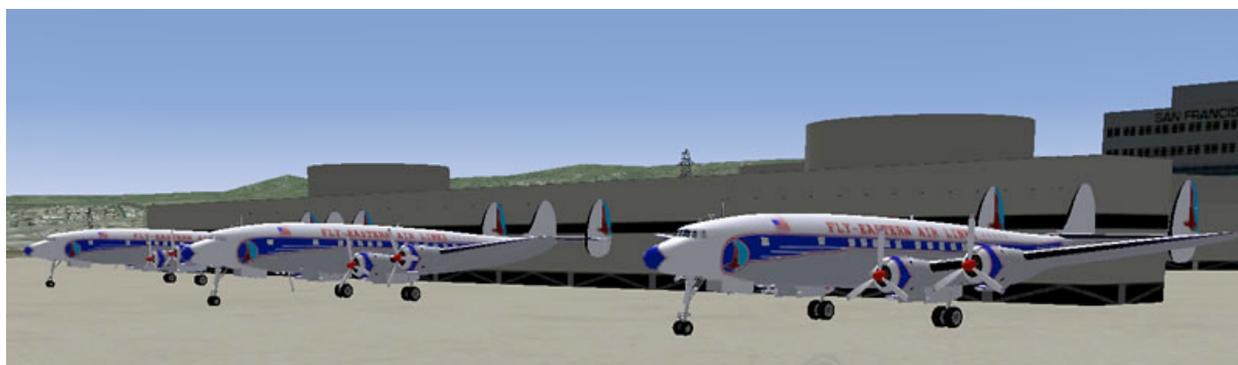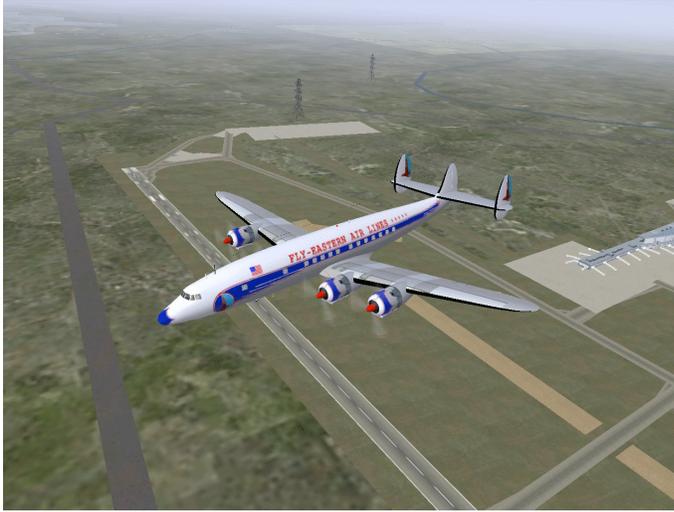# The
Lockheed 1049H
for Flightgear

A 3D Model for the Flightgear 2.0 Flight Simulation System

Last Revision: November 3, 2010 (4:05pm)
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Introduction:

This document is intended to do what is not often been done in the Flightgear world - provide an easy to understand guide to the airplane model in a well formatted, illustrated document.

For those who are either new or novice flight simulation users, this will hopefully get you not only flying with the model but understanding more about it than "push the throttles and go up".

This guide should also be useful for people who need or want additional information to understand the Flightgear Lockheed 1049h model in detail, and may provide amusement to anyone with too much time on their hands who wants to read my attempt at documentation.

This document is NOT, and can never be interpreted or represented as, a reference for use in any real world aviation or flight activity. Do not attempt to use anything written here as a guide to any aircraft operation - this only pertains to the Lockheed1049h virtual model offered for the Flightgear simulator software.

So come take a step back in time, when air travel was truly something special, where people dressed in their formal attire for the occasion. A time before metal detectors, no-fly lists, body cavity searches and cattle-call boarding. When people bought a plane ticket with actual cash and no I.D., and that was considered normal. In-flight meals were served on real plates, with real utensils and drinks came in real glasses. A world very removed from today's air travel for sure.
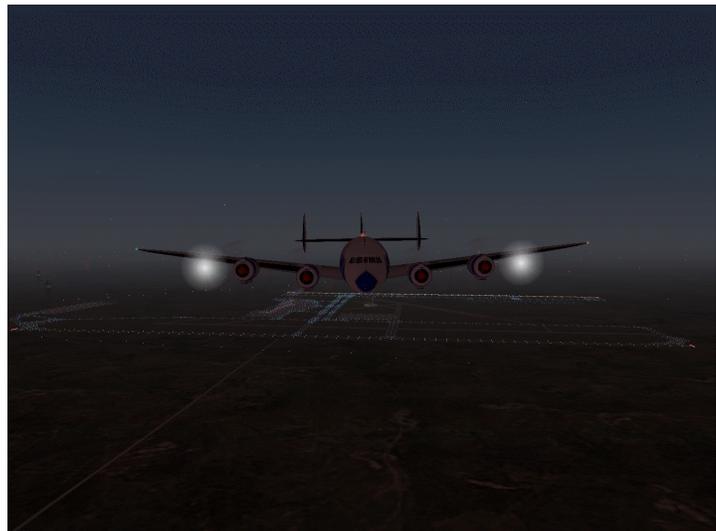
The upper picture on this page shows the 1049h in a daytime simulated flight, showing off its vintage Eastern Air Lines red-white-and-blue trim package with the falcon motif. The lower picture is a simulated sundown flight, to show off Flightgear's runway and airport lighting effects as well as the 1049h's lighting.

Part One: Panel Familiarization

The main instrument panel is divided into three sections - there is the pilot's panel on the left side, the co-pilot's panel on the right side and the center panel in the middle. In addition there are several flight engineer's panels. This section will present each portion of the panels with instruments numbered, and summarize what each instrument is for.

Figure 1 - the pilot's side instrument panel

1 - Ground Proximity Warning Radar Display

These 3 lamps give warning of close proximity to terrain (ground). The orange lamp lights up between 2000 and 1000 feet above ground level, the yellow lamp shows between 500 and 1000 feet above ground level, and the red lamp indicates 500 feet or less above ground level.

2 - Outer/Middle/Inner Marker Indicator with Test Switch

These 3 lamps indicate passing over the outer, middle and inner markers at airports equipped with RF marker beacons. Normally a beeping tone is heard as well to alert the pilot that a marker has been passed over. The test switch just illuminates all 3 lamps.

2A - Autopilot Warning Lamp

This lamp is illuminated whenever any mode of the Flightgear autopilot is activated. The autopilot functionality is part of Flightgear itself and not specific to the 1049h model at this time.

3 - Flight Control Surface Position Indicator

This is a FlightGear specific indicator which would not likely be seen in a real aircraft - its purpose is to show you the current position of the elevator, aileron and rudder - this is very useful for people who use either the mouse or keyboard to control the flight surfaces since there is no visual or tactile feedback of current position using those methods.

4 - Clock

This indicates the current simulation time, which may or may not actually be in sync with real world time depending on simulation settings. The displayed time may be adjusted with left and middle mouse clicks on the small knob (all clickable controls adhere to this adjustment technique).

5 - Airspeed Indicator

This instrument shows the current airspeed of the model in knots.

6 - Attitude Indicator

This instrument shows the orientation of the model in relation to level flight. Sometimes referred to as an artificial horizon, it gives the pilot a consistent reference even when outside visibility is zero. The small knob allows the user to set/calibrate the center line to match level flight attitude.

7 - Altimeter

This instrument shows the height of the model above sea level in feet. Note that it does NOT take into account terrain (so yes 500 feet above seal level+800 foot tall mountain=extreme pain). The small knob allows calibration for varying barometric pressure to ensure accurate readings.

8 - Zero Reader

This instrument is a very sophisticated device that in reality is capable of displaying a wide range of navigational and attitude information. In the current 1049h model, this unit only implements the deviation indicator functionality, which means it will display glide slope and localizer path deviations for instrument landing procedures. It will be discussed in more detail in the **Navigation Radios** section of this document.

9 - Turn Co-Ordinator/Rate Of Turn Indicator

This is a dual-function instrument which shows the turning speed of the model with the needle, and the black ball in the center indicates slip. In a well coordinated turn using both rudder and ailerons, the black ball will remain centered throughout the entire maneuver. In real life the 1049h aircraft (like most "heavy" planes) normally executed turns at a speed where a complete 360 degree circle would be completed in four minutes.

10 - Gyro Compass

This instrument provides a stable short-term heading indicator. The magnetic compass is only accurate in straight and level flight, it experiences fluctuation as the model turns and/or changes altitude, taking some time to return to a stable indication. This gyrocompass does not experience those variances, so in executing maneuvers it is preferable to refer to it. However, it does not remain synchronized to the magnetic compass, so it must be recalibrated to the magnetic compass before executing a maneuver. The knob on the left adjusts the gyrocompass itself, the right knob moves the small red "heading bug" indicator around the compass face (often used with the Flightgear autopilot options).

11 - Vertical Speed Indicator

This instrument shows the rate of ascent or descent of the model in thousands of feet per minute.

12 - Radio Magnetic Indicator

This instrument is the indicator for the radio navigation systems. It has 2 needles which can be linked to either a VOR radio receiver or ADF receiver. This will also be discussed in more detail in the **Navigation Radios** section of this document.

13 - Parking Brake Indicator

This lamp illuminates to show when the parking brake is ENGAGED.

The co-pilot's panel closely emulates the pilot's side, but with fewer instruments. The numbers in Figure 2 correspond to the matching instrument descriptions for the pilot's side panel.

Note that the magnetic compass is not on the main instrument panel. It is mounted at the top center of the windshield.

Figure 2 - the co-pilot's side instrument panel

The center instruments. For the moment the focus of discussion will be on the instruments themselves. The levers on the central pedestal will be discussed in detail under the Controls section of this document.

Figure 3 - the center instrument panel

14 and 15 - Manifold Pressure

These instruments indicate the intake manifold pressure for each engine - both instruments have dual needles, the left hand dial showing the pressure for engines 1 and 2, the right side dial showing the pressure for engines 3 and 4. On close look you will see the needles are in fact numbered to reference which engine that particular needle is linked to.

16 and 17 - Engine RPM

Like the manifold pressure instruments, each of these dials have dual needles which indicate the current RPM of the engines - the left hand dial shows engines 1 and 2, the right hand dial 3 and 4. The numbered needle system is used here as well.

18 - Flaps Position Indicator

This instrument shows the current position of the wing flaps.

19 - Trim Indicator

This instrument shows the position of the trim tabs associated with the flight control surfaces.

20 - Ambient Air Temperature Indicator

This instrument shows the ambient air temperature outside the model, in Centigrade degrees.

The Fire Warning indicator is currently not active but modelled for realism and future usage. In reality it would illuminate if a fire condition existed in any of the 4 engines.

21- Landing Gear Status Display

This set of lights shows the current status of the landing gear - the 3 green lights will illuminate when the landing gear is extended and locked down. The red lamp shows the landing gear as extended but not locked, and no lamps illuminated shows the landing gear to be in the fully retracted position.

22 - Propeller Reverse Indicators

These 4 orange lamps are keyed to engines 1-4 and will be illuminated when the propeller associated with each engine is set for negative pitch.

The flight engineer's upper panel primarily focusses on fuel level indicators. It has some mirrors of instruments that appear on the main panels as well, which are numbered according to their previous discussion.

Figure 4 - the flight engineer's upper instrument panel

23-29 - Individual Fuel Tank Level Indicators

These instruments show the level of fuel in each specific fuel tank. They are labelled as to which tank they represent. The fuel control system will be covered in detail under its own section in this document.

30 - Fuel Totalizer Indicator

This instrument shows on a single indicator the total amount of fuel remaining, as a sum of all the individual tanks.

30a - Cowl Flaps Indicators

These instruments show the position of the cowl flaps for each engine.

The flight engineer's lower panel is primarily focussed on engine performance monitoring. Instruments which are mirrored on the main panel are numbered according to their previous explanation. Engine management will be covered in detail under its own section.
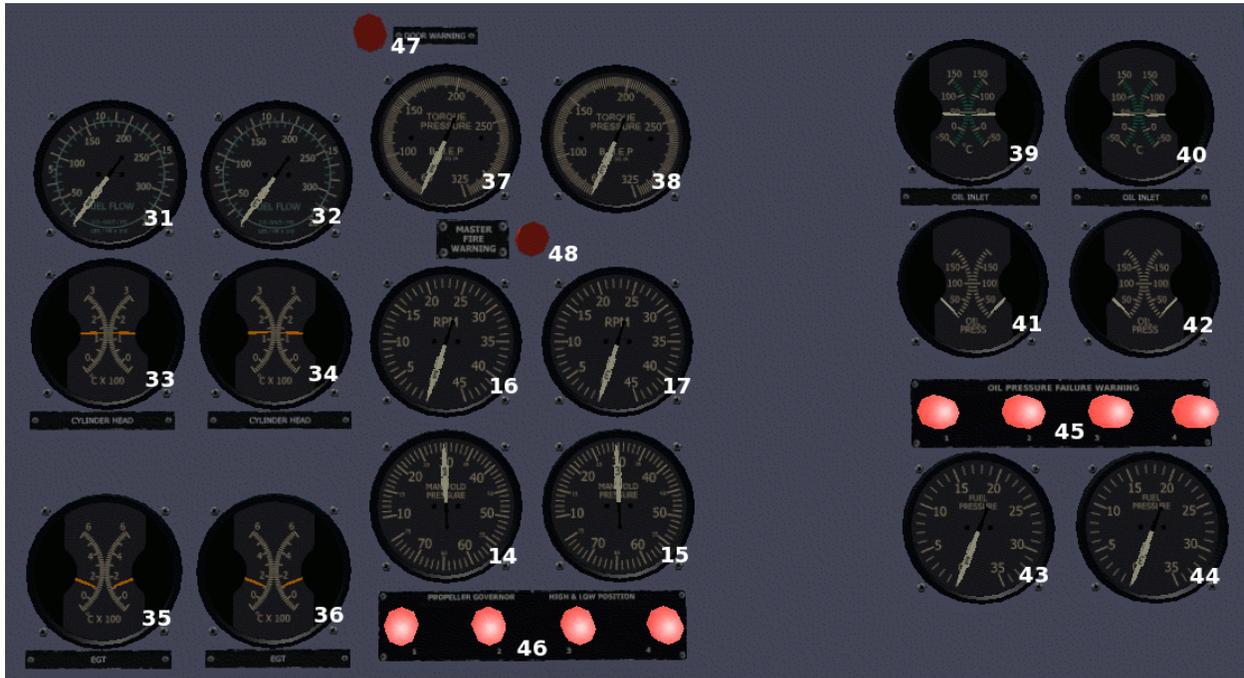

Figure 5 - the flight engineer's lower instrument panel

31-32 - Fuel Flow Indicators

These 2 instruments show the amount of fuel being consumed by each engine in gallons per hour and pounds per hour. Each instrument has two needles in the same manner as the RPM and Manifold Pressure indicators.

33-34 - Cylinder Head Temperature Indicators

This pair of instruments shows the cylinder head temperature of each engine (each instrument contains 2 needles). In reality a radial engine has multiple cylinder heads, and this instrument should indicate the hottest one. {NOTES A and D}

35-36 - Exhaust Gas Temperature Indicators

This pair of instruments shows the exhaust gas temperature from each engine. Like the cylinder head temperature, a radial engine has more than one exhaust port and in reality this would show the highest measured value for that engine. {NOTE C}

37-38 - BMEP Indicators

This pair of instruments shows the BMEP power factor for each engine, which is a ratio of torque and RPM. This value is useful for adjusting the engine controls for best efficiency. Like the Fuel Flow Indicators, the dual needle system is used.

39-40 - Oil Temperature Indicators

This pair of instruments shows the oil temperature for each engine. {NOTE A}

41-42 - Oil Pressure Indicators

This pair of instruments indicates the oil pressure in each engine. {NOTE A}

43-44 - Fuel Pressure Indicators

This pair of instruments shows the fuel pressure present at each engine. {NOTE B}

45 - Oil Pressure Warning Lamps

These lamps will come on if the oil pressure drops below the minimum safe value. {NOTE A}

46 - Propeller Governor Indicators

These lamps will illuminate when the propellers are turning either too fast or too slow.

47 - Door Warning Lamp

This lamp will come on if one of the aircraft doors is open. Clicking on the door of an aircraft will open or close it, or it can be toggled from the CTRL-I dialog box. This lamp will only indicate if there is DC power applied to the electrical bus.

48 - Master Fire Lamp

This lamp will come on if a fire condition is present in any of the engine nacelles. This is not yet implemented.

NOTE A: The values indicated by these instruments are only estimated, not delivered from the simulation software directly. This is because of an issue in the portion of the simulation that handles piston engine parameters which, on larger engines, generates values that are physically impossible (negative oil pressure and cylinder head temperatures that approach that of the surface of the sun), When this is corrected in the simulation, these instruments will be changed to take advantage of that.

NOTE B: Right now the fuel pressure indicator is just an estimated value which varies according to changing fuel flow conditions.

NOTE C: In real life, the instruments in this position would be the Carb Air Inlet Temp. indicators, but since Flightgear does not measure that differently than ambient air temperature the EGT instruments were placed here instead. A real world 1049h aircraft does not seem to have any EGT instruments that we have been able to determine.

NOTE D: Opening the cowl flaps will cause the indicated CHT reading to decrease slightly based on the amount of opening. At the moment this is also simply estimated but will be implemented more accurately in the future.

The Flight Engineers MJB (Main Junction Box) #1 panel contains instruments and controls for the aircraft electrical system. The instruments are explained here, the controls will be explained in the **Controls Familiarization** section of this manual.
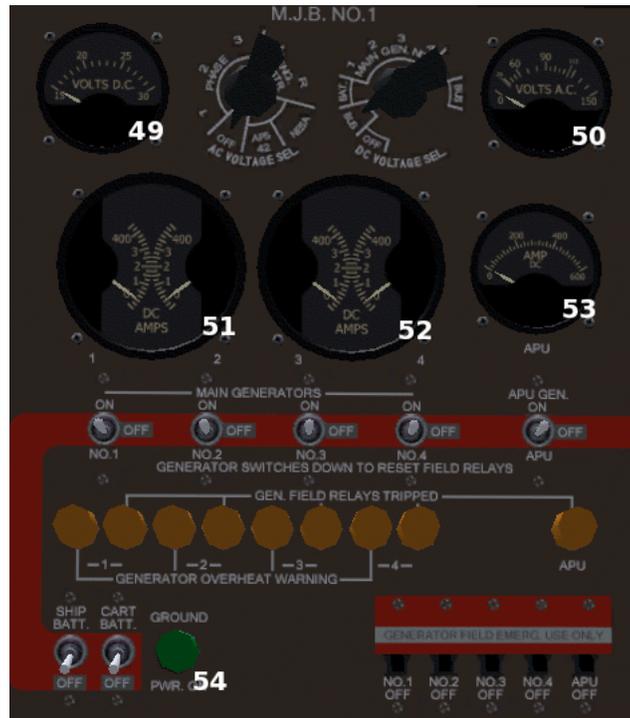

Figure 5a - the M.J.B. #1 panel

49 - D.C. Voltage Indicator
This instrument shows the current DC voltage of the source chosen by the D.C. Voltage Selector Knob {NOTE D}.

50 - A.C. Voltage Indicator
This instrument shows the current A.C. voltage of the source chosen by the A.C. Voltage Selector Knob. This function is not yet implemented.

51-52 - Main Generator D.C. Amps Indicators
This pair of instruments shows the current flow from each of the 4 main generators. Each engine has a generator and these provide primary electrical power in flight. {NOTE D}

53 - A.P.U (Aux. Power Unit) D.C. Amps Indicator
This instrument shows the current flow from the Aux. Power Unit. This is a small (compared to the main generators) unit intended to provide electrical power to an aircraft when the primary engines are not running. It should not be in use when the primary engines are running except in emergency situations. {NOTE D}

54 - Ground Power Indicator Lamp
This lamp will come on when the CART BATT switch is turned on, indicating that electrical power is available from an external source. It should only be ON when the model is at rest on the ground.

NOTE D: At this time, voltage and current indications are static values just to indicate the status of the electrical system. As the model and Flightgear itself evolve, these indications will become more realistic with regard to actual electrical usage.

Part Two: Controls Familiarization

As with the instruments, the control levers are numbered and each number will be described below. Levers and knobs that are not numbered in the diagram are not functional at this time. The yoke and rudder pedals are not shown, but their usage should be obvious.

The center pedestal between the pilot and co-pilot chairs has a significant number of knobs and levers.   Some of them are modelled strictly for appearance sake and do not do anything, while other ones are animated and will respond to keyboard commands. At this point in the model development only a few of the center pedestal controls are directly mouse-clickable, so any of the non-clickable controls presented here need to be adjusted with keyboard, from the flight engineer's station where applicable or appropriately configured game controllers.
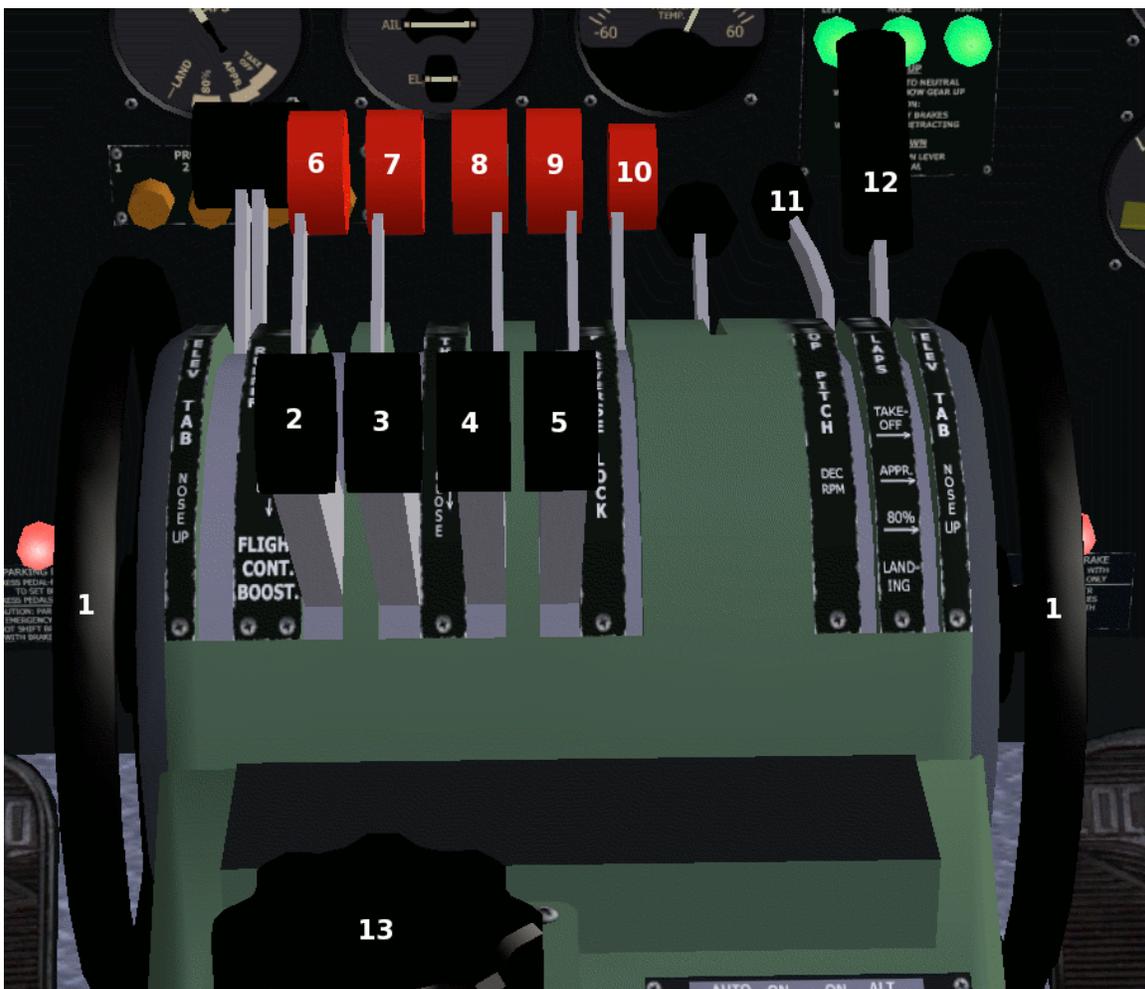

Figure 6 - the center pedestal top half

1 - Elevator Trim
> This large wheel adjusts the elevator trim (it can be moved by using the "1" and "7" keys or by left and middle clicking on the object).

2-5 - Throttles

These levers adjust the throttle setting for each engine. Normally they are moved as a single unit (by using the PageUp and PageDown keys) but they can be adjusted individually via mouse clicks from the flight engineer's control station.

6-9 - Propeller Reversing Levers

These 4 levers, when pulled back toward the rear of the model, place the propellers into a negative pitch mode which gives a measure of reverse thrust to assist in braking. The CTRL-B key combination toggles them back and forth. However, they can only be moved when the Reversing Lever Lockout has also been pulled to the rearward position.

10 - Reversing Lever Lockout

This lever prevents the Propeller Reversing Levers from being engaged unless it is pulled rearward, unlocking the reversing system. This is a safety measure to prevent accidentally reversing the propellers in flight. This lever is toggled back and forth with the CTRL-L key combination.

11 - Propeller Pitch Control

This lever adjusts the pitch of the propellers between FINE/MAX RPM (all the way forward) and FULL/MIN RPM (all the way back). It has a matching lever on the engineer's control station which can be adjusted by mouse clicks, or it can be moved forward by using the "n" key, and moved rearward by using the SHIFT-N key combination.

12 - Wing Flaps Control

This lever extends and sets the angle of the wing flaps. It can be moved in and out with the "[" and "]" keys.

13 - Aileron Trim Knob

This knob adjusts the aileron trim tabs. Unfortunately there is no keyboard command to adjust this knob, but since aileron trim is a very useful control it is advisable to, if possible, configure a game controller button pair to adjust this. If a controller is configured to adjust the aileron trim value, this knob is animated and will rotate. It may also be adjusted by left and middle clicking on the object itself.
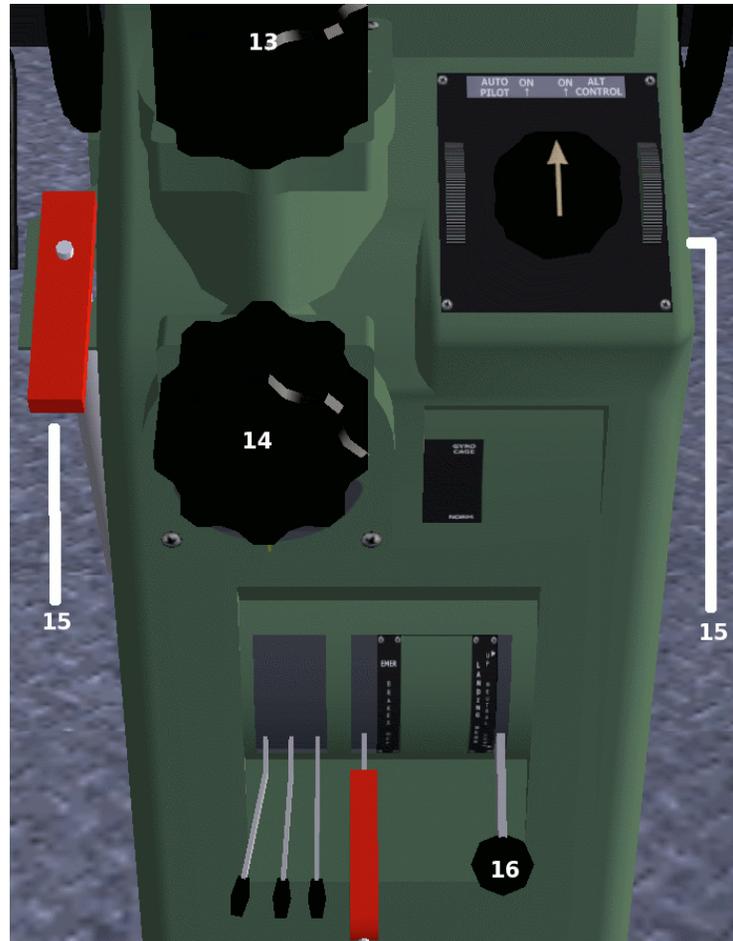
Figure 7 - the center pedestal lower half

14 - Rudder Trim Knob

This knob controls the rudder trim tabs - like the aileron trim knob there is no keyboard command to adjust this knob, but it can normally be left alone. If a controller is configured to adjust the rudder trim value, this knob is animated and will rotate. This also is adjustable with left and middle mouse clicks.

15 - Parking Brake Control Knob

This knob is present on both sides of the pedestal, but the co-pilot's side cannot be easily seen from this viewpoint. On the pilot's side it is hidden behind the inoperative red lever, and it is more easily visible on the co-pilot's side. It is moved in and out with the SHIFT-B key combination.

16 - Landing Gear Control Lever

This lever raises and lowers the landing gear. It is moved up with the "g" key to raise the landing gear, and lowered with the SHIFT-G key combination which lowers the landing gear.

The flight engineer's control station levers and floor levers are all mouse-clickable - and in fact most of the controls presented here HAVE to be operated with mouse clicks directly to the controls since there are no keyboard commands for what these do. In order to accurately adjust these controls, it is advisable to switch your viewpoint to the flight engineer's chair with the CTRL-E key combination (engineer view must be enabled in VIEW OPTIONS). The CTRL-V key combination will switch your viewpoint back to the pilot's chair.
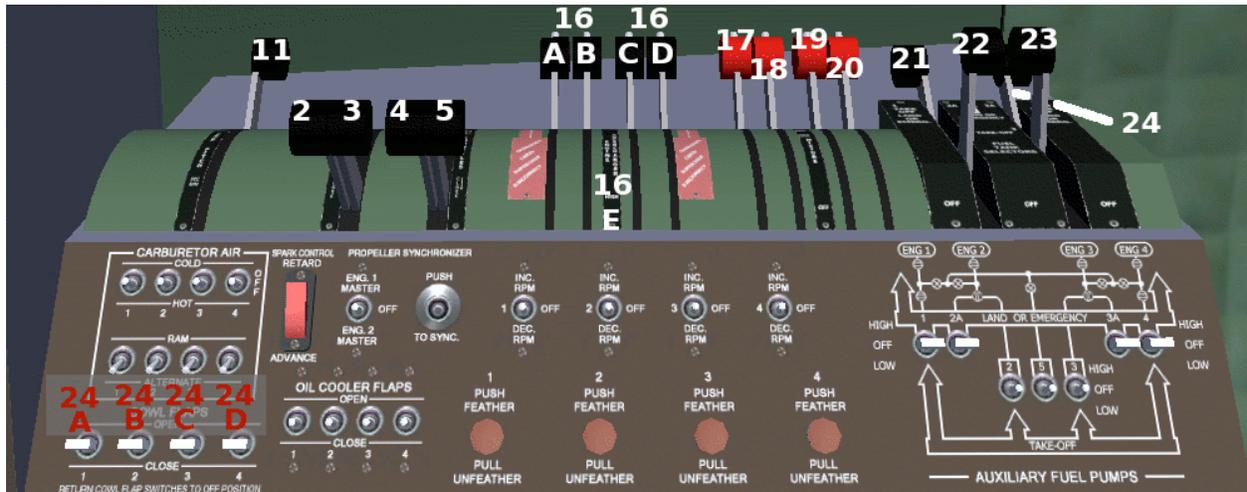

Figure 8 - the flight engineer's control station

Note that lever 11 and 2-5 match companion levers on the center pedestal, but when accessed from this station they may be adjusted with mouse clicks. The supercharger control levers are functional in Flightgear 2.0 and up.

16a-16d - Supercharger Control Levers
These 4 levers select between LOW and HIGH speed for the superchargers on each engine. Moving the levers away from the viewer selects LOW speed for lower altitudes, pulling them toward the viewer selects HIGH speed for higher altitudes. There is no keyboard command for these. They can be toggled individually with mouse clicks or clicking on the spot indicated by 16E will toggle all 4 levers at once.

17-20 - Mixture Control Levers
These 4 levers adjust the mixture of each engine. Moving the levers away from the viewer increases the mixture to FULL RICH, pulling them toward the viewer adjusts the mixture to FULL LEAN/OFF. The levers can be moved together by using the "m" key to move toward rich and SHIFT-M to move toward lean. They can also be adjusted individually with mouse clicks.

21-24 - Fuel Tank Selector Levers
These levers control valves that allow or block the flow of fuel from the fuel tanks to the engines, with the exception of the center tank which is controlled from the flight engineer's floor lever station. The fuel system will be covered in its own section of this document. These levers cannot be adjusted by keyboard command - the only way to change these controls is via mouse clicks.

24A-24D - Cowl Flap Actuator Switches
These momentary up/down switches control the cowl flaps for the indicated engine. Left click to open the cowl flap one step (20% per step), middle click to close the cowl flap one step. These cannot be activated via keyboard.
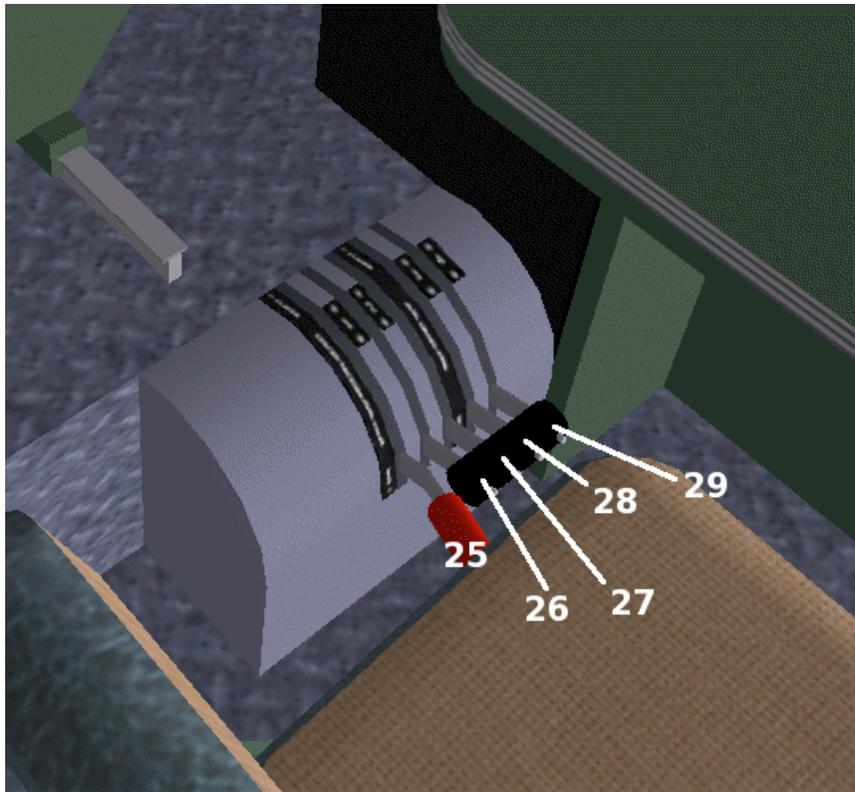
Figure 9 - the flight engineer's floor station

25 - Center Tank Shut Off Lever

This lever opens and closes the center tank control valve. This lever also must be controlled by mouse clicks directly on the control, no keyboard command exists for this control.

26-29 - Fuel Cross Feed Levers

These levers control the fuel cross-feed valves, which can allow each engine to draw fuel from any tank containing fuel. These levers also have no corresponding keyboard command so they must be directly clicked with the mouse.

The pilot's overhead console and left side electrical control panel are also controls that need to be directly mouse-clicked on in order to operate them. Only some of the switches on these panels are operative, the ones which are not numbered do not function at this time.

Figure 10 - the pilot's overhead switch panel

30-33 - Engine Magneto Switches

These 4 switches control the magneto settings for each engine. The may be adjusted all at once with the SHIFT-[and SHIFT-] keyboard commands, or clicked individually.

34 - Instrument Panel Light Control

This knob adjusts the instrument panel illumination from OFF to BRIGHT. It must be clicked on, there is no keyboard command. In reality, each panel section would have its own brightness knob, but in the interest of simplicity this knob and its companions elsewhere in the cockpit control all the instrument lighting in unison.

34a - Command Bell Button

This button simply dings the command bell when clicked. This button has no keyboard command.

35-36 - Landing Light Retraction Controls

These 2 switches control the left and light landing light retraction/extension. They extend from under the wing for use and are retracted into the wing in flight to prevent damage to the lights and reduce drag. They must be clicked on, there is no keyboard command.

37-38 - Landing Light Lamp Controls

These 2 switches turn on and off the under-wing landing lights. However, if the lights are not extended you will not be able to see them. Again, these are mouse click only controls.

38A-38B - COM1 Radio Controls

These 2 knobs are concentric controls - clicking the outer part will change the value to the left of the decimal point, and clicking the smaller inner part will change the value to the right of the decimal point. On both sections, the left mouse button increases the value and the middle mouse button decreases the value. You can hold the appropriate mouse button down as long as needed to get to the desired value. The small square TFR button in between the 2 readouts (not numbered but present on all radios) will swap the active and standby values. One thing to keep in mind is if you are using the fgcom voice over IP application with Flightgear, you probably want to tune the standby section then swap rather than flip through all the channels on the active - fgcom tends to get overloaded and crash when you scan through channels that rapidly on it.

38C-38D - COM2 Radio Controls

These work exactly the same as the COM1 controls described above.

38E-38H - NAV1 and NAV2 Radio Controls

These knobs work in pretty much the same way as the COM radio controls. However since fgcom doesn't link to the NAV radios there is no concern with cycling through channels on the active, although it is usually good procedure to stay in the habit of tuning the standby then swapping here as well.

38I-38L - ADF1 and ADF2 Radio Controls

These work similarly to the COM and NAV radios, but since there is no decimal point in their frequency range the outer ring on the knob controls the hundreds value, and the inner stud controls the lower 2 digits.

The pilot's left side electrical panel has some additional lighting controls. All of these controls must be accessed by mouse clicks, there are no keyboard commands for these functions.
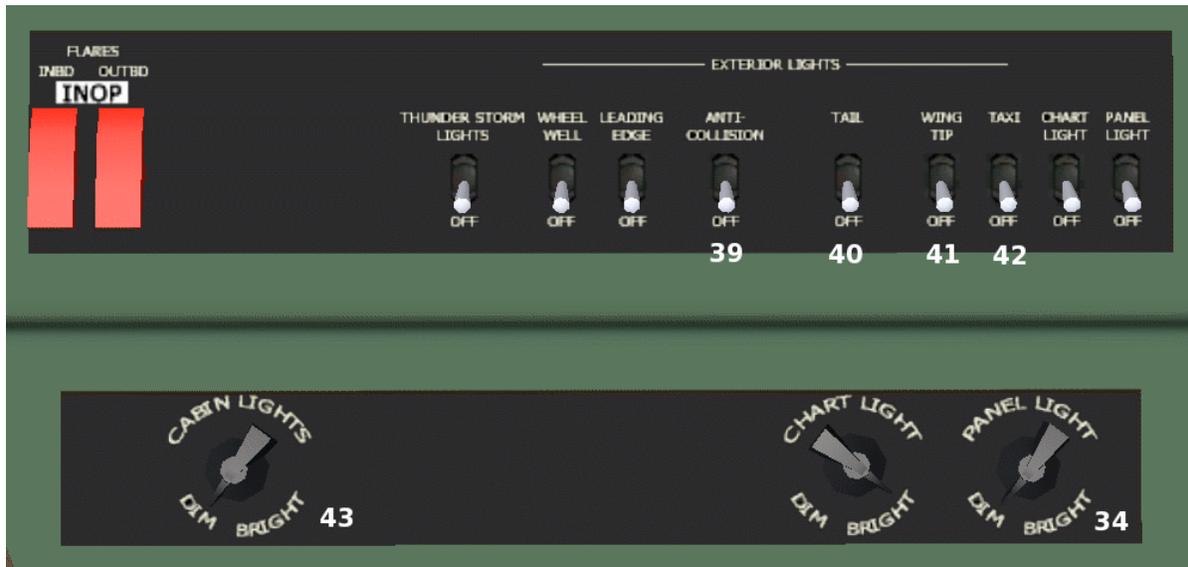
Figure 11 - the pilot's left side electrical panel

39 - Anti-Collision Light Switch

This switch turns on the flashing red anti-collision lights on top of and below the model.

40 - Tail Light Switch

This switch turns on the white tail light at the very back of the model.

41 - Wing Tip Light Switch

This switch turns on the red and green wingtip navigation lights.

42 - Taxi Light Switch

This switch turns on the white taxi lamp attached to the nose gear - sometimes also turned on as a center landing light.

43 - Cabin Light Control Knob

This knob works similar to the panel light control knob, but adjusts the simulated cabin lighting seen through the windows of the model.

The center arch switch panel has selectors to control the operation of the Zero Reader instrument as well as the RMI instrument on the main panel for radio navigation and instrument landing purposes. These too are accessible only by mouse click. These controls will also be covered in much more detail under the **Navigation Radios** section.
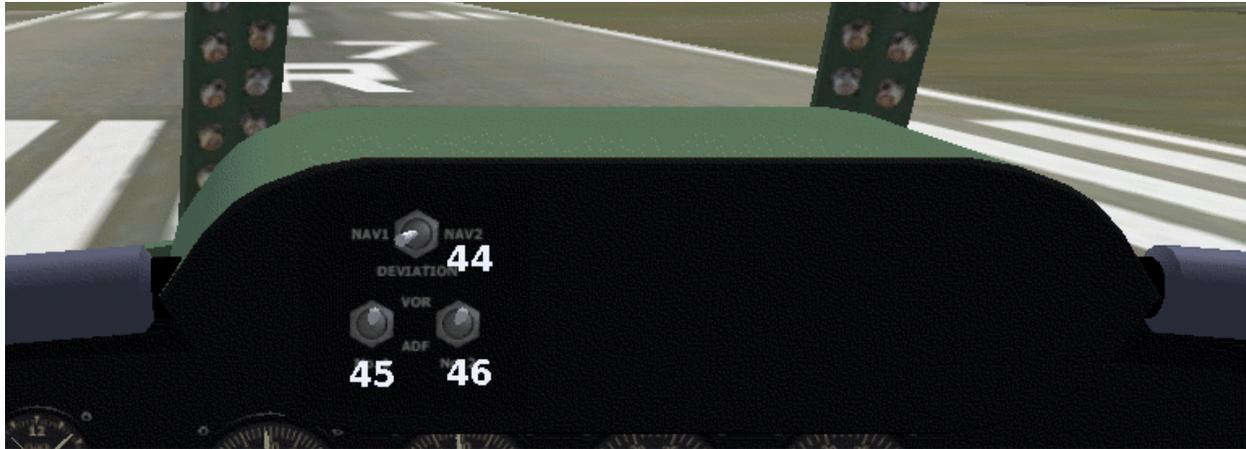
Figure 12 - the center arch switch panel

44 - Deviation Selector Switch
> This switch chooses whether the Deviation Indicator function of the Zero Reader instrument will use the signals from the NAV1 or NAV2 radio receiver.

45 - Needle One Selector Switch
> This switch selects whether Needle #1 on the RMI instrument displays a bearing based on the NAV1 or ADF1 radio receiver

46 - Needle Two Selector Switch
> This switch selects whether Needle #2 on the RMI instrument displays a bearing based on the NAV2 or ADF2 radio receiver

The Flight Engineers MJB (Main Junction Box) #1 panel contains instruments and controls for the aircraft electrical system. The controls are explained here, the instruments were explained in the **Panel Familiarization** section of this manual. All of the switches and knobs on this panel MUST be activated with the mouse, there are no keyboard commands for these.
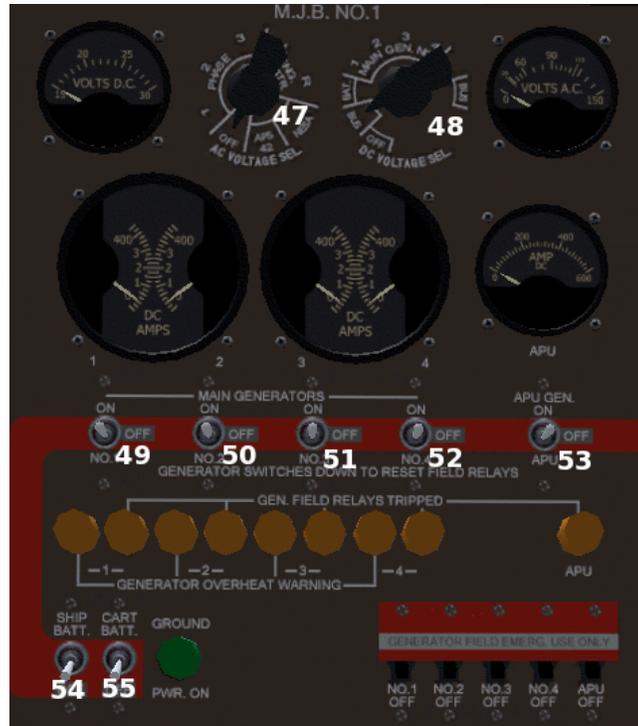

Figure 13 - The MJB #1 panel

47 - A.C. Voltage Selctor Knob
This knob chooses which source is displayed the A.C. Voltage Indicator instrument. At the moment this knob is inactive.

48 - D.C. Voltage Selctor Knob
This knob chooses which source is displayed the D.C. Voltage Indicator instrument. BUS monitors the aircraft electrical system overall, or each source can be monitored individually.

49-52 - Main Generator On/Off Switches
These switches control which main generators are feeding power to the electrical system bus.

53 - A.P.U. Generator On/Off Switch
This switch controls the APU generator - turning it ON provides power from the APU to the electrical system bus.

54 - Ship Battery On/Off Switch
This switch turns on and off the on-board battery bank - it would normally be ON when an aircraft is in operation unless an electrical emergency (like a shorted battery) requires turning it off.

55 - Cart Battery On/Off Switch
This switch turns on and off the external ground power feed. It should only be ON when the model is parked - in real life it would only be on when a ground cart power source was attached to the aircraft.

The Flight Engineer's MJB #2 Panel has controls related to electrical and engine operations. Most of these controls are inactive for the moment, with the exception of the ones labelled by numbers. As with the other panels, the instrument light control knob adjusts ALL instrumentation lighting, not just the ones associated with this panel.

Figure 13a - The MJB #2 switch panel

56 - Starter Selector Warning Lamp

This lamp illuminates when the starter selector knob is in any position other than OFF to warn the user that the starting system is enabled, as long as power is present on the D.C. electrical bus.

57 - Priming Button

This button primes the engine by introducing fuel directly into the intake system in order to ease cold condition starting. It is not necessary or operational for use in Flightgear at this time. There is no keyboard command for this control.

58 - Starter Activation Button

This button activates the starting motor on the selected engine. It may also be activated by pressing "s" on the keyboard. There must be DC voltage present on the electrical bus for the starter to operate.

59 - Starting System Selector Knob

This knob selects which engine the PRIME and START buttons will effect. Repeatedly clicking on it cycles through the OFF-3-4-2-1 sequence. There is no keyboard command for this control.

The Pilot's Overhead Engine Shutoff Drum contains levers that control fluid flow to each engine, and the fuel dump levers. The black handled levers are shutoff levers, the red handled levers are the fuel dump levers (which are not operational at this time).
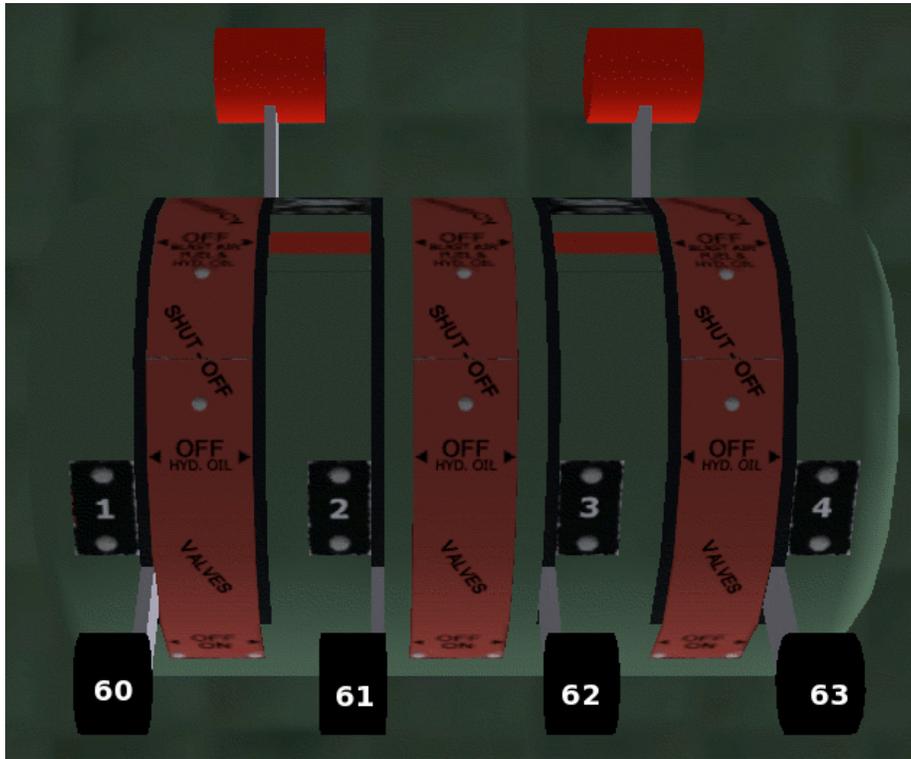
Figure 14 - the Overhead Engine Cut-Off Drum

60-63 - Engine Fuel Overhead Shut-Off Levers

These levers are fuel shut off valves for each engine. These are 4 position levers, although at present only 2 operation functions are modelled in Flightgear. In the forwardmost 2 positions (toward the nose of the model) engine fuel flow is enabled, in the rearmost 2 positions (toward the tail of the model) engine fuel flow is inhibited. Default setting when Flightgear is started is for these to be in the forwardmost position as shown. There are no keyboard commands for these controls.

The **CTRL-I** dialog box is opened with the CTRL and "i" keyboard combination. It gives access to some controls and settings which are not accessible through mouse clicks or keyboard commands. It also gives convenient access to an improved radio frequency dialog, allowing the user to set the frequency of all the radios (including ADF #2 which the standard Flightgear radios dialog does not).
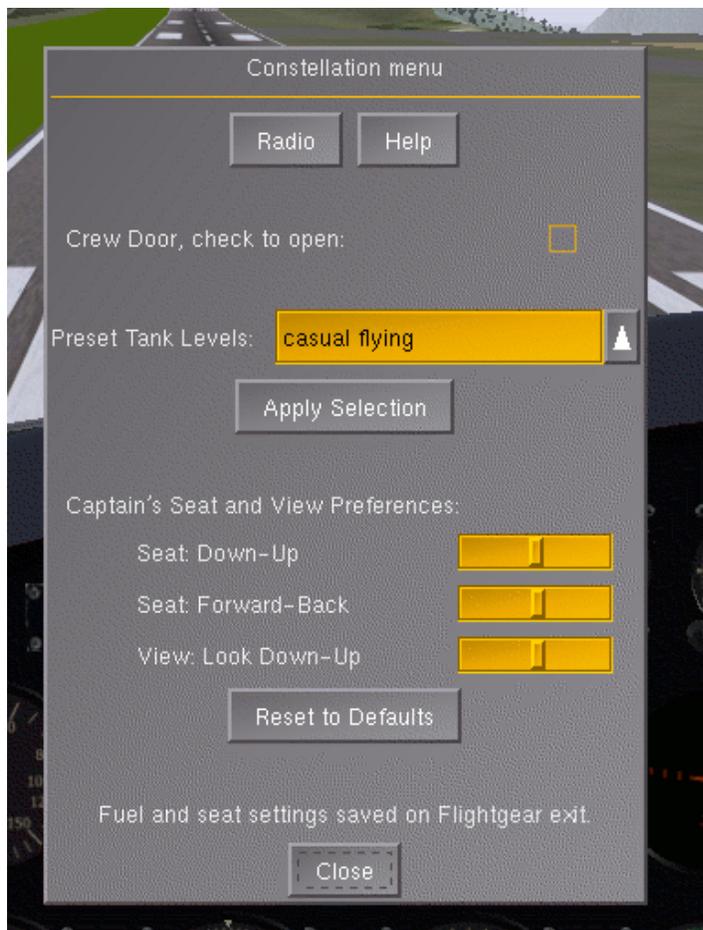
The RADIO button opens the improved radio frequencies dialog, and is discussed in more detail under **Navigation Radios**.

The HELP button opens the model's quick-help dialog box, the same as accessing it from the Flightgear HELP menu item.

Checking the CREW DOOR box will toggle the aircraft crew door open and closed (in Flightgear 1.9 and up you can click on the door itself also).

The PRESET TANK LEVELS expansion arrow and "Apply Selection" button allows the user to select from preconfigured fuel level settings. This is discussed in more detail under **Fuel System Operations**.

Figure 14a - the CTRL-I dialog box

The CAPTAIN'S SEAT AND VIEW settings allow adjusting the position of the pilot's viewpoint by simulating movement of the chair up and down as well as forward and back. The model will animate the chair moving forward and back, but it does not visually move up and down.

Also on the main Flightgear menu bar to the far right is a special Constellation menu (not pictured) which lets you select a livery from the installed choices, and instantly flip the COM1 radio to 122.75 which is FGCom's Air-2-Air channel.

When Flightgear is exited cleanly from the menu (not a force-quit, terminal control-c or unexpected program termination) the selected fuel preset, pilot's seat settings and selected livery will be saved so that the next time Flightgear is opened with this model, those settings are automatically applied.

Part Three: Fuel System Operation

These procedures ONLY apply to the 1049h model in Flightgear - do not attempt to operate any real world aircraft or engine using these procedures!

The Flightgear 1049h fuel system consists of seven fuel tanks, four "buffers" (which Flightgear sees as low-capacity tanks) to serve as an interface between the seven fuel tanks and the engines, the four tank selector levers on the flight engineer's console, the 4 cross feed levers on the flight engineer's floor station, the center tank shutoff lever also on the flight engineer's floor station and finally the fuel shut off/dump lever drum above the pilot.

Flightgear is not completely configured internally to handle multiple fuel tanks, so the 1049h system utilizes Nasal programming to simulate the process in a manner more accurate to the real aircraft. The 4 "buffer" tanks are an artificial construct which give Flightgear a simple source for each engine to draw from, and the Nasal code takes care of transferring fuel values from the seven actual tanks into those buffers according to the control selections. If you look at the internal Flightgear properties you will see 11 fuel tanks configured, the first four are the buffer tanks of 1.8 gallons and the remaining 7 are the actual fuel tanks.

Fuel can be fed to the engines in two ways, either a direct draw configuration or a crossfeed configuration. Both methods are discussed here.

In the direct draw configuration, the crossfeed levers and center tank shutoff levers on the floor station are closed. Each engine draws from an individual fuel tank using the four tank selector levers on the control console as on/off valves, with each engine being fed from only the tank indicated on its selector lever. Using this configuration, engine #1 can only draw from tank #1, and engine #4 can only draw from tank #4. Engine #2 can draw from either tank #2 or #2A, likewise engine #3 can draw from either tank #3 or tank #3A. None of the engines draw from the center section tank in this configuration.

In the crossfeed configuration, things can get a little fuzzier. When a fuel tank selector valve is opened, it makes fuel available not only to that engine, but also to the crossfeed line (the exception to this is the #5 center section tank lever which only makes fuel available on the crossfeed line). When the crossfeed valves are closed, the engines cannot draw fuel from the crossfeed line and are limited to accepting fuel from their specific tank selector lever on the control console. When the crossfeed valve for an engine is opened at the floor station, it allows that engine to accept fuel from the crossfeed line, which means that engine can draw fuel from any of the tanks which have their selector valve open, including the center section tank. It should then be apparent that the only way to access the fuel in the center section tank is through the crossfeed line. In a low-fuel situation, the crossfeed line can keep all 4 engines running even if only one tank has fuel, but this will not reduce overall fuel consumption.

In Flightgear the fuel is actually fed into those 4 1.8 gallon buffers which the engines in fact draw from. The buffer tanks can almost be thought of as large capacity carburetor float chambers on each engine - when a tank runs dry the engine will continue to run until that tiny amount of fuel is also consumed then it will shut down. Also, the overhead fuel shutoff levers will shut off fuel flow to the engines regardless of any of the other levers.

The 1049h model has some pre-configured fuel settings for convenience, accessible through the CTRL-I dialog box. Bring it up on screen with CTRL-I and you can select one of 4 preset configurations from the pop-up menu.
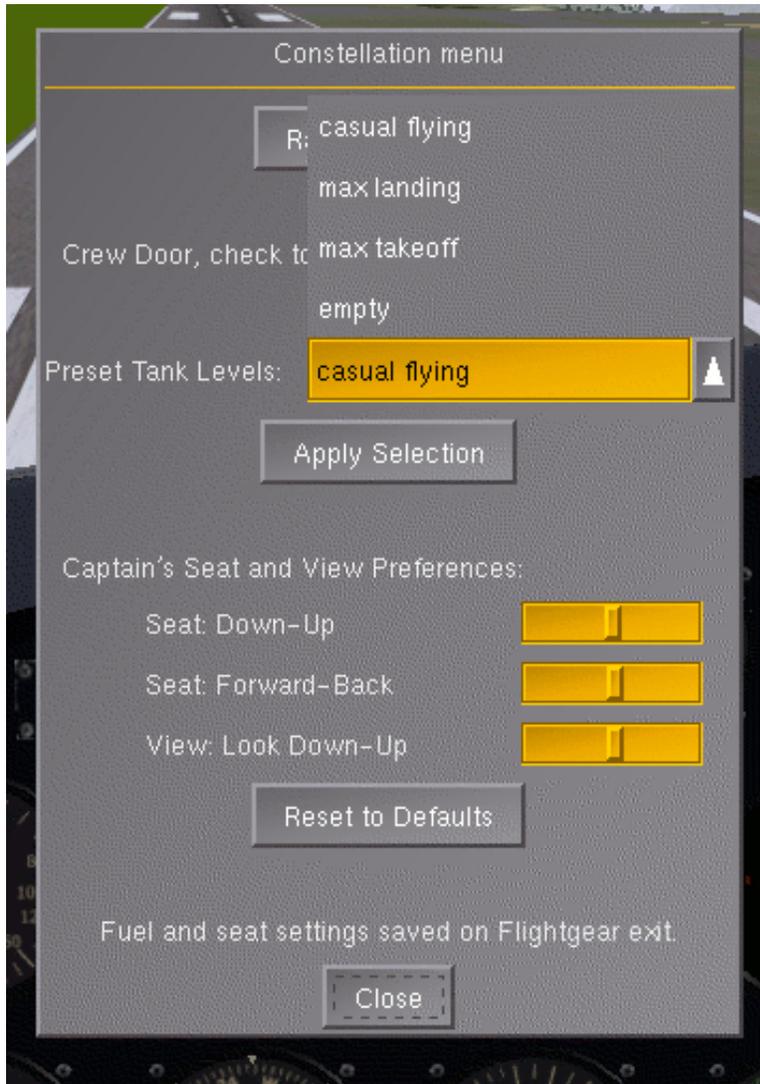

MAX TAKEOFF gives a full fuel load, the maximum amount which can be loaded and still be within safe parameters. It also sets the fuel tank selector levers to the appropriate tank selections for takeoff, closing the center tank and crossfeed valves.

MAX LANDING sets the fuel tanks to what would be the maximum weight allowable for a safe landing - in reality an aircraft would either fly a holding pattern to burn off fuel down to this level or dump fuel down to this level prior to landing. This preset also sets the fuel selector levers to the appropriate landing settings, closing the center tank and crossfeed valves.

EMPTY puts all tanks at 0 level, and places all the tank selector levers into the same configuration as for max takeoff.

Figure 15 - the CTRL-I dialog box with fuel preset menu expanded

CASUAL FLYING gives a reasonable fuel load for practice flights, and sets the center tank and crossfeed valves to OPEN in order to make use of all available fuel without further user input.

You can customize the fuel presets by editing the XML files, adding or altering the existing ones as you desire. In addition, fuel can be added/removed from any tank simply by clicking on the left or right side of that tank's fuel gauge on the flight engineer's upper panel (or by using the EQUIPMENT menu in Flightgear 1.9 and higher). The fuel system presets will not set the position of the pilot's overhead fuel shutoff levers, so those controls need to be checked manually to ensure that the engines will receive fuel.

Part Four: Engine Operation

These procedures ONLY apply to the 1049h model in Flightgear - do not attempt to operate any real world aircraft or engine using these procedures!

NOTE: Some of the engine operating parameters shown on the instrument panel are in fact estimated values, not directly read from the Flightgear properties. This is because of some issues in how Flightgear and JSBSim handle large piston engine calculations, which result in some parameters being set to unrealistic or physically impossible values (for example, the oil pressure as computed by Flightgear itself is around -40PSI at times, the cylinder head temperature can be reported as high as 20,000 degrees F/11000 degrees C and oil temperature may be reported as high as 5000 degrees F/2760 degrees C). Therefore a short section of Nasal code is employed to take the values from Flightgear that are calculated in a realistic manner (such as torque, RPM, exhaust gas temperature) and estimate the other values from the known good ones. As Flightgear and JSBSim improve, this extra code will be phased out.

In real life, the Lockheed Constellation was one of, if not the, most complex piston engine powered aircraft ever flown. In the interest of gaining more power and better efficiency, the engines were modified, adapted and tuned to the highest degree possible. The engines had to be monitored and adjusted (by the flight engineer - no computer controlled engine management systems) constantly during the flight or significant if not catastrophic failure could occur. Every parameter of engine operation was shown on the flight engineer's panel, including a real time spark analyzer. Techniques such as water injection and exhaust gas recovery turbines added to the complexity of these highly-tuned supercharged power plants, making the flight engineer's job even more difficult. Also the hydraulic and aircraft electrical systems had to be monitored and controlled by the flight engineer as well.

The Flightgear 1049h is nowhere near as complicated as its real life counterpart, but it is not a "gas it and go" model. Some attention to engine operation is needed in order to enjoy a successful simulated flight. The main controls used at this time to adjust the engines are the throttles, mixture levers, propeller pitch lever and supercharger selector levers. The starting system consists of the starter selector knob, priming button and starter activation button.

As the engines are throttled up, you will see the fuel flow increase and fuel pressure decrease (faster fuel consumption), manifold pressure and RPM swing upward, the exhaust gas temperature indicators will rise, and slowly the oil temperature and cylinder head temperature will come up as well. Oil pressure will come up but slowly come down again as the oil gets warmer, and the BMEP instruments will indicate that the engines are developing more power.

Adjusting the mixture toward LEAN will cause the exhaust gas temperature to rise to a peak and then it will start to fall off again. This is the peak EGT setting and in theory represents the most efficient burning of the fuel, but it is not the ideal setting for best engine performance within Flightgear. Normally you want to adjust the mixture to burn about 75 to 100 degrees F/45 degrees C below the peak EGT on the rich side, so the proper procedure is to lean out for max EGT than richen up to 75-100 degrees F/45 degrees C below that value (or full rich whichever comes first). You can fine tune the exact amount by watching the BMEP instruments, when those reach their peak value that is the setting you want.

It is worth noting some research which indicates that on real world engines of this type, it was not uncommon to have the power and EGT peak together, and the BMEP would acheive maximum value at that point. This would indicate that the engines should be operated at max EGT in real life. Also it was not unusual to see max EGT temperatures well above what we see in Flightgear, (1200-1500 degrees F/650-815 degrees C from what we have been able to find). But operating the model like that within Flightgear does not yield optimal results.

Altitude comes into play when adjusting the mixture, since at higher altitudes there is less oxygen in the atmosphere. This causes the air/fuel mixture (technically the oxygen to fuel ratio) to go richer on its own during an ascent, and leaner on a descent. So during a flight you will need to lean out the mixture as you ascend, and richen up again as you descend. Generally at sea level and up to around 5000 feet you want to use a full rich setting. If you leave the mixture at full rich, the engines will start to lose power around 7000-8000 feet and will likely cut out completely around 9000. Likewise if you lean out on an ascent and forget to richen up on descent, you will lose power as you descend (usually an embarrassing thing to do right when landing). An important note to this is that Flightgear version 1.0.0 was much less sensitive to mixture settings than 1.9.x or 2.0 builds.

At lower altitudes you want to use the low speed supercharger to get maximum air volume, it provides higher volume at lower boost pressure. Once you get above around 9000 feet, the air is getting thin and the lower speed supercharger cannot push enough air into the engine to maintain manifold pressure. Switching to the high speed supercharger at altitudes above 9000 feet gives you more boost, allowing you to ascend up to and over 20,000 feet with adequate manifold pressure to sustain flight. 1.9 and previous versions of Flightgear did not use the 2 speed superchargers so this is a new control for 2.0 fliers. The superchargers are a centrifugal type that actually build more boost as RPM comes up, so the expected behavior of manifold pressure rising as RPM comes down does not occur.

In the 2.0 version of Flightgear, manifold pressure is affected by the throttles, supercharger setting, engine RPM, barometric atmospheric pressure, temperature and airspeed, so a change in one of those factors usually requires a subsequent adjustment to some others. Propeller pitch is often compared to the transmission in a car or truck, where the fine or low pitch is similar to first gear (lots of power at low speeds, RPMs go way up, lower manifold pressures) and coarse/full pitch is similar to 5th gear (lower RPMs, less power at low speeds, higher manifold pressures). The throttles control manifold pressure primarily, but the other factors will cause it to change as the airflow to and through the engine changes.

The main goal of engine management is to maintain the best possible speed while minimizing fuel consumption, without exceeding the minimum or maximum safe parameters for engine operation. Takeoff is a special circumstance, where fuel consumption is traded for more power to get off the ground, and the engines are run in an overly high power state for a short time. So for example, on a sea level takeoff the appropriate settings would be fine/low pitch, a high throttle and full rich mixture without worrying about the EGT values or fuel consumption. Once off the ground, the settings would be changed to a normal climb configuration to reduce fuel consumption and keep the engine RPM and temperatures within allowable parameters. Normally this would involve backing off on the throttles, adding on some propeller pitch and adjusting the mixture during the ascent to maintain correct BMEP and speed while not exceeding RPM, temperature, or manifold pressure limits.

Once at cruise altitude, the configuration would be changed again, with the intent to minimize fuel consumption while maintaining cruise speed. Normally this would be to take the propellers to an even higher pitch/lower RPM, set the throttles to a manifold pressure that maintains constant speed and keep the mixture set around 75-100 degrees F/45 degrees C rich of peak. Slow climbs and descents can be achieved by adding in a small amount of throttle to increase power for ascent or pulling off a small amount for descent without changing airspeed...keeping in mind that mixture may need to be readjusted for altitude change.

Approach and landing is yet another reconfiguration, where speed control is most critical. Fuel consumption and engine temperature usually are not a concern on approach and landing since descending takes much less power, but the engines are generally configured similar as for climb so if an approach has to be rejected, there is no frantic changing of controls to go around, just add throttle and increase RPM to climb out of the rejected approach. As the model is slowed to approach speed the pitch is adjusted forward (RPM is set to 2400 according to Airline History Museum checklist) and speed is controlled on the throttles. Mixture comes to full rich around 5000 feet (high altitude landings require keeping a leaner mixture), superchargers are set to LOW and the throttles are adjusted to maintain approach speed as flaps and gears are lowered. On a short strip landing, the propellers may be put into negative pitch configuration and throttle/RPM added to assist in stopping after touchdown.

IMPORTANT: In Flightgear 2.0 you do not want to use full fine/max RPM pitch for approach or landing. This is because of the way Flightgear 2.0 handles manifold pressure and propeller drag. What seems to happen is this: as you make an approach and slow to landing speed, the manifold pressure (which is affected by more than just throttle position in Flightgear 2.0) drops off and there is a decrease in thrust. When this takes place, airspeed falls off sharply and since approaches are made at fairly slow speed a stall is likely. Smooth landings are easier to perform when you use the real world recommended setting of 2400 RPM. This allows a slightly higher throttle setting at approach speeds, keeping manifold pressure up enough to maintain power on the engines. Decreasing manifold pressure too much can still result in the loss of power/stall scenario but it is easier to avoid and at the higher pitch the resultant drag when the RPM drops to near idle is not as severe.

Flightgear 1049h min/max engine parameters

RPM	2900 max	
Cyl Head Temp	520F/270C max	200F/93C min
Oil Temp	210F/100C max	80F/26C min
Oil Pressure	130PSI max	10PSI@idle/80PSI@full RPM min
Manifold Pressure	57 max	

At this particular point in time, the 1049h model does not experience negative consequences for exceeding these parameters, but as the model is developed and refined there are plans to add engine failure simulations when operating parameters are exceeded.

Notes:

The maximum temperatures, RPM and manifold pressure are taken from actual documents regarding the operation of Wright-Cyclone R3350 engines, as is the minimum oil pressure value. The minimum temperatures are estimated based on knowledge of other engines, but are subject to correction if and when actual R3350 data is found.

Maximum allowed manifold pressure is also dependant on fuel grade - 57 inches was only allowable when using 140 octane aviation fuel (which is now very difficult to obtain). Using 110 octane aviation fuel reduced the maximum manifold pressure to around 51 inches. Since Flightgear does not simulate different fuels, the high octane values may be used.

Maximum power was only allowable for a short time (less than 2 minutes) for take off. After the landing gear was raised, power was immediately reduced to the "Maximum Except Take Off" setting for initial climb. According to the flight engineer's quick reference documents from the Airline History Museum, METO is 44 inches of manifold pressure, 2600 RPM and a BMEP of 216. Within the Flightgear 2.0 environment, using that manifold and RPM setting will maintain a constant 1200 foot/minute ascent with around 240 BMEP. Previous versions of Flightgear were considerably overpowered at that RPM/manifold pressure setting.

The Airline History Museum also had notes for standard and maximum climb settings, which were:
> STANDARD=38 inches manifold, 2400 RPM, BMEP 185
> MAXIMUM =40 inches manifold, 2500 RPM, BMEP 200

The Flightgear 2.0 environment comes fairly close to matching these settings.

Normal cruise power was around 36 inches of manifold at fairly low RPM (2000 RPM and BMEP of 170 for 195-200 knot cruise according to Airline History Museum documents). In Flightgear 2.0 using this setting pretty closely matches the real world aircraft, manifold pressure of around 34 and 2000 RPM gives a 200 knot speed at half fuel load. Changes in weight from fuel or payload will cause deviation from these the exact settings, as will atmospheric conditions. In real life a published power table is available to aid in setting correct power based on altitude/temperature/barometric pressure - we have not yet obtained a copy of that document.

Part Five: Navigation Radios

These procedures ONLY apply to the 1049h model in Flightgear - do not attempt to operate any real world aircraft or engine using these procedures!

Flightgear implements a very complete and realistic radio navigation system, complete enough that real world Aviation Sectional Charts and most Approach/Departure Procedures can be used in conjunction with Flightgear for simulated cross-country flights (at least in the USA). The 1049h model gives good access to the underlying Flightgear navigational modelling through the use of the RMI instrument, the Zero Reader and the NAV/ADF radios.

In addition to having the NAV/ADF radio controls available on the overhead panel, access to them is also available through the CTRL-I dialog box on screen. Bring it up on the screen like you would for the fuel presets, and press the RADIO button.
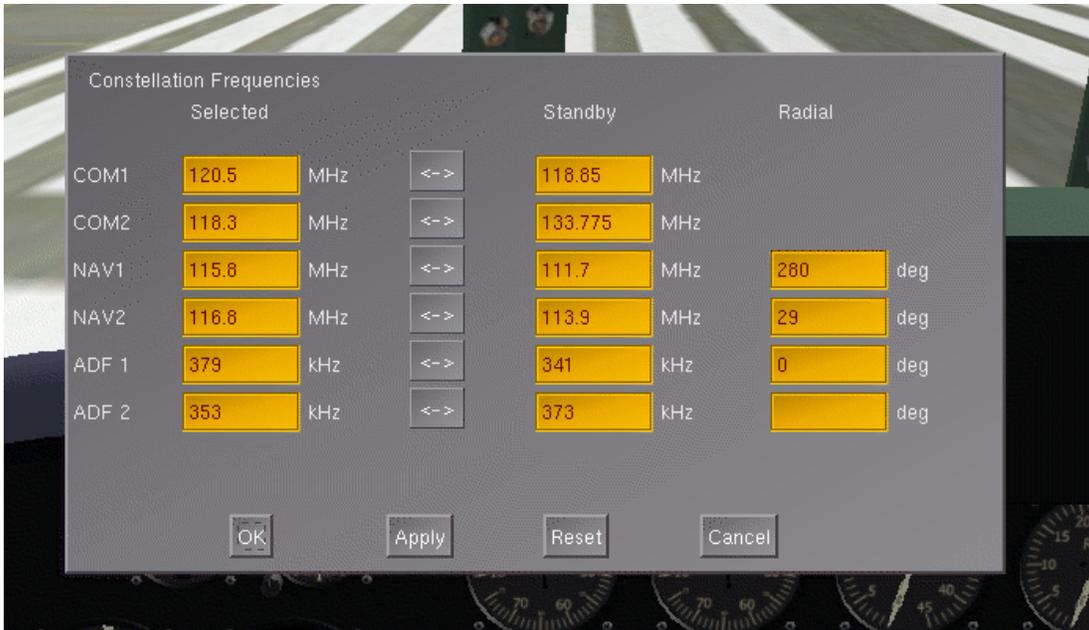

Figure 16 - the radio options in the CTRL-I dialog

This will allow you to quickly set the frequencies for any of the simulated radios. It is a subtle but important distinction to note that this dialog box is slightly different than the standard Flightgear EQUIPMENT/RADIOS dialog in that using the CTRL-I dialog box will allow you to set the frequency for the ADF2 radio which is not accessible from the standard Flightgear menu dialog. In this dialog you can also set the RADIAL values, which are not currently displayed on any of the 1049h instruments but will be rendered on the Flightgear Atlas companion application if you are running it in conjunction with Flightgear.

The COM1 and COM2 settings are generally used just to get the automated ATC/ATIS functions built into Flightgear, but you can also use COM1 in conjunction with the fgcom application for voice over IP as well. The fgcom application is well covered in other Flightgear resources - see *http://wiki.flightgear.org/index.php/FGCOM* for more information.

While a full discussion of radio navigation is beyond the scope of the 1049h model description, it is useful to briefly summarize several different types of Navigational Aid transmitters in order to effectively explain how to use the 1049h model's instrumentation. A full and complete discussion and tutorial on radio navigation and instrument approach/landing can be found in the United States Federal Aviation Administration's Instrument Flight Handbook which is available from the FAA web site. For details visit the FAA site http://www.faa.gov/library/manuals/aviation/instrument_procedures_handbook/

VOR (VHF Omni Range) transmitters are a special radio station that send out a pattern of calibrated high frequency signals called radials (because each one projects out in a straight line from the transmitter like spokes in a wheel). These signals are calibrated in such a way that the receiving radio can display WHICH of the radial signals it is receiving, and thus tell the user which direction the physical location of the transmitter is relative to the receiver. The practical application of this is that a VOR receiver can tell the user which direction to travel in order to track a straight line to the transmitting station. Place such a transmitter at an airport and it becomes a very valuable tool for aircraft to fly to that airport, even when unable to see it. Some VOR transmitters also incorporate a DME (Distance Measuring Equipment) signal as well, which are timed pulses that allow a receiver to determine the distance between the transmitter and receiver.

An ILS (Instrument Landing System) transmission is actually 1, 2 or 3 separate pieces of information transmitted together. Part 1 is the localizer signal, which is similar to the VOR radial transmission but much more precise. This portion of the signal allows a radio receiver to detect whether it is on a transmitted center line, and to a limited extent how far off from the center the receiver is. The second part of an ILS transmission is the glideslope signal, which transmits a straight line upward at an angle from the transmitter, and the receiving radio can determine if it is on that line, or if not it can detect if it is above or below the line. The 3rd part of an ILS transmission can be the DME signal in the same manner it can be part of a VOR transmission. An ILS transmitter is normally positioned and calibrated to guide aircraft to a safe landing on a specific runway at an airport, and an aircraft equipped with the proper receivers can execute an approach and landing even if the runway itself is completely obscured by weather.

An NDB (Non-Directional Beacon) is an older technology system that just sends a simple signal similar to a commercial radio station. The ADF (Automatic Direction Finding) receiver uses a rotating directional antenna to determine what direction the transmitter is in relation to the receiver based on signal strength. While not as precise as VOR it allows a receiver to determine which direction to travel in order to arrive at the transmitter location.

In the 1049h model, the NAV1 and NAV2 radios are used for either receiving VOR transmissions for navigation or ILS transmissions for instrument approaches and landings. Each radio can receive one or the other, but not both at the same time. VOR reception results may be shown on the RMI instrument, ILS reception results may be shown on the Zero Reader instrument.

The 1049h model also includes two ADF receivers for utilizing the NDB transmissions. These radios do not perform any other function, they only receive NDB signals. The results of the NDB signal reception may be shown on the RMI instrument.

Choosing what results get shown on the RMI and Zero Reader is accomplished with the center arch selector switches (refer to Figure 12). When no appropriate signal is being received, the needles of the RMI instrument will go to a flat horizontal rest position, and the Zero Reader will go blank.

The Zero Reader can display output from either the NAV1 or NAV2 radio if the selected radio is receiving valid localizer and/or glideslope signals as part of an ILS transmission. If the NAV radios are receiving VOR signals the Zero Reader will go blank (note: Zero Reader functionality will be modified to include VOR omni bearing display in the future). The Deviation Selector Switch on the arch panel selects which NAV radio the Zero Reader is linked to for display.

When receiving an ILS transmission, the Zero Reader displays a horizontal and vertical line on its face. The vertical line represents the runway centerline as transmitted by the localizer portion of the ILS signal, and the horizontal line represents the glide slope as transmitted by the glidelope portion of the ILS signal. DME information is ignored if present for now. Since the vertical line represents the runway centerline, it shows the user which direction to adjust in order to rejoin the center line. Likwise the horizontal line shows the center of the glide slope, and whether the user is above or below that projected slope.

Figure 17 - off center Zero Reader

Figure 18 - on center Zero Reader

For example, in Figure 17 the vertical line is shown to be significantly to the left of center on the Zero Reader. It means the receiver is off to the right side of that centerline and the user needs to adjust their course to the left to regain the centerline. The horizontal line in Figure 17 is also well above the centerline which means the user is significantly below the optimal glideslope and needs to ascend in order to re-establish a proper approach. Figure 18 shows a well centered approach with both the localizer and glideslope indicators nicely centered on the instrument.

Be aware some airports have localizer but NOT glideslope signals. In that special circumstance, only the vertical line can be trusted to give a valid deviation indication and the glide slope must be determined by other means - a non-moving horizontal line may appear in the Zero Reader under that circumstance or it may show just the vertical line. Also in Flightgear 2.0 the glideslope portion of the ILS signal has a much shorter range than the localizer portion, so until the model is close enough to receive glideslope information the horizontal line will remain centered.

One extra note concerning glide slope reception in Flightgear 2.0 - the simulator attempts to model the effect of "false positive" readings if the receiver is severely above or below the true glide slope. This is seen as a fairly rapid cycling of the glide slope indicator line from low to high and back again, usually when very close to an airport but not actually on the true glide slope. It can lead to following a false reading so cross checking altitude and distance from the runway is always a good idea.

The RMI instrument has 2 needles. Needle #1 can link to either NAV1 or ADF1, while Needle #2 can link to NAV2 or ADF2. The RMI will only respond to a NAV radio if it is receiving a valid VOR signal - ILS signals will not be displayed and the needle will go to the horizontal rest position if linked to a NAV radio receiving an ILS transmission. If the needle is linked to the ADF receiver and there is a NDB signal being received by that receiver, the RMI needle will display the results of that signal. Which radio is linked to the RMI needles is chosen by using the Needle 1 and Needle 2 Selector Switches on the center arch panel. When an RMI needle is linked to a radio receiving an appropriate signal, the needle will swing around the compass face and indicate the heading which would need to be travelled in order to arrive at the transmitting station.

Figure 19 - RMI with no signal

Figure 20 - RMI receiving signals

In Figure 19 you can see the RMI instrument at rest, with both needles in the default no-signal rest position. In Figure 20, Needle #1 has been linked to NAV1 receiving a VOR station, and Needle #2 has been linked to ADF2 receiving an NDB signal. The model is heading due north in this example - if the course were changed to 010 degrees the model would fly directly toward the VOR transmitter NAV1 is tuned to, and if the course were adjusted to 300 degrees the model would fly directly toward the NDB transmitter which ADF2 is tuned to.

Part Six: Check Ride

These procedures ONLY apply to the 1049h model in Flightgear - do not attempt to operate any real world aircraft or engine using these procedures!

The control settings described in this section are intended for Flightgear 2.0 users. If you are using an earlier version the control settings will be different (most likely lower power settings to obtain similar performance).

To make sure everyone can start on the same page, this tutorial will start the flight at San Francisco Airport (KSFO). This way there is no need to download any additional scenery if you are new to Flightgear. You can connect to the multiplayer system if you prefer (and you think you're enough of a hotshot to get this right the first time with an audience). I usually start on runway 19R just to stay out of the way of people who default spawn on 28R, so when I first start up Flightgear it looks like this:

Figure 21 - initial startup

Before takeoff, a simple preflight checklist makes sure everything is working properly:

0 - Switch on electrical power
       Set SHIP BATT and MAIN GENERATOR switches to ON and APU and CART BATT to off.

1 - Calibrate altimeter to runway altitude
       Note that in Figure 21 the altimeter shows 120 feet below sea level. Runway 19 is 11 feet above sea level so click the altimeter calibration knob until it shows close to 11 feet.

2 - Set parking brake (if not already on)
       Parking brake should be ON when Flightgear starts but make sure it didn't get turned off by accident.

3 - Set engine controls
* Full rich on the mixture (levers fully away from viewer)
* Propellers to LOW/FINE pitch (lever fully forward)
* Propeller reversers DISENGAGED (warning lights on main panel OFF)
* Reversing lever lock-out ENGAGED (lever forward)
* Magneto switches to OFF
* Supercharger levers on LOW (levers away from viewer)
* Throttles to IDLE (levers all the way back toward the viewer)
> These (except for mixture) are also the default startup positions, but after flight and/or playing with the keyboard commands they could have gotten changed so it is best to double check.

4 - Select a fuel preset and configure fuel system
If the fuel preset is set to EMPTY this is going to be a real short trip. Call up the CTRL-I dialog and select/apply CASUAL FLYING from the pull-down for a short pattern flight like this one. Ensure the 4 black levers (60-63) on the overhead engine cut-off drum are in the fully forward position.

5 - Start engines (this is slightly different than the normal Flightgear startup procedure)
* Switch all magnetos to BOTH (either by keyboard or mouse control)
* Recheck throttles at idle, mixtures to full rich
* Click starter selector knob on the MJB panel until the desired engine is selected, lamp should light
* Press "s" or mouse-click the start button on the MJB panel to start the selected engine
* Repeat for the remaining engines
* Return starter selector switch to the OFF position
* Open cowl flaps to 40% on all 4 engines
- Realism notes:
> -The engines would be cranked through approximately 3 or 4 complete revolutions with the mixture set to FULL LEAN (levers all the way back) prior to bringing the mixture up to FULL RICH. This was to allow oil trapped into the lower cylinders to cycle out prior to the engines starting in order to prevent a damaging hydraulic shock to the pistons.
> -They were warmed up to standard operating temperature before being powered up past idle, the cowl flaps were opened and closed as needed to maintain proper engine temperatures.
> -If the engines has not been run for a while, the PRIME button would have been used to prime the cylinders with fuel for easier starting.
> -The engines should be started in a balanced order (3-4-2-1)

6 - Calibrate gyrocompass
The gyrocompass is somewhat random until the engines are running since it operates on vacuum. Once the engines are running it can be set to match the reading of the magnetic compass, which is visible in the upper right corner of Figure 21 (just above the fuzzy dice).

7 - Verify operation of the attitude indicator
Note that in Figure 21 the Attitude Indicator shows a non-level condition even though the model is sitting level on the runway. This is because, like the gyrocompass, the Attitude Indicator requires a source of vacuum for operation so it will not work properly until #1 engine is running.

8 - Tune the radios and set the RMI/Zero Reader selectors
If possible, it is good to tune the radios to the needed frequencies prior to takeoff (one less thing to do in flight). The RMI may already show some headings and bearings from Flightgear's default values, but the next pages will give custom settings to demonstrate more functionality of the navigation radios.

The Flightgear add-on program Atlas will be used to fill in as a simplified sectional chart, simply because a real sectional chart is copyrighted material and cannot be reproduced here. Atlas is useful for quick setup, but a real sectional chart has much more detailed information. Web sites such as http://www.runwayfinder.com and http://www.fltplan.com will show real sectional and airport procedure charts with all the detailed information available.
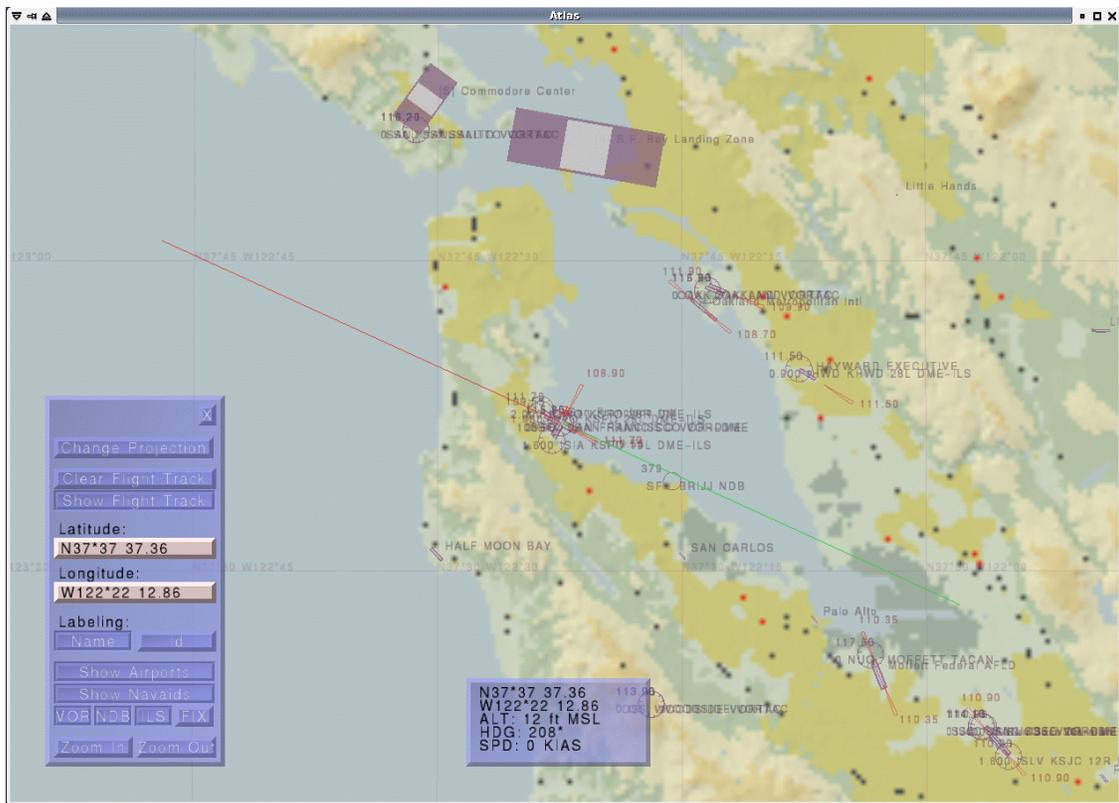
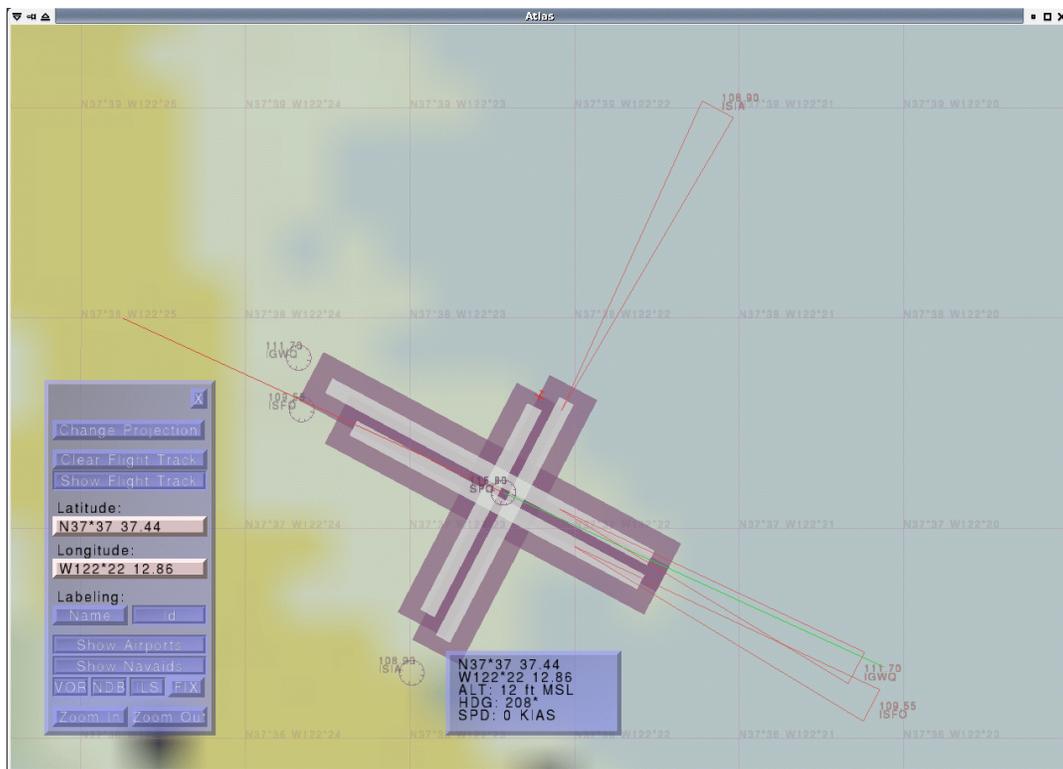*Figure 22 - the Atlas add-on program showing KSFO area*

Figure 23 - Atlas zoomed in close on KSFO to show VOR and ILS transmitters

Looking at Figure 23, notice that the ILS transmitter for runway 28L is 109.55, and the VOR in the center of the runways is 115.80. This alone would be enough information to do a simple flight, but when looking at Figure 22 there is also an NDB transmitter (labelled BRIJJ) right in line with the 28L and 28R runways on frequency 379. So for this flight, set NAV1 to the 115.8 VOR at the airport, set NAV2 for the ILS frequency of 109.55, and tune ADF2 to 379 to catch the BRIJJ NDB transmitter on the approach path.

Figure 24 - main panel ready for takeoff

Note in Figure 24 that the arch panel selectors are switched to feed the appropriate signals to the RMI and Zero Reader, and that the Zero Reader has come on and is showing the glide slope and localizer deviation for runway 28L.

9 - Switch on the landing, running and anti-collision lights

In real life these would be turned on even in the daylight to alert other aircraft that a plane is about to start moving. Use the overhead panel and left side switch panel as shown in Figure 10 and Figure 11 to switch on the lights.

Figure 25 - engine instruments in normal range

10 - Confirm engine instruments are in normal range

Right now the model does not generate engine failures if the engines are operated out of specification, but that will be implemented and it is good practice to confirm all instruments reading normal before takeoff since sometimes Flightgear program glitches will manifest themselves as very unusual values.

11 - Set flaps for takeoff position

Use the] key to move the flaps to the takeoff position, confirm position on the Flaps Position Indicator on the main panel.

12 - Engine Run-Up

This is where in real life all 4 engines would, one at a time, be run up to a set RPM/manifold pressure/BMEP with the magnetos switched between left, right and both. Any significant variation in performance would indicate an engine problem and the flight would be aborted until the problem was corrected. In Flightgear it is not truly necessary other than as a token of realism.

13 - Gyrocompass recheck

The gyrocompass drifts sometimes, and if significant time has been taken to go through the other procedures it may need to be adjusted slightly one last time to match the magnetic compass.

This concludes the Flightgear preflight procedure.

Preflight Realism Notes:

- In real life, a flight actually starts at the parking ramp (or terminal gate with larger aircraft), not on the runway. Most of the preflight procedures (and a real flight would have significantly more steps to follow) would be done prior to the aircraft even moving to the taxiway. Flightgear will let you start off at a parking or terminal gate position at some airports, but this is not universal on all versions.
- At a large international airport such as KSFO, every step from engine startup to takeoff would be done under the supervision of the control tower and clearance/permission would need to be obtained from ground and/or air traffic control prior to any aircraft startup or movement. Flightgear has a rudimentary automatic ATC (Air Traffic Control) facility, but that goes beyond the scope of this document.

Flight Procedures

(note that engine power settings mentioned here are based on Flightgear 2.0 performance and will differ significantly from real world engine performance)

14 - Take Off

Bring engines to 51 inches manifold, release the brake and steer the model down the runway with the rudder controls (manifold pressure rises with speed, adjust as needed). Around 150 knots it will lift off from the runway. Once the model leaves the ground, it will start to roll slowly to the left because of the engine torque. A little bit of right aileron control is needed to compensate and maintain a straight climb. As soon the model is clear of the ground, bring the landing gear up and at 160 knots retract the flaps. When the flaps retract the nose dips down so be ready with some elevator control to maintain climb.

15 - Climb out

Set engines for 44 inches of manifold pressure and 2600 RPM using the throttles and pitch controls. Maintain between 160 and 180 knots and around 1200 feet per minute of ascent to 5000 feet, then level out, maintaining 5000 feet and allow the model to accelerate to 230 knots.

Figure 26 - climb out over the Pacific Ocean

16 - Set cruise power and fly a right circuit maintaining 5000 feet.

When the model reaches 230 knots, adjust propeller pitch to 2100 RPM and set manifold pressure just under 40 inches. This will maintain around 230 knot cruise and while maintaining 5000 feet at 230 knots, execute a standard right turn to 010 degrees using the Rate Of Turn/Turn Coordinator instrument to measure turn speed. Correct turn speed is indicated when the needle lines up on the hash mark and the black slip indicator ball remains centered. Fly the 010 degree heading for 6 minutes.

Pay attention to the Attitude Indicator, Rate Of Turn/Turn Coordinator, Vertical Speed Indicator and Altimeter while executing turns. A smooth steady turn should not deviate more than around 50-100 feet in altitude from beginning to end. Slight elevator back pressure is usually needed to maintain altitude during a turn, and be ready to ease off the elevator pressure when levelling out to avoid an unwanted ascent at the end of the turn (more detail on this is discussed on page 41). A **very slight** amount of rudder will help keep the Turn Coordinator ball centered while the turn is initiated, but it is very easy to over use the rudder and make for an even more uncoordinated turn.

Figure 27 - cruising over the San Francisco Bay Bridge

While maintaining the 010 degree heading recheck the gyrocompass against the magnetic, keeping in mind that the magnetic compass is only accurate when the model is flying straight and level, neither changing altitude or course. Elevator and aileron trim can help make for a smooth straight flight. When you cross the projected centerline of the 28L runway you will see the Zero Reader vertical line swing from right to left.

After the 6 minute cruise at heading 010, execute a right turn to a heading of 100 degrees to fly the next leg of the pattern. This is where the RMI instrument becomes useful. Remember that Needle #1 is showing the direct heading to the airport, and that Needle #2 is pointing toward the BRIJJ NDB beacon several miles from the threshold of runways 28R and 28L.

Figure 28 - the RMI instrument showing the appropriate time to turn to 190

Since this flight will use a straight in approach to 28L, that BRIJJ NDB beacon is a very useful waypoint. Fly until the RMI Needle #2 indicates a heading of 240 degrees to the NDB beacon. At this point the Zero Reader should show a centered glideslope (because the model is too far away to get a glideslope signal) and the localizer is off-center (similar to what is shown in Figure 28). This is the appropriate time to check the gyrocompass calibration again, and then execute a standard right turn to heading 190 degrees while maintaining 5000 feet.

While on the 190 heading slow to 200 knots: reduce manifold pressure to around 34 and set 2000 RPM. Watch the Zero Reader and RMI needles - when both RMI needles point close to 270 degrees the cruise portion of the flight is over and it is time to configure for approach and landing.

Note: Before any significant course changes and periodically during straight and level flight, it is important to recheck the Gyro Compass against the magnetic compass to ensure it has not drifted. When making timed turns or precise heading changes it should be checked before every turn to ensure the maneuver is ended on the correct heading.

IMPORTANT: It is worth spending some time practicing making smooth controlled turns, since this is often one of the most difficult skills to master (particularly on a simulation program which offers no motion feedback to "feel" when something is changing). The 1049h model offers all the basic instrumentation necessary to accomplish this:

In the instrument cluster detail to the left, the 6 key instruments are shown while executing a right turn at 5000 feet. The numbers correspond to the following points:

1 - Bank at Standard Turn Rate which for a large/heavy aircraft such as an airliner is generally a 4 min=360 deg turn. So a 90 degree turn from 190 degrees to 280 degrees would take 1 minute.

2 - Maintain basically level attitude - the "horizon line" should intersect or nearly intersect the center point on the instrument - crosscheck against #3 and #4 to ensure no altitude change

3 - Should indicate zero rate of climb/descent. This instrument is often slightly delayed so crosscheck on #2 and #4 for signs of attitude and/or altitude change.

4 - Watch the altimeter, it gives direct and immediate feedback of change in altitude. In a well controlled turn, deviation of 50 feet is considered good and any deviation under 100 feet is considered acceptable.

5 - Maintain speed. Turning places additional drag on the aircraft, a slight power increase may be needed especially if turning at slower speeds. At 250 knots, a slight drop in speed would not be problematic, but at near stall speeds (under 140 knots in particular) this is vital to watch.

6 - The turn indicator shows a proper rate of turn (needle on the tick mark) and the black ball should be between the centering lines (indicating a properly coordinated turn). In this example, a VERY slight amount of rudder would center the ball.

7 - Watch the heading - begin to level off about 10 degrees before the desired heading to avoid overshooting.

Figure 29 - Approach configuration

Execute a right turn to heading 280, watching the RMI and Zero Reader while maintaining 5000 feet. The Zero Reader will show deviation left or right, so after executing the turn begin adjusting course to center up on the Zero Reader. Note in Figure 29 the Zero Reader not quite lined up (in this figure we see that the turn was executed slightly late and the runway centerline is now to the right of the model position), altitude still at 5000 feet and speed down to 200 knots. Also note that the RMI Needle #2 is pointing the same direction as the model's flight path, indicating that the model is flying directly toward the NDB transmitter as well.

Configure the engines for approach and landing. Bring the throttles back to around 22 inches of manifold pressure, and bring the RPM up to 2400. Maintain 5000 feet until the speed drops to 180 knots. A setting of 2400 RPM gives good control, using the throttles to adjust power for descent.

At 180 knots extend the wing flaps to the first position, at 150 knots extend them to the second position. This is the approach configuration. Descend to 3500 feet while centering up on the localizer portion of the ILS signals, keeping the speed around 150 knots. This will correctly position the model vertically for glide slope intercept once the glideslope signal comes into range. Maintain 150 knots at 3500 feet until the glide slope line on the Zero Reader activates, then continue descending while keeping both the glide slope line and the localizer line centered on the Zero Reader with gentle course and elevator/power corrections. Maintain between 140 and 150 knots using engine power, do not go too slow or a stall can occur.

Figure 30 - crossing over the outer marker

Right after crossing the outer marker (indicated by the flashing blue light to the left of the turn coordinator instrument), lower the landing gear and be prepared to add some power to compensate for the additional drag. Note in Figure 30 the landing gear has not yet been lowered, but the outer marker lamp is lit, as is the 2000 foot Terrain Warning Radar lamp. The Zero Reader is still very near center, speed is 140 knots, flaps are extended to the approach setting and the runways are barely visible at the horizon.

Note that even with good visibility, using the Zero Reader helps make a smooth controlled approach since the model is already properly lined up with the runway before it even becomes visible.

As the approach continues, bring the flaps to the 80% position at around 1500 feet above the runway and allow the speed to drop to 130 knots. Set the flaps to the full landing position at around 1000 feet above the runway and add a little power if needed in order to hold airspeed at least at 125 knots. Do not slow down below 120 knots at any time during the approach and do not reduce power so much that the engines quit providing power - this is the stage of the flight is where a stall is most likely to happen.

Figure 31 - just before touchdown

Maintain 125-130 knots until approximately 200 feet above the runway, then reduce engine power slightly to slow down to 120 knots for touchdown. Use small control movements to maintain runway alignment, being aware of side drift due to crosswind. Note in Figure 31 that the Zero Reader indicates centered but approaching very slightly above the glide slope. Speed is at 130, landing gear is down, flaps are at the landing position and altitude is just under 300 feet. Also note the 500 foot Terrain Warning Radar lamp is lit. Figure 31 shows the appropriate position to begin reducing power for touchdown.

Be aware that at times, crosswind may cause the model to drift off of the centerline of the runway. The crosswind can vary at differing altitudes as well, and it is not unusual for an otherwise near-perfect approach to get bent out of shape just before touchdown. Be prepared to use some very delicate rudder control and light adjustments of power during an approach, especially if you have real weather enabled.

Figure 32 - immediately after touchdown

Right at the moment of touchdown, use the rudder to adjust the model so it is moving straight ahead. Once the wheels touch down, bring the engine power all the way back to idle and use the brakes to slow down the model while steering with the rudder controls to remain centered on the runway. Ideally the touchdown should be with the nose wheel on the center line of the runway, but often crosswinds make it necessary to touch down at a slight angle to the runway and then ground steer to center.

In Figure 32, notice that the Zero Reader still shows centered on the localizer but the glide slope line is at the center rest position. That is because the model has passed the termination of the glide slope. Also note the manifold pressures at the bottom of the indicators showing engines at idle, the airspeed is under 100. This is the appropriate time for light braking - because KSFO has nice long runways reversing prop pitch is not necessary to slow down. On a shorter runway, it would have been necessary to use the propeller reversers to safely stop.

This completes the basic 1049h Check Ride - it is not easy to get exactly right without practice so do this until you can just fly around the pattern without even thinking about it. The nice thing about simulations is that the price of experimentation is zero, so don't be afraid to try different engine settings, flap settings, approach angles and such - the worst that happens is you have to reset and start over, but your insurance won't go up and no one calls the fire department. Don't be afraid to experiment with flying this pattern at night - Flightgear has some very nice runway lighting effects visible when set for night flying, and the 1049h cockpit has very realistic looking instrument lighting.

If you have "Fetch Real Weather" enabled on your Flightgear, each time you practice you will be faced with different wind and cloud conditions, possibly even rain which makes for an even more realistic simulation.

Closing Notes

This document was compiled without any direct input from aviation professionals in any way.

Unfortunately, I am not a licensed pilot of any type, and therefore any and all of the procedures and descriptions covered in this document were derived strictly from study of various written material and many hours of experimentation with Flightgear itself to determine what did and did not work. I have no illusions of accuracy, it is fully expected that any real pilot reading this document will find serious errors in both procedural and theory discussions.

All procedures were developed and refined through many days of testing (initally with Flightgear 1.9.1, and then retested with Flightgear 2.0.0) to determine speeds, engine settings, instrument readings and such that work well in the Flightgear environment. They may not be accurate to the real life aircraft. This version of the manual used Flightgear 2.0.0 as the basis for all values and settings.

Serious suggestions for improvement are always welcome. If anyone reading this document has either direct or indirect knowledge that corrects errors with facts, I would be delighted to hear from them.

This document is based on (and merely supplemental to) the Lockheed 1049H model for Flightgear designed, created and maintained by Gary "Buckaroo" Neely. Without his work, there would be no buttons to push, levers to pull or dozens of elegantly designed instruments to be hypnotized by.

All screen captures were done using Flightgear (versions 1.9.1 and 2.0.0) on Slackware Linux (with the exception of the title page image which was done with a Macintosh).   This document contains no copyrighted images, monosodium glutamate, transfats or calories. This document is free to distribute in whole or part, via print form or electronically. If it is not distributed in whole form, the warning notices that state this document cannot be used as reference for real world flight must be kept intact. Void where prohibited. Not suitable for children under 12 without adult supervision. Batteries not included. Mileage may vary based on vehicle condition and driving habits. Do not eat or ingest. For external use only.

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Unsolicited commercial or annoying email messages should not be sent to that address (or any other for that matter).