the following conditions are met;

- **RADAR power knob** – ON or EMER
- **Air to Ground Radar mode** - OFF
MPD/MCPD AIR TO GROUND RADAR PAGE

Display Information
The Air to Air Ground page shows FSX AI Traffic within the specified radar range on the screen. The display is orientated from the top to the bottom of the screen in furthest to nearest distance.

The air to ground radar features four modes:

Real Beam Map (RBM) Mode - RBM mode displays radar returns from different terrain elements in front of the jet as an arc projected onto one of the MPD/ MPCD’s. On the image the F-15E is on the bottom of the display.

High Resolution Map (HRM) Mode – The HRM image covers a rectangular area with equal sides. For the purposes of this product, the HRM is a square terrain map with no symbology.

Ground Moving Target (GMT) Mode – To pick up moving ground objects the AN/APG-70 features a specific radar mode called GMT. GMT utilizes doppler shifts of ground returns to detect ground movements. For the purposes of this product, the GMT mode only shows VOR and NDB positions.
Interleaved Ground Moving Target (IGMT) Mode – IGMT is the same as GMT with respect to detecting moving ground objects. It however superimposes target crosses over the usual RBM image, thus giving the WSO the added advantage of seeing the targets in their surroundings.

Display range is adjusted by the radar range increase and decrease buttons as shown above.

The air to ground radar will only operate when the following conditions are met:

- **RADAR power knob** – ON or EMER
- **Air to Air Radar mode** - OFF
MPD/MCPD TACTICAL SITUATION DISPLAY (TSD) PAGE

**Display Information**

The TSD is an integral part of the pilot and WSO’s navigation and attack systems. The TSD displays a top down view of the area around the aircraft, either centred on the bottom or middle of the display depending if the Present Position (PP) button is pressed.

A monochrome moving map can be viewed by pressing the FLR button (colour on the MPCD) and all symbology can be removed with the exception of the aircraft symbol and heading with the declutter (DCL) button.

The TSD range can be adjusted and unlike the radar system, is independent to each MPD/MPCD unit, allowing both pilot and WSO the opportunity to view various map distances.
**Display Information**

The Terrain Following (TF) Radar has been customised specifically for this product and allows the pilot to view a coloured area in front of the aircraft which alters based on a selected filter.

The filters operate as follows:

- **1000** – The radar map displays a gradient terrain map from black at 0 feet to full green at 1000 feet and above.
- **2000** – The radar map displays a gradient terrain map from black at below 1000 feet to full green at 2000 feet and above.
- **3000** – The radar map displays a gradient terrain map from black at below 2000 feet to full green at 3000 feet and above.
4000 – The radar map displays a gradient terrain map from black at below 3000 feet to full green at 4000 feet and above.

5000 – The radar map displays a gradient terrain map from black at below 4000 feet to full green at 5000 feet and above.

The terrain following radar will only operate when the following conditions are met:

- TF Radar Mode switch – ON
- RADAR power knob – ON or EMER
ADI/HSI NAVIGATION MODE

ADI

- COMMAND HEADING BUG
- CALIBRATED AIRSPEED
- ANGLE OF ATTACK
- WATERLINE PITCH TRIM
- BANK STEERING BAR
- CURRENT ATTITUDE SOURCE
- TURN RATE
- HEADING SCALE
- PITCH SCALE
- BARO ALTITUDE
- VERTICAL VELOCITY
- ATTITUDE SPHERE
- PITCH STEERING BAR
- MINIATURE AIRCRAFT
- BANK POINTER
- INCLINOMETER (SLIP INDICATOR)

HSI

- COMPASS CARD SCALE (RADIUS)
- LUBBER LINE
- COMMAND HEADING
- AUTO PILOT (AP) SHOWN HERE IF SELECTED
- TACAN DATA BLOCK
- NAV (INS) BEARING POINTER
- CURRENT COURSE SELECTED
- STATIONARY AIRCRAFT SYMBOL
- NAV POSITION SYMBOL
- NAV DATA ON STEEPPOINT SELECTED
- NAV STEERING MODE SELECTED
- STEERING MODES
ADI/HSI INSTRUMENT LANDING SYSTEM MODE

ADI
- Command Heading
- Bearing to TACAN
- Course Pointer
- ILS Inbound Course Selected Here

HSI
- CDI
- ILS TACAN Mode Selected
- ILS Inbound Course Selected Here

LOCALISER DEVIATION (SCALE)
LOCISER
GLIDESLOPE INDICATOR
GLIDESLOPE DEVIATION (SCALE)
FLIGHT PATH SYMBOL (SCALE)
TURN RATE
INCLINOMETER (SLIP INDICATOR)

HEADING INDICATOR
GLIDESLOPE
MARKER BEACON
APPENDIX 1: AIRCRAFT ORDNANCE CONFIGURATIONS

The following is an example of recommended ordnances which can be carried on your IRIS Mudhen Driver product. Please note that whilst these ordnances are based on real F-15E mission ordnances, some items may have been changed to fit with the product requirements.
APPENDIX 2: RELEASING ORDNANCE

For many, the mass appeal of the Strike Eagle isn’t just the ground hugging night missions with your mate on a shared cockpit, but the dropping of bombs and the firing of weapons!!

The IRIS Mudhen Driver product continues the elements of ground attack that we’re proud to have pioneered back in 2008 with the Pilatus PC-9 product.

Now with the assistance of RAZBAM, who also broke new ground with being the first to have droppable ordnance within FSX free flight, we have the best of both worlds... CDIP ordnance delivery in free flight with weapons YOU select!

Not only can you attack anything you choose on the ground, you can also launch air to air missiles which are viewable in multiplayer!

The following section will outline the steps necessary to manage operate the IRIS Mudhen Driver ordnance manager, set up for ground or air attack and release your ordnance.
Ground Attack

To release air to ground ordnance, the following must occur.

- Air to Ground ordnance loaded via the ordnance manager
- A/G Master Mode selected via the UFC panel
- Master Arm switch – ARM
- Weapon selected via the armament page:
  - MPD – MAIN MENU
  - MPD – ARMT
  - MPD – A/G ARMT
  - MPD – SELECT WEAPON RACK FROM TOP BUTTONS
  - MPD – SELECT QTY OF ORDNANCE TO DROP
  - MPD – SELECT DROP MODE
  - MPD – ARMT PAGE - Check for ‘RDY’ indication.

- Press ‘CTRL+SHIFT+C’ to drop ordnance or alternately assign a joystick button to the ‘Cowl Flaps (close incrementally)’ command.

Air to Air Missile Launch

Much like the ground attack ability, to release air to air ordnance, the following must occur.

- Air to Air ordnance loaded via the ordnance manager
- A/A Master Mode selected via the UFC panel
- Master Arm switch – ARM
- Appropriate Weapon selected via the armament page:
  - MPD – MAIN MENU
  - MPD – ARMT
  - MPD – A/A ARMT
  - MPD – SELECT A/A MODE FROM TOP BUTTONS

- Press ‘CTRL+SHIFT+C’ to launch missile or alternately assign a joystick button to the ‘Cowl Flaps (close incrementally)’ command.
The ordnance manager can be turned on or off using the FSX dropdown menus as shown in the previous page. It can also be turned on and off using the Shift+2 keyboard shortcut.
The ordnance manager features displays of current fuel amounts, ordnance types and amount along with an overweight warning when you exceed the maximum take-off weight for the aircraft.

The ordnance manager can only be interacted with (and the aircraft therefore loaded) when the following conditions are met;

- **Aircraft parking brake** – ON
- **Left engine** – OFF
- **Right engine** – OFF

**OR**

- **Armament Safety Override Switch** – ON

The Armament Safety Override switch is located next to the cockpit wall on the left console beside the pilot seat and defaults to the off position. The choice to tie the ordnance manager override to this switch was made during testing so that the testers and developers could quickly change and modify ordnance in flight.

It was then decided that many customers would also like the option to ‘cheat’ by being able to load the aircraft, change fuel settings etc. in flight too.

The default setting for the aircraft is what we call the ‘display configuration’. The aircraft is clean with no pylons fitted, and has full internal fuel, but empty conformal fuel tanks.

The following areas on the ordnance manager are as follows;

**Overweight Light** – Illuminates when the aircraft’s weight exceeds maximum take-off weight.

**Internal** – The current fuel quantity in pounds of the aircraft’s internal tanks.

**Wings** – The current fuel quantity in pounds of the aircraft’s wing tanks.

**CFTs** – The current fuel quantity in pounds of the aircraft’s conformal fuel tanks.

**External** – The current fuel quantity in pounds of the aircraft’s external tanks (if fitted).

**Refuel Aircraft button** – Press to refuel the aircraft to maximum capacity of all currently fitted tanks.

**Clean Aircraft button** – Press to remove all stores and pylons from the aircraft. *(Note: this does NOT remove the fuel from the CFT’s but it WILL remove the fuel if external tanks are removed during the process.)*
F-15E ACES II EJECTION SEAT

- Canopy Breaker
- Emergency Oxygen Hose
- Lap Belt Fittings
- Manual Parachute Deploy Handle
- Radio Beacon Selector Switch
- Ejection Control Handle
- Ejection Control Handles
- Pitot Sensing Inlets
- Manual Parachute Deploy Handle
- Survival Kit Auto/Manual Deployment Selector

Additional features include:
- Installed Seat Safety and Storage
- Shoulder Harness Lock Unlock Handle
- Recovery Parachute
- Ejection Hose Quick Disconnect Coupling
- Emergency Oxygen Bottle
- Emergency Oxygen Indicator
- Emergency Oxygen Green Ring
- Shoulder Harness Lock Unlock Handle
- Ejection Control Safety Lever
- Ejection Control Unlock Handle