How Gliders Work

In its simplest form, a glider is an unpowered aircraft, an airplane without a motor. While many of the same design, aerodynamic and piloting factors that apply to powered airplanes also apply to gliders, that lack of a motor changes a lot about how gliders work. Gliders are amazing and graceful machines, and are about as close as humans can get to soaring like birds.

From paper airplanes to the space shuttle during re-entry, there are many types of gliders. In this article, we will focus on the most common type of glider, often referred to as a **sailplane**.

Parts of a Glider

A glider has many of the same parts as an airplane:

- fuselage
- wings
- control surfaces
- landing gear

But, there are significant differences in these parts on a glider, so let's take a look at each.

Fuselage

Gliders are as small and light as possible. Since there is no large engine taking up space, gliders are basically sized around the cargo they carry, usually one or two people. The cockpit of a single-seat glider is small, but it is large enough for most people to squeeze into. Instead of sitting upright, pilots recline with their legs stretched out in front of them. The frontal exposure of the pilot is reduced and the cross-sectional area of the cockpit can be substantially smaller.

Gliders, along with most other aircraft, are designed to have skins that are as smooth as possible to allow the plane to slip more easily through the air. Early gliders were constructed from wood covered with canvas. Later versions were constructed from aluminum with structural aluminum skins that were much smoother. However, the rivets and seams required by aluminum skins produce additional drag, which tends to decrease performance. In many modern gliders, composite construction using materials such as fiberglass and carbon fiber are quickly replacing aluminum. Composite materials allow aircraft designers to create seamless and rivet-less structures with shapes that produce less drag.

Glider Cockpit

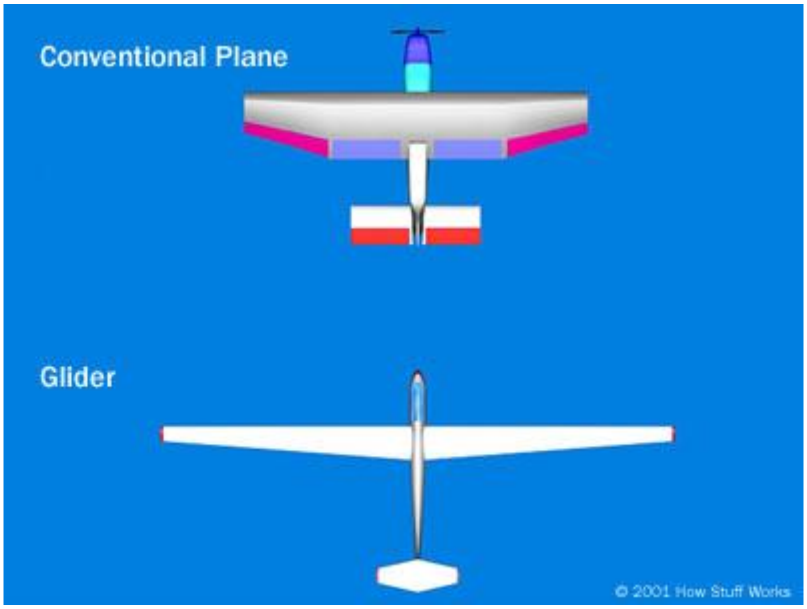
Inside a typical glider cockpit, you'll find the following:

- **Altimeter** (to indicate your altitude)
- **Air-speed indicator** (to tell how fast you are going)
- **Variometer** (to tell what the air around you is doing)
- **Radio** (to contact other planes or someone on the ground)
- **Control stick** (located between pilots legs)
- **Tow rope release knob** (to disengage the tow rope)

Wings

If you look at a glider next to a conventional powered plane, you'll notice a significant difference in the wings. While the wings of both are similar in general shape and function, those on gliders are longer and narrower than those on conventional aircraft. The slenderness of a wing is expressed as the aspect ratio, which is calculated by dividing the square of the span of the wing by the area of the wing.

Glider wings have very high aspect ratios -- their span is very long compared to their width. This is because drag created during the production of lift (known as induced drag) can account for a significant portion of the total drag on a glider. One way to increase the efficiency of a wing is to increase its aspect ratio. Glider wings are very long and thin, which makes them efficient. They produce less drag for the amount of lift they generate.



The aspect ratio of a wing is the wingspan squared divided by the area of the wing. The glider has a much larger aspect ratio than a conventional plane.

Why don't all planes have wings with high aspect ratios? There are two reasons for this. The first is that not all aircraft are designed for efficient flight. Military fighters, for example, are designed with speed and maneuverability well ahead of efficiency on the designer's list of priorities. Another reason is that there are limits to how long and skinny a wing can get before it is no longer able to carry the required loads.

Control Surfaces

Gliders use the same control surfaces (movable sections of the wing and tail) that are found on conventional planes to control the direction of flight. The ailerons and elevator are controlled using a single control stick between the pilot's legs. The rudder, as in conventional aircraft, is controlled using foot pedals.

- **Ailerons**
  Ailerons are the movable sections cut into the trailing edges of the wing. These are used as the primary directional control and they accomplish this by controlling the **roll** of the plane (tilting the wing tips up and down). Ailerons operate in opposite directions on each side of the plane. If the pilot wants to roll the plane to the right, he moves the control stick to the right. This causes the left aileron to deflect down (creating more lift on this side) and the right aileron to deflect up (creating less lift on this side). The difference in lift between the two sides causes the plane to rotate about its long axis.
- **Elevator (horizontal stabilizer)**
  The elevator is the movable horizontal wing-like structure on the tail. It is used to control the pitch of the plane, allowing the pilot to point the nose of the plane up or down as required.
- **Rudder (vertical stabilizer)**
  The rudder is the vertical wing-like structure on the tail. It is used to control the yaw of the aircraft by allowing the pilot to point the nose of the plane left or right.

Landing Gear

Another way to reduce the size of an airplane is to reduce the size of the landing gear. The landing gear on a glider typically consists of a single wheel mounted just below the cockpit.

Getting off the Ground

Three basic forces act on gliders: lift, gravity and drag (airplanes have a fourth force: thrust):

- **Lift** is the all-important force, created by the wings and counteracting the weight, which allows an aircraft to stay aloft. In the case of a glider, the lift is enhanced through the use of highly efficient wings.
- **Drag** is the force that tends to slow a plane down. Drag reduction is critical on a glider, even more so than on a conventional airplane. In motorized aircraft, a pilot can simply increase the thrust (using the engines) to overcome drag. Since there is no engine on a glider, the drag must be minimized wherever possible or the plane won't remain in the air for long.
- **Weight** can be made to work for or against a glider. A lighter overall weight, for example, may allow the glider to stay aloft longer or travel further. A heavier weight, on the other hand, can be an advantage if greater speed is the objective. Many gliders contain ballast tanks that pilots can fill with water before takeoff. The added weight of the water allows greater speeds while in the air. If the pilot wished to reduce his weight, he can dump the tanks while in the air to lighten the plane.

Without an engine, a glider's first problem is getting off the ground and up to altitude. The most common launching method is an aero-tow. A conventional powered plane tows the glider up into the sky using a long rope. The glider pilot controls a quick-release mechanism located in the glider's nose and releases the rope at the desired altitude. Right after release, the glider and the tow plane turn in opposite directions and the glider begins its unpowered flight. The tow plane is then free to return to the airport and set up for another tow.

Since the glider's wings generate more lift, it takes off before the tow plane.

Another popular launching method is winch launching. An engine powers a large winch on the ground and a long cable connects the winch to another release mechanism located on the underside of the glider. When the winch is activated, the glider is pulled along the ground toward the winch and takes off, climbing rapidly. As the glider rises, the pilot can release the winch line as in an aero-tow and continue his flight.

Staying in the Air

The wings on a glider have to produce enough lift to balance the weight of the glider. The faster the glider goes the more lift the wings make. If the glider flies fast enough the wings will produce enough lift to keep it in the air. But, the wings and the body of the glider also produce drag, and they produce more drag the faster the glider flies. Since there's no engine on a glider to produce thrust, the glider has to generate speed in some other way. Angling the glider downward, trading altitude for speed, allows the glider to fly fast enough to generate the lift needed to support its weight.

Why Gliders Carry Ballast

A plane's lift, drag and glide ratio characteristics are governed solely by its construction, and are predetermined at takeoff. Without thrust, the only other characteristic that the pilot has control over (besides normal control surfaces) is the weight of the plane.

A heavier glider will sink faster that a light glider. The glide ratio is not affected by weight because while a heavier glider will sink faster, it will do so at a higher airspeed. The plane will come down faster, but will cover the same distance (at a higher speed) as a lighter glider with the same glide ratio and starting altitude. In order to help them fly faster, some gliders have tanks that can hold up to 500 pounds of water. Higher speeds are desirable for cross-country flying.

The downsides of heavier sailplanes include reduced climb rates in a lifting environment (such as a thermal) and, possibly, shorter flight duration if suitable lift cannot be located. To prevent this, the water ballast can be jettisoned at any time through dump valves, allowing the pilots to reduce the weight of the plane to increase climb rates, or to reduce speed as they come in for a landing.

The way you measure the performance of a glider is by its glide ratio. This ratio tells you how much horizontal distance a glider can travel compared to the altitude it has to drop. Modern gliders can have glide ratios better than 60:1. This means they can glide for 60 miles if they start at an altitude of one mile. For comparison, a commercial jetliner might have glide ratios somewhere around 17:1.

If the glide ratio were the only factor involved, gliders would not be able to stay in the air nearly as long as they do. So how do they do it?

The key to staying in the air for longer periods of time is to get some help from Mother Nature whenever possible. While a glider will slowly descend with respect to the air around it, what if the air around it was moving upward faster than the glider was descending? It's kind of like trying to paddle a kayak upstream; even though you may be cutting through the water at a respectable pace, you're not really making any progress with respect to the riverbank. The same thing works with gliders. If you are descending at one meter per second, but the air around the plane is rising at two meters per second, you're actually gaining altitude.

There are three main types of rising air used by glider pilots to increase flight times:

- Thermals
- Ridge lift
- Wave lift

Thermals

Thermals are columns of rising air created by the heating of the Earth's surface. As the air near the ground is heated by the sun, it expands and rises. Pilots keep an eye out for terrain that absorbs the morning sun more rapidly than surrounding areas. These areas, such as asphalt parking lots, dark plowed fields and rocky terrain, are a great way to find thermal columns. Pilots also keep a look out for newly forming cumulus clouds, or even large birds soaring without flapping their wings, which can also be signs of thermal activity.

Once a thermal is located, pilots will turn back and circle within the column until they reach their desired altitude at which time they will exit and resume their flight. To prevent confusion, gliders all circle in the same direction within thermals. The first glider in the thermal gets to decide the direction -- all the other gliders that join the thermal must circle in that direction.

Ridge Lift

Ridge lift is created by winds blowing against mountains, hills or other ridges. As the air reaches the mountain, it is redirected upward and forms a band of lift along the windward side of the slope. Ridge lift typically reaches no higher than a few hundred feet higher than the terrain that creates it. What ridge lift lacks in height however, it makes up for in length; gliders have been known to fly for a thousand miles along mountain chains using mostly ridge lift and wave lift.

Wave Lift

Wave lift is similar to ridge lift in that it is created when wind meets a mountain. Wave lift, however, is created on the leeward side of the peak by winds passing over the mountain instead of up one side. Wave lift can be identified by the unique cloud formations produced. Wave lift can reach thousands of feet high and gliders can reach altitudes of more than 35,000 feet.

Detecting Lift

Columns and bands of rising air obviously benefit any glider pilot, but how can you tell if you are flying in one? The answer is the **variometer**, a device that measures the rate of climb or descent. The variometer uses static pressure to detect changes in altitude. If the glider is rising, then the static pressure drops (because air pressure decreases the higher you go). If the glider is sinking, then the static pressure rises. The needle on the variometer indicates the rate of change in altitude based on the rate of change of static pressure. When flying through a rising mass of air (like a thermal), the needle on the variometer will jump (and usually beep to notify the pilot) before any change on the altimeter is even noticeable.

Detecting Yaw

The glider is yawing when it is not pointing exactly in the direction it is flying (relative to the air around it). Instead the glider is angled sideways and is "slipping" or "skidding" through the air. The string on the windshield indicates whether the glider is flying straight (string straight) or whether it is yawing (string left or right). The glider produces the least drag when it flies straight through the air. When it is yawing, the drag increases -- so in general, glider pilots try to keep the string straight.

The string on the windshield tells the pilot if the plane is yawing

Landing

Landing a glider is much like landing a conventional plane, except there is usually a single small wheel located directly under the pilot. The wings on gliders are very strong, and the tips are reinforced to prevent damage in case they scrape along the ground during a landing. Even so, pilots can usually manage to keep both wing tips off the ground until the plane has slowed sufficiently (kind of like riding a fast bike down the runway). Glider tails typically have a tiny wheel that prevents the tail from scraping while on the ground.

When landing the glider, the pilot needs to be able to control the glide path (the rate of descent relative to distance traveled) in order to bring the glider down in the right location. The pilot has to be able to reduce the amount of lift produced by the wings without changing the speed or attitude of the glider. He does this by deploying spoilers on each wing. The spoilers disrupt the airflow over the wing, drastically reducing the lift it produces and also increasing the drag.

Glider World Records
(as of March 2001)

- Absolute Altitude: 49,009 ft
- Speed over 100 km triangular course: 135.09 mph
- Free Distance: 907.7 mi
- Distance around a triangular course: 869.52 mi
- Free distance with up to three turning points: 1,272.70 mi

Note the raised spoiler on the wing during landing

On July 23, 1983, a brand new Air Canada Boeing 767 was forced to glide to a landing after running out of fuel in midair. The plane essentially became an enormous glider. Even descending at a paltry glide ratio of about 11:1, the pilots managed to land safely at an abandoned airport in Gimli, Canada. The story of why the plane ran out of fuel is a long one, but it was partly due to an error in confusing English units with metric units.

If you are interested in learning more about this incident, you can read more by searching the Web for "Gimli glider" or by clicking here.

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