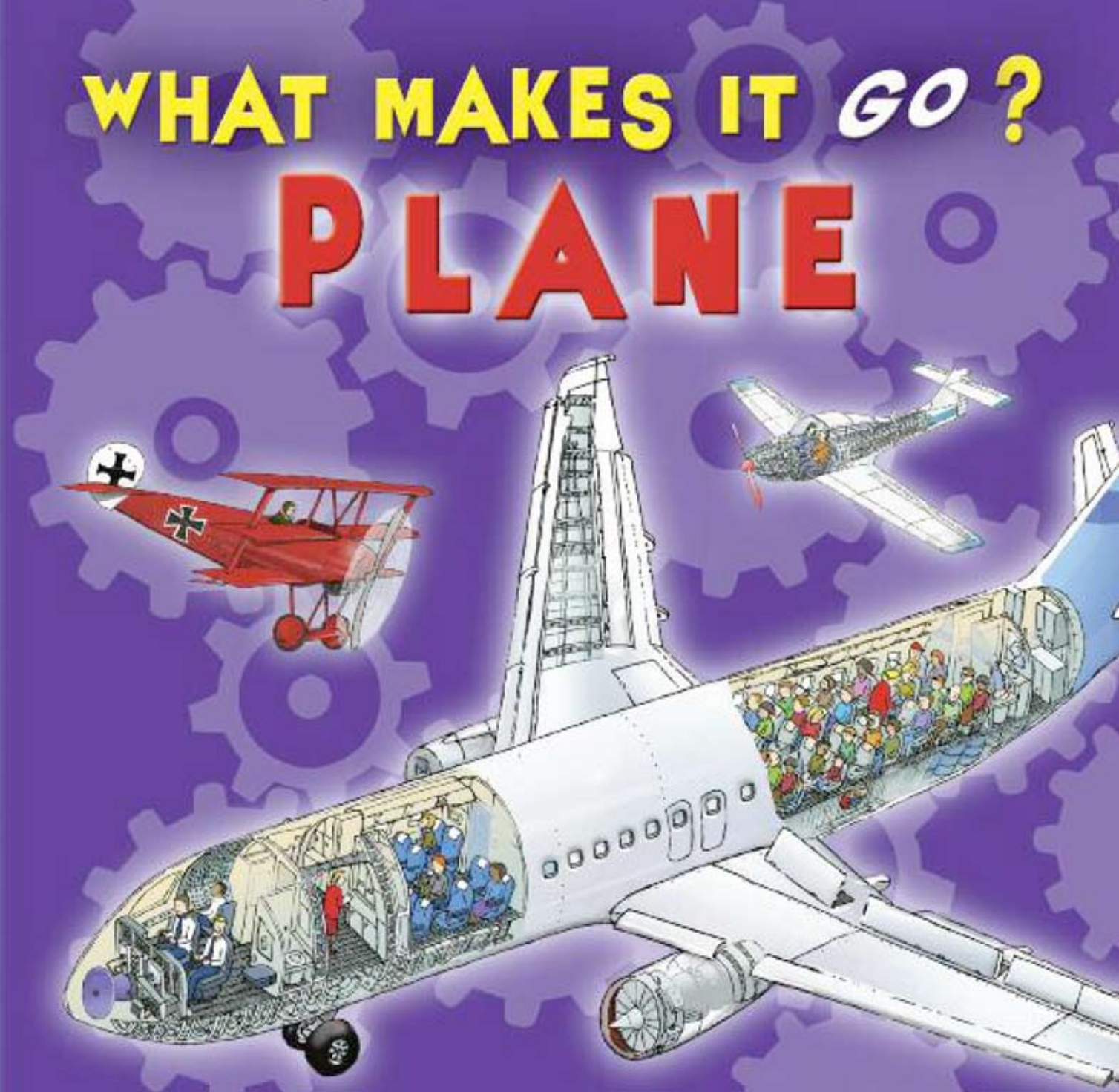
WHAT MAKES IT GO?

PLANE



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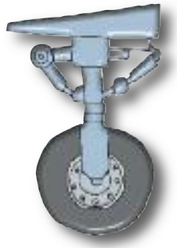

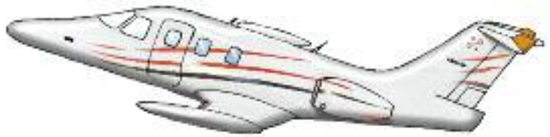

WHAT MAKES IT GO?

PLANE

Orpheus

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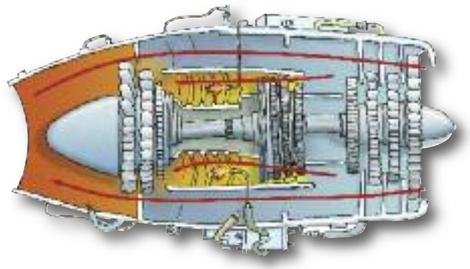
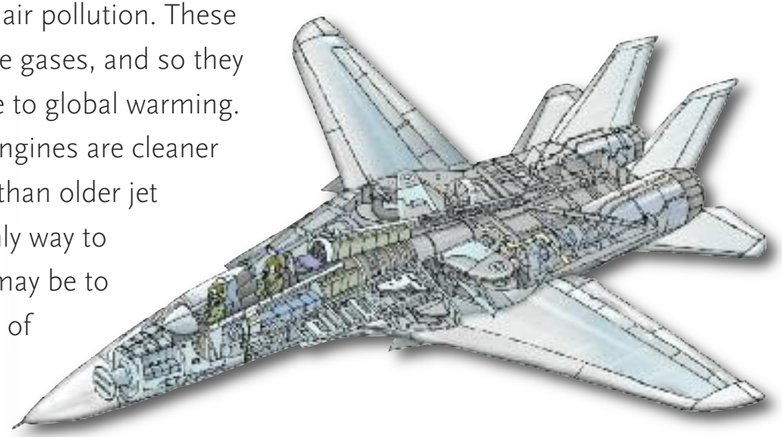


INTRODUCTION

This book tells you all about how an aeroplane works. You'll discover how the engines drive it forward, how it is steered and how the pilot, assisted by computers, controls the plane. You can also find out about airliners, light aircraft and military jets.

An aeroplane is a fixed-wing, heavier-than-air, powered aircraft. All modern aeroplanes have the same features, but those of airliners are the largest and most complex. In recent years, there has been a huge growth in air travel, with more and more airliner flights being made worldwide.

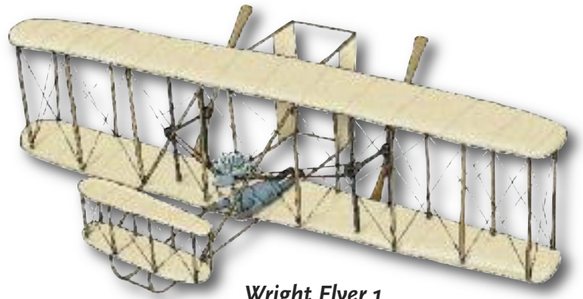
Airliners use kerosene as fuel. Unfortunately, the waste gases they give off create air pollution. These are also greenhouse gases, and so they probably contribute to global warming. Modern turbofan engines are cleaner and more efficient than older jet engines, but the only way to reduce emissions may be to reduce the number of flights in future.



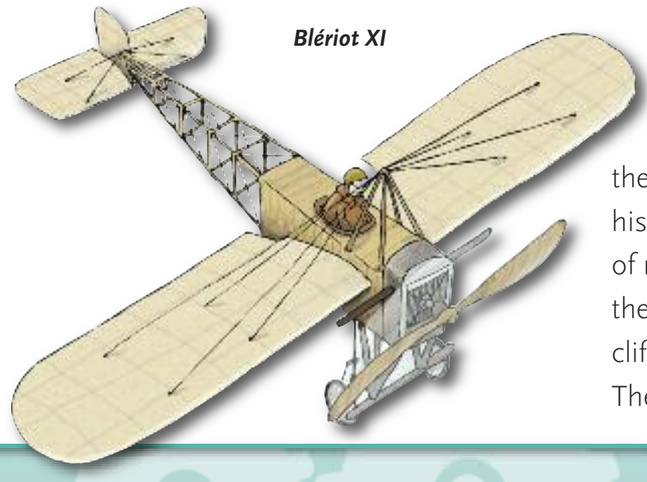
THE FIRST PLANES

On 17th December 1903, the American inventors Orville and Wilbur Wright made the first controlled, powered flight in an aeroplane. *Flyer 1* was based on gliders the Wright brothers had designed earlier. The pilot could steer by twisting ("warping") the wings, which rolled the plane to the left or right.

***Flyer 1's* first flight, on the sand dunes of Kitty Hawk, North Carolina, covered only 36.6 m and lasted 12 seconds.**



Wright Flyer 1



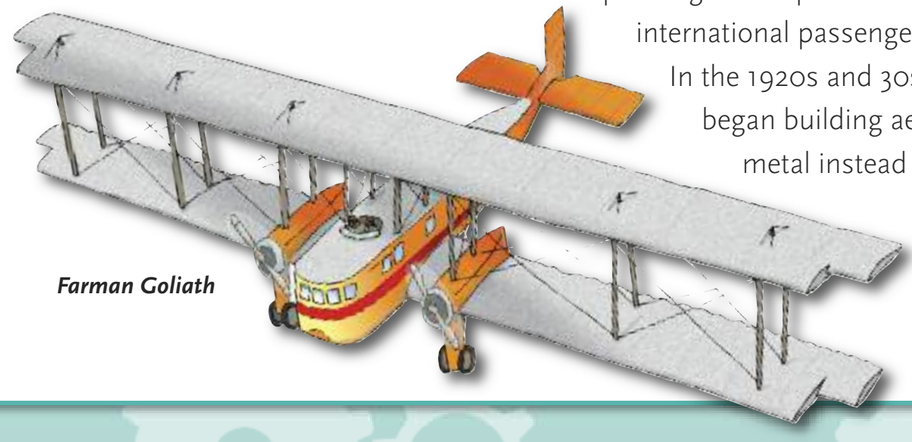
Blériot XI

Just six years after the *Flyer 1's* first flight, in 1909 French aviator Louis Blériot flew across the 35-km-wide English Channel in his monoplane. He had no means of navigation, but simply set off into the mist and crash-landed above the cliffs, 37 minutes after taking off. The flight won him a prize of £1000.

Very soon, planes became weapons of war. During World War I (1914-1918), biplanes and triplanes—planes with two or three sets of wings respectively—took to the skies. German aviator Manfred von Richthofen, the "Red Baron", flew a Fokker triplane painted bright scarlet. The plane was fitted with a machine gun and an interrupter gear, a device that allowed the gun to fire forward without hitting the plane's propeller.

Fokker Dr.1

The first passenger airlines started business after the war. Early airliners, such as the Farman Goliath, were converted wartime bombers. It was able to carry up to 14 passengers. It opened the first scheduled international passenger service in 1920. In the 1920s and 30s, engineers began building aeroplanes out of metal instead of wood.



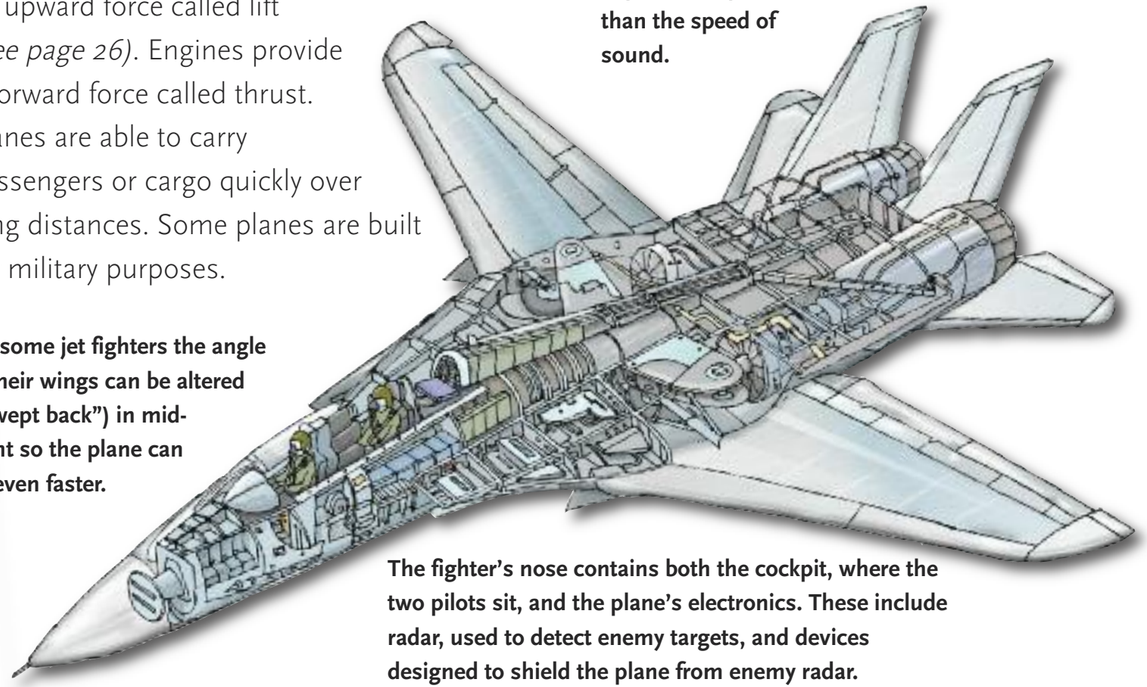
Farman Goliath

TYPES OF PLANE

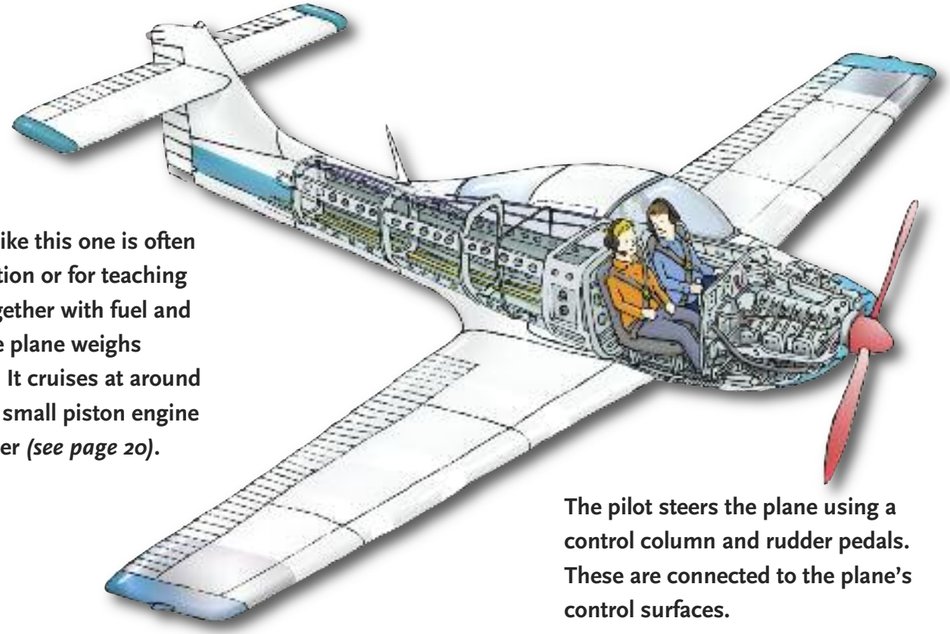
A plane, or aeroplane, is a fixed-winged aircraft that is heavier than air. Wings support the plane in the air by creating an upward force called lift *(see page 26)*. Engines provide a forward force called thrust. Planes are able to carry passengers or cargo quickly over long distances. Some planes are built for military purposes.

A military jet fighter *(below)* is designed for high speed and manoeuvrability in the air. It may be used to combat other jet fighters or to intercept enemy bombers and attack them with guns or missiles. It can also be used to attack targets on the ground. It can fly at supersonic speeds: faster than the speed of sound.

On some jet fighters the angle of their wings can be altered ("swept back") in mid-flight so the plane can go even faster.



The fighter's nose contains both the cockpit, where the two pilots sit, and the plane's electronics. These include radar, used to detect enemy targets, and devices designed to shield the plane from enemy radar.



A light aircraft like this one is often used for recreation or for teaching pilots to fly. Together with fuel and passengers, the plane weighs around 600 kg. It cruises at around 200 km/h. The small piston engine drives a propeller *(see page 20)*.

The pilot steers the plane using a control column and rudder pedals. These are connected to the plane's control surfaces.

Planes vary in size from small single-seaters to huge machines able to transport hundreds of passengers *(see page 10)* or heavy cargo. They all have the same basic layout: a long tube, called a fuselage, with a set of wings attached. A plane also has a tailfin and tailplane, to keep it flying straight and level, hinged sections, known as control surfaces, to steer it, and a set of wheels.

AIRLINER

An airliner is a large plane that transports passengers from one airport to another. It is designed to fly long distances without refuelling. An airliner's engines, usually turbofan jet engines *(see page 24)*, are encased in pods often fixed to the underside of each wing.

Airliners have a large fuselage inside which the passengers, crew and baggage travel. The space where baggage is stored, the cargo bin or hold, is separate from the passenger cabin.

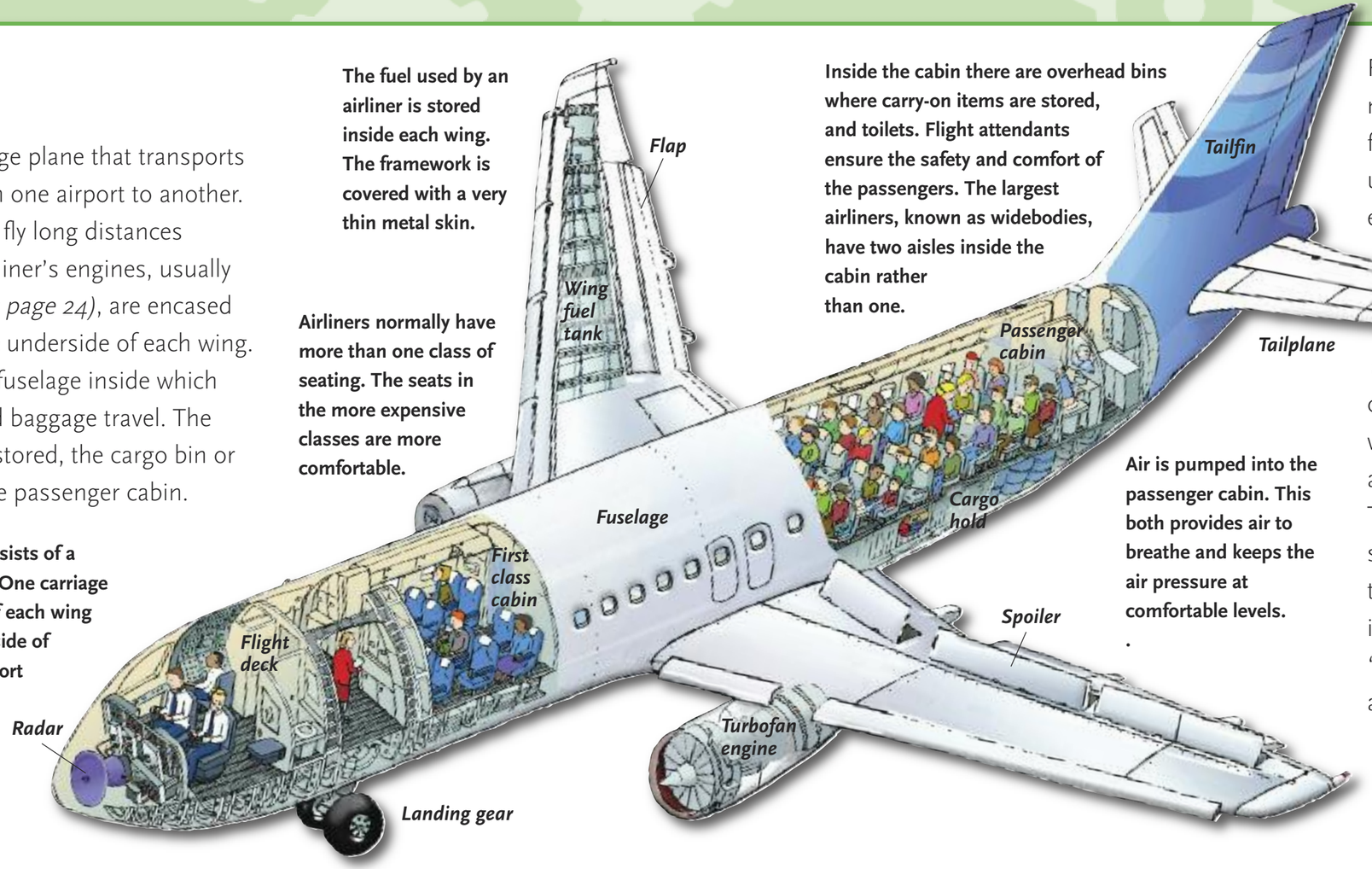
The airliner's landing gear consists of a number of wheeled carriages. One carriage is attached to the underside of each wing and one (or two) to the underside of the fuselage. The wheels support the plane's great weight on the runway. The impact of landing is borne evenly by all the carriages through their shock absorbers.

The fuel used by an airliner is stored inside each wing. The framework is covered with a very thin metal skin.

Airliners normally have more than one class of seating. The seats in the more expensive classes are more comfortable.

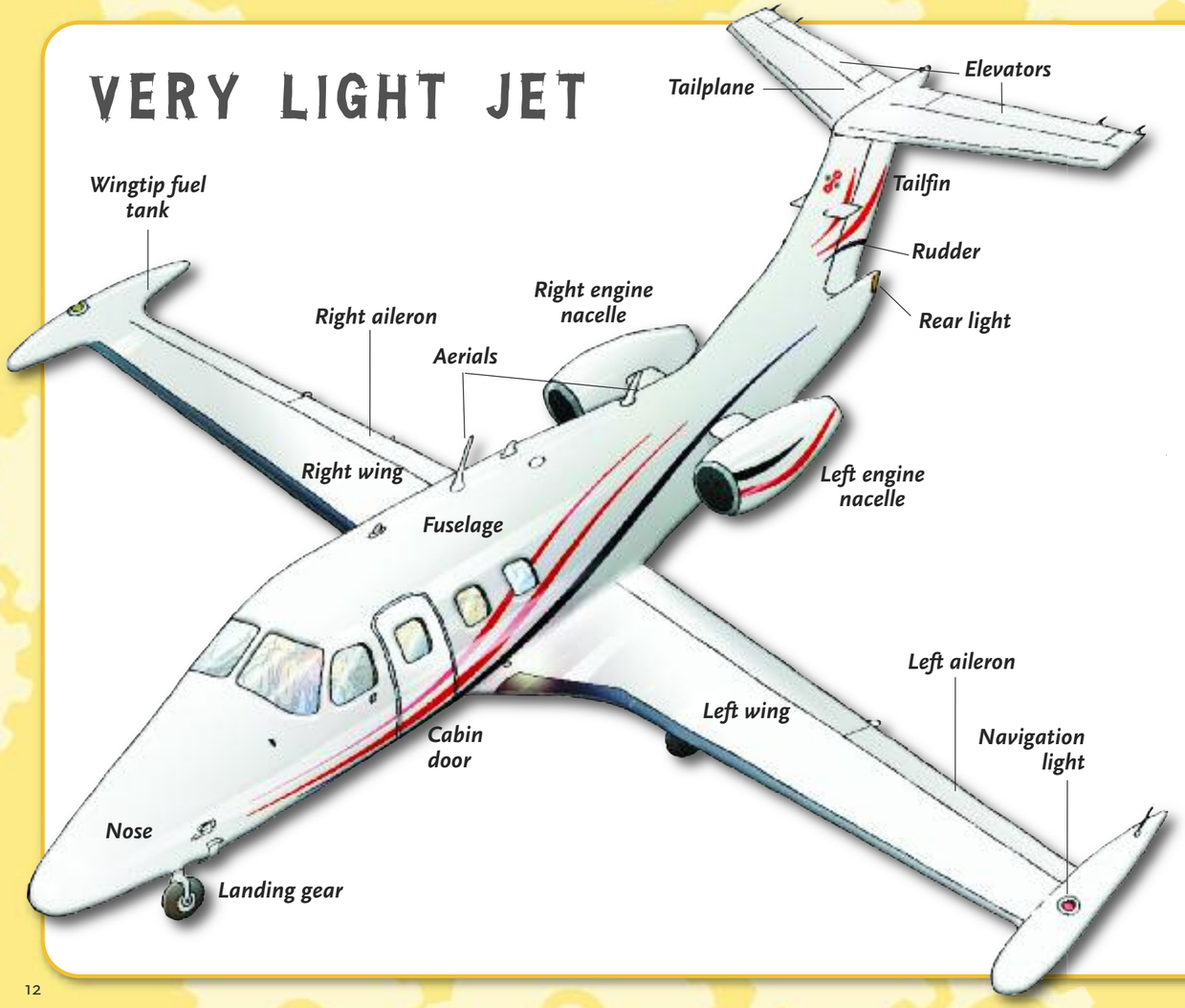
Inside the cabin there are overhead bins where carry-on items are stored, and toilets. Flight attendants ensure the safety and comfort of the passengers. The largest airliners, known as widebodies, have two aisles inside the cabin rather than one.

Air is pumped into the passenger cabin. This both provides air to breathe and keeps the air pressure at comfortable levels.



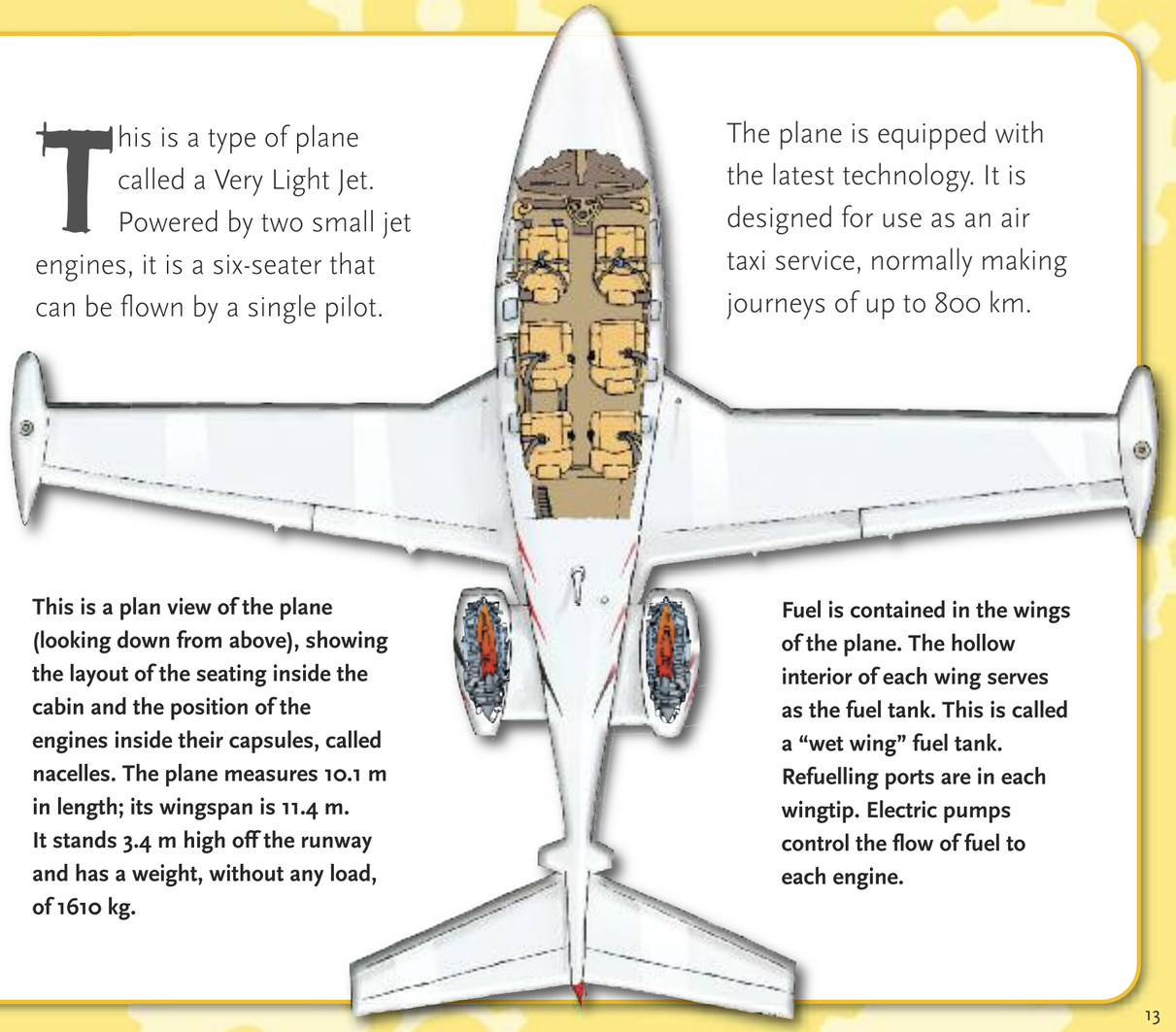
For any plane, maximum lift is needed at take-off. An airliner has flaps fitted to its wings. These are used to extend the wing surface and exaggerate its curved profile in order to provide extra lift for this particularly heavy plane. When an airliner takes off, the flaps extend outwards at the rear edge of its wings. Spoilers are used to help bring a plane to a halt after it has landed. The flat surfaces, fixed to the upper side of the wings, flip upwards when the plane touches down. This increases drag. The spoilers also "dump" lift, by suddenly making the air pressure higher above the wing than below it. The full weight of the plane is now put on its wheels, which helps to prevent skidding.

VERY LIGHT JET



This is a type of plane called a Very Light Jet. Powered by two small jet engines, it is a six-seater that can be flown by a single pilot.

The plane is equipped with the latest technology. It is designed for use as an air taxi service, normally making journeys of up to 800 km.

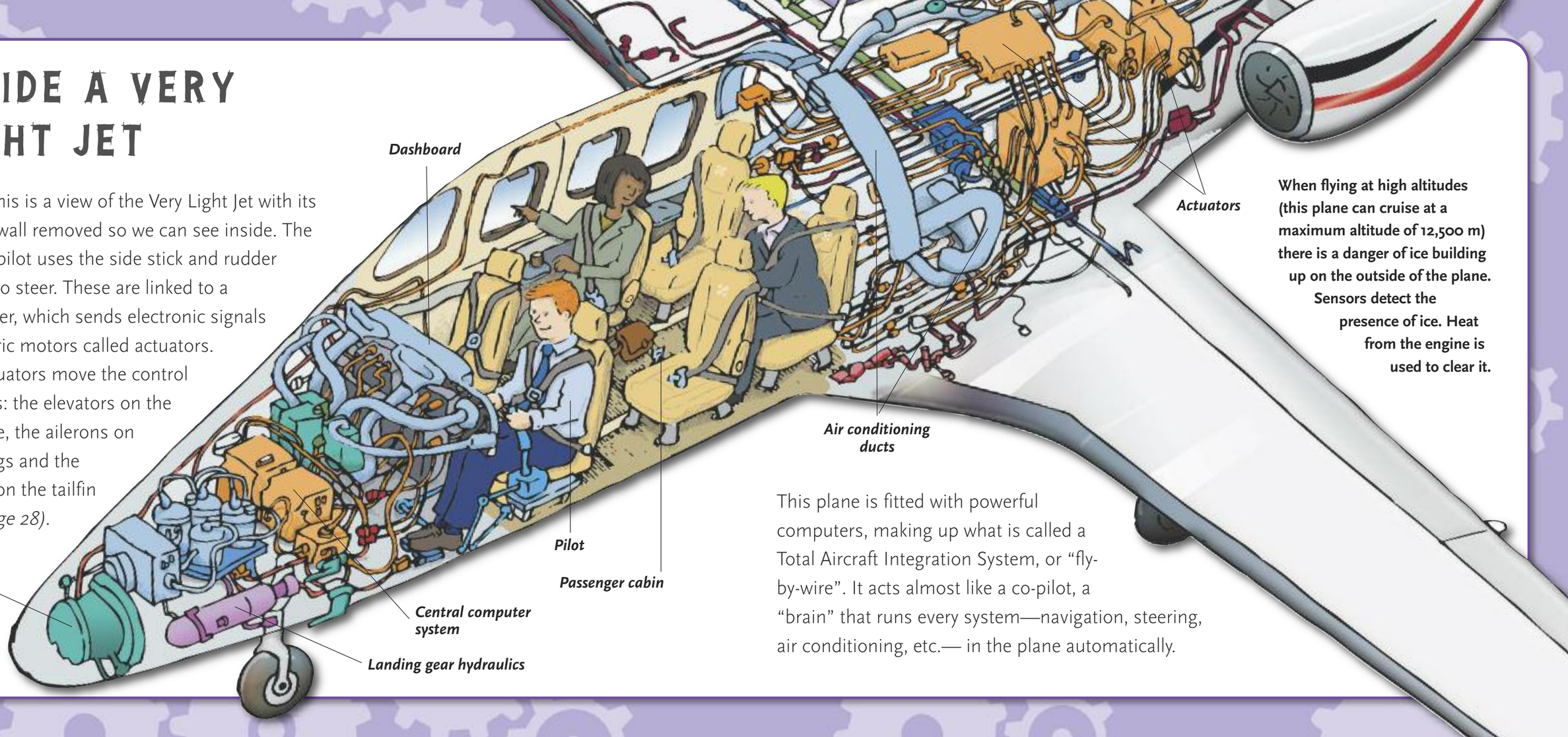


This is a plan view of the plane (looking down from above), showing the layout of the seating inside the cabin and the position of the engines inside their capsules, called nacelles. The plane measures 10.1 m in length; its wingspan is 11.4 m. It stands 3.4 m high off the runway and has a weight, without any load, of 1610 kg.

Fuel is contained in the wings of the plane. The hollow interior of each wing serves as the fuel tank. This is called a "wet wing" fuel tank. Refuelling ports are in each wingtip. Electric pumps control the flow of fuel to each engine.

INSIDE A VERY LIGHT JET

This is a view of the Very Light Jet with its wall removed so we can see inside. The pilot uses the side stick and rudder pedals to steer. These are linked to a computer, which sends electronic signals to electric motors called actuators. The actuators move the control surfaces: the elevators on the tailplane, the ailerons on the wings and the rudder on the tailfin *(see page 28)*.



This plane is fitted with powerful computers, making up what is called a Total Aircraft Integration System, or "fly-by-wire". It acts almost like a co-pilot, a "brain" that runs every system—navigation, steering, air conditioning, etc.— in the plane automatically.

AT THE CONTROLS

1 SIDE STICK Controls ailerons and elevators; disconnects autopilot.

2 LEFT PANEL Controls cabin air and electrics, extra oxygen supplies.

3 PRIMARY FLIGHT DISPLAY (PFD) Indicates plane's attitude (angle of flight), course, speed and altitude.

4 THRUST Levers control plane's speed.

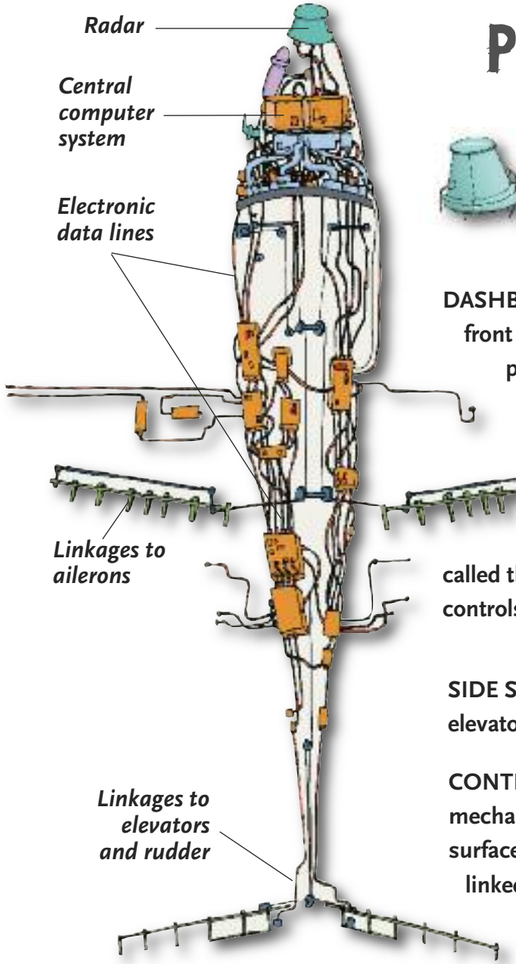
5 CENTRE SWITCH PANEL Controls landing gear, ice protection and lighting.

6 AUTOPILOT CONTROL PANEL Pilot uses this to set course, speed and altitude.

7 MULTI-FUNCTION DISPLAY (MFD) Monitors plane's systems and engines.

8 GLOBAL POSITIONING SATELLITE (GPS) Monitors plane's position.

PARTS OF A PLANE



RADAR The radar, positioned in the nose, transmits and receives back radio signals. These detect other aircraft or bad weather.

DASHBOARD The displays in front of the pilot give the plane's course, altitude and speed; they show the plane's position; they also monitor the engine and other systems *(see pages 16-17)*. For much of the flight, all the pilot has to do is keep an eye on the displays to check all systems are working properly. An automatic control system, called the autopilot, flies the plane. It constantly adjusts the controls to maintain the course, speed and altitude set by the pilot.

SIDE STICK On this plane, the pilot controls the elevators and ailerons through use of a side stick.

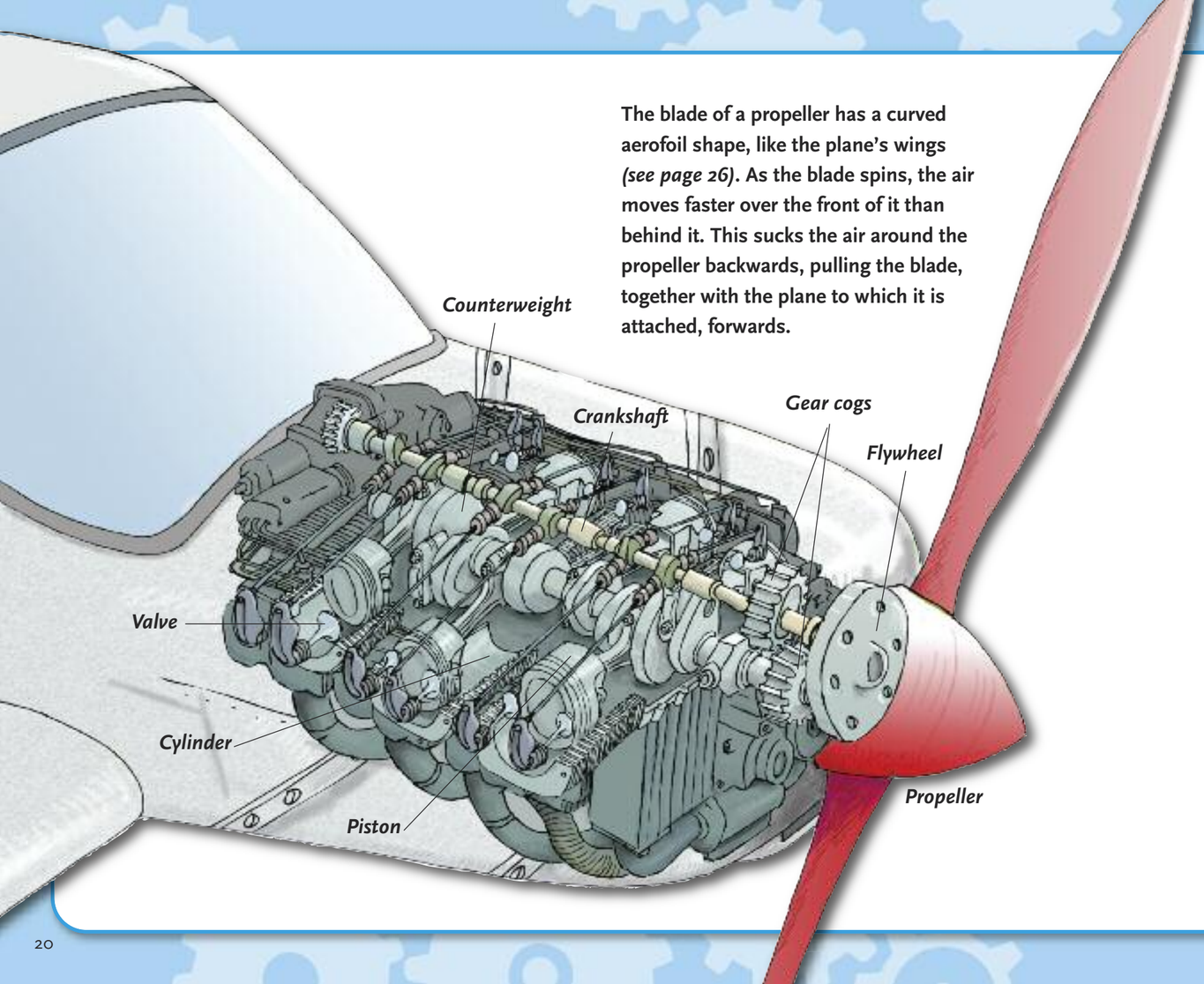
CONTROL LINKAGES For this plane, instead of mechanical linkages between flight controls and control surfaces, there are electronic data lines, or "buses", linked to a central computer system. This is called "fly-by-wire" technology.

LANDING GEAR During flight, the wheels are folded up into the nose and undersides of each wing.

AIR CONDITIONING
The plane's electronic climate control system keeps a constant temperature inside the cabin. Air pressure is also kept at comfortable levels for the pilot and passengers.

ENGINES
This plane is powered by two very small turbofan engines (see page 24). They are fitted inside pods, called nacelles, on either side of the fuselage. Besides driving the plane through the air, the engines supply the power needed for the electricity used on board. Air is also diverted from the engine compressor to pressurize the cabin.

PEDALS Rudder pedals control the movement of the plane to the left or right.

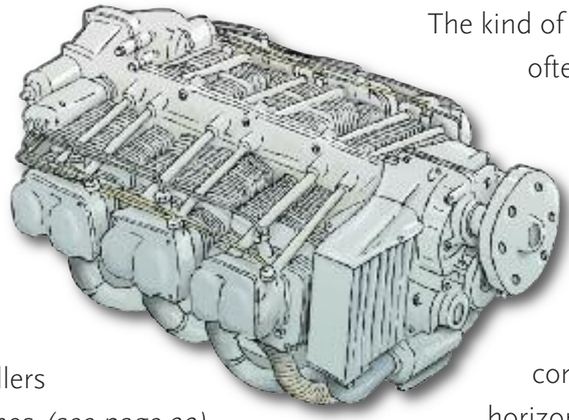


The blade of a propeller has a curved aerofoil shape, like the plane's wings *(see page 26)*. As the blade spins, the air moves faster over the front of it than behind it. This sucks the air around the propeller backwards, pulling the blade, together with the plane to which it is attached, forwards.

PISTONS AND PROPELLERS

Until the invention of jet engines in the 1930s, planes were powered by piston engines. Nowadays, usually only light aircraft have piston engines. Airliners and high-speed military planes are jets. Many small airliners have propellers powered by jet engines *(see page 22)*.

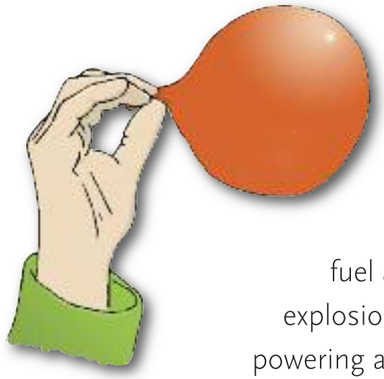
A kind of internal combustion engine, this is very similar to engines used in road vehicles. A mixture of fuel and air is sucked into the engine's cylinders. The mixture is ignited and the resulting explosions push down pistons inside the cylinders. These turn a crankshaft, which is connected to the propeller.



The kind of piston engine most often used in a light aircraft is called a flat engine. It has two banks of cylinders opposite one another. The pistons are connected to a horizontal crankshaft. .

The engine runs at maximum power for a few minutes during taking off. It then switches to a cruise setting, between 65 and 75% of full power. Because the engine runs at high speed, it can be cooled by the air, so does not need a radiator. This reduces weight and makes the engine less complex.

HOW JET ENGINES WORK

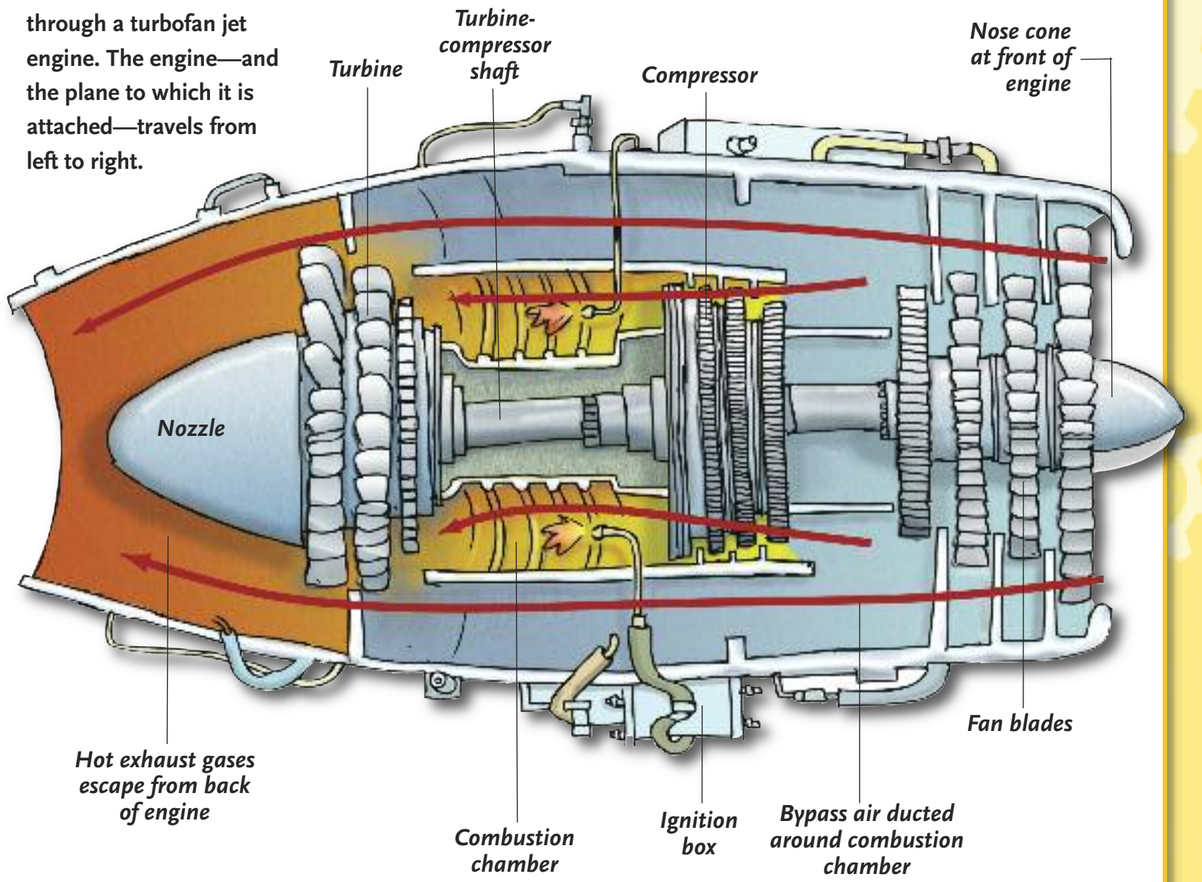


All jets work in the same way: hot, compressed air is expelled from the back of the engine, driving it forwards. The air is drawn in through the opening at the front of the engine and compressed by spinning blades. Then, in the combustion chamber, it is mixed with kerosene fuel and ignited. The hot exhaust gas produced in the explosion escapes at speed through the rear of the engine, powering a turbine, which drives the compressor, as it spurts past. The backward-flowing air provides a forward thrust, like the kick of a rifle after a bullet is fired.

In a turbofan engine, air is sucked into the engine by a whirling fan in front of the compressor. Some of the inflowing air is ducted around the combustion chamber to join the exhaust gas.

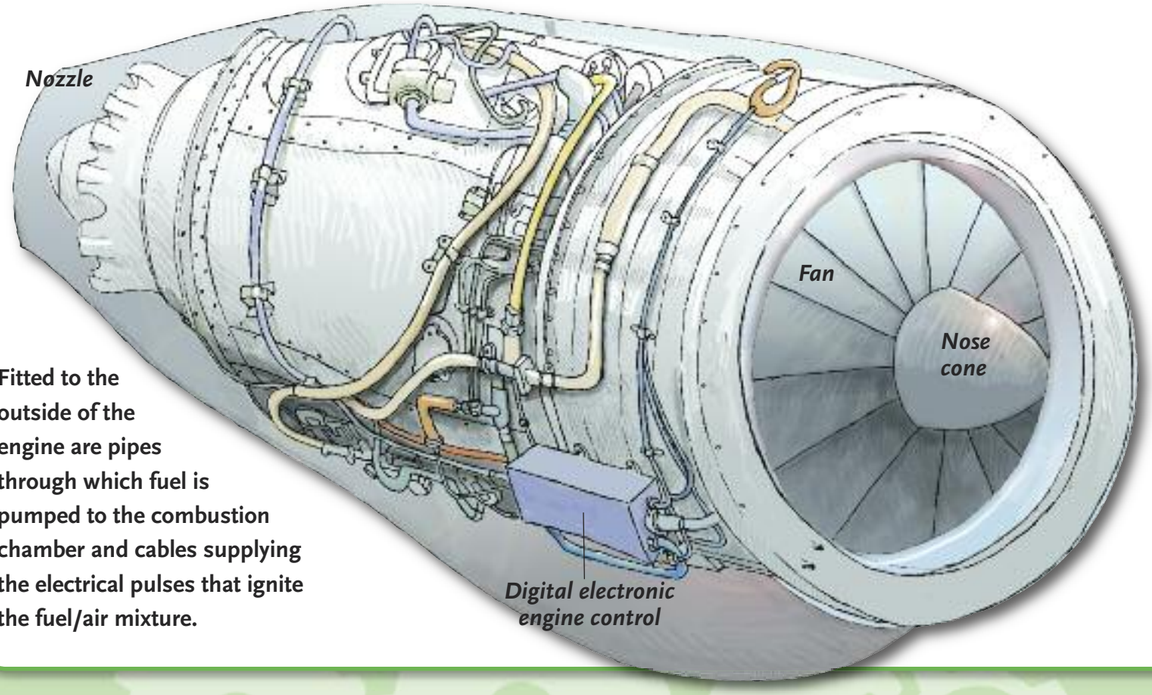
The force of air escaping from a balloon sends it in the opposite direction. A jet engine works in exactly the same way: a jet of gases blasted out of the back of the engine drives it forwards.

This is a cross-section through a turbofan jet engine. The engine—and the plane to which it is attached—travels from left to right.

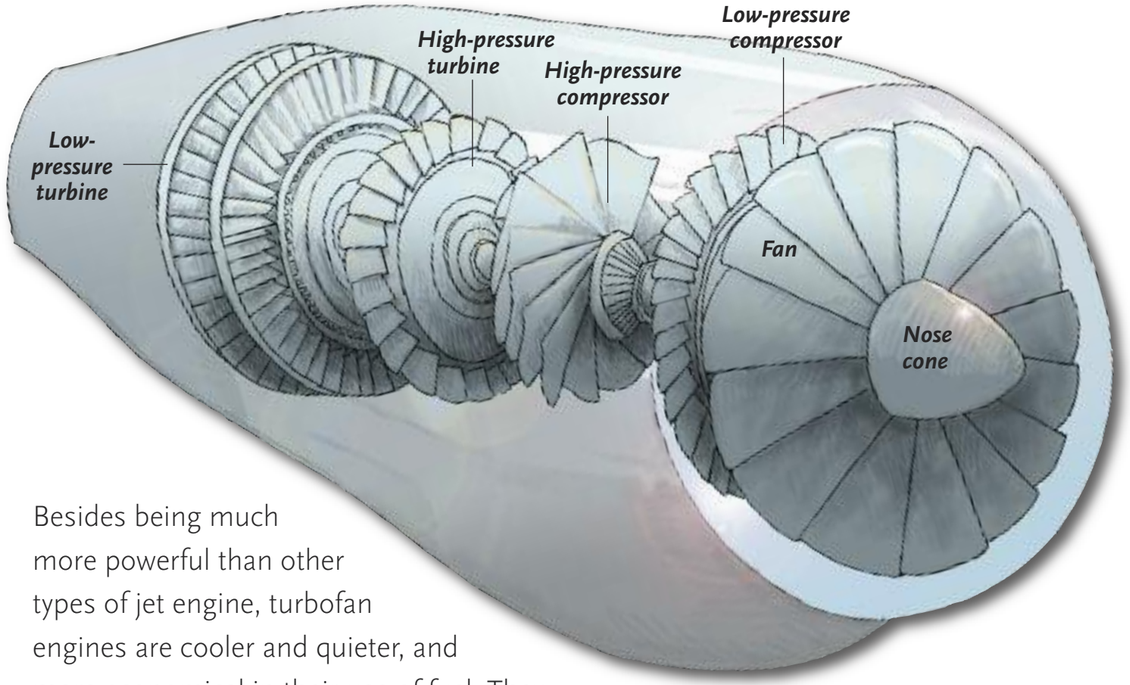


TURBOFAN ENGINE

The engines fitted to the Very Light Jet are among the smallest turboprops to be manufactured. The fan has a diameter of just 37 cm—about the span of two hands (those in use on a A-380 superjumbo airliner measure 295 cm across).



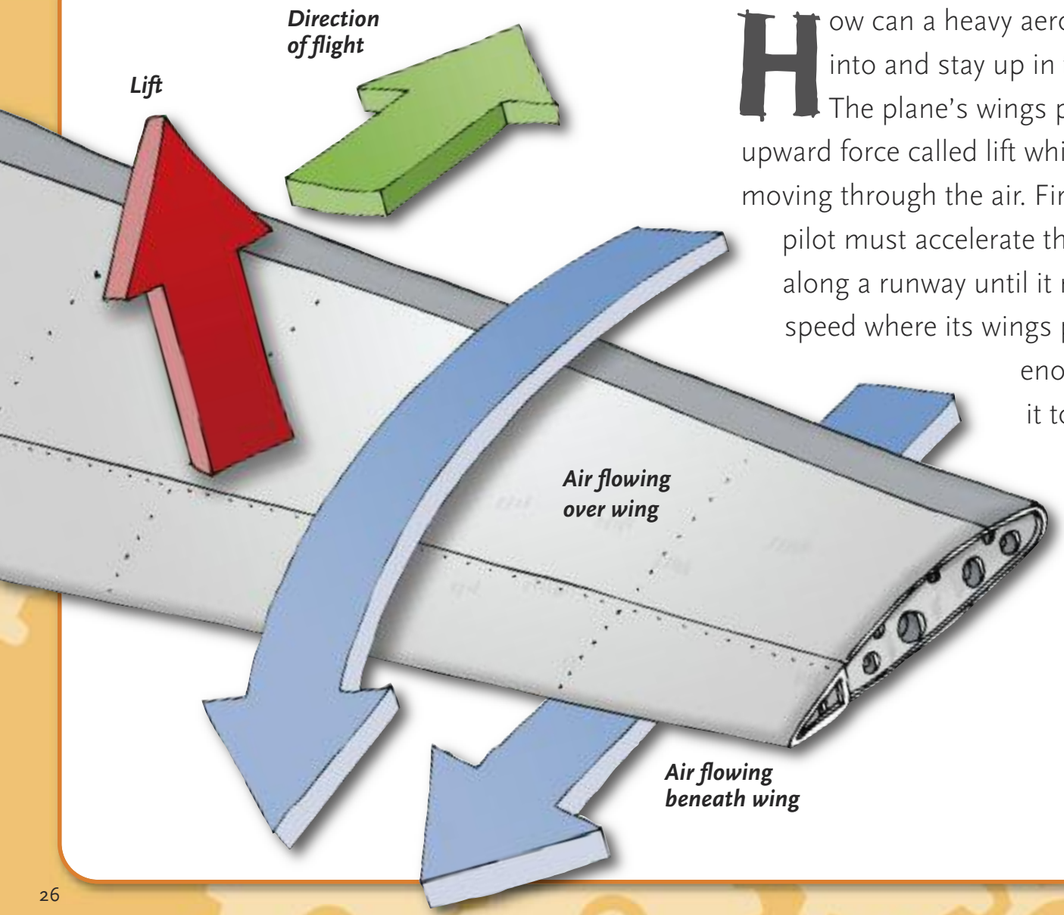
Fitted to the outside of the engine are pipes through which fuel is pumped to the combustion chamber and cables supplying the electrical pulses that ignite the fuel/air mixture.



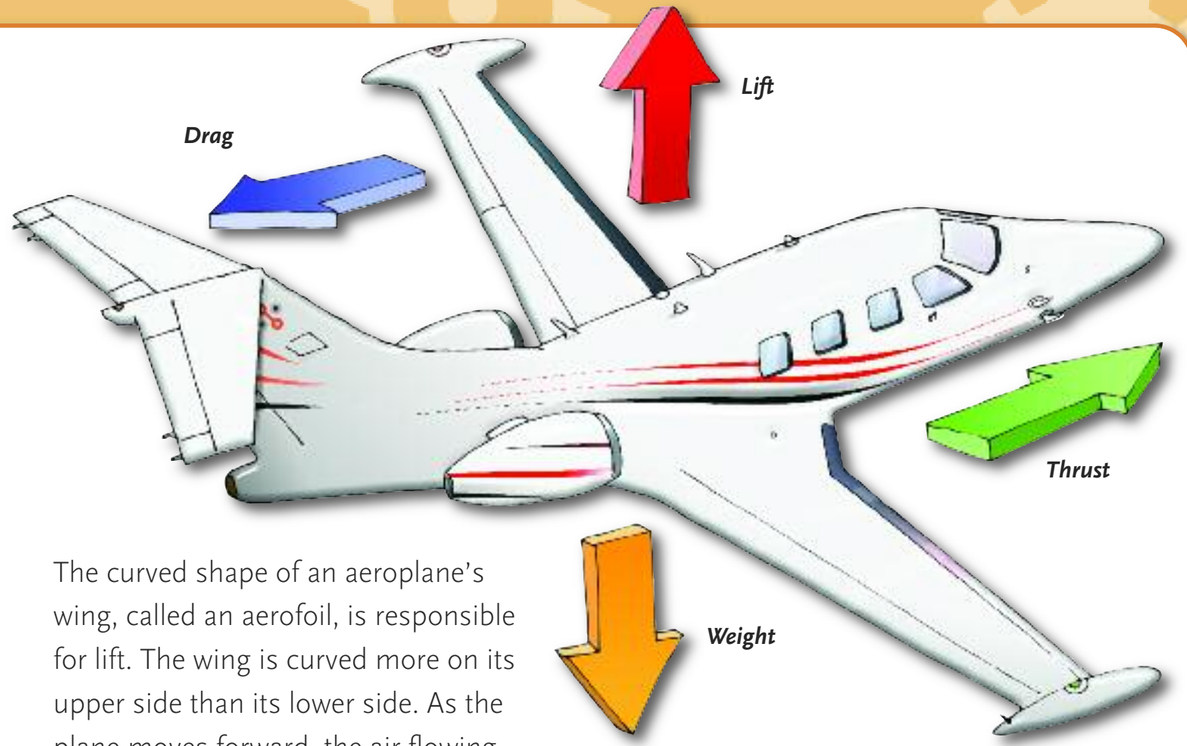
Besides being much more powerful than other types of jet engine, turbofan engines are cooler and quieter, and more economical in their use of fuel. They are also equipped with thrust reversers. When in use, the jet of hot exhaust gases is deflected forwards instead of backwards, producing a force which rapidly slows down the plane landing on the runway.

This is a two-spool turboprop. A high-pressure turbine turns the high-pressure compressor, while the low-pressure turbine turns the low-pressure compressor. The low-pressure shaft fits inside the high-pressure one. This arrangement makes the engine run more efficiently.

HOW A PLANE FLIES



How can a heavy aeroplane rise into and stay up in the air? The plane's wings provide an upward force called lift while it is moving through the air. First, the pilot must accelerate the plane along a runway until it reaches the speed where its wings provide enough lift for it to take off.



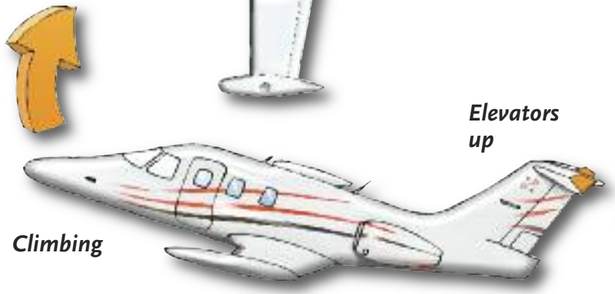
The curved shape of an aeroplane's wing, called an aerofoil, is responsible for lift. The wing is curved more on its upper side than its lower side. As the plane moves forward, the air flowing over it is made to move faster than the air flowing beneath it. The moving air creates less pressure on the upper side than on the lower side. An upward force, called lift, is the result.

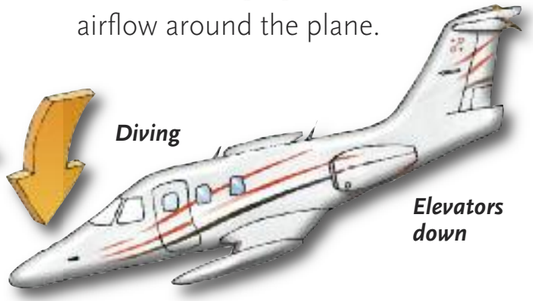
As a plane flies, four forces are acting on it. Its weight pulls it downwards, but this is balanced by the upward force of lift. Thrust provided by the engines propels the plane forwards, overcoming the backward force of drag, or air resistance.

STEERING THE PLANE

Steering a plane is not the same as steering a car, where a turn of the wheel sends it either to the left or right.

A plane can move in three different ways. As well as turning to left or right (yawing), it can climb or dive (pitching) and it can bank to one side or the other (rolling). To steer, the pilot adjusts the control surfaces on the wings and tail, changing the airflow around the plane.





Swivelling the rudder on the tailfin pushes the nose left or right. Raising flaps on the tailplane, called elevators, causes the nose to rise and the plane to climb. Lowering them causes the nose to drop and the plane to dive.

To roll the plane, the pilot adjusts flaps on the wings, called ailerons. Raising the left aileron deflects the airflow higher over this wing, causing it to drop. Lowering the right aileron causes that wing to rise. This makes the plane roll to the left.

To make a smooth turn, the pilot yaws and rolls the plane at the same time. The wing dips into the turn in the same way that a cyclist leans into a corner.

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