NORTHROP

FLIGHT MANUAL

Tigershark is ready...
are you ?

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Aircraft general description

The simulation of the F-20 on flightgear depicts three variants, the prototypes as built and two would be versions A and C.

Commercial documents (cockpit mockups, information leaflets) indicate that the F-20 was to feature as standard features from the onset a ALR-56 radar warning receiver, conformal counter-measure dispensers and an emergency tail hook and a slightly enlarged nose section to integrate a larger antenna for the radar. All those items have not been seen on the prototypes as built.

The A version depicted in the simulator introduces those items while retaining the shape of the basic F-20 for aesthetic reasons

Also in the plans of Northrop due to demand of certain customers was the introduction of a self contained starting method different from the hazardous and maintenance intensive (if light and reliable) hydrazine cartridge starter. This was to take the form of a Jet Fuel Starter.

An advanced gun was to take the place of the ageing Pontiac M-39 cannons, dating back to the F-86 era, and by F-20 entry into service, becoming hard to procure.

Liberally a “what if” variant has been added, the C variant, introducing an electrically started jet fuel starter (standard air force starters use hydraulic accumulators to start), an autopilot, and support for ECM and electro-optical pods. The cannon has not been introduced as its actual shape is an unknown (event though it was described in some detail in the now defunct f20.com website).

This C variant also replaces the original F404-GE-100A engine by a derivative of the F404-GE-400 or even better the RM-12 as installed on the Saab Gripen, the KAI-T-50 or the HAL Tejas.

Engine

Engine controls

To be completed

Engine start system

Start cart

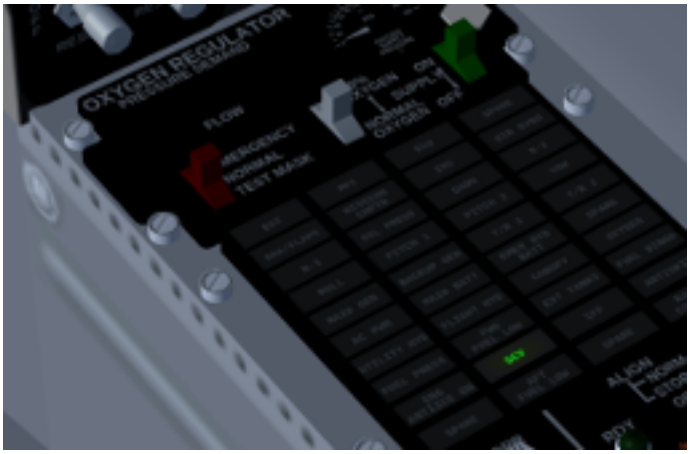
The standard method for starting the F-404 on pre-C variants is the use of an external start cart.

The aircraft needs to be on chocks to prevent it from moving on its own due to idle residual thrust.

The start cart is then connected to the aircraft automatically powering the electrical system.

To initiate the start procedure air is sent from the cart into the Air Turbine Starter, via a start control valve. For this to be possible the engine needs to be shutdown

Positive indication of connection is available on the indicator panel



The engine will then accelerate to 25 percent N2 (high pressure compressor rpm) and the throttle can be moved in the idle detent (**Shift-q** with the throttle at idle) to start admitting fuel. The start sequence will continue until positive engine start by which time the start control valve will automatically shut off and the start cart will stop supplying compressed air.

Cartridge system

The F-20 was basically equipped with a hydrazine cartridge system for in-flight engine start in case altitude did not allow for a windmill airstart. Hydrazine, a mono-propellant fuel, was decomposed over a catalyst and hot gases were sent to the air turbine starter.

This system needs DC power to be activated so at least the main battery should be on for this purpose.

Northrop advertised the cartridge system as a way to achieve quick scramble times without ground support. This may be dubious since hydrazine is a serious health hazard and regular use of the system would have implied manipulating the product a lot.

In order to start the engine just energize the DC bus and depress the cartridge starter button

As for the start cart procedure wait for 20% N2 before pushing the throttle past the stop detent (**Shift-q** with the throttle at idle).

Bear in mind that hydrazine supply is limited to the contents of the cartridge and so is cranking time and the number of starts possible through this method,

Not that connecting the start cart air supply will automatically shut the cartridge starter down

Windmill start

In flight, in case of engine shutdown, it can be restarted by keeping N2 above 25% and moving the throttle past the stop detent into idle detent (**Shift-q**). For this to happen you will need forward airspeed.

If airspeed is insufficient to maintain 25%, you will need to initiate a dive in order to regain speed or initiate a cartridge start if altitude is insufficient to do so,

Jet Fuel Starter (F-20C)

The C variant introduces another self contained start method in the form of a Jet Fuel Starter. This is a small, electrically started, jet fuel fed, gas turbine providing compressed air to the Air Turbine Starter for engine start.

It as a fairly unlimited operation time (even though at the expense of fuel consumption), but is restricted to lower airspeeds and altitudes for operation, as it is intended for ground starts mainly.

The introduction of the JFS also introduces a manual control to the start control valve (SCV) to crank the engine. This alters the start procedure because the valve needs also to be manually selected for start cart.

The start procedure becomes :

- Provide DC power to the aircraft (e.g. main battery)
- Start the JFS with the JFS start switch or connect the start cart air supply as described previously
- Wait for the JFS ready light to illuminate if JFS is needed
- Use the crank switch to start the SCV
- Wait for 20% N2 before pushing the throttle past the stop detent (**Shift-q** with the throttle at idle).

The SCV will automatically shut when engine is started and the JFS will be stopped after 10 minutes operation, even though it is recommended to stop it after engine start to avoid unnecessary fuel consumption and possible damage to the intake flap if flying too fast.

Shutdown procedure

The engine can be shutdown following :

- By placing the throttle in the stop detent (Shift-q with the throttle at idle)
- By using the guarded fuel cutoff switch
- A failure

Fuel system

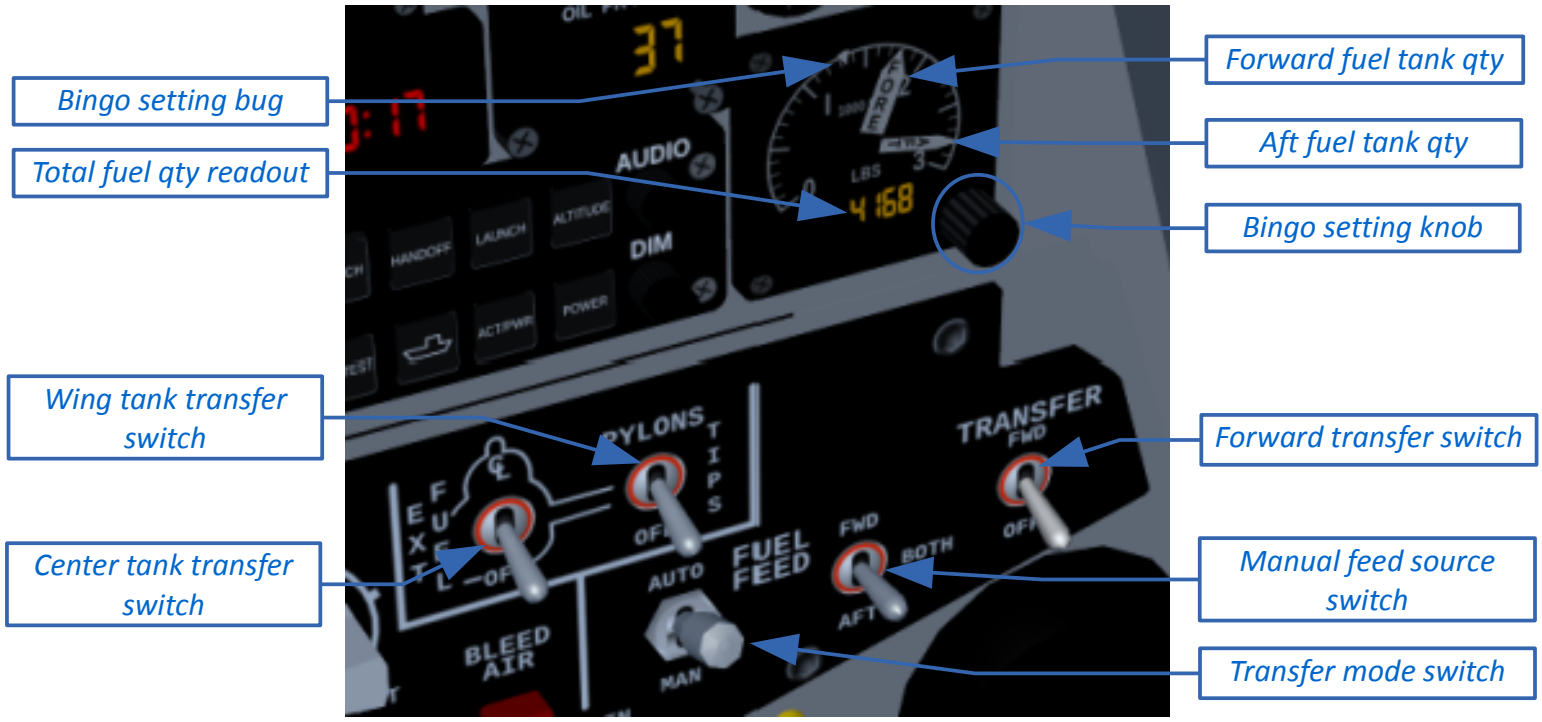
Storage and feed system

Fuel is carried in two fuselage tanks and optionally up to three 1800lb gal drop tanks.

The forward tank holds up to 1700 pounds of fuel, the aft tank holds 2700 pounds.

The normal consumption sequence starts by consuming 1500 pounds from the aft tank only, then both tanks are used until 150 pounds remain (unusable in automatic sequence) in the aft tank.

This logic can be changed through the operation of two switches located in the fuel panel :



Manual transfer forward can be used in case of failure of the FCS to improve controllability at the expense of maneuverability by moving the CG forward. This switch will automatically revert to off once level in the aft tank drops

Manual selection of the feed tank can be used to prioritize consumption from a tank that is leaking for instance. It is also the only means to consume the 150 last pounds of fuel remaining in the aft tank during automatic feeding sequence.

Both forward transfer and manual feed source selection can only be achieved if the transfer mode switch is placed on the MAN position.

The fuel is normally provided to the engines through 3 AC powered fuel pumps (AC1 bus), 2 in the aft tank and one in the forward tank. Those pumps should be switched on before engine operation on the corresponding panel:

If the AC1 bus is not powered a backup DC boost pump will automatically start.

Display and alert

The fuel gauge consists of a two needles dial with a digital readout, one needle per fuselage tank. The gauge has a knob and pointer to set the bingo (low fuel) alert according to "mission" requirements.

If the total fuel quantity drops below the level displayed by the bug, the bingo alert light will illuminate and a master warning will be triggered (with the subsequent audio).

The FWD FUEL LOW light illuminates with forward tank quantity below 700 pounds and the AFT FUEL LOW light illuminates below 150 pounds in the aft tank.

If no AC boost pump is feeding the engine, the pressure in the feed line will drop and the FUEL PRESS light will illuminate.

Jettison system

The jettison system can operate in three ways:

- Selective jettison : each station is selected individually and the press on the jettison button ejects the store and adapter at the selected station

- Emergency jettison : all stores are jettisoned at once

Emergency jettison is activated through its own switch-guarded temporary push-button.

- Complete jettison : all stores, adapters and pylons are ejected at once, with the exception of the wing tip stores

The selective stores jettison can be used to trigger the smokewinders on and off as it will activate the normal firing sequencing for the tip store.

Electrical system

Generation/distribution

On the F-20, AC power is provided by two generators, a main 40KVA generator mounted on the airframe gearbox and a backup 5KVA generator mounted on the engine accessories gearbox. On ground AC power can be provided by the start cart.

AC current is distributed through 3 main buses and an essential bus that can be power through the main battery using a static inverter

DC power is normally provided by a pair of transformer/rectifiers connected to AC2 bus with backup from a 17Amp.hour battery all connected to the essential DC bus.

DC current is supplied through 2 buses (essential and main)

In case of hydraulic failure, a DC motor powered pump supplies pressure to the flight controls hydraulic circuit. This pump is connected to a dedicated electrical bus that can be powered in case of total electrical failure by its dedicated 58Amp.hour battery.

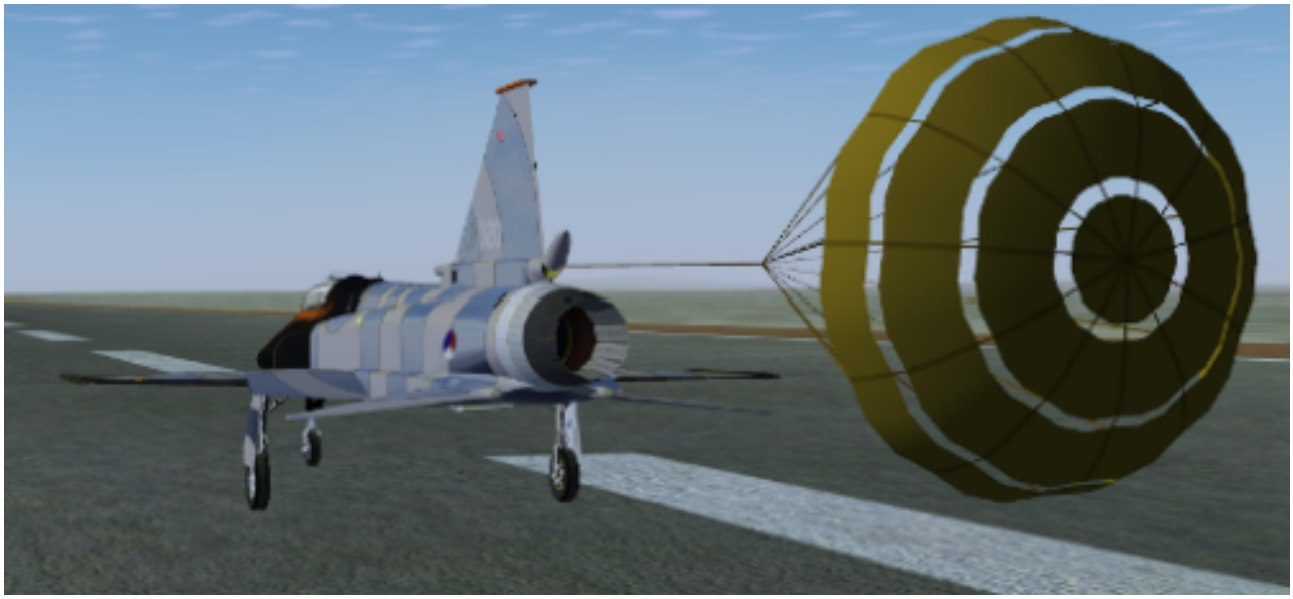
Landing gear system

The landing gear is a standard tricycle configuration with nose-wheel steering and main wheel hydraulic brakes with anti-skid.

Retraction/extension is through hydraulic actuation with aerodynamic assistance for the main gear through a movable flap on the doors attached to the gear leg. As a backup the gear can be extended by gravity.

In order to shorten take off run, the nose gear can be raised (hiking system) to give a 3 degrees nose up stance on ground.

Drag chute



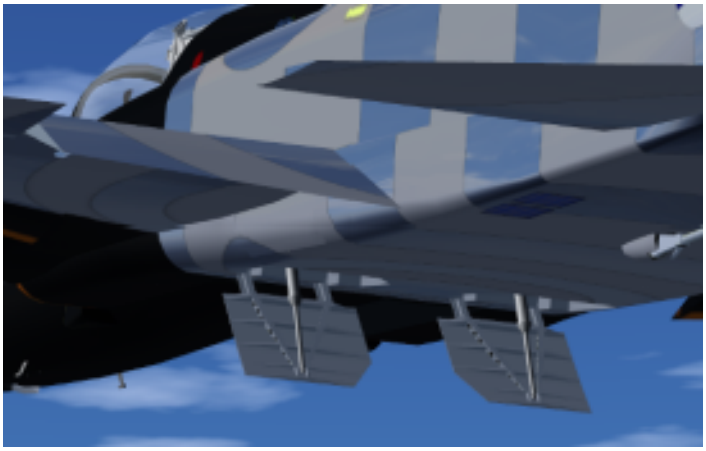
The drag chute is installed in all aircaft and is operated by a 3 position handle in the upper left part of the front panel.

Pulling once the handle (**o** key or click on the handle) will deploy the drag chute. Note that deploying the chute, or flying with a deployed chute above 400 knots (to be adjusted) will tear it away.

Pulling twice the handle will cut its lines (for instance to continue taxiing).

Once the chute is spent it can be repacked in the aircraft only on the ground by use of the ground handling menu.

Speed brake system



The F-20 has two hydraulically actuated, electrically signaled speed brakes.

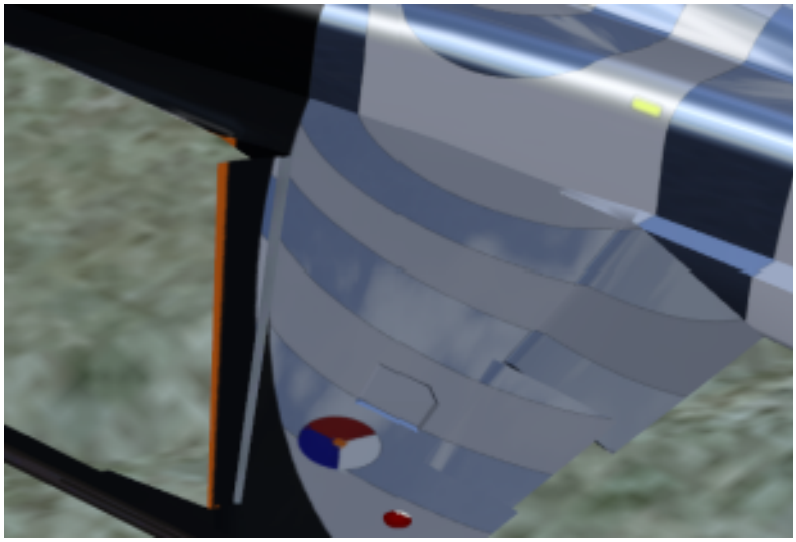
They are powered by the utility hydraulic system and the essential DC bus.

The controls for the speed brakes are on the throttle in the form of a spring loaded two way switch. Pulling the switch aft extends the speed brakes (**e** key) pushing it forward retracts them (**r** key).

The speed brakes can be left at any intermediate position.

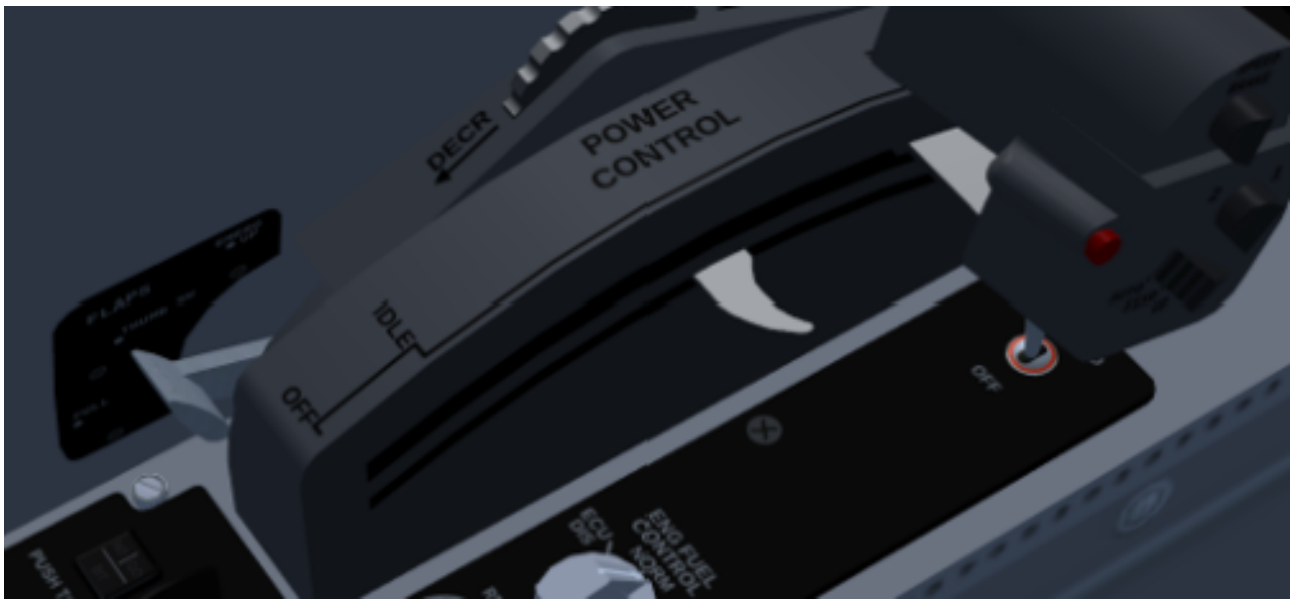
Full extension is 45º, restricted to 35º when a centerline store is carried

Wing flap system



The F-20 flap system uses leading edge and trailing edge flaps for three functions :

- High lift for take off and landing
- Automatic maneuver flaps
- Provide the most adapted configuration for long range and loiter flights



The flap handle located besides the throttle allows the selection of three modes (through the use of the mousewheel on the lever):

- Forced full
- Thumb switch controls
- Emergency Up

The default mode is thumb switch control which permits a selection (keys **d** and **f**)of three submodes

- Auto

- Fixed
- Up

The auto schedule will adapt high lift system position according to angle of attack, speed, altitude and gear position to maintain optimum maneuvering flight conditions and control. In this mode, gear extension results in full flaps application

Fixed mode places the flaps in a position intended to maximize the lift to drag ratio

The up mode allows flying the aircraft without parasitic motion related to the automatic schedule, even though those are usually minimized by the flight control system

The right flaps are power by AC2 electrical bus and left flaps are powered by AC1

Flight control system

The F-20 is equipped with a mechanical flight control system supplemented by a high authority control augmentation system (CAS).

Primary control is achieved by the use of conventional ailerons, all moving stabilizer in pitch only and rudder all hydraulically actuated.

The CAS actually provides almost fly by wire behavior while retaining high authority in case of system failure. The CAS provides the following augmentation

Roll

The roll rate is directly commanded as a function of stick deflection, doubled with aileron-rudder connection to prevent roll coupling phenomena

Yaw

The yaw law besides the ARI also provides limits in lateral load factor as well as yaw damper function and null side-slip with the rudder centered

Pitch

The pitch control law with the gear up is a g-demand law with a mild limit of angle of attack at low speed and pitch stabilization throughout. It should be noted that for most of its CG envelope the F-20 is pitch unstable without the CAS to promote maneuverability.

The g-demand law ensures that almost no trim is needed in this condition as releasing the stick will put the aircraft in a 1-g condition without roll, regardless of thrust excursions.

The aircraft can be controlled up to 30 degrees AOA.

For landing, once the landing gear is down, the CAS will bias pitch to increase speed stability. The aircraft needs to be trimmed for speed as the throttle will be used to control the flight path angle

To be completed

Display system

Heads Up Display (HUD)

The F-20 HUD displays conformal symbology according to the current navigation mode or combat mode (the latter is not implemented). The field of view for the HUD is roughly +/- 5.5 degrees in azimuth, -10.5 to +1.7 degrees in elevation.

The HUD is controlled through a brightness knob, a declutter button and a backup reticle switch all located on the Data Entry Panel (DEP).

Digital Display Indicators (DDI)

The F-20 is equipped with two monochrome cathode ray tube Digital Display Indicator, which are multi-function displays capable of displaying and controlling radar, weapon (neither implemented), navigation, communication and identification systems.

They are controlled through a Data Entry Panel located below the HUD and 20 bezel keys located around each display. Labels in front of those keys indicate their purpose according to the selected page.

The central page is the index (IDX) page and allows accessing all

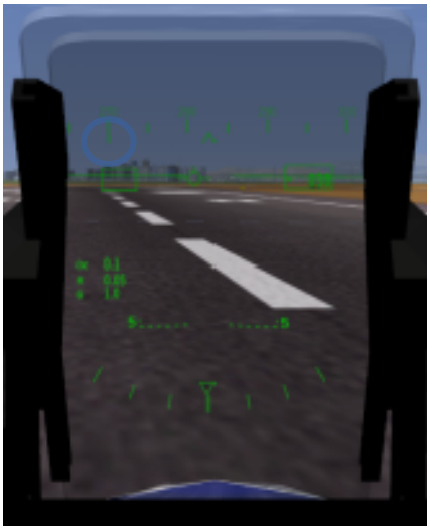
Navigation

Heading selection

The F-20 is equipped with a simple heading selection bug that is reflected both on the HUD and the HSI page of the DDI.

To select the heading, enter the desired value on the DEP and press the HDG bezel key on an HSI page :

If the heading bug was not displayed, this will display it on both the HUD and HSI, otherwise the bug will just be reallocated. To toggle the bug on and off the HUD and HSI press repeatedly the HDG key on an HSI page.



TACAN

TACAN (for TACtical Air Navigation) is a radio-navigation system similar to VOR. A beacon either ground based or installed in a vehicle such as another aircraft or vessel, sends a number of radio

signals that are used by the receiver to estimate its relative bearing, distance and radial speed.

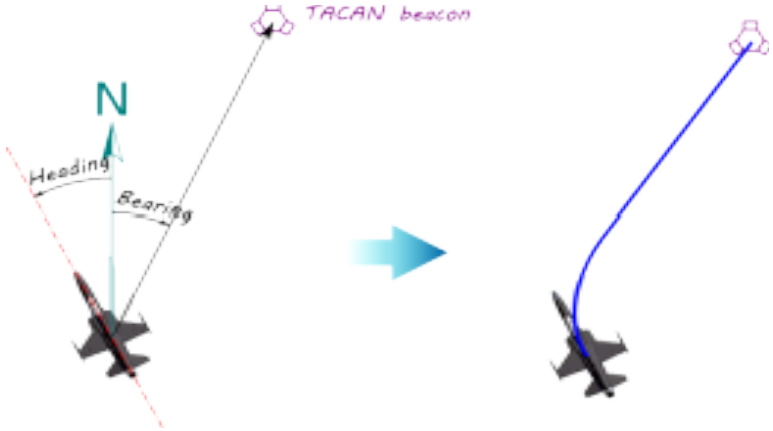
The direct consequence of this is that the system is limited in range due to the need of being within the line of sight of the beacon (it does not work over the horizon) and have a sufficiently strong signal.

For the TACAN to be operational, the receiver must be set on on the CNI power page, an a channel selected corresponding to a valid, in-range beacon.

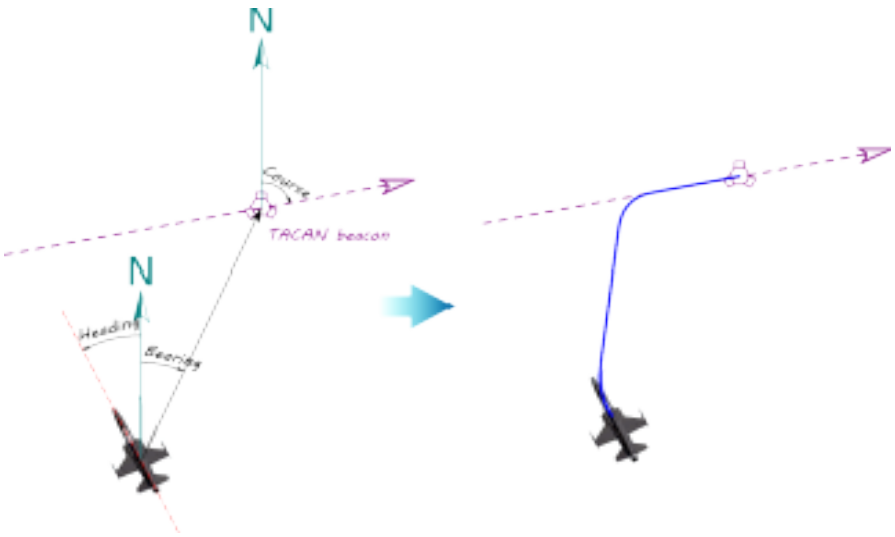
The TACAN is tuned using channel designation composed of a number between 0 and 128 and a single letter X or Y. The digit is entered with the DEP and the TCN bezel key at the bottom of all DDI pages (except for radar pages). The letter is toggled between X and Y by pressing repeatedly this key with an empty scratchpad.

Navigation with TACAN can be achieved by two different means, either flying directly towards the beacon (DIR mode) or choosing to join the beacon by a pilot-specified bearing (course mode CRS).

In the DIR mode, the guidance cue is a bearing needle showing the heading towards which the aircraft should turn to join the beacon :



In the course mode, the pilot selects a course along which the aircraft should rejoin the beacon, and is given cues on how to rejoin the route defined by this course.



Inertial navigation system

The F-20 is equipped with a laser ring gyro inertial navigation system (INS). This system allows navigation without the need of external supporting means (such as GPS or ground beacons) but requires alignment for proper operation.

This alignment can be done under four conditions (three are modeled in the simulation):

- The aircraft is stationary, the gyros are left enough time (4 minutes) to zero out earth motion in order to find the reference inertial frame (hence the term alignment) and thus the position of the aircraft. This is normal alignment.
- The aircraft is stationary, the heading is either the same as the one before power shutdown or entered manually by the pilot. The IRS uses that information to simplify the alignment process which is shortened to 22 seconds for full accuracy. This is called stored alignement

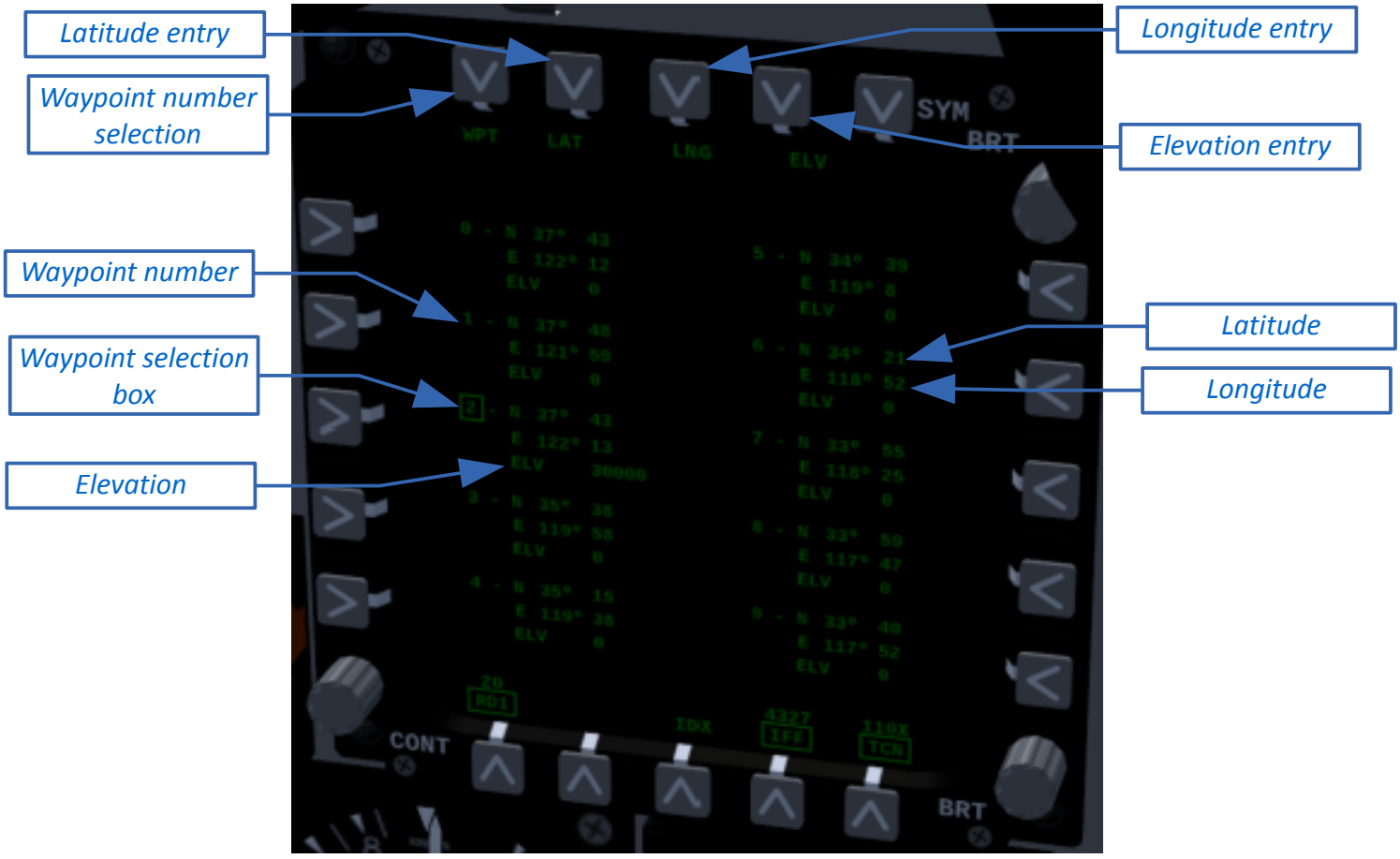
- The aircraft is flying, the crew signals the overfly of a landmark assigned to a waypoint to correct positioning error.
- The aircraft is flying, the crew designates a landmark assigned to a waypoint with the cross-hair on the ground mapping mode of the radar to correct positioning error (not implemented).

The last two modes are important because the INS estimated position will drift with time after its alignment (in the order of 1 nautical mile per flight hour, somewhat more if violent maneuvering is performed).

To be completed (INS align page and INS selector)

The inertial navigation system stores also up to 10 navigation waypoints given by their latitude, longitude and elevation.

On the real aircraft the waypoints were entered through the WPT page :



In order to modify or enter a waypoint, first select its data block by either :

- Entering a waypoint number in the scratchpad and pressing the “WPT” key
- Pressing the “WPT” key repeatedly until the appropriate waypoint is designated by a box around its number
- Using the bezel key in front of the corresponding waypoint data block

Navigation is achieved by estimating latitude, longitude, ground speed and track/heading and using this information together with the waypoint information to generate navigation cues on the HUD and the HSI

ADF

VOR/ILS (F-20C)

To be completed

Autopilot coupling (F-20C)

To be completed

Communication, IFF

Environment control system

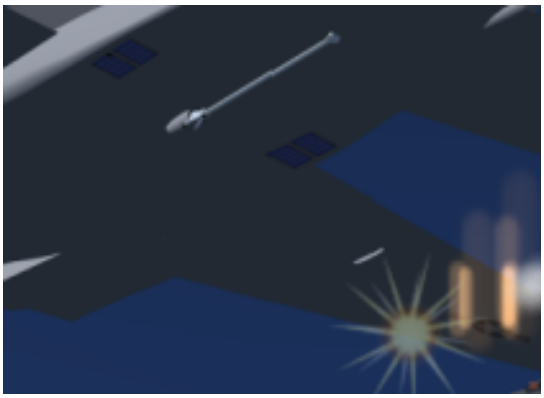
To be completed

Anti-icing system

To be completed

Counter-measures

Expandables



The F-20A carries 4 ALE-40 counter measure dispensers, the F-20C carries two of them, Each dispenser carries 30 rounds which can be either chaff or flares.

The selection of countermeasures to be launched is achieved on the corresponding control panel on the left console.

To be completed

In order to operate the CMDS (countermeasure dispenser system), first select a mode on the corresponding knob (mousewheel) and depress the red throttle launch button (**ctrl-f**)

Radar Warning Reiceiver

To be completed

External pod

To be completed

Anciliaries

To be completed

Keyboard controls summary

Shift-q.....toggle engine idle detent
f.....flaps thumbswitch forward
d.....flaps thumbswitch back
e.....extend speedbrakes
r.....retract speedbrakes
Ctrl-f.....release expendable countermeasures
g.....toggle landing gear