Lockheed CF-104 Starfighter
Nuclear Strike Version
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Appendix I – Part 3 - Climb

Appendix I – Part 6 – Level Speeds
1. Requirements, Recommendations, and Information

1.1 Recommendations

• Programmable Stick and Throttle Controls (you can fly with a mouse but a lot of systems will be inaccessible).

1.2 Things to Know

• Updates, forums, and information for the CF-104 is here: http://www.classicjetsims.com/CF-104/CF-104main.html
• Contact me at greg@classicjetsims.com for support or any Starfighter-related question or comment.
• Do not use the standard X-Plane interface to load weapons on the F-104. Use the custom interface as described in section 5.1.2 Selecting Ordnance (Fuel Tanks & Weapons).
• Do not use the standard X-Plane interface to set fuel levels. Use the custom interface as described in section 5.1.1 Refueling.
• Do not modify the F-104 in PlaneMaker and expect your changes to have any effect. The plugin controls most settings related to engine thrust, fuel flow, and control surface functions. The plugin code has a custom engine model, a custom hydraulic system, and a custom electrical system.

1.3 Credits

• Cockpit textures, texture effects, and Canadian camo and Centennaires versions by Luca Zappala
• Pilot by Bob Feaver
2. Development History

I've loved the Starfighter ever since I first saw it do a high-speed pass at an air show when I was a kid. I've been almost obsessed with the plane since then.

Illustration 1: CF-104s from CFB Cold Lake in the Seventies

The CF-104 was taken out of service and replaced by the CF-18 Hornet. A few civilian operators in the U.S. had begun to purchase a few of the ex-Canadians CF-104s, these being Starfighters Inc. out of Florida and Mark Sherman in Phoenix. They now have the only flying Starfighters on the continent. I hadn't known this until about 10 or 12 years ago when the air show at CFB Cold Lake in northern Alberta announced the return of the Starfighters. I was very excited and drove the 6 hours to get there to watch them fly again. It was really great to see their high speed show and hear them again as well.
Illustration 2: CF-104D flown by Starfighters Inc. in around 1998 - 2000

After this I became interested in flight simulation and began building aircraft for X-Plane. I had a fascination with all of the old jet aircraft that I saw at air shows when I was a child and focused mainly on building those. My work caught the attention of John Kezele, a civilian pilot in the U.S. flying an ex-Canadian T-33. He asked if I was interested in helping them with a simulator that could be used for training. I spent a couple of years working on that for them and during that time John and I became very good friends. I went down several times to go flying with them and now have a few hours in the T-33 and can fly from the front seat. It was really a dream come true for me flying in this jet.

John and Kay, who actually own the jet, are both members of the Classic Jet Aircraft Association. I joined as well and over the past many years have attended fly-ins and conventions and have had the chance to meet other jet owners. It was at a convention at Davis Monthan AFB in Tucson, Arizona where I first met Mark Sherman who owned an ex-Canadian CF-104D! He also happens to be a very nice guy and we've become friends over the years. It was a year ago that I actually got to go for a ride in Mark's 104. This event was surely one of the highlights of my life and something I won't ever forget. Flying in the manned missile is a bit intimidating. This plane held the world speed and altitude records simultaneously. It was probably the 1st fighter jet that had a thrust-to-weight ratio greater than 1:1. This was with a light fuel load but is still impressive. I believe it still holds the low-altitude speed record. With its short, thin wings and low aerodynamic profile, it really moves at low level and is immune to turbulence unlike the modern fighters with their huge wings and low wing loading. There are many stories regarding the Starfighter that make it legendary. It was able to intercept U-2s at 75,000' from above. Although the placarded speed limit was M 2.0 due to heat limitations, it has been flown up to M 2.35 and was still accelerating.

During our flight we flew from Phoenix out to the Grand Canyon at 18000' and did some aerobatics. The takeoff was breathtaking. The acceleration put any race car I've ever been in to shame. Mark told me that the acceleration would be much better when we came back and did some touch and gos with a light fuel load. It's no wonder that Gilles Villeneuve had a hard time keeping up with an Italian 104 in his Formula-1 car during a
promotional event. See this video on youtube (http://www.youtube.com/watch?v=PqNwDJonNzo). They traded victories and Gilles had to take the wing off his car to win in the end.

Anyway, Mark let me fly for a while on the way out and we did some aerobatics. The stick forces are quite heavy compared to the T-33 but that adds to the stability. The plane is very stable and stays in pretty much any attitude you put it in. Roll rate is very rapid even with full tip tanks. After turning around at the Grand Canyon, we dived down low over the desert. Mark mentioned to me at this time that there was an airport just over the next hill that we were not able to cross over below 18,000'. So Mark lit the afterburner pointed up at 45 degrees and accelerated during the climb. In only 45 seconds we were at 20,000' looking way down at this airport. It makes airliner flight seem kind of silly. We flew back through the valleys at low level at speeds up to 500 knots. It was fun to watch the aircraft shadow on the ground. The sensation of speed is really great at this altitude. Finally we arrived back in Phoenix and did some touch-and-gos. Mark was right. The acceleration was much more rapid now. Finally we landed and $4000 later the plane was fueled up ready to go for next time. Here's a video from my flight:

http://www.youtube.com/watch?v=vYwV9K_cxNw
Finally some notes about the simulator. The aircraft manuals have been used to obtain most of the data in regards to systems and performance. Some performance data not found in the manual was obtained from flight tests. Mark has been very helpful in explaining things to me. Sounds were recorded using a professional sound recorder and these were built into the sim. I think you'll quite like the startup sounds. Level speeds, acceleration numbers for subsonic and supersonic flight, fuel burn, climb rates, etc. match what it is in the manual within half a percent. I developed a custom engine model to achieve these results. Other interesting characteristics such as pitch-up due to high angles of attack, rolloff when the throttle is reduced rapidly with flaps down, Boundary Layer Control flap characteristics are all modeled in the sim. I even tried to model other interesting characteristics. If you do an APU start, you'll notice the engine rpm gauge reading moves up in a non-linear way. This matches the recording I made of rpm gauge when the engine was starting. Little things like this add to the realism. This plane has been a passion of mine for years and that has gone into the development of this simulator. I hope you enjoy it and please send me any comments or questions. I'm always more than happy to talk about the plane and to help out. Have fun!
3. Installation

3.1 Installation

3.1.1 PC

Install OpenAL Sound Driver

The CF-104 plugin uses some advanced sound features supported by OpenAL. If you are using a PC, you have to install the OpenAL sound driver for the plugin to work. The plugin will not function at all if this is not installed and the plane will not run or draw correctly without the plugin running. You can get the OpenAL sound driver here:

http://connect.creativelabs.com/openal/Downloads/Forms/AllItems.aspx

Download the oalisint file and run it to install the OpenAL sound driver.

Run the installer and follow the directions. Make sure you select the main X-Plane folder as your installation folder!! If you don't, most files will not get installed to the correct locations and the simulation will not function correctly. You can move the CF-104 folder or rename it afterwards if you don't like its default location.

3.1.2 Mac

1. After you download the CF-104 zip file, double click on it to extract the contents out into a folder "CF-104Installer".
2. Open the "CF-104Installer" folder in a FileFinder window. Inside that folder there will be several others.
3. Open your "X-Plane" folder inside of another FileFinder window.
4. Drag the "CF-104" folder from the "CF-104Installer" folder to the "X-Plane/Aircraft/Fighters" folder or wherever you want the aircraft to reside.
5. Drag the "ClassicJetSimUtils" folder from the "CF-104Installer" folder to the "X-Plane" folder.
6. Drag the "ColdLake" and "CYOD2" folders from the "CF-104Installer/Custom Scenery" folder to the "X-Plane/Custom Scenery" folder.
7. Drag the file "tacan.dat" from the "CF-104Installer/tacanData" folder to the "X-Plane/Resources/default data" folder.
8. Drag the file "cf-104_route_1.fms" from the "CF-104Installer/FMS Plans" folder to the "X-Plane/Output/FMS plans" folder.
9. ENSURE that your folder structure matches that as described below in section 3.6.
3.2 Registration (PC Version Only)

There are both DRM and non-DRM plugins available for this aircraft. The DRM plugin requires a license file to run. With it you can download all updates from the CF-104 web site. E-mail me at greg@classicjetsims.com for a non-DRM plugin. This version doesn’t require a license file but you have to e-mail me for updates.

Before the DRM plugin code that manages the engine and aircraft systems will run, the plugin needs to be registered. You must open the CF-104 in X-Plane which will cause it to generate a serial number for you. There are two ways to find the serial number:

1. With the CF-104 open in X-Plane, go to the “Plugins - CF-104 Systems - Registration” menu. This will display a serial number as shown below. Send that to me and I’ll send you a license key that you need to enter into the text box. After you enter it, close the window and re-open the aircraft. It should tell you that it is now registered.

![Registration Screen](image)

2. Alternately you can send me the CF-104Systems.txt file in the main CF-104 directory. This file contains the serial number so you don’t have to worry about making typos.

4 Setup

4.1 Field of View

To see most of the cockpit a field of view of around 87 degrees is recommended. This is set in the rendering options menu. Of course you can adjust this to suit your preferences.

4.2 Flight Model Cycles

These should be set to at least 2 in the X-Plane Settings – Operations & Warnings menu. The plane may be unstable otherwise if the value is set to 1.

4.3 Key Command Menu

The default key to activate the key command menu is F12 on the PC and F6 on the Mac. This can be changed though in the CF-104 Joystick Setup menu as described in section 4.4 Joystick Setup.
Press **F12** to activate the key command menu and press **F12** again to deactivate it (**F6** on Mac). Press the number key associated with the menu you want to navigate to. The **backspace** key takes you to the previous menu. Nearly all custom CF-104 systems such as the radar, weapon system, autopilot, etc. can be controlled from this menu. These are the functions controlled by the key command menu:

1. **General Equipment**
   - Open/Close Canopy
   - Drag Chute Deploy/Release/Repack
   - Start Engine
   - Stop Engine Start

2. **Navigation Functions**
   - TACAN Channel Set
   - Waypoint Set
   - Desired Ground Speed Set
   - Route File Select

3. **Radar Functions**
   - Radar Mode
   - Radar Range
   - Memory
   - Antenna Tilt
   - Range Cursor
   - Range Cursor Mode
   - Azimuth Cursor
   - Azimuth Cursor Mode
   - Drift Adjust

4. **Autopilot Functions**
   - Autopilot Engage
   - Altitude Hold
   - Mach Hold
   - Steering Mode
   - Turn Left
   - Turn Right
   - Fly Straight

5. **Weapon System Functions**
   - DCU-9/A Mode
   - Ordnance Selection
   - Bomb Mode
   - Run-In Timer
   - Release Timer
   - Reticle Mode

6. **Lighting**
   - Exterior Landing and Taxi Lights
   - Instrument Light Level
   - Flood Light Level

7. **Emergency Operation**
   - Eject
   - Canopy Jettison
   - Stores Jettison
   - Pylon Jettison
   - Ram Air Turbine
   - Emergency Gear Extension
   - Generator 1 Reset
   - Generator 2 Reset
   - Arrester Hook Extension

8. **Multiplayer Aircraft Info**
   - Aircraft Id Select
   - Relative Heading
   - Distance
   - Attitude

See the section on CF-104 Systems for information about the specific systems controlled by the key command menu.
4.4 Joystick Setup

Make sure you configure your joystick controls though the Plugins - CF-104 Systems - Joystick Setup Menu.

Illustration 5: Joystick and Keyboard Setup Window

There are some custom commands not supported by x-plane that need to be configured from here. Also the aileron trim button must be configured here. The normal X-Plane assignments will not work for this. You don't have to change your default joystick button assignments in the X-Plane menu. Especially important is the nose-wheel steering button. This needs to be pressed when the rudder pedals are moved to turn the plane on the ground.

To set up joystick buttons, first check on the X-Plane function. Then push the button on the stick that you want to associate with that function.

To assign joystick axes, first move the joystick wheel or axis that you want to assign a function. You'll see one of the sliders on the left move back and forth. Click in the box next to the slider to designate that axis. Then check the function on the right that you want to associate with that axis.

To assign function keys, first check the function key that you want to assign a function to. Next check the function that you want to assign to that function key. Note that for the Key Command menu, you can use the same or different function keys to open and close the menu.

For the Throttle/Idle Cutoff function, if you have a mixture control lever with your control hardware, you can
designate that lever instead to toggle the throttle between idle and cutoff in the Preferences Window (see next section). If you do that, don't assign a function key here for throttle idle/cutoff.

4.4.1 Custom Commands

If you do not wish to use the function keys for the custom functions, you may assign keys or joystick buttons of your choice to the custom functions. To do this:

- Go to the X-Plane Settings – Joystick & Equipment menu.
- From there select either the Buttons: Adv or the Keys tab.
- Select the button or key that you want to assign a command to.
- On the top-right of the window there is a box and a text field labeled custom cmnds from plugins. Click the box and a selection menu will be provided. From the selection menu, select the desired command that you wish to associate with your button or key. The available commands are:
  - `cjs/cf104/master_caution_reset` – Reset the Master Caution Light and tone
  - `cjs/cf104/engine_idle_cutoff_toggle` – Toggle the throttle between Idle and Cutoff
  - `cjs/cf104/toggle_key_commands_menu` – Toggle the Key Commands Menu on or off to control CF-104-specific systems
  - `cjs/cf104/drag_chute_hangle_toggle` – Deploy/Release the drag chute
  - `cjs/cf104/tracking_camera` – Activates the tracking camera for weapon ranges
  - `cjs/cf104/open_key_commands_menu` – Open the Key Commands Menu to control CF-104-specific systems
  - `cjs/cf104/close_key_commands_menu` – Close the Key Commands Menu

Please e-mail me if you'd like other commands to be added.

4.5 Setting Preferences

Make sure you set the preferences as desired from the Preferences menu described in section 5.5 Preferences Menu.

4.6 Throttle Setup

The CF-104 simulator works best with throttles that have adjustable afterburner detents such as the Thrustmaster HOTAS Cougar. The last 10% of throttle travel is used for the multi-stage, variable-thrust afterburner. Your thrust level is considerably higher at maximum afterburner thrust than at the minimum afterburner setting.
4.7 Folder Structure

The PC installer will place files in the correct folders provided that you have selected the X-Plane folder as your installation folder. For the Mac you have to place the folders manually. If you’re having problems selecting TACANs, using the pre-defined route files, or loading the Cold Lake scenery, verify that the installed files are in the following folders:

```
X-Plane ---- aircraft ---- Classic Jet Simulations ---- CF-104 Starfighter Nuclear Strike Version
<---- This is where the main CF-104 is loaded but may be placed anywhere else after installation.

|<----- Formation ---- CF-104 Formo <----- If the formation application is installed (not available in 1st release)
| the plane used as your wing mate will go here. Do not fly this plane!
| This plane can't be moved.

|-- ClassicJetSimUtils ---- WeaponRanges <---- The user-defined weapon range file goes here.
|-- Custom Scenery ---- ColdLake <---- The main Cold Lake air base scenery.
|   |-- CYOD2 <---- The 2nd half of the Cold Lake air base scenery.

|-- Output ---- FMS plans <---- User-defined route files for the Inertial Navigation System (cf104_route_n.fms) where n is from 1 to 40.
|-- Resources ---- default data <---- The tacan.dat file is installed here and is used for TACAN navigation in the CF-104 and other future aircraft.
```

4.8 TACAN Database Information

As shown above in the folder structure, a TACAN database is included for TACAN navigation. Many VOR stations share the transmitter with a TACAN transmitter. These are known as VORTAC stations. The following table relates how the TACAN channel relates to a VOR frequency. You’ll see that there are both X and Y TACAN channels. Only the X channels were supported by the old fighter aircraft receivers so the Y channels can be ignored.
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<td>36Y 109.95</td>
<td>62Y 112.55</td>
<td>98Y 115.15</td>
<td>124Y 117.75</td>
</tr>
<tr>
<td>37X 110.00</td>
<td>63X 112.60</td>
<td>99X 115.20</td>
<td>125X 117.80</td>
</tr>
<tr>
<td>37Y 110.05</td>
<td>63Y 112.65</td>
<td>99Y 115.25</td>
<td>125Y 117.85</td>
</tr>
<tr>
<td>38X 110.10</td>
<td>64X 112.70</td>
<td>100X 115.30</td>
<td>126X 117.90</td>
</tr>
<tr>
<td>38Y 110.15</td>
<td>64Y 112.75</td>
<td>100Y 115.35</td>
<td>126Y 117.95</td>
</tr>
<tr>
<td>39X 110.20</td>
<td>65X 112.80</td>
<td>101X 115.40</td>
<td>127X 118.00</td>
</tr>
<tr>
<td>39Y 110.25</td>
<td>65Y 112.85</td>
<td>101Y 115.45</td>
<td>127Y 118.05</td>
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<td>66X 112.90</td>
<td>102X 115.50</td>
<td>128X 118.10</td>
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<tr>
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<td>66Y 112.95</td>
<td>102Y 115.55</td>
<td>128Y 118.15</td>
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<td>41Y 110.45</td>
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<tr>
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<td>68X 113.10</td>
<td>104X 115.70</td>
<td>130X 118.30</td>
</tr>
<tr>
<td>42Y 110.55</td>
<td>68Y 113.15</td>
<td>104Y 115.75</td>
<td>130Y 118.35</td>
</tr>
</tbody>
</table>

Illustration 6: TACAN Channel – Frequency Map
4.9 User-Defined Weapon Ranges & Tracking Cameras

Included is a file that defines weapon ranges (see folder structure diagram). This file specifies the center of a target and also the position of a tracking camera. You may define as many as you like if you develop or find scenery with bombing ranges. When a bomb is dropped, the plugin code will check to see what bombing range is closest. The tracking camera for that range is active as long as you are within a few kilometers. When the bomb is dropped, a bombing score will be provided telling how close your bomb hit from the center of the target. No results is displayed if you are more than 2 kilometers from the target.

The weapon range file looks as shown below:

Fields in order are:
----------------------
Camera Lat
Camera Lon
Camera Alt (ft ASL)
Target Lat
Target Lon

START
54.90075  -109.9456  2150  54.89629  -109.95081
54.40000  -110.2800  2100  54.40000  -110.2800
END

The top few lines are informational with the bomb range definitions defined between the START and END keywords. Camera position is first with lat/lon coordinates and the altitude of the camera above sea level. The last two fields define the lat/lon coordinates of the center of the target. One camera is positioned right above the Cold Lake air base so can be activated when you open that scenery. The other range is defined north of the air base and the included mission route for the INS (see below section) will provide navigation info to the range.

4.10 User-Defined Routes for the Inertial Navigation System

Included is a file that defines a route that can be used by the INS to take you out to the weapon range (see folder structure diagram). The files must be called cf104_route_n.fms where n is a number between 1 and 40. The route file must only include lat/lon coordinates and not airport names or VOR names, etc. This is the route file included:

I
3 version
1
0
29 CYOD 31 54.42   -110.3
29 WPT_2 0 54.74   -109.7
29 WPT_3 0 54.87344 -109.87888
29 WPT_T 0 54.89629 -109.95081
29 WPT_5 0 54.57    -110.4
0 ---- 0 0.0000000  0.000000
0 ---- 0 0.0000000  0.000000
.

The "29" identifies the waypoint as a lat/lon coordinate. The second field is the waypoint name which can be anything. The 3rd field is normally just zero and the last two fields are the lat/lon coordinates of the waypoints. In the above file, the 4th waypoint corresponds to the target center so you'll see that it matches the coordinates of the bombing range defined in the weapon ranges file.
5. CF-104 Menu Interface

5.1 Flight Preparation Menu

From the Plugins menu option in X-Plane, select the CF-104 Systems - Flight Preparation option to open the Flight Preparation window. Moving the mouse over different parts of the window will show different options available for flight preparation.

5.1.1 Refueling

Clicking the fuel truck opens the refueling window. Refueling is also performed automatically any time the aircraft is shutdown, but in case you want to change the fuel level with the engine running or when the aircraft is in the air, this option may be selected. This window allows you put fuel into any tanks mounted on the aircraft.

Note: The X-Plane refueling window will have no effect on fuel levels in the CF-104 due to the CF-104 application implementing a custom fuel system.

5.1.2 Selecting Ordnance (Fuel Tanks & Weapons)

Clicking the group of fuel tanks and weapons opens the Ordnance Loadout window. From there, select the fuel tanks and weapons you want loaded onto the aircraft. This ordnance is not available in the X-Plane weapons menu.

5.1.3 APU Start

Clicking the APU will cause the APU to connect to the aircraft and start running as long as the engine is not already running. This supplies power for the electrical system and compressed air to the engine to allow it to start. Refer to the Starting Procedure in the Normal Procedures section of the manual for details on the starting procedure.
5.1.4 Clearing Failures

Clicking the aircraft will clear all current failures on the aircraft. This will clear electrical failures, engine failures, hydraulic failures, will stow the Ram Air Turbine (RAT), and retract the tail hook.

5.2 Electrical System Status Menu

This will display a dynamic schematic diagram showing the current status of the electrical system. Online components are shown in green and offline components are shown in red. Note that in normal operations, not all bus supply paths are operational. Also note that many electrical components are tied to more than one bus so if one bus goes offline, these components can get power from the other buses they are attached to. For a detailed description of the CF-104 electrical system, refer to the section 10.5 Electrical System in the manual.

5.3 Hydraulic and Electrical Systems Failures Menu

This menu allows the use to setup various systems failures. Systems can be set to fail at random times (not yet implemented), at specific times, at specific altitudes, or at specific speeds, or not at all.

Illustration 8: Systems Failure Window
5.4 Radio Setup Menu

This window allows you to associate communication frequencies with channels. Channels are changed by the UHF Radio Channel Selector dial on the bottom left of the main panel. Of course in the real world these would map to actual UHF frequencies but we don't have support for that in X-Plane so I've mapped them to standard radio frequencies.

![Radio Channel Frequency Setup Window](image)

**Illustration 9: Radio Channel Frequency Setup Window**
5.5 Preferences Menu

Make sure you set your Preferences through the Plugins - CF-104 Systems - Preferences Menu.

**Illustration 10: Preferences Window**

**Plugin Controls Lateral Head Movement**
This is an useful option if you are not using TrackIR. When you look backwards, it will move your head sideways a bit so you can see past the ejection seat so you can see the wings instead of the head rest.

**Save Fuel Levels Between Flights**
Selecting this option will save fuel levels between flights. When you re-start X-Plane, your fuel level will be the same as when you last exited.
Symmetric BLC
Boundary Layer Control (BLC) Flaps are designed to provide more lift over the wings during landing to keep landing speeds reasonable. Engine air is ducted over the flaps when they are in landing configuration to prevent airflow separation over the flaps, thereby increasing lift. Engine RPMs must be over 83% for BLC to be effective. Below this value, you will lose lift. In some Starfighters, you'd lose lift over the flaps at roughly the same time. This is symmetric BLC. More often than not, you'd lose lift over the one flap before the other. This would cause the plane to roll if you reduced engine power below 83% rpm. If you were slow enough, one wing would stall and you would find yourself in a very fast uncommanded roll. Leave this box unchecked if you want to have some fun. This is why engine RPMs must be kept above 83% during landing until the aircraft is on the ground.

Play Outdoor Sounds when Engine is Off
If you want to hear the odd Starfighter fly over or hear the glorious sounds of nature and chirping birdies, check this box. With the engine off and the canopy open, you will hear nature at its finest. If anyone actually likes this, I may offer a choice between nature sounds or more industrial sounds. If you don't like my sounds, you can substitute your own. The sounds are prefixed by "amb" and are in the CF-104/sounds folder. No ambient sounds can be heard with the engine running.

Use Mixture Control for Throttle Idle/Cutoff.
If you have a separate mixture lever, once the mixture lever is set more than half way, the throttle will go from cutoff to idle. If you are using this option you can un-assign the function key for Throttle Idle/Cutoff in the Plugins-CF-104 Systems-Joystick Setup window.

Auto Refuel from Fuel Truck
If this option is on, a fuel truck will stop by your plane and refuel you when you turn your engine off. The refueling rate is fast and accurate.

Stick Shaker Sound
The stick shaker always seems to be on when turning or flying at all slow. A sound is used as an indication that the stick shaker is active. Un-check this option if this sound annoys you. I know I don't like it.

Engine Howl Sounds
The engine in the Starfighter has a unique howling noise at certain engine rpms. I've tried to replicate it. I think it needs improvement. You can turn it off if you don't care for it.

Display Critical Events
Critical flight events will be displayed to the screen such as over-speeds, failures, etc. This can be useful for learning or if the plane is exhibiting behavior that you don't expect.

Display Normal Events
Normal flight events will be displayed to the screen such as engine start/shutdown, normal takeoff, etc.

Starfighters in Circuit
If this option is selected, 2 CF-104s will fly circuits over your starting location at the airport at the desired heading and altitude as described below.

Starfighters Use Our Heading
If this option is selected, the Starfighters in the circuit will fly circuits using the heading your aircraft is currently at. The heading can also be selected using a slider as described below.

AI CF-104 Circuit Heading
If the box above is unchecked, the Starfighters will fly using the heading selected by this slider.

AI CF-104 Circuit Height
The AI CF-104s will fly over you at 500 feet AGL. Once past the airport, they will climb to the altitude as selected by this slider.

Engine Volume Slider
If you find the engine volume too loud, you can use this slider to turn it down. Flying in a Starfighter is however, quite loud and the sounds are recorded from the real jet so hook up your computer to your stereo and crank up the volume.

**Wind Volume Slider**
If you find the wind volume too loud, you can use this slider to turn it down. When flying in the Starfighter, the wind is the most prevalent sound. I find max volume to be the most realistic setting.

**Warning Tone Volume Slider**
If you find the cockpit warning sounds like Master Caution, Fire, or other cockpit sounds too loud, adjust this slider down.

**Ambient Sounds Volume Slider**
This slider adjust the volume levels for the ambient sounds such as the birds and the AI CF-104s as they fly over.

**Aileron/Pitch Trim Sensitivity Sliders**
Some people find the pitch and aileron trim too sensitive. While realistic at the max settings, you can move the sliders down to decrease sensitivity.
6. CF-104 Technical Specifications & History

The CF-104 Starfighter is a single-place, high-performance, all-weather fighter-bomber. The aircraft is powered by an axial-flow turbojet engine with afterburner and is capable of high subsonic and high supersonic combat. Notable features of the aircraft include extremely thin flight surfaces, short straight wings with negative dihedral, irreversible hydraulically powered flight controls, a controllable horizontal stabilizer mounted at the top of the vertical stabilizer, engine inlet duct anti-icing, an anti-skid brake system, a maneuvering autopilot, and an automatic pitch control system. The wings have leading and trailing-edge flaps and a boundary layer control system, which is used in conjunction with the trailing-edge flap to reduce landing speeds. Emergency escape is accomplished with an upward ejection system. A drag chute is installed to reduce landing roll. Single-point pressure refueling is included for both external and internal tanks.

SPECIFICATIONS

Engine: One Orenda Engines-built J79-OEL-7 rated at 10,000 lb.s.t. dry and 15,800 lb.s.t. with afterburning. Performance: Maximum speed (dash): 1550 mph (Mach 2.35) at 40,000 feet, 915 mph (Mach 1.2) at sea level. Climb to 30,000 feet in 1.5 minutes. Weights were 13,909 pounds empty, 21,005 pounds loaded (clean), 28,891 pounds maximum takeoff.

DIMENSIONS

Overall dimensions of the aircraft are as follows:

a. Wing Span 21.94 feet
b. Length (with boom) 58.26 feet
c. Height (to top of vertical stabilizer) 13.49 feet
d. Tread 8.79 feet

AIRCRAFT GROSS WEIGHT

Depending upon aircraft configuration and weapon loads, the gross weight can vary between approximately 20,500 and 27,500 pounds.

HISTORY
In the late 1950s, the Canadian government had a clear need for a supersonic replacement for the Sabre Mk.6 in RCAF service. Several aircraft were considered in the competition, including the McDonnell F4H Phantom II, the Lockheed F-104 Starfighter, and the Grumman F11F-1F Super Tiger. The RCAF clearly preferred the Phantom as the Sabre replacement, but this was rejected fairly early on, probably due to its high cost. As the alternative, the RCAF preferred the Super Tiger (even though it had not been purchased by the US Navy), but on July 2, 1959, it was announced that Canada had chosen the F-104 Starfighter as the replacement for the Sabre Mk.6 in service with the RCAF’s European Air Division. The choice was probably made because of a better deal (in terms of economics) being struck between the manufacturer and the Canadian government.

However, since the Canadian government wanted equipment to be fitted that was specific to RCAF requirements, it opted to manufacture the aircraft under license in a Canadian factory rather than to buy the aircraft outright from Lockheed. On August 14, it was announced that Canadair of Montreal had been selected to manufacture 200 aircraft for the RCAF under license from Lockheed. In addition, Canadair was to manufacture wings, tail assemblies, and rear fuselage sections for 66 Lockheed-built Starfighters that were destined for the West German Luftwaffe. The license production contract was signed on September 17, 1959.

The Canadian-built Starfighter was initially designated CF-111 by the RCAF, but this was later changed to CF-104. They were designated CL-90 by the Canadair factory.

The CF-104 was basically similar to the F-104G, but was fitted with equipment specialized for RCAF requirements. It differed from the F-104G in being optimized for the nuclear strike role rather than being a multi-mission aircraft. The F-104G was fitted with NASARR F15A-41B equipment which was optimized for both air-to-air and air-to-ground modes, but the CF-104 was fitted with R-24A NASARR equipment which was dedicated to the air-to-ground mode only. The main undercarriage members were fitted with longer-stroke liquid springs and carried larger tires. The CF-104 also differed from the F-104G in retaining the removable refuelling probe that was fitted to the F-104Cs and F-104Ds of the USAF. Another difference from the F-104G was the ability of the CF-104 to carry a ventral reconnaissance pod equipped with four Vinten cameras. The 20-mm M61A1 cannon and its associated ammunition were initially omitted from the CF-104, and an additional fuel cell was fitted in their place.

In parallel with the production of the Starfighter by Canadair, Orenda Engines, Ltd. acquired a license to build the J-79 engine which was to power it. The CF-104 was powered by a Canadian-built J79-OEL-7 rated at 10,000 lb.s.t. dry and 15,800 lb.s.t. with afterburning.

Lockheed sent F-104A-15-LO serial number 56-0770 to Canada to act as a pattern aircraft for CF-104 manufacture. It was later fitted with CF-104 fire control systems and flight control equipment (but not the strengthened airframe of the true F-104G) and turned over to the RCAF, where it was assigned the serial number of 12700. The first Canadair-constructed CF-104 (RCAF serial number 12701) was airdropped to Palmdale, California in the spring of 1961, where it made its first flight on May 26. The second CF-104 (12702) also made its first flight at Palmdale. The first two CF-104s to fly at Montreal were Nos. 12703 and 12704, which both took to the air on August 14, 1961.

CF-104s were initially assigned Canadian serials 12701 through 12900. On May 18, 1970, they were reserialized as 104701 through 104900. The Lockheed-built F-104A pattern aircraft was reserialized from 12700 to 104700. The 200th and last CF-104 (No. 12900) was completed on September 4, 1963 and delivered to the RCAF on January 10, 1964. Many early production aircraft were modified to the standard of the last production machines. Following the delivery of the last CF-104, Canadair switched over to the manufacture of F-104Gs for delivery to NATO allies under the provisions of MAP.

Beginning in December of 1962, the RCAF used its CF-104s to equip eight European-based squadrons of its No. 1 Air Division. Other CF-104s were assigned to the No. 6 OTU based at Cold Lake, Alberta. Apart from the operational conversion unit established at Cold Lake, Alberta in late 1961 (eventually redesignated No 417 Squadron), RCAF CF-104s were all committed to the support of NATO’s nuclear deterrent mission in Europe. No. 427 Squadron was the first to form, with initial deliveries to Zweibrucken in December of 1962. In February of 1964, even before France withdrew from NATO in 1966, 2 Wing at Grostonquin was disbanded, and its two CF-104 squadrons were transferred elsewhere, No 421 moving to 4 Wing at Baden-Soellingen and No. 430 moving to Zweibrucken. The RCAF’s other French base at Marville was closed by March of 1967, and its two CF-104 reconnaissance squadrons (439 and 441) moved to Lahr in Germany. Nos 434 and 444 Squadrons were disbanded in 1967-68, reducing CF-104 strength to four nuclear strike squadrons and two tactical
reconnaissance squadrons.

In May of 1969, 3 Wing at Zweibrucken was closed, and No 427 Squadron was relocated to Baden and No 430 to Lahr. Air operations at Lahr ceased in 1970, when it became a Canadian Army base, but 1 Canadian Army Group remained at Lahr, co-located with the Canadian Forces Europe headquarters. The airfield at Lahr remained operational for air transport operations as well as being a deployment base for the CF-104s from Baden-Soellingen.

In 1970, the Canadian government decided to reduce the strength of the Air Division to only three squadrons and to relinquish its nuclear strike role in favor of conventional attack by 1972. By January of 1972, the CF-104s had been converted from their nuclear role to that of conventional ground attack. A 20-mm Vulcan cannon was installed, and the fairing was removed from the cannon port. Twin bomb ejector rack carriers and multi-tube rocket launchers were installed.

In 1972, 1 AirDiv was redesignated 1 Canadian Air Group with headquarters remaining at Lahr. Squadron Nos. 422, 427, and 430 Squadrons were disbanded. Nos. 439 and 441 replaced all but 421 Squadron in No 4 Wing at Baden. Of the remaining three squadrons, 421 was committed to converting to ground attack roles, together with No. 431 Squadron, leaving only No. 441 Squadron to continue tactical reconnaissance missions with the Vinten VICON underfuselage camera pod. However, I don't think that No. 441 Squadron remained a reconnaissance unit for all the time until the final phaseout in 1986.

A number of former Canadian Forces single-seat CF-104 fighter-bombers and CF-104D two-seat trainers were transferred to Denmark and Norway after having been brought up to F-104G/TF-104G standards. By the end of 1980, these transfers along with attrition had brought European-based RCAF strength down to only three Starfighter squadrons. These were Nos. 421, 439, and 441, all based at Baden-Soellingen in West Germany. At that time, No. 417 Squadron at Cold Lake was still functioning as a CF-104 Operational Conversion Unit. By 1983, all single-seat CF-104s had been modified with the Litton LW-33 digital inertial navigation/attack system, which replaced the original LN-3 analog inertial navigation system. The LW-33 was much more accurate and less expensive to maintain than was the earlier LN-3. In addition, the LWV-33 had an attack function.

Beginning in 1983, the CF-104 Starfighters were replaced in Canadian Armed Forces service by McDonnell Douglas CF-18 Hornets. The last CF-104 was phased out by No. 441 Squadron on March 1, 1986. Canada then offered Turkey an initial batch of 20 CF-104s, later increased to 52, including six CF-104Ds. Twenty of these were sent to MBB at Manching in Germany in March of 1986 for inspection before being transferred to Turkey. The remainder were broken down for spares.

About 110 CF-104/CF-104Ds were lost in accidents, out of 239 delivered--a loss rate of no less than 46 percent. However, it is only fair to point out that the Canadian CF-104s probably had the highest flying time of any country operating the Starfighter. At the time of retirement, average airframe times were of the order of 6000 hours as compared to 2000 hours for the Luftwaffe.

At the time of retirement, some Canadian-based CF-104s were made available for museums in Canada.

The following Canadian Armed Forces units operated the CF-104:

2. 6 Strike-Recce OTU, reformed as No. 417 Operational Training Squadron (1962-1983).
3. No 421 (Red Indian) Squadron, 2 Wing, Grostonquin/Baden-Soellingen Dec 1963 to Dec 1985
6. No 430 (Silver Falcon) Squadron, 2 Wing, Grostonquin/Lahr, September 1963 to 1972.
9. No 441 (Silver Fox) Squadron, 1 Wing, Marville/Baden-Soellingen, September 1963 to Feb 1986.
7. Instrument Panel Layouts

Illustration 11: Main Panel

1. Arrestor Hook
2. Landing Gear / Start Switch / Trim Indicator Panel
3. Armament Panel
4. Main Panel
5. Radar Panel
6. Radar Setting Panel
7. Warning Display Panel
8. Dual Timer Panel
9. Radar Control Panel
10. Ground Speed Set Panel
11. Generator Switches Panel
12. TACAN Panel
13. PHI / Nav Panel
14. DCU-9/A Fusing Mode Panel
15. Inertial Navigation System Alignment Panel
Detailed Description

Automatic Pitch Control (APC) Gauge

The APC gauge reads from 0 to 5 and displays a combination of Angle-Of-Attack (AOA) and Pitch Rate information to the pilot. The CF-104 is prone to pitch-up at high AOA and pitch rate so an automatic pitch control system was developed to provide some warnings to the pilot when ever the aircraft is approaching dangerous flight conditions. A stick-shaker will shake the stick to alert the pilot that he is approaching a high AOA. As the AOA reaches a dangerous level, a stick-kicker will activate and apply forward pressure on the stick. The kicker will activate as the APC gauge displays a reading of 5. If the pilot continues to pull back on the stick beyond this value, pitch-up is imminent.

The APC reading relates to AOA in this manner. When the APC is reading a value of zero, the AOA can be between 0 and 3 degrees. A value of 5 corresponds to approximately 13 degrees AOA. The pitch-up angle of attack is around 16 degrees. Needless to say, the APC gauge should be monitored during slow flight and aggressive maneuvering. During landing, it is essential as well to keep the AOA with safe limits. A value of 3 on the APC during landing is typical. The stick shaker in the simulator is modeled as a chattering sound that is played. You will hear this often. During dogfights, it is common practice to turn hard until the stick shaker activates.

Compressor Inlet Temperature Gauge and Warning Light

The Compressor Inlet Temperature Gauge monitors engine inlet temperature. Top speeds of the CF-104 are extremely high and the aircraft will accelerate beyond M 2.3 unless the engine is throttled back. At high speeds, the inlet temperature can get very high. Beyond 100 deg C, the warning light marked SLOW will begin to flash as a warning that the inlet temperature is getting too hot. Prolonged flight at high inlet temperatures can cause serious damage to the engine. In flight tests and speed record attempts, M 2.3 was regularly achieved for short time periods with no damaging effects on the engine. At higher altitudes and colder temperatures, the aircraft may be flown at higher Mach numbers and lower inlet temperatures.
G Meter

The G Meter reads current G load, minimum G load, and maximum G load. The button on the bottom left of the gauge may be used to reset the maximum and minimum values back to 1.

UHF Radio Channel Selector

Nineteen preset UHF channels and one Guard channel may be defined for UHF voice radio. UHF radio is inoperative in this simulation.

Combined Mach / Indicated Airspeed Indicator

The airspeed indicator combines both Mach number reading and indicated airspeed reading in knots. Indicated airspeed does not read below 60 knots. There is also a rotating drum in the top part of the gauge that displays the “tens” value of the airspeed reading to provide a more precise indication. Along the top of the gauge is a rotating dial that displays indicated Mach number up to M 2.2. The push button is inactive in the simulator.
Altimeter

The altimeter has one needle which reads the altitude in hundreds of feet. The digits in the middle read hundreds, thousands, and ten-thousands. The knob on the bottom left is used to adjust barometric pressure.

Attitude Indicator

The Attitude Indicator displays several pieces of data. Power to the attitude indicator is received from the Inertial Navigation System (INS). The INS is on the right side panel. The INS mode switch must be turned on in order for the Attitude Indicator to receive power. The INS detects magnetic heading and sends this data to the attitude indicator which displays heading along the horizon line of the ball. See the section 10.6 Navigation System in the manual for more information on the INS. Besides heading information, the ball also displays pitch angle and roll attitude.

The bottom of the Al incorporates a needle and ball to display yaw information.

On the left side of the gauge is a vertical tape display. The difference between actual ground speed as determined by the INS and desired ground speed as entered on the desired ground speed indicator, to the right of the radar, is displayed on this vertical tape. An arrow will appear on the tape when the two values are within +/- 9 knots.

The knob on the bottom right of the AI will tilt the ball so can be adjust as different aircraft attitudes as desired by the pilot to show level flight.

Position and Homing Indicator (PHI)

See the section 10.6 Navigation System section in the manual for information on this gauge.
8. Normal Procedures

NOTE: Procedures highlighted in GREEN are available in X-Plane. All others are listed for informational purposes.

Video Tutorials Included in this section (more to come):
Starting Engine
Landing Pattern

8.1 After Entering Aircraft

FORWARD COCKPIT INTERIOR CHECK

1. Foot retractors - Attach
2. Seat belt, shoulder harness, and parachute arming cable - fasten.
   
   **WARNING**
   
   Failure to attach the straps in the following proper sequence may prevent separation from the ejection seat after ejection.
   
   a. Place the right and left shoulder harness loops over the manual release end of the swivel link.
   b. Place the automatic parachute arming cable over the manual release end of the swivel link.
   c. Fasten the seat belt by locking the manual release lever.

3. Oxygen hoses and other personal leads - Connect.
4. Head set, oxygen mask - Connect.
5. External Power - ON. Select APU Start from plugins - CF-104 Systems - Flight Preparation Window. You'll hear the APU start and electrical power will be available to run the instruments. The APU start cart will appear outside.
   
   **Note**
   
   MASTER CAUTION, INST ON EMER POWER, HYDRAULIC SYSTEM OUT, AUTO PITCH CONT OUT, NO.1 AND NO. 2 GENERATOR OUT, CANOPY UNSAFE and ENGINE OIL LEVEL LOW lights will be illuminated until engine is started.

6. Attitude indicator - Check, large warning flag retracted.
7. Left console circuit breakers - In.
8. Auxillary trim selector switch - STICK TRIM.
9. Auxillary trim control switch - NEUTRAL
   
   **CAUTION**
   
   • Do not use auxillary trim control without hydraulic pressure as this may damage the trim motors.
   • Do not attempt to move control stick without hydraulic pressure.

10. APC switch - ON and safetied.
11. Stability control switches (roll, pitch, and yaw) - ON.
12. A/R probe light rheostat - OFF.
13. Pylon jettison switch - OFF.
14. Engine motoring switch - OFF.
15. Camera shutter switch - As required.
16. IFF control panel - As required.
17. External tanks refuel selector switch - As required.
18. Refuel switch - OFF.
19. Dual Timer Panel - As required.
20. Fuel shut-off switch - ON (Guard down and secured by safety clip).
21. Radar control panel - As required.
22. Rudder trim - Neutral.
23. Exhaust nozzle control switch - AUTO.
24. Wing flap lever - UP (check indicator).
25. Throttle - OFF.
26. Speed brake switch - NEUTRAL.
27. Red landing gear light - OFF.
28. Green landing gear lights - ON.
29. Landing and taxi lights - OFF.
30. Anti skid - ON.
31. Drag chute handle - Stowed.
33. Armament control panel - As required.
34. Rudder pedal adjustment - As required.
35. Radar control switches - As required.
36. Control transfer panel - As required.
37. External stores rotary selector switch - SAFE.
38. Canopy jettison handle - Stowed.
39. Clock - Check.
40. UHF channel selection - As required.
41. Accelerometer - Reset.
42. Airspeed setting index - Set as required.
43. Mach reset - Check.
44. Altimeter - Set

WARNING

It is possible to rotate the barometric set knob through full travel so that the 10,000 foot pointer is 10,000 feet in error. Special attention should be given the altimeter to assure that the 10,000 foot pointer is reading correctly.

45. Attitude indicators - Set.
46. PHI Indicator - As required (refer to section on Navigation Equipment for more details).
47. Ram air turbine handle - Stowed.
48. Clearance plane and antenna tilt indicator - Check.
49. External fuel quantity selector switch - As desired.
50. Storm lights switch - OFF.
51. Liquid oxygen gauge - Check.
52. Canopy defogger - OFF.
53. Fuel quantity and fuel indicating system - Check.
54. Warning light system test switch - WARNING LIGHTS TEST
55. Generator switches - RESET.
56. Oxygen system - Check.
57. Oxygen regulator panel - As desired.
58. TACAN - As required.
59. Exterior lights control panel - As required.
60. Eject frequency override switch - OFF.
61. PHI - As required.
62. Inertial navigator panel - Set the INS to Align to provide nav info to the Attitude Indicator (AI). The OFF light on the AI will go away once this is done. The INS green mode light will start flashing when ILS alignment is complete. At this time, change the INS mode to NAV. This normally takes about 9 minutes in the real aircraft. In the sim, the alignment time has been shortened to one minute.
63. Pilots fresh air scoop lever - CLOSED.
64. BTC - As required.
65. DCU 9/A panel - As required.
66. UHF - As required.
8.2 Before Starting Engine

Before starting engine, make sure danger areas are clear of personnel, aircraft, and vehicles. The boundary layer control outlets for the intake ducts on each side of the lower fuselage will have a strong suction when the engine is starting which may be strong enough to draw articles of clothing or loose equipment into the engine. Start engine with airplane heading into the wind when practical. An external electrical power source will be connected when starting the engine unless an emergency condition exists.

**CAUTION**

- The starter is limited to 1 minute of continuous operation, after which 2 minutes must be allowed for cooling before using the starter again.
- The auto-start control cable between the airplane and the auto-start control valve must be connected so that the start switches control starting air. If the auto-start control cable is not connected, the pilot has no control over starting air in the event of starter overspeed. Repeated exposure to overspeed conditions (above 40% rpm) will cause starter fatigue and subsequent disintegration of the starter. This can result in serious damage to the airplane.

8.3 Starting Engine

**Video Tutorial**

Occasionally it may be necessary to start the engine without the recommended ground starting equipment. Basically there are three types of starts that may be used. These are AUTOMATIC, MANUAL, and BATTERY. Currently only AUTOMATIC start is supported in the simulator.

**AUTOMATIC START**

The X-Plane preference to start aircraft with engine running is used by the plugin to determine if the Starfighter will open with the engine on or off. That option is found in the X-Plane - Settings - Operations and Warnings window. See the Setup Instructions on how to configure the Throttle Idle/Cutoff key and how to use the Key Command Menu.

Start the engine as follows:

1. Throttle - CUTOFF.
2. Ground turbine compressor and auto-start control cable - Connected and ON. (Done automatically for you in sim).
3. Push either start switch on the left forward panel and release (panel 2 on the panel diagram in this section: 7. Instrument Panel Layouts). You may also operate the start switch from the key command menu. Push the function key you have assigned to activate the key command menu, select General Equipment (Option 1) and then option 3 which is the start switch.
Note

• Successive engine starts should be alternated between ignition systems. This procedure will serve as a check on system operation. Make the first engine start on the No. 1 ignition system and the second start on the No. 2 ignition system.
• The maximum starting time should not exceed 60 seconds from the time the start switch is actuated until reaching idle rpm.

4. After a few seconds the engine RPMs start increasing. When they do, push the Idle/Cutoff function key that you have assigned, to move the throttle from cutoff to idle. This will cause fuel flow and the EGT should start reading to indicate a positive start. Turning on the fuel too soon can cause a hot start and an engine fire.
5. Fuel flow 450 - 700 pounds per hour - Check 10 to 12% rpm.
6. As the engine starts, system warnings will extinguish on the warning system panel on the right forward panel (panel 7 on the diagram in this section: 7. Instrument Panel Layouts). The engine start sequence may be stopped by pushing either start switch down. You may also use the key command menu option General Equipment - Stop Start.
7. Turn the radar to one of Standby mode if required. The radar controls are on the front of the left side panel (panel 9 on the diagram in this section: 7. Instrument Panel Layouts). The radar takes a couple of minutes to warm up before other radar modes are available so be patient.
8. Turn on the reticle using the reticle power switch on the right side of the Armament Panel. In this strike version of the CF-104, this was displayed in a fixed position but could be adjusted using the "Depression" dial (not functional yet). In the upcoming conventional attack version, the sight allowed advanced computed bombing modes such as CCIP and CCRP and the lead-computing (LCOSS) sight for air-to-air combat.

CAUTION

• If fuel flow exceeds 700 pounds per hour, a hot start may result. If fuel flow is less than 450 pounds per hour for ground starts, it may be too low at altitude to accomplish an air start. Therefore the aircraft should be cleared by maintenance personnel before flight.
• Combustion should occur before reaching 20% rpm or within 20 seconds after fuel flow is established. If no combustion occurs within this rpm or time limit after fuel flow indication, or the engine fails to accelerate to normal idle rpm, or exhaust gas temperature exceeds starting limits, a False Or Hanging Start condition has occurred. Press the start switch down to STOP-START and signal ground crew to stop air flow.

CAUTION

If the throttle is unintentionally retarded to OFF, a flameout occurs immediately. Do not reopen, as relight is impossible and resultant flow of unburned fuel into the engine will create a fire hazard.

9. External electrical power and ground turbine compressor - Disconnect at idle rpm. (Done automatically for you)
10. Engine instruments for proper indications - Check.
   • Nozzle position - Approximately 7.5.
   • Tachometer - 67% +/- 1%
   • Exhaust Gas Temperature - Normal (320-420 degC)
   • Oil pressure - 12 psi minimum
   • Fuel flow - 1000 - 1300 lbs/hr
8.4 Ground Operation

With the assistance of ground personnel, proceed as follows:

1. Generators - ON – RESET

To insure operation of the generator bus transfer circuits:
   a. No. 1 generator - OFF, check warning light and RESET.
   b. No. 2 generator - OFF, check warning light and RESET.

2. UHF, IFF, and TACAN - As required.
3. Hydraulic systems – Check

To insure that the hydraulic systems are operating properly, perform the following checks:

• Operate speed brakes through a complete cycle. Pressure indication on the No. 2 gauge should drop quickly to approximately 2300 psi then rise momentarily to approximately 3300 psi and return to normal.
• Move stabilizer only through a complete cycle. Pressure indications should drop quickly to approximately 2700 psi then rise momentarily to approximately 3300 psi and return to normal.
• Move ailerons only through a complete cycle. Pressure indications should drop quickly to approximately 2600 psi then rise momentarily to approximately 3300 psi and return to normal.
• Move rudder through maximum travel and check that hydraulic pressure drops, rises, and returns to normal.

4. Flight controls - Check for full travel.
5. Trim system - Check.

CAUTION

It is possible to damage the trim mechanism by operating the trim controls with the control stick in the full throw position. To preclude this possibility, make all trim system checks with control stick NEUTRAL.

Make the following checks and have the ground crew assure you that control surfaces respond correctly:
   a. Rudder trim - Operate through full travel and return to neutral.
   b. Aileron and horizontal stabilizer trim switch - Test (all four positions).

WARNING

An improperly installed or defective trim switch is subject to sticking in any or all of the actuated positions, resulting in application of extreme trim. If this condition occurs during preflight check and the switch does not return automatically to the center OFF position, do not fly the airplane.

Note

Take-off trim indicator lights should momentarily illuminate as the trim motors pass through the take-off setting.

6. Trim - Set for takeoff and verified by ground personnel.

Note

Leading edge of horizontal stabilizer should be aligned with black "T" index painter on the vertical stabilizer.

7. Auto-pitch, stick shaker, and stability control augmentation system - Check

8.5 Before Taxiing

Observe the following instructions:

1. Hydraulic door - Closed.
2. Canopy - As desired.
3. Ground crew interphone - Disconnected.
4. Canopy initiator safety pin removed - Check.
5. Ejection seat safety pin - Removed.
7. After clear of other aircraft, external stores auto-drop system safety pins – Removed

Note
When armament stores are carried, the safety pins are to be removed in the designated area.

8.6 Taxiing

1. Nose wheel steering - Engage (use Nose Wheel Steering button as configured on your stick in the section 4.4 Joystick Setup.

   The nose wheel and rudder pedals must be in the same relative position before the steering mechanism can be engaged.

   **WARNING**
   Do not operate canopy handle at aircraft speeds in excess of 50 knots IAS or damage to the canopy frame and locking mechanism can result.

2. Brakes - Check

   **CAUTION**
   To prevent possible damage to the main landing gear wheel assemblies from excessive side-loads, avoid high speed taxi turns.

3. Flight instruments and navigation equipment - Check

<table>
<thead>
<tr>
<th>BEFORE TAKE-OFF CHECK</th>
</tr>
</thead>
<tbody>
<tr>
<td>H  Harness Locked - Arming cable, spurs - hooked</td>
</tr>
<tr>
<td>Hydraulics 2800 - 3100 psi</td>
</tr>
<tr>
<td>Hood Locked</td>
</tr>
<tr>
<td>T  Trim Set for take-off</td>
</tr>
<tr>
<td>F  Fuel Internal and External</td>
</tr>
<tr>
<td>Flaps Take-off, speed-brakes- IN</td>
</tr>
<tr>
<td>G  Gyros Erect and aligned</td>
</tr>
<tr>
<td>S  Switches As required</td>
</tr>
<tr>
<td>C  Controls Full travel</td>
</tr>
<tr>
<td>O  Oxygen Sufficient for flight</td>
</tr>
</tbody>
</table>
ENGINE CHECK

Illustration 12: Throttle Position Graph

See figure Illustration 12: Throttle Position Graph for exhaust nozzle positions at various throttle settings. While the take-off area make the following checks:

1. Align aircraft with runway - Check nose wheel centered.
2. Throttle, MILITARY - Check instruments.
   - RPM - 100% (plus or minus 1%).
   - Exhaust gas temperature (588 degC +/- 11 degC).

Some EGT gauges may indicate a momentary fluctuation of +/- 5 degC over normal limits. This indication is allowable provided the fluctuation does not exceed a maximum of +/- 5 degC and does not occur more often than once every 20 seconds.

- Nozzle position - 1 to 3.
- Fuel flow - Check
- Oil pressure - Check

3. Throttle - Rapidly retard to IDLE, check for compressor stall.
4. Throttle - MILITARY
5. Throttle - Reduce slowly to 80% rpm, check for compressor stall

If compressor stall is encountered, abort flight.

6. Throttle - Rapidly retard from 80% rpm to IDLE - Check fuel flow.
Fuel flow should momentarily drop to approximately 450-700 lb/hr. This fuel flow indicates that sufficient minimum fuel flow will be available during idle descents and for air starts. If the fuel flow is not within these limits the flight should be aborted.

7. **Throttle - MILITARY.** Advance throttle to MILITARY and check for normal engine acceleration (10 seconds maximum).

### 8.7 Takeoff

Prior to takeoff, set Radar to GMS or GMP ground-mapping modes or Air-toAir mode if desired.

**NORMAL TAKE-OFF**

1. **Throttle - Minimum Sector Afterburner** (ensure light-off - a successful afterburner light is by a stable EGT of 588 degC and the nozzle opening above a value of 2).

   **Note**
   It is recommended that a stabilized afterburner light be obtained prior to advancing throttle to Maximum Afterburner.

2. **Brakes - Release**
3. **Throttle - Maximum Afterburner Thrust**

   **Note**
   • Maximum or Military Thrust may be used for take-off. Military thrust take-offs however will result in extended takeoff rolls especially if external stores are being carried.
   • During afterburner take-offs avoid throttling into the sector range (nozzle position between 1.5 and 4)

4. **Engine instruments - Check**
5. **Use nose wheel steering as necessary for directional control.**

   **CAUTION**
   • Nose wheel steering should be disengaged prior to nose wheel lift-off to ensure proper steering clutch release.
   • With the nose wheel steering system engaged, a large amount of shimmy damping is lost; therefore, if nose wheel shimmy is encountered, release nose wheel steering.

6. **Assume take-off attitude.**

   **Note**
   Proper technique is to anticipate the acceleration of the aircraft and rotate the nose so that take-off attitude and speed are reached smoothly and simultaneously. As external stores are added, an increase in nose wheel lift off speed can be expected due to the change in weight and center of gravity. Takeoff speeds can range from 180 knots to 240 knots depending on aircraft weight, airport altitude, and weather conditions. Maximum tire speed is 243 knots.

**CROSS-WIND TAKE-OFF**
In addition to normal takeoff procedures, increase nose wheel lift-off and take-off speed 5-10 knots to compensate for gusts. Nose wheel steering may be required in excess of 100 knots if strong crosswinds are present.

8.8 After Take-Off - Climb

1. Landing gear lever - UP.

When airplane is definitely airborne, retract get and check red and gree landing gear position indicator lights off.

CAUTION

Immediate retraction of the gear is important when making afterburner take-offs to prevent exceeding the landing gear transient limit airspeed. The landing gear doors should be completely up and locked before the placard speed is reached; otherwise excessive airloads may damage the mechanism, or stall gear retraction.

2. Wing flap lever - UP.

Check indicator.

Note

• Do not retract wing flaps before reaching 240 knots IAS as buffeting will be experienced.
• Expect an easily controllable nose-up tendency as the flaps retract.
3. Throttle - As desired. (Retard to MILITARY at minimum of 300 knots IAS)

As soon as afterburner thrust is no longer needed, shut down the afterburner by moving throttle aft and inboard (In X-Plane move throttle to 80% travel). Monitor the nozzle position indicator to check that the nozzle closes normally as the throttle is being retarded from maximum afterburning.

4. Engine instruments and fuel quantity - Check.
5. Airspeed - Best climb.

---

8.9 Climb

The climbing attitude with Maximum Thrust is extremely steep and until experience is gained, some difficulty in holding the climb schedule will be experienced. Refer to climb charts for recommended speeds to be used during climb, and for rates of climb and fuel consumption.

**CAUTION**

The roll stability augmenter should be turned off before reaching 575 knots IAS with the tip stores installed. With tip stores installed and the roll stability augmenter operating, wing torsional oscillations sufficient to cause structural damage may be experienced at high indicated airspeeds. Missile launchers are not considered as tip stores; therefore, the roll stability augmenter should be left on when carrying bare launchers.

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8.10 Cruise

**Flying Video**

Refer to Appendix for Cruise Operating Data.

The windshield and canopy defogging system should be operated throughout the flight at the highest flow possible so that a sufficiently high temperature is maintained to preheat the canopy and windshield areas. It is necessary to preheat because there is insufficient time during rapid descents to heat these areas to temperatures which prevent the formation of frost or fog.

**Note**

The auto-pitch and stick shaker may be checked in flight as follows: While applying a slow stick deflection, note APC reading increase in relation to angle of attack and increasing G force indicating satisfactory system operation from sensing of vane angle. Apply a small rapid stick deflection and note APC indicator reading increase rapidly in relation to the pitch rate gyro. The stick deflection should be great enough to induce a pitch rate sufficient to actuate the stick shaker. The APC gauge reads from 0 to 5. In the real aircraft, the stick-kicker would activate when the gauge reached 5 to let the pilot know that he was close to the pitch-up limit. If you keep increasing the AOA, the plane will pitch up soon after. There is also a stick shaker which rattle the stick when you are near the stall speed. I added a sound for this so you'll hear it a lot. I'll let you pull the breaker in a future beta to disable the shaker and the sound.

Maximum takeoff flap speed is M 0.85. They are intended to be used for maneuvering. Corner velocity is between M 0.8 and M 0.85. Maximum sustained turn rate is 5.5G with flaps and 5.2 G without.

Top speeds of up to M2.4 have been achieved in the CF-104. The normal limit is M2.0. The top speed is limited by aerodynamic heating. The compressor inlet temperature is monitored and a light in the cockpit marked "SLOW" will flash when the maximum compressor inlet temperature is exceeded which is at around M2.0 at high altitudes but can occur at significantly lower Mach numbers at low altitude. Prolonged flight at high CIT temperatures will cause engine failure.
8.11 Afterburner Operation

Before moving the throttle into the afterburner range, check that the nozzle position indicator is in its normal range for military thrust. Move the throttle smoothly outboard and forward into the afterburner range (last 10% of throttle travel in X-Plane). Check exhaust gas temperature, rpm, and nozzle position.

**CAUTION**

If an afterburner light is not obtained within approximately 3 seconds at sea level or approximately 5 seconds at altitude after the throttle is moved into the afterburner range, move the throttle inboards to MILITARY and then after 3 to 5 seconds, return to the afterburner range. After the initial light is obtained, move the throttle forward with a positive motion if maximum thrust is desired.

**Note**

The fuel flow indicator does not indicate afterburner fuel flow.

When shutting the afterburner off, retard the throttle aft and inboard to the Military Thrust position (93% throttle setting in X-Plane).

8.12 Flight Characteristics

Refer to Flight Characteristics section in the manual.

8.13 Descent

Refer to Appendix for recommended descent technique and accomplish the following steps:

1. Engine/duct anti-ice and pitot heat - As desired.
2. Armament switches - OFF
3. Radar mode selector switch - As desired.
4. No.1 and No. 2 hydraulic system pressures - Check.
5. Shoulder harness lever - Locked.

8.14 Before Landing

The procedures set forth below will produce the results shown in the landing chart in Appendix.

**Note**

The airspeeds listed herein are based on a landing gross weight of 15,200 lbs. (1000 lbs fuel remaining). Increase approach and landing speeds 5 knots for each 1000 lbs of fuel remaining above 1000 lbs.

**INITIAL**

1. Wing flap lever - TAKE-OFF before pitch (check indicators).

**DOWNWIND**

1. Landing gear lever - DOWN below 260 knots IAS (check indicators).
2. Wing flap lever - LAND below 240 knots IAS and above 210 knots IAS (check indicators).

Maintain lever flight and keep hand on flap lever until it is determined that the flaps and BLC are functioning normally.

**Note**
A mild roll transient may be experienced on some aircraft as flaps move from TAKE-OFF to LAND position. This is attributed to asymmetric difference in boundary layer control systems and will vary in intensity and direction with individual aircraft but not exceed one inch of lateral stick displacement. After the flaps are in the full down position some lateral unbalance may persist. This unbalance can be trimmed out, if desired.

**BASE LEG TURN**

1. Landing gear down and locked - Check.
2. Anti-skid switch - ON.
3. Airspeed - 200 knots IAS minimum

**FINAL**

When on final approach, accomplish the following:

1. Roll out on final approach, minimum distance from end of runway - 6000 feet; recommended airspeed - 190 knots IAS.
2. Engine speed are required (approximately 87 - 90% rpm, but not less than 85% rpm).
3. Airspeed - 170 knots IAS recommended.

**Note**

The recommended final approach speed includes sufficient margin to cover most operating conditions such as turbulent air, minor landing weight variation, etc. This margin makes additional allowances for such factors unnecessary.

**WARNING**

Under various conditions of heavy gross weight or high ambient temperatures, with flaps in the land position, sufficient thrust may not be available at MILITARY to maintain proper rate of descent and airspeed during turn from downwind to final. Refer to Heavy Weight Landing in this section.

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**8.15 Landing**

**Video Tutorial**

**BOUNDARY LAYER CONTROL**

The installation of boundary layer control to effect low landing approach and touchdown speeds has resulted in some new flight characteristics and changes in required piloting technique. The pilot should remember, at all times, when using land flaps that the additional lift afforded by BLC is dependent on engine airflow. This lift, therefore varies with airspeed, altitude, and engine rpm. The greatest effect is realized at low airspeed, low altitude, and engine speeds above 83%, although some effectiveness is still retained at lower power settings. The significance of this is that under the landing condition, especially as touchdown is approached, proper use of the throttle is mandatory to accomplish a smooth reduction in engine rpm so that a smooth reduction in the effects of BLC on lift will result.

**LANDING TECHNIQUE**

The recommended landing pattern results in a flat powered approach similar to that used for ILS and Radar Approach patterns carrying approximately 88% rpm until touchdown is approached. A straight-in approach of 6000 feet minimum, is recommended to simplify the technique and judgement involved in the landing flare. The thrust should be controlled to hold airspeed and sink rate to the recommended values on the final approach. (Use of the recommended speeds provides ample speed margin from the back side of the power required curve). Airspeed response to throttle adjustments is extremely positive and rapid, aiding considerably in establishing a good approach. The high drag of the airplane in the landing configuration makes it unnecessary to use speed brakes in the landing pattern (especially on the approach). Speed brakes may be used during roundout to aid in controlling touchdown point. The approach should be maintained to establish a flare-out just short of the runway. As the touchdown point is approached, flare-out rotation should be started, followed by a smooth reduction in thrust to 82-83%. The gradual rpm reduction induces a right roll-off which is associated with the thrust reduction and BLC since a similar roll-off is experienced accompanying a thrust reduction with take-off flaps. An abrupt thrust reduction results in abrupt roll-off tendency and a rapid increase in sink rate. These characteristics make it necessary to approach touchdown carrying power, and to reduce power to idle as the main gear contacts the runway. The smooth thrust reduction reduces roll-off tendency thereby making it easy to maintain wings-level flight throughout the flare as well as provide positive control of rate of sink. It may seem unnatural to touchdown with more than idle thrust; however, with
the drag of the landing flaps, it is possible to slow down rapidly enough so that idle thrust need not be used. Adhere to recommended approach and touchdown speeds. If the aircraft is held of to lower speeds, lateral stability and control will deteriorate and wing drop tendencies will be experienced. In addition, the high pitch angle required for flight at these low airspeeds will be excessive and can result in tail dragging.

Illustration 14: Typical Landing Pattern

NORMAL LANDING

1. Throttle - Retard to IDLE (after touchdown).
2. Nose wheel - Lower
3. Nose wheel steering - Engage.
4. Drag chute - Deploy.

To obtain maximum aerodynamic braking, deploy drag chute as soon as nose wheel is on the ground.

CAUTION

- Because of its location, the drag chute will cause a nose down pitching moment when deployed, do not deploy the chute until all three gear are on the ground to prevent damage to the aircraft.
- High velocity exhaust gases can fail the drag chute canopy; therefore the drag chute should not be deployed at higher than idle rpm.

CROSS WIND LANDING

Wind drift may be compensated for by "crabbing" or the "wind down" method, or a combination of both. In strong crosswinds the "wing down" or a combination of the two is more suitable. The most important things to remember are the following: lower the nose immediately after touchdown, engage the nose wheel steering before deploying the drag chute. The drag chute may be deployed in 90 degree crosswinds of 20 knots or 45 degree crosswinds of 30 knots provided the nose wheel steering is engaged. The airplane tends to weather vane, but directional control can be maintained with nose wheel
steering. After landing, some difficulty may be encountered releasing the drag chute; however, turning the airplane directly into the wind should solve this problem.

**HEAVY WEIGHT LANDING**
When a heavy weight landing must be made, adjust the approach and touchdown airspeeds for gross weight. Refer to the landing charts in Appendix for the airspeed at any landing gross weight. Fly a larger than normal pattern or make a straight-in approach. This is especially important on approaches under hot and/or high altitude landing conditions. Rate of descent should be monitored closely and not allowed to become excessive. Be prepared to use afterburning thrust if necessary. Under marginal conditions, a straight in approach is recommended. In addition, minimize drag by using a take-off flap or gear up configuration for the approach, changing to the final landing configuration when landing is assured. If landing roll distance is a major consideration use land flaps to reduce the touchdown speed and delay gear extension until the flare is assured.

**WARNING**
Under these conditions, the afterburner will have to be used if a go-around is attempted after the landing gear has been extended.

**MINIMUM RUN LANDING**
For a landing with minimum ground roll, fly the approach so that close control can be exercised over touchdown point and airspeed. Land as near the end of the runway as possible, touching down at 140 knots for normal landing gross weight. Use the speed brakes to aid in controlling touchdown point and speed as well as for maximum drag during the rollout. Plan the chute deployment so that it blossoms as the nose wheel touches down. Smoothly apply anti-skid brakes with constantly increasing pedal pressure. If cycling occurs indicating maximum braking, pedal force should be reduced.

**Note**
Cycling of the anti-skid system can be detected by the change in longitudinal deceleration as braking action is automatically released and re-applied by the anti-skid system.

**LANDING ON SLIPPERY RUNWAYS**
Land on wet or icy runways using the same procedure as for a minimum run landing. Leave the flaps at LAND during the landing roll for maximum aerodynamic drag.

**TOUCH AND GO LANDINGS**
No special technique is required during touch and go landings.

After touchdown proceed as follow:

1. Flaps - TAKE-OFF.
2. Throttle - MILITARY.
3. Speed brakes - IN.
4. Use normal take-off technique
Illustration 15: Typical Go-around

Make decision to go-around as soon as possible and observe the following procedures:

1. Throttle - MILITARY (Maximum Thrust if necessary).

   **CAUTION**
   The available excess thrust to perform a go around varies with gross weight, airspeed airplane configuration, field elevation, and ambient temperature. As extremes of these variable are approached the ability to perform a successful go-around with Military Thrust decreases, thus requiring afterburning thrust. Refer to Appendix for illustrations and charts showing the variations in performance to expect with changes in these operating conditions.

2. Speed brake switch - IN.
3. Landing gear lever - UP. (When definitely airborne and rate of climb is established).
4. Wing flap lever - TAKE-OFF - at not less than 175 knots IAS.

   **Note**
   • Expect a definite nose-up trim change when raising the flaps to take-off.
   • It is desired to raise flaps from TAKE-OFF to UP do so at not less than 240 knots IAS.

   **WARNING**
When making a go-around, leave the wing flap lever in the TAKE-OFF position for 30 to 60 seconds. This action will cool the BLC ramp and keep the retracting flaps from pinching the ramp. Pinched BLC ramps can cause undesirable rolling moments when the BLC system is operating.

---

### 8.16 After Landing

Maintain directional control with nose wheel steering and brakes and proceed as follows:

1. Speed brake switch - OUT.
2. Wing flap lever - TAKE OFF - After 30 to 60 seconds, move flap lever to UP
3. Rain remover - OFF
4. Engine/duct anti-ice and pitot heat - OFF
5. Drag chute - Jettison in appropriate area.

**Note**

If armament is carried, proceed to designated area for replacement of armament safety pins.

---

### 8.17 Engine Shut Down

1. Electrical Equipment - OFF
   - Put radar into Standby mode if on, then to off
   - INS should be set to the standby mode and then off
2. Run engine at three minutes at IDLE for proper engine cooling (taxi time can be included in idle time)
3. Speed brakes open - Check.
4. Throttle - OFF (Use throttle Idle/Cutoff function key as defined in Plugins-CF-104 Systems-Joystick Config menu).

**Note**

• Check that engine decelerates freely. Listen for any excessive noise during shut down.  
• Check speed brake closure.

---

### 8.18 Before Leaving Airplane

1. Ejection seat safety pin - Installed.
2. Oxygen lines - Capped and stowed.
3. Wheels - Chocked.

**CAUTION**

In addition to established requirements for reporting any system defects, unusual and excessive operations, the pilot will also make entries in appropriate form to indicate when any limits in the Aircraft Operating Instructions have been exceeded.
9. Emergency Procedures

NOTE: Procedures highlighted in GREEN are available in X-Plane. All others have no effect in the sim or are listed for informational purposes.

Video Tutorials Included in this section (more to come):

9.1 Engine Failure

Engine failure is defined as a complete power failure which, in the pilot's judgement, makes it impossible or inadvisable to attempt a new start. Examples are engine seizure, explosion, etc.

ENGINE FAILURE DURING TAKE-OFF RUN

If engine failure occurs before airplane leaves ground:

1. Abort take-off.

Refer to Abort Procedure under Take-Off and Landing Emergencies in this section.

ENGINE FAILURE DURING TAKE-OFF (AIRPLANE AIRBORNE)

Abandon the aircraft rather than land on an unprepared surface.

Note

If a decision to eject is made, the aircraft should be allowed to climb as far as possible. Ejection should be accomplished while the nose of the airplane is above the horizon but prior to reaching a stall or sink.

ENGINE FAILURE DURING FLIGHT (NO RELIGHT)

If a complete loss of thrust occurs and an airstart is impossible or inadvisable, proceed as follows:

1. Throttle - OFF.
2. Ram-air turbine extension handle - PULL.
3. Wing flap lever - TAKE-OFF.
4. Glide speed - Reduce to 245 knots IAS.
5. IFF - EMERGENCY
7. Eject or attempt forced landing.

ENGINE AIR START

Note

The hydraulic generator will remain operative to energize the primary fixed frequency bus if windmill rpm is in excess of approximately 20%. This will give the pilot fuel flow indication during an air start attempt.

If a flameout has been experienced, an airstart may be made using the following procedure:
1. Both start switches - START (hold momentarily)

   Monitor engine instruments for immediate relight if engine rpm is still high.

2. If immediate re-light is not obtained, throttle - positively OFF, then immediately move to MILITARY.
3. Establish glide speed - 275 knots IAS.

   While establishing best glide speed, the aircraft should be headed toward the nearest suitable landing field.

4. If no air start occurs within 20 seconds, both start switches - START.

   Do not move throttle to OFF again before this second actuation of the start switches.

5. Ram-air turbine extension handle - PULL

   **Note**

   Do not extend the RAT above 35,000 feet as chances of obtaining normal engine operation are remote and the increased drag will reduce glide distance.

   6. Wing flap lever - TAKE-OFF.

   7. Glide speed - Reduce to 245 knots IAS.

   **Note**

   With the RAT extended, the same glide distance may be realized at 245 knots IAS and TAKE-OFF flaps as with 275 knots IAS and no flaps. However, the slower speed will result in a lower rate of descent.

   If time and altitude permit:

   8. Start switches - START.

   If re-light is successful:

   9. Throttle - Adjust as required.

   Allow engine instruments to stabilize and adjust throttle to settings necessary for flight. Engine instruments will give the most reliable indication of a re-light. If re-light is unsuccessful decide whether to attempt forced landing or eject.

   **Below 15,000 feet**

   1. Throttle - Immediately to IDLE, outboard and positively OFF.

   2. Both start switches - START.

   3. RPM - 70% or below.

   4. Throttle - MILITARY

   5. Monitor rpm to 100%. Land as soon as possible. Do not decrease rpm below 97% until landing is assured.

   6. If rpm stops at 94%, a cold shift has occurred. Land as soon as possible, adjusting pattern for maximum rpm of 94%.

   **Note**

   • Thrust will be equal to, or greater than, that obtained at 94% under normal conditions.

   • Throttle may be manipulated throughout the entire IDLE to Military range. Afterburner operation may be initiated for emergency use if CIT indicates +38 degC or less.

   **Above 15,000 feet**

   **Note**

   Any of the following procedures may clear the engine stall and all procedures need not be accomplished in the event the stall clears.
1. Throttle - MILITARY
2. Throttle - IDLE; check for abnormal EGT and rpm for possible hangup
3. Throttle - OFF.
4. Engine airstart procedure.
5. If stall still exists at 15,000 feet, use the procedure for clearing stall below 15,000 feet.

MAXIMUM GLIDE

Windmilling or Frozen Engine

Illustration 16: Glide Distance Chart shows the glide distance obtainable with a windmilling or frozen engine. The recommended configuration is with take-off flaps and 245 knots IAS. The same distance can be obtained by gliding with flaps up at 275 knots; however, the rate of descent with take-off flaps is approximately 1000 feet per minute less due to the lower speed for the same glide ratio. In addition, no change in configuration or speed is required when the flame-out landing pattern is entered. The data shown in the chart are for RAT extended since this configuration represents the highest drag and is necessary for flap extension under any engine inoperative condition and for hydraulic power under a frozen-engine condition. Gliding without the RAT extended would increase these distances approximately 2 nautical miles per 10,000 feet of altitude.

Note
Unless the engine is damaged, the windmilling engine speed will produce sufficient hydraulic pressure to operate the flight control system.
EJECTION VS. FORCED LANDING

Because of the many variables encountered, the final decision to attempt a flame-out landing or to eject must remain with the pilot. These variables make a quick and accurate decision difficult. Furthermore, it is impossible to establish a predetermined set of rules and instructions which would provide a ready made decision applicable to all emergencies of this nature because unique circumstances will be associated with each emergency. However, certain basic conditions as listed below, must exist before attempting a flame-out landing. Otherwise, ejection is the best course of action.

1. Flame-out landings should only be attempted by pilots who have satisfactorily completed simulated flame-out approaches in this aircraft.
2. Flame-out landings should only be attempted on prepared or designated suitable surfaces that provide at least twice the landing distance normally required.
3. Approaches to the landing field must be unrestricted (clear areas of approximately 3000 to 5000 feet in length). No attempt should be made to force-land in a heavily populated area.
4. Weather and terrain conditions must be favorable. Night landings should never be attempted.
5. Flame-out landings should only be attempted when either a satisfactory High Key or Low Key position can be achieved.
6. If at any time during the flame-out approach conditions do not appear ideal for successful completion of the landing, eject. Eject no lower that the Low Key altitude.

All of the above basic conditions, combined with the pilot's analysis of the condition of the aircraft, type of emergency, and his proficiency, are of a prime importance in determining whether to attempt a flame-out landing or to eject.

Note

If a decision to eject is made, the pilot should first attempt to turn the aircraft toward an area where injury or damage to persons or property on the ground or ware is least likely to occur.

FORCED LANDING

The recommended procedures for making a forced landing are set forth in Figure 8-2. The 360 degree overhead pattern offers the most accurate control of the touch-down point and should be utilized when possible. However, since it may not be possible to enter the pattern at the High Key point in all cases, conditions should be practiced with pattern entry at any point up to the Low Key point to develop technique and proficiency for these cases as well as the ideal situation.
Simulated forced landings and/or precautionary landing patterns may be accomplished by using the following configuration.

<table>
<thead>
<tr>
<th></th>
<th>Simulated</th>
<th>Precautionary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Throttle</td>
<td>83% rpm</td>
<td>83% rpm</td>
</tr>
<tr>
<td>2. Speed brakes</td>
<td>IN</td>
<td>OUT</td>
</tr>
<tr>
<td>3. Landing gear</td>
<td>DOWN</td>
<td>UP</td>
</tr>
<tr>
<td>4. Flaps</td>
<td>TAKE-OFF</td>
<td>TAKE-OFF</td>
</tr>
<tr>
<td>5. Ram-air turbine</td>
<td>IN</td>
<td>As required</td>
</tr>
<tr>
<td>6. Indicated airspeed</td>
<td>245 Knots</td>
<td>245 Knots</td>
</tr>
</tbody>
</table>

These configurations produce the approximate drag that occurs during a dead engine descent with take-off flaps and RAT extended and gear retracted. It is recommended that practice glides and flame-out patterns be made using only the simulated configuration so that the additional safety of having the landing gear extended during the flare can be realized. Simulation of the drag produced by landing gear extension during the flare may be made by opening the speed brakes. The precautionary pattern should be used only during an actual emergency wherein loss of thrust is possible. If it is desired to simulate a glide to the flameout pattern with flaps up, gear up, and RAT retracted; glide at 275 knots IAS and 87% rpm with the speed brakes fully extended.
9.2 Fire

ENGINE FIRE DURING START

Illumination of the fire warning lights or other evidence of fire during engine starting is an indication of a broken or disconnected fuel line. If this condition occurs proceed as follows:

1. Throttle - OFF.
2. Start switches - STOP START.
3. Fuel shut-off switch - OFF.
4. Abandon aircraft as quickly as possible.
5. If conditions permit, have ground electrical power source disconnected.

ENGINE FIRE DURING TAKE-OFF

Not yet modeled in sim.

ENGINE FIRE DURING FLIGHT

Fire Confirmed During Flight

1. Eject

Fire Warning Light Illuminates During Flight

1. Throttle - IDLE.
2. If the fire warning light remains illuminated at IDLE, throttle - OFF.
3. Head toward nearest suitable aerodrome - 275 knots IAS.
4. If light remains ON - Eject.
5. Light out, throttle on or off - Check for fire as follows:

• Warning light - TEST
• Light does not illuminate - Eject.
• Light illuminates and no signs of fire exist, make decision to eject or land as soon as possible. Fire may be confirmed be a report from the ground, other aircraft, engine instruments, smoke in the cockpit or visible smoke trail behind the aircraft.

ENGINE FIRE AFTER SHUTDOWN

Not yet modeled in sim.

ELECTRICAL FIRE

Not yet modeled in sim.

ELIMINATION OF SMOKE OR FUMES

Not yet modeled in sim.

9.3 Ejection

EJECTION ATTITUDES

Whenever possible, ejection should be accomplished with the aircraft in a climb attitude. This will provide the most time under any circumstances for seat separation and parachute deployment.

EJECTION ALTITUDES

While the ejection system will permit successful ejections at zero altitudes above 120 knots IAS, it is advantageous when flying at very low altitudes and if circumstances permit to zoom the aircraft and exchange excess airspeed for altitude, before ejecting.
EJECTION SPEED

Eject at the lowest practical airspeed above 120 knots IAS. Below 120 knots IAS, airflow is not sufficient to assure rapid parachute deployment. Therefore, it becomes extremely important during low altitude ejection to obtain at least 120 knots IAS, if possible, to assure complete parachute deployment at the greatest height above the terrain. During high altitude ejection, observing this minimum airspeed (120 knots IAS) becomes less important since there is adequate time for chute deployment. If the aircraft is controllable, aircraft speed should be reduced to as low as practical. Wind blast will exert minor forces on the body up to 400 knots; appreciable forces from 400 to 550 knots; and excessive forces above 550 knots.

9.4 Take-off & Landing Emergencies

All landing emergencies involving landing on prepared or unprepared surfaces should be made with the landing gear extended. The extended gear, even on reasonably rough terrain provides an absorption of the initial shock resulting in less injury to the pilot and damage to the aircraft.

**Note**

These instructions also apply in those cases in which the runway is overshot or undershot and touchdown cannot be avoided.

**WARNING**

Whenever there is a possibility of structural distortion which could cause the canopy to be jammed in the closed position, the canopy should be jettisoned.

ABORT PROCEDURE

Abortor Hook Operation

**Note**

Nosewheel steering and power brakes become inoperative when throttle is retarded to OFF.
1. Throttle - IDLE, or OFF (as necessary).
3. Drag chute - Deploy.
5. Hook - Release. (Note **Clear Failures** option from **CF-104 Flight Preparation** menu must be used to raise the hook back. It could not be raised from inside the cockpit.
6. External fuel tanks - Jettison. (Retain tanks if empty.)
7. Aim for center of barrier.
9. Canopy jettison handle - As desired.

### Runway Overrun Barrier

1. Throttle - IDLE, or OFF (as necessary).
3. Drag chute - Deploy.
5. External fuel tanks - Jettison. (Retain tanks if empty.)
6. Aim for center of barrier.
8. Canopy jettison handle - As desired.

### MAIN GEAR TIRE FAILURE ON TAKE-OFF

The following procedure is recommended when a main gear tire fails during the take-off run. This recommended technique applies to all gross weights and airplane configurations. Directional control of the airplane is naturally more difficult at the higher gross weights.

1. If the speed is less than 150 knots IAS, abort take-off. Refer to abort procedure above.
2. If speed is greater than 150 knots, but below nose wheel lift-off speed, jettison external stores and continue take-off.
3. If nose wheel lift-off speed has been attained, external stores should be retained and take-off continued.

**WARNING**

If take-off is continued, the landing gear should not be retracted if the tire has failed or is suspected to have failed, until the tire has been visually checked for fire by a report from another plane or the tower. After the tire is checked and if the gear is to be retracted, the wheel brakes should be applied with the anti-skid switch OFF to stop wheel rotation before retraction to prevent tire fragments from damaging equipment in the wheel well. Landing should be made in accordance with the instructions in **Main Gear Flat Tire Landing** in this section.

### NOSE GEAR TIRE FAILURE ON TAKE-OFF

1. If speed and runway permit - Abort. Refer to abort procedure above.
2. If committed to take-off, continue climb at maximum afterburner.
3. Remain in full afterburner and climb to safe altitude for a precautionary pattern.

**Note**

Engine may sustain damage from foreign objects.

4. Land as soon as possible using precautionary pattern.

### BELLY LANDING

Successful belly landings have been made on prepared surfaces. Abandon the aircraft rather than attempt a belly landing on an unprepared surface. If a gear-up landing is unavoidable proceed as follows:

1. External stores - Jettison.

**Jettison external stores in appropriate area:** retain tip and pylon tanks if they are empty.

2. Rudder limit control circuit breaker - Pull.
3. Make normal pattern.

Make normal pattern with landing gear lever UP and landing flaps extended.
4. Make flat approach.
5. Throttle - OFF at touchdown.
6. Drag chute - Deploy.
7. Fuel shut-off switch - OFF.

**NOSE GEAR FLAT TIRE LANDING**
If landing with a flat nose gear tire, proceed as follows:

1. Nose gear - Hold off.

Hold the nose wheel off as long as practical, the lower gently to runway.

2. Drag chute - Deploy after nose wheel contacts runway.

*Do not deploy the drag chute until nose wheel is on the ground because of the nose down pitching moment which occurs when the drag chute inflates.*

**MAIN GEAR FLAT TIRE LANDING**

1. Touch down on good tire,

Touch down on the side of the runway away from the flat tire.

2. Nose wheel - Lower.
3. Nose wheel steering - Engage.
4. Drag chute - Deploy.

**ASYMMETRIC TIP TANK FUEL LOAD LANDING**
Adequate control is available for landing with one tip tank full and one tank empty under smooth air conditions; however, consideration should be given to the added aileron requirements under strong or gusty cross-wind conditions before attempting a landing with an asymmetric fuel load. A crosswind from the side with the light tank increases the aileron requirements in the same direction as used to balance the heavy tank. It is recommended that low speed control be evaluated prior to entering the landing pattern. If the lateral control appears marginal for the existing landing condition, the tanks should be jettisoned.

**PARTIAL GEAR LANDING**

**Landing With Nose Gear Retracted**

1. Make normal landing.
2. Lower nose at minimum of 110 knots.

*Note*

If necessary, light braking action may be used with nose held off.

3. Throttle - OFF.
4. Fuel shut-off switch - OFF.
5. Drag chute - Deploy after nose contacts runway,
6. Apply brakes, using differential braking to maintain directional control.

**Landing with One Main Gear Up or Unlocked**
If one main gear remains up or in an intermediate position, after all procedures to extend have failed, elect to eject or land. (Refer to Landing Gear Emergency Extension paragraph in this section for gear extension procedures.) It is recommended that a decision to land be based on the availability of a long, wide runway with an adjoining unobstructed runout area; the condition of surface and area adjacent to runway, the weather conditions, etc. To land, proceed as follows:

1. External stores - Jettison (if required).

Retain empty tip and pylon tanks to absorb initial shock.

*Note*
If time and conditions permit, fire all ammunition and burn excess fuel to lighten airplane and to minimize fire hazard.


Ensure seat belt and harness are tight.

3. Canopy - Jettison.

**Note**
- The canopy should be jettisoned prior to landing if it has been determined by ground or air check that a gear is up or in an intermediate position.
- Before jettisoning the canopy, place helmet visor in the down position.

4. Make normal approach and landing.

Touch down on the side of the runway away from the failed gear, bring throttle to IDLE, engage nose wheel steering after nosewheel is on the ground, and deploy drag chute.

**CAUTION**
Do not deploy drag chute in excess of 200 knots IAS or at engine speeds above IDLE rpm.

5. Hold faulty gear off as long as possible.

6. Brakes - As required.

Use nosewheel steering and brakes to control direction of aircraft.

**CAUTION**
Anti-skid brakes will not be available after the manual landing gear release handle has been used. Required brake pedal pressure will be greater than normal to effect braking.

7. Throttle - OFF, after nosewheel steering system is no longer effective.

8. Fuel shut-off switch - OFF.

**BOUNDARY LAYER CONTROL SYSTEM MALFUNCTION**
If a boundary layer control system malfunction is experienced, as manifested by a strong rolling moment as the wings flaps travel to the LAND position, proceed as follows:

1. Immediately return the wing flap lever to TAKE-OFF.
2. Throttle - Adjust to minimum safe setting to reduce the effect of asymmetric BLC.
3. Fly final approach at not less than 195 knots IAS with takeoff flaps.
4. Touchdown at 165 knots IAS.

**NO-FLAP LANDING**
Because of the high approach and touchdown speeds required to accomplish a no-flap landing, it is recommended that the following instructions be observed.

**Note**
All of the following speeds are based on a landing gross weight of approximately 15,000 lbs. which includes 1000 lbs. fuel remaining. Increase approach and touchdown speeds 5 knots for each additional 1000 lbs. of airplane weight.

**Trailing Edge Flap Failure**
If the trailing edge flaps fail to extend (regardless of the position of the position of the leading edge flaps) the following procedure is recommended

1. Wing flap lever - UP.
2. Recommended runway length - 10,000 feet.

**Note**
A runway length of 10,000 feet is recommended as an added safety precaution in event of brake or drag chute failure.

5. Make flat approach.

A flat approach will decrease required rotation for flare.

**Note**
Airframe buffeting will be experienced as speed is reduced and/or G-load is increased.

6. Touchdown speed - 195 knots IAS minimum.
7. Lower nose, retard throttle to IDLE, and deploy drag chute immediately.

**Leading Edge Flap Failure Only**

1. If only the leading edge flaps fail and the trailing edge flaps can be lowered to the LAND position thereby making boundary layer control available, normal pattern and touchdown speeds can be used.
2. If trailing edge flaps can be extended only to the take-off position, fly final approach at not less than 195 knots IAS and touchdown at not less than 165 knots IAS.

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**9.5 Ditching**

Ditch only as a last resort as the nose section of the fuselage may break off. Also the airplane will probably sink quite rapidly. All emergency survival equipment is carried by the pilot, consequently, there is not advantage to riding the plane down.

---

**9.6 External Stores Jettison**

To jettison the external stores during an emergency, use the following procedure:

1. External store jettison button - Depress. (This button is directly above the two engine start switches)

Depressing the external stores jettison button jettisons pylon and tip stores and tanks.

**Note**

- Refer to the section 10.7 Weapon Systems for normal method of jettisoning external stores.

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**9.7 Afterburner Failure**

**9.7.1 Loss of Afterburner During Takeoff**

If the Afterburner fails during take-off:

1. Abort if speed and runway permit.

Refer to Abort Procedures in this section.

If committed to take-off, proceed as follows:

1. Throttle - MILITARY.
2. Continue take-off at Military Thrust.
WARNING

• Afterburner failure during take-off roll, when past refusal point and committed to take-off, becomes particularly critical under conditions of heavy gross weight or high runway temperatures, or a combination of these conditions. Under extreme circumstances, aircraft may not become airborne with Military thrust unless gross weight is reduced. If the pilot is faced with this emergency situation, and has any doubt whatsoever regarding capability to become safely airborne at Military thrust, he should immediately jettison external stores.

• If afterburner thrust becomes necessary, do not advance the throttle beyond the minimum afterburner position until a positive light is obtained. Thrust available above minimum afterburner throttle position it less than MILITARY if afterburner light does not occur.

9.7.2 Afterburner Surge

Afterburner surge can easily be detected by a feel of instability and EGT gauge and nozzle position indicator oscillation. If afterburner surging occurs, proceed as follows:

1. Throttle - MILITARY.

Move the the throttle out of the afterburner range as soon as possible, preferably before more than 2 cycles of surge. This action is necessary to prevent compressor stall and possible engine flame-out.

2. Throttle - Afterburner range.

Note

Afterburner surge normally occurs around the switchover point; an attempt should be made to select afterburner operation below or above this point.

3. If afterburner surging continues, throttle - MILITARY.

Avoid using afterburner.

9.8 Exhaust Nozzle Control System Failure

The following procedures are recommended in event of exhaust nozzle control system failure. (Read in conjunction with Engine Oil Level Low Warning Light procedures in this section.

Note

Under any of the following conditions, subsequent landing should be made with flaps at TAKE-OFF position. Also, landing gear should not be extended until on final approach and landing is assured.

9.8.1 Nozzle Fails to Wide Open Position

Non-Afterburning:

• Most critical failure because of significant thrust decrease. Also reduction in EGT will be observed.
• Sufficient thrust is not available to maintain level flight with any configuration or airspeed at take-off gross weights.
• At normal gross weight, level flight cannot be maintained at any speed if gear or land flaps are extended or external stores are carried.
• Level flight can be maintained up to 3500 feet in the clean configuration at 300 knots IAS with normal landing gross weight, for standard day or cooler temperatures.
• At higher than standard day temperatures, it is highly improbably that level flight can be maintained at normal landing gross weight in either the clean configuration or with TAKE-OFF flaps extended.

Afterburning:

• Indicated by a slight reduction in thrust and EGT, and in increase in nozzle area.
• Failure will probably not be detected by the pilot.
• Afterburner will continue to operate provided throttle is not retarded to sector range.
• As long as afterburning is maintained, immediate corrective action is not required.

**WARNING**

If afterburning is being used, maintain afterburning operation until a safe position is established to accomplish the emergency procedures.

If Nozzle Fails to Open Position During Take-Off (Take-Off Not Committed)

1. Abort.

Afterburner Take-Off, Take-Off Committed

1. Maintain full afterburner and attain safe altitude.
2. Carry out Nozzle Fails Open During Flight procedure.

If Nozzle Fails to Open Position During Military Thrust Take-Off.

2. External stores - Jettison.
3. Zoom.
4. Check for nozzle closure and monitor EGT.
5. Land as soon as possible from a precautionary approach.

If Nozzle Fails to Open Position During Flight

**WARNING**

Prior to afterburner shutdown, determine if nozzle control is available by retarding throttle slowly in afterburner range and check if nozzle is closing. If nozzle is not closing, momentarily place exhaust nozzle control switch to MANUAL and return to AUTO. Proper functioning of the control system will be indicated by sharp rise in EGT. Extreme caution must be used when actuating the switch because a severe overtemperature condition will result if nozzle is allowed to close fully while in afterburning.

If switch controls nozzle position, procede with the following procedures. If switch does not control nozzle position, establish position from which a safe landing may be made with open nozzle.

1. Throttle - MILITARY.
3. Check for nozzle closure and monitor EGT.
4. Establish precautionary landing pattern to ensure safe landing in case nozzle re-opens.
5. If failure occurs during landing pattern, reduce drag by doing the following:
   • Speed brakes - In.
   • Landing gear - Up.
   • Flaps - TAKE-OFF.
   • External stores - Jettison.

If Nozzle Fails to the Mechanical Schedule Position

1. Afterburner - OFF.
2. EGT - monitor.
3. Exhaust nozzle control switch - MANUAL.

If Severe Nozzle Fluctuations Occur

1. Establish safe altitude.
2. Throttle - Retard to just below temperature modulating range - (approximately 570 deg C).
3. If nozzle does not stabilize - Switch to MANUAL.
4. EGT - monitor.

If Exhaust Nozzle Fails to Close When Exhaust Nozzle Control Switch is in Manual Position

1. Throttle - Advance rapidly to maximum thrust.
2. If afterburner light is obtained, exhaust nozzle control switch - AUTO.
3. Obtain desired altitude and airspeed.
4. If afterburner fails to light - Carry out Nozzle Fails Open During Flight procedure.
5. Land as soon as possible from a precautionary approach.

Note
An afterburner light with a wide-open nozzle at low indicated airspeed (such as in the take-off or landing patterns) is not certain, but possible. A 3 to 5 second delay may occur before afterburner light is obtained. If an afterburner light is not obtained, leaving the throttle in the afterburner range will not adversely affect engine operation and will reduce fuel load.

9.9 Oil System Failure

In general if an oil system malfunction (as evidenced by high or low oil pressure) has caused prolonged oil starvation of engine bearings, the results will be a progressive bearing failure and subsequent engine seizure. The time interval from the moment of oil starvation to complete failure depends on such factors as: condition of bearings prior to oil starvation, operating temperatures of bearings, and bearing loads. Bearing failure due to oil starvation is generally characterized by a rapidly increasing vibration. When the vibration becomes moderate to heavy, complete failure is only seconds away and in most instances the pilot will increase his chances for a successful ejection or power-off landing by shutting down the engine. For oil system failure during take-off, follow Abort Procedure in this section.

Note
A decrease in oil pressure may indicate an oil loss to the engine which will lead eventually to a complete loss of oil to the bearings.

The engine will operate with a complete stoppage of oil to the engine for a period of at least 1 minute at Military Thrust before engine seizure. Limited experience has indicated the engine should operate for a period of 4 to 5 minutes at 80% to 90% rpm before a complete failure occurs. In view of the above, the following operating procedures shall be observed for oil pressure changes:

1. Reduce rpm to 86% - 89%.

Reduce thrust to that necessary to maintain safe altitude and level flight (86% to 89% for a clean airplane.)

**WARNING**

Loss of engine oil (as indicated by the ENGINE OIL LEVEL LOW warning light) will also result in loss of exhaust nozzle control. The resulting loss of thrust with the nozzle in the open position may be as much as 70% at 100% rpm. Refer to Exhaust Nozzle Control System Failure in this section.

2. External stores - Jettison (if necessary).

Jettison external stores if necessary to maintain safe altitude and level flight. Retain external tanks if safe level flight can be maintained and fuel is needed.

3. Avoid abrupt maneuvers causing high G forces.

4. Avoid rapid and large throttle movements. Hold throttle changes to a minimum.

**Note**

High thrust setting should be avoided if at all possible in order to keep temperature and bearing loads at a minimum. Upon detection of an oil system malfunction (as evidenced by the oil pressure gauge) a minimum thrust setting should be established depending on aircraft configuration, gross weight and altitude. This setting should be sufficient to maintain level flight and allow for safe approach maneuvers (subsequent throttle movements should be avoided if possible). However, if the malfunction has gone unnoticed and has progressed to the point where bearing failure has started, as evidenced by vibration, the throttle should not be retarded. If the throttle is retarded, the resistance to rotation offered by one or more failing bearings may cause further deceleration and complete engine seizure in a very short time.

**WARNING**

Increasing vibration is an indication of a bearing failure. Extreme vibration, usually accompanied by a rise in EGT, indicates engine seizure will occur within a few seconds. The throttle should be cut off to prevent excessive damage to the engine, resulting in possible damage to the aircraft structure.
5. Land as soon as possible using a precautionary pattern to insure a safe landing in the event of engine failure.
6. Throttle - OFF at touchdown.

**Engine Oil Level Low Warning Light**

Illumination of the ENGINE OIL LEVEL LOW warning light indicates that the oil quantity is down to a reserve of approximately 0.7 Imp. gallons and that the exhaust nozzle can be expected to fail to the open position. If the oil loss is due to a leak in the engine hydraulic system, sufficient reserve oil will be available to lubricate the engine for approximately 2 hours. However, if the loss of oil is due to a leak in the lubricating system, as indicated by a drop in oil pressure, a rapid engine bearing failure will occur. Refer to Oil System Failure in this section. In view of the above, proceed as follows:

1. If light illuminates prior to take-off - Abort the flight.
2. If light illuminates during takeoff and sufficient runway remains - Abort.
3. If the light illuminate in flight, land as soon as possible using a precautionary pattern to insure a safe landing. Depending on the oil pressure indications, use one of the following procedures:
   - If light illuminates without an oil pressure drop - Follow procedure for Exhaust Nozzle Control System Failure.
   - If light illuminates with an oil pressure drop - Follow procedure for Oil System Failure.

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**9.10 Fuel System Failure**

**EXTERNAL FUEL TRANSFER FAILURE**

**Pylon Tanks Not Feeding**

1. Air refuel switch - OFF.
2. Pull external tank fuel transfer circuit breaker.
3. Reset circuit breaker after pylon tanks are empty.
4. If malfunction is not corrected - Jettison pylons using the selective jettison system described here: [10.7.1 Jettisoning Ordnance and Weapons in Manual Bombing Mode](#).

**Tip Tanks Not Feeding**

1. Air refuel switch - OFF.
2. Pull external tank fuel transfer circuit breaker.
3. Reset circuit breaker after tanks are empty.

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**9.11 Electrical System Failures**

See [10.5 Electrical System](#) section in manual for more information on the Electrical System.

**GENERATOR FAILURE**

If generator failure occurs, accomplish the following as applicable:

**NO. 1 or NO. 2 GENERATOR OUT**

If No.1 or No.2 generator-out warning light illuminates:

1. Move corresponding generator switch to ON-RESET and release when light is out (2 - 3 seconds).

This will restore generator to service if failure was caused by momentary overvoltage.
NO.1 and NO. 2 GENERATOR OUT

If both No. 1 and No. 2 generators fail as evidenced by failure of all electrical equipment except that powered by the primary fixed frequency bus and the batteries, proceed as follows:

1. No. 1 generator switch - ON-RESET position until light is out (2 - 3 seconds).
2. No. 2 generator switch - ON-RESET position until light is out (2 - 3 seconds).
3. If generator operation is not restored and electrical power is required - Extend RAT.

Refer to Flight with RAT Extended in this section.

4. Land as soon as possible.

Note
If both No. 1 and No. 2 generators and the RAT-driven generator become inoperable, the batteries will last approximately 30 minutes, therefore, a landing should be made as soon as possible.

HYDRAULIC GENERATOR FAILURE

If the INST ON EMER POWER warning light illuminates, the hydraulic generator has failed. A relay then closes which connects variable-frequency power from the emergency ac bus to both fixed-frequency ac busses.

Fixed-frequency-power flight instruments operate adequately on variable-frequency, however, the radar system will be inoperative without primary dc power.

PRIMARY DC BUS FAILURE

If the primary dc bus fails as indicated by illumination of the primary dc bus out warning light, a landing should be made as soon as possible. Refer to the Electrical System Diagram Illustration 20: Electrical System Schematic for those systems rendered inoperable when the primary dc bus fails.

9.12 Hydraulic System Failure

NO. 1 SYSTEM OUT

If the No. 1 hydraulic system fails as indicated by the HYD SYSTEM OUT and AUTO-PITCH OUT warning lights, proceed as follows:

1. Monitor No.2 pressure for remainder of flight.
2. Land as soon as possible. Failure of the No. 1 hydraulic system will causes the yaw damper to become inoperative.

NO. 2 SYSTEM OUT

WARNING
Close speed brakes if a hydraulic failure is imminent. Without No. 2 hydraulic system pressure, the speed brakes cannot be closed.

Failure of the No. 2 system will render the pitch and roll dampers inoperative in addition to those items operated by the utility hydraulic system. If a No. 2 system failure is experienced as indicated by the illumination of the HYD. SYSTEM OUT warning light, proceed as follows:

1. Monitor No. 1 pressure for remainder of flight.
2. Land as soon as possible. Extend gear with the manual landing gear release handle.

Note
Nosewheel steering and anti-skid brakes are inoperative with No. 2 system out.
CAUTION

If the No. 2 hydraulic system fails or fluctuates do not use nose wheel steering. Use of nose wheel steering under these conditions allows air to enter the system causing violent shimmy action with possible substantial damage.

BOTH NO. 1 AND NO. 2 SYSTEMS OUT

WARNING

Close speed brakes if a hydraulic failure is imminent. Without No. 2 hydraulic system pressure, the speed brakes cannot be closed.

1. Ram-air turbine extension handle - Pull (above minimum recommended airspeed).
   (Refer to Flight with RAT Extended in this section.)
2. Monitor No. 1 hydraulic system pressure gauge.
3. If pressure builds up, land as soon as possible. Continue to monitor pressure and extend landing gear with manual release handle.

Note

Maximum hydraulic flow available under these conditions is reduced, however, it is sufficiently high for safe flight and moderate maneuvers necessary for landing.

4. If pressure fails to increase sufficiently for adequate flight control response - Eject.

9.13 Flight With RAT Extended

The ram-air turbine is available for emergency electrical and hydraulic power when the engine-driven power sources are lost. Extension of the RAT with the engine running can under certain conditions adversely affect engine operation. Because several inadvertent RAT extensions have been experienced, an operating envelope with the engine running and the RAT extended is provided below.

NOTE: In X-Plane the only aerodynamic effect modeled so far with the RAT extended is a strong right roll tendency at low airspeeds.

1. The RAT can be extended in level flight without affecting engine operation at any speed up to 550 KIAS, except as follows:
   - At 40,000 feet and above - 350 KIAS minimum.
   - At 35,000 feet - 325 KIAS minimum.
   - At 30,000 feet and below - No minimum limit
2. Normal airstarts with the RAT extended can be made at all altitudes up to 35,000 feet.
3. Maneuverability is satisfactory with the No. 1 and No. 2 hydraulic pumps inoperative with the RAT supplying hydraulic pump power up to 500 KIAS.
4. Spiral climbs and descents can be made without affecting normal engine operation or airplane maneuverability.
5. Best range with the RAT extended and 3,000 lbs of fuel remaining is realized by cruising at M 0.82 at 27,000 feet. Range will be approximately 170 nautical miles per 1000 lbs of fuel used.
6. Factors such as G's, yaw, abrupt maneuvers, or rapid throttle movements may induce engine instability, stalls, or flame-outs with the RAT extended, especially above 30,000 feet. Below 30,000 feet, 45 degree banks do not affect engine operation.

Deploy the ram-air turbine only for:

1. Double hydraulic failure.
2. Double electrical failure.
3. Flame-out landing.
5. Dead engine descent in weather.

**Note**
If a flame-out or engine stall occurs when the RAT is extended, accomplish normal air-start or stall-clearing procedures.

When flying with the RAT extended, avoid abrupt or uncoordinated maneuvers and move throttle slowly and only when necessary. Land as soon as practical and use thrust as required.

**Note**
The leading and trailing edge flaps are sequenced to extend separately to the TAKE-OFF position only when using ram air turbine driven generator for electrical power. Therefore, the LAND or UP position should never be selected under this condition as it may stall the generator. Keep airspeed above 200 KIAS until flaps have reached TAKE-OFF position. (The wing flap position indicator will be inoperative.)

---

### 9.18 Landing Gear Emergency Operation

**LANDING GEAR LEVER MALFUNCTION**
If the landing gear lever will not move to the UP position when airborne, proceed as follows:

1. Reduce airspeed.

Keep airspeed below transient landing gear structural limit.

2. Landing gear lever override button - Depress.
3. Landing gear lever - UP.

**LANDING GEAR RETRACTION FAILURE**
If the landing gear warning light remains on after the lever has been placed in the UP position, proceed as follows:

1. Reduce airspeed.

Keep the airspeed below the transient landing gear structural limits. Use speed brakes if necessary.

2. Recycle gear at lowest practical airspeed.
3. If warning light remains on, lower gear and land.

**LANDING GEAR EMERGENCY EXTENSION**
If the landing gear indicators do not show gear down and locked after lever is placed in the DOWN position, keep airspeed below transient landing gear structural limit and proceed as follows:

1. Recycle gear.
2. If gear does not lock down; leave gear lever down and pull manual landing gear release handle.

**CAUTION**
The landing gear cannot be retracted in flight after being lowered by means of the manual landing gear release handle.
10. Aircraft Systems

10.1 Engine

Throttle Control and Nozzle Position:

The throttle control for this add-on works a bit differently than for default X-Plane aircraft. The Starfighter has a multi-stage afterburner with variable thrust throughout the afterburner range. You will notice in X-Plane that the afterburner turns on when the throttle is at about 90% towards its forward position. The remaining 10% of the throttle movement controls thrust in the afterburner stages. Nozzle position as shown in the graph below is the primary indicator of afterburner operation. The nozzle will fully close in military thrust and will be reading close to 1 on the nozzle position gauge. As the afterburner lights, the nozzle will open again and will read close to 8 when in maximum afterburner. In real life the nozzle position is varied to keep EGT below 600 degrees. The engine EGT should be stable at slightly below 600 degrees with the afterburner on.

The CF-104 plugin features a custom engine model to provide accurate thrust settings to provide level speed values and acceleration values to match the charts within half a percent throughout the subsonic and supersonic flight range.

Illustration 19: Throttle Position Chart

T2 Reset and Cutback
This affects engine rpms at high speeds or low outside air temperatures. When you cut the throttle at high Mach numbers (high compressor inlet temperatures) the engine rpms will not decrease to prevent compressor stall. At very cold temperatures, max engine rpms are limited.
10.2 RADAR

Video Tutorial - Air-to-Air Radar Mode

NOTE: All sections below are taken from the CF-104 manual. Functions not operational in the simulator or working differently are noted.

10.2.1 General

The APG 502 radar set provides the aircraft with the capability of visual or blind attack in air-to-air and air-to-ground modes. During tactical operation, the radar is integrated with the air data computer and the vertical reference of the inertial navigation system.

The radar set provides contour and ground mapping modes for navigation and blind bombing, and tracking solutions in the air-to-air mode for visual and blind attacks against airborne targets.

The radar set performs the following operational functions:

- Ground mapping for blind navigation and bombing.
- Contour mapping for blind navigation, bombing, and terrain clearance.
- Tracking solutions for air-to-air combat.

10.2.2 Air Data Computer

The air data computer supplies angle of attack information in the terrain avoidance mode and pressure altitude information in the ground mapping modes.

10.2.3 Vertical Reference

The vertical reference (LN3 inertial navigator) provides aircraft pitch and roll attitude information to the radar set for radar search stabilization and for horizon line presentation on the direct view indicator (DVI).

10.2.4 Modes of Operation

The following modes of operation may be selected on the MODE SELECT switch.

10.2.4.1 STANDBY

The purpose of the standby mode is to provide the radar set with a preparatory 3-minute warm-up period. (NOTE: This is shortened to 20 seconds in the simulator). No target display is presented on the radar indicator when in the standby mode.

CAUTION

Whenever the radar set is to be turned off, a 5 to 10 second pause in STBY must be observed before the MODE SELECT switch is turned to OFF. This pause is necessary to allow time for the antenna to cage and lock onto the boresight axis. If this procedure is not observed, the antenna will be free to swing and damage to the radar mechanical mounts can occur.

10.2.4.2 GROUND MAP SPOILED AND GROUND MAP PENCIL

In the ground map modes, the radar presents the pilot with a PPI sector display of the terrain ahead of the aircraft. Mapping ranges of 10, 20, 40, and 80 nautical miles are available. In the ground map spoiled (GMS) mode, the antenna provides a search pattern in elevation by means of a retractable spoiler. In the ground map pencil (GMP) mode, the spoiler is retracted.
<table>
<thead>
<tr>
<th>MODE</th>
<th>EFFECTIVE AZ BEAM WIDTH</th>
<th>EFFECTIVE ELEVATION BEAM WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMP</td>
<td>2.2 deg</td>
<td>6.2 deg</td>
</tr>
<tr>
<td>GMS</td>
<td>2.2 deg</td>
<td>Approx. 57 deg</td>
</tr>
</tbody>
</table>

NOTE: In all other modes, azimuth beam width is 3.6 degrees and elevation beam width is 6.2 degrees.

In a typical high altitude application the pilot identifies the general area with the 80-mile sweep (NOTE: X-Plane limitations prevent the radar from reading more than 40 Nm in front of the aircraft). The pilot then switches to the 40-mile sweep and identifies the checkpoint. During blind bombing modes, the pilot flies the aircraft in such a direction that the target blip is superimposed on the azimuth cursor. In a typical blind low altitude application the pilot identifies the general area at preselected checkpoints with the 20-mile sweep. Depending on the checkpoint, either GMP or GMS mode of operation may be selected. The information obtained from the radar scope is used to cross-check the inertial navigation system and, if necessary, the IN system will be updated. During blind bombing under no wind conditions, the pilot flies the aircraft in such a direction that the target blip is superimposed on the azimuth cursor. When the blip intersects the range cursor on the display, the pilot presses the bomb release button to initiate the dual timers and completes the delivery manoeuvre.

10.2.4.3 CONTOUR MAP

Inoperative - Not calibrated

10.2.4.4 AIR-TO-AIR

In the A/A mode, the radar presents the pilot with a PPI sector display of the area ahead of the aircraft. Search areas of 10, 20, and 40 nautical miles are available.

Two options are available to the pilot in the air-to-air mode. The visual acquisition method (NOT YET IMPLEMENTED) permits the pilot to automatically lock on to a target that is directly in front and between 500 and 4000 yards in range. This is primarily used to obtain range information on the analog bar for visual firing of guns (conventional attack version only). The blind acquisition method permits a manually acquired lock-on at any azimuth or elevation within scope limits, and out to ranges of approximately 20 nautical miles. A scope display of the solution (NOT YET IMPLEMENTED) directs the pilot on a curve of pursuit attack, ie, to the stern position, from which a visual or blind firing attack may be carried out.

10.2.4.5 AIR-TO-GROUND RANGING

Inoperative

10.2.4.6 GROUND-MAP EMERGENCY

The ground map emergency mode is available in the event of failure of the INS. In this mode, the signals are the same as in GMP except that the antenna scan is caged to the aircraft armament datum line (ADL) and is not compensated for pitch or roll.

10.2.5 Operating Controls

10.2.5.1 COCKPIT CONTROLS

The controls and indicating devices necessary for operation of the radar set are located on four cockpit panels, the pilot's control stick, and the instrument panel.

10.2.5.2 RADAR CONTROL PANEL

The radar control panel is located on the left console just aft of the throttle. Among other controls, the panel
contains the MODE SELECT switch which is used to connect primary power to the system. A function description of each control is described below.

<table>
<thead>
<tr>
<th>Control or Indicator</th>
<th>Normal Position</th>
<th>STBY</th>
<th>A/A</th>
<th>GMP</th>
<th>GMS</th>
<th>GME</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODE SELECT Switch</td>
<td>OFF</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Applies primary power to the APG-502 radar set; selects the desired mode of operation.</td>
</tr>
<tr>
<td>RANGE SWEEP Switch</td>
<td>20</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>Selects the range in miles that the range sweep on the indicator face will represent. The range selected is shown by the RANGE light on the radar indicator control panel. The 10 mile range is selected by operating the action reject button on the control stick with the RANGE SWEEP set at 20. In A/A selection of 80 gives 10 mile sweep. The action reject button is configurable in the Plugins-CF-104 Systems-Joystick Setup menu in X-Plane.</td>
</tr>
<tr>
<td>ALT SET and RANGE GATE control</td>
<td>Detent</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>Not yet implemented in X-Plane. GMP, GMS, and GME modes: When adjusted so that ground targets begin to appear at the apex of the radar indicator, targets are displayed at the ground range. A/A mode: Detent for visual acquisition, out of detent for blind acquisition.</td>
</tr>
<tr>
<td>ANT TILT Control</td>
<td>Centre</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Tilts the antenna up or down. The amount of tilt in degrees is shown by the antenna tilt indicator on the clearance plane and antenna tile indicator panel to the right of the radar display. In X-Plane, this control can be programmed to a wheel on your stick or can be controlled from the key command menu. The dial in the virtual cockpit is inactive. The Plugins-CF-104 Systems-Joystick Setup menu in X-Plane can be used to associate the antenna tilt function with a joystick wheel.</td>
</tr>
</tbody>
</table>
### 10.2.5.3 RADAR BOMBING CONTROL PANEL

The Radar Bombing Control Panel is used to configure the radar cursors for bombing runs. See the section on bombing missions for an example on how to use this. The panel is used in conjunction with the dual timers during radar bombing to set the initial run-in point for the bombing run. When the target on the radar intercepts the range cursor, the pilot presses the weapon release button on the control stick to initiate the dual timer sequence and bombing maneuver.

**NOTE:** All of these functions can be set using the controls in the virtual cockpit or through the key command menu.

1. **X1000 FT range selector switch** - Selects range cursor display at slant angle ranges of 45,000 and 54,000 feet. In VAR selection, provides for the setting of slant ranges by the Range Cursor control.
2. **Range Cursor Control** - Sets range cursor display at variable slant range settings between 14,000 and 64,000 feet. Range setting in increments of 100 feet is indicated on the illuminated digital dial.
3. **Offset Switch** - Positions the azimuth cursor display left, right or center.
4. **Azimuth Cursor Control** - NOT FUNCTIONAL in X-PLANE - Set azimuth cursor display offset in increments of 100 feet, from 0 to 30,000 feet. Setting is indicated on the illuminated digital dial.
5. **Drift Adjust Control** - Compensates for target drift by adjustment of the azimuth cursor 5 degrees left or right.
10.2.5.4 RADAR INDICATOR

Most of the radar scope functions are related to the CRT adjustment and so are not implemented in the sim. The following controls are functional:

- Memory Control - this is the big knob on the left. It can be used to adjust how long the radar image is displayed before fading out.
- Radar Range Lights - the Radar Indicator displays the currently selected range on the left side of the display.
- Radar Mode Lights - the Radar mode currently active is indicated by a light along the lower arc of the radar bezel.
10.2.5.5 RADAR INDICATOR BEZEL

1. References for the azimuth position of the radar PPI sweep, and therefore azimuth position of the antenna at +/- 45 degrees.
2. Shows the point at which the PPI sweep should start. Also provides a references for adjusting the ALT SET and RANGE GATE control during ground map.
3. Provides a 900-knot reference point for the range rate gap in A/A mode. Closing rates between 0 and 900 knots are estimated by the pilot.
4. +/- 30 degree azimuth references for positions of the PPI sweep line.
5. +/- 15 degree azimuth references for positions of the PPI sweep line.
6. Indicates ranges represented by the range sweep.
   - In 10 mile range, the indices represent 2.5, 7.5, and 10 miles
   - In 20 mile range, the indices represent 5, 15, and 20 miles
   - In 40 mile range, the indices represent 10, 30, and 40 miles
   - In 80 mile range, the indices represent 20, 60, and 80 miles
   - The center of the bezel represents the second increment of range in all four ranges (5, 10, 20, and 40 miles respectively)
7. Reference for the time circle in A/A mode.
8. Represents the wings of the aircraft to show the pilot which direction to correct for roll, using the artificial horizon as an indicator.
10.2.5.6 ANTENNA TILT INDICATOR

The antenna tile indicator located on the lower instrument panel, to the right of the radar display, shows the elevation angle of the antenna in all modes of operation. The antenna tilt can be controlled from the key command menu or from a wheel on your stick or throttle if you have it configured. See the section 4.4 Joystick Setup for details.

10.2.5.7 ACTION/REJECT SWITCH

This switch can be assigned to a button on your throttle or control stick. See the section 4.4 Joystick Setup for details.

The action/reject switch, located on the stick grip, has two functions. In all modes except for air-to-air, it is used to select 10NM scope range when the RANGE SWEEP switch is set to 20NM. A further activation will return the scope to 20NM.

Visual Acquisition Mode (Not Yet Supported in X-Plane)
When A/A is selected on the mode selector, depression of the action/reject switch will cause the radar antenna to cease its 90 degree azimuth sweep. If a visual acquisition is being attempted, i.e. ALT SET/RANGE GATE control in detent position, the antenna will search a position along the ADL (i.e. straight ahead). At that time the range gate marker will start sweeping out from 500 to 4000 yards and will automatically lock on to the closest target illuminated by the radar beam. To reject the target and lock onto a target further out in range, the action/reject button is pressed until the desired target is acquired. To return to a full 90 degree azimuth search, the RES SEARCH button on the radar control panel is pressed.

Blind Acquisition Mode
When the ALT SET/RANGE GATE control is out of the detent position (always the case in X-Plane right now), depression of the action/reject button will cause the antenna to search a narrow band at the elevation position set by the elevation control and at the azimuth position of the antenna at the time the action/reject button is pressed. The radar will lock onto the first aircraft illuminated by the radar beam. The action/reject button may be pressed again to resume the 90 degree scan.

10.2.6 Operating Instructions

The instructions in this section are intended as a guide to airborne operation of the radar set. The procedures covered assume adequate pre-flight check out of the radar set and satisfactory set operation.

The operating instructions are presented in a normal operating sequence. Described first are the preliminary procedures common to all modes of operation followed by separate instructions for each mode, and then the steps necessary for the completion of a mission in one mode. Procedures for air-to-ground ranging, contour mapping and terrain avoidance and not discussed as these features of the system are inoperative.

10.2.6.1 PRELIMINARY PROCEDURES - TURN ON

This procedure covers initial set activation and preliminary control settings and is common to all modes of operation. It must be followed for all modes except those otherwise indicated.
To apply primary electrical power to the set, turn the MODE SELECT switch clockwise to STBY. In X-Plane this can be done in the virtual cockpit or by using the CF-104 Key Command menu described in section 3.3. The time delay circuits prevent tactical operation of the set during the 3-minute warm-up period (this has been shorted to 20 second in X-Plane). The radar should not be operated in the STBY mode for longer than 15 minutes or in any other operating mode for longer than 3 minutes while the aircraft is on the ground with the engine running since serious damage can result to the radar set due to a lack of cooling air. If the set is placed in the STBY mode just prior to taxiing, it should be “timed in” and ready to operate before take-off.

**WARNING**

Failure of the radar power supply may cause the potting compound within the power supply to give off a toxic smoke. Should the radar indicator emit smoke during operation, the radar set should be immediately turned off, 100 percent O2 selected, the fresh air scoop opened and the aircraft landed as quickly as possible.
10.2.6.2 GMP / GMS OPERATION

Preliminary Control Settings

After approximately 3 minutes (20 second in the simulator), or at the button of the runway, turn the mode select switch to GMP or GMS. No damage to the set will result from switching before the time delay period has elapsed because the time delay circuits prevent operation until the end of the period and no target returns will appear on the indicator. When the antenna begins sweeping a one bar 90 degree scan in front of the aircraft and a search display appears on the radar indicator, the radar indicator controls should be adjusted as desired.

GMS Mode

In the following example, this is what the radar displays in GMS ground mapping mode. The radar beam height is quite high in this mode so the beam will illuminate much of the terrain in front and below the aircraft. You can think of the radar being like a big flash light shining on the terrain in front of it. You can clearly see the mountain lit up by the radar beam with a big shadow behind indicating terrain that the radar can not see. This is known as radar shadow. This mode is very useful for ground mapping.
**GMP Mode**
In the following example, this is what the radar displays in GMP pencil beam mode. The radar beam is narrow in this mode so the beam will illuminate only what is in its path. If the beam elevation is level, the terrain in the same elevation range of the aircraft is lit up. In this example, the radar beam is illuminating the mountains on either side of the valley. The valley in front of the aircraft is black indicating that there is no terrain at the current altitude. This mode is very useful for terrain avoidance.

![GMP Mode Example](image)

**10.2.6.3 RADAR BOMBING ATTACK**

The radar, operating in conjunction with the dual timer bombing system and the radar bombing control panel may be used to provide information for blind bombing missions.

Navigation along the planned course is accomplished by using the ground map modes. Target area, target, or offset ID point may be identified through target study and/or indicator display predictions.
Ground Map Method

In the ground map mode, the targets are displayed in true ground range and the range cursor is slant range (NOTE: In X-Plane, true ground range is used for the cursors as well). The procedure is as follows:

• Set the range cursor controls as calculated on the radar bombing control panel to the desired bomb range pickle point.
• Adjust the azimuth cursor drift control to align the azimuth cursor with the target (as configured in the INS).
• Steer the aircraft so that the target tracks down the azimuth cursor.
• Reduce range down through 20 and 10 miles as required.
• When the target and the range cursor merge, press the bomb release button and maintain aircraft heading. The bomb will release automatically when the dual timers run out.

10.2.6.4 AIR-TO-AIR MODE

The air-to-air mode provides a means of locking on to an airborne target at ranges between 500 yards, and 20NM. The scope display presents a steering and tracking solution to the pilot to assist them in closing to a visual or blind firing position at the rear of the target. The air-to-air more provides two methods of locking on to an airborne target, automatic lock-on (visual acquisition) and manual lock-on (blind acquisition).

NOTE: Only blind acquisition mode is currently supported in the sim. Visual Acquisition will be added in a future release. If anyone understands how the steering cues work, please let me know!

When A/A mode is selected, the functions of certain controls and operation of some systems change from those normally accepted in the ground mapping modes. Changes common to both visual acquisition and blind acquisition are discussed in the text immediately following; changes that apply to one of these methods, are discussed with that method.

Controls

Action/Reject Button - In the air-to-air mode, the action/reject button is used to stop the antenna from sweeping through 90 degrees of azimuth and cause it to sweep 5 degrees each side of the selected azimuth. It is also used to reject a locked-up target and achieve lock-on to another target at the same azimuth.

RANGE SWEEP Selector - In the air-to-air mode, the action/reject button no longer switches the display to or from 10NM scope range. 10NM range on the scope is obtained by selecting 80NM on the range selector.

ALT SET/RANGE GATE Control - fixed in Blind Acquisition mode in simulator

RES SEARCH Button - not yet implemented in simulator

IF GAIN Control - not implemented in simulator

Elevation Control - Any sector of the area forward of the aircraft can be searched within elevation limits of +/− 43 degrees by use of the elevation control. Whereas in the ground mapping modes, the antenna sweeps a single bar in elevation at the elevation selected, in the air-to-air mode, the antenna sweeps a two-bar scan. From right to left it sweeps 2 degrees below the selected elevation: from left to right it sweeps 2 degrees above the selected elevation. This effectively increases the elevation coverage.

The air-to-air parameters of the system are:

• Beam width - 3.6 degrees
• Beam elevation - 6.2 degrees (with 2 bar raster scan 10.2 degrees effective)
• Pulse length - 1.4 usec
• Range Sweep - 40NM, 20NM, 10NM (80NM selected)
• Antenna tilt - +/− 43 degrees
• Azimuth sweep - 45 degrees left and right of center
• Lock-on range - 500 yards to 20NM
• Breakaway cross - 800 feet minimum (not yet implemented)

**Operation - Visual Acquisition Mode**

Not yet implemented

**Operation - Blind Acquisition Mode**

For the blind acquisition method of operation, the radar controls should be set as follow:

- MODE SELECT switch - A/A
- ALT SET/RANGE GATE - fixed in sim to Blind Acquisition mode
- Elevation - As required
- Range - As required (10NM, 20NM, 40NM)

To obtain a radar lock-on using this method, the airborne target must be displayed on the radar scope and be within 20NM. On initial contact, the target may be painted on one sweep only, i.e. left to right, or right to left. If this occurs, adjust the elevation until the target is painted on both sweeps. If initially, the target is only seen on the right to left sweep, it must be below the selected average elevation. In this case, lower the antenna 2 or 3 degrees until firm contact is made on both sweeps.

When the antenna sweep is approaching the target azimuth, and remember that it is sweeping 90 degrees per second, depress the action/reject button. This will cause the antenna to stop its full 90 degree sweep and to search an area of 10 degrees in azimuth at that position. Once a target is within 20NM and in the beam width, a lock-on should result.

**NOTE:** If the antenna is not stopped at the correct azimuth or a return to full sweep is desired, the action/reject button may be pressed again to resume a full scan.
10.3 Autopilot

The autopilot can be controlled using the switches on the autopilot panel or from the Key Command Menu. See information on how to use the key command menu in this section 4.3 Key Command Menu.

The X-Plane implementation of the autopilot provides some limitations on what you could do with the CF-104 autopilot. These limitations are:
- The real autopilot allows Heading Hold mode and Turn mode to be engaged without having to have Altitude Hold mode or Mach Hold mode turned on.
- The real autopilot will bank the aircraft much steeper than what X-Plane provides

10.3.1 Autopilot Engage

Before any autopilot functions can be used, the autopilot must be turned on using the Autopilot Engage Switch on the far left. Set this to ENGAGE.

10.3.2 Altitude Hold

Before the Altitude Hold Mode can be engaged, the aircraft must be flying close to level with bank angle not exceeding 20 degrees. Also the controls must be in the neutral position. Moving the controls will disengage the autopilot so you can't turn it on with the controls deflected. You will get a Master Caution light and an Autopilot Disconnect message come up on the Warning Light Panel if the autopilot turns off as a result of the controls being moved.

Once the Altitude Hold mode is engaged, the aircraft will hold that altitude at the time the switch was turned on. Mach Hold must be OFF before Altitude Hold can be engaged.

10.3.3 Mach Hold

Before the Mach Hold Mode can be engaged, the aircraft must be flying close to level with bank angle not exceeding 20 degrees. Also the controls must be in the neutral position. Moving the controls will disengage the autopilot so you can't turn it on with the controls deflected. You will get a Master Caution light and a Autopilot Disconnect message come up on the Warning Light Panel if the autopilot turns off as a result of the controls being moved.

Once the Mach Hold mode is engaged, the aircraft will adjust its pitch angle to maintain the Mach number at the time the switch was turned on. Engine power may be increased or decreased to adjust the climb rate. Altitude Hold must be OFF before Mach Hold can be engaged.
10.3.4  **Turn Mode**

Altitude Hold or Mach Hold mode must be on for Turn Mode to function. Set the switch LEFT or RIGHT to turn the aircraft.

10.3.5  **Heading Mode**

Altitude Hold or Mach Hold mode must be on for Heading Mode to function. The normal Heading Mode is the Hold Mode which simply keeps the aircraft on its present heading.

The NAV Mode can only be engaged when the aircraft is more than 5 miles (as indicated on the PHI) from the currently-selected waypoint. Inside of this range, the Heading Mode will automatically switch to Heading Hold Mode. In Nav Hold mode, the aircraft will fly towards the waypoint or TACAN selected and displayed on the PHI.
10.5 Electrical System

Illustration 20: Electrical System Schematic

GENERAL

The aircraft electrical components utilize either or both alternating current (ac) or direct current (dc) electrical energy. Variable frequency ac is provided by two engine-driven ac generators for normal operation and a ram air turbine-driven, fixed-frequency, ac generator for emergency operation. Constant frequency ac is supplied by a hydraulic-motor-driven ac generator. The dc power requirements are supplied by two transformer rectifiers for normal operation and two batteries for emergency operation. Refer to electrical power distribution. See Figure 1-17. Auto-transformers are provided for those components requiring reduced loads. Some of the components contain their own integrated power reduction units for circuits that require decreased loads.

AC ELECTRICAL POWER SUPPLY

The electrical power supply is derived from two engine-driven ac generators, a hydraulic driven ac generator and a ram air turbine-driven generator. Their description and function follows:

ENGINE DRIVEN GENERATORS

The 20 kva engine generators, supplying 115/200 volt 3-phase variable frequency (320 to 520 Hz) ac, constitute the main electrical power source. Each generator is controlled by means of a voltage regulator, protection panel, relays for automatic bus transfer and an individual pilot operated switch. Normally the No. 1 generator energizes the No. 1 primary and secondary ac buses and the No.2 generator energizes the No.2 ac bus and emergency ac
If an over-voltage or under-voltage condition exists for either generator, that generator is automatically
removed from its respective bus and the warning light panel illuminates to indicate which generator is
inoperative. If both generators fail, there will be no warning light indications until the ram air turbine is extended.
The automatic bus transfer system provides six possible modes of operation. See Figure 1-17. The No.2 ac bus
also directs power to the 120 amp transformer rectifier which changes the ac to 28 volt dc to energize the
primary dc bus. The emergency ac bus directs power to the 20 amp transformer rectifier that provides 28 volt dc
to energize the No. 1 and No.2 battery busses for normal operation.

NOTE

The electrical supply system is equipped with under-frequency relays which cut the two 20 kva
generators off the buses when the engine rpm drops below approximately 65%. Under this condition, all
electrically operated equipment will be inoperative, EXCEPT the No. 2 boost pump, the battery buses,
and the buses operated by the hydraulic driven generator. The boost pump will continue to operate at
lower engine rpm (down to approximately 40%). This feature assures sufficient boost pump pressure for
high altitude air starts.

HYDRAULIC DRIVEN GENERATOR

A 2.5 kva hydraulic driven generator provides 115 volt 3-phase constant frequency (400 Hz) ac power to the
primary and secondary fixed frequency buses whenever the No. 2 hydraulic system is functioning. These buses
energize those components requiring fixed frequency ac power. See Figure 1-17. If both main generators fail,
the fixed frequency bus tie relay opens, de-energizing the secondary fixed-frequency bus. In addition an APG
502 radar power interlock relay is energized which cuts out all generator fails, as indicated on the warning light
panel, a relay closes connecting variable frequency power from the emergency ac bus to both fixed frequency
buses. Thus, those components powered by the fixed frequency bus that can also operate on variable
frequency will be energized.

NOTE

The No. 2 hydraulic system will produce enough pressure to operate the hydraulic motor driven
generator at engine windmill speeds as low as 20% rpm. Thus the fuel flow indicator will be inoperative
to provide the pilot with fuel flow indications during air-starting procedures.

RAM AIR TURBINE DRIVEN GENERATOR

The aircraft is equipped with an extendable ram air turbine which drives an emergency hydraulic pump and a 4.5
kva generator that supplies 115/200 volt, 3-phase fixed frequency (400 Hz) ac power for emergency operation.
Once extended, the ram air turbine cannot be retracted in flight. If the hydraulic driven generator is not operating
and both No. 1 and No. 2 generators fail, the ram air turbine generator, when extended, will energize the
emergency ac bus. This in turn, energizes the primary fixed-frequency dc buses and both battery buses through
the 20 amp transformer rectifier.

NOTE

The emergency ac bus will not operate the primary fixed-frequency ac bus if the hydraulic driven
generator is operating.

EXTERNAL POWER SUPPLY

The aircraft is equipped with a receptacle for connecting an external ac power source to the electrical system.
This receptacle, see Figure 1-2, is located on the lower right side of the fuselage and is accessible through a
door above the hydraulic panel. When an external power supply is connected to the aircraft, the No. 1 and No. 2
generators automatically disconnect from their respective buses, and all ac buses receive power from the ground
power unit. A two position switch installed in the external electrical power receptacle will permit the LN-3 to be
energized from an external power source without energizing the aircraft main electrical power buses. This
permits energizing the LN-3 for warm-up without energizing other equipment. In the NORMAL position external
power is applied to the main buses. In the STANDBY position the main buses are de-energized and heat is applied to the LN-3 only. An engine start can be accomplished with the limited ground power input. Electrical power transfer to aircraft internal power will occur when main generators come on the line.

DC ELECTRICAL POWER SUPPLY

GENERAL

The direct current requirements of the aircraft normally are supplied from the No.2 ac bus through a 120 amp transformer rectifier. This changes the 115/200 volt ac to 28 volt dc which is directed to the primary dc bus. Power is drawn directly from this bus to operate the various units shown in Figure 1-17. The No. 1 and No. 2 dc emergency buses furnish power to units which are considered essential for safe operation of the aircraft. Due to this requirement, an alternative source of power to these buses is provided in the event that power from the primary dc bus is disrupted. Under this condition, the No. 1 and No. 2 emergency dc buses will be connected automatically to the 20 amp transformer rectifier unit which is connected to the ac emergency bus. When the ram-air turbine-driven ac generator is operative (Emergency Mode), it is important that the load on the emergency ac bus be minimized when using the aircraft leading and trailing edge flaps since they are powered directly from the emergency ac bus. To reduce loads and ensure maximum flap effectiveness, the No. 1 emergency dc bus is automatically disconnected from the 20 amp transformer rectifier as long as the flaps are in operation, and those units which are powered from this bus, including the UHF command radio, will be inoperative during the period of flap operation.

EMERGENCY DC POWER SUPPLY

If the ram air turbine and both engine driven generators fail, the batteries will furnish a supply of direct current to the battery buses. The batteries are the only independent source of direct current in the aircraft electrical system. Normally, the batteries and battery buses are paralleled with the 20 ampere transformer rectifier, and the batteries are thereby maintained in a fully charged condition. In emergency operation, battery output is prevented from discharging to the 20 amp transformer rectifier by blocking rectifiers in order to conserve the limiter power supply for those units connected directly to the battery buses. There is no battery control switch in the cockpit, and operation of the battery system is entirely automatic.

CIRCUIT BREAKERS

The circuit breaker panels, on the left and right cockpit consoles, contain push-to-reset, pull-out type breakers for certain ac and dc circuits. All of the distribution circuits in the electrical system are protected by various types of circuit breakers. Circuit breaker panels which are not accessible during flight, but which should be inspected before flight, are located in the electronic compartment aft of the cockpit and in the lower electrical bay on the right side of the fuselage.

CAUTION

Circuit breakers should not be pulled or reset without a thorough understanding of all the effects and results. Pulling circuit breakers can eliminate from the system some related warning system, interlocking circuit or canceling signal, which could result in an undesirable reaction.

GENERATOR SWITCHES

A generator switch is provided for each of the 20 kva generator systems. These switches, see Figure 1-7, are identical and are located on the right forward panel. The switches are powered from the No. 2 battery bus. Each switch has three positions: ON-RESET, OFF, and a centre NEUTRAL position which is the normal position of the switch when covered by the guard. The switches are spring loaded to return to the NEUTRAL position. Placing either switch up to the ON-RESET position will return the generator to normal operation if it has been removed from the line for any reason other than complete generator failure. When placed down to the OFF position either switch will energize the generator control relay which will remove the generator from its associated bus.
10.6 Navigation System

The Navigation System consists of several integrated components to allow the pilot to navigate using various methods with navigation information displayed on the Position and Homing Indicator (PHI). The various components are described in the following sections.

Inertial Navigator Panel and Align Control Panel

This Inertial Navigator panel on the right side panel is used to turn on the INS. Setting the switch from OFF to STBY (Standby) sets the INS into warmup mode. This will also supply power and heading information to the Attitude Indicator. See the section 7. Instrument Panel Layouts in the manual for more information on the Attitude Indicator. When the INS is placed into STBY mode, the orange heat light on the top right of the panel will light up indicating that the INS is warming up. The pilot must wait for this light to extinguish before placing the INS in ALIGN mode.

Before the INS is aligned, aircraft position is entered onto the Align Control panel. In this simulator, this is done automatically for you. Once in ALIGN mode, the INS will take another minute before it aligns itself and is able to provide navigation information. The alignment procedure is done in two parts. After course navigation is performed, the Mode light will turn on to solid green. Finally after final fine alignment is complete, the Mode light will start flashing. Only after this event occurs can the mode switch be placed into NAV mode providing inertial navigation information to the PHI.

Note: If the aircraft is started in the simulator in a running state, the INS will start up in the aligned state so you don't have to perform any action to get it working.
TACAN Receiver

The TACAN receiver panel is located on the right side panel. The TACAN channel may be selected by rotating the inner and outer knobs. The TACAN channel may also be changed using the key command menu. Push F12 - Navigation Functions - TACAN Channel and then use the +/- keys to change the channel. See the section 4.8 TACAN Database Information to see how TACAN channels relate to VORTAC stations and how the database is defined. The section below describes how the PHI can be used to navigate to the selected TACAN station.

The two knobs on the right of the panel are non-functional in this simulator.

Position and Homing Indicator (PHI) and PHI/NAV Panel

The PHI is the main navigation display instrument in the CF-104. It will display the distance and heading to a waypoint as read by the INS or to a TACAN station defined on the TACAN control panel. For waypoint information calculated by the INS, there is also a small arrow on the outer ring of the compass. This shows the wind-compensated heading the aircraft should fly to to fly directly towards the waypoint. In the image above, this arrow is directly above the needle indicating that there is no crosswind component.

INS Waypoint Navigation
Once the INS has been aligned, the PHI mode on the top left can be set to IN to read waypoint bearing information from the INS. The needle will point to the selected waypoint and the distance in nautical miles to the waypoint is displayed in the middle of the gauge.

The PHI / Nav Panel allows you to cycle through the waypoints. You can cycle through waypoints using the joystick button you configured in the CF-104 Joystick Setup Menu. If you have not defined a joystick key you can also use the key command menu for that. Push F12 - Navigation Functions - Waypoint Set and then use the +/- keys to cycle through the waypoints.

The Grivation value is the current magnetic variation. This is entered for you automatically in the simulator.
TACAN Navigation

To use the PHI to navigate to the selected TACAN, set the PHI Mode on the top left of the PHI to **TCN**. The PHI will show distance and bearing info to the selected TACAN assuming that it is line-of-sight of the aircraft and in reception range.

**Dead Reckoning Navigation:**
Set the PHI selector switch to DR to navigate in Dead Reckoning mode. This is primarily used if the INS has failed. The nav computer uses true airspeed, aircraft heading, and wind speed/direction as set on the PHI/NAV panel to calculate the aircraft's position.

**Re-alignment of INS:**
Set the PHI selector switch to set. The PHI will operate in INS mode until you change either the distance or bearing knobs. You can use these to reposition the INS coordinates relative to the currently-selected waypoint. Moving the PHI selector switch out of SET will activate the changes.

**INS Route Files**
The INS will read the route as defined in the file **cf104_route_n.fms** where n can be from 1 to 40. These files can be defined by the user and are found in the **X-Plane/Output/FMS plans** folder. See the section 4.10 User-Defined Routes for the Inertial Navigation System for information on how to create your own routes. One route is included for you that you can fly out to the Cold Lake Weapons Range in the included Cold Lake scenery.

To select which route file to use, use the key command menu. Push **F12 - Navigation Functions - Route File Select** and then use the +/- keys to traverse through the routes if you have more than one defined.

**Navigation Using the Supplied Scenery and Route File**

**TACAN Navigation:**
If you've installed the Cold Lake scenery, the TACAN channel for Cold Lake is 82. Set that on the TACAN control panel and set the PHI selector switch on the main panel to TCN. The distance and bearing will be displayed on the PHI.

**Inertial Navigation System Navigation:**
A sample route to the bombing range has been installed for you. It can be found in the "X-Plane/Output/FMS Plans" directory and is called "cf-104_route.fms". I'll be adding an utility to modify this file and to let you create other files. For now, this is the file used by the INS for navigation. It can be edited by hand if desired.

To follow the route, set the PHI to INS once the ILS has been aligned and set to INS. Use the switch you configured in the joystick setup menu to advance the waypoint or click on the waypoint switch on the PHI/NAV panel. The PHI needle will show you the bearing and distance to the selected waypoint. There is also an indicator which shows the wind-corrected heading you need to follow to fly directly to the waypoint.

**Time-on-Target:**

During practice missions, the time-on-target is calculated within a few seconds. Careful mission planning is needed to determine takeoff time and required ground speed to arrive over the target at the planned time. To aid in this, the desired ground speed for each leg of the route can be entered onto the Groundspeed Set Panel"
(panel #10 on the diagram). The INS computes groundspeed and the attitude indicator has a scale on the left side. It has a marker that moves up and down and is centered when the ground speed is equal to that set. The top and bottom dots on this scale indicate ground speeds of 9 knots too fast, or 9 knots too slow respectively.
10.7 Weapon Systems

10.7.1 Jettisoning Ordnance and Weapons in Manual Bombing Mode

In an emergency, the "Emergency Jettison Button" above the landing gear lever (panel #2 on the diagram) can be pushed to jettison all ordnance from the aircraft.

Normally, (not sure if this is correct) the bomb mode switch is set to MAN, the ordnance to drop is selected on the Armament Panel by pushing the green-lit buttons, and the bomb release button on the stick is pressed.

The wing pylons may also be jettisoned using the guarded Pylon Jettison switch near the rear of the left side panel (not shown on diagram).

Manual Mode:
1. DCU-9/A - set selector to "Air" if BDU-8/B bomb is selected or leave off if using practice bomb dispenser or when jettisoning fuel tanks.
2. Set bomb mode switch from "OFF" to "MAN" on Armament Panel.
3. Select green-lit ordnance light on armament panel for the weapon to release. On the MN1A, this opens the dispenser doors.
4. Push bomb release button to drop bombs.

10.7.2 Bombing Using Dual-Timer Bombing Mode

This mode is used for precision visual pop-up attacks and level visual low-level attacks and blind low/mid level attacks in conjunction with the radar. Two types of weapons can be carried on the aircraft, BDU-8/B practice nuclear weapon. This has a drogue chute that will deploy shortly after release from the aircraft. The other weapon is the practice bomb of which six are carried in the MN1A practice bomb dispenser. These have the same ballistic characteristics as the BDU-8/B so the same bomb charts can be used for calculating the run-in and release timer values.

10.7.2.1 Weapon System Setup
1. Dual Timers - set values as calculated by the Bombing Calculator (see section 9.7.2.4).
2. DCU-9/A - set selector to "Air" if BDU-8/B bomb is selected or leave off if using practice bomb dispenser.
3. Bomb Mode - set to "DUAL TIMER" on Armament Panel.
4. Ordnance Selector Light - select green-lit ordnance light on armament panel for the weapon to release. On the MN1A, this opens the dispenser doors.
10.7.2.2 Visual Pop-Up Attack

1. Push bomb release button when over Run-In Point. The run-in timer will start accompanied by a buzzer tone.
2. When the run-in timer expires, the release timer will start accompanied by a buzzer tone in a different pitch. At this point begin at 45 degree climb. Climb angle should be obtained in 3 seconds.
3. When the release timer expires, the bomb will automatically drop.
4. Roll inverted, and dive to the programmed bomb burst altitude and accelerate at maximum thrust.
5. When the bomb hits the target you will be given your bombing score (displayed in orange text on the left side of the screen).
10.7.2.3  Level Low-Altitude Visual Attack or Mid-Altitude Blind Attack

The level attacks are typically done at altitudes between 50 and 2000 feet. For the low-level attacks where the run-in point was clearly visible, the weapon release button would be pressed as the aircraft passed above the run-in point. For higher-altitude attacks where the run-in point was not clearly visible, the weapon release button would be pressed as the target on the radar intersects the range cursor arc. The range cursor is set to be the distance between the run-in point and the target so when the target intersects the range cursor, the aircraft should be above the run-in point.

1. Push bomb release button when over Run-In Point using visual identification or when the target intersects the range cursor line on the radar. The run-in timer will start accompanied by a buzzer tone.
2. When the run-in timer expires, the release timer will start accompanied by a buzzer tone in a different pitch.
3. When the release timer expires, the bomb will automatically drop.
4. Roll inverted, and dive to the programmed bomb burst altitude and accelerate at maximum thrust.
5. When the bomb hits the target you will be given your bombing score (displayed in orange text on the left side of the screen).

Note that it doesn't matter in this case what value is assigned to the release timer and what value is assigned to the run-in timer, as long as the total is equal to the time value calculated by the bomb calculator. The start of the Release Timer would normally signal to the pilot to begin a 45 degree climb in the pop-up attack but with a level attack, the altitude and speeds remain constant.
10.7.2.4 Bomb Calculator and Mission Planning

The Bomb Calculator can be opened from the Plugins-CF-104 Systems-Bomb Calculator window. This is used to calculate the dual timer values for both pop-up and level attacks.

**Target Coordinates**
Enter the latitude and longitude of the target in decimal degrees. The X-Plane map will show you coordinates in hours, minutes, and seconds so those values must be converted to decimal. The target altitude is entered as feet above sea level. The magnetic variation can be read from aviation maps or can be displayed in X-Plane. Go to Settings - Data Input & Output window in X-Plane and select pitch, roll, and headings to display to the screen. Magnetic Variation is one of the parameters displayed for your current location.

**Run-In Point Coordinates**
Enter the latitude and longitude of the run-in point. The run-in point that you select should be an easily-identifiable landmark if you are planning a visual attack. Something like a building, bridge, intersection, edge of a lake, etc. will make a good run-in point.

**Release Parameters**
The approach speed to the target is entered as a Mach Number. The ground speed will vary based on altitude and temperature so ensure you have the weather conditions entered correctly.

For a pop-up attack, the run-in altitude is normally 50 feet. This is the altitude above ground at which you approach the target. The bomb release altitude should be at least 1000' AGL. The calculated release timer value should time-out when you reach the release altitude.

For a level attack, the run-in and release altitudes will be the same.

**Target Weather Conditions**
Enter the weather conditions at the target.

**Dual-Timer Values**
Enter the calculated Run-In Timer and Release Timer values onto the timers on the left side panel of the CF-104. The Key Command menu may also be used to enter these values.

**Distance to Target (Range Cursor)**
This calculated value should be entered on the Radar Range Cursor panel on the right side panel. This is the...
distance between the run-in point and the target. See the section 10.2 RADAR in the manual for more information on that.

**Track to Target**
This is the calculated track to the target from the run-in point.

### 10.7.3 Creating a INS Route

Once you have determined your target coordinates, run-in point coordinates, and have planned your route, you can create a route for the INS to help you with navigation to the target. This is especially important if you plan on performing blind attacks using the radar. See section 4.10 User-Defined Routes for the Inertial Navigation System for information on how to create your own routes.

### 10.7.4 Sample Route

The Bomb Calculator screenshot above shows how it would work with the included Cold Lake mission scenery. The run-in point is a small plant on the edge of a lake, and the target is a weapon range on the other side of the lake.

For the included Cold Lake scenery and bombing range and route supplied, the Release Timer should be set to 5.2 seconds and the Run-in Timer should be set to 9.9 seconds. Fly the route as follows:

1. Take off on runway 13L. Set the waypoint to #1 and fly to this waypoint after takeoff and an altitude of around 5000 feet.
2. When waypoint #1 is reached, advance to waypoint #2, the run-in waypoint. You should be flying at around 50 feet AGL and M 0.85.
3. Immediately overhead a small plant at waypoint #2 push the bomb release button to start the run-in timer, and advance the waypoint to waypoint #3, which is the bombing range target.
4. As soon as the run-in timer expires (indicated by a change in pitch of the tones as the release timer starts), start a 45 degree climb. This should be attained in 3 seconds.
5. The bomb will release automatically when the release timer expires. You'll be at about 5000' AGL at this point. Roll inverted and dive at full-throttle to the programmed air burst altitude.
6. A bombing score will be displayed for you telling how far your bomb impacted from the center of the target.
7. Select waypoint #4 to return to base, and then waypoint #5 to head in on the runway heading.

The F11 (configurable) key can be used to activate the bombing range camera when over the range. The camera has a free view in which moving the mouse will control the camera's position. Pushing F11 again will switch to aircraft tracking view. Once the aircraft has dropped a bomb, the camera will track the bomb to the target. Use the number pad "+" and "-" keys to zoom in and out.

### 10.7.5 User-Defined Weapon Ranges

You'll see a file in the "X-Plane/ClassicJetSimUtils/WeaponRanges" folder that lets you define the position of a bomb target and the position of the tracking camera for that weapons range. The track camera is activated by pressing F11 to get into free view and F11 again to get into aircraft/bomb tracking view. The weapon range closest to the aircraft is the active one. See section 4.9 User-Defined Weapon Ranges & Tracking Cameras in the manual for information on how to create your own weapon ranges.
Appendix I – Part 3 - Climb

Figure A3-1
Appendix I – Part 6 – Level Speeds
NAUTICAL MILES PER 1000 LB OF FUEL

15,000 FEET

NO EXTERNAL STORES

Engine: J79-1
Fuel Grade: J1

Figure A6-5
NAUTICAL MILES PER 1000 LB OF FUEL
20,000 FEET
NO EXTERNAL STORES

Model: F-104A
Date: 1 Dec. 1961
DATA BASIS: FLIGHT TEST

Engine: J79-GE-3A
Fuel Grade: JP-4
Fuel Density: 6.5 lb./gal.

Figure A6-6
NAUTICAL MILES PER 1000 LB OF FUEL
25,000 FEET
NO EXTERNAL STORES

Model: F-104A
Date: 1 Dec. 1961
DATA BASIS: FLIGHT TEST

Standard Day
Zero Wind
Engine: J79-GE
Fuel Grade: JP-
Fuel Density: 6.8

Figure A6-7
Part 6—F-104A Miles per Pound

NAUTICAL MILES PER 1000 LB OF FUEL

30,000 FEET
NO EXTERNAL STORES

Model: F-104A
Date: 1 Dec. 1961
DATA BASIS: FLIGHT TEST

Standard Day

Zero Wind

Engine: J79-GE-3A
Fuel Grade: JP-4
Fuel Density: 4.5 lb/gal

Figure A6-8
Appendix I – Part 10 – Combat Performance

Figure A10-1
MAXIMUM THRUST LEVEL FLIGHT ACCELERATION

40,000 FT PRESSURE ALTITUDE

NO EXTERNAL STORES

STANDARD DAY

F-104A & B
1 Dec. 1961

BASIS: FLIGHT TEST

TIME TO ACCELERATE

DISTANCE TO ACCELERATE

FUEL TO ACCELERATE

ENGINE: J79-GE-3A
Fuel Grade: JP-4
Fuel Density: 4.5 lb/Gal

Figure A10-2
MAXIMUM THRUST LEVEL FLIGHT ACCELERATION
45,000 FT PRESSURE ALTITUDE
NO EXTERNAL STORES

Model: F-104A & B
Date: 1 Dec. 1961
DATA BASIS: FLIGHT TEST

STANDARD DAY
Engine: J79-GE-3A
Fuel Grade: JP-4
Fuel Density: 6.5 lb/Gal

TIME TO ACCELERATE
DISTANCE TO ACCELERATE
FUEL TO ACCELERATE

0 1000 2000 3000 4000
1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0

Figure A10-3