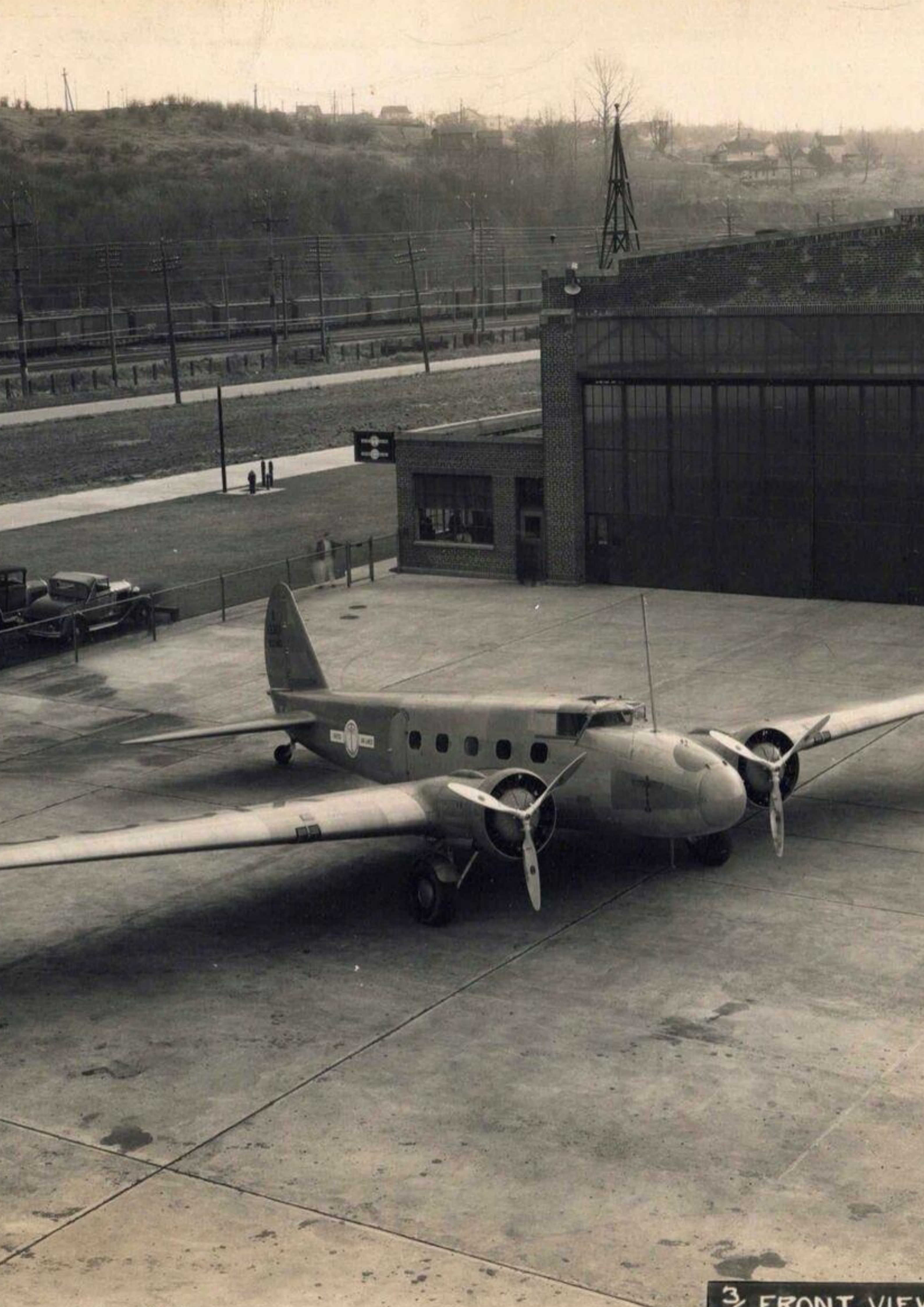
Wing42
Boeing 247D

Simulation manual

Last Revision: 2/04/2022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1 Preface

In the name of the developer team at Wing42, I want to thank you for your purchase of our Boeing 247D for Microsoft Flight Simulator. This add-on has been in development for over a year and countless hours of work, copious amounts of coffee, a plethora of sleepless nights, and a lot of love went into the creation of it. The result of this work is one of the most comprehensive simulations you can find in MSFS.

The add-on features the first installment of our Prop-o-Tronic physics engine, which replaces a lot of calculations that are usually done within MSFS by the means of lookup tables. Prop-o-Tronic uses algorithms from real-life physics and engineering to better simulate the systems of your aircraft. It is not a trivial matter either – for instance, there are around 600 parameters calculated at all times for each engine, and all of them are interlinked. Needless to say, that tuning these parameters to match real world data is a never-ending endeavor and I predict that we will keep tweaking those numbers even weeks after release, based on the feedback that we gather from the users.

It is simply impossible to test for every conceivable configuration the aircraft can be subjected to, and I hope you will have patience with us, if you find situations in which the simulation doesn’t match reality. Send me an email via our support-page on the Wing42 website, describe the situation you encountered and we will use the data to further tweak our engines for a future update.

However, please also keep in mind that, just like in the real-world, sometimes things happen that you didn’t anticipate. If you encounter an engine failure, despite flying “by the numbers”, there could be a dozen reasons for it. Was the engine in bad shape when you left it in your previous flight? Did you monitor your engine temperatures? Did the oil pressure go through the roof, or drop rapidly? Did you remember to fill the oil tank? Did you use the right oil grade according to the outside temperature? Did you remember to operate the oil shutters to regulate the oil temperatures?

So please be patient when learning the ins and outs of this aircraft! There are a lot of novel elements combined in this aircraft, which may feel daunting to learn and difficult to master. We try our best to provide you with training materials, like this manual and our upcoming video tutorial series and I highly encourage you to use all of it with great diligence.

And keep in mind that you can always disable the engine malfunctions and just enjoy the flight, learn to operate a taildragger, or familiarize yourself with the 1930s radio range navigation equipment. After all, we hope that you will enjoy our add-on in the way you want to use it and hope you get the most out of the experience of flying an aircraft from the Golden Age of Aviation!

Kind Regards,

Otmar Nitsche
Founder of Wing42

2 The Wing42 Boeing 247D

On the 8th of February 1933, the first modern airliner, the Boeing 247 first took to the sky. She was a remarkable culmination of all the design lessons learned over the previous two decades. She featured an all-metal fuselage and wings.

2.1 Prop-o-Tronic physics engine

The Wing42 Boeing 247D is the first aircraft that features our custom-coded *Prop-o-Tronic physics engine*. Prop-o-Tronic is a set of algorithms derived from real-world physics and engineering to simulate more realistic systems. The algorithms were first introduced in our Lockheed Vega for P3D/FSX and constantly improved over the past few years.

For the different systems, Prop-o-Tronic is either bypassing or overwriting some of MSFS' internal calculations and we use a mix of Web Assembly, SimConnect and behavior code to achieve the desired results.

Prop-o-Tronic is currently used for the calculation of the following systems:

- Electrical system
- Lubrication
- Heat exchange between different components as well as the surrounding air
- Realistic instrument needle movements
- Engine temperatures for each of the 18 cylinders separately
- Propeller feathering components
- Malfunctions, wear & tear

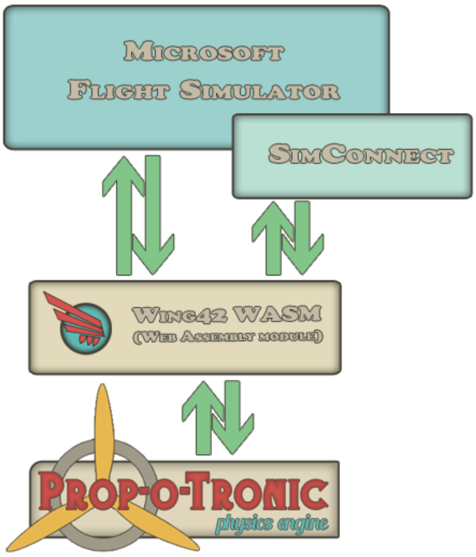


Figure 2-1: Functional diagram of Prop-o-Tronic and how it interacts with MSFS.

Where it is feasible, we also preserve system parameters between sessions. When starting a new flight, you will find the aircraft in the exact same state as you left it.

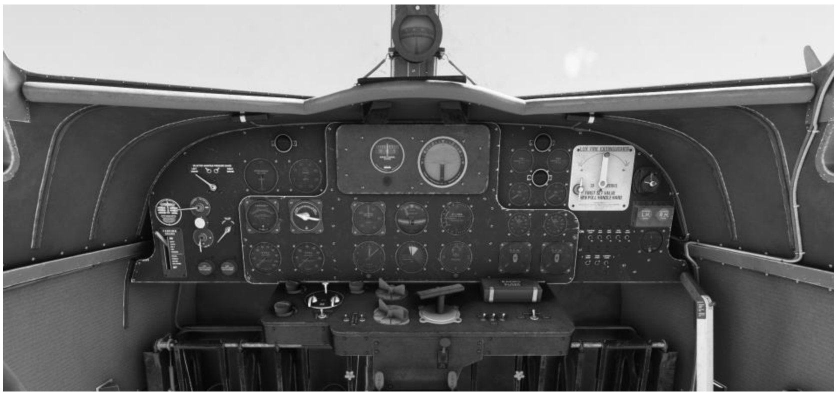
2.2 User Interactions and Animations

It is worthwhile mentioning that we deploy custom animations and user interactions throughout the entire aircraft. In coding these interactions, great care was taken to make them feel authentic to move, without sacrificing user-friendliness. Most simple interactions, like switches, are operated with a simple click, whereas most of the larger mechanical devices require the user to click & drag the control.

We also programmed varying degrees of dynamic resistance to the movement of those levers. For instance, if you try to operate the wobble pump with the fuel tank selector closed, you will barely be able to move it. This is done to simulate the back pressure in the device, analogous to trying to pump a bicycle pump while pressing your finger on the nozzle.

2.3 Cockpit Layout

When entering the cockpit for the first time, you might find yourself a tad bit confused. This feeling won't leave you for a long time because the cockpit is laid out in a way that makes little sense. For example, the gear indicator occupies a large amount of space and sits top center of the view, while the manifold pressure gauges for engines one and two are combined into one instrument with one needle. You will have to flick a switch to toggle between the manifold pressures of your two engines.



The handles for the trim are different for all three axis and you will find the elevator trim on the center console, the aileron trim is located on the floor, bottom left to the pilot, while the rudder trim is sitting on the floor just in front of the center pedestal.

The German 247

In 1934, Germany acquired two Boeing247s. While the aircraft were officially purchased for the German airline Lufthansa, they were given to an aeronautical research center of the Luftwaffe. One of them, D-AGAR left the facility one year later, while D-AKIN remained there to perform test-flights for the development of navigational equipment.

The aircraft was thoroughly examined and the findings played a big part in the subsequent development of multiple German "Schnellverkehrsflugzeuge" (=fast commercial airliner).

About the layout of the cockpit, the final lines of the report of the first test flights read:

"The American arrangement of the instruments takes some getting used to."

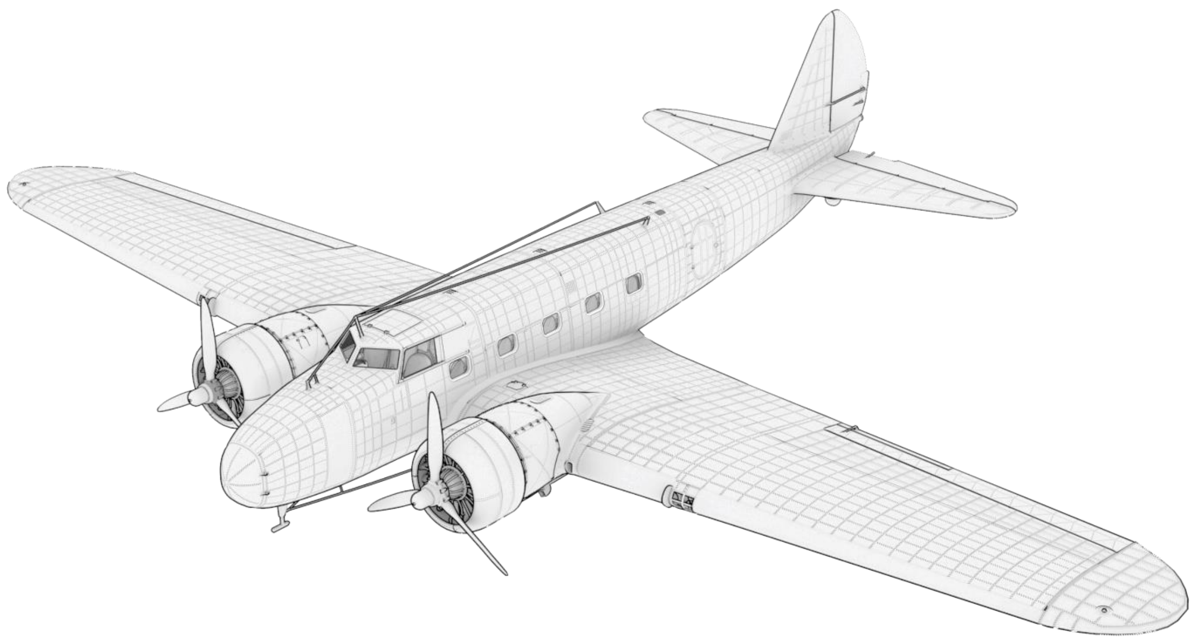
Wing42 agrees with this statement.

To make things worse, the operation of some of the crucial instruments is awkward and unnecessarily complicated (looking at you, engine temperature gauge!). So please take the time to familiarize yourself with the controls and instruments before you take your first flight.

3 Aircraft Specifications

Characteristics	*Model 247D*
Crew	2 pilots + 1 stewardess
Length	51' 5"
Wingspan	74' 0"
Height	12' 0"
Empty weight	8,921 lb
MTOW	13,650 lb
Fuel capacity – Left Main	136.0 gallons
Fuel capacity – Right Main	66.7 gallons
Fuel capacity – Auxiliary	70.0 gallons
Oil capacity	2x10 gallons
Powerplants	Pratt & Whitney Wasp S1H1-G
Propeller	Hamilton Standard 3D40 hub, controllable pitch, 24 to 20.5 degrees of pitch

Performance	
Max. Engine power	550 h.p. at 2,200 r.p.m.
Cruise Speed	189 m.p.h.
Max. Speed	225 m.p.h.
Climb rate	1,150 ft/min
Max. Ceiling	25,000 ft
Range	647 nmi.
Endurance	~4 hours
Fuel consumption full power	50 gal/h per engine
Fuel consumption ¾ power	35 gal/h per engine
Oil consumption	1-2 gal/h



4 MSFS Limitations

Just like with any flight simulator, MSFS presents us with some limitations that need to be pointed out.

Smoke effects

The effect system of MSFS allows us to dynamically create smoke effects for the two engines and our add-on makes heavy use of it. Unfortunately, there currently is an issue with the textures of those smoke effects turning yellow/green when they fade out in the distance.

We filed a report with Asobo about this issue and hope for a fix for this in the near future.

Default failures

The failure model of MSFS is rather simplistic and to make matters worse, not entirely accessible through the different programming interfaces. Consequently, all malfunctions in our Boeing 247D add-on are custom-coded and work independent of any settings in the sim. Therefore, please make sure to keep the malfunction in the MSFS settings turned off and instead use the Boeing's clipboard to toggle various realism options for the aircraft.

Landing gear

The landing gear lever of MSFS is a simple Boolean variable, meaning that it only has two settings: "UP" and "DOWN". Furthermore, most controllers that have a dedicated gear switch also utilize a simple ON/OFF solution.

This presents some issues, since the 247D's landing gear lever also has a "NEUTRAL" position. To make things worse, there's also an emergency gear system that uses a ratchet-type mechanism to manually lower the gear.

If you are using a controller with the aforementioned UP/DOWN convention and want to *test* the emergency gear in flight, you need to first use your mouse to move the gear lever on the center pedestal in the "neutral" position. Depending on your setup, it might be that this can only be done if the switch on your controller is in the "down" position.

Alternatively, you could temporarily remove the fuse for the landing gear circuit, thusly disabling the motor that operates the gear.

MSFS Ground services

MSFS introduced new ground services that can be called via the radio. But since all the related 3D models represent the modern era, we decided to not support any of MSFS' native ground services and substitute them with our own.

Furthermore, since we integrated a custom payload manager to our clipboard, any interaction with the default payload manager of MSFS will cause issues and should therefore be avoided. This is particularly the case for the fuel tanks and the different cargo stations in the aircraft (see chapter 7.2 for more information).

Jittery custom ground equipment

Because the custom ground equipment our addon uses is added as a part of the 3d model of the aircraft itself, some jittering or similar movement of these items is unfortunately unavoidable.

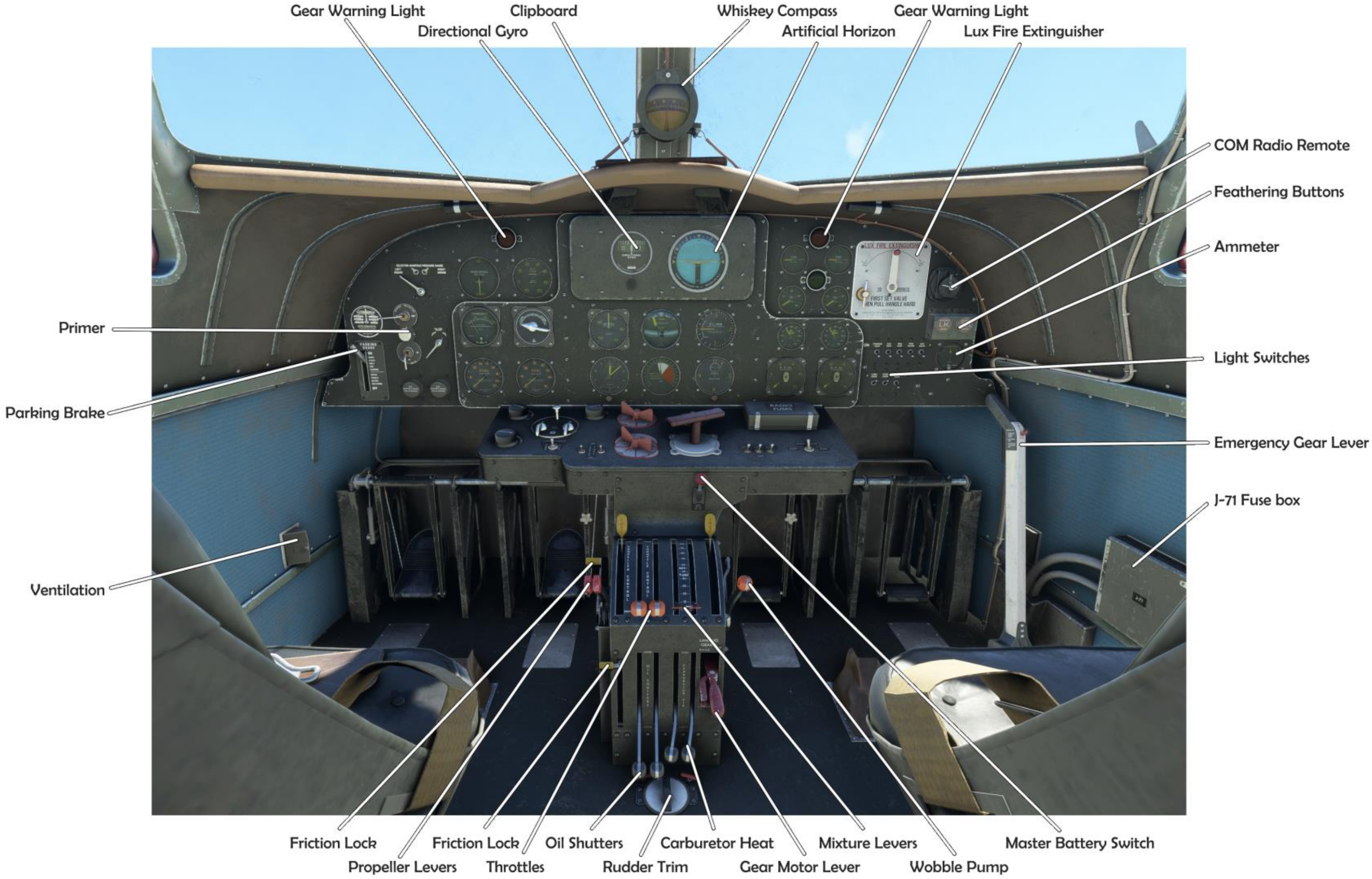
Carburetor Heat

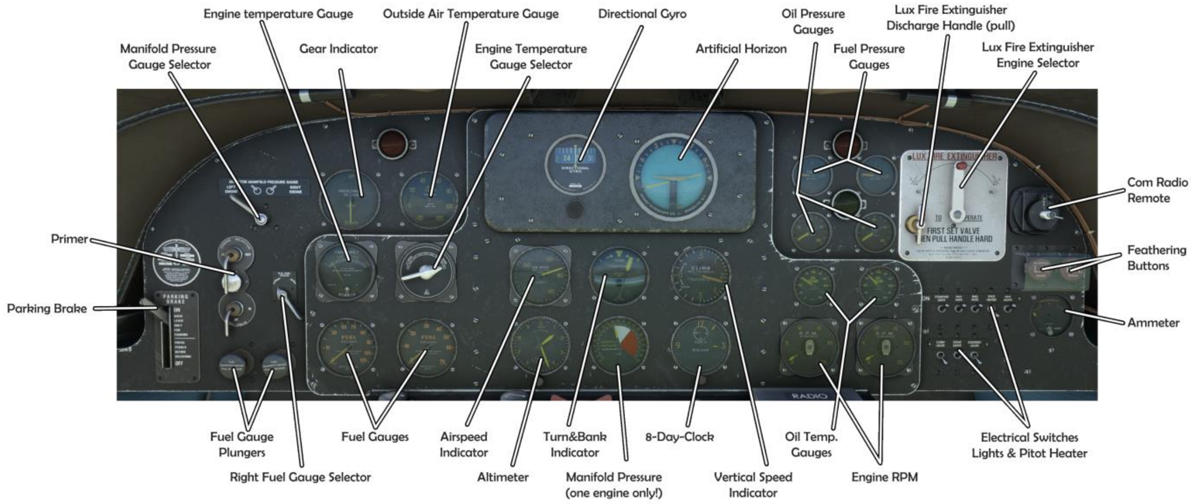
The engine's intake air can be heated using a carburetor heat system. It diverts the airflow of the intake over the pipes of the engine's exhaust, which in turn heats up the intake air. In its current state, MSFS has a bug that makes the intake air heat up even if the engine is shut down.

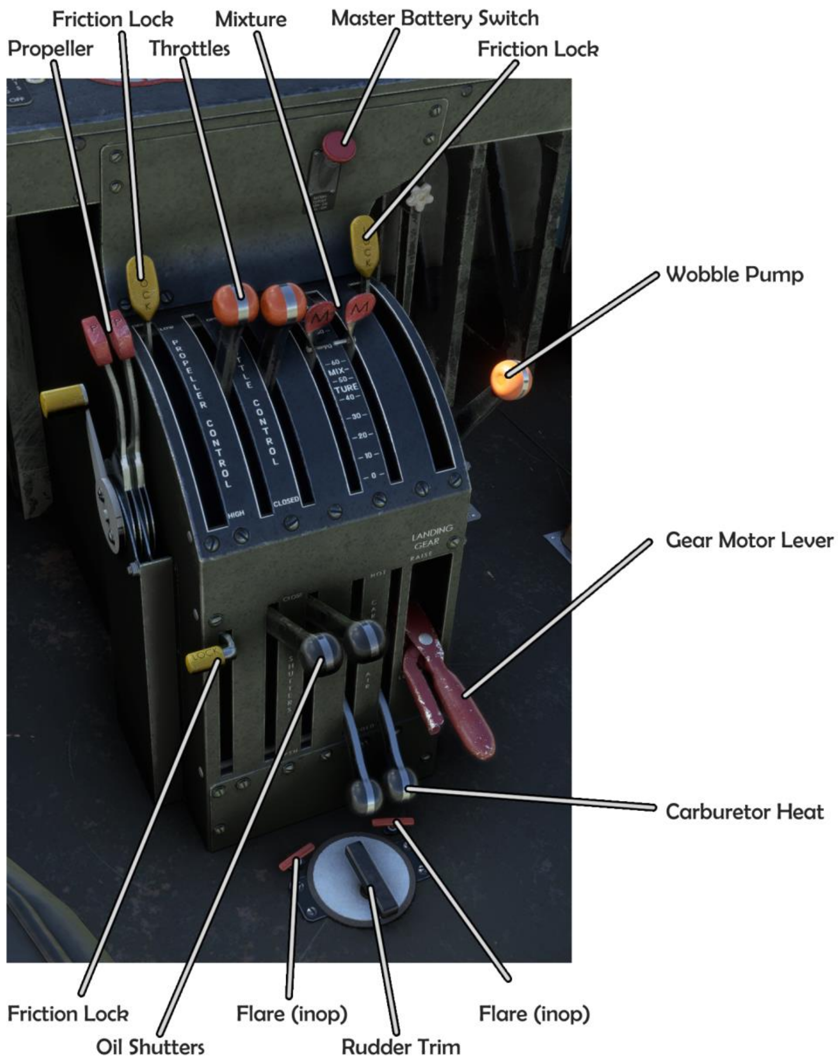
Heads-up Displays

We highly recommend switching of the heads-up displays for a more immersive experience.

5 Finding your way around







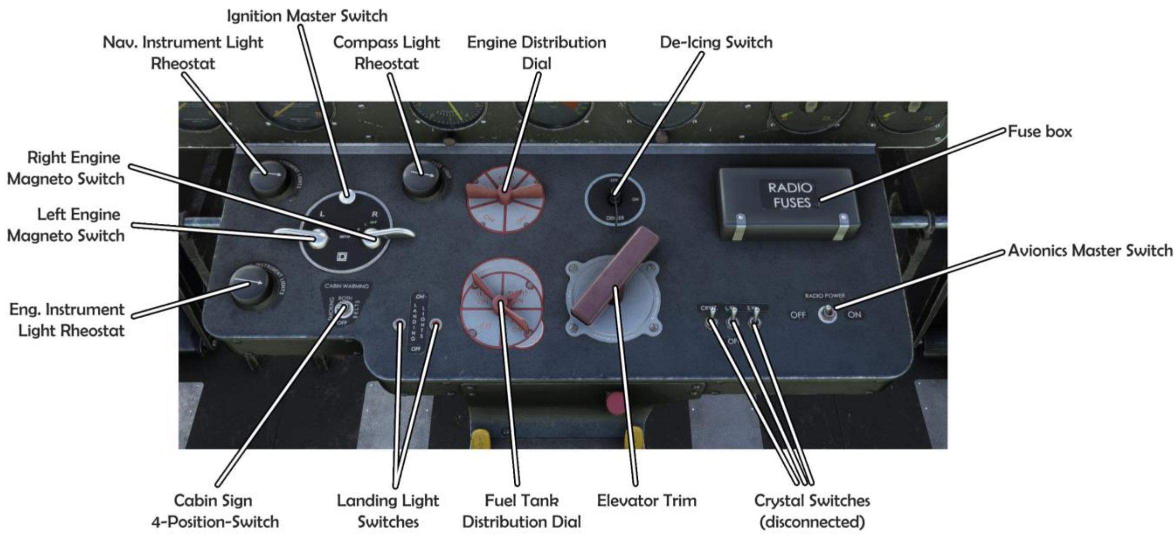
A word from the creators…

Congratulations! You are the proud owner of the most detailed aircraft available for MSFS! The Boeing 247D was called "The first Modern Airliner" and Wing42 has done a remarkable job of bringing your 247D to life for your enjoyment.

No stone was left unturned in the development of the 247D for MSFS. Wing42 tapped the archives of Boeing's Museum of Flight to find the details modelled into your 247D! And, your aircraft isn't simply modelled but is engineered to breathe life into the systems of your "new" historic 247D.

Your 247D knows how you're treating her. Is your oil level too low? Your mixture too lean? Your cylinder head temperature too high? She knows, and she remembers from one flight to the next. Mistreat her and you're likely to get busy in a hurry. Treat her well and she's sure to treat you to a most enjoyable flight experience. Enjoy!

- Donald Spence USAF Pilot, Airline Pilot, Wing42 Flight Tester



6 Your virtual ground crew

The Wing42 Boeing 247D features a fully simulated, albeit invisible, ground crew to interact with. The ground crew will fetch and install various ground equipment, load and refuel your aircraft and assist you in the start-up process of the two radial engines.

Figure 6-1: The members of your ground crew.

The ground crew consists of two ramp agents, or “rampies” and a mechanic. Each has his own list of tasks which you can fill up and he will work through them one by one. Some tasks trigger additional tasks to be added to the job-list of your crew. For instance, in order to board passengers, your mechanic will first install the wheel chocks, while your ramp agents will bring the ladder and open the passenger door. Only after those tasks are completed will the boarding begin.

Keep in mind that every task requires a certain amount of time to be completed, and some tasks take longer than others.

7 The Clipboard

You interact with your crew by means of the interactive clipboard, which can be found on top of the dashboard. Click on the bottom edge once to move it into view, click the same spot again to move it away (see Figure 7-1).

Figure 7-1: Location of the clipboard. Highlighted is the click spot to move it in and out of view.

The clipboard contains important information for the various stages of your flight, let's you set your payload and start the engines, change the oil and help you with the radio. You can navigate through the different chapters of the clipboard with the "next page" and "previous page" buttons on the bottom.

7.1 Performance and Limitations

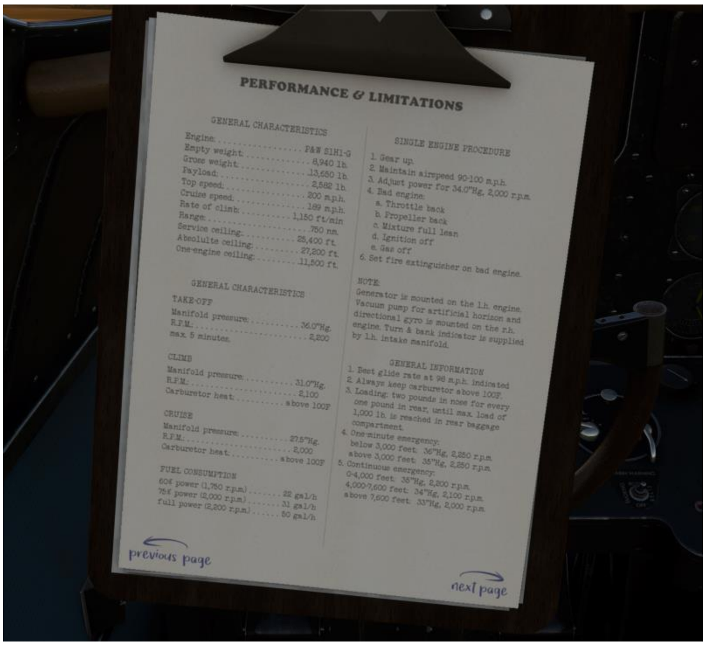


Figure 7-2: Performance and Limitations page.

The Performance and Limitations page (Figure 7-2) is a reference sheet containing information for all stages of the flight.

7.2 Weight and Balance

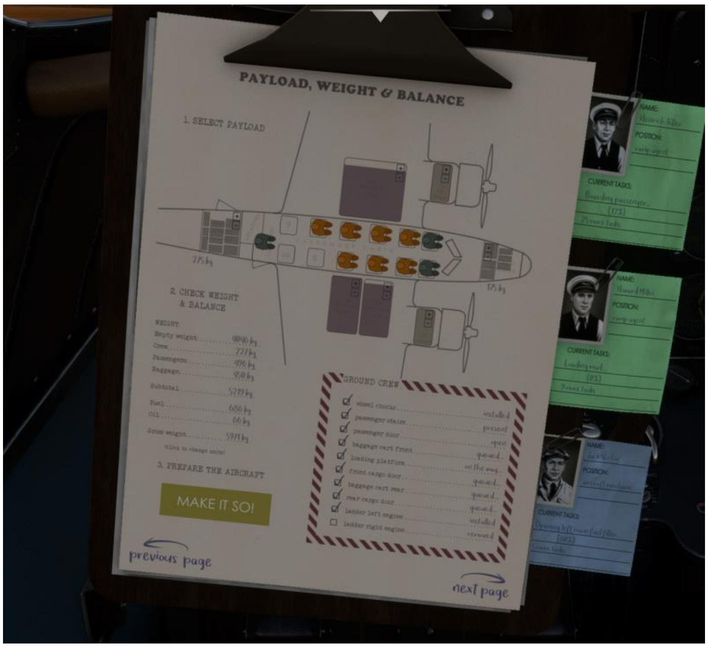


Figure 7-3: Payload, weight & balance page. Also shown are the crew notes that inform the pilot what tasks are currently being performed.

The weight and Balance page (Figure 7-3) is used to set the payload for your next flight and enables you to toggle some of the ground equipment.

To change the payload of your aircraft, you first need to select what you want to change on the aircraft diagram. Once done, click on the "MAKE IT SO" button to advise your ground crew to perform the required tasks.

7.3 Engine Startup Procedure

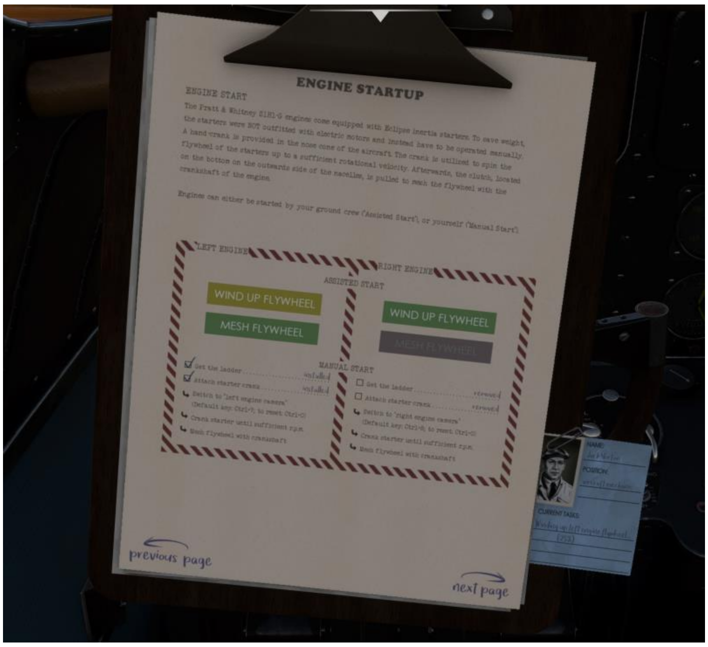


Figure 7-4: Engine start-up page. Jack was asked to wind up the flywheel of the left engine and is ready to engage the starter clutch.

The S1H1-G engines require some work to start up. The Engine Startup Procedure page (Figure 7-4) of the clipboard lets you instruct the mechanic to fetch the necessary equipment and operate the inertia starters.

7.4 Maintenance

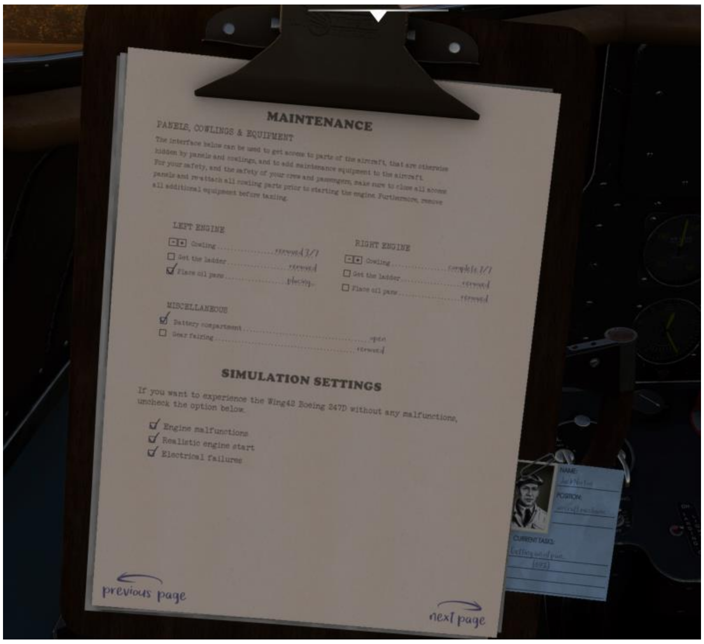


Figure 7-5: Maintenance page. Jack is currently getting the oil pan for the left engine.

The Maintenance page (Figure 7-5) is used to install maintenance-related equipment, remove the engine’s cowlings, install optional gear fairings, and access maintenance panels of the aircraft. Furthermore, the page contains configuration options to enable/disable various aspects of the Prop-o-Tronic physics engine.

If the “ENGINE MALFUNCTIONS” box is checked, the damage model for the engine is enabled. This means that you need to operate the engines within their performance limitations lest they suffer the consequences. For instance, if an enabled, an engine can seize if the lubrication is insufficient.

If the “REALISTIC ENGINE START” option is checked, more rigorous tests are performed when cranking over the engine to calculate the probability of a successful start. If disabled, the simulator will ignore the priming of the engine and fuel pressure checks.

The “Electrical Failures” option enable malfunctions of the electrical system. If this option is checked, the different fuses can blow at any time, depending on the circuit load.

7.5 Oil System

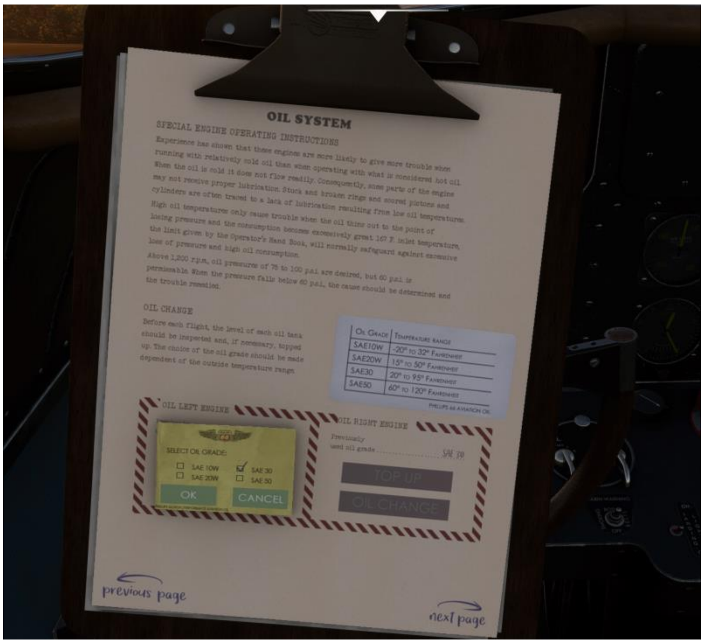


Figure 7-6: Oil System page. After clicking on "top up" or oil change", you need to select the oil grade in the selection note.

The Oil System page (Figure 7-6) provides more detailed control over the engine's oil. It is used to either top up your oil tanks or to initiate a complete oil change. Both cases let you choose the oil grade you wish to use for your next flight.

See chapter 12 for more information on the oil system of the Boeing 247D.

7.6 Radio Equipment

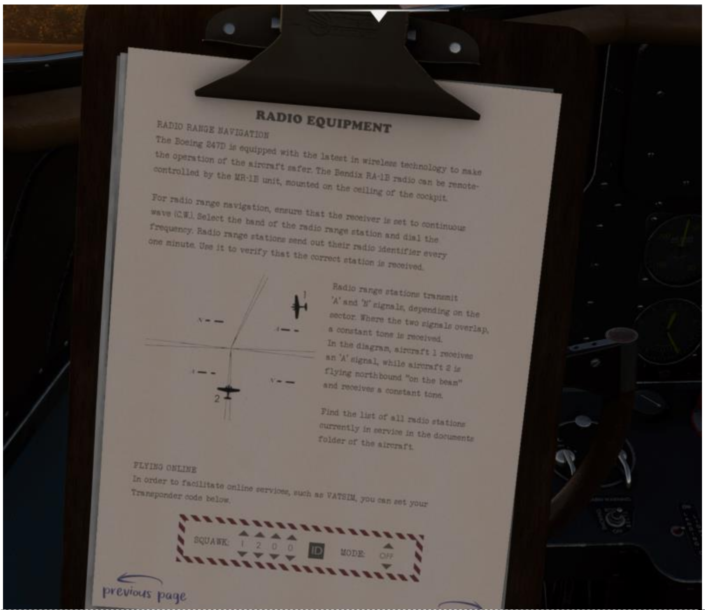


Figure 7-7: Radio Equipment page.

The radio equipment page (Figure 7-7) contains a quick sum up of how the radio range navigation works, however it is recommended to cross-reference with chapter 0 of this manual and with the training material provided.

Since transponders haven't been invented in 1933, no such equipment is installed in our Boeing 247D. However, to facilitate online-flying, we added a virtual transponder to the radio equipment page.

8 Startup

Starting up a radial engine from the 1930s is a very different experience from starting any modern combustion engine, let alone a turbo fan. The procedures are usually extensive and need to be followed meticulously for a successful start and the better you understand how things work, the easier time you'll have getting it running. Generally speaking, you first create the conditions for an engine to startup, and then you have the propeller to crank over, which in turn will initiate the internal combustion process.

A word from the creators…

While you wait for those big radials to warm up, look to your left and right and take a mental picture of how the nose is angled in relation to the ground. Also note how high the wings are off the tarmac. This is the attitude to aim for when you come in for landing later and it will reward you with a perfect three-point landing.

As you increase your speed for take-off, keep the yoke pulled back, close to your chest. Now simply let her fly herself! From a three point attitude, the plane will take off at around fourty miles per hour and quickly accelerate upwards at manoeuvring speed. Lower the nose slightly and set your trim.

- Pamela Brooker, Wing42 flight model engineer

8.1 Preparations

1. Make sure the parking brake is set.
2. Verify the fuel levels by checking the fuel quantity gauges.
3. Turn the engine selector to "BOTH", to allow fuel to run to both carburetors.
4. Open the valve of one of the fuel tanks by turning the fuel tank selector to the desired tank.
5. Use the wobble pump to bring up the fuel pressure to around 4-5 psi.
6. If the engine is cold, you need to prime it!
    a. Open the main valve of the primer and select the engine you want to start.
    b. Use the primer handle to prime the selected engine by gently pulling the primer out and pushing it back in. use 1-3 strokes if it is warm outside, 4-5 if it is below freezing.
7. Turn on the master ignition switch.
8. Set the magnetos to "BOTH".
9. Set the mixture full rich.
10. Set the propellers to "fine pitch" (full forward).
11. Crack the throttle open to about 10%.

Your engines are now ready to start up; the only thing left to do is to crank them over. For this purpose, the Boeing 247D is equipped with state-of-the-art Eclipse inertia starters. Those starters consist of a flywheel and a clutch, which mesh the flywheel to the crank-shaft of the engine once it gained sufficient kinetic energy. To spin up the flywheel, a hand crank is attached to the starter, through a hole in the cowling on each nacelle. The spring-loaded lever for the clutch is found on the outboard bottom side of the engine.

In the real world, the ground crew would operate the starter of the engine on command of the pilots. In MSFS you can either do this yourself, or request your virtual ground crew to do it for you. In either way, ready the clipboard and open the page "Engine Start"

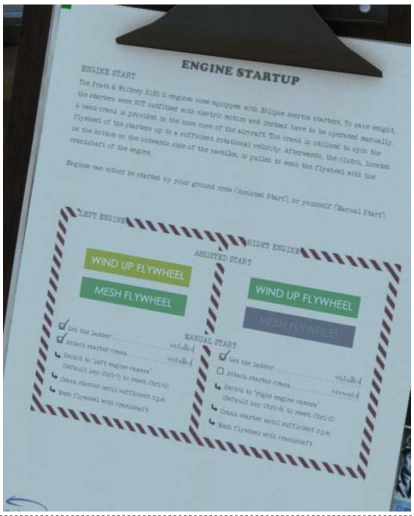


Figure 8-1: The engine startup page on the clipboard.

Before we get cranking, let's quickly have a look at our fuel pressure. During the whole startup process, you need to make sure that you keep the fuel pressure up! As long as the engines are not running, the pressure will drop rather quickly; therefore, it is important that you keep wobbling the wobble pump right before meshing the flywheel to crank over the propeller!

8.2 Manual start

Figure 8-2: Controls for the manual start. (1) Starter crank. (2) Starter clutch.

1. Get the ladder and attach the hand crank to the engine you wish to start up first by clicking on the respective checkboxes on the clipboard. Note that it will take a few moments until the equipment is ready.
2. Switch the camera view to the engine nacelle using Ctrl+6 for the left engine or Ctrl+7 for the right engine.
3. Click and hold on the hand crank to start winding up the flywheel. Keep cranking until a sufficient RPM is reached. Listen to the whining of the flywheel to judge when this is achieved.
4. Jump back in the cockpit (Ctrl+1) and operate the wobble pump to ensure sufficient fuel pressure.
5. Get back out (Ctrl+6 or Ctrl+7) and pull the clutch of the flywheel by clicking and holding it with the left mouse button. This should crank over the propeller for around 2 full rotations, sufficient to start up the engine.
6. Remove the equipment from the engine by clicking the respective option on the clipboard.
7. Repeat the process for the second engine.

8.3 Assisted Start

1. On the clipboard, click on the "WIND UP FLYWHEEL" button. The virtual ground crew will bring the ladder and attach the hand crank before winding up the flywheel.
2. Before meshing, make sure that the fuel pressure is sufficient by operating the wobble pump to maintain 3-5 psi.
3. When the flywheel reaches sufficient RPM, the "MESH FLYWHEEL" button will become available. Click the button to have the ground crew mesh the flywheel with the crankshaft to turn over the engine.
4. After a successful start, the ground crew will independently remove the crank and ladder.

9 Control Surfaces

At a glance

What is simulated?	What is not simulated
- **Realistic trim behavior.**	- Malfunctions of the control surfaces.

9.1 Trim surfaces

The Boeing 247 was an early adopter of trim tabs, added to the control surfaces for all three axes. The location of the controls for those trim tabs might take some time getting used to (see **Error! eference source not found.**).

Figure 9-1: Trim controls. (1) Aileron trim. (2) Elevator trim. (3) Rudder trim.

The location for the aileron trim is mounted on the floor, forward left of the pilot's seat. The elevator trim can be found on top of the control panel and the rudder trim is in a central position, on the floor, directly in front of the pedestal.

The purpose of the trim tab is to relief some of the pressure from the controls by adjusting the control surface's equilibrium position in the air flow. By moving a trim tab downwards, the airstream at the trailing edge of the control surface gets pushed downwards, which creates an upwards force on the control surface (see Figure 9-2).

Figure 9-2: Forces induced by the trim tab.

10 Undercarriage

At a glance

What is simulated?	What is not simulated
- **Accurate 3-position-switch to control the electrical gear motor.** - **Manual gear "ratchet" for emergency operation.**	- Malfunctions of the gear motor. - Flat tires or issues with the shock absorber.

The main landing gear can be retracted for less drag and higher cruise speeds. The retraction mechanism consists of a torque shaft that lowers and raises both the left and right gear simultaneously. In normal operation, it is powered by one DC motor, located below the forward floor board in the cabin. The motor is controlled by a landing gear lever on the center pedestal of the cockpit (see Figure 10-1). It has three positions: raise-neutral-lower. Both, the "lower" and the "raise" position activate solenoids that supply power to the circuit of the landing gear. The gear is equipped with limit switches that open the circuit when the maximum extension/retraction of the gear is reached.

Figure 10-1: Location of the gear lever.

In case of an electrical failure, or a failure of the gear motor, the gear can be operated manually. To do so, the landing gear lever needs to be put in the neutral position. The selector on the emergency gear lever should then be set to the desired operation (raise gear or lower gear). The emergency gear lever acts like a ratchet and by pushing and pulling it, the gear will gradually extend or retract (Figure 10-2).

Figure 10-2: Manual gear lever. (1) Select mode: raise or lower (2) operate the ratchet mechanism.

The tailwheel is free-castering and equipped with an oleo shock absorber. No tailwheel locking mechanism is deployed. Regular maintenance is required for save operation.

11 Power Plants

At a glance

What is simulated?	What is not simulated
- Realistic engine parameters as per manuals and pireps. - Real world physics for the entire combustion process. - Parts heat up, depending on friction, mixture, pressure, oil flow and air flow. - Engine malfunctions when operating outside of the specifications. - Accurate, custom-build engine controls. - Accurate prop feathering system.	- Wear & tear. - Regular maintenance.

The Boeing 247D is equipped with two air-cooled Pratt & Whitney R-1340 S1H1-G engines. The engines are rated at 550 horse power at 2,200 r.p.m.. Through the 2:1 gearbox, they drive three-bladed Hamilton Standard constant speed propellers with a diameter of 10'¾" (3.06m).

Figure 11-1: The Pratt & Whitney Wasp S1H1-G radial engine.

The 23D40 propeller hub allows for a beta angle between 17 and 23 degrees, which is automatically controlled by a governor, mounted on the rear of each engine. For single engine operation, the propellers can be fully feathered to reduce drag and one engine is powerful enough to maintain stable flight condition for up to 5,000 feet altitude.

For the longevity of the engine and the safety of crew and passengers, it is of the highest importance to operate the engine within the limitations set by the manufacturer. Special care needs to be given to keep within the limits of the engine's temperature and manifold pressure range, as to not overstress the engine.

11.1 Engine Malfunctions

If the option "Engine Malfunctions" on the maintenance page of the clipboard is checked, extra care needs to be taken to maintain the condition of the engine. In our add-on, the engine can malfunction in two ways: either due to overheating or due to insufficient lubrication. A malfunctioning engine can seize up or even catch fire and it is the duty of the pilots to constantly monitor the condition of the engines by observing the engine gauges.

To monitor the temperature of your engines, sensors are mounted on the number 1 and number 4 cylinders of each engine. These thermocouples are connected to the engine temperature gauge, located on the left side of the main instrument panel (see Figure 11-2). The selector next to the gauge is used to cycle through the different temperature probes. The settings are wired as follows, from left to right:

1 – left engine cylinder 1 head temperature
4 – left engine cylinder 4 head temperature
C – left engine carburetor intake air temperature
0 – not connected / off
0 – not connected / off
0 – not connected / off
C – right engine carburetor intake air temperature
4 – right engine cylinder 4 head temperature
1 – right engine cylinder 1 head temperature

Figure 11-2: Engine temperature gauge to monitor cylinder head temperatures and carburetor temperatures.

The normal operating temperature is between 200 and 350 degrees Fahrenheit, however temperatures of up to 450 F are permitted during take-off and in emergency situations.

Excessive wear and tear occurs, if the engine temperature exceeds 400 Fahrenheit over a prolonged period of time. It can lead to engine backfiring, generally rough running of the engine, and/or excessive smoke.

The lubrication of the engine is insufficient, either when the oil temperature is not within the normal operating range, or if there is insufficient or low-quality oil in the oil tank. Either of those cases lead to insufficient lubrication of the moving parts inside the engine, which in turn lead to excessive wear and tear due to the increased friction.

This can be observed if the oil pressure is either below or above the normal operating range. If that is the case, pilots should land as soon as possible to prevent the engine from seizing up. The issues around lubrication are discussed further below in the chapter "Oil System" (chapter 12).

11.2 Engine Damage and Replacement

In case of an engine failure, there is no option to "reset" it, other than starting a new flight.

The status of the engine is saved from session to session and the condition of the engines will deteriorate over time if they are not operated within their limits. The notable exception to this is if the condition of your engine is extremely poor, in which case Jack and his team will have the engine replaced by the time you have loaded your next flight.

11.3 Design principles of Propellers

Generally speaking, there are four different types of propellers and there is a natural progression between them. The four types are fixed pitch, variable pitch, two-speed and constant speed. Noticeably, all those types make a differentiation between the pitch angles of the propeller blades and there's a good reason for it.

The angle of the propeller blades act very similarly to the gear ratio of a gearbox. The beta angle effectively converts the engine's energy to either torque or rpm. In the different stages of flight, different ratios of torque vs rpm are desirable, which gave rise to the development of modern day constant speed propellers.

Fixed-pitch propellers are propellers that have no way of adjusting the inclination of the blade (also referred to as the beta angle). Such a propeller was used on early aircraft, such as the Blériot XI, when propellers are usually just made of big chunks of wood.

Variable pitch propellers are usually metal or composite propellers with their propeller blades being separate components to the propeller hub in the center. This allows for mechanics to adjust the beta angle of the blades on the ground. However, once an angle is set, it can't be changed during flight.

Two-speed-propellers were the first devices that were able to change the beta angle of the propeller in flight. Engineers found both mechanical and hydraulic solutions to deal with the high forces required to make those adjustments. Despite its name, the pitch of these propellers could usually be fine controlled gradually between the two settings.

The latest improvements for the propeller hubs was the introduction of governors that did not require the pilot to set the pitch of the propellers, but rather a speed at which he wants his engine to run. The governor would then automatically adjust the pitch to reach the set speed.

11.4 The Hydromatic Quick-feathering 23D40

The Boeing 247D featured such an advanced system which made her faster and more efficient than her predecessor, the 247. The three-bladed propeller of the 247D is a constant speed, "Hydromatic, quick-feathering" Hamilton Standard 23D40 with their hydraulic governors being mounted on the rear plate of the engines.

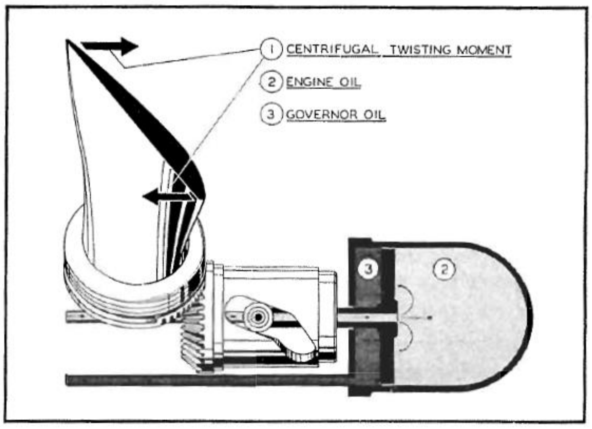


Figure 11-3: Fundamental Forces Diagram (Hydromatic quick feathering propellers, Hamilton Standard Propellers, East Hartford, Connecticut,)

As the name suggests, the propeller is actuated by means of hydraulic oil, which is provided by the engine itself, and governed by the propeller governor.

The operating principle of the propeller hub can be seen in Figure 11-3. The pitch of the propeller blades is adjusted through hydraulic forces acting upon a piston, which are transformed mechanically into twisting forces acting upon the blades.

Due to this mechanism, it takes up to 10 seconds to cycle between high-pitch and low-pitch position of the propeller. Since the hub requires a fair amount of oil pressure to operate, no adjustment of pitch can be observed while the engine is shut-down. The exception to that being the feathering position.

In normal operation, the oil flow to the propeller hub is controlled by the propeller governor, which in turn is controlled by means of a mechanical linkage with the propeller levers in the cockpit.

11.5 Feathering the propeller

In the event of an engine failure, the propeller turns from a thrust-producing machine to a drag-inducing obstacle. In the non-feathered position, the propeller of a shut-down engine will continue turning, also called wind-milling, caused by the airflow over the blades. Wind-milling induces a great amount of drag, requiring the good engine to produce even more power to maintain level flight.

To counter this problem, the 23D40 propeller can be "feathered", which means that the blades are twisted until they are parallel to the airflow. At this high pitch angle (89.5 degrees), the normal forces acting on the blades are virtually zero and the propeller stops spinning.

Figure 11-4: Feathering buttons for both engines are located on the far right side of the instrument panel.

Since the propeller hub operates by means of high-pressure oil, and since the oil pump of a shut-down engine won't turn fast enough to produce sufficient oil pressure, a different source of pressure needs to be used. On the Boeing 247D this is done by auxiliary oil pumps, especially fitted for this purpose. The pumps are operated by the feathering buttons on the far right side of the instrument panel (see Figure 11-4).

A word from the creators…

Let's say it: the ability to create a truly immersive simulated plane has not been possible to this extent before MSFS. There are many reasons for this, but I will focus on the ones concerning my field of expertise: audio.

The main reason is simply that no simulator prior to MSFS has had access to an audio engine as powerful as Wwise. Combine that vastly powerful engine with a very intricate simulation and you have the power to fine-tune the audio to an exceedingly high degree of detail and precision.

Sadly, the current state of MSFS does not exploit the full potential of Wwise. For instance, Microsoft's license for Wwise does not include Soundseed Grain, the one plugin that would render the task of producing high quality engine combustion sounds mostly trivial. I have had to work around this limitation, in essence creating my own pseudo granular synthesizer from scratch. So the combustion sounds you hear, while technically never looping, are only semi-synthetic.

None of the limitations of the engine can ultimately pose any real danger to an ambitious team. Even vanilla Wwise is a mind-bogglingly powerful tool, and I have been so delighted to be able to join Wing42 in digging into all of its hidden functionality.

I hope that, above all, you at times are able to feel like you might actually be in the cockpit. That's what good audio should do.

- Zak Spence, Wing42 Sound engineer

When a feathering button is pressed, a few things happen at the same time. Firstly, the button closes an electric circuit that connects the feathering pump to the main bus of the aircraft. The pump will start pumping oil from the engine's oil tank to build up pressure. Secondly, a bypass valve is opened to disconnect the propeller governor from the propeller hub so that oil can flow directly from the feathering pump into the propeller hub. Lastly, an electromagnetic coil will activate to hold the feathering button in place for as long as the feathering pump is running.

Once the auxiliary pump produced enough pressure to counteract the centrifugal force of the propeller, the propeller blades will start twisting into the feathering position. Once the full-feathered position is reached, the pumps will disconnect and the feathering button will release. The propeller will be fully feathered at that point and greatly reduce the drag. In this configuration, level flight can be achieved up to an altitude of around 8,000 feet.

11.6 Un-feathering the propeller

The same auxiliary pumps are being used for feathering and unfeathering the propellers. When pressing the feathering button of a feathered propeller, the auxiliary pump will start up again and the closed electrical circuit will hold the button in the depressed position.

A mechanically operated valve will automatically redirect the high-pressure oil to the opposite side of the hub's pressure plate, which in turn will reverse the twisting force of the propeller blades. Once the propeller blades return to the normal operating range of pitch, the pumps will disconnect, the bypass valve of the governor will close and the feathering buttons will release.

It takes around 10 seconds to un-feather the propeller.

11.7 Run-up tests

Periodically, during an engine-run-up, prior to take-off, the proper operation of the feathering pumps should be tested. With the engine operating at approximately 1,500 r.p.m. and 22 inches Hg. Manifold pressure, depress the feathering switch. When the propeller has reached full-feathered position, the switch will automatically open, and the engine r.p.m. will have decreased to approximately 500.

Immediately after the feathering test has been satisfactorily completed, again depress the push-button switch. The engine r.p.m. should recover to previous speed of 1,500 within about ten seconds.

12 Oil System

At a glance

What is simulated?	What is not simulated
- Real world physics and engineering algorithms calculate temperature, pressure, viscosity, and other parameters for around 100 different parts in the engines. - Realistic oil consumption and oxidization, depending on various factors. - Realistic temperature exchange between the oil and the different engine components. - Oil change with the option of four different grades. - Malfunctions due to bad lubrication of the pistons. - Persistent oil parameters on reloading of the aircraft. Make sure to top up your oil tanks!	- Oil component failures. - Oil deterioration over time.

Oil is the lifeblood of any internal combustion engine. It lubricates all moving parts and removes some of the heat developed by the combustion of fuel. If for whatever reason the lubrication is lacking, friction in the engine increases, resulting in excessive wear and tear. If this condition is maintained over a prolonged period of time, the engine is likely to seize, overheat or fail in another way.

It is therefore of vital importance to monitor the pressure and temperature of the oil and, if necessary, control the heat by means of the oil shutter levers on the center pedestal.

Each engine is supplied by an independent oil system with its own oil tank. The oil system of the l.h. and r.h. engine is identical.

12.1 Oil Cycle

Figure 12-1 shows the general arrangement of the oil system of one engine. Oil is supplied by a 10-gallon tank, mounted behind each engine and can be accessed by removing the panels of the nacelle. In addition, a hinged panel is installed on the inboard side of the nacelle to allow access to the filler neck of the tanks.

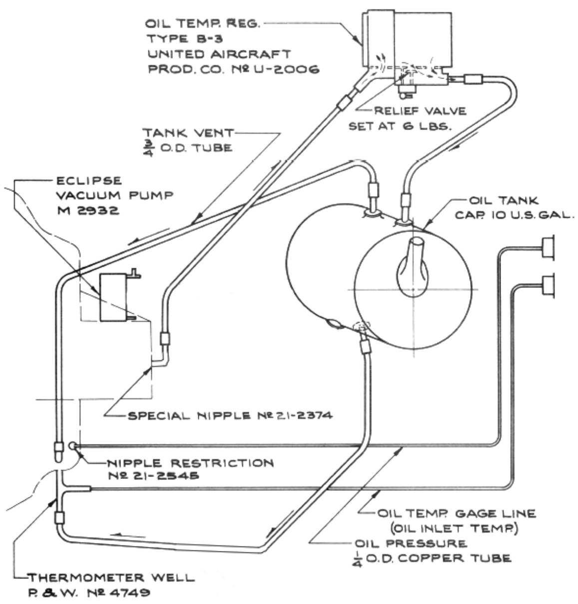


Figure 12-1: Schematic drawing of the 247D's oil system.

The oil is pumped by an engine-driven oil pump, connected to the oil tank. At the oil inlet of the engine, an oil fine filter is installed to filter out particles and other contaminants. A pressure valve protects the engine from an over-pressurization; the return line delivers the oil back into the tank.

Furthermore, a check valve is installed, which only opens if the oil pressure is sufficient. This prevents oil flowing from the tank to the cylinders when the engine is parked over a long period of time.

Inside the crankcase, the oil gets circulated to the different moving parts, such as the cylinder walls, push rods, rockers, low pressure parts and the propeller governor. Used oil gets collected in the sump and the return path of the oil pump sucks the oil through a strainer to the oil cooler. From the oil cooler, the oil flows back into the tank.

12.2 Oil Cooler

The oil cooler is located aft of the oil tank and faired into the cowling. Air flow is maintained by means of a duct that collects air between cylinders 9 and 1, directing it through the oil cooler. It gets released on the top-rear of the nacelles.

The oil cooler has a low-pressure bypass valve, which allows oil to bypass the cooler to directly flow back into the tank. This effectively acts as a temperature controller. As the oil heats up, it becomes less viscos and thus provides less resistance as it is flowing through the cooler. This leads to a low pressure in the oil cooler, at which point the pressure valve will close, allowing more oil through the cooler.

To allow efficient cooling, the air flow into the oil cooler can be controlled by the means of oil shutters. The shutters are operated by two “OIL SHUTTER” levers in the center pedestal of the cockpit and regulate the airflow through the oil cooler.

12.3 Engine Instruments

Located on the right-hand side of the cockpit are the engine instruments and the oil temperature and oil pressure gauges can be found there.

Both instruments take the measurement at the oil inlet of the engine. As such, the temperature gauges measure around 10-20 degrees lower than the outlet temperatures. Since all oil is cycled through the oil tank, before entering the engine, operating temperatures are only reached once the whole volume of oil in the tanks are sufficiently heated up.

12.4 Maintaining Temperature and Pressure

When starting a cold engine, the oil temperature is below the operating limit. Cold oil is more viscous resulting in a high flow resistance. That is why you might see the oil pressure spike up during the engine start. After a few seconds, the oil pressure will drop, as the relief valve opens up to safeguard the engine from an over pressurization of the oil.

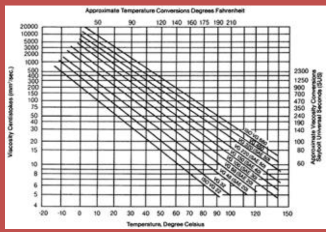
This however means that less oil is pumped through the engine, which results in poor lubrication. It is therefore important to let the engine idle for a while after engine start, to allow for the oil to heat up, become less slushy and thus improve lubrication of the engine.

Additionally, it is important to use engine oil designed for the outside temperatures during operating conditions. Using summer-rated oil in winter, results in even higher viscosity when the engine is cold.

During your flight, you should constantly monitor the oil pressure and temperature gauges to maintain save operating conditions. The oil heats up as it gets cycled through the engines, and the hotter you run the engines, the more the oil will heat up. By closing the oil shutters, for instance during cruise, you can increase the oil temperature and inversely, by opening the oil shutters, you can decrease the oil temperature – provided there is enough speed to provide a constant airflow over the oil cooler.

Mineral Oil Parameters

The most important property in determining the performance of any engine oil is its viscosity. The viscosity number describes how liquid a fluid is, and can be determined in flow or drip experiments.



Generally speaking, the colder a liquid is, the more “gooey” it becomes, as indicated by a high viscosity. Engine oil at -40 degrees turns into a thick paste with the consistency of Nutella.

However, engine oils are designed for specific temperature ranges to mitigate at least part of the problem. Nowadays synthetic oil is predominantly used as a lubricant for engines, because it can cover a wide range of temperatures.

In the 1930s on the other hand, synthetic oil was not invented yet and thus mineral oil was used in most cases. Since mineral oils have a smaller range of operating temperatures, it was necessary to change oil type, depending on the season and outside temperature.

On the other hand, it is also important to keep the oil temperature below 165F (around 73°C). If engine oil gets too hot, it becomes too thin to effectively lubricate the moving parts of the engine. This results in a higher than usual oil consumption and higher wear. Figure 12-2 demonstrates the correlation between those different properties of the oil.

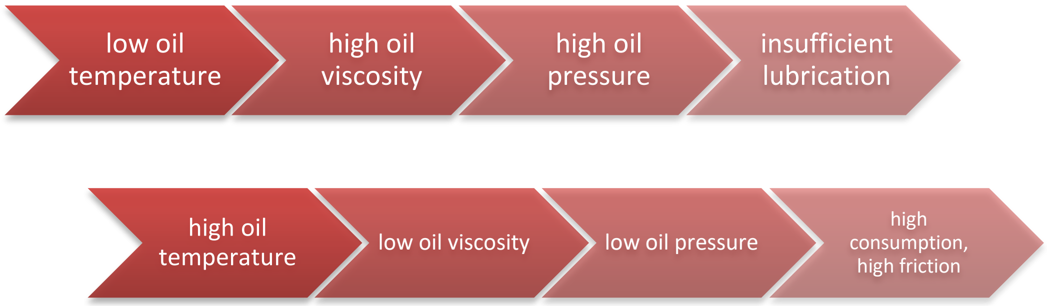


Figure 12-2: Effects of either too low or too high oil temperatures.

12.5 Topping up

Because the engines consume a lot of oil over time, it is necessary to top up the two oil tanks on a regular basis. This can be done using the clipboard, either on the PAYLOAD, WEIGHT & BALANCE, or the OIL SYSTEM page.

The +/- buttons in the oil tank of the aircraft's schematic are used to adjust the desired oil level. After preselecting the amount, the MAKE IT SO button needs to be pressed to advise the mechanic to top up the tank to the desired amount (see Figure 12-3). Note that there's no option to change the oil grade and as such the tanks will be filled up with the oil grade that was previously selected (SAE 30 by default).

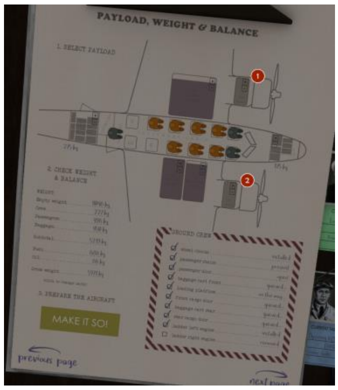


Figure 12-3: To top up oil, without making any changes to the oil grade, use the +/- buttons on the payload manager.

The OIL SYSTEM lists some crucial information about the 247's lubrication, oil pressures and temperatures and the sticker that is stuck to the page lists some reference temperatures for each of the selectable oil grades. The units on the sticker can be changed from Fahrenheit to Celsius by clicking on it.

When clicking on "TOP UP" for either the l.h. or r.h. oil system, you can select the desired oil grade from a list of four. Click on OK to advise your mechanic to use the selected oil to top up, or CANCEL to make no changes.

Please be advised that topping up will only add oil to the oil tank until it is full, thus mixing the old oil with the new oil. If, for instance, half of the tank is filled with SAE 10W and it is then topped up with SAE 50, the two oil grades mix and as a result will perform neither like SAE 10W nor SAE 50, but somewhere in between.

12.6 Oil Change

In addition to topping up, the OIL SYSTEM page also allows you to have a full oil change initiated (see Figure 12-4 and Figure 12-5). Oil changes are performed regularly for two reasons. The most obvious one is that by changing the oil, one gets rid of any contamination or oxidation of the oil, which otherwise leads to a lack in lubrication of vital parts of the engine.

Figure 12-4: Oil change interface. (1) Temperature reference sheet. (2) Click to top up. (3) Click to change oil.

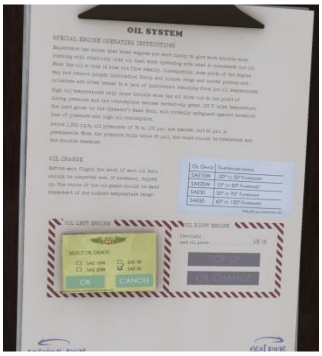


Figure 12-5: Select the oil grade in the note.

The second, less obvious reason is that draining the oil from the sump allows checking it for metal shavings, which are indicative of some excessive wear and tear inside of the engine.

In the Boeing 247D, such wear and tear is not simulated. However, since the simulator allows you to quickly change the temperature ranges of the environment, it might be necessary to perform a complete oil change when doing so. Selecting the right oil for the outside temperatures when performing an oil change ensures that all moving parts in the engine are sufficiently lubricated.

In a similar fashion to topping up, the oil grade has to be selected after clicking on the OIL CHANGE button. Oppose to topping up, the mechanic will then first drain all the oil from the tank, oil lines and sump, before refilling them with fresh oil of the selected rating.

A word from the creators…

I want to express my deepest gratitude and appreciation to the team that brought this aircraft together. It was an absolute pleasure working with you and solving problems together – I couldn't have asked for a better crew to bring this aircraft alive!

Approaching Pam with a crazy suggestion about the flight or engine model usually prompts an answer like: "no, this can't be done. It's impossible to do! " One day later, she found a way to get exactly what was proposed. Thank you Pam for your expertise, wizardry and friendship!

Zak's sound packs never seized to amaze me. I always get very excited to find out what's new and how it sounds. His background in music really shows in the amazing sounds he produces for the 247. Thank you for your tireless work and your creative ideas!

Eric's knowledge in the ancient ways of navigation is outstanding and his work on the radio is that of a true engineer. This man learned a new programming language within a few weeks to get our radio working in the way it's supposed to. Thank you for your time and effort!

Don has been instrumental in the development of this add-on. He managed to provide us access to Boeing 247 documents that would've otherwise been out of our reach and his experience has been an incredibly important resource in getting the details about this aircraft right. Thank you for all your feedback!

I also want to extend my gratitude to all the testers, streamers and writers that helped us tremendously in the last weeks of developing this add-on. You all have been integral to the development and I feel very fortunate of leaning on you for advice.

- Otmar Nitsche, lead developer Wing42

13 Fuel System

At a glance

What is simulated?	What is not simulated
- Complex fuel system. - Fluctuating fuel pressure indication. - Realistic engine priming. - Working wobble pump with varying resistance.	- Fuel leaks. - Fuel contaminations.

Fuel is stored in three wing tanks located in the section between the fuselage and the engines. The left wing contains a main tank of 136 gallons (515 liters), whereas the right wing contains a main tank of 66 gallons (250 liters) and an auxiliary tank of 70 gallons (265 liters).

Both engines are supplied with fuel from a common valve that is operated from the cockpit. This means that both engines will always draw fuel from the same tank and pilots must switch between the available fuel tanks regularly during flight (see Figure 13-1).

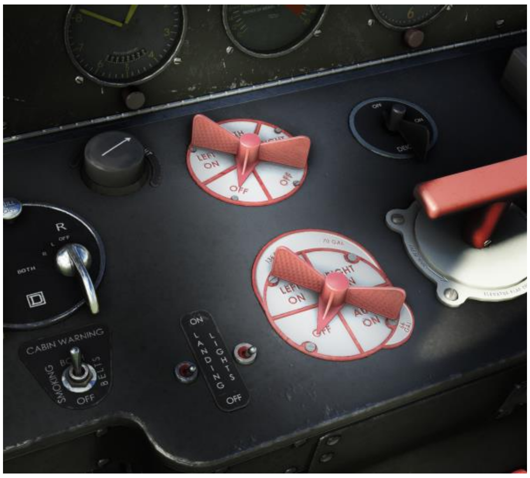


Figure 13-1: Top - engine distribution dial. Bottom - fuel tank distribution dial.

The tank selector dial operates a central four-way-valve that opens the supply of fuel from the selected tank. From there, the fuel passes through a wobble pump that can be operated from the cockpit to build up fuel pressure prior to engine start-up. From there, the line continues to another set of valves that are operated from the engine distribution dial, located on the center console. This dial is used to cut the fuel supply to either or both of the engines. From this engine valve, flexible fuel lines connect to the inlet connection of the engines' fuel pumps.

Two fuel pressure gauges are mounted on the right side of the main instrument panel to provide information on each engine's fuel supply. The instruments are connected directly to the fuel inlet of the Wasp engines.

The aircraft is equipped with a Lunkenheimer dual-engine primer to prime each engine prior to engine start-up.

14 Electrical System

At a glance

What is simulated?	What is not simulated
- Complex electrical system with all consumers taken into account - true to the original aircraft. - Realistic voltage and current. - Voltage drop as more load is being put on the battery. - All lights dim as the voltage of the main bus drops. - Replaceable fuses that can blow.	- Malfunctions of electrical consumers.

The electrical system is powered by a 12 Volt battery, located in a sealed battery compartment in the leading edge of the right wing. The battery can be recharged with a 25-Watt Eclipse generator, mounted on the rear of the left engine. Care needs to be taken when operating any electrical consumers, as to not drain the battery too much. It should therefore be avoided to operate any of the high-power devices over a prolonged period of time.

All circuits are protected by Bussmann fuses, which are readily accessible in junction box J-71, located on the right side of the cockpit (see Figure 14-1). In addition, the wireless equipment is connected via a separate bus, for which both the bus, as well as each individual component of the radio is protected by fuses. The junction box for the radio equipment is labelled "RADIO FUSES" and can be found on the right side of the central control column.

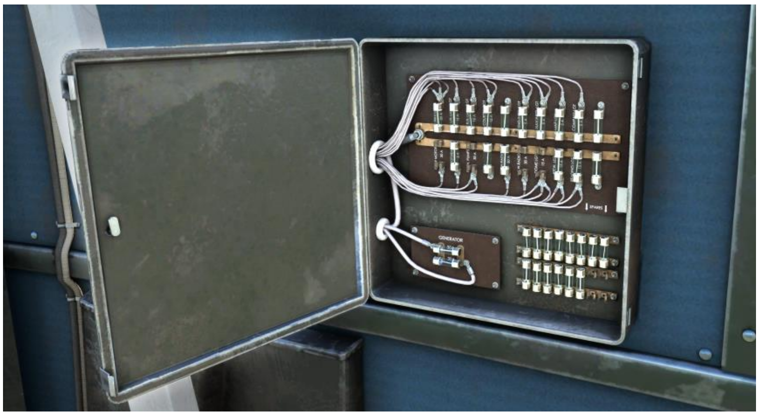


Figure 14-1: Junction box J-71, located on the right cockpit wall, contains the fuses that protect most of the ship's electrical components.

The J-71 junction box also contains a rack for sufficient spares, which can be refilled while on the ground. Only when the aircraft is stationary, a tin box of spares will appear inside the junction box. By clicking on the box, the rack of spares will be restocked.

14.1 Battery and Generator

Electrical power is stored in a 12V, 60 Ampere-hour battery, installed in a special compartment in the right wing.

The generator is an Eclipse 25 Ampere 15 Volt, shunt-wound type and mounted on the left engine.

14.2 Monitoring Electricity

The monitoring of the electrical system is crucial on this aircraft and at no point should too much power be drawn from the battery. While the aircraft is not equipped with a voltmeter to monitor the charge status of the battery, there's an ammeter that can accurately inform the pilots if the battery is charging or discharging at any point during operation.

Figure 14-2: The ammeter shows a positive current, the battery is recharging.

Figure 14-3: The ammeter shows a negative current, the battery is discharging.

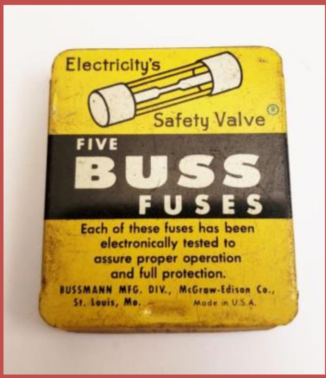
Pilots might want to consider preserving power by switching off non-crucial parts of the system. At night especially, it is important to manage your electrical system well and keep an eye on the ammeter to not overload any circuits. For instance, the landing lights may be switched off before operating the landing gear motor. Courtesy lights should only be used while on the ground and the navigational radio should only be turned on when needed.

The ammeter is located on the far-right side of the main instrument panel and has a usable range from +/-10 Ampere. It indicates a negative current when the battery is discharging, i.e. more power is drawn than produced, and a positive current when the battery is being charged by the generator.

Note that when re-charging a low battery, the current flow will drop over time as the voltage levels of the battery rises again. It is therefore perfectly normal to see an indication close to 0 Ampere when the lights and radios are turned off; the battery is full and the generator running.

Melting-type fuses

Modern circuit breakers were not invented yet in the 1930s and instead melting-type fuses, like the Bussmann's in our Boeing 247D were used.



The fuses consist of glass, or ceramic cylinders with conductive caps on each end and a thin filament connecting both. These fuses are put in series with any electrical component one wishes to protect.

During normal operation, electrical current will freely pass from one terminal, through the filament to the other terminal and from there further to the light, or any other electrical device that needed power.

In the event of a short-circuit, the current through the filament exceeds the rating of the fuse. As a result, the filament will melt and thus disconnect the power from the electrical device to protect it from a surge.

Consequently spent fuses need replacement before the circuit can be powered up again.

15 Lighting

At a glance

What is simulated?	What is not simulated
- Accurate wiring of all lights, including different buses. - Lights dim when the voltage drops. - Working rheostats for the instrument panel lighting. - Realistic radium luminescent instrument faces and needles. - Passengers toggling their reading lights at night.	- Light bulbs failing.

The lighting of the aircraft is in accordance with 1930s standards. All lights can be controlled by a series of two-way switches, located on the far-right side of the main instrument panel.

15.1 Cockpit lighting

Note that there is no dome light installed in the cockpit and some controls and instruments won't be illuminated sufficiently at night. Therefore, it is advisable to have a flash light handy when entering the cockpit (default keyboard shortcut: Alt+L).

To illuminate the main instrument panel, there are three dashboard lights installed on the bottom of the glare shield. Those lights can be toggled in two segments. The "NAV INSTR LIGHTS" switch controls the center of the panel, while the "ENG INSTR LIGHTS" switch controls both the left and the right side of the lighting. Both of those circuits have a corresponding rheostat on the center console, with which the lights can be dimmed.

The light for the magnetic compass has its own independent circuit, which can be controlled with the "COMPASS LIGHT" switch and the "COMPASS LIGHT" rheostat on the center console.

Furthermore, the light for the radio remote control can be controlled with a switch marked "LIGHT" directly on the left side of the box. Note that the power for this light is provided through the radio circuit.

A map light is installed on the copilot's side of the cockpit. The socket holds a red-tinted bulb to improve the pilots' night vision.

15.2 Radium luminescence

All instrument faces and needles are painted with radium-phosphorous-latticed paint to enable luminescence for enhanced instrument visibility at night. Be aware that the luminescence decreases over time, so make sure to “recharge” it by turning on the cockpit lights every 20 minutes or so.

Note that the flashlight doesn’t recharge the luminescent gauges, the instrument lights need to be turned on for it.

Passengers on your flight will utilize their reading lights. Depending on the time of day, they might toggle their switches to read the latest edition of Street & Smith’s “Picture Play”.

15.3 Exterior Lighting

For night flying, the Boeing 247D is fully equipped with exterior lights, all of which can be controlled from the lighting panel on the main dash. Keep in mind that the landing lights should only be operated directly before landing, as to not drain the battery too much.

For ground operation, the aircraft is equipped with courtesy lights, mounted right in front of the landing lights. Courtesy lights are turned on for better visibility while maneuvering on the ground.

15.4 Cabin lighting

The lighting for the cabin is separated in two different circuits. The lights are generally controlled directly from the cabin, but there is a master switch in the cockpit to turn off the dome and reading lights, to avoid reflections on the wing during approach.

The “CABIN LIGHTS” switch should generally stay in the “ON” position during flight. This allows the passengers to use their reading lights at their discretion. The dome lights in the cabin can be controlled by three-position switches, one of which can be found on the instrument panel, the other is mounted in the cabin, next to the main door.

Radium-Girls

An important fact about the luminescent paint used for the instruments in the 1930s wasn’t known at the time: the paint was highly toxic, due to its radioactivity.

Predominantly young woman worked at the factories that painted the instrument faces and needles. The workers would often lick the paint brushes to restore the tip, or play with the luminescent paint by using it as makeup.

The nasty awakening came a few years later, when those women started to get sick and a lot of them subsequently died.

It is a sad a gruesome story, that has even made it to the theatres with the movie “Radium Girls”.

16 Vacuum Instruments

At a glance

What is simulated?	What is <u>not</u> simulated
- **Realistic simulation of the complete vacuum system.** - **Pressure based on engine state and vacuum pump rpm.** - **Individual gyro rpm calculations for each instrument.** - **Gyro drift errors, both mechanical and apparent.**	- Failure conditions, apart from engine shutdown causing instruments to fail.

There are three vacuum-powered instruments installed on the instrument panel of the Boeing 247D. The Directional Gyro (modern: heading indicator), Artificial Horizon (modern: attitude indicator) and Turn and Bank indicator (similar to the modern turn coordinator).

Both the directional gyro and the artificial horizon are powered by an engine-driven vacuum pump, installed on the right-hand engine. The pump creates low pressure that is governed at around 4 p.s.i. by means of a pressure relief valve.

The Turn and Bank indicator is powered by a suction inlet on the manifold of the left-hand engine. This is done so that, in the event of an engine failure, either of the instrument sets will remain powered and can be relied on for navigation.

17 Radio Equipment

At a glance

What is simulated?	What is not simulated
- **Historical 1930s radio equipment.** - **Radio range navigation – navigate by ear and "fly the beam".** - **A.M. and C.W. radio mode.** - **Signal attenuation.** - **Picking up of radio broadcasting stations**	- Geographic and weather influences of the radio signal.

One important feature of the Boeing 247D was that she had the latest radio technology of the time installed. But radio technology in the 1930s was still very new and many of the modern high and very high frequencies could not be utilized yet. This is cause for some compromise when it comes to the historicity of the add-ons.

The Boeing 247D is equipped with a Bendix RA-1B radio receiver, located in the radio compartment in the nose section of the aircraft. To operate the radio, a MR-1B remote control is installed on the ceiling of the cockpit. The radio covers six frequency bands, ranging from 190 kHz to 1,750 kHz.

A retrofitted VHF type radio is mounted on the far right side of the instrument panel to facilitate communication with air traffic control.

Note however that the radio is not set up for the narrow modern frequency bands and can only be fine-tuned to the precision of .25 kilohertz.

A word on 1930s terminology

While studying the additional reading material we added to our add-on, you will come across a great deal of old-fashioned terminology.

For instance, nowadays we use "Hertz" and subsequently "Kilohertz" as a unit of frequency. Back in the 1930s, the term "cycles" and "kilocycles" was more commonly used.

Another example would be the fact that the term "wireless" was commonly used for anything we'd call "radio".

The old manuals also reference the "aether" as a physical mechanism for electromagnetic wave propagation, a principle that has been disproven by the Michelson-Morley experiment.

Don't be deterred by this – it's part of the fun!

17.1 The RA-1B / MR-1B wireless set

The Bendix RA-1B is a vacuum-tube operated radio set, covering a broad range of frequencies, distributed over six different bands. It supports two different operating modes: amplitude-modulation and continuous wave.

It can be used for navigation by picking up the signal of radio range stations. Those stations were the predecessor of modern day VOR and provide the pilots with a "directional beam" they can follow during their flight.

The system is entirely aural, meaning you need to tune in to your station and then listen and interpret the sound being received by your radio.

17.2 Modern day avionics

With the exception of the Wemac VHF transmitter/receiver and the virtual transponder (accessible via the clipboard, see chapter 7.6), no modern avionics are installed on our representation of the Boeing 247D. There's no ADF, no VOR, no GPS or INS, no marker beacon indicators, no autopilot.

The reason for this is that, with our add-on, we want to provide you with the most authentic, historical experience possible. We feel that providing you with any of the modern equipment, or even the *option* of installing, say a modern GPS, would greatly impede on that experience.

17.3 Those three ominous switches...

There are three switches mounted on the center control column, labeled "CRYST", "S.W." and "L.W." respectively (see Figure 17-1). Those switches are the remanence from an older radio installation that was using crystal radios for communication.

Figure 17-1: The three obsolete crystal switches.

Crystal radios are designed to operate without any additional power source. The received radio signal induces enough voltage to operate the equipment. However, to boost a signal received by a crystal radio, additional amplifiers could be turned on. The three switches in the cockpit were installed for that purpose, but after upgrading the radio equipment to the latest Bendix RA1/MR1B model, they became obsolete.

Rather than removing the switches, leaving three holes in the panel, Boeing decided to leave them installed but simply disconnect the switches. They since serve no function in the operation of the radio.

17.4 Radio Range Tutorial

Navigating the skies by listening to Morse-code is a daunting task and it takes some time to get the hang of it. To help you with the first steps, we included a document with a tutorial flight, which goes through the entire process from flight planning to execution.

Furthermore, you'll find original manuals from the 1940s in the documentation folder, in case you want to dive even deeper into the subject matter.

17.5 Old School Navigation Discord server

If you want to exchange your experience with other fellow radio range navigators, sign up to the "MSFS Astro Navigators Lounge" Discord! This server is owned and operated by Eric van der Veen, the author of the radio range equipment used in the Boeing 247D.

https://discord.com/invite/vtpde4ufsg

A word from the creators…

The crew grows increasingly anxious as the aircraft drones on through the pitch-black night. The rugged wilderness of the Chugach mountain range in Alaska is the worst place imaginable to get lost. With no chance for a successful emergency landing in this weather, the fate of the crew and passengers rests with finding the airport.

Frantically the crew searches for clues to find their position after having swerved around a thunderstorm. Then, faint but unmistakably the co-pilot picks up very faint beeps through the hissing of static in his earphones. From a lifetime experience he recognizes the morse signal dot-dash for 'A'. And shortly, Anchorage Radio Range station broadcasts its unique code. A sigh of relief!

"Come left 10 degrees, Capt'n!", and swiftly the Boeing gracefully turns to intercept the inbound beam into Anchorage. Another flight about to complete safely.

- Eric van der Veen, Wing42 Radio Range Navigation developer

18 Night Flying

The Boeing 247D is fully equipped for operation and navigation at night. However, compared to modern day equipment, it is still dangerous and limited.

19 Credits

Lead Design, 3D modelling, texturing and coding	***Otmar Nitsche***
Flight model magician	***Pamela Brooker***
Sound Design	***Zak Spence***
Radio expert	***Eric van der Veen***
Character design	***Natalya Kopylova***
Radio broadcast stations	***Cynthia Camasca***
Video tutorials and camera setup	***Rob Crawshaw***
Additional effect textures	***Martyn (TwoCats)***
Testers	***Don Spence***
	Peter Matthess
	Matt Childs
	Santiago Vázquez
	Tom Harnish
Chief Debugger	***Admiral Nelson***

Additional licensing:

The Wing42 Boeing 247D proudly uses the WWise sound engine to bring the aircraft to life.

powered by Wwise®

With Special Thanks to:

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