The Lockheed Vega project is dedicated to Ada, who helped through hard times and supported us every step of the way. You will be missed.
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1 Preface

Thank you for your purchase. I am aware of the risk involved in the purchase of a product in the early stage of development and I am very grateful for the trust you put into us. The product you bought is still full of flaws and unfinished parts and I assure you that we’re working very hard to bring everything up to a high standard!

I also want to welcome you to participate in the development of Wing42’s Lockheed Vega 5! With your purchase comes the opportunity for you to have a say in the development process. It is exactly this input we seek early in the development to make sure that you receive the product you want. So please feel welcome to post in our forums (forum.wing42.com) any suggestions, criticism or bug reports you have. Also feel free to commend us when we do something right – every form of feedback is welcome!

Kind Regards,

Otmar Nitsche

Founder Wing42
2  A word about the manual

With the installation of the Lockheed Vega5, you installed a few PDF documents designed to help you understand the product and its functions better. The document you are reading right now is the Simulation manual, which will guide you through the operation of the aircraft within your chosen flightsim platform. Since every add-on aircraft for FSX/Prepar3D operates slightly differently, it is necessary to give you the information about our simulation and how the Vega handles in the sim. Since the Wing42 Lockheed Vega comes with a lot of custom animations and a highly detailed system simulation, it is imperative to point out the major differences to other aircraft and the implications when handling the Vega.

Additionally we provide you, admittedly anachronistically, a checklist for the aircraft that will assist you in every stage of flight. You can access it through the Windows start menu.

Similar to the software you installed, this manual too is a work-in-progress and will grow as we add more functionality to the aircraft. Here you will find information on the simulation of the various modules and the physics that govern those processes.

You will come across a lot of red textboxes in this document. Those notes always indicate a missing system or known bugs of the simulation. As new versions of the Software are released, the number of red boxes will decrease!

With version 0.85 of the Lockheed Vega, you’ll also find a 70-page e-book about the history of the Lockheed Aircraft Company in general and the Lockheed Vega in particular. The book was meticulously researched and beautifully written by Tom Harnish.
3 Persistency

The Lockheed Vega is using a persistency file to maintain persistency. This means that every time you load the Lockheed Vega in you flight simulator, it will restore the state of the aircraft when you left it.

This includes the states of all controls, levers, switches and buttons. It will restore the previous quantity of fuel in the tanks and the cargo that was left in the aircraft. It will however unload any passengers, since they are assumed to have gone home after you left them sitting on the tarmac for a while. Any malfunctions or errors will carry over – a blown fuse will still be blown when you come back and the static port will still be blocked if you left it this way. Any installed ground equipment will still be there as well.

If you are curious, you can find the persistency file under:

%LOCALAPPDATA%/Wing42/Lockheed Vega/data.dat

You can open and edit the file with any text editor.

If you find yourself in a situation where your edits caused some unexpected problems, you can always just delete the file. The Lockheed Vega will reset to a default when you use her the next time, and the file will be restored when exiting again.

Please note that there is only ONE persistency file that is shared between all platforms you use and variations of Vegas you fly.
4 The Aircraft

Like many other aircraft from the era of the Lockheed Vega, none of the produced planes were the same. There was considerable variation in engine configuration, seating, navigation equipment and instrumentation.

Our flight simulator add-on currently comes in one variation, namely the Lockheed Vega 5C. It is a seven-seater aircraft, powered by a Pratt & Whitney R-1340 C “Wasp” radial engine and is equipped with the newly developed “NACA cowling” to improve its performance. Instead of modeling it based on one specific aircraft, we tried to incorporate interesting features from a number of different aircraft.

We will include more variations in future updates.

Currently included are the following liveries for the Lockheed Vega 5C:

- Lockheed factory default livery (NC-14236)
- Fictional Wing42 livery (NC-5542)
- Shell No.7 livery (NC-13705)
- Braniff Airways livery (NC-8495)
- Green "military" paintjob
- Jimmy Mattern’s "Eagle" (NR-869-E)
- Mirow Air Service, an Alaskan airline (NC-162-W)
- Fictional “The Sky Lounge” livery (N5KY)
- Transcontinental and Western Air Inc. TWA (NC-624-E)
- DL-1B special (metal fuselage), privately owned (NC-12288)
- DL-1 / Y1C-12 (metal fuselage), U.S. Army transport aircraft (A.C. 31405)
- Mexican Transportes Aéreos de Chipas S.A. (XA-BAW / XA-BKG)

Furthermore, we included a preview of the upcoming “Winnie Mae”, Wiley Post's aircraft as it was used for his first around-the-world flight with Harold Gatty in 1931. Please note that this variant of the Vega comes with a separate 3D model and changes to the aircraft’s performance and internal coding. Those changes are not completed; hence the aircraft is not fully functional yet. Note especially that the 400 gallon fuel tank in the center of the fuselage is not hooked up to the fuel system yet and thus cannot be used. A fully functional “Winnie Mae” will be available with the upcoming update to version 0.90.
The Wing42 Lockheed Vega 5 features effects, carefully crafted by FSFX Packages, a company specialized in the development of effect files for add-on aircraft.

Those effects included in the Vega 5 are:

- A new volumetric landing light
- Start-up smoke effects
- Engine wash and wheel water splashes at rainy and snowy days
- Touchdown effects
- Splashing dirt when taxiing over non-sealed ground

Check out the website of FSFX Packages to find out more about their outstanding products.

www.fsfxpackages.com
The Lockheed Vega features Wing42’s own physics engine called the Prop-o-Tronic physics engine. This module is responsible for the physics calculations that constantly run in the background of the aircraft and enable an incredible level of realism.

The physics engine is currently under development and new features will be added bit by bit, with the goal to make the aircraft function as realistically as possible in the flight simulator. The algorithms developed for Prop-o-Tronic are all derived from real-world formulas used in physics and engineering to ensure the most accurate behaviour of the airplane and its engine.

The physics engine features a suite of algorithms for electrical calculations, fluid dynamics, motion dynamics, heat exchange and energy conservation with more realms of physics and engineering being implemented with every update.
7 First Flight

When running the Lockheed Vega 5 for the first time in FSX/FSXSE, your simulation platform will issue a warning as seen in Figure 1.

Figure 1: Trusted software dialog.

It is important that you select “Run” in this dialog, since otherwise the Vega won’t be simulated properly. You will then be presented with a second choice, as seen in Figure 2.

Figure 2: Select “Yes” to remember the selection.

Choose “Yes” to prevent the previous dialog to show up the next time you load the Vega into your simulator.
8 Cockpit overview

8.1 Main Instrument Panel

![Diagram of the Main Instrument Panel]

8.2 Left Wall

![Diagram of the Left Wall]
8.3 Right Wall
9  Ground Crew Interface

Whether you want to prep your aircraft for your next flight, or secure it for the night, you will be assisted for any tasks by your loyal ramp agent. Meet Heinrich Adler, German immigrant to the U.S.A., always willing to carry the suitcases of your passengers and move the ground equipment around for you (Figure 3).

Provided the Vega is on the ground, you can talk to Heinrich by hovering over the yellow bar on the left side of the screen. It will expand and reveal two options, the first giving you access to the dialog options (Figure 4, A). The second button (Figure 4, B) opens the settings window for the aircraft, which is further explained in chapter 15 “Settings panel”.

After clicking on the “Talk to Heinrich” button, you can select between the different dialog option in the dialog selection window (Figure 5, A). Heinrich will acknowledge your request and give a short reply when the task is completed (Figure 5, B).

Keep in mind when assigning tasks to your ramp agent, that Heinrich can only ever do one thing at a time. When assigning multiple tasks to him, he will work through his task list one at a time. Note that he won’t be responding all the time, but only after completing the last task in his queue.

To close the dialog screen choose “That’s all”.

You can also use the dialog interface to open the payload manager by choosing the “Show me the Payload Sheet”. Alternatively, you can always use SHIFT+2 to access the payload manager.
10 Payload Manager

The Payload Sheet can be used to set the passenger, cargo and fuel load for the flight. The left side of the panel shows the layout of the fuselage. Here, you can board passengers and cargo (Figure 6).

Click on an empty seat to fill it or click on an occupied seat to remove the passenger again. The weight calculations will be updated in the table on the right immediately; however be aware that this is merely a pre-selection!

In order to make any real changes to the passengers on board, click the “BOARD PASSENGERS” button. By doing so, the ramp agent will begin to prep the aircraft for boarding by installing wheel chocks and the passenger stairs. After that the passengers will board the aircraft one by one. Once everyone is seated, Heinrich will remove the equipment again and call out when everything is done.

Loading of additional cargo happens in a similar fashion. First, pre-select the desired loadout using the “+” and “-” buttons in the baggage compartment. Alternatively, you can use your mouse wheel while hovering over the “baggage compartment” to adjust your loadout. Once you’re happy with the selection, order your ramp agent to load the ship by clicking on “LOAD CARGO”. Similar to the boarding of passengers, Heinrich will bring the required equipment before loading the aircraft. He’ll let you know when he finished all tasks.

To refuel the aircraft, select the desired fill level for each tank first and order the ramp agent to fill the tanks accordingly by clicking on “LOAD FUEL”. Heinrich will install the wheel chocks, before filling your fuel tanks one by one.

The table on the bottom right of the panel shows the weight distribution of the selected loadout. Click anywhere on the table to switch between metric and imperial units. Be aware that the numbers represent your selected loadout! Only by clicking the appropriate “LOAD…” buttons will the weight table representative of your actual loadout.

Please note that passengers are not represented in the 3D model of the Vega yet. This feature will be included in a future update.
11 Walkaround Interface

By pressing Shift+3 you have access to the walkaround interface of the Vega. This panel lets you perform the pre-flight inspection of crucial parts of the airframe, engine and control surfaces to ensure its function.

The right side of the panel shows the different stations that need inspecting. By clicking on the yellow “CHECK” button, you will perform the required inspections of that station and the result of your inspection will be written on the left side of the panel under “findings”. If the inspection reveals a problem, buttons will be displayed below the text that will help resolve the issue.

Please note that the color of the “CHECK” button on the right indicates the readiness of the inspected station. It will turn green if no issues were found and red if there is a serious problem at the station. The yellow color indicates that further action may or may not be necessary.

Please note that the walkaround interface is not fully functional yet, since many of the items you inspect cannot fail as of version 0.85. This means that the inspection of the majority of items will always lead to a green mark. However, some items serve a useful function already. I.e. the engine oil check, the inspection of pitot and static port and the fuel level verification.
11.1 The inspection of the propeller

Some stations also require additional actions before being cleared. Take the first station, the propeller, as an example. The check requires a visual inspection of the blades to make sure it’s not damaged. But you are also required to pull the propeller through a few rotations to ensure that the engine is ready to go (see Figure 5).

To perform this task, simply click and hold the left mouse button for a few seconds. You will see the propeller of the aircraft turning slowly. After a few rotations the check button will turn green, indicating that the engine is ready to go. The resistance of the crankshaft as well as the moment of inertia are modelled into the aircraft and it can happen that the inertia is not sufficient to overcome the resistance in the cylinders. If this is the case release the button, wait until the propeller swings back a bit and then click and hold the button again. The momentum should now be sufficient to wing the propeller over the bump.
11.2 The inspection of the oil

At station two you’re asked to check the engine oil of the aircraft. When clicking the check button in the list, the oil level will be checked and reported under “findings”. For a more thorough investigation, you can click on the “INSPECT OIL” button, which will open a new window (Figure 6).

![Figure 9: Oil inspection window, with additional information of the engine oil in the tank.]

The oil inspection window gives you a more detailed analysis of the oil in the tank. At the top you see what type of oil is currently in the tank and you’ll see the tank level. On the bottom, below the sample, you see a description of the condition the oil is in.

If your tank level is not completely full, you can use the buttons on the right to refill the missing oil. Simply choose the oil you want to use by clicking the corresponding button. You can also click on the “HELP” button to get some clues in what conditions which oil should be used.

Please note that oil does not deteriorate just yet. Also, the engine currently does not consume oil. Both are planned features for the upcoming version 0.90.
11.3 Inspection of the pitot tube and static port

Station three lets you inspect the pitot tube and the static port. If additional actions are needed, the buttons for those actions will be displayed below the findings (see Figure 7).

Note here that you can use the walkthrough interface to remove the cover of the pitot tube, bypassing the ground crew interface. Furthermore, if either of the two ports appears clogged up, you will see an option to remove the blockage (see picture).
12 Maintenance Tool

Pressing **SHIFT+4** will open the following maintenance tool (Figure 8):

![Maintenance tool](image)

The book is divided into different chapters that correspond to various systems of the Lockheed Vega. You can flick through the book using the “NEXT PAGE”/“PREVIOUS PAGE” buttons (B and C), or access an individual chapter directly by clicking on the name in the table of contents (A).

You will find some pages empty at this point, since some of the Vega’s systems are not fully developed yet.
When accessing any of the chapters of the maintenance manual, the following data is being generally presented to you (Figure 9):

The left page typically shows a diagram of the system you’re examining. In the above example you can see the wiring diagram of the electrical system (A). The right side lists all relevant components of the system (C) and is used to interact with your mechanic Jack.

To inspect a component, either click on the word “INSPECT” next to it, or select it directly on the diagram on the left page. Similar to the ground crew interface, you can queue up a number of tasks and your mechanic will work through them one by one. Once finished, the button next to the component will change from “INSPECT” to “REPORT” to indicate that the mechanic finished his assessment. Concurrently, the inspected component will be highlighted on the left page. The highlight will either be green, indicating that no issues were found, or red to let you know that there mechanic found a problem.

Please note that the tab “Mechanic’s notes” doesn’t serve any purpose yet.
Click the “REPORT” button, or the corresponding component in the diagram, to open the mechanic’s report card (Figure 10).

It will display the name of the component and a picture (A). Click on “ATTEMPT TO FIX COMPONENT” (C) to advise your mechanic to take care of the issue. The task will be queued and performed in order.

Please note that the report itself (B) is not fully implemented yet. Please ignore it for now; it will come in a future update.

There are a few things to keep in mind:

- Just because your mechanic didn’t find any issues or malfunctions does not automatically mean that there aren’t any! He might overlook an issue if it is difficult to find.
- Similarly, your mechanic might not have resolved an issue after the attempt of fixing it was made.
- You won’t know for sure if this is the case, since any problem your mechanic thought he took care of will be marked green.
- You can advise Jack to perform an inspection of the every component of a system by clicking the button “INSPECT ALL COMPONENTS” (Figure 9, D). This will add the inspection of every item to the mechanic’s queue.

Please note that the maintenance manual is in the early stages of development and therefore subject to change.
13 Handheld Radio

In 1927, radio communication was still in its early development and the standards were different to what they are now. Back then most radio communication, even for aviation, took place in Morse code and on low frequencies. For the most part, the 500 kilocycle standard that was set by the maritime industry was used in early radio communication for aircraft as well.

13.1 Installation

Since these frequencies and the equipment of that time is incompatible with modern day avionics, the Vega does not come equipped with a radio. However, to satisfy the needs of those flight simulation enthusiasts who would like to communicate with ATC on their flight, we provide you with a simple handheld radio that you can install if you need it.

To get access to the radio, you need to perform two simple steps. First, locate the aircraft.cfg file of the Wing42 Lockheed Vega. You’ll find it in the directory of your simulator under:

```
<sim root>/SimObjects/Airplanes/Wing42 Lockheed Vega 5/aircraft.cfg
```

To include the radio in the Winnie Mae as well, find her aircraft.cfg under:

```
<sim root>/SimObjects/Airplanes/Wing42 Lockheed Vega 5 special/aircraft.cfg
```

Open the file with a simple text editor like Windows Notepad and scroll down until you find the section [RADIOS]. Under the entry Com.1 change the first “0” into a “1” and save the file (see Figure 11).

Next, open the panel.cfg file that you’ll find under:

```
<sim root>/SimObjects/Airplanes/Wing42 Lockheed Vega shared/panel/panel.cfg
```

Under the section [Window Titles], remove the two leading slashes of the line “Window05” and save the file (see Figure 12).
13.2 The radio

Once these changes have been made, you’ll be able to access the handheld radio pressing **SHIFT+6** on your keyboard.

The radio provides you with some basic functions to interact with the simulator’s air traffic controllers. You can switch it on and off using the large volume button on the top right of the radio.

Change the frequency by pressing on the buttons of the interface and hitting “ENT” afterwards. For example, if you want to switch to the frequency 119.75, press:

```
1 1 9 7 5 ENT
```

You can use the CLR button to reset the input if you mistyped.

Note that only the numerical buttons, the ENT and CLR buttons are operational.
14 Debug Panel

As an Early-Alpha customer, you have access to our Debug Panel, which provides insights into the guts of the Lockheed Vega simulation and helps to trace down issues or bugs. You can access the Debug Panel by pressing **SHIFT+9** on your keyboard (Figure 14).

The first page shows the versions of various parts of the Vega. This information can be important when tracking issues. The following pages display a large chunk of internal and Simulator specific variables. They are grouped by their various systems and you can flick through the panel using the “[NEXT]” and “[PREVIOUS]” buttons on the bottom of the page.
15 Configuration panel

Using the side-panel while on the ground, or pressing \textbf{SHIFT+6} at any time will open the Lockheed Vega Configuration panel (Figure 18).

Use this panel to update the Vega’s configuration in real-time. You can change the audio levels, or mute a channel completely (A). Be aware that any changes to the audio level need to be saved in order to take effect (E).

A future update will allow changing several realism parameters. This feature is not implemented yet (B).

You can select one of two pre-configured aircraft states. Select “Cold and Dark” to shut down the engine and configure the aircraft as if it was secured for the night. Select “Ready to Fly” to remove any ground equipment and have the engine running, ready to take-off (C).

Furthermore, you can use the “Fix All Issues” button to quickly resolve any malfunctions of the aircraft.

Figure 18: Configuration Panel. A) Change audio levels. B) Realism settings are not implemented yet. C) Select a pre-configured configuration of the aircraft. D) Bypass the mechanic and simply resolve any malfunctions of the aircraft. E) Save your changes.
16 I/O Philosophy of the Virtual Cockpit

All animations of the Lockheed Vega have been customized with two main objectives in mind: immersion and intuitiveness and sometimes there is a challenge to balance the two. The Wing42 Lockheed Vega follows one simple principle: if the real-world control moves in a certain way, the user needs to replicate that movement with the mouse. That’s why many controls don’t respond to simple mouse clicks, but instead require a click and drag action. This applies to most of the levers and valves, as well as the magneto switch and the elevator trim. Most of those controls also react to the movement of the mouse wheel.

Any single-action controls, such as the switches and buttons can be toggled using a single mouse click or the mouse wheel.

Some levers, such as the handle of the wobble pump, the primer and the two plungers of the fuel quantity gauges can be twisted as well. This serves no other function than making the cockpit more realistic.

Some of the controls are a bit more complex though and therefore require some explanation.

The parking brake mechanism is of a ratchet-type and needs to be operated in a similar manner as the parking brake in a car. It is set by pulling (click+drag) the lever fully backwards and then release it. It will spring a few inches forward. To release the parking brake you first need to pull the lever fully back and in the same motion move it forward before releasing it.

The hatch in the cockpit can be opened by first pulling the latch downwards (click+drag) and then pushing the hatch backwards. When you close it again, the latch will automatically snap into place.

The four single seats in the cabin can be stowed by pulling the backrest fully forward and then pushing the bottom part of the seat towards the cabin wall. The bench in the back can only move its backrest to allow access to the cargo compartment.
17 Engine Simulation

Thanks to the Prop-o-Tronic physics engine, the Wing42 Lockheed Vega 5 features a highly detailed simulation of the original Pratt and Whitney R-1340 C engine.

The simulation runs in two different modes, a low-rpm mode and a high-rpm mode. The low-rpm mode is active when the engine’s speed is less than 85 rpm and thus covers the engine at rest, start-up and shut-down. The high-rpm simulation kicks in when the engine speed runs faster than 85 rpm and is therefore active as soon as a successful engine start was performed.

In the low-rpm regime, all moving parts of each of the nine cylinders are being properly calculated. The crank-angle of the crankshaft is calculated in real-time and in correspondence to that, the position of each piston and the opening of the intake and exhaust valves are all updated as well. The timing of the ignition is calculated based on the timing gear’s current angular position and the voltage produced by the magnetos is accurately simulated.
18 Engine Starter

Starting a historical radial engine is not as easy as just flipping a switch. Aircraft engines of the 1920s up to the 1950s required the pilots to follow complex start-up procedures to ensure a reliable and safe operation. A big technological development for early aircraft engines was the implementation of electrical starters. Prior to the 1920s most aircraft engines were started by a member of the ground crew by manually “throwing” the propeller around with the ignition engaged. This procedure is not only strenuous but also very dangerous to the personnel.

With advancements in electrics, engineers started to think about the implementation of electrical starters. But there were several hurdles to overcome. First off, installing a starter motor meant an increased dry weight of the aircraft, not only because of the electric motor itself, but also the battery that needed to be big enough to provide enough power. To produce enough torque to crank over a big radial engine required a big starter motor and a high-capacity battery.

A compromise was found using electrically enhanced inertia starters instead of direct-cranking motors. Inertia starters work in two steps: Firstly, a flywheel is spun up to speed. Then a clutch engages the flywheel with the crankshaft of the engine. The “meshing” results transferring the kinematic energy, stored in the spinning flywheel, to the crankshaft to turn over the engine for one or two full rotations. This is usually enough for the combustion process to start and the engine to come to life.

Earlier inertia starters would be charged using a crank that was attached to the flywheel and operated manually, while later models included an electric motor to spin up the flywheel. The big advantage of this method of electric starters was that the motor used to crank the flywheel would be less powerful, thus lighter, compared to a direct-crank starter. Additional weight would be saved by utilising a smaller battery.

Such an electrically assisted inertia starter was the Eclipse starter used in the Wasp C engine of the Lockheed Vega 5 and is simulated in the Wing42 adaptation of this aircraft. The starter switch is located at a very awkward position - at least for us flight simmers. It sits directly on the firewall under the instrument panel and is not clearly visible in the default view.

Figure 19: Location of the three-position inertia starter switch and the corresponding clickspot in the virtual cockpit.
To alleviate this problem we made two provisions to the simulation: 1. With version 0.85 there’s an additional camera defined that shows the location of the switch. Press “A” on your keyboard until that camera is active. 2. You don’t need to click on the switch itself to operate it; instead you can click and drag in the centre under the instrument panel to operate the switch.

The switch is a spring-loaded three-position switch. In the full-in position, the switch closes the circuit of the starter motor which will then begin to spin up the flywheel. The full-out position opens the starter motor circuit and closes the circuit for a solenoid which engages the clutch, meshing the flywheel with the crankshaft of the engine. The spring-loaded, centre position is neutral/off.

In the sim, click on the switch or the aforementioned click spot under the dashboard. Hold the left mouse button, drag the mouse upwards and keep this position. You will hear the flywheel spin up, increasing pitch and volume as it turns faster and faster. Keep holding the switch in the wind-up position until the whining of the flywheel is steady, indicating the maximum rpm of it. Next, move the mouse down while still holding the left mouse button. This pulls the switch in the full-out position, therefore meshing the flywheel with the engine. You will hear a few squeaky noises as the flywheel decelerates very quickly and you should be seeing the propeller spinning for about two full turns.

Provided that there’s enough of a combustible charge in the intake manifold and the ignition is set properly, this will start-up the engine. Chapter 27 will explain the full start-up procedure in more detail.
19 Heat-exchange

The Wing42 Lockheed Vega 5 features highly realistic calculations to work out the heat energy of various components of the aircraft. For this the aircraft and its engine are broken down into small units each having their own set of physical properties like mass, volume, heat capacity, material, etc.

Next, relationships between all those components are being established with various properties guiding the nature of the relationship. For instance the cylinder barrels are in direct contact with the crankcase of the engine and thus they will pass on heat energy to the crankcase via conduction over a defined contact area.

Heat can be exchange via conduction, convection and radiation and at present around 140 of those heat-exchange-relationships are being calculated internally for the Lockheed Vega.

This exchange of heat comes into effect in the calculations for the engine’s temperature, e.g. the cylinder head temperature, and the calculation of the lubricating oil (see chapter 15).

Please note that the cylinder head temperature is currently taken directly from the simulator and not calculated by the Prop-o-Tronic engine yet. The whole simulation of the combustion process and its heat generation will be part of the next update to version 0.90.
20 Lubrication

The Wing42 Lockheed Vega 5 features a highly accurate representation of the real aircraft’s lubrication system. Figure 20 shows a diagram of the system as it is currently implemented.

The Vega is equipped with a 10 gallon oil tank. The oil is passed through a temperature control unit that is used to ensure optimal performance of the engine oil.

An engine-driven high-pressure oil pump is generating the oil flow through the various engine’s components, acting as an agent for both lubrication and cooling.

A filter filters out any contaminations in the oil, such as metal shavings or other particles.

The oil then passes through a check valve that closes off while the engine is not running, to prevent oil collecting in the downward facing cylinders of the engine.

From there, engine oil is directed to the various parts of the engine, such as the crankshaft, low-pressure accessories, pushrods and rockers, the cylinders and the propeller.

The scavenge oil is then collected in the sump, passes through a screen and is pumped back through a secondary engine-driven pump.

The temperature control unit is measuring the oil temperature at the engines inlet. The various valves of the unit will then open or close according to conditions, so either recirculate the oil from the sump, or cool it down through the oil cooler before passing it to the main tank.

For each of the components of the lubrication system the various physical properties of the oil are being calculated, such as the temperature, density, pressure, viscosity, flow etc. Those variables greatly influence the overall condition and performance of your engine.

Please note that the lubrication system, as implemented in version 0.85, is still work-in-progress and as such does not directly influence the aircraft performance yet. While all the calculations for the various physical parameters are being performed accurately, the boundary conditions for those calculations still need some fine-tuning.

You can however already observe the effects that different temperature conditions have on the engine’s oil. For instance you will note a sharp rise of the oil pressure if you’re trying to start the engine in cold conditions.

The oil system will be further refined with the upcoming updates.
21 Fuel System

The components of the fuel system of the Lockheed Vega 5C are the following:

- Three 32 gallon fuel tanks, located in the wings
- The fuel tank selector, located to the right of the pilot’s seat
- A strainer to remove fuel contaminations
- The wobble pump below the instrument panel on the right
- A fuel dump valve, located below the wobble pump
- The primer
- The engine-driven fuel pump
- The plumbing, pipes and connections
- Two fuel quantity gauges on the lower left of the instrument panel

Each of those components are part of the simulation of the Lockheed Vega and are calculated in real-time.

21.1 Wobble pump and Primer

The purpose of the wobble pump is to manually bring up the fuel pressure before starting your engine. This is a necessary step to ensure the engine doesn’t starve of fuel when engaging the starter. It is recommended to get the fuel pressure to about 2 - 3 p.s.i. before attempting to start the engine.

The Primer is a smaller pump used to squirt fuel vapour directly into the manifold, thus bypassing the carburetor and helping the first firing of the engine. It is protected by a shutoff valve with a metal handle, which also holds the plunger in place when not used. To operate the primer, first turn the metal handle to the right to open the valve of the primer and activate the plunger. Slowly pull the plunger out, to make sure that the cylinders fills with fuel and in a swift motion push it back in to atomize the fuel.

Dependent on the air temperature and temperature of the engine, different amounts of fuel are needed to successfully start the engine:

- Warm engine or warm day: 1-3 strokes
- Cold engine or cold day: 3-5 strokes

Both wobble pump and primer control have been programmed with the real physics in mind. The controls work by left clicking and dragging the lever towards the desired position, a single click doesn’t do anything. We tried to simulate a certain resistance when operating the controls. You can test this by closing the main fuel selector and then operate either of the pumps. The control will get harder and harder to move the more you try. You can compare this to an attempt to pump air with a bicycle pump while putting your thumb on the opening.

Please note that the primer needs fuel pressure to operate properly. Thus first bring up the fuel pressure using the manual pump, then prime the engine with the primer.
21.2 Fuel dump valve

Just below the wobble pump, you’ll find a small valve that can be used to dump fuel. Move it to the vertical position to open it. Make sure that you set your fuel tank selector to the tank you want to dump fuel from, no fuel will be dumped if the fuel selector is in the off position.

Please note that due to the small cross-section of the fuel pipe, it will take a while for all the fuel to be removed.

21.3 Fuel Quantity Gauges

You’ll find two fuel quantity instruments on the left-bottom part of the instrument panel. The instruments are of the pneumatic type and require a small amount of pressure to operate. This pressure can be generated by pulling and releasing the plunger situated under each respective instrument. When sufficient pressure is provided, the needle will settle to indicate the current fuel quantity in the tanks.

Please note however that these meters are notoriously imprecise and are calibrated for level flight only. Using them on the ground will return an erroneous reading and therefore only provide a rough estimate of the fuel content in the tanks.
22 Ignition

The ignition system of the Lockheed Vega consists of two engine mounted magnetos, an additional booster coil, the ignition harness and the spark plugs.

To ignite the fuel-air mixture when the engine is running, an electric spark is generated in the combustion chamber of an engine by the sparkplugs. For the sparkplug to function properly, a significant voltage is required which is generated by the magnetos of the engine.

22.1 Spark Advance
23 Barometric Components

An essential component of every aircraft’s instrumentation is the barometric system and its gauges. Barometric readings are being used to compute the aircraft’s altitude, its vertical velocity and airspeed. Wing42’s Lockheed Vega features a set of re-written algorithms to enhance the realism of the simulation. The barometric module we programmed takes the readings of ambient pressure, dynamic pressure, Angle of attack, etc. to calculate and display the corresponding values on the barometric instruments. This allows us to induce errors or malfunctions the pilot has to account for.

Figure 16 shows you an overview of all components of the barometric system. The Vega has two external ports, the static port and the Pitot tube. The static port connects with all three barometric instruments and supplies them with ambient pressure, i.e. the outside air pressure. As you fly higher, the air gets less dense and altimeter and vertical speed indicator measure this change to display altitude and vertical speed respectively.

The Pitot tube is a forward-facing tube which exposes it to the airflow around the aircraft. The airspeed indicator is utilising this dynamic pressure in conjunction with the static pressure. The difference between both these values is being used to calculate the indicated airspeed. In the Lockheed Vega, the Pitot tube and static port are combined in one sensor, located on the port wing.

Inside the cockpit you’ll find a valve that can be used to activate an alternate port. The alternate port is essentially a filtered opening, inside the cockpit, that can be used in case the static port fails or is clogged up.

Please be aware that the Lockheed Vega is not equipped with a Pitot heater element and the sensors are therefore subject to icing.

23.1 Altimeter

The sensitive altimeter is measuring the ambient pressure from either the static port or the alternate port inside the cockpit and relates the data to an indicated altitude. It’s utilising a pressure-sensitive diaphragm, connected to the instrument’s needles and is calibrated using the standard atmospheric model to convert the pressure into altitude. It can be adjusted by changing the Kollsman setting to the local atmospheric conditions.

Be aware that the Wing42 Lockheed Vega does not support an automatic adjustment of the Kollsman setting (“B” key)! This is a distinct feature of our aircraft that was included for an improved immersion.
23.2 Airspeed Indicator

The airspeed indicator is measuring the pressure differential between the dynamic pressure, provided by the Pitot tube, and the static pressure, which is supplied either by the static port or the alternate port inside the cockpit. Through a diaphragm, this differential is translated to the rotational movement of the Instrument’s needle.

Please be aware of the following limitations of this instrument:

- The instrument is only sensitive when the airspeed reaches around 20 m.p.h. and will indicate “0” below that airspeed.
- The measurement will be erroneous outside of a level flight. In other words, the higher your angle of attack is, the more pronounced the error will be. The same error can be observed when the aircraft slips.

23.3 Issues to deal with

Since both, the static port and the Pitot tube, consists of small openings and are exposed to the exterior, they are subject to blockage. While the aircraft is close to the ground, there is a small chance of particles being pushed into one of the openings, clogging it up over time. There’s also a chance of one of the ports being clogged by insects if you leave the sensors unprotected. To prevent this, make sure to have your ground crew install the pitot cover before exiting the flight simulator. Also make sure to remove the pitot cover before taking the Vega out for a spin!

23.3.1 Blocked Pitot tube

If the Pitot tube is blocked, you’ll notice that the airspeed indicator will be erroneous. One of the observed effects is that it will indicate an increased airspeed during a climb. This is caused by the measured dynamic pressure staying constant, while the ambient pressure from the static port decreases. The opposite effect can be observed with a blocked pitot tube during the descent, i.e. the indicated airspeed will decrease as the ambient pressure increases over time.

If you find yourself in the situation where you cannot trust the airspeed indicator, you need to rely on your senses to judge the speed of the aircraft. Make a landing asap and check the cause of the issue.

23.3.2 Blocked Static port

A clogged up static port is generally a more severe problem, since it affects all three of the barometric instruments. You will notice that the indicated altitude will stay fixed, the vertical speed will be locked 0 ft./min and the airspeed indicator will show a decrease of airspeed during climb and increase in airspeed during the descent, thus reversing the effect of a blocked Pitot tube.
If you see an indication of wrong readings of all of your barometric instruments, you can open the alternate port via a lever located on the lower-left of the instrument panel. Be aware however that using the alternate port in the cockpit as your static source will result in a lower response rate of your instruments. Always be alert that your readings, especially of vertical speed and airspeed, might be higher than indicated!

The simulation does not include malfunctions or systematic errors of the instruments, other than the one described above. Future versions of the Lockheed Vega will include malfunctioning instruments.
24 Vacuum System

The Lockheed Vega 5 is delivered with a sophisticated vacuum system and three important instruments that are powered by it. Those instruments are the Artificial Horizon, the Turn and Bank indicator and the Directional Gyro. Great care has been given to accurately simulate each component as realistically as possible.

Figure 17 shows an overview of all the components and instruments of the vacuum system.

Artificial Horizon and Directional Gyro are powered by means of an engine-driven vacuum pump. A relief valve regulates the airflow to around 2 p.s.i. The vacuum source for the Turn and Bank indicator can be switched between said pump and the Venturi tube. On the top-right side of the main instrument panel you’ll find a lever to select the vacuum source for this instrument.

All three gauges operate by means of a gyro that spins inside each instrument. The gyros are being spun by jets that use the airflow produced by the negative pressure of the selected vacuum source. In essence, Venturi or vacuum pump suck in air through the instruments and it is this airstream that accelerates the gyros.

24.1 Venturi

The Venturi tube is simple, yet effective way to produce negative pressure. It operates by the means of air flowing through the tube with a decreasing diameter. Since the air will get compressed at the smaller diameter, a pressure differential between inlet and the inside of the tube can be observed. It is this pressure differential that is being used to produce the negative pressure required to power the instrument.

When selecting the Venturi tube as your vacuum source you will observe that the airstream produced by the propeller is barely enough to power the Turn and Bank indicator. However with increased airspeed, its readings become less erratic.

Standard procedure is to always select the Venturi tube as a vacuum source for the Turn and Bank indicator. This is to increase redundancy in case of a failure of the vacuum pump. An exception should be made in case of cold weather, since the pressure port of the Venturi tube can freeze up and thus limit the airflow.

The Venturi tube of the Vega is located on the starboard side of the aircraft just outside the cockpit.
Note that there are no malfunctions of the Venturi tube programmed yet. So you don’t need to worry about running into trouble utilizing the Venturi tube as your vacuum source just yet. This will however be part of a future update. The same applies for weather effects, no freezing of the Venturi tube currently occurs in the simulator.

24.2 Engine-driven vacuum pump

The Pratt & Whitney R-1340 engine is equipped with a vacuum pump, driven by the main shaft. The pressure it produces is therefore dependent on the engine’s r.p.m. However note that the pressure relief valve will try to limit the maximum pressure to about 2 p.s.i.

There are currently no malfunctions implemented for the vacuum pump. For now, it will reliably produce enough pressure to maintain all three vacuum instruments.

24.3 Plumbing

The Lockheed Vega simulates the pressure loss occurring in the piping of the system. This pressure loss is naturally caused by friction and increases with both length of the tube as well as the pressure applied to it. The plumbing is divided into four segments each connecting one system to another. The four sections are:

- The vacuum line from the Venturi tube to the selector inside the cockpit.
- The vacuum line coming from the engine-driven pump to the selector in the cockpit
- The vacuum line from the selector to the Turn and Bank indicator.
- The vacuum line from the pump’s relief valve to the Artificial Horizon and the Directional Gyro.

Each of these lines is simulated as an independent system to enable malfunctions or blockage.

Please note that the vacuum lines and connectors won’t fail by itself yet, since this type of malfunction is not implemented yet. You can, however induce an error by manually editing the data file of the Vega and under the “Vacuum” section increase the value of one or more of the “leakage” fields. A future update will include the possibility of bursting a pipe or connector.

24.4 Pressure relief valve

The pressure relief valve is a spring-operated vent that opens up when an upper pressure limit is reached, thus maintaining a steady pressure of about 2 p.s.i. The simulation calculates the spring forces of the valve and releases pressure accordingly to the opening, adding to the overall realism of the Vega.

24.5 Gyroscopes

All three vacuum-powered instruments use gyroscopes to operate. Inside each instrument is a gyro with varying degrees of freedom, depending on the type of instrument. The gyroscopes are discs that are spun to a few thousand r.p.m. using the airflow of the vacuum source. To achieve these high speeds, small jets blow air onto vanes mounted on the side of the discs thus causing the gyro to spin.
The gyro effect makes the discs stay stationary inside the aircraft during manoeuvring and the orientation of the gyro relative to the aircraft is translated into the movement of the needles or similar indicators.

The Lockheed Vega simulates each gyro independently and with different characteristics. When powering the vacuum system, you will notice how each instrument will slowly come to life as the gyros spin faster.

### 24.6 Artificial Horizon

The artificial horizon uses a two degrees-of-freedom gyroscope for its operation. It features a gravity-based self-erecting mechanism that keeps it level relative to the ground (take that, flat-earthers!).

Please keep in mind that there are a few limitations on the instrument.

1. Make sure that the instrument is supplied with enough negative pressure. Too low of a pressure differential leads to the gyro spinning too slow, thus inducing erroneous indications.
2. You will observe the tumbling of the instrument during the initial powering of the instrument. While this is perfectly normal please be aware that extreme deflections of the gyro can lead to an increased load and friction on the gyro’s bearings. It is therefore recommended to cage the gyro before power-up.
3. Extreme manoeuvres can lead to the gyro’s gimbals reaching their limits. When this happens the gyro will experience increased friction in the bearings that can lead to a complete stop of the mechanism. You can use the caging mechanism to resolve the error, but be aware that the gyro will take time to reach its operating speed again.

No other malfunctions of the artificial horizon have been implemented to the Lockheed Vega yet. Those will come in a future update of the software.

### 24.7 Turn & Bank Indicator

The Turn and Bank indicator combines two instruments in one. The turn indicator is operated by a vacuum-driven gyro that indicates the rate at which the aircraft is turning during a manoeuvre. The bank indicator is an inclinometer, a “ball in a tube”, that reacts to slip forces of the aircraft. Both of these indicators in conjunction can be used to perform a coordinated, standard turn.

Please note that the instrument is referred to by its historical, and somewhat inaccurate, name. A more precise term to use is “turn and slip indicator”, since the inclinometer does not really indicate a bank angle, but rather the lateral forces (slip) of the aircraft.

No malfunctions of the turn and bank indicator have been implemented to the Lockheed Vega yet. Those will come in a future update of the software.
24.8 Directional Gyro

The Directional Gyro, sometimes referred to as Heading Indicator, is an instrument used to indicate the aircraft’s heading. It’s operated by means of a vertical gyroscope with one degree-of-freedom. Similar to the other two vacuum-driven instruments you will observe erroneous readings during the instrument’s power-up phase. Once the gyro is stabilized you can turn the heading knob to set the aircraft’s heading using the magnetic compass as reference. It is advisable to add or subtract the local magnetic deviation thus making the instrument showing the aircraft’s true heading.

The simulation features a variety of errors:

1. *Gimbal error*: the directional gyro will produce a small error induced by the aircraft bank, and pitch orientation.
2. *Drift*: The directional gyro will drift over an extended period of time. Therefore make sure to reset the heading indicator every 20 to 30 minutes, using the magnetic compass as a reference. The drift is dependent on your longitudinal position on the earth and your course.
3. *Gyro error*: If there’s a lack of airflow onto the gyroscope of the instrument, the indicated heading might not be correctly indicated after a prolonged turn.

Please note that the instrument does not support the automatic adjustment via simulator event ("D" key). This was done deliberately in an attempt to further the realism of the aircraft.

No additional malfunctions of the directional gyro have been implemented to the Lockheed Vega yet. Those will come in a future update of the software.
25 Electrical System

Great care has been given to the simulation of the electrical system. The electrical module used in Wing42’s Lockheed Vega is a complete re-write of the system to guarantee a high level of realism. This allowed us to include features that haven’t been seen in flight simulator yet.

25.1 Components

Figure 18 shows you a comprehensive overview of all components of the electrical system. Electrical power is provided by three power sources, namely the battery, generator and ground power unit (g.p.u.). The main battery switch engages main power to all other components of the aircraft. Each sub-system is safeguarded by means of fuses of the melting-type and each component’s properties (e.g. resistance and current) are calculated individually.

25.2 The battery

The battery is the main power source for the aircraft. It is a 12 Volt lead battery with a capacity of around 40 Ampere-hours. Meaning that it can supply 40 Ampere for one hour before it is fully drained. Note however that the battery’s capacity is not a constant value, but is dependent on factors such as atmospheric conditions (particularly the temperature) or the age of the battery. Also, be aware that the battery will experience a drop in voltage with an increase of current demanded by the electrical components. Since most components require a minimum voltage to properly operate, this bears some limitations to the simultaneous use of multiple electrical devices at the same time. One effect of the above limitation is the dimming of the cockpit and cabin lights when engaging the starter motor if the battery is sufficiently drained of power already.

Be aware that the battery will drain over time when you don’t fly.

25.3 The generator

The engine-driven generator (sometimes referred to as alternator) is the primary means of recharging your aircraft’s battery. It is driven by the driveshaft of the engine and thus the voltage produced by the generator is directly linked to the engine’s r.p.m. The faster your engine turns, the more electrical power is produced by the generator.

Be aware that the generator won’t produce enough power to charge the battery at low r.p.m.! This might be of consideration during prolonged ground operation during which it is always advisable to connect an external g.p.u. If in doubt, refer to the Ammeter, located on the fuse-box on the right cockpit wall. The battery is charging when the gauge indicates a positive current and discharging when indicating a negative current.
25.4 The Ground Power Unit

While on the ground you can advise your ground crew to install a Ground Power Unit (g.p.u.), which in case of the Vega is just an additional battery providing your aircraft with electrical power. For simplicity we decided to make the g.p.u. a constant power source, meaning that it won’t be drained over time.

25.5 Fuses?? Fuses.

On the right wall of the cockpit, you’ll find the fuse-box for the electrical system. You can open it by unscrewing the two butterfly screws and lowering the lid.

Each fuse safeguards a particular sub-system. Different to a circuit breaker, the fuses of the Vega are of the melting type. They consist of a glass tube with a metal strip on the inside, mounted between two electrical terminals. The wire’s dimensions are chosen in a manner that they will melt when the current flowing through the fuse reaches its maximum rating, thus opening the circuit and cutting the power to all connected electrical components. A blown fuse can’t be restored and needs to be replaced.

You’ll find a box of replacement fuses inside the fuse-box. You can change a fuse by clicking on it or the terminal it connects to. The first click removes the fuse. If the fuse is blown, it will be discarded. If the fuse is functioning, it will be placed in the box with the rest of the spares. Clicking on the terminal a second time will install a new fuse, provided you have spares left.

Your mechanic will replace the spares during an inspection if you’re running low.

25.6 Lights

The aircraft’s lights can be operated with the switches located on the fuse-box at the right cockpit wall. The Landing light switch activates a powerful 40 Watt spotlight installed on the port wing of the Vega. It illuminates the ground and helps you judging your height during the final approach.

The navigational lights consists of a red light on the port wings tip, a green light on the starboard wings tip and a white light installed in the tail cone of the aircraft.

The cabin lights consist of two dome lights mounted on the ceiling of the cabin.

The Cockpit light is a dome light mounted on the wing spar of the starboard side.

Please note that malfunctions of the lights are not implemented yet. Malfunctions will be included in a future update.
25.7 Warning Lights

The cockpit of the Lockheed Vega features two warning lights, the low-fuel-pressure warning light, and the critical-oil-pressure warning light. The lights are secured by a dedicated fuse.

Please note that malfunctions of the warning lights are not implemented yet. Malfunctions will be included in a future update.

25.8 Starter Motor

The electric motor of the Eclipse inertia starter is a 12V DC, low-power device which is supplied by the aircraft’s battery. It is secured, together with the booster coils, by a 60 Ampere fuse that can be found in the fuse-box on the cockpit wall to the right.

Keep in mind that the coils of the motor will heat up when you activate the starter. If you activate the starter for a prolonged period of time, this heat might be high enough to melt the insulation of the coil’s wiring, resulting in a short circuit of the motor.

As discussed in chapter 19, please note that the starter of the Lockheed Vega is not directly cranking the engine, but instead spins up a flywheel which can be meshed with the crankshaft to start up the engine.

Provisions have been made to include more malfunctions of different variations; those will be included in a future update.

25.9 Booster Coil

The booster coil is a secondary coil, similar to the magnetos, which can be activated to increase the current, and thus the “power” of the spark plugs during start up. It feeds current from the battery to the ignition distributor and harness of the engine.

Please note that the booster coil should only be used for a short period of time to ensure the starting of the engine. If left on for too long, the insulation of the coil’s wire might melt causing a short circuit.
26 Miscellaneous

26.1 Magnetic compass

The algorithm for the magnetic compass was built up from scratch to allow for a more realistic simulation. The instruments movements are programmed in a way to mimic a real-world compass. You can, for example, observe the acceleration error under the following conditions: if the aircraft is pointing due east or due west on the northern hemisphere and you accelerate forward, the compass needle will accelerate towards north.

26.2 8-day clock

The clock installed on the Lockheed Vega is of the wound-up type. It’s called an 8-day-clock, because it will accurately measure the time for a minimum of eight days if fully wound up. It has two controls. On the left you’ll find a knob that serves two functions. First, it is used to wind up the spring-loaded mechanism (left click and drag). Second, it can be used to set the time by pulling the knob and then turning it (right click and drag). The button on the right side of the clock controls the stop-timer function. Pressing it once to activate the stopwatch, pressing it for a second time will stop the stopwatch and pressing it a third time will reset the handle.

Note that the clock, like everything else in the Vega, is persistent. If the clock is set to the wrong time and you exit the flight simulator, the error will be carried over in your next session. The persistency also takes care of the winding of the clock. If you didn’t fly the Vega for more than eight days, chances are your clock stopped working. So make sure to re-wind it and set it to the current time before the next flight.
27 Start-up procedure

This chapter will guide you through the engine start-up procedure of the Lockheed Vega 5C and will familiarize you with the various controls and instruments.

27.1 Before starting

Upon entering the cockpit in a “cold & dark” state, first make sure that the parking brake is set by pulling back the parking brake lever to the right of the pilot’s seat. Open the walkaround interface (SHIFT+3) and make sure that all stations are ready for the flight.

Back into the cockpit, on the right cockpit wall you’ll find the electrical installation. Open the fuse-box by first unscrewing the two big butterfly screws (left mouse button click) and then draw open the lid (click and drag downwards). Make sure that all the terminals have undamaged fuses installed and close the box again.

On the instrument panel wind up the 8-day clock (left mouse button click and drag horizontally to the right) and make sure that the correct time is set (right mouse button click and drag horizontally left/right to set the time).

Check the fuel quantity of the two wing tanks by pulling and releasing the plungers of both fuel quantity instruments on the left side of the panel (left mouse button click and drag downwards, then release the mouse button).

Find the fuel tank selector on the pilot’s bench, to the right of the seat. Turn the fuel tank selector valve either to the fullest fuel tank (left mouse button click and drag left/right until the valve snaps in the right position).

27.2 Engine start

In short, four essential conditions have to be met in order for the engine to start:

1. **Sufficient momentum** – the engine needs to be cranked by outside forces to get the combustion process going. This is done by means of the inertia starter.

2. **Combustible mixture in the cylinders** – by priming the engine, you manually inject fuel vapour directly into the intake manifold. When the engine turns, this charge is being sucked into the cylinders, ready to ignite. The mixture ratio is important, so don’t under- or over prime the engine!

3. **Ignition** – for the charge in the cylinders to ignite, an ignition source is necessary. That source is the electrical arc created by the sparkplugs in each cylinder. The spark must be strong enough and timed right for ignition to occur. So check the magnetos, the booster coil and the spark advance.

4. **Fuel supply and pressure** – to ensure that the engine keeps running, check that the tank selector is set to the fullest tank and verify that fuel pressure is at an adequate level before engaging the starter. By maintaining a fuel pressure of around 2 to 3 p.s.i. you guarantee continuous supply of fuel to the carburetor.
Find the main battery switch box just right of the fuse-box on the right cockpit wall. You might need to adjust your viewpoint to see it in full, or cycle through the different camera angles using the “A” key on your keyboard until you have a good view of the electrical panel. Turn the switch in the “on” position (left mouse button click and drag to the right of the screen).

Make sure that the two warning lights for oil pressure and fuel pressure respectively, turn on. These warning lights are located in the centre of the main instrument panel just below the magnetic compass. Note that you can adjust the brightness of the warning lights by twisting the metal ring (left mouse button click and drag horizontally).

Set the mixture to full rich (fully backwards).

Find the wobble pump on the right cockpit wall and operate it until the fuel pressure reaches around 2 to 3 p.s.i. (left mouse button click and drag vertically forward and backwards repeatedly). The “low fuel pressure” warning light should extinguish to indicate an adequate fuel pressure.

The primer is located on the left side of the instrument panel, above the two fuel gauges. To operate the primer, first open the valve by turning the metal safety guard horizontally (left mouse button click & drag right). Slowly pull the plunger out to fill it’s cylinder with fuel (left click & drag downwards), then, in a swift movement, push it all the way in (left mouse button click and drag upwards). This will inject a small quantity of fuel directly into the engine’s manifold through the priming nozzles. Prime the engine, depending on the temperature conditions. If it’s cold outside prime 3-5 times, if it’s warm, or the engine is still hot from a recent flight, prime the engine 1-3 times.

Crack the throttle ½ of an inch and retard the spark to about ½ inch. Do so by moving the Spark Control Lever backwards. Turn the magneto switch to “both” to engage the engine’s ignition.

Find the red booster button located on the instrument panel just under the altimeter. Engage the booster coil by pushing the button in (left mouse button click).

Note: The original button is spring-loaded and only active while it is pressed. Due to the limitations in the sim, this is not possible to replicate since you need to activate other controls simultaneously. Therefore the button is programmed like a toggle-switch. Click on it to activate and click on it again to de-activate it. It is important to keep in mind that you need to un-press the booster button after a successful engine start, because otherwise you might damage the component through excessive heat developing in the coils.

To crank over the engine, first wind up the flywheel by pushing the starter switch inwards. Note that it is awkwardly located under the instrument panel on the firewall. To reach that switch, you can either toggle through the different virtual cockpit cameras (keyboard “A”), or use the click spot under the instrument panel (see chapter 19). Click on the click spot and drag the mouse upwards on your screen to activate the wind-up circuit. Once the flywheel gained sufficient momentum, move the mouse downwards to throw the switch in the “meshing” position, activating the clutch and thus cranking the engine over.
The momentum of the flywheel should be sufficient for about two full rotations of the crankshaft, which in turn should be enough to initiate the combustion process. However, if your start-up attempt wasn’t successful, make sure that there’s still enough fuel pressure, wind up the flywheel and try again.

As the engine starts, pay close attention to the engine’s r.p.m. and the oil pressure. You should see the oil pressure rise straight away, but be careful not exceed the maximum oil pressure by carefully regulating the engines RPM.

To prevent after-fire in the exhaust, advance the spark by pushing the Spark Advance Lever forward.

Adjust the throttle to idle the engine at 600 to 800 r.p.m. for about 10 seconds and 1,000 r.p.m. thereafter.

Engage the engine’s generator to recharge your battery by switching the generator switch to the “on” position. It is located on the fuse-box.

The selector switch for the vacuum-powered instruments is located on the top right side of the instrument panel. Turn it either to the “Venturi” or the “Vacuum pump” position (left mouse button click and drag left/right). It is recommended to cage the artificial horizon until the gyro has spun up (left mouse button click on the “cage” button).

After the gyro of the directional gyro has stabilized, set the heading using the magnetic compass. Take into consideration both declination and deviation of the magnetic field.

This concludes the cockpit preparation and engine start-up procedure.

Besides "knocking", there are two ways the combustion can turn sour due to timing or mixture issues in an old radial engine. Either, the unburnt mixture finds its way through the intake valve and combusts in the manifold down to the carburetor, or it exits through the exhaust valve and ignites in your exhaust stack. Colloquially both can are referred to as "back-fire", however technically only the first case is an actual back-fire, because the charge travels "backwards". The unwanted combustion in the exhaust system is therefore referred to as after-fire to distinguish between the two.
28 References

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  - ATC 93, Lockheed Vega 5 and SA Executive
  - ATC 384, Lockheed Vega 5-C (Army UC-101)
  - ATC 58, Pratt & Whitney Wasp SC & SC-1