How Blimps Work

You've probably seen a Goodyear blimp providing TV coverage to a sporting event, such as a football game or golf tournament. Blimps are a type of lighter-than-air (LTA) craft called an **airship**. Like a hot air balloon, blimps use a gas to generate lift. But unlike a hot air balloon, blimps can move forward through the air under their own power, like airplanes. They can hover like helicopters, travel in all kinds of weather and stay aloft for days. In this edition of **HowStuffWorks**, we will show you how these fascinating vehicles work.

Inside a Blimp

Unlike a balloon, a blimp has a shape and structure that enable it to fly and maneuver. The following parts allow it to do this:

Blimp History tells you how, why, where and when blimps were first developed.

- **envelope** - contains the helium gas
- **nose cone battens**
- **forward ballonet**
- **aft ballonet**
- **catenary curtain**
- **suspension cables**
- **flight control surfaces** - rudders, elevators
- **engines**
- **air scoops**
- **air valves**
- **helium valve**
- **gondola** - holds passengers and crew

Envelope

The **envelope** is the large bag that holds the helium gas. The envelope is generally cigar-shaped, for aerodynamic purposes, and made of a durable, airtight, lightweight fabric (polyester composites) that is much like the fabric of a space suit. In fact, many envelopes are made by ILC Dover Corporation, the company that makes spacesuits for NASA.

The envelopes can hold from 67,000 to 250,000 ft^3 (1,900 to 7,093 m^3) of helium, depending upon the particular blimp. The pressure inside the envelope is low, approximately 0.07 pounds per square inch (0.005 ATM).

Nose Cone Battens

The **nose cone battens** are supports that radiate from the tip of the blimp. They stiffen the front of the blimp so that it is not damaged when it is moored to the **mooring mast**. They also give the nose an aerodynamic shape, and prevent it from pushing in as the blimp travels forward. In addition to the battens, the **mooring hooks** are located in the nose of the blimp.

Photo courtesy American Blimp Corporation
Nose cone battens (gray)

Ballonets

Ballonets are air-filled bags that are located inside the envelope. The blimp has two ballonets, one fore and one aft. The ballonets are similar to the ballast tanks of a submarine. Because air is heavier than helium, the ballonets are deflated or inflated with air to make the blimp ascend or descend, respectively. They are also used to control the **trim**, or levelness, of the blimp.

Catenary Curtain and Suspension Cables

The two **catenary curtains** are located inside the envelope along the length of the blimp. They are made of fabric and sewn into the envelope, and **suspension cables** attach them to the gondola. The curtains help to support and shape the envelope and attach the gondola.

Flight Control Surfaces

The **flight control surfaces** are stiff, movable parts of the blimp that are mounted to the tail. They consist of the rudder and elevators. The **rudder** is used to steer the blimp to the starboard or port directions (yaw axis). The **elevators** are used to control the angle of ascent or descent (pitch axis) of the blimp. The flight control surfaces are operated by the pilot as he/she flies the blimp, and can be arranged in a "+" or "x" configuration.

Engines

The two **engines** on the blimp provide the thrust necessary to move ahead. The engines are turbo-propeller airplane engines that use gasoline fuel and are cooled by air. The engines can generate several hundred horsepower, depending upon the particular blimp. They are located on either side of the gondola. With the engines, blimps can cruise around 30 to 70 mph (48 to 113 kph).

Photo courtesy Goodyear Tire & Rubber Company
The engines (left) and air scoops (right)

Air Scoops

The **air scoops** direct exhaust air from the propellers into the ballonets. This is how the pilots can fill the ballonets with air while in flight. When the engines are not running, electric fans move air into the ballonets.

Air Valves

The pilots must be able to vent air from the ballonets as well as add it. This is accomplished by **air valves** that are located on each ballonet. There are four valves -- two fore, two aft.

Photo courtesy Goodyear
Air valve of a blimp

Helium Valve

The pressure of the helium in the envelope is adjusted by changing the amount of air in the ballonets. Normally, blimp pilots do not have to add or remove helium from the envelope. However, there is a **helium valve** on the envelope that can be used to vent helium should the helium pressure exceed its maximum safe limit. The valve can be opened manually or automatically.

Gondola

The **gondola** holds the passengers and crew. It is enclosed, and holds two pilots and up to 12 crew, depending upon the type of blimp (Goodyear's Eagle and Stars & Stripes each hold two pilots and six passengers). Some gondolas have specialized equipment, such as a camera, attached to them.

Photo courtesy American Blimp Co.
Blimp gondola with an attached camera (round object in front)

Photo courtesy American Blimp Co.
Forward view inside of gondola, showing pilot seats/controls (front) and passenger seats

The **control panels** used by the pilots include the following:

- **Propeller controls** - monitor and regulate speed (throttle), blade angle (blade pitch) and direction of the engine (forward, reverse)
- **Fuel mixture/heat** - monitor and regulate the fuel-to-air ratio of the engine and the temperature of the mix to prevent icing at higher altitudes
- **Envelope pressure controls** - monitor and regulate the helium pressure in the envelope and the air pressure in the ballonets by opening and closing the air scoops and valves
- **Communications** - maintain radio contact with ground-support team and air traffic controllers
- **Flight surface controls** - control the rudder (left/right movement) and the elevators (up/down movement)

- **Navigation equipment** - compasses, airspeed indicators, radio beacon equipment, GPS, etc. (Some blimps also have weather radar, and are instrument-rated for night-flying.)

Blimp pilots are FAA-certified for **lighter-than-air** (**LTA**) craft. Goodyear's pilots undergo a comprehensive training program prior to FAA certification. In addition to piloting, Goodyear's pilots also serve as ground-support crew, including electronics technicians, mechanics, riggers and administrative personnel. A ground crew follows the blimp wherever it goes, bringing several support vehicles, including a bus that serves as the administrative office, a tractor-trailer that serves as an electrical/mechanical shop, and a van that is the command car/utility vehicle.

Night Signs

Some blimps (like Goodyear) are equipped with electric lights for nighttime advertising. In the Goodyear blimp, the night signs consist of a matrix of red, green and blue light-emitting diodes (LEDs). The intensities of the LEDs can be adjusted to create various colors. The messages are programmed in with a small laptop computer that is carried aboard.

Now that we have seen all of the parts of a blimp, let's look at how it flies!

How a Blimp Flies

Airships are called lighter-than-air (LTA) craft because to generate lift, they use gases that are lighter than air. The most common gas in use today is helium, which has a lifting capacity of 0.064 lb/ft^3 (1.02 kg/m^3). Hydrogen was commonly used in the early days of airships because it was even lighter, with a lifting capacity of 0.070 lb/ft^3 (1.1 kg/m^3) and was easier and cheaper to acquire than helium. However, the Hindenburg disaster ended the use of hydrogen in airships because hydrogen burns so easily. Helium, on the other hand, is not flammable.

While these lifting capacities might not seem like much, airships carry incredibly large volumes of gas -- up to hundreds of thousands of cubic feet (thousands of cubic meters). With this much lifting power, airships can carry heavy loads easily.

A blimp or airship controls its **buoyancy** in the air much like a submarine does in the water. The ballonets act like ballast tanks holding "heavy" air. When the blimp takes off, the pilot vents air from the ballonets through the air valves. The helium makes the blimp **positively buoyant** in the surrounding air, so the blimp rises. The pilot throttles the engine and adjusts the elevators to angle the blimp into the wind. The cone shape of the blimp also helps to generate lift.

As the blimp rises, outside air pressure decreases and the helium in the envelope expands. The pilots then pump air into the ballonets to maintain pressure against the helium. Adding air makes the blimp heavier, so to maintain a steady cruising altitude, the pilots must balance the air-pressure with the helium-pressure to create **neutral buoyancy**. To level the blimp in flight, the air pressures between the fore and aft ballonets are adjusted. Blimps can cruise at altitudes of anywhere from 1,000 to 7,000 ft (305 to 2135 m). The engines provide forward and reverse thrust while the rudder is used to steer.

To descend, the pilots fill the ballonets with air. This increases the density of the blimp, making it **negatively buoyant** so that it descends. Again, the elevators are adjusted to control the angle of descent.

When not in use, blimps are moored to a mooring mast that is either out in the open or in a hangar. To move the blimp into or out of its hangar, a tractor tows the mooring mast with the blimp attached to it.

Photo courtesy Goodyear Tire & Rubber Company
The Spirit of Goodyear coming out of its hangar at Wingfoot Lake Airship Base outside of Akron, Ohio

Uses of Blimps and Airships

Photo courtesy Goodyear
Blimp covering a Cleveland Browns football game

Because gas provides the lift in an airship or blimp, rather than a wing with an engine as in an airplane, airships can fly and hover without expending fuel or energy. Furthermore, airships can stay aloft anywhere from hours to days -- much longer than airplanes or helicopters. These properties make blimps ideal for such uses as covering sporting events, advertising and some research, like scouting for whales.

Recently, there has been renewed interest in using rigid airships for lifting and/or transporting heavy cargo loads, like ships, tanks and oil rigs, for military and civilian purposes. Modern airships, such as the Zeppelin NT and CargoLifter, use lightweight, carbon-composite frames that allow them to be huge, light and structurally sound. In addition to hauling cargo, airships may once again be used for tourism. So, the sight of a large airship moving across the sky may become more common in the near future.

Blimp History

In 1783, two French brothers, Jacques Etienne and Joseph Michel Montgolfier, invented the hot-air balloon and sent one to an altitude of 6,000 ft (1,800 m). Later that year, the French physicist Jean Pilatre de Rozier made the first manned balloon flight. While balloons could travel to high elevations, they could not travel on their own propulsion and were at the mercy of the prevailing winds. The shape of the balloon was determined by the pressure of the air or gas (such as hydrogen or helium).

Types of Airships

All airships have solid gondolas, engine-powered propellers and solid tailfins.

- **Rigid** - usually long (greater than 360 ft/120 m) and cigar-shaped with an internal metal frame and gas-filled bags. Example: Hindenburg
- **Semi-rigid** - pressurized gas balloon (envelope) attached to a lower metal keel. Examples: Norge, Italia **Non-rigid (blimp)** - large gas-filled envelopes. Examples: Goodyear, MetLife, Fuji

In 1852, Henri Giffard built the first powered airship, which consisted of a 143-ft (44-m) long, cigar-shaped, gas-filled bag with a propeller, powered by a 3-horsepower (2.2-kW) steam engine. Later, in 1900, Count Ferdinand von Zeppelin of Germany invented the first rigid airship.

The **rigid airship** had a metal framework -- 420 ft (123 m) in length, 28 ft (12 m) in diameter -- containing hydrogen-gas-filled rubber bags. The first Zeppelin had tail fins and rudders, and was powered by internal combustion engines. It carried five people to an altitude of 1,300 ft (396 m) and flew a distance of 3.75 mi (6 km). Several models of Zeppelins were built in the early 1900s. These vehicles were used for military and civilian purposes, including transatlantic travel. The most famous Zeppelin was the **Hindenburg**, which was destroyed by a fire in 1937 while landing at Lakehurst, New Jersey. See Fall of the Hindenburg to learn about the ship and the crash.

Photo courtesy Goodyear
Goodyear's original fleet of blimps in 1930

In 1925, Goodyear Tire & Rubber Company began building airships of the blimp design. These aircraft were used for advertising and military purposes (such as surveillance and anti-submarine warfare) throughout World War II. In 1962, the U.S. military stopped using blimps in their operations. Today, blimps are used mainly for advertising, TV coverage, tourism and some research purposes. However, the airship is coming back.

For more information on airships and related topics, check out the links on the next page.

Lots More Information

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- MetLife Blimp
- American Blimp Corporation: How Airships Fly
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History

- Airship Heritage Trust
- Airships: The Zeppelin Page
- FBI Report on the Hindenburg Disaster
- U.S. Navy Airship Picture Book
- Navy Lakehurst Historical Society
- Naval Airship Association, Inc.
- Hydrogen Newsletter: Hydrogen Exonerated in Hindenburg Disaster

Blimp and Airship Companies

- 21st Century Airships
- American Blimp Corporation
- Cargolifter AG
- Skyship Cruise Ltd.
- Zeppelin-NT
- The LightShip Group
- Advanced Technologies Group - Skycat 1000
- Rigid Airship Design
- ILC Dover - makes blimp and airship envelopes
- Mobile Airships, Inc. - radio-controlled model blimps