



TRANSPORTATION

06 – The Starship Fleet

SUMMARY

The focus on this book is the fleet of fully reusable Starships because its development is so much in the public's eye. It is currently the best example of how very large-scale development will occur on the Moon. The evidence is clear that a fleet of Starship is well nigh inevitable. Cheap access to space (CATS) really is the game-changer it has always promised to be.

Three key assumptions underlying this book are that:

- The Starship rocket will be developed to the level of capability intended by SpaceX.
- A fleet of Starships will eventually be produced in the hundreds to thousands.
- Flight turnaround times will increase until each Starship is being launched from the Earth or Moon at a rate of about once a day.

Together, by the end of the 2030s, this capability represents an increase over our current capability of at least two orders of magnitude greater than our current launch capability with the resulting decrease in cost per kg and per crew. The result will be the ability to simultaneously send tourists to LEO and develop large and growing bases on both the Moon and Mars.

What is Starship?

"Starship" is the name of the rocket system being developed by SpaceX. SpaceX's primary goal is that a Starship fleet will eventually deliver cargo and crew to the surface of Mars in such large quantities that a self-sustaining city would be established there with a million residents by 2050 - 2055. Yes, it does sound like science fiction, but if one looks at the remaining milestones, engine production rate, factory producing the Starship bodies, and revenue from the Starlink satellite constellation, it seems as though SpaceX could be on track to achieve that goal.

For the purpose of this book, I focus on the Starship fleet rather than the alternative Earth-Moon transport system being developed by Jeff Bezos' company, Blue Origin. More is publicly known about the Starship, it

will be more capable, and it should likewise be capable of delivering cargo and passengers to the surface of the Moon.

The Starship is composed of the booster first stage called the Super Heavy and then its upper stage is confusingly also called the Starship. One must rely on the context to determine whether one is talking about the whole system or just the upper stage when using the term "Starship".

As of this writing, the Super Heavy booster has 33 engines giving it more thrust than even the Saturn V that took astronauts to the Moon. It has also been designed to return to and be caught by its launch tower about eight minutes after launch. This was first demonstrated on November 22, 2024. The significance is that 33 out of the stack's total of 39 engines was retrieved to be used again resulting in dramatic savings whether or not the upper stage Starship eventually achieves reusability. When the upper stage also achieves reusability, the cost of sending large payloads to space will have decreased to between 20x and 100x what it has been costing to date. It would truly represent a revolution in space access completely negating expectations based upon past experience.

The upper stage Starship currently has six engines although that may increase to nine. However, different variants may have a different number of engines. For example, variants that will remain in space (depot and lunar lander) won't need the sea level engines with their smaller nozzles.

Propellant Depots and Tankers

One variant of the Starship will be the propellant depot in low Earth Orbit (LEO). This "gas station" will allow cargo Starships to launch their heaviest possible payloads into LEO with very little residual propellant in their tanks. The cargo Starships would then dock with the depot and completely refill their propellant tanks before heading to the Moon or Mars with their full payload. It is hard to overstate how important this is for building up and sustaining large and growing bases and even settlements beyond Earth. In the "How Soon" chapter, we'll get into the question of how difficult it will be to develop and operate the depot in LEO including storing propellants without boil-off.

Another essential variant will be the one that delivers propellant to the Starship depot in LEO. These will be reused and so will have a heat shield. They will have docking and alignment mechanisms to allow tankers to dock, connect, and transfer propellant from tanker to depot.

LUNAR HUMAN LANDING SYSTEM (HLS)

NASA has its lunar HLS program that is funding both SpaceX and Blue Origin to develop lunar landers to return NASA astronauts to the lunar surface before 2030. This is an important program because, without it, NASA will only have the capability to send its astronauts to high lunar orbit.

The program is also important for the participating companies because it gives them the cash to do what they already want to do which is to develop their vehicles. In the case of SpaceX, it has been funded to modify their upper stage Starship to land on the Moon. Since Starship is fundamentally a Mars rocket, it is perhaps surprising that it was selected as a lunar lander. It is certainly much larger than is necessary to land just a few astronauts to repeat Apollo's scientific exploration. But the ability for Starship to land 120 or more metric tons of habitat, equipment, etc. at a time is right in line with this book's proposal that governments fund the development of a large and growing International Lunar Base.

As for Blue Origin, they have a logical stepwise development plan for landers of increasing size. Because, from the beginning, it has been designed as a lunar lander and not for Mars, it will be able to source all of its propellant from lunar resources -- perfect for a lunar ferry. And the non-propellant portion of the lander (aka its dry mass) will likely be proportionately less than that of Starship. Whereas SpaceX gets all the attention, Blue Origin is a company worth keeping an eye on. They are progressing well and, having chosen a simpler lander and chosen our nearby Moon as their ultimate destination, they may surprisingly take the lead in how quickly an International Lunar Base will grow to the level of settlement.

Other Variants

Other Starship variants could include one with a clam shell fairing that would open to deliver very satellites such as large telescopes. SpaceX even talks about using Starship to do deliveries of cargo and crew from one point to another (e.g. Los Angeles to Shanghai in 30 minutes).

CAPABILITY

We don't yet know for sure how much payload that Starship will take to orbit. But it is likely to achieve 120 tonnes to orbit in full reusable mode. SpaceX hopes to get it up to as much as 150 tonnes. In fully expendable mode the Super Heavy doesn't return but splashes down into

the Atlantic and Starship has no heatshield nor remaining propellant and so burns up on re-entry. SpaceX estimates that, by so doing, they would be a one to deliver as much as 250 tonnes to LEO. This is far above the typical 13 +/- tonnes sent to LEO by SpaceX's partially reusable Falcon 9 rockets.

Crew Capability

A fair question is whether Starships will be able to safely launch passengers into space. The Starship is not designed with a launch abort system. This makes many space advocates very nervous. But commercial airlines also don't have abort systems. How does that work.

It appears that SpaceX believes that they can get the reliability of launch high enough such that it would meet and exceed NASA's level of risk acceptability. A key part of that is engine out capability which has already been demonstrated on previous flights. It is like commercial airplanes having two engines. Even if they lose one engine, the remaining engine has sufficient power to fly and safely land passengers.

SpaceX has described the Starship as large enough to transport 100 people at a time to Mars. Many space advocates feel as though this is a bit on the tight side. Perhaps by having passengers on a sleep schedule and by spreading awake passengers throughout the floors even among the provisions and equipment it might be possible. But, for the purpose of making the case for the Moon, one can envision more than 100 passengers taking a limited three-day flight to the Moon.

THE STARSHIP FLEET

At Starbase, TX, SpaceX has buildings designed to construct and assemble not just individual Starships but an assembly line to produce a fleet of Starships as though they are an airline fleet. In a short video posed by Elon Musk within the Starship Factory, the nose cones for twelve Starships are seen. So, SpaceX has the facility to mass produce Starships.

In his May 2025 presentation titled, "Mars Game Plan" Elon stated that they hope to eventually produce 1,000 Starships a year. To put this into perspective, in 2023, Boeing delivered 528 airplanes. But those require significantly more sophisticated manufacturing, materials, tolerances, and suppliers. So, it seems that a fleet of Starships is in the works.

Quick Launch Turnaround

In order to launch many tanker and passenger ships leading up to and during an Earth-Mars departure window lasting 45 to 60 days, launches need to be happening multiple times a day. Anticipating this need, SpaceX has developed its launch tower with two arms affectionately called the "Mechazilla" named after the monster in five different Japanese movies. This tower was intended to literally catch the returning stages of a Starship. And catch it, it did! On October 14, 2024, the world was stunned to watch the first ever catch of a Super Heavy booster. As of this writing, an upper stage Starship has not been caught but a couple have conducted pinpoint landings in the ocean indicating that they are getting close. When that happens, history will be made by proving that full reusability is now possible.