A2A simulations

"Passion for Flight"

Accu-Sim

EXPANSION PACKS

"No two flights are ever the same..."

The P-40 Accu-Sim Expansion Pack

About This Manual

While much of the information in this manual is basic to many of our readers, we assume that the reader has no knowledge of combustion engine theory. This manual is for ***everyone***, and uses colorful illustrations to teach the basics. The Accu-Sim system, however, is not basic, but is programmed with advanced physics which the professional pilot will appreciate. If you are an advanced pilot, you can likely just briefly skim over the contents of this manual; however, if you are eager to learn a bit about how a great big piston-powered engine works, welcome and read on.

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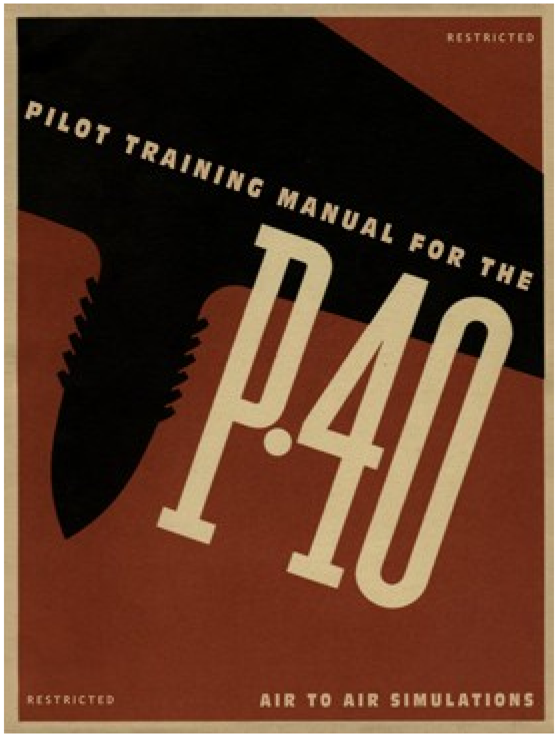
Chapter 1: Welcome

Installation

Once your A2A Simulations P-40 is installed, run the P-40 Accu-Sim expansion pack installer and follow the on screen prompts. The installer should find both Prepar3D and the A2A Simulations P-40 automatically. If not, it will ask you to BROWSE for the correct location. Keep in mind, if Lockheed Martin Prepar3D is properly installed, the Accu-Sim installation should be simple and straight forward.

Refer to Your A2A Simulations P-40 Pilot's Manual



Included with your A2A Simulations P-40 is a detailed pilot's manual that covers most of what you need to know to operate the aircraft with the Allison V-12 engine.

The Accu-Sim upgrade is built into this product from the ground up, so refer to your pilot's manual for specific systems operation and limitations.

Designer's Notes

The rugged P-40 with it's Flying Tigers shark-toothed paint scheme may very well be the world's most recognized image of an American Word War II fighter aircraft. Yet, the P-40 with all of its fame, still remains misunderstood even today. It was called underpowered by some who perhaps, were quick to judge and never understood its true potential. But if you look at this aircraft, and the facts that surround it, you will see quite a different story. One fact that cannot be overlooked is, when in the hands of Colonel Chennault, commander of the AVG (American Volunteer Group), his then controversial hit and run tactics ended up giving that group the worlds highest kill ratio which is still not matched to date. It was not without its flaws, but when you compare the technologies and performance against aircraft being developed by other nations at that time, you will see quite a remarkable aircraft.

Part of the secret of the P-40 was in it's rugged Allison engine and its high dive speeds. Some squadrons pushed it's capabilities well beyond it's official limits in combat. This high power matched with an airframe that held onto energy better than the Japanese counterparts, meant an experienced pilot could command the fight. He could decide when to engage and when to escape.

When we read about Middle East and Australian squadrons over-boosting their Allison engines, we couldn't wait to Accu-Sim this bird and experience it ourselves. This resulted in us digging even deeper into not just the function of this engine at such high power levels, but the sound.

Additionally, other systems like the P-40's unique hydraulics required us to take our Accu-Sim to yet another level of detail. You may notice when a fighter raises it's gear, the gear sometimes comes up at different times. Instead of us simply and without condition, telling the aircraft to raise the gear one leg at a time, we decided to dig deeper and create the entire underlying system, allowing whatever behaviors be the result of actual systems at work. In fact, this is the philosophy behind Accu-Sim from the start. Build it right, and enjoy the experience.

When looking to the construction, the newest modeling and advanced material-making techniques results in an aircraft that you can just spend not just minutes but hours admiring the beauty of the shape and look of the aircraft. Together, with professionally recorded sounds and physics, the end result is the sense of having a complete, real, majestic, raw, flying machine stuffed inside your computer.

We hope you enjoy your new beautiful bird, and hope you learn to fly and treat her well.

Welcome to the world of Accu-Sim.

Scott Gentile
Accu-Sim Project Manager

A2A simulations

The A2A Simulations P-40 Accu-Sim Expansion Pack Features

- A **true propeller simulation**
- **Feel the exhilaration** of flying an Accu-Sim powered P-40.
- Allison V-12 liquid cooled V-1710-33 (C15) engine built to manufacturer's specifications.
- Curtiss multi-position and / or constant speed type **electric propeller**.
- **Inertia starter** with inertia wheel and engagement.
- **Dynamic ground physics** including both hard pavement and soft grass modeling.
- **Primer-only starts** are now possible. Accu-Sim monitors the amount of fuel injected and it's effectiveness to start and run the engine.
- **Cold mornings require as many primer strokes** and warm starts may only need a single shot.
- Immersive in-cockpit, physics-driven sound environment from A2A engineered P-40 recordings.
- **Complete maintenance hangar** including landing gear, internal systems and detailed engine tests including compression checks.
- Understand how a high-performance aircraft behaves and see how well you can cope with all of the unexpected things that can happen. **No two flights are ever the same**.
- **Piston combustion engine modeling**. Air comes in, it mixes with fuel and ignites, parts move, heat up, and all work in harmony to produce the wonderful sound of a V-12, liquid-cooled racing engine. Now the gauges look beneath the skin of your aircraft and show you what Accu-Sim is all about.
- Airflow, density and it's temperature not only affect the way your aircraft flies, but how the internal systems operate.
- Real-world conditions affect system conditions, including engine temperatures. **Manage temperatures with a radiator flap and**

proper flying techniques.

- Spark plugs can clog and eventually foul if the engine is allowed to idle too low for too long. Throttling up an engine with oil-soaked spark plugs can help clear them out and smoke.
- Overheating can cause scoring of cylinder head walls which could ultimately lead to failure if warnings are ignored and overly abused.
- **Engine, airframe, cockpit panel and individual gauges tremble** from the power of a high-performance combustion engine.
- Authentic component drag. Dropping your gear will pull your aircraft realistically as the landing gear is deployed along with cooling flaps, or even opening the canopy. Drop your gear, deploy your flaps, or just try a dive, and **listen to your airframe**.
- System failures, including flaps that can independently break based on the actual forces put upon them. If you deploy your flaps at too high a speed, you could find yourself in a very dangerous situation.
- **Total audible cockpit** made with recordings from the actual aircraft. Before you fly, enjoy clicking everything.
- **Authentic battery. The battery capacity is based on temperature. The major draw comes from engine starting.**
- Oil pressure system is affected by oil viscosity (oil thickness). Oil viscosity is affected by oil temp and oil dilution level. Now when you start the engine, you need to be careful and not raise RPM too much until oil temp is high enough to give proper oil pressure. If you raise RPM too high on a cold engine, especially very cold, oil pressure can raise to over 150 psi. Oil pump failure can result. Extended inverted flight (negative g) can uncover the oil sump and reduce oil pressure. Do not fly in a negative g situation for more than 5 seconds.
- **Oxygen starvation (hypoxia) is modeled.** Just take off and climb without oxygen to see.

Chapter 2: Accu-Sim and the Combustion Engine

The Combustion Engine

The combustion engine is basically an air pump. It creates power by pulling in an air / fuel mixture, igniting it, and turning the explosion into usable power. The explosion pushes a piston down that turns a crankshaft. As the pistons run up and down with controlled explosions, the crankshaft spins. For an automobile, the spinning crankshaft is connected to a transmission (with gears) that is connected to a driveshaft, which is then connected to the wheels. This is literally “putting power to the pavement.” For an aircraft, the crankshaft is connected to a propeller shaft and the power comes when that spinning propeller takes a bite of the air and pulls the aircraft forward.

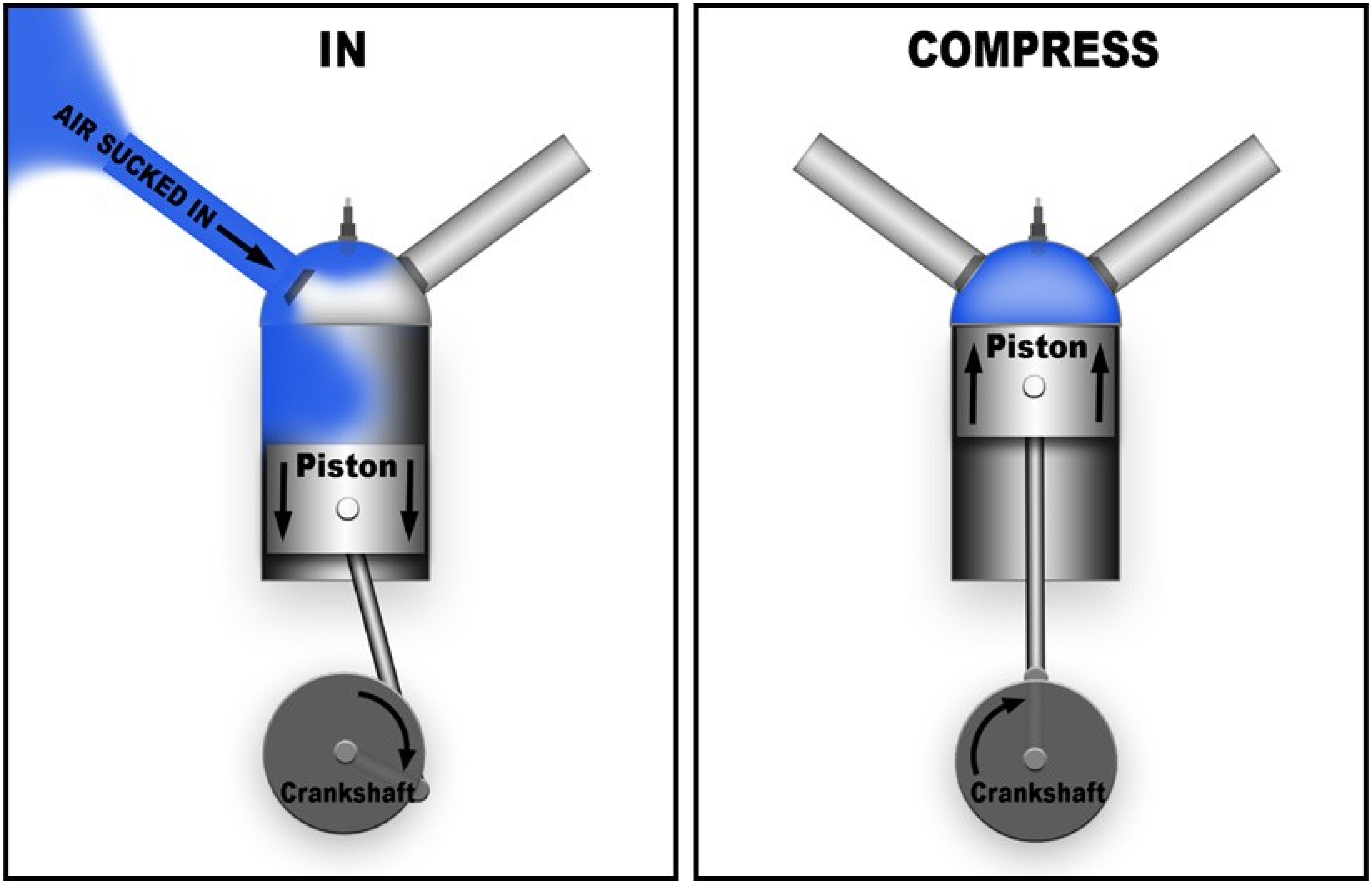
The main difference between an engine designed for an automobile and one designed for an aircraft is the aircraft engine will have to produce power up high where the air is thin. To function better in that high, thin air, a supercharger can be installed to push more air into the engine.

Overview of How the Engine Works and Creates Power

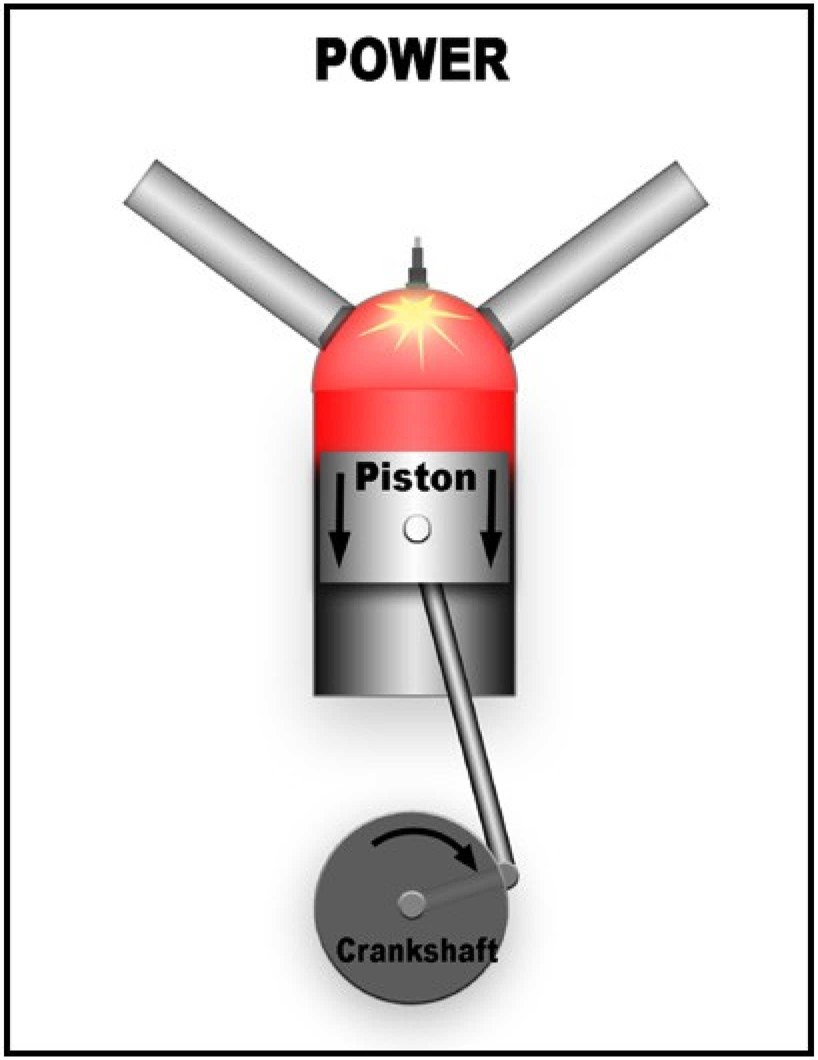
Fire needs air. We need air. Engines need air. Engines are just like us as – they need oxygen to work. Why? Because fire needs oxygen to burn. If you cover a fire, it goes out because you starved it of oxygen. If you have ever used a wood stove or fireplace, you know when you open the vent to allow more air to come in, the fire will burn more. The same principle applies to an engine. Think of an engine like a fire that will burn as hot and fast as *you* let it.

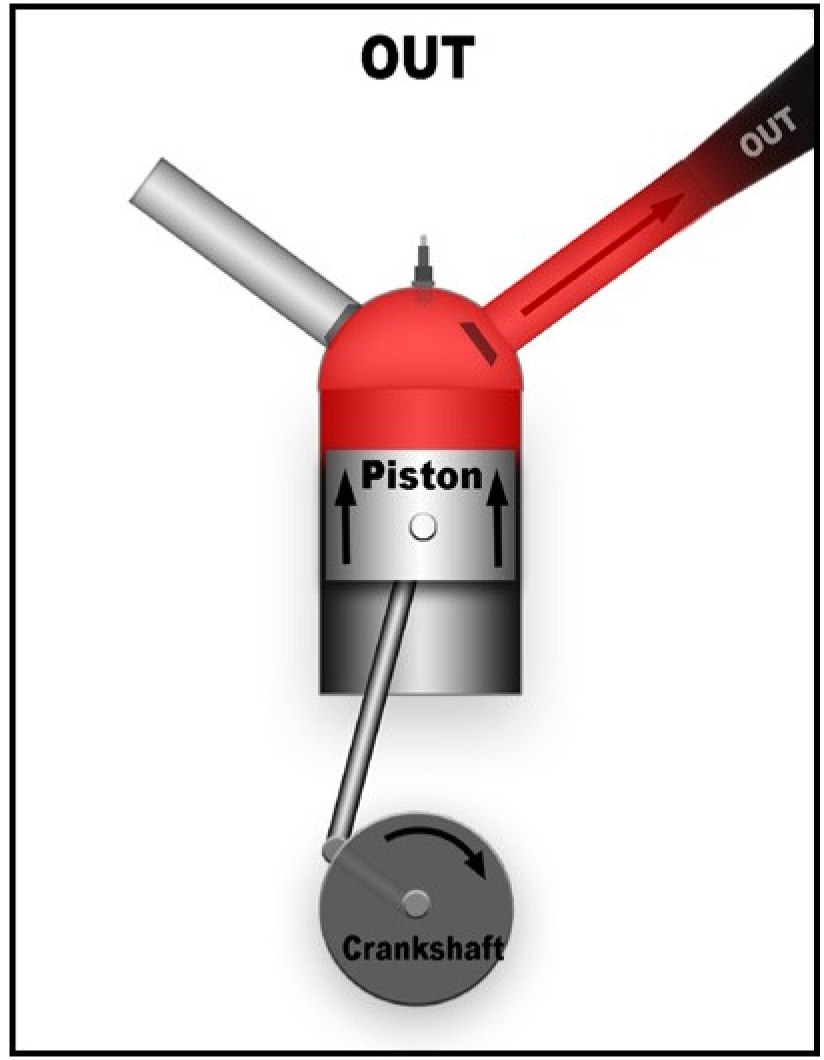
Look at the four pictures below and you will understand basically how an engine operates.

The piston pulls in the fuel / air mixture, then compresses the mixture on its way back up.



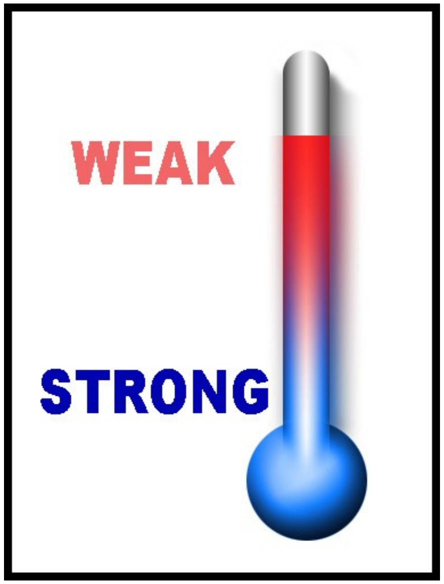
The spark plug ignites the compressed air / fuel mixture, driving the piston down (power), then on it's way back up, the burned mixture is forced out the exhaust.





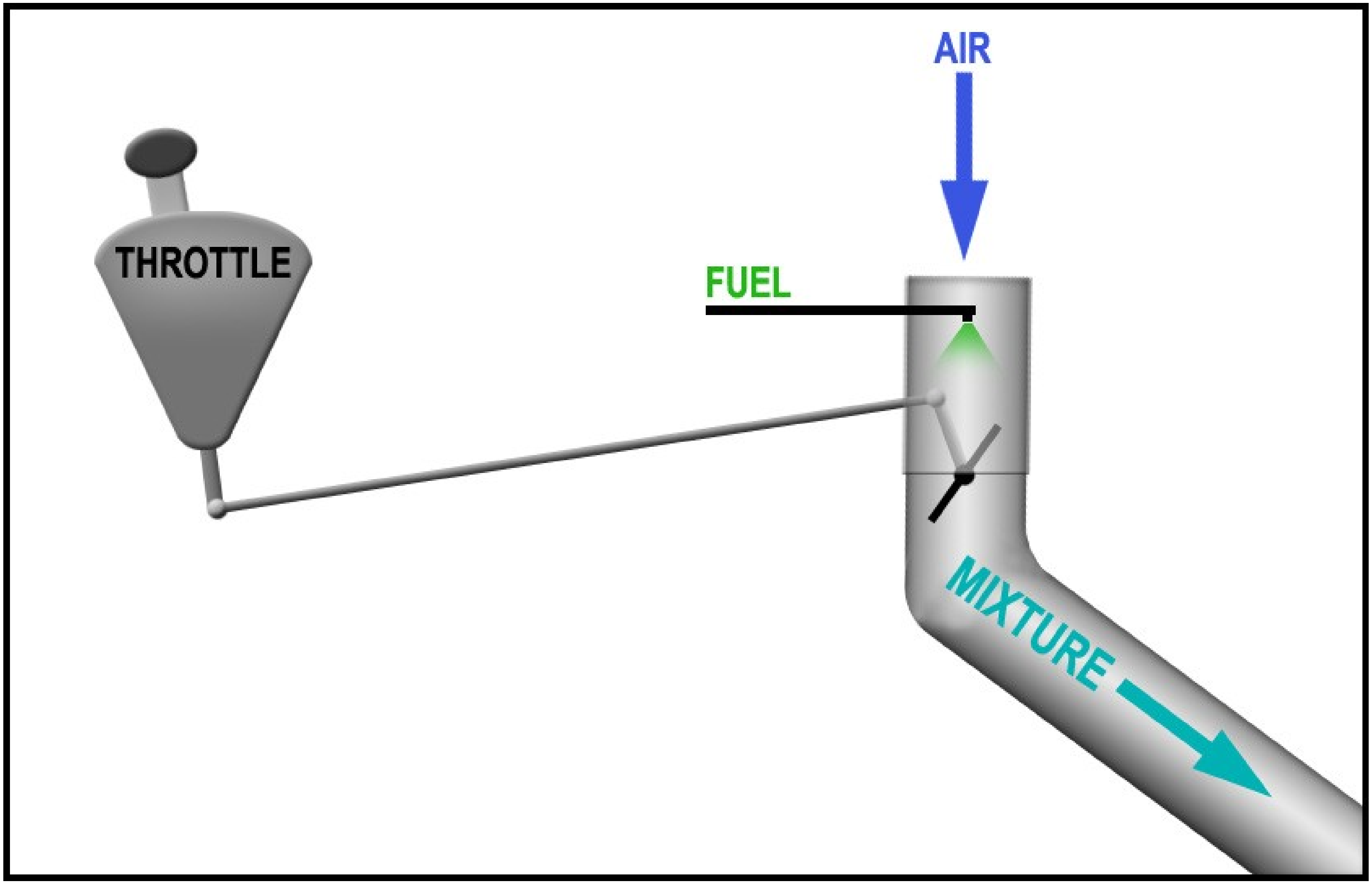
Air Temperature

Have you ever noticed that your car engine runs smoother and stronger in the cold weather? This is because cold air is denser than hot air and has more oxygen. Hotter air means less power.



Mixture

Just before the air enters the combustion chamber it is mixed with fuel. Think of it as an air / fuel mist.



A general rule is a 0.08% fuel to air ratio will produce the most *power*. 0.08% is less than 1%, meaning for every 100 parts of air, there is just less than 1 part fuel. The best economical mixture is 0.0625%.

Why not just use the most economical mixture all the time?
Because a leaner mixture means a hotter running engine. Fuel actually acts as an engine coolant, so the richer the mixture, the cooler the engine will run.

However, since the engine at high power will be nearing its maximum acceptable temperature, you would use your best power mixture (0.08%) when you need power (takeoff, climbing), and your best economy mixture (.0625%) when throttled back in a cruise when engine temperatures are low.

So, think of it this way:

For HIGH POWER, use a RICH mixture.
For LOW POWER, use a LEAN mixture.

The Mixture Lever

Most piston aircraft have a mixture lever in the cockpit that the pilot can operate. The higher you fly, the thinner the air, and the less fuel you need to achieve the same mixture. So, in general, as you climb you will be gradually pulling that mixture lever backwards, leaning it out as you go to the higher, thinner air.

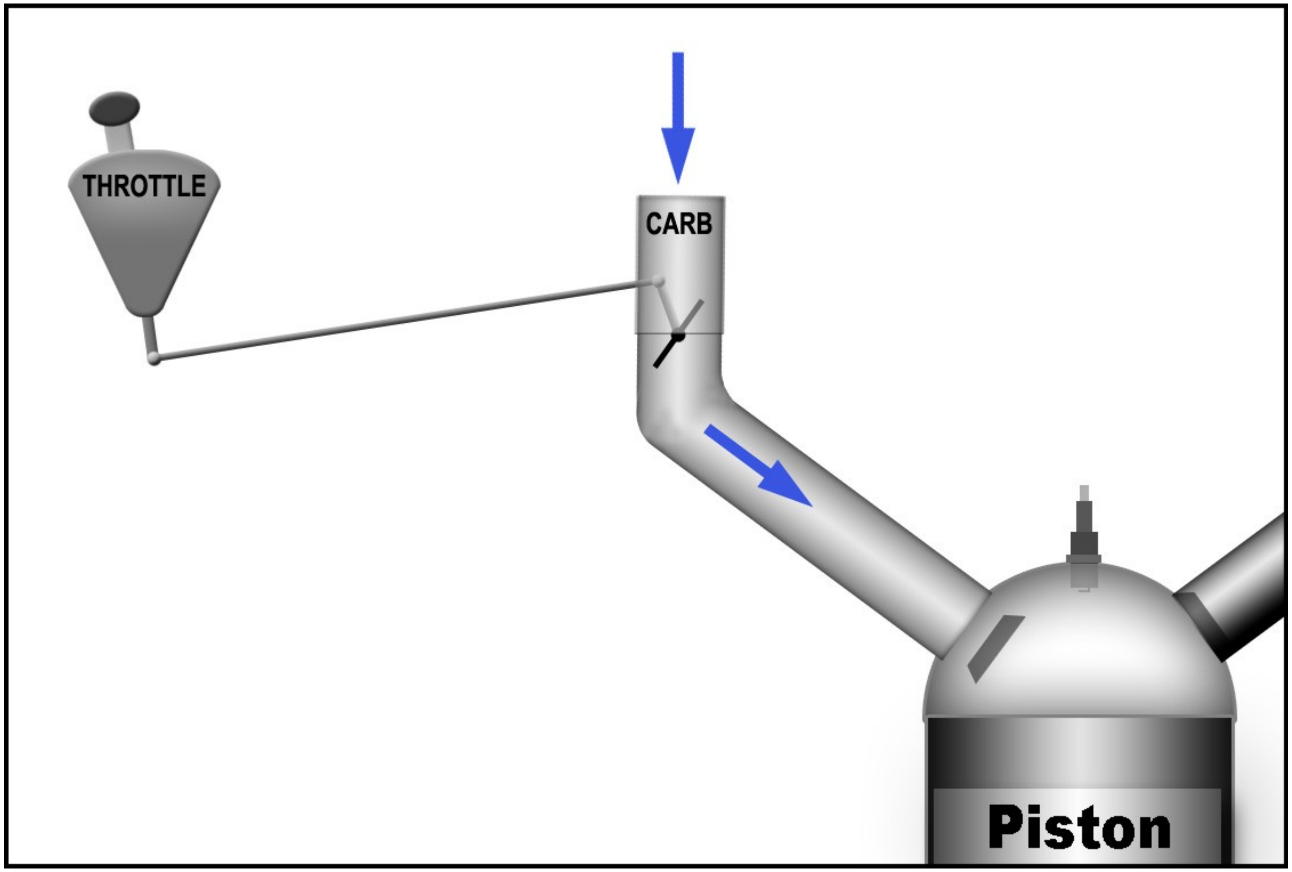
How do you know when you have the right mixture?
The standard technique to achieve the proper mixture in flight is to lean the mixture until you just notice the engine getting a bit weaker, then richen the mixture until the engine sounds smooth. It is this threshold that you are dialing into your 0.08%, best power mixture. Be aware, if you pull the mixture all the way back to the leanest position, this is mixture cutoff, which will stop the engine.

Auto-Rich and Auto-Lean

More advanced aircraft may have an AUTO-MIXTURE system, with AUTO-RICH and AUTO-LEAN settings. You simply select which one you want and the auto-mixture system automatically adjusts the mixture for you based on altitude and power setting. NOTE: In the British Spitfire, for example, the term WEAK is used for LEAN.

Induction

As you now know, an engine is an air pump that runs based on timed explosions. Just like a forest fire, it would run out of control unless it is limited. When you push the throttle forward, you are opening a valve allowing your engine to suck in more fuel / air mixture. When at full throttle, your engine is pulling in as much air as your intake system will allow. It is not unlike a watering hose – you crimp the hose and restrict the water. Think of full power as you just opening that water valve and letting the water run free. This is 100% full power.



In general, we don't run an airplane engine at full power for extended periods of time. Full power is only used when it is absolutely necessary, sometimes on takeoff, and otherwise in an emergency situation that requires it. For the most part, you will be 'throttling' your motor, meaning you will be be setting the limit.

Manifold Pressure = Air Pressure

You have probably watched the weather on television and seen a large letter L showing where big storms are located. L stands for LOW BAROMETRIC PRESSURE (low air pressure). You've seen the H as well, which stands for HIGH BAROMETRIC PRESSURE (high air pressure). While air pressure changes all over the world based on weather conditions, these air pressure changes are minor compared to the difference in air pressure with altitude. The higher the altitude, the ***much*** lower the air pressure.

On a standard day (59 F), the air pressure at sea level is 29.92Hg BAROMETRIC PRESSURE. To keep things simple, let's say 30Hg is standard air pressure. You have just taken off and begin to climb. As you reach higher altitudes, you notice your rate of climb slowly getting lower. This is because the higher you fly, the thinner the air is, and the less power your engine can produce. You should also notice your MANIFOLD PRESSURE decreases as you climb as well.

Why does your manifold pressure decrease as you climb?
Because manifold pressure ***is*** air pressure, only it's measured inside your engine's intake manifold. Since your engine needs air to breath, manifold pressure is a good indicator of how much power your engine can produce.

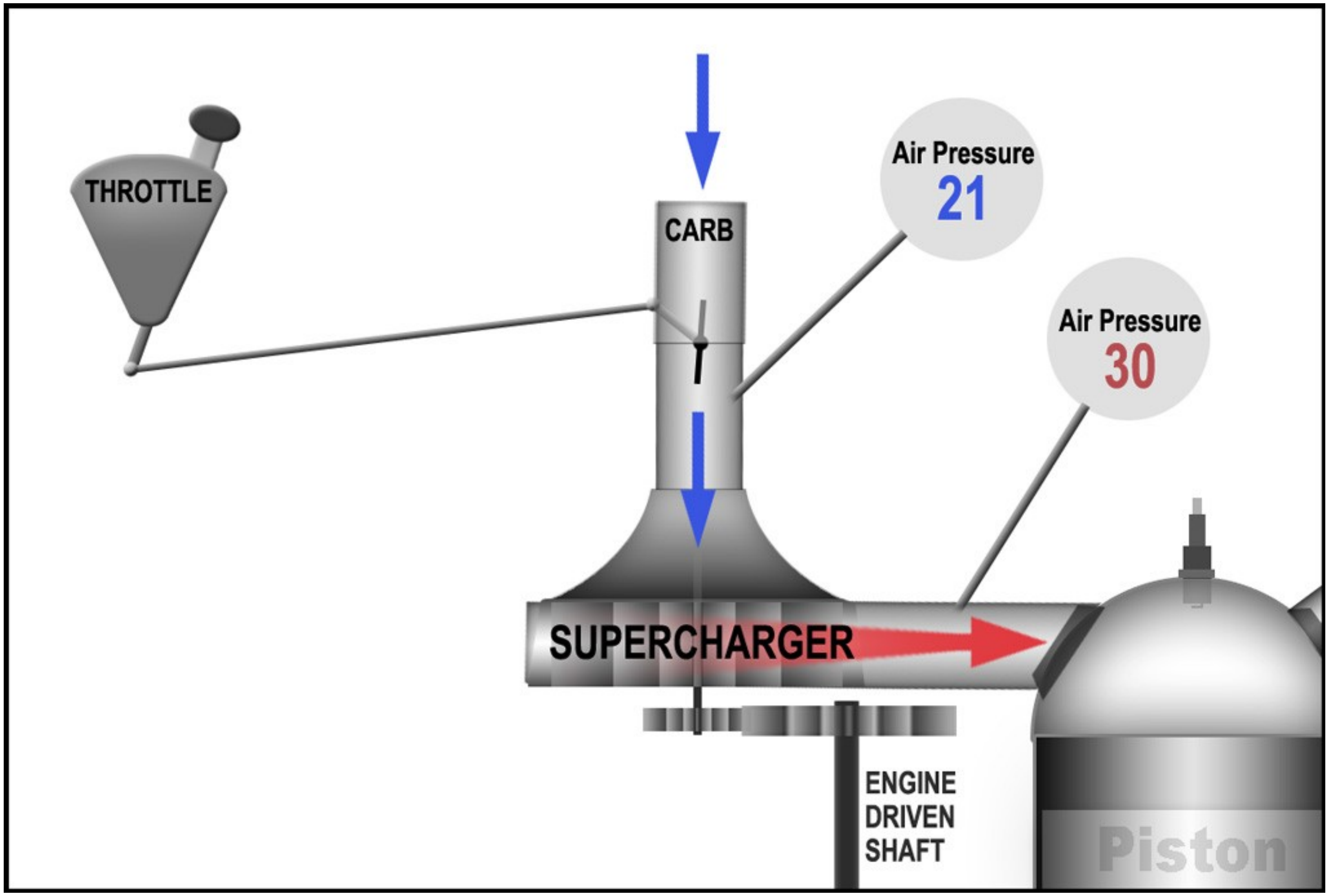
Now, if you start the engine and idle, why does the manifold pressure go way down?
When your engine idles, it is being choked of air. It is given just enough air to sustain itself without stalling. If you could look down your carburetor throat when an engine is idling, those throttle plates would look like they were closed. However if you looked at it really closely, you would notice a little space on the edge of the throttle valve. Through that little crack, air is streaming in. If you turned your ear toward it, you could probably even hear a loud sucking sound. That is how much that engine is trying to breath. Those throttle valves are located at the base of your carburetor, and your carburetor is bolted on top of your intake manifold. Just below those throttle valves and inside your intake manifold, the air is in a vacuum. This is where your manifold pressure gauge's sensor is, and when you are idling, that sensor is reading that very low air pressure in that vacuum.

As you increase power, you will notice your manifold pressure comes up. This is simply because you have used your throttle to open those throttle plates more, and the engine is able to get the air it wants. If you apply full power on a normal engine, that pressure will ultimately reach about the same pressure as the outside, which really just means the air is now equalized as your engine's intake system is running wide open. So if you turned your engine off, your manifold pressure would rise to the outside pressure. So on a standard day at sea level, your manifold pressure with the engine off will be 30".

So how can an engine produce more power at high altitudes where the air is so thin?
Since the power an engine can produce is directly associated with the pressure of the air it can take, at some point during your climb (above 10,000 feet or so), that engine will be producing so little power that the aircraft can no longer climb. This is the point where the engine can barely sustain level flight, and is considered the aircraft's service ceiling. A supercharger can raise this ceiling.

Supercharging

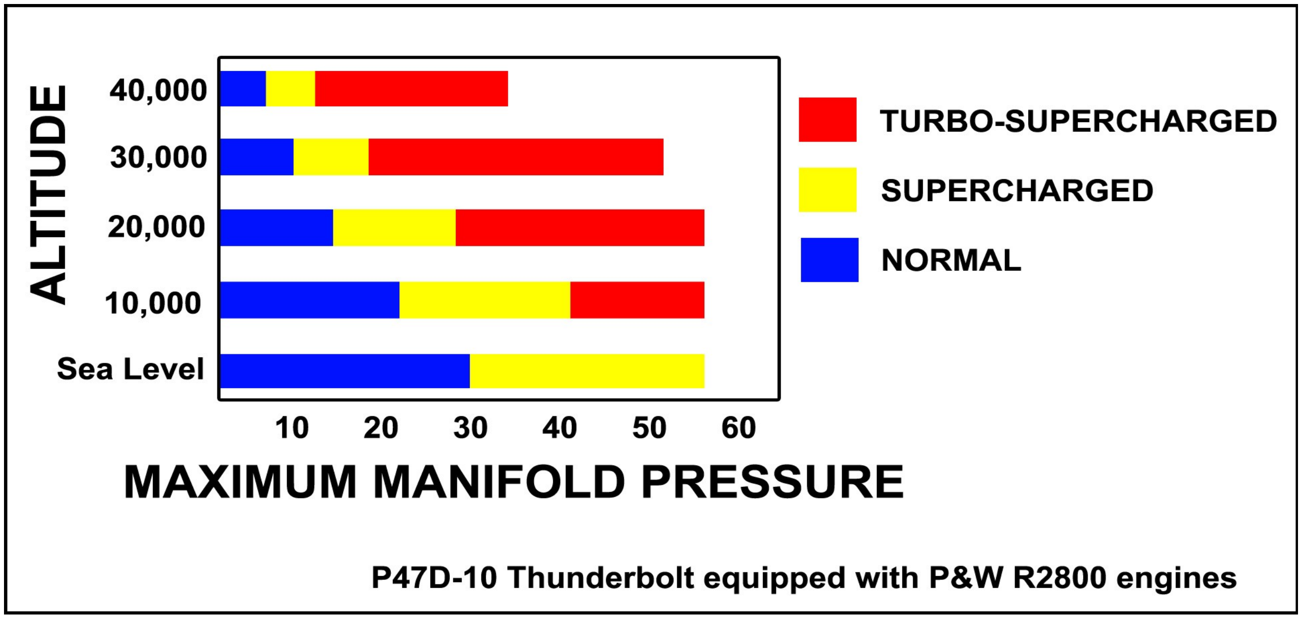
The supercharger has a powerful fan installed in your intake system that forces *more* air into the engine. As you fly higher and the air pressure decreases, your supercharger will help to compensate and keep air pressure higher than it would be otherwise.



Let's say while air pressure at sea level is 30", it is 21" at 10,000. At 10,000 feet, your supercharger fan pushes in more air to increase your manifold pressure to 30". Now your engine will produce the same power at 10,000 feet as it would at sea level. It would feel every bit as strong as it did when you took off.

However, even a supercharger has its limitations. At some point, it will hit its own limit of how much air it can force and manifold pressure will again start to drop off. Some aircraft, like the Merlin-powered, P-51 Mustang include a second stage supercharger, this is basically a HIGH / LOW gear. Some planes may automatically kick into HIGH at a certain altitude. When you hit this altitude, you will notice a nice punch of power. Other planes, like the P-47 Thunderbolt, use both a turbocharger and a supercharger. A turbocharger does the exact same thing as a supercharger, except while a supercharger is driven directly off the engine by mechanical gears, a turbocharger is driven by the power of the exhaust pressure. This is where the term 'turbo lag' comes from. Turbo lag is the time delay after you apply power and before the exhaust has enough pressure to spin the turbo charger hard enough to push more air into your engine. The turbo, being driven off exhaust, is only applying power when the engine is *producing* power. So the turbo process is a cycle – engine power produces more turbo power that produces more engine power and so on. It's like rolling a snowball down a hill, this is your turbo 'spooling' up. Since the supercharger is gear driven, it moves perfectly in step with engine RPM – it's there and ready when you apply throttle.

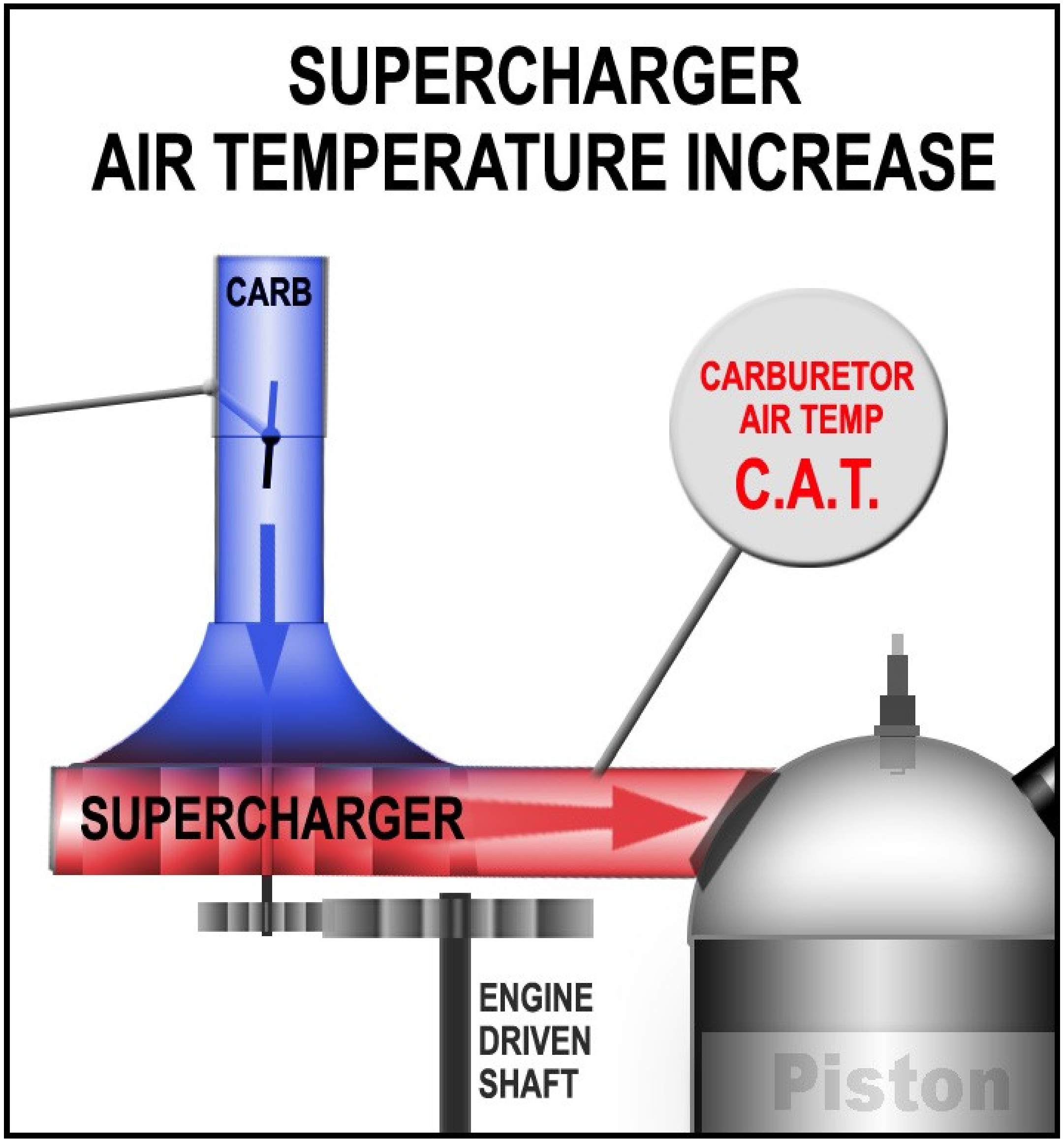
While turbo and superchargers can be used to compensate for lost air pressure up high, they can also be used to *over-boost* the power at sea level. This is called "ground boosting." Ground boosting adds more air pressure (and power) at sea level than would normally be available.



If you add power and see your manifold pressure rise above 30", then you have some form of supercharging or turbocharging adding more air into the engine than would normally be available. A normal engine that is producing 1,000 horsepower at 30" will produce 2,000 horsepower at 60", since it is twice the pressure. 45" produces 1,500 horsepower and so on.

Supercharging Heats The Air

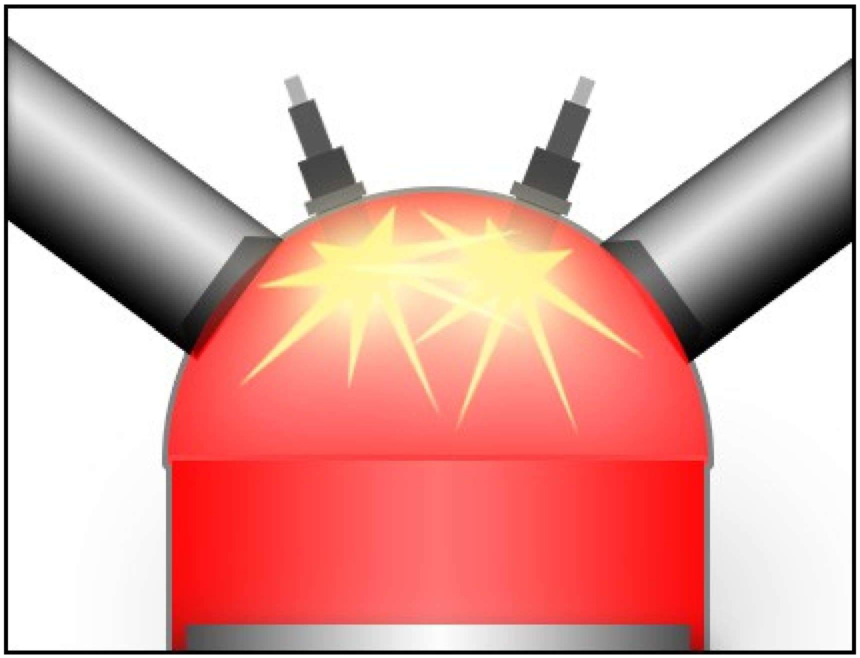
The downside to supercharging is heat. The more you compress air, the more the temperature increases, therefore more supercharging = higher CAT temperatures. The increase in temperature can be extreme. -40 degree air coming into the intake system can be 100 degrees hotter after it exits the supercharger. This is where your INTERCOOLER comes into play. The INTERCOOLER is a heat exchange, and is basically a radiator taking heat out of the incoming air. Use your INTERCOOLER FLAPS to transfer heat out of your intake manifold and out the flap doors. The more you open your intercooler flaps, the more heat you remove. Use your intercooler flaps to keep CAT temps nice and low for a strong and healthy running engine.



Ignition

The ignition system provides timed sparks to trigger timed explosions. For safety, aircraft are usually equipped with two completely independent ignition systems. In the event one fails, the other will continue to provide sparks and the engine will continue to run. This means each cylinder will have two spark plugs installed.

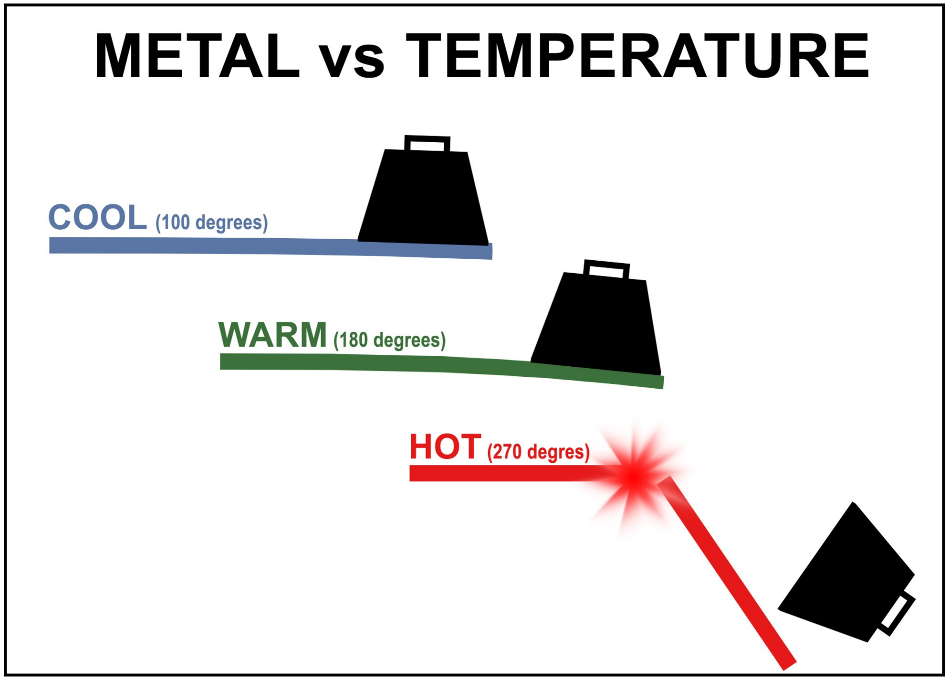
An added advantage to having two sparks instead of one is more sparks means a little more power. The pilot can select Ignition 1, Ignition 2, or BOTH by using the MAG switch. You can test that each ignition is working on the ground by selecting each one and watching your engine RPM. There will be a slight drop when you go from BOTH to just one ignition system. This is normal, provided the drop is within your pilot's manual limitation.



Engine Temperature

All sorts of things create heat in an engine, like friction, air temp, etc., but nothing produces heat like COMBUSTION.

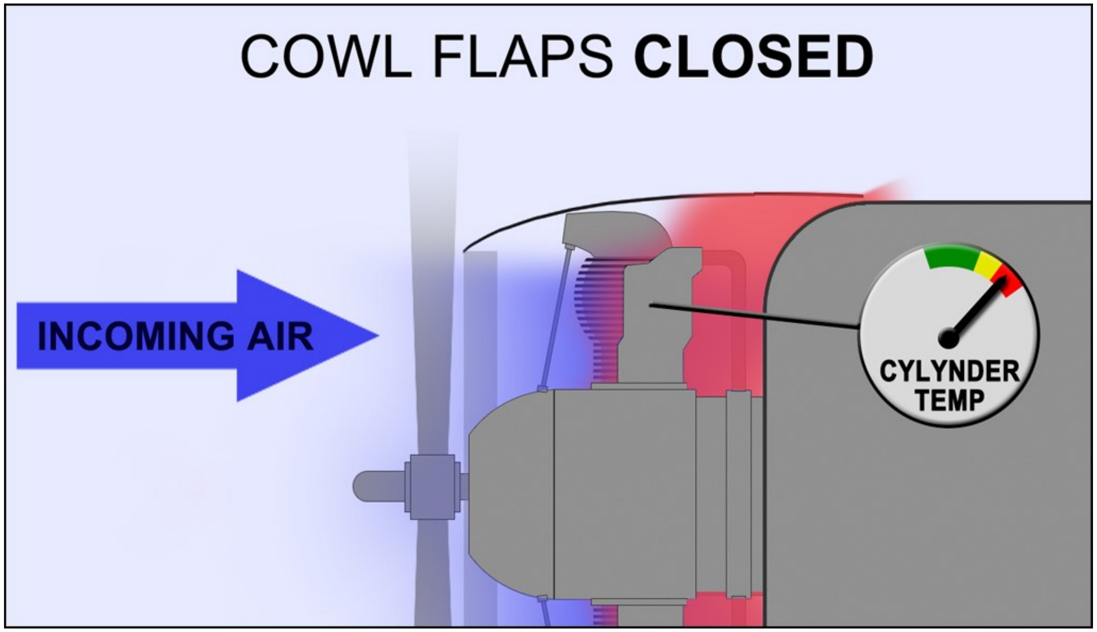
The hotter the metal, the weaker its strength.

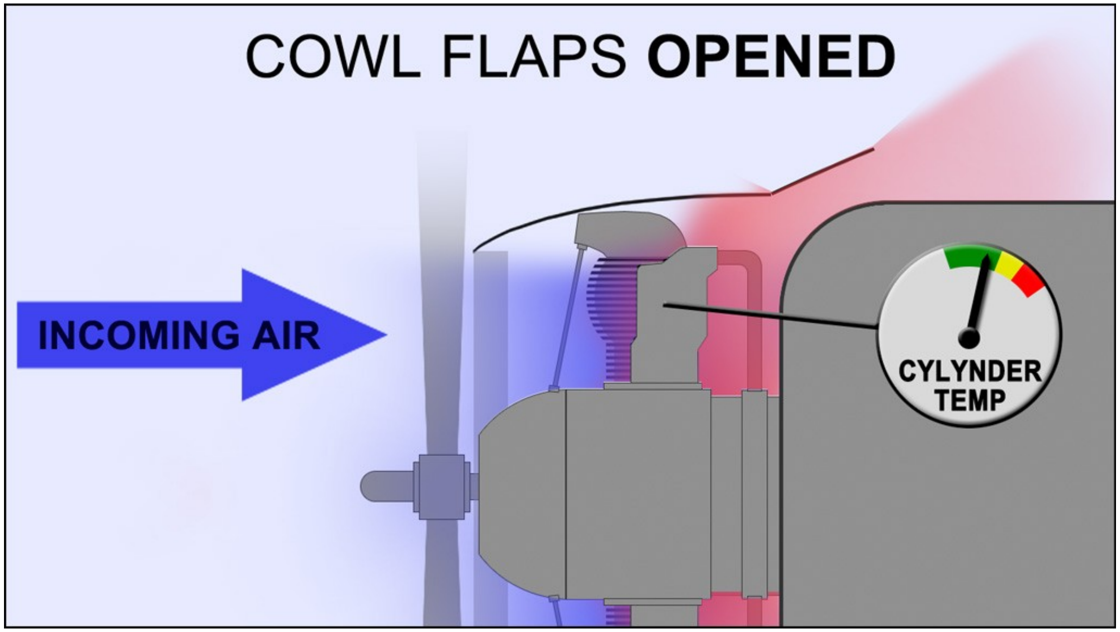


Aircraft engines are made of aluminum alloy, due to its strong but lightweight properties. Aluminum maintains most of its strength up to about 150 degrees Celsius. As the temperature approaches 200 deg C, the strength starts to drop. An aluminum rod at 0 degrees Celsius is about 5X stronger than the same rod at 250 degrees Celsius, so an engine is most prone to fail when it is running hot. Keep your engine temperatures down to keep a healthy running engine.

CHT (Cylinder Head Temperature)

CHT is a measurement of the temperature in the back of the cylinder head. The combustion is happening right inside the cylinder head, so high power will increase temperature rapidly. The key is to watch and manage your cylinder head temperature by being aware of the outside air temp, keeping your speed up, and using your cowl flaps to control how much cooling is applied. The largest CHT rise will come from sitting on a hot ramp, just after takeoff, or in a slow and steep climb.



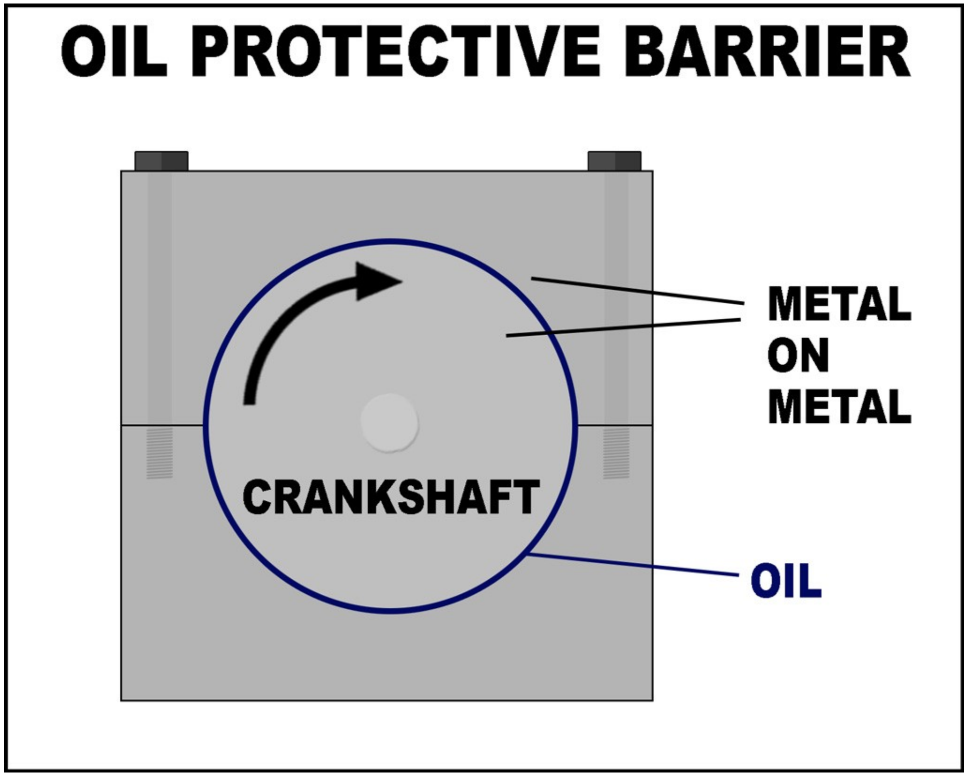


Lubrication System (Oil)

An internal combustion engine has precision machined metal parts that are designed to run against other metal surfaces. There needs to be a layer of oil between those surfaces at all times. If you were to run an engine and pull the oil plug and let all the oil drain out, after just minutes, the engine would run hot, slow down, and ultimately seize up completely from the metal on metal friction.

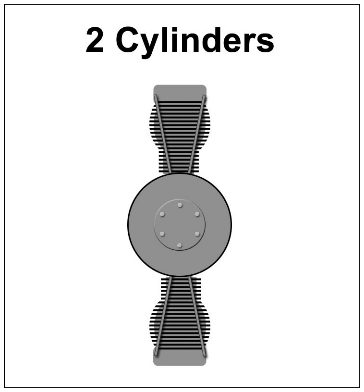
There is a minimum amount of oil pressure required for every engine to run safely. If the oil pressure falls below this minimum, then the engine parts are in danger of making contact with each other and incurring damage. A trained pilot quickly learns to look at his oil pressure gauge as soon as the engine starts, because if the oil pressure does not rise within seconds, then the engine must be shut down immediately.

Below is a simple illustration of a crankshaft that is located between two metal caps, bolted together. This is the very crankshaft where all of the engine's power ends up. Vital oil is pressure-injected in between these surfaces when the engine is running. The only time the crankshaft ever physically touches these metal caps is at startup and shutdown. The moment oil pressure drops below its minimum, these surfaces make contact. The crankshaft is where all the power comes from, so if you starve this vital component of oil, the engine can seize. However, this is just one of hundreds of moving parts in an engine that need a constant supply of oil to run properly.



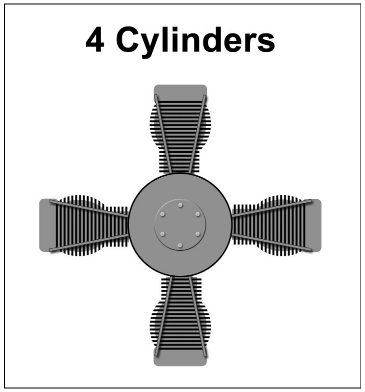
More Cylinders, More Power

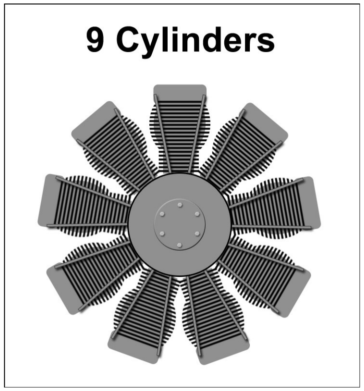
The very first combustion engines were just one or two cylinders. Then, as technology advanced, and the demand for more power increased, cylinders were made larger. Ultimately, they were not only made larger, but more were added to an engine.



Here are some illustrations to show how an engine may be configured as more cylinders are added.

The more cylinders you add to an engine, the more heat it produces. Eventually, engine manufacturers started to add additional "rows" of cylinders. Sometimes two engines would literally be mated together, with the 2nd row being rotated slightly so the cylinders could get a direct flow of air.





The Pratt & Whitney R4360

Pratt & Whitney took this even further, creating the R4360, with 28 Cylinders (this engine is featured in the A2A Boeing 377 Stratocruiser). The cylinders were run so deep, it became known as the "Corn Cob." This is the most powerful piston aircraft engine to reach production. There are a LOT of moving parts on this engine.

Torque vs Horsepower

Torque is a measure of twisting force. If you put a foot long wrench on a bolt, and applied 1 pound of force at the handle, you would be applying 1 foot-pound of torque to that bolt. The moment a spark triggers an explosion, and that piston is driven down, that is the moment that piston is creating torque, and using that torque to twist the crankshaft. With a more powerful explosion, comes more torque. The more fuel and air that can be exploded, the more torque. You can increase an engine's power by either making bigger cylinders, adding more cylinders, or both.

Horsepower, on the other hand, is the TOTAL power that engine is creating. Horsepower is calculated by combining torque with speed (RPM). If an engine can produce 500 foot pounds of torque at 1,000 RPM and produce the same amount of torque at 2,000 RPM, then that engine is producing twice the HORSEPOWER at 2,000 RPM than it is at 1,000 RPM. Torque is the twisting force. Horsepower is how fast that twisting force is being applied.

If your airplane has a torque meter, keep that engine torque within the limits or you can break internal components. Typically, an engine produces the most torque in the low to mid RPM range, and highest horsepower in the upper RPM range.

Chapter 3: Accu-Sim and the P-40

Developed for:

Microsoft Flight Simulator X

Accu-Sim Expansion Pack

Accu-Sim is A2A Simulations' growing flight simulation engine, which is now connectable to other host simulations. In this case, we have attached our Accu-Sim P-40 to Lockheed Martin Prepar3D to provide the maximum amount of realism and immersion possible.

What is the philosophy behind Accu-Sim?

Pilots will tell you that no two aircraft are the same. Even taking the same aircraft up from the same airport to the same location will result in a different experience. For example, you may notice one day your engine is running a bit hotter than usual and you might just open your cowl flaps a bit more and be on your way, or maybe this is a sign of something more serious developing under the hood. Regardless, you expect these things to occur in a simulation just as they do in life. This is Accu-Sim, where no two flights are ever the same.

Realism does not mean having a difficult time with your flying. While Accu-Sim is created by pilots, it is built for ***everyone.*** This means everything from having a professional crew there to help you manage the systems, to an intuitive layout, or just the ability to turn the system on or off with a single switch. However, if Accu-Sim is enabled and the needles are in the red, there will be consequences. It is no longer just an aircraft, it's a simulation.

Actions Lead to Consequences

Your A2A Simulations Accu-Sim aircraft is quite complete with full system modeling and flying an aircraft as large and complex as a WWII Warbird requires constant attention to the systems. The infinite changing conditions around you and your aircraft have impact on these systems. As systems operate both inside and outside their limitations, they behave differently. For example, the temperature of the air that enters your carburetor has a direct impact on the power your engine can produce. Pushing an engine too hard may produce just slight damage that you, as a pilot, may see as it just not running quite as good as it was on a previous flight. You may run an engine so hot, that it catches fire. However, it may not catch fire; it may just quit, or may not run smoothly. This is Accu-Sim – it's both the realism of all of these systems working in harmony, and all the subtle, and sometimes not so subtle, unpredictability of it all. The end result is when flying in an Accu-Sim powered aircraft, it just feels real enough that you can almost smell the avgas.

Your Aircraft Talks

We have gone to great lengths to bring the internal physics of the airframe, engine, and systems to life. Now, when the engine coughs, you can hear it and see a puff of smoke. If you push the engine too hard, you can also hear signs that this is happening. Just like an actual pilot, you will get to know the sounds of your aircraft, from the tires scrubbing on landing to the stresses of the airframe to the canopy that is cracked opened.

Be Prepared – Stay Out of Trouble

The key to successfully operating almost any high performance aircraft is to stay ahead of the curve and on top of things. Aircraft are not like automobiles, in the sense that weight plays a key role in the creation of every component. So, almost every system on your aircraft is created to be just strong enough to give you, the pilot, enough margin of error to operate safely, but these margins are smaller than those you find in an automobile. So, piloting an aircraft requires both precision and respect of the machine you are managing.

It is important that you always keep an eye on your oil pressure and engine temperature gauges. On cold engine starts, the oil is thick and until it reaches a proper operating temperature, this thick oil results in much higher than normal oil temperatures. In extreme cold, once the engine is started, watch that oil pressure gauge and idle the engine as low as possible, keeping the oil pressure under 120psi.

The oil and coolant temperature gauges are critical throughout your flight. Idling too long on the pavement will make your aircraft run hot because there is a large, warm engine with very little air flowing through it's radiator. Plan to be off the ground in under ten minutes. Don't let your engine exceed 100 degrees Celsius before your takeoff roll.

Once airborne, you will want to avoid steep climbs, especially in hot weather, to keep good airflow to your radiator. You will also want to keep your radiator opened at all times during flight, adjusting it to maintain temperatures around 100 degrees if possible, never more than 120 degrees. High engine power increases both water and oil temperatures, but oil is also heated up quite a bit by engine friction (RPM). So if you are running hot oil temperatures, you may wish to also decrease your engine RPM.

Key Things to Keep Engine Temperatures in Check

1. Open radiator cooling flap
2. Get off the ground as soon as possible. Prolonged idling and taxiing can overheat your engine.
3. Reduce power immediately after takeoff to climb power
4. Do not climb too steeply to ensure adequate airflow – keep speeds at or above 160mph if possible
5. Lower RPM to further reduce oil temperature

Engine Priming

Accu-Sim models the priming system which basically pumps fuel into the intake so the engine can start. If you do not prime the motor prior to starting, it is unlikely it will start. Over priming can also make for hard starts. If you do over prime, wait a few minutes then try to start again.

Recommended Primer Strokes

Air Temperature °C	Primer Stokes
+20	2
+10	4
0	6

Engine Starter

Inertia Starter

The Allison 1710 is a big heavy engine, and turning it over to start requires a lot of power. A conventional starter is heavy and back in the 1940's during wartime, lowering weight was critical. The solution was an inertia starter. Basically, an inertia starter starts by spinning a wheel up to very high speeds (takes up to 20 sec to reach its maximum RPM), then engage that spinning wheel to the engine. If you have ever jump started a car, the inertia starter uses the same principle. When you push a car and "pop it" into gear, you are taking the stored energy (momentum) in the moving car and using that energy to turn the motor. In the case of the inertia starter, the energy is stored in the spinning wheel. When you engage this spinning wheel, the prop will lunge ahead. You may get 5 or 6 blade moves before the energy is absorbed and the engine stops. In this case, start the process over again.

To start, make sure the engine is properly primed and crack the throttle open. Click the starter switch DOWN to ENERGIZE. You will hear the wheel begin to spin. In about 10-20 seconds, you will notice the wheel is at its peak speed. At this moment, move the starter switch to ENGAGE.

Manifold Pressure

The manifold pressure is your best way to judge the power your engine is producing. However, be aware that manifold pressure is simply the pressure of the air before it enters your engine and, more accurately, is an indication of "potential" power.

Assuming manifold pressure is the same, the following things can affect the actual power your engine is producing:

1. RPM. Remember, your engine is an air pump, so a higher RPM will produce more power than a lower RPM at the same manifold pressures. **NOTE:** Never use low RPM and high manifold pressure. This condition can create critically high torque and stress a motor.
2. Mixture. If your mixture is too lean or too rich it will produce less power than if it is at the optimum power-rich setting. Your mixture is constantly changing based on the power your aircraft is producing. In certain circumstances, a LEAN mixture setting can produce more power than RICH mixture setting, since at high power settings more fuel is added to keep the engine cool. If the power is high enough, a LEAN mixture setting may actually provide the best power mixture. However, you do not want to apply high power with a LEAN mixture setting as this will create high engine temperatures, This is just something you should be aware of.
3. Engine health. An old worn engine will not have the tight compression a new engine will have and this older engine will produce less power than the newer one at the same manifold pressure.
4. Air Temperature. For the most part, cooler air is denser and will produce higher manifold pressure, but manifold pressure and power output can be inconsistent at different air temps.

Fuel Pressure

A new feature introduced with the P-40 is an even more advanced fuel system. Fuel actually drops from the tanks and passes through a cutoff valve, feeds either an electrical, hand-powered, or engine-driven pump. Fuel pressure is a result of the fuel being in the lines and pressurized by these pumps. Additionally, the engine consumes the fuel from the fuel lines while it is drawn out of the fuel tanks and through these lines.

You may think, "why bother with such detail?" Well: when you want to model something correctly in a simulation, there are really two philosophies, the quick cheap way and the long, proper way. Quick and cheap gets the product out the door, but these features are literally "boxed in" because now: you really can't experiment a whole lot because you are constantly at risk of exposing the fact the system is not proper: but rather for lack of a better word: "faked." If you are in the business of making a product, selling it, then moving to another audience, the quick way may be the profitable way, but in our case, we are in the flight simulation business for the long haul, so doing things properly pays off handsomely in the long run, as you are building a solid foundation to build other systems on top of.

For example:

Primer-only engine starts

Primer-only engine starts You can now finally start your engine like the professional pilots who fly these amazing Warbird, with your mixture in IDLE-CUTOOFF, by pumping primer only. This was easy for us to do, now that we have a proper fuel system. We simply create a primer, adjust the amount of fuel a single stroke injects: and inject it.

My engine is smoking

Remember, your engine is a piston-powered air pump. Valves open, a piston sucks in air / fuel, ignites it, another valve opens on the next stroke, and it ejects the burned mixture out the exhaust. During this time, oil below is lubricating those cylinder walls and piston rings keep that oil below and out of the combustion chamber. Also, there are water cooling channels that pass in between these areas, and gaskets keeping that water in those channels and out of these high-vacuum combustion chambers. Well, all the above is how things are supposed to work, but as all things in life, nothing is perfect.

Blue Smoke

If your cylinders are worn or damaged, the cylinders can suck oil up past these rings. This oil is then present when the chamber combusts, burning it, and ejecting it. Two things happen. You will see blue smoke coming out the exhaust and oil sediments will build inside your combustion chamber, slowly degrading that cylinder's ability to properly work.

Black Smoke

Many of these pressure carburetor's have automatic mixture systems that adjust the fuel to air mixture based on air pressures and power settings. At high power settings, these carburetors sometimes intentionally inject more fuel to keep the cylinder cool during such high power operations. The result can be too much fuel that the cylinder can burn, thus, ejecting unburned fuel out the exhaust. Also, engine problems when a cylinder is not properly functioning can do the same. The result is black smoke seen coming out of the cylinders.

White Smoke

Sometimes cracks or blown gaskets allows a small opening between the combustion chamber and the water channels, resulting in coolant actually being sucked into the cylinders. This coolant gets burned and the result seen is white smoke coming out of the engine (steam). Also, you can see large puffs of white smoke when starting an engine due to the condensation inside the engine that gets burned off as things heat up. All of this is present in Accu-Sim, not because we simply created the effect, but rather the proper system is showing you what is actually going on inside your engine.

Oil Pressure

Oil is the lifeblood of your engine. The countless metal parts in motion depend on constantly having a film of oil covering and separating them. Theoretically, there should be no metal on metal contact, but pressurized oil in between. Some times simply having oil continuously splashed on the part is enough, yet other times actual pressure is required to keep these metal parts separated. The heavy crankshaft that is responsible for twisting the propeller is one part that is in critical need of this pressure at all times. Running the engine without oil pressure for just minutes is enough to seize up the engine.

Additionally, the thickness of the oil changes with temperature. Colder temperatures can make oil flow almost like molasses whereas very hot temperatures can make it run almost like water. Accu-Sim models this oil thickness, which is known as *oil viscosity.*

So when you start your engine on a cold morning, know that the oil inside your engine is thick. You must be respectful of this as you may see oil pressures as high as 120 psi or more. This is a lot of pressure, far more than the system needs or wants, so do not push the engine as long as the oil temperature is cold. Pushing an engine with thick, cold oil can cause premature oil system leaks or worse.

If you must start a very cold engine, give it just enough throttle to keep it running (not so low that it is struggling to run). Hold the idle at the lowest possible RPM and wait for the oil temperature to rise. As it rises, the oil will thin, and you may also notice the RPM actually increase due to the thinner oil being easier to push through all those small areas. So ultimately, as the oil temperature rises the oil pressure drops.

Hydraulic System

Instead of using complex mechanical linkage to transmit power, hydraulics use pressurized fluid to transmit that power. The size of the actuator acts as a gear box, allowing large heavy objects to be moved with relatively low force.

The hydraulic system is based on Pascal's Principal that states:

"Pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid such that the pressure ratio remains the same."

This principal tells us that it is very efficient to transmit power through fluids.

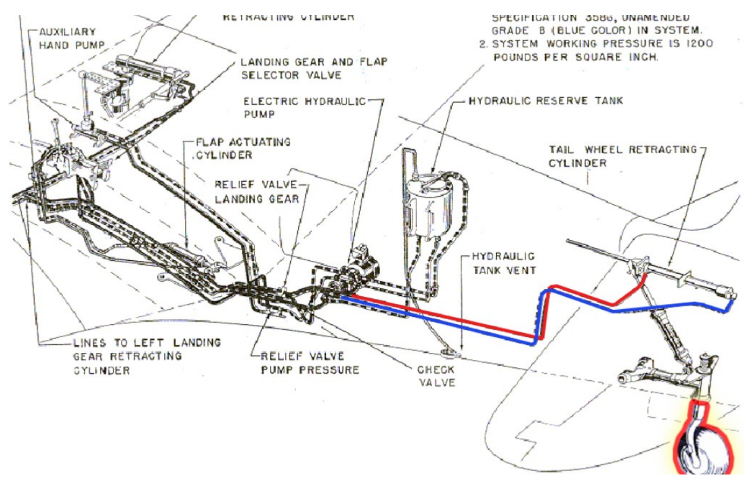
Hydraulics work very well in aircraft because you can take small little hydraulic lines and send them through all of these cavities and twists and turns, and provide power to virtually every area of that aircraft.

You can see in this cutaway drawing, some of the hydraulic lines in the P-40.

You can use one of your hand pumps to pressurize the system or the electric pump that is triggered by a trigger on your control stick.

So now, all kinds of things in flight are possible. First, you can actually see the movement of your gear and flaps is being done by actual physics. So your flaps and gear move, not because we told it to, but because the weight, air pressures, and hydraulic pressures are all working in concert to move things. You the pilot are in control of the the hydraulic pressure and how it affects these other physical forces.

This means when things are not working properly, or for that matter, fail, the world doesn't stop affecting these critical systems (gear and flaps). All of this simply makes you a more aware, more experienced, safer, and better pilot.



Landing Gear

Do not lower your landing gear if you are above 160mph IAS (indicated airspeed). Once down, the left and right gear strut and tire each creates their own drag out on the wing. Keep in mind that the left and right landing gear do not operate in sync. So, as you drop your gear, one wheel may pop out while the other is still in the wheel well. At this point, you may experience extreme yaw to that side. This is normal and is experienced in the actual P-40. Also, take care on your landings as the landing gear on the P-40 is adequate, yet not that rugged.

Flaps

Do not lower your flaps above 140mph IAS. Doing so can damage, jam, or possibly even break your flaps. Accu-Sim measures the forces on the flap based on the actual air pressure on the flap itself. As the flap moves to higher angles, the pressure (and drag) quickly builds up. If you were to, for example, jam your left flap down and then raise your flaps, you could be in a dangerous situation. If this happens, lower your flaps until they are equal and land at the nearest airfield. If you were to break a flap at high speeds when deployed, your aircraft could immediately go into an uncontrollable flying attitude. Watch your speeds and LISTEN to your aircraft.

Oxygen and Hypoxia

The higher the altitude, the thinner the air, and the less oxygen available for each breath you take. Without an oxygen mask, above 12,500 feet you can start to feel the effects of hypoxia (oxygen starvation). Hypoxia is very dangerous as it can sneak up on a pilot without him realizing, and render him unconscious. As you gain experience as a pilot, you learn to notice these signs. On the oxygen regulator, change the altitude to the altitude you are flying at, as this meters the amount of oxygen needed at that chosen altitude.

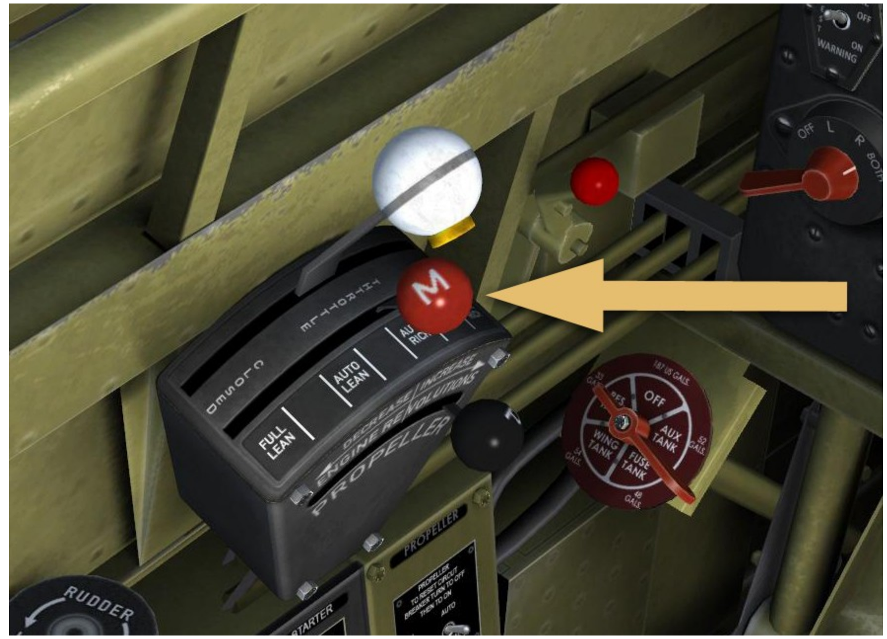
Accu-Sim has secret and subtle ways to let you know you are starting to experience hypoxia. At some point, you may notice your breathing is heavy. If this happens, make sure your oxygen is working properly. If not, **IMMEDIATELY** dive to lower altitudes. If you end up not responding to these signs and pass out, you will lose complete control of the aircraft. Only when you return to lower altitudes will you awaken.

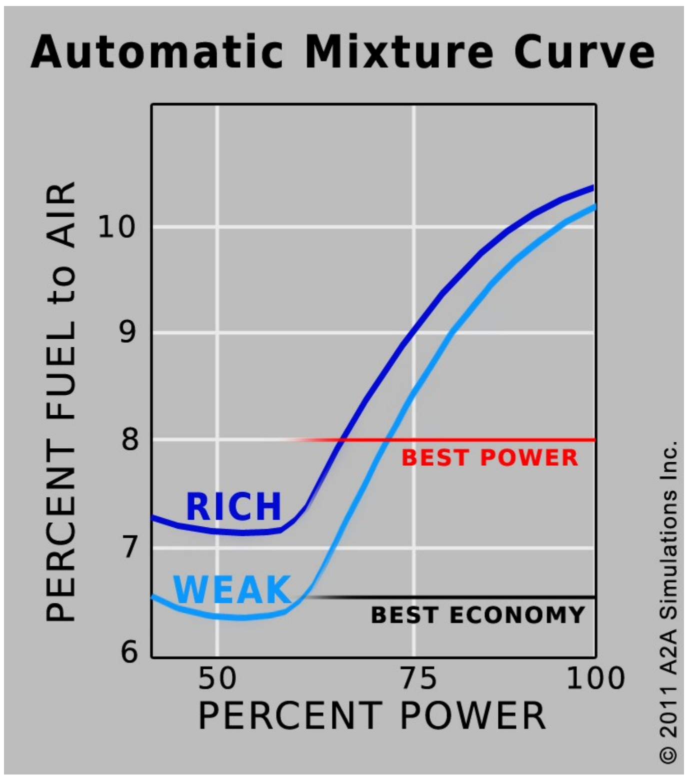
Auto Mixture

Your engine is equipped with an automatic mixture control, which can be set to RICH or LEAN via a lever next to your throttle (LEAN means the same as WEAK).

Both settings automatically adjusts the mixture based on air density and engine power. This allows for a more accurate mixture than is possible through manual mixture settings.

In general, you should use a RICH setting (lever forward) for all operations except when you are throttled back in cruise for the longest range / best fuel economy. You should avoid high power with a LEAN mixture, as this can lead to high engine temperatures.





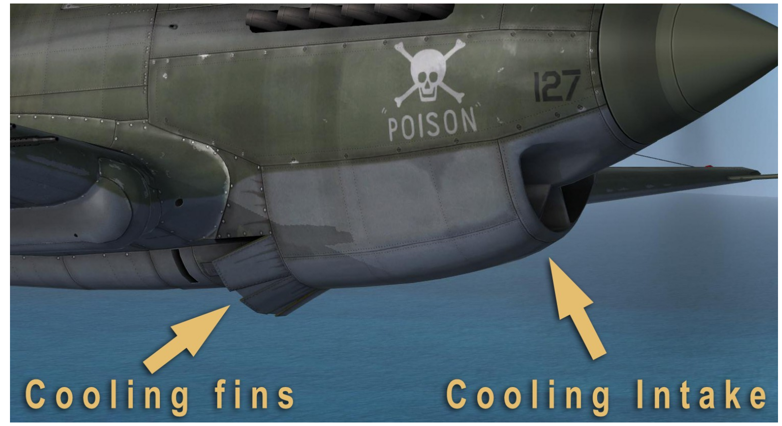
You can see that the LEAN setting gives you about a 6.5% fuel mixture, which is ideal for maximum efficiency (and maximum heat) when at a lower, cruise power. RICH scales the entire curve upwards giving more fuel, and greater power.

Also notice how both curves exceed the 8% best power mixture. Above 8% is entering what is called a RICH RICH condition, which is used to help keep your engine cooler at these higher power settings. This is actually producing less power than if an 8% mixture was held, however, the engineer's adjust this curve to suite each engine.

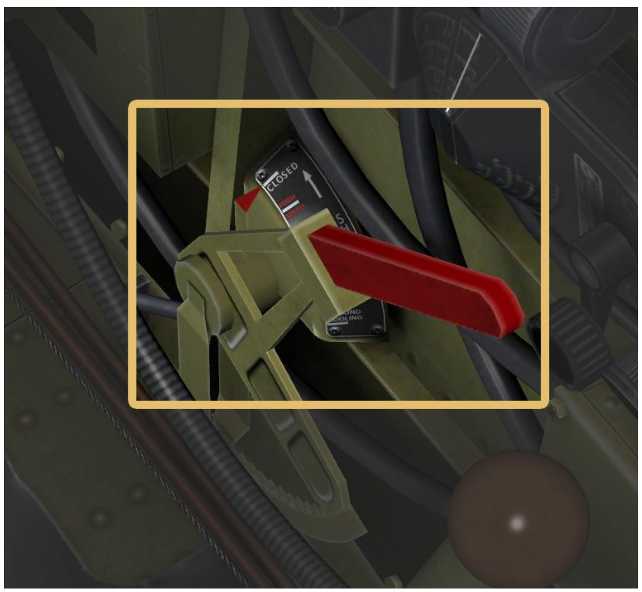
All of our Accu-Sim aircraft, including our Boeing 377 use a mixture curve similar to what is shown here. If you ever notice black smoke under very high power settings, do not be alarmed, this is normal. You can see from the graph that high power settings use a very high fuel mixture which cannot all be burned off in the combustion process, therefore unburned fuel (black smoke) is ejected from the engine. Later, with the introduction of water injection (on our P-47), this RICH RICH condition was bypassed as the water was adequate for engine cooling.

Coolant and Oil Temperature

Air enters below the prop into the coolant intakes and pass through both oil and coolant radiators. The cowl flap lever in your cockpit is used to adjust the cooling fins in the rear, which controls the volume of air. On the ground when airflow is lowest, open the flap all the way. During climbs where power is high and airflow is not optimum, keep the flaps somewhere in the middle position then open or close based on conditions. High speed, when airflow is at its highest, you can have them just slightly opened.



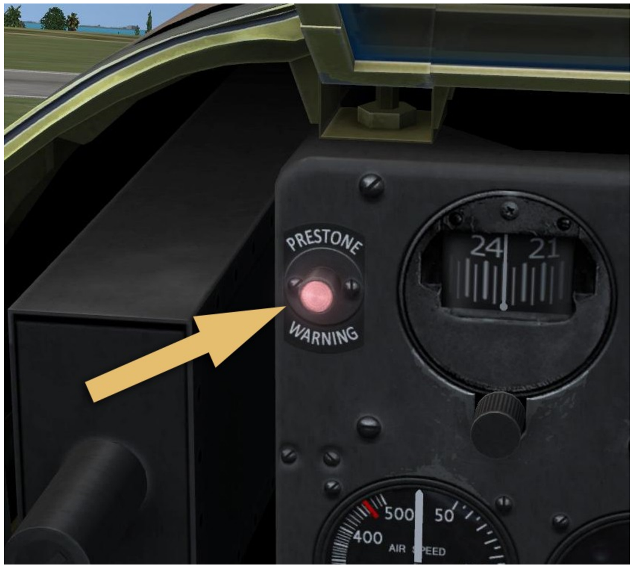
Engine temperatures will rise based on the power, air temperature, and the air flow through the radiator. Use common sense and make gradual adjustments with power and speed. Avoid high power, steep climbs, and low power descents with the radiator flap opened.



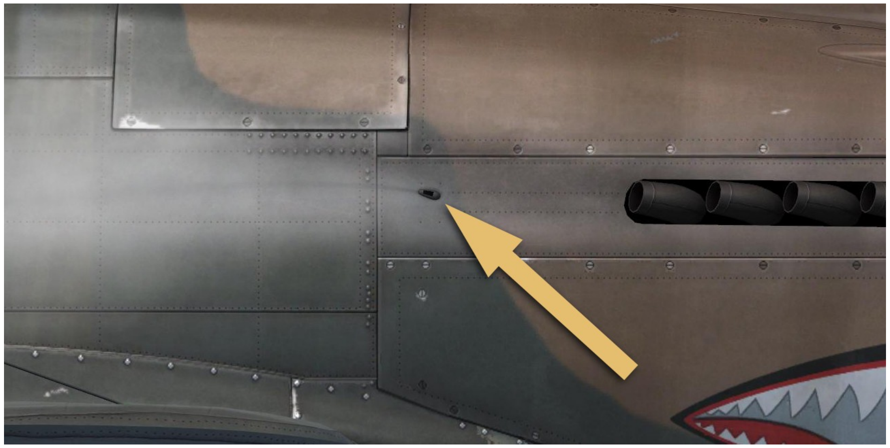
Also, being a water-cooled engine, it takes time for the coolant to travel through the engine, through coolant lines to the radiator, then to your temperature gauge, so the temperature gauge tends to lag behind the actual heating of the engine. For example, you may perform a run up, and only at the end you will notice a sharper increase in coolant temperatures. Then as you are idling, temperatures may continue to rapidly climb as that heated water from the run-up is now reaching your temperature gauge. This is normal behavior, but you do need to understand why this is happening to anticipate heating and cooling. Your engine CAN overheat, so either get it in the air, or get it to it's parking spot and shut it down.

Coolant Pressure Release Valve

If your coolant system pressures are too high or your coolant temperature exceeds 125° C, a Prestone warning light will illuminate. You should take action to lower your temperatures immediately.



Should temps continue to rise, at about 125° C a pressure relief valve will open allowing high temperature air to escape. This relief valve helps prevent damage to your coolant system due to extreme pressures. The coolant vent is located just aft of the right exhaust stack.



Persistent Aircraft

Every time you load up your Accu-Sim P-40, you will be flying the continuation of the last aircraft which includes fuel, oil, coolant levels along with all of your system conditions. So be aware, no longer will your aircraft load with full fuel every time, it will load with the same amount of fuel you left off when you quit your last flight. You will learn the easy or the hard way to make, at the very least, some basic checks on your systems before jumping in and taking off, just like a real aircraft owner.

Additionally, in each flight things will sometimes be different. The gauges and systems will never be exactly the same. There are just too many moving parts, variables, changes, etc., that continuously alter the condition of the airplane, its engine and its systems.

NOTE: Signs of a damaged engine may be lower RPM (due to increased friction), inconsistent manifold pressures, or possibly hotter engine temperatures.

Electrical System and Battery

Accu-Sim installs an authentic period battery into a feature-rich electrical system, thanks to close consultation with our own on-staff electrical engineer and high time pilots. Batteries suffer from reduced capacity as they age, have a limited output (34 amp hours), can overheat if you demand too much from them, and can even load up your entire system if you have a brand new, but dead battery on-line. (ever try to jump start a car with a dead battery and nothing happens? You have to disconnect the dead battery and try again, since the dead battery is stealing all the electricity). The physical laws governing electricity are inexorable as those which govern running water. Our latest and most sophisticated version of Accu-Sim accurately replicates those physical laws and permits you to see the electrical system at work, via the ammeter on your electrical panel and through sounds and behaviour of the various electrically driven systems.

Volts, amps, watts, what does this all mean?

Without getting too technical, the pilot in command must understand the basics of what is happening in the aircraft's electrical system and components. Volts X Amps = watts. If we use a water hose as an analogy, volts would be the water pressure, amps would be the hose width, and watts would be the amount / rate of water coming out the end. You could have, for example, a 120 volt, 1 amp light bulb would be the same brightness as a 12 volt, 100 amp bulb. The high voltage system is sending high pressure down a small pipe, and the low voltage system is sending low pressure down a large pipe, but each putting out the same amount of water (watts).

If you take a huge draw, for example running your hydraulic pump, voltage will plummet as the battery struggles to supply this current. Your Ammeter will show the current draw. However, play with your lights, pitot heat, etc. and watch how these little changes affect these systems.

Remember, your electrical system has a battery and an engine driven electrical generator. The battery puts out about 24 volts, while the generator puts out a little more (about 28 volts). This allows your generator to not only drive all of the systems, but charge the battery at the same time. Remember, your generator is powered by the engine speed, and it does not reach it's full capacity until about 1,800 RPM. Watch your meters, and you will see and enjoy a genuine electrical system in action.

In addition, weather affects a battery's performance. Fortunately, you can always visit your maintenance hangar for a quick charge or replacement. If you use your battery wisely and correctly, it will last a long time.

While you can start your engine with your internal battery, why not use the APU and give that little on-board battery a well-deserved break? So before starting your engine, you can attach your APU in your CONTROLS menu (Shift-3).

NOTE:
The Tomahawks (British and Russian) come with a British built APU, while the U.S. P-40's come with a Hobart APU.

Sounds Generated by Physics

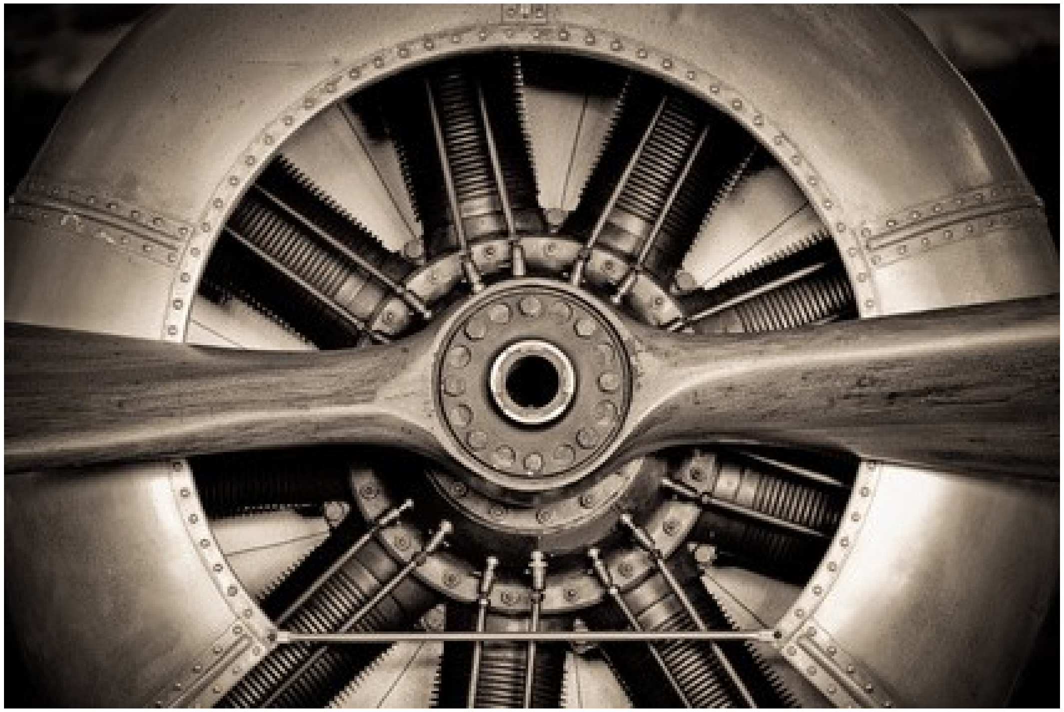
Lockheed Martin Prepar3D, like any piece of software, has its limitations. Accu-Sim breaks this open by augmenting the sound system with our own, adding sounds to provide the most believable and immersive flying experience possible. The sound system is massive in this Accu-Sim P-40 and includes engine sputter / spits, bumps and jolts, body creaks, engine detonation, runway thumps, gear doors and flaps, dynamic touchdowns, authentic simulation of air including buffeting, shaking, canopy, broken flaps, jammed gear, oxygen sounds, primer, and almost every single switch or lever in the cockpit is modeled. Most of these sounds were recorded from the actual aircraft and this sound environment just breaks open an entirely new world. However, as you can see, this is not just for entertainment purposes; proper sound is critical to creating an authentic and believable flying experience. Know that when you hear something, it is being driven by actual system physics and not being triggered when a certain condition is met. There is a big difference, and to the simulation pilot, you can just feel it.

Gauge Physics

Each gauge has mechanics that allow it to work. Some gauges run off of engine suction, gyros, air pressure, or mechanical means. The RPM gauge may wander because of the slack in the mechanics, or the gyro gauge may fluctuate when starting the motor, or the gauge needles may vibrate with the motor or jolt on a hard landing or turbulent buffet.

The gauges are the windows into your aircraft's systems and therefore Accu-Sim requires these to behave authentically.

Propellers

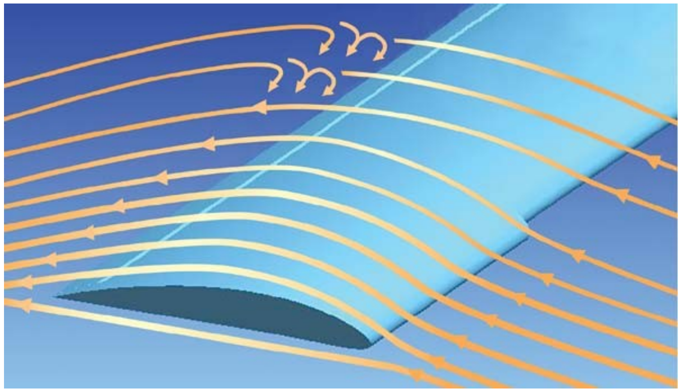


The propeller to an aircraft is like the tires to a race car.

The propeller is where the engine meets the air. Propeller technology and physics is the foundation of not only prop-based aircraft, but jets, and even ships. A lot happens when an engine drives a propeller to such a speed that it can move a multi-ton piece of machinery, especially through the thin air. The prop blades are basically little wings, biting and grabbing the air, sending it backwards over the airframe and moving surfaces. It torques and twists the aircraft, and twirls the air around it.

As a pilot, you don't need to be an aeronautical engineer to understand the basics of what is going on, so let's just go over the basics.

The Airfoil: How a wing creates lift



Before you learn about how different propellers work, first you must understand the basics of the common airfoil, which is the reason why a wing creates lift, and in this case, why a propeller creates thrust.

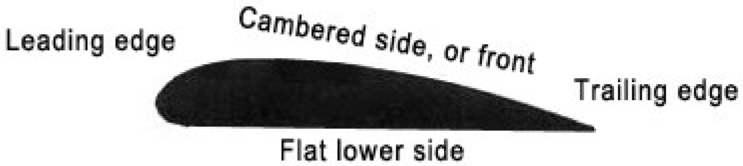
The Bernoulli Theory
This has been the traditional theory of why an airfold creates lift:

Look at the image to the right which shows you how the shape of an airfoil splits the oncoming air. The air above is forced to travel further than the air at the bottom, essentially stretching the air and creating a lower pressure, or vacuum. The wing is basically sucked up, into this lower pressure. The faster the speed, the greater the lift.

The Newton Theory
As the air travels across the airfoil's upper and lower surfaces, lift is created by shoving the air down with great force at its trailing edge, and to some degree, the Newtonian force of opposite and equal reaction apply.

What we do know (and what the pilot needs to know)
The airfoil is essentially an air diverter and the lift is the reaction to the diverted air. Regardless of what role each theory plays, an airfoil's lift is dependent upon its shape, the speed at which it is traveling through the air, and its angle to the oncoming air (angle of attack).

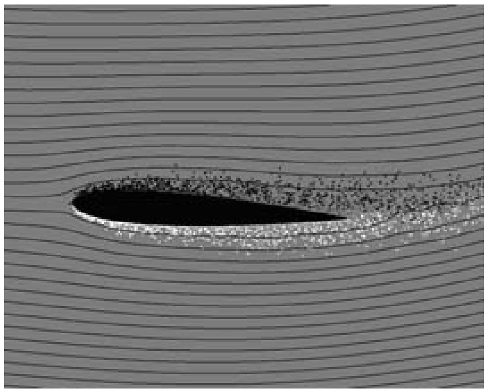
Look at the cross section of a propeller blade. Essentially, the same process creates lift.



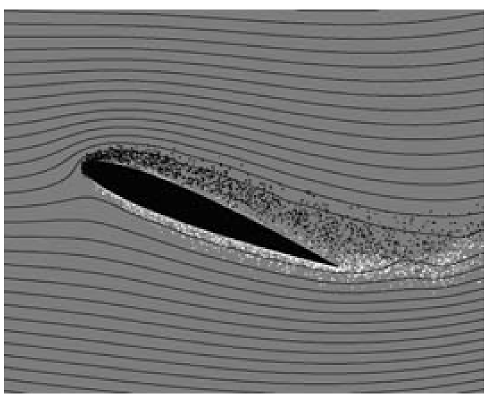
Cross section of a propeller blade

Below are some graphical representations of an airfoil travelling though the air in various conditions:

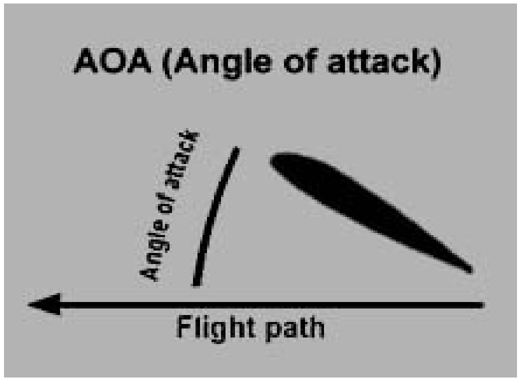
Level Flight
A wing creating moderate lift. Air vortices (lines) stay close to the wing.



Climb
Wing creating significant lift force. Air vortices still close to the wing.



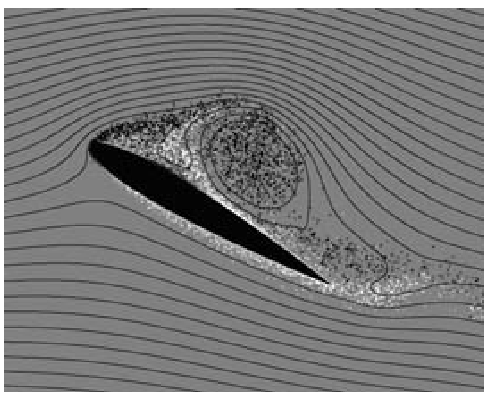
What is a stall? In order for a wing to produce efficient lift, the air must flow completely around the leading (front) edge of the wing, following the contours of the wing. At too large an angle of attack, the air cannot contour the wing. When this happens, the wing is in a "stall."



Typically, stalls in aircraft occur when an airplane loses too much airspeed to create a sufficient amount of lift. A typical stall exercise would be to put your aircraft into a climb, cut the throttle, and try and maintain the climb as long as possible. You will have to gradually pull back harder on the stick to maintain your climb pitch and as speed decreases, the angle of attack increases. At some point, the angle of attack will become so great, that the wing will stall (the nose will drop).

Stall

The angle of attack has become too large. The boundary layer vortices have separated from the top surface of the wing and the incoming flow no longer bends completely around the leading edge. The wing is stalled, not only creating little lift, but significant drag.



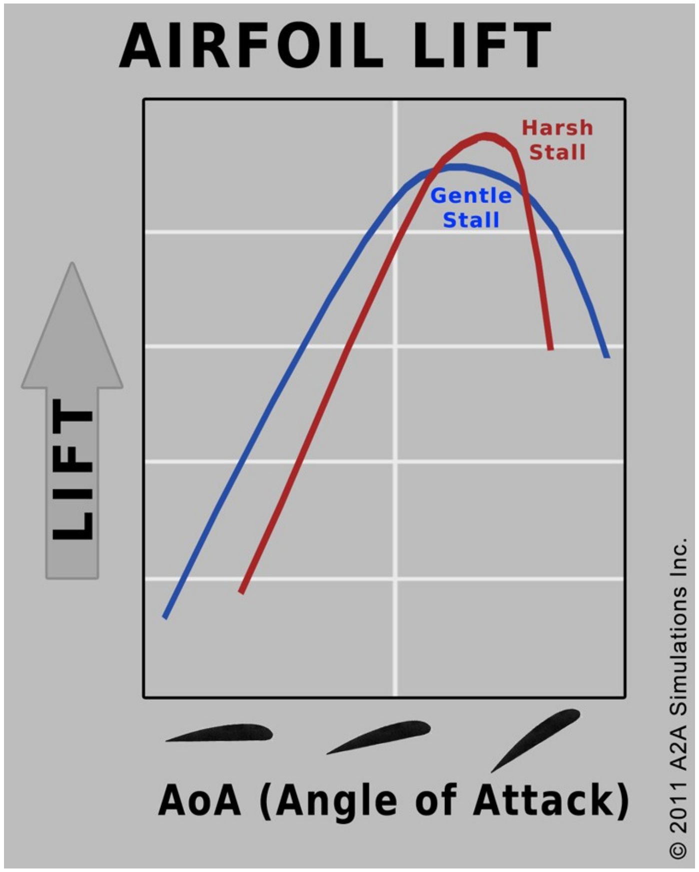
Can a propeller stall?

What do you think? More on this below.

Lift vs Angle of Attack

Every airfoil has an optimum angle at which it attacks the air (called angle of attack, or AoA), where lift is at it's peak. The lift typically starts when the wing is level, and increases until the wing reaches its optimum angle, lets say 15-25 degrees, then as it passes this point, the lift drops off. Some wings have a gentle drop, others can actually be so harsh, as your angle of attack increases past this critical point, the lift drops off like a cliff. Once you are past this point of lift and the angle is so high, the air is just being plowed around in circles, creating almost no lift but plenty of drag. This is what you experience when you stall an aircraft. The buffeting or shaking of the aircraft at this stall position is actually the turbulent air, created by your stalling wing, passing over your rear stabilizer, thus shaking the aircraft. This shaking can sometimes become so violent, you can pop rivets and damage your airframe. You quickly learn to back off your stick (or yoke) when you feel those shudders approaching.

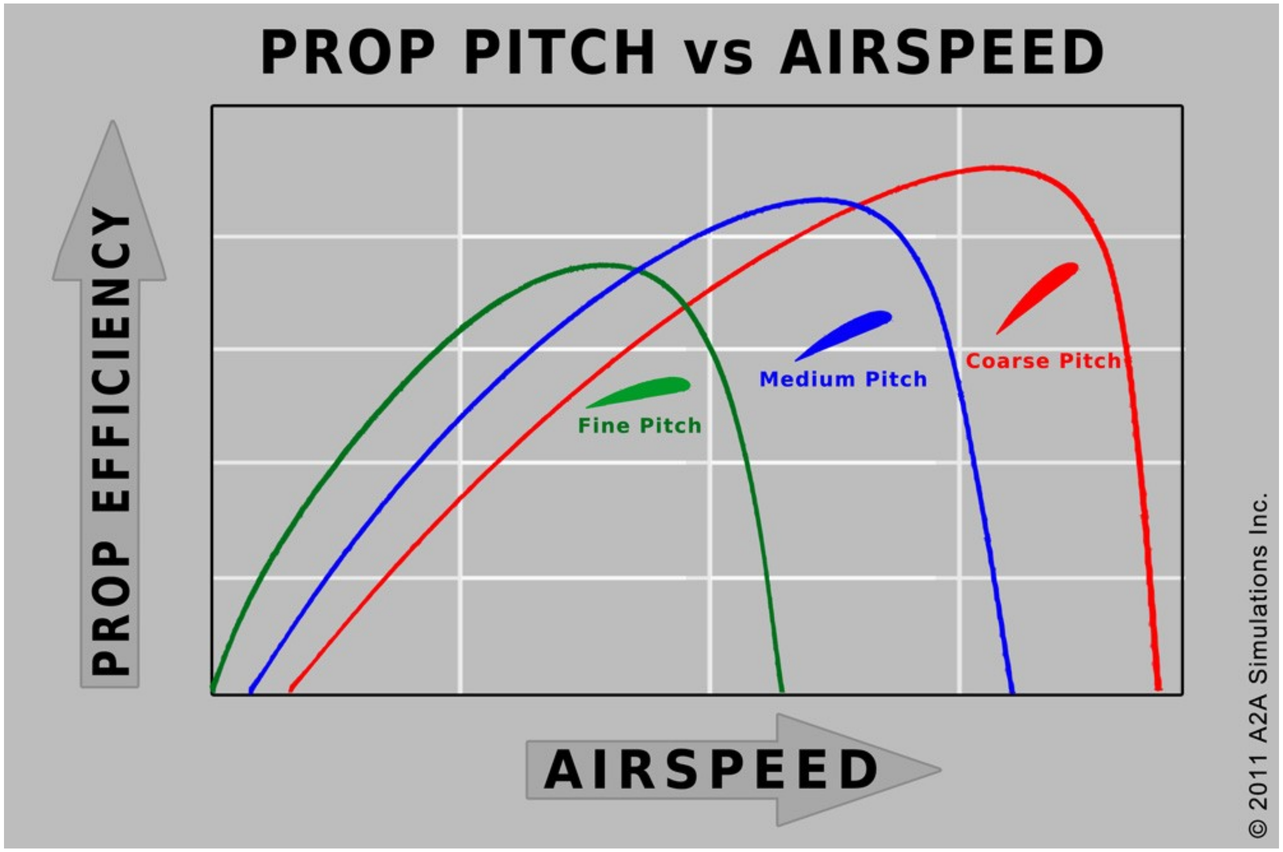
Notice in the diagram to the right, how the airfoil creates more lift as the angle of attack increases. Ideally, your wing (or propeller) will spend most of it's time moving along the left hand side of this curve, and avoid passing over the edge. A general aviation plane that comes to mind is the Piper Cherokee. An older version has what we call a "Hershy bar wing" because it is uniform from the root to the tip, just like an Hershy chocolate bar. Later, Piper introduced the tapered wing, which stalled more gradually, across the wing. The Hershy bar wing has an abrupt stall, whereas the tapered wing has a gentle stall.



A propeller is basically a wing except that instead of relying on incoming air for lift, it is spinning around to create lift, it is perpendicular to the ground, creating a backwards push of air, or thrust. Just remember, whether a propeller is a fixed pitch, variable pitch, or constant speed, it is always attacking a variable, incoming air, and lives within this lift curve.

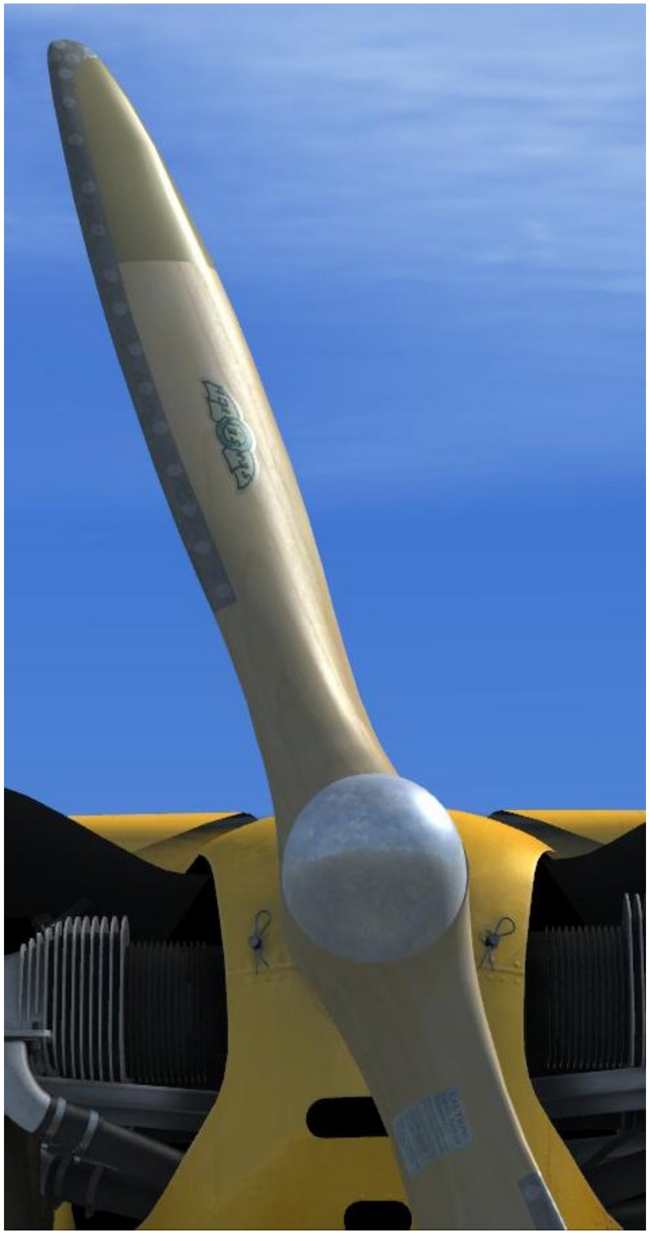
Propeller Efficiency

Higher RPM, bigger diameter (faster tip speed), and higher angle (referred to as coarse angle) all contribute to the propeller moving more air, faster. Now remember as the incoming air increases in speed (airspeed), the propeller has to increase in either speed or pitch to keep up with this incoming air. If the prop is too slow or the pitch is too shallow (also called FINE), then the prop will act as a brake as the faster air rams into the slower prop. As the prop speed and / or angle increases, it surpasses the incoming air and starts to bite the air and pull the aircraft forward. So a higher angle (coarser pitch) will work better at higher speed. A lower angle (finer pitch) will work better at slower speeds (create more thrust). This relationship of the prop speed and angle to the speed of the incoming air helps to determine how efficient the propeller is operating. For example, a Supermarine Spitfire's fixed pitch wooden propeller is designed to be most efficient at the very highest speeds, therefore it is set to a very coarse pitch. Look at the red "coarse pitch" line below, and look how inefficient it operates at lower airspeeds. This is why it takes so long to get the plane rolling and airborne, and is only a mediocre climber.



The Fixed Pitch Propeller

This, like an aircraft wing, is set at a fixed angle. The prop is directly connected through a shaft, usually through a reduction gear, to the engine crankshaft. More power means more engine speed which means more propeller speed. A fixed pitch propeller is basically the art of compromise. The propeller engineer chooses an angle that typically does one thing fairly well, but has no choice to accept everything else it does is either fair or just flat out poor. For example, if you are looking for a “climb prop” you will typically want a propeller with a more shallow angle, allowing for higher RPM's to be achieved at slower climb speeds. If you wish to have a 'cruise prop' you will typically choose a prop that has a larger angle, to be able to take larger grabs of air at higher altitudes, and when the RPM is low.



This wooden prop on our Accu-Sim Spitfire was designed to create the best top speed (remember, this is a racer). The engineer's took the altitude at which the Merlin engine created the most horsepower, then pitched the prop so the aircraft arrived at it's top speed when the engine RPM was at it's maximum RPM (3,000 RPM). This is sort of like predicting when two changing lines converge, as the engine speed gives power, and the power gives speed, and the speed pushes the prop. They didn't have the convenience of modern computers; they had to do things the hard way, but they knew what they were doing and they delivered the prop which does exactly what it was meant to do – provide the highest possible speed at 18,000 feet. However, you have traded this top speed performer for very poor takeoff performance.

NOTE: Accu-Sim Piper J-3 Cub Wooden Propeller Shown

The Variable Speed Propeller

Unlike the fixed pitch propeller that is just what it says it is, fixed, the variable speed prop allows the pilot to change the prop pitch (angle) with a lever in the cockpit. So now, at takeoff, a pilot can choose a shallow pitch for higher RPM and thrust at these very low airspeeds, and when up high in the thinner air at faster airspeeds, the pilot can choose a coarse pitch allowing the propeller to keep up and continue to be efficient.

2-Pitch

The 2-pitch prop is what it says it is. It has two settings, high and low. The fine pitch is made for slower airspeeds (takeoff or climb), and the coarse pitch is made for higher airspeeds (cruise, high altitude flight, top speed). The A2A Simulations Spitfire MkIa is fitted, by default, with a De Havilland 2-pitch propellor.

Variable

Unlike the 2-pitch propeller, the pilot no longer has to choose between two settings, but to smoothly change the pitch from fine to coarse. This is better than a 2-pitch because it allows for the perfect pitch in almost any situation. However, this can be a lot of work. As the conditions can rapidly change in the air (especially in a life or death combat situation), the variable requires the pilot to also respond as quickly as the situation changes. Your P-40 runs as a true variable when operated in MANUAL mode.

Constant Speed

This constant speed prop represents the ultimate solution, as all the pilot needs to do is set the prop lever to the “desired” speed, and the prop constant speed governor does the rest for you. Lets say, for example, the pilot moves the lever ¾ forward, where he knows this is about a 2,600 RPM speed. As he throttles up, the propeller “governor” turns the prop to it's lowest pitch to allow for the highest possible RPM. As it approaches this desired RPM, it begins to coarsen the pitch, adding more drag / thrust, and slowing the engine down. The pilot has not moved either the throttle or prop lever, but the prop has, all by itself, adjusted it's pitch to maintain the RPM the pilot has set with his prop lever. So, at almost any flight regime, takeoff, cruise, top speed, dive, or landing, the constant speed prop will try to maintain the desired RPM. Notice that I used the word “try” because even a constant speed has it's limitations, of which you the pilot must understand.

The only situation when a constant speed prop cannot deliver the pilot requested RPM is when the prop reaches it's max or min pitch stops, or limit. For example, when static and on the ground, lets say you move your prop lever to it's highest speed, which is 3,000RPM on the P-40. The prop is hitting still air, creating huge amounts of force as the RPM increases. The constant speed unit continues to flatten the pitch in its effort to reach the requested RPM. However, with many constant speed props, it hits the stop for the minimum pitch before it can reach the desired RPM. So, what you the pilot will notice is the RPM stopping somewhere short of the 3,000 RPM you requested. As you start to roll down the runway and get some help from the incoming air feeding it, the prop can slowly reach it's goal. Conversely, on a high speed dive, the speed can become so great that the propeller reaches it's coarse pitch stop, essentially becoming a fixed pitch prop. If the speed continues to increase, the RPM will exceed the desired RPM. Finally, when on final, and with a high RPM being requested, as your aircraft slows and you start to pull the RPM back, your engine is now wanting to slow down, yet the incoming air is now pushing the propeller. When you start to notice your RPM drop on final, this is your constant speed unit hitting it's fine pitch stop.

From Stall to Full Power

With brakes on and idling, the angle at which the prop attacks the still air, especially closer to the propeller hub, is almost always too great for the prop to be creating much lift. The prop, is mostly, behaving like a brake as it slams it's side into the air. In reality, the prop is creating very little lift while the plane is not moving. With your Accu-Sim P-40, you can achieve higher power without nosing over than in most Prepar3D aircraft because prop stall is part of the Accu-Sim prop physics suite.

Once done with your power check, prepare for takeoff. Once you begin your takeoff run, you may notice the aircraft starts to pull harder after you start rolling forward. This is the propeller starting to get its proper "bite" into the air, as the propeller blades come out of their stalled, turbulent state and enter their comfortable high lift angles of attack it was designed for. There are also other good physics going on during all of these phases of flight, that we will just let you experience for the first time yourself.

The bottom line is when you open up that Allison engine, you will see, hear, and feel a lot of new things going on. It is our hope that all of this new feedback not just helps you become a more capable pilot, but you will simply enjoy the experience that much more.

Prop Overspeed

A fixed speed prop spends almost all of it's life out of it's peak thrust angle. This is because, unless the aircraft is travelling at a specific speed and specific power it was designed for, it's either operating too slow or too fast. Lets say you have your P-40 propeller in MANUAL mode, and you are cruising at a high RPM. Now you pitch down, what is going to happen? The faster air will push your prop faster, and possibly beyond it's 3,000 RPM recommended limit. If you pitch up your RPM will drop, losing engine power and propeller efficiency. You really don't have a whole lot of room here to play with, but you can push it (as many WWII pilots had to).

Now, take a constant speed prop. You may think, "No problem, it will change pitch and keep the speed proper." Well, theoretically you are correct, but in reality, things don't happen instantly in life (and airplanes), they take time. The governor in your constant speed hub, has to strike a happy medium between being too responsive, or too sluggish. If it was engineered for immediate response, you would run into oscillation problems (can get dangerous very fast, ending up in destroying your engine as it is yanked from one extreme to the next). If it is too sluggish, well then it is just always behind you, the pilot. So, consider your unit it tuned to deliver the most response with the lowest risk of oscillating. So, if you throw your throttle forward at takeoff, or even in flight, you will likely see your propeller surge ahead, then back off. If you pull the throttle back suddenly, the RPM will drop down, then as the pitch starts to flatten, creep back to your desired RPM.

It is important to know how this unit works, as a pilot, because this is your critical connection of your engine to the air, as said above, just like a car is connected to it's tires.

Air, Humidity, Visibility

Your new P-40 doesn't have many things we take for granted in a modern airplane. For example, a heated air defroster. Moving rapidly through various areas and altitudes means air quality can rapidly and radically change within seconds. This can result in very fast (and dangerous) fogging up of the windows and you, as a pilot, must understand what is happening and why, so you can be prepared for this and know how to deal with it.

Think of air as a wash cloth. The warmer the air, the thicker the wash cloth, and the more water it can hold. Down low, the wash cloth is thick and heavy. Take it up high, it's thin and dry. Now imagine, you are flying at 15,000 feet, and the temperature is about -10 degrees Celsius. The aircraft is cold, the seats, and most importantly, the windows. You now make a dive for that warm, moist air below. In just minutes, that warm, moist washcloth is being slammed on your icy-cold window, just wringing out it's water because, your window is still frigid and dry. If you want to experience this yourself, put a perfectly dry mirror in your freezer for just 10 minutes. Take it out, and what happens? It immediately fogs up. It's now wet. Hello morning dew. Well, the mirror didn't absorb any water from your freezer, but it basically sucked the water out of the air that was in your kitchen. The warm air in your kitchen hit that cold mirror, the air was then cooled to the point where it could no longer hold the water, and it deposited it on that mirror. In just a few minutes the mirror is clear, why? Well, the mirror slowly returned to room temperature, and the water was then absorbed back into the air.

So when you dive to lower altitudes, your thick canopy will fog up, largely because it is thick enough to hold onto it's cold temperatures. No heat in the cabin means the whole cabin is like an ice cube.

Well, here at A2A, we don't believe in re-inventing the wheel, or faking it for that matter. We also don't like tricks. These are all short term gains with long term headaches. So what we do is model the air with proper meteorological properties. When your canopy fogs up, it could be the above, or it could be your own breath fogging up the inside. Ever sit with a special someone in a car, with the windows up? It's amazing how us humans can can act as humidifiers. Well, this is an entire car interior. It takes a lot less to heat up a small, cramped cockpit. When on the ground, at the very least have your vent opened, as even just a 5mph breeze will help exchange that air with the outside (remember, we're talking Accu-Sim here :)) Better yet, do what the pilots do and keep that canopy opened until you start your motor. Then you will have plenty of air passing over the cockpit to flush out any humidity you are putting out.

Landings

Bumps, squeaks, rattles, and stress all happens in an aircraft, just when it is taxiing around the ground. Now take that huge piece of lightweight metal and slam it on the pavement. It's a lot to ask of your landing gear. Well, remember, this is a race horse we are talking about, and so every pound counts. Aircraft engineer's don't design the landing gear any more rugged than they have too. So treat it with kid gloves on your final approach. Kiss the pavement. Anything more, is just asking too much from your aircraft. The same goes for the air forces in the air. Remember, these are air forces in excess of a hurricane. Keep it well under the airspeed limits before dropping your landing hear (or flaps for that matter).

Accu-Sim watches your landings, and the moment your wheels hit the pavement, you will hear the appropriate sounds (thanks to the new sound engine capabilities). Slam it on the ground and you may hear metal crunching, or just kiss the pavement perfectly and hear just a nice chirp or scrub of the wheels. This landing system part of Accu-Sim makes every landing challenging and fun.

Your Turn To Fly

The early P-40 is a hands-on, raw, yet honest airplane. You actually have to manually run the hydraulic system, adjust the cowl flaps, and be careful not to over-boost your engine. However, this is your airplane and, you can choose to baby it or work it hard. After all, many combat pilots did just that.

Whatever way you choose to fly, take a little time to get to know her first. Look around the cockpit and learn her limitations. She is pure and trustworthy.

Enjoy

Accu-Sim is about maximizing the joy of flight. We at A2A Simulations are passionate about aviation, and are proud to be the makers of both the A2A Simulations P-40, and its accompanying Accu-Sim expansion pack. Please feel free to email us, post on our forums, or let us know what you think. Sharing this passion with you is what makes us happy.

Microsoft: Creators of Microsoft FSX and its excellent open-architecture system that allowed us to port in our Accu-Sim technology

Lockeed Martin: For continuing to support and grow Prepar3D

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Aircraft Painting: Martin Catney

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Public Relations, Web Design, Maintenance Hangar Concept: Lewis Bloomfield

Manual: Scott Gentile

Quality Control Beta Team: The world's most effective and knowledgeable flight simulation beta team, including Cody Bergland, Forest "FAC257" Crooke, Glenn Cummings (GlennC), Ryan "Hog Driver" Gann, Mitchell Glicksman, Darryl “KillRatio” Hackett, Jake “Captain Jakey” Gentile, James “Big Juicy Spider”, Matt "Mattgn" Newton, Krzysztof "Sundowner" Oleksy, Gunter "Snorre" Schneider, Erwin “Dutch 506” Schultze, Guenter “Guenseli” Steiner, Paul "Gypsy Baron" Strogen, Oskar “Lone Wolf 47” Wagner.

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- Graham White, author of “Allied Aircraft Piston Engines of World War II” for his engaging discussions about behaviors of these engines and helping us to uncover some widely unknown characteristics

Very Special Thanks to our friends and families who stuck by us and worked hard to support our efforts

Coming home after a nice long flight...

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