

Flying Circus

Guide:
Building Your Own Engine



Tetragramm



„Flugsport“, Organ d. Flugzeug-Fabrikanten, Flugzeugführer u. d. Modellflugvereine. 1919.

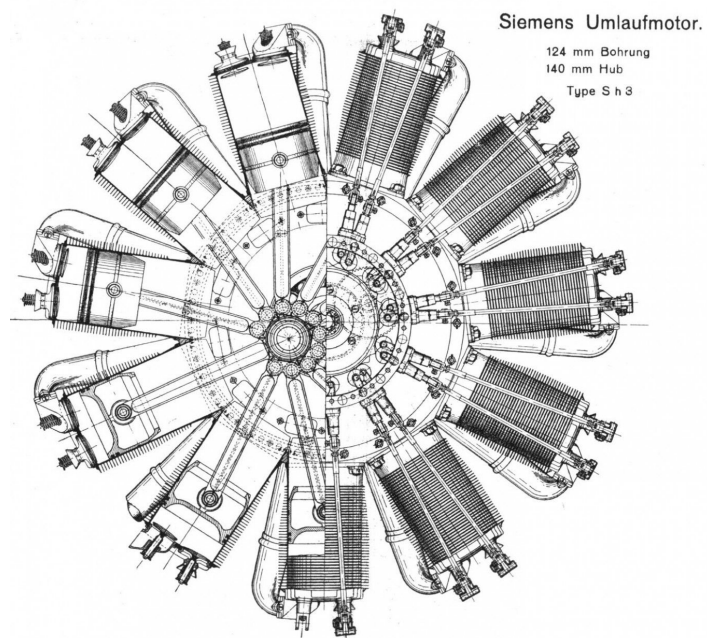


Figure I: (image source: Arizona Model Aircrafters)

On the building of Custom Aircraft engines, and the art of not being absurd.

A note on Custom Engines

The Engine Builder is tricky for several reasons. Not only can it be difficult to find the proper numbers to input, but balance is hard as well. While when handled correctly, it creates very accurate representations of engines, you can easily tweak or manipulate numbers to produce something wildly better than any real engine. This guide is not about creating the best engine possible, but how to replicate a real engine. First, open the [Engine Builder](#) and look at the sections.

Engine Builder

This section is the main one you will use. The vast majority of real airplanes until the end of World War II used a piston engine such as you build here.

Pulsejet Builder

The pulsejet is a real engine type, most famous for it's work pushing the V1 "buzz bomb" of WWII fame. However, the first working one was made in 1907 before World War I, and the aesthetics are perfect for a crazy fantasy flight game.

Turbine Builder

Turbine engines were first built in 1937 with the first turbojet, followed the next year by the first turboprop, and after the war, the turbofan, and even later, the propfan. These are frequently used in modern aircraft, and WWII.

List Management

This section is where you do things like organizing, saving, and deleting engines. All the little things to tell the computer what to actually do.

Engine Builder

The ability to recreate an engine depends on how well you can find accurate numbers for that engine. Below are the inputs available, and what you need to know about them.

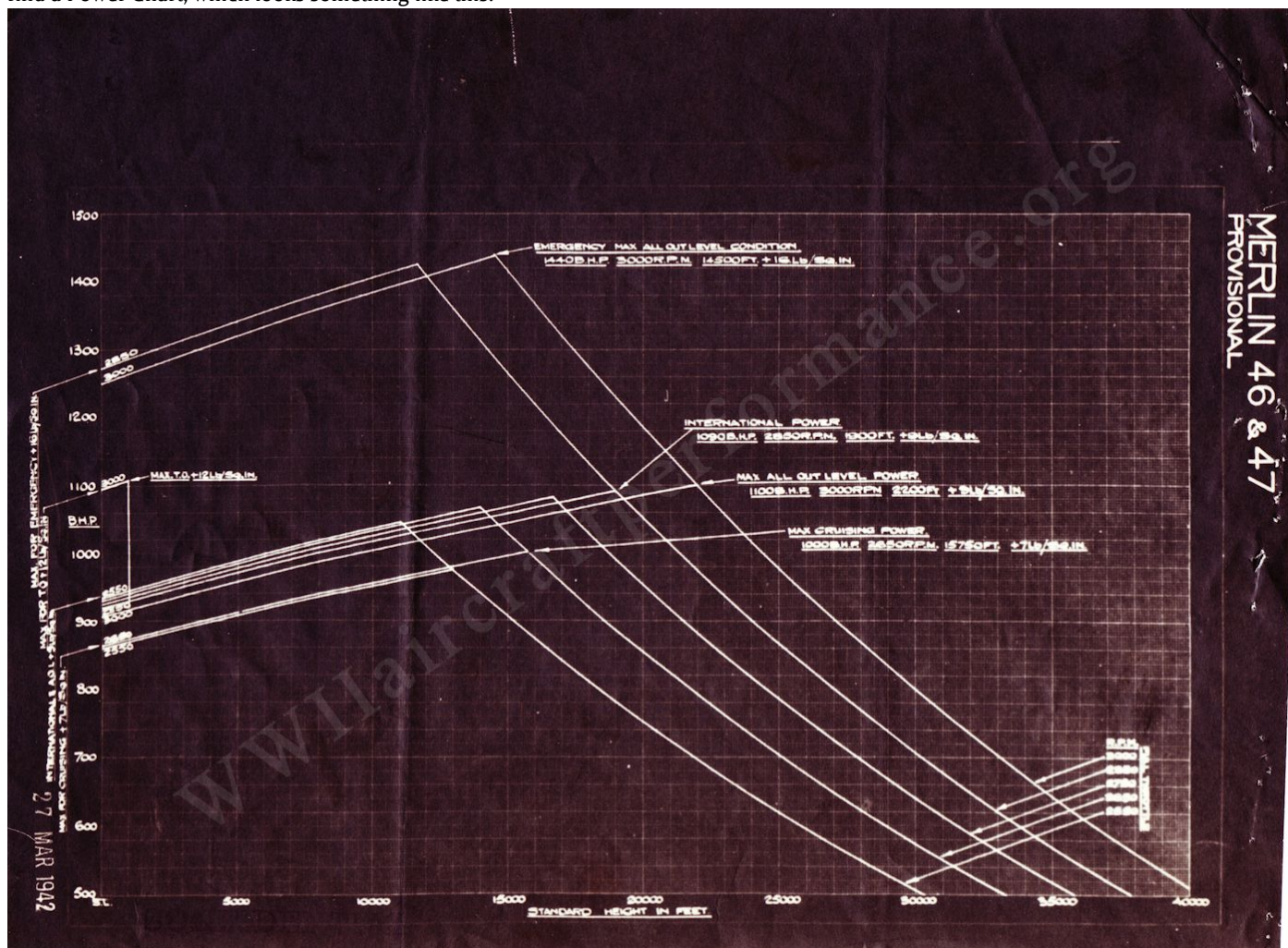
Input Values		Upgrades		Engine Stats	
Name	SAM Kurier XX 200hp	Compressor Type	None	Name	SAM Kurier XX 200hp
Era	WWI	Compressor Count	0	Power	20
Engine Type	Liquid Cooled	Minimum Ideal Altitude	0	Mass	8
Engine Displacement (L)	11.2	War Emergency Power	<input type="checkbox"/>	Drag	3
Compression Ratio (N:1)	5.3	Fuel Injector	<input type="checkbox"/>	Reliability	-1
Cylinders per Row	2	Diesel	<input type="checkbox"/>	Required Cooling	9
Number of Rows	4			Overspeed	28
RPM Boost	1.1			Fuel Consumption	16
Material Fudge Factor	1			Altitude	0-29
Quality Fudge Factor	1			Torque	1
				Cost	8
				Oil Tank	No
				Geared RPM	20.41

- Name - Duh
- Era - This uses the same definitions as the airplanes do. Pick the one appropriate for the version of the engine you're using. Remember an engine may be designed well before it's used, but others may be upgraded repeatedly, like the Rolls-Royce Merlin (First in 1933, with a dozen upgrades).
- Engine Type - How does the engine work?
 - Liquid Cooled: Has a radiator for cooling, but isn't a radial or one of the other categories.
 - Air Cooled: Depends on airflow for cooling, but isn't a rotary.
 - Rotary: The whole engine spins, not just the propeller shaft. This moves it through a lot of air for cooling.
 - Contrarotary: The portion of the engine that spins does so opposite the direction of the propeller, for less torque.
 - Semi-Radial: Like a radial engine, but only a portion of the circle has pistons.
 - Liquid Radial: A circular arrangement of pistons, cooled by a radiator.
- Engine Displacement - This is the volume of the pistons, in Liters. Usually readily available.

- Compression Ratio - The ratio of minimum to maximum volume of air during the stroke. Very important.
- Cylinders per Row - Self-descriptive, if you know that a row is across the engine, and additional rows increase the distance front to back.
- Number of Rows - Also Self-descriptive.
- RPM Boost - This is a tuning number. You will adjust this to make the engine power match.
- Material Fudge Factor - This is a tuning number. You will adjust this to make the engine mass match.
- Quality Fudge Factor - This is a tuning number. You will adjust this to make the reliability match.
- Compressor Type - Does your engine have a compressor? Choose it here!
- Compressor Count - Superchargers and Turbochargers can have multiple stages.
- Minimum Ideal Altitude - Some engines are optimized for a high altitude. This represents that.
- War Emergency Power - Does the engine have a special, high stress high power mode?
- Fuel Injector - Does the engine use fuel injection instead of a carburetor?
- Diesel - Does it use Diesel Fuel? (See a special note below.)

So, you've entered all the parameters, and not messed with the tuning numbers, so you're all done right? ... Right? Nope! The outputs on the right look nothing like the real engine's stats. Why? First is unit conversions. Flying Circus is a bit granular so for the purposes of building engines, 1 Power = 10 HP and 1 Mass = 25 Kg. Keeping that in mind, take the engine's horsepower rating and adjust RPM Boost until the power matches.

WARNING! The engine's horsepower rating must be the continuous sea level power. For WWI engines, this is usually the only power available. For WWII engines... not so much. For example, look at the Rolls-Royce Merlin. Note how the power output section has three listed powers. One is the takeoff-power, and two at different altitudes. None of these are what you need. You must do research and find a Power Chart, which looks something like this.



Sometimes the axes are reversed, but the important thing is the multiple curves relating altitude and horsepower. You need to find the "continuous" or "max cruising" power at sea-level. So again, use RPM Boost to adjust the power.

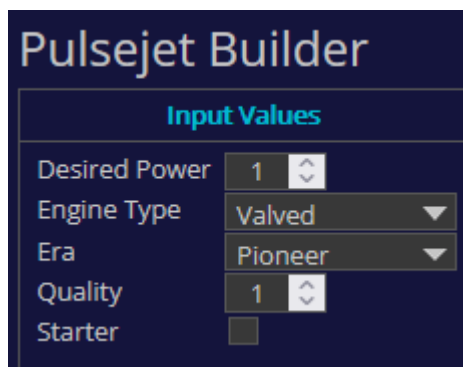
The next step is to get the correct mass. Adjust the Material Fudge Factor until the engine's mass is correct. Remember that 1 Mass = 25 Kg for engines.

Lastly, use the reports of historical reliability to adjust Quality Fudge Factor. If an engine has no real reports about it's reliability or lack thereof, adjust it into the range [-1, +1]. Otherwise, a bit above or below, and if it's amazingly, legendarily, reliable, or unreliable you can go to -7 or +7.

Pulsejet Builder

The pulsejet builder is very simple, just like pulsejets. Consisting of a barely shaped steel tube, with the most complicated part being (sometimes) some spring-steel valves, pulsejets don't have much to tweak. Set your desired power, and era, choose between valved or valveless. Valved engines have less mass and drag for the same power, but a bit less reliability. The name is generated automatically, so don't worry about it.

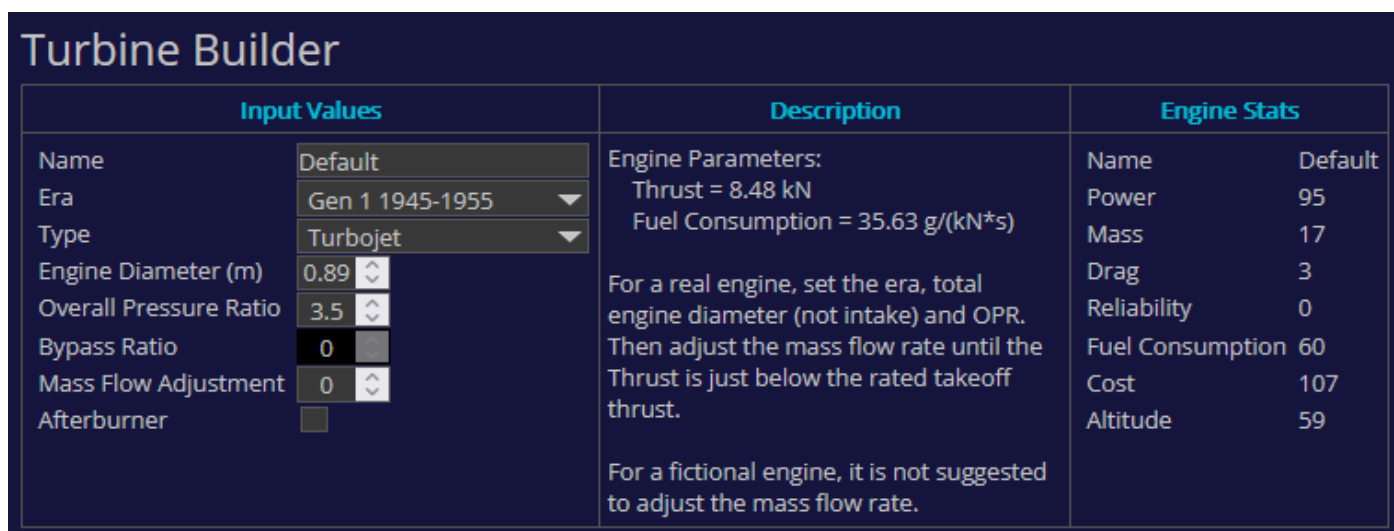
Leave Quality at 1, and starter makes no mechanical difference, and is left over from an older version of the system.



Turbine Builder

The turbine builder is simpler than the engine builder, but more complicated than the pulsejets. Again, finding the required engine parameters can be the difficult portion. Unlike piston engines though, the true numbers are often classified for more recent aircraft, not lost to history. Also, turbine engines often go through many design revisions, and determining which values go with which model can be hard.

It is important to note that this section is in testing, and can be changed at any time, and backward compatibility is not guaranteed in any way. You may open it one day to find that all jet planes you made are broken and have to be rebuilt. You almost certainly will, actually, there's things on the todo list that will break them.



- Name - Duh
- Era - Which generation of engines does this come from?
- Type - Which category of engine is it?
 - Turbojet - The first, and simplest, type of jet engines. Inlet -> Compressor -> Combustor -> Turbine -> Exhaust
 - Turbofan - Like a turbojet, but the compressor is larger than the combustor, and pushes air like a fan. Hence the name. More fuel efficient than a turbojet, for a small decrease in power.

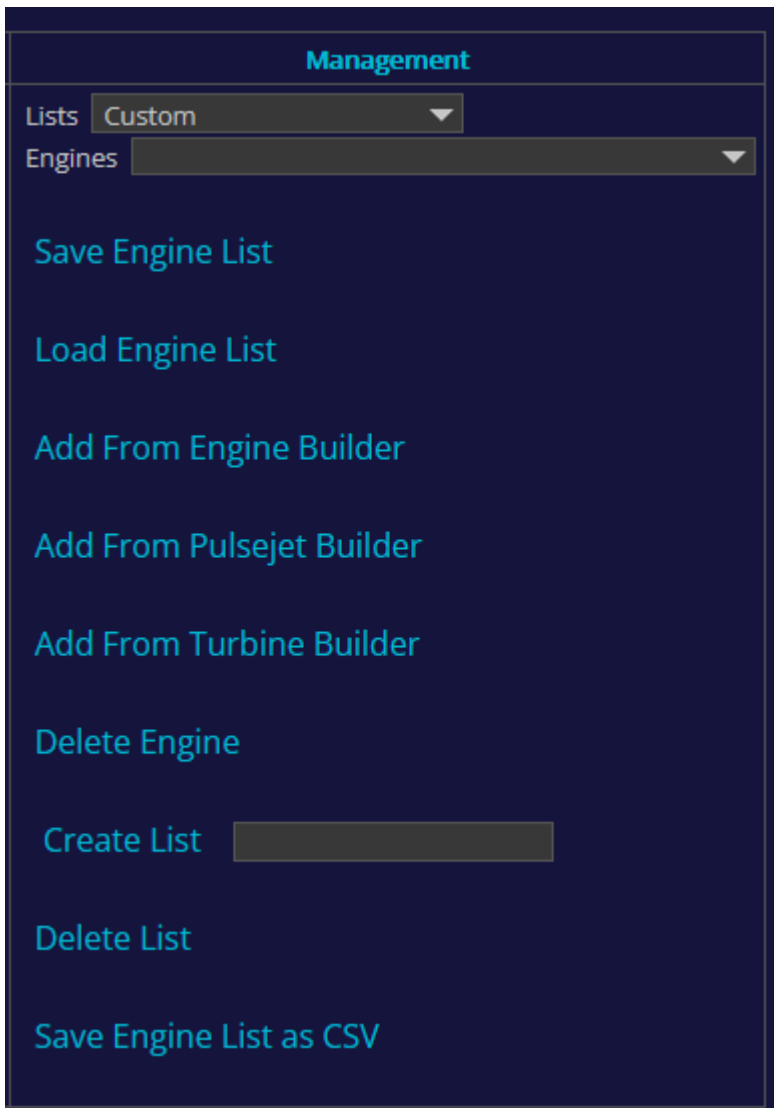
- Propfan - Like a turbofan, but the compressor blades stick out of the cowling and also go supersonic. Pushes air like a fan. A small amount of power from the exhaust too.
- Turboprop - A cross between a propeller and a turbojet. Uses the excess power to drive a traditional propeller. A small amount of power from the exhaust too.
- Engine Diameter - The diameter of the engine in meters. The maximum diameter, if your reference has more than one.
- Overall Pressure Ratio - The pressure ratio between the intake and the end of the compressor. (Greater than 0. No ramjets.)
- Bypass Ratio - The ratio of air that goes around the combustion chamber to the air that goes through it. Only used for Turbofans.
- Mass Flow Adjustment - This is the tuning parameter, but also based in real physics. You just have to back it out from the final results.
- Afterburner - Does nothing yet, check it if the engine can afterburn, otherwise don't.

The method is simple. Input the engine parameters, then set the Mass Flow Adjustment so that the reported Thrust (in kN) matches your takeoff power. All done. If you are making your own engine, you probably shouldn't mess with the Mass Flow Adjustment, unless you're aiming for a particular reliability.

List Management

The list management is where you actually save engines you make, delete ones you don't want, and organize them. The first thing to point out is that you can't alter the default lists, or the engines within them. You also can't make engines with the same name as a default engine. So! The buttons

- Lists - Choose an Engine List to work with.
- Engines - Choose an engine from that list to work with. Loads it's stats into the appropriate builder.
- Save Engine List - Save the currently selected list to a json file for sharing.
- Load Engine List - Load an engine list from the json file.
- Add From Engine Builder - Adds the engine currently specified by the Engine Builder to the current list.
- Add From Pulsejet Builder - Adds the engine currently specified by the Pulsejet Builder to the current list.
- Add From Turbine Builder - Adds the engine currently specified by the Turbine Builder to the current list.
- Delete Engine - Delete the currently selected engine from the list (shown to the left).
- Create List - Type in a name, and create an empty engine list with that name.
- Delete List - Delete the currently selected engine list, and all it's engines.
- Save Engine List as CSV - Saves the stats of the all the engines on the list for analysis.



Conclusion

And that's it! You now have the power to make your own engines for Flying Circus. Use it responsibly.