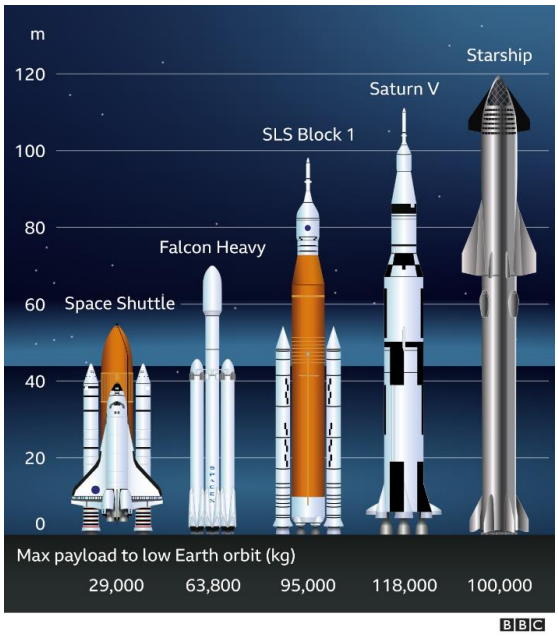
What is Elon Musk's Starship?

Paul Rincon, 17 November 2021

Realising this dream requires a vehicle that's up to the task. Starship is a rocket and spacecraft combination that could ferry more than 100 people a time to the Red Planet.

The system is designed to be fully and rapidly reusable. Being fully reusable means the principal hardware elements are not discarded in the sea or allowed to burn up, as happens with some other launch systems, but return to the ground so they can be flown again.

Rapid reusability means that after coming back from space, Starship can be re-filled with propellant and be ready to launch again in a short period of time - like an aircraft. This reduces the cost of the whole enterprise.



Starship: An overview

At launch, the spacecraft, called Starship, will sit atop a rocket called Super Heavy. The combined system will stand 120m (394ft) -tall and is also referred to as Starship.

Let's take the spacecraft first. With its nosecone and landing fins, the stainless-steel vehicle resembles the rocket-ships from the golden age of science fiction.

At the rear of the 50m (160ft) -long craft are six highly efficient Raptor engines, developed over the course of a decade by SpaceX. The combustion takes place in stages, and the engine's design cuts the amount of propellant that's wasted.

Towards the middle of the vehicle are the propellant tanks. These feed liquid methane (CH4) and liquid oxygen (O2) to the Raptors.

Methane is the fuel and oxygen acts as an oxidiser - a chemical that makes the fuel burn. The combination is dubbed methalox. The choice of fuel is unusual for rocket engines, but methane can generate plenty of thrust. It's also a prudent choice in light of Musk's designs on Mars. The SpaceX

founder says that CH4 could be synthesised from Martian subsurface water and from atmospheric carbon dioxide (CO2), using a chemical process known as the Sabatier reaction. Re-fuelling Starship for the return trip to Earth using Martian resources would confer a level of self-sufficiency, making journeys both more feasible and cost-effective.

Towards the front of the spacecraft - which is sometimes referred to as the upper stage - is a huge payload compartment that will be able to haul large cargo or people to destinations in deep space.

Now, let's turn to the rocket. Measuring 70m (230ft) -long, Super Heavy will be filled with 3,400 tonnes (6.8 million lbs) of cryogenic (chilled) methalox. It will be powered by around 32 Raptor engines (this specification has changed several times) and should achieve more than 70 Meganewtons (16 million lbs) of maximum thrust. It should be able to lift at least 100 tonnes of payload, and possibly as much as 150 tonnes, to low-Earth orbit. This will make Super Heavy more powerful than the immense Saturn V launcher used for the Apollo Moon missions in the 1960s and 70s.

Launch and re-filling

As it ascends from the launch pad, the combined Starship system will begin to pitch over towards the intended orbit. When the upper stage separates in space, Super Heavy flips over while falling back towards Earth. As it descends, Super Heavy will deploy steel structures called "grid fins", shaped a bit like potato waffles, from the sides of the booster. These will help steer the rocket stage back towards its launch pad so it can be flown again.

SpaceX has an ambitious plan to then catch the falling booster using its launch tower.

This tower provides engineers and crew members with access to the spacecraft and rocket while they are sitting on the pad before launch. A pair of steel arms will extend out from the launch tower. The grid fins will then take the load as the spent booster falls onto these arms. The tower has been dubbed "Mechazilla" because of its resemblance to a creature from the Godzilla movies.

Meanwhile, the Starship upper stage could be inserted into a "parking orbit" after separation, allowing it to be re-filled with propellant. "If you just fly [Starship] to orbit and don't do any refilling, it's pretty good — you'll get 150 tonnes to low-Earth orbit, and have no fuel to go anywhere else," Musk explained in 2017. "If you send up tankers and re-fill in orbit, you could re-fill the tanks up all the way to the top, and get 150 tonnes [of payload] all the way to Mars."

To re-fuel, the spacecraft would dock, or mate, with another Starship - already circling the Earth - that acts solely as a propellant depot.

What will Starship be used for?

For long-haul trips to Mars and back - which could take up to nine months each way - Musk is looking to install around 40 cabins in the payload area near the front of the upper stage.

Starship will also play a key role in Nasa's Artemis programme, which aims to establish a long-term human presence on the Moon. In April 2021, the US space agency awarded SpaceX with a $2.89bn contract to develop Starship into a lander capable of delivering astronauts to the lunar surface this decade.

SpaceX plans to launch Starship on Super Heavy for its first orbital test flight in 2022.