Second Level Technologies
Benchmark TCH 2-20a

Power for Flight Pt 8

Exploring how we can produce thrust without air

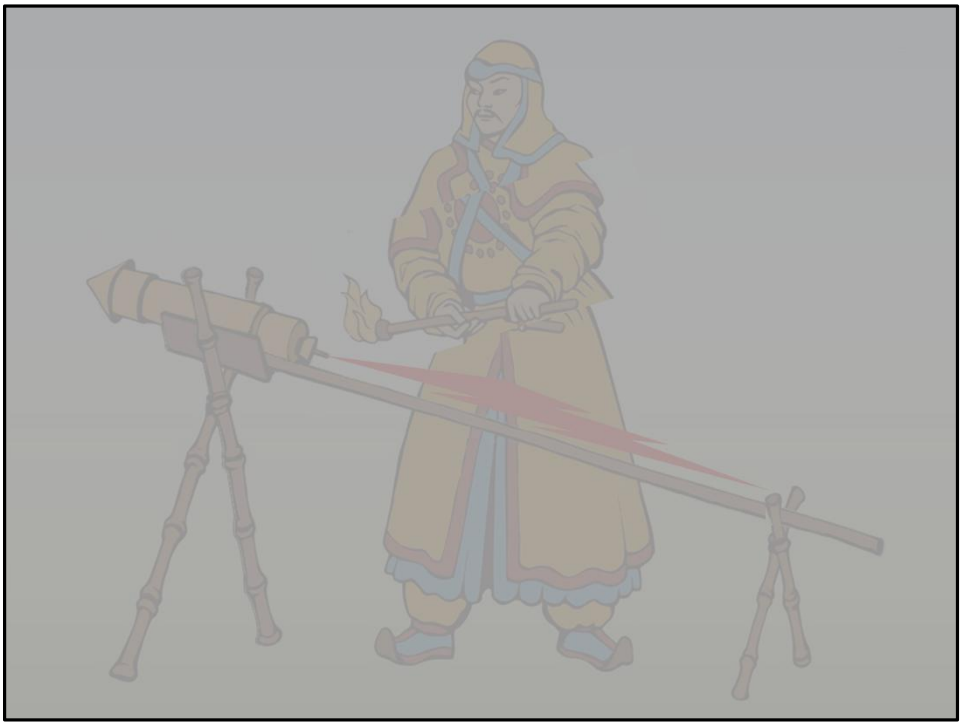
WE COULD USE AN ENGINE THAT DOES NOT NEED AIR TO PRODUCE THRUST

So far, in this story about ways of producing thrust using engines, we have talked about air-breathing engines and aircraft that fly through air using lifting surfaces.

All these engines use the oxygen in the air to burn the fuel and the thrust is produced by accelerating a large mass of air backwards by a propeller, fan or jet exhaust.

However, there is another type of engine
that does not need the air in the atmosphere to work,
this is called a rocket engine.

The next story is about them.



Rockets have been around for many years, the Chinese were firing rockets into the sky in the 13th century. These types of rockets used gunpowder to produce the thrust just like the modern rockets that we light at fireworks displays.

It was not long before the Chinese discovered that the rocket projectile was a good weapon. It could be fired at a safe distance and caused havoc as it arrived amongst the enemy at high speed. These types of rockets have been used by the armed forces around the world up to the present day.

These types of rockets are called “solid fuel” rockets because the fuel is a highly combustible material that will burn when ignited. There is usually no way of controlling the thrust of these kinds of rockets, just light it and stand well back.

Solid fuel rockets are useful if you want a lot of thrust for a few seconds. They have been used to fire lifelines to people needing rescued from a shipwreck.

This photo, taken in 1940, shows a lifesaving rocket being set up ready for firing. The Coastguard Service used these rockets to fire a line out to a ship that was in distress close to the shore. The line could then be attached to a heavier rope so that the ship's crew could pull it out to the ship to allow them to be pulled ashore sitting in a sling that ran along the rope. This system was invented back in the 18th century.

This C130 Hercules transport aircraft is using the extra thrust of eight solid fuel rockets, attached to both sides of the fuselage, to achieve a very short take-off and steep climb.

What was really needed was a rocket motor that could be controlled so that the thrust could be varied to suit the conditions. This would require a liquid fuelled rocket so the flow of fuel to the combustion chamber could be controlled.

One of the first designs of controllable rocket motors was developed in Germany and was used to power a high speed interceptor aircraft designed to shoot down bombers during the Second World War. The method of controlling the thrust was simple. There were two combustion chambers, one producing four times the thrust of the other. The idea was to use both for the take-off and climb and then use the lower power one to attack the bomber formation while the fuel lasted. The total fuel burn time was about fifteen minutes. The aircraft could climb at 29,000ft/min and could reach 32,000ft in 2 minutes.

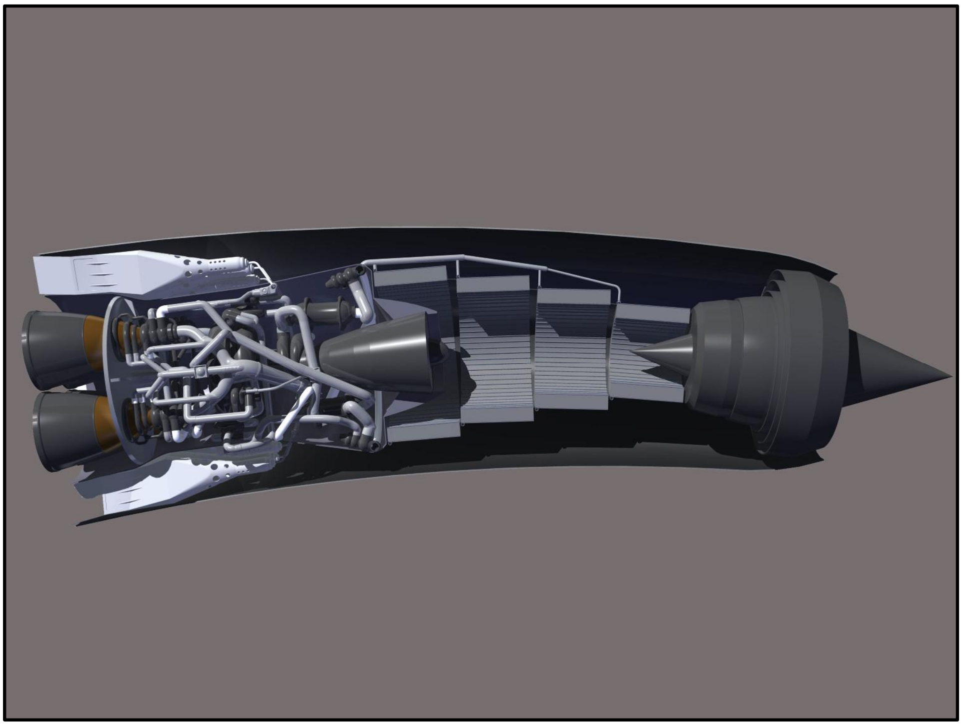
However the fuel used in this rocket was very unstable and liable to explode if mishandled or subjected to shock loads.

In October 1947, Charles “Chuck” Yeager became the first man to deliberately fly faster than sound by reaching 670 mph at 42,000ft in the rocket powered Bell X-1.

The aircraft was propelled by four liquid fuelled rocket motors so that the thrust could be controlled by switching on and off the four motors individually.

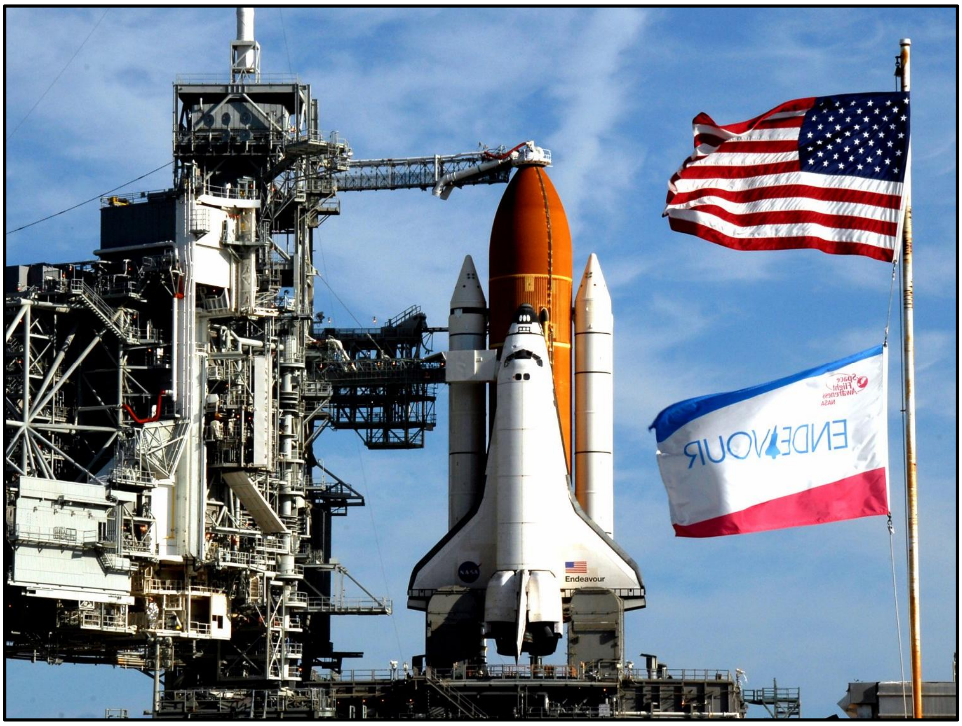
This aircraft the SR53, designed by the Saunders Roe company, was intended to be able to intercept enemy aircraft. It had to be able to climb to altitude very quickly and achieve a supersonic top speed.

The specification for this interceptor aircraft was drawn up and it was proposed that the aircraft should have two engines, a turbojet and a liquid fuelled rocket motor. The idea was that the rocket motor, which could run for about seven minutes, would allow the aircraft to climb very quickly and then the relatively small turbojet engine would allow the aircraft to be recovered to a normal landing at an airfield. The problem with this idea was that after the rocket motor had stopped the aircraft did not have enough thrust to effectively fight off an attack by any enemy fighters. Only one aircraft was built and tested and did achieve a speed of Mach 1.33. The RAF decided that, in future, hostile aircraft would be attacked by ground to air missiles.



In the 1950's, engine designers started to think about ways that an engine could be made to combine the advantages of both a turbojet engine and a rocket motor. After about 30 years this idea developed into an engine called the SABRE.

This engine is still to fly but it is expected that it will be able to allow an aircraft to take-off from a runway and accelerate to about five times the speed of sound at a very high altitude using the turbojet part of the engine and then when the air become too thin at high altitude the engine will turn into a pure rocket motor to further accelerate the aircraft to about 17,500 mph to place the aircraft into earth orbit.



It was not until the exploration of space really got going that very high power rocket engines were developed.

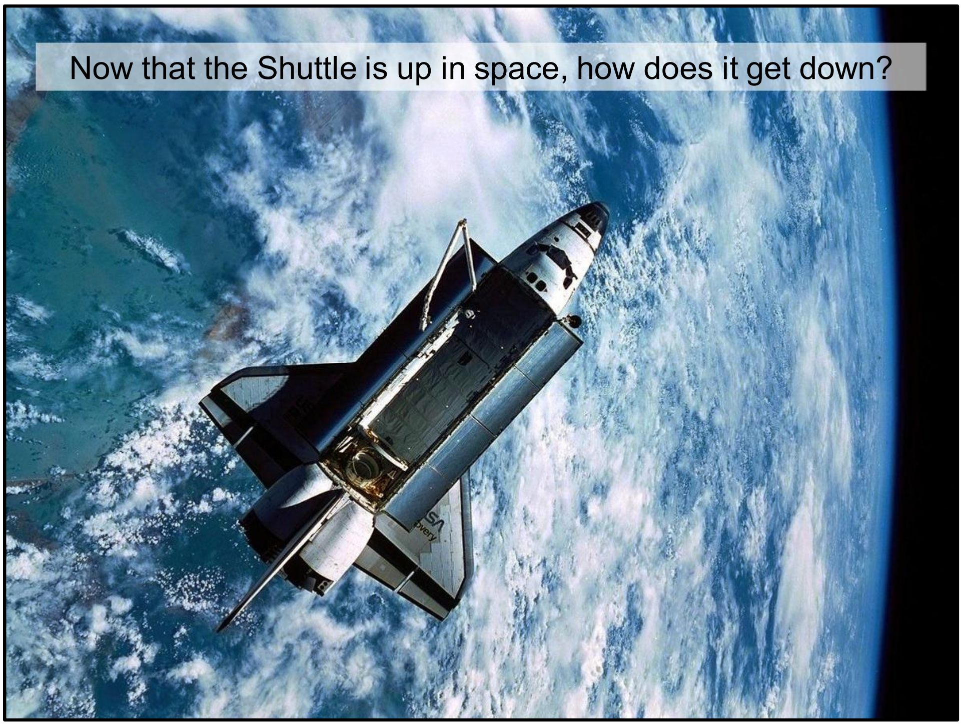
Vertically launched space rockets only briefly pass up through the atmosphere on the way to space and could not be described as aircraft since they are entirely supported by their engines and so do not form part of this story about flight.

However, one of the spacecraft from the 1980's was actually intended to come back to earth as an aircraft, this was the Space Shuttle. The strange thing about this aircraft was that it had the most powerful engines in the world but they were used only to get the aircraft up into earth orbit and that left the aircraft with no power to be able to make the descent and landing back on the ground. So it would be a glider.

The problem facing designers was that this glider orbited the world travelling at about 17,500 miles an hour and about 200 miles above the atmosphere.

The American Space Shuttle used two solid fuel rockets to blast off into space. These rockets burned for two minutes and fired the Shuttle up to a height of 45 kilometres. These were the most powerful solid fuel rockets devised by man and each rocket produced 3,000,000 lb [1,300 tons] of thrust. The whole Space Shuttle assembly, at lift-off, weighed 4,400,000 lb [2,000 tons].

The Shuttle also has its own three engines run from liquid hydrogen and oxygen stored in the very large external fuel tank. The shuttle’s three main liquid fuelled rocket motors could each develop 512,300 lb of thrust and could be throttled back to about 67% of their full thrust to avoid the shuttle from travelling at too high a Mach number as it travelled up through the atmosphere. The engines could run for about 8.5 minutes before they ran out of fuel and the large fuel tank was then jettisoned.



About 12,000 miles away from the landing site the Shuttle's small retro rockets are fired and the aircraft begins to drop out of orbit.

About 25 minutes later it is rotated into a nose high attitude and it starts to encounter the earth's atmosphere. The drag of the atmosphere slows the aircraft even further and the friction of passing through the air creates a huge amount of heat which would destroy the aircraft if it did not have its protecting outer layer of insulation. The aircraft glows red hot and slows even further.

At about 140 miles from the landing the aircraft is at an altitude of about 40 kilometres. It is now flying as a glider and the pilot flies down a slope of about 20 degrees towards the runway. This is about 10 times steeper than an airliner approach.

At an altitude of 1 kilometre on the approach the landing gear is lowered and the aircraft is gradually slowed to about 354 kph for the touch down.

The Space Shuttle about to touch down. It is a strange fact that the aircraft fitted with the most powerful set of engines in the world returns to earth as a glider. The Space Shuttles flew 135 missions into space before they were retired in 2011.

And so our story of powered flight turns full circle with this very special glider descending from space over a distance of about 20,000 kilometres.

Percy Pilcher and Otto Lillienthal, the gliding pioneers, could never have imagined that such a thing was possible.