A Starship for Mass-Produced Space Flight

By John Benson

January 2025

1. Introduction

I started posting papers to Energy Central in 2016, only a few years after I retired from Siemens. I started posting papers about microgrids, energy storage and renewables, since I was the Microgrid Product Manager for Siemens (energy storage and renewables, especially PV are typically major components of microgrids). At some point, the frequency of posts increased and the subjects diversified, and I decided to use categories to keep track of everything. My earliest categories included microgrids, renewables and mobility. My first post in the latter category was "Imminent Unexpected Electric Loads," posted in 2018. This, and many other early posts were on EVs, which led me to a post on "Tesla Inc." in 2020. I live about 20 miles from Tesla's mothership factory in Fremont, California.

Then Elon did something strange – he started SpaceX. I followed him and wrote my first posts on his early Falcons ("Elon's Amazing Adventures, Vol 1") in 2020[1]. It wasn't long thereafter that the Falcon 9 became the backbone transport of the private space industry (still is). Elon created more rockets, and landed on "Starship," and thus this post.

2. Cheap Star-Trips

On four occasions this year, the world's largest and most powerful rocket, a 120-meter-tall stick of stainless steel, roared into space on the fire of 33 engines. But it was the 13 October landing of Starship's booster stage that ended up seared into collective memory. Falling out of the sky faster than the speed of sound, the booster relit some of its engines, slowed itself nearly to a hover, and was snatched out of the air by claws on the tower it had launched from just 7 minutes earlier. The remarkable technical feat heralds a new era of affordable heavy-lift rockets that could slash the cost of doing science in space (see image on the top of the next page).[2]

Reclaiming and rapidly reusing the booster—and eventually the upper stage, too—is the key. SpaceX, the rocket company founded and run by Elon Musk, has already cut the price of getting cargo into orbit by about a factor of 10 with its partially reusable Falcon 9 and Falcon Heavy rockets. A fully reusable Starship is expected to cut that price by another order of magnitude. Then, Musk's vision of people on Mars will seem realistic.

Scientists stand to benefit, too. Access to space is too precious to risk failure, which is why NASA missions tend to be expensive and laborious, tested to the nth degree. But with routine Starship flights, scientists will be able to take more chances, building instruments with cheap, off-the-shelf parts and launching them often. Scientists imagine not one Mars rover, but a herd of them, or a fleet of formation-flying mirror segments self-assembling into an instrument many times the size of the Hubble Space Telescope. Falcon 9 has already touched off the transformation in space-based earth science, allowing companies such as Planet and ICEYE to launch squadrons of cheap satellites to replace the functions of one-off, billion-dollar behemoths.

[1] https://energycentral.com/c/cp/elon%E2%80%99s-amazing-adventures-vol-1

[2] Eric Hand, Dec 13 Science, 2024 Breakthrough of The Year | Runners-Up, "Starship sticks the landing," https://www.science.org/content/article/breakthrough-2024

In June, SpaceX's giant Starship rocket took off from Texas in a major flight test. PHOTO: SPACEX VIA UPI/ALAMY

Many scientists are put off by Musk's right-wing politics and his alliance with U.S. President-elect Donald Trump. But they might cheer the upheaval his rocket will bring to NASA. For starters, it could spell the end of the Space Launch System, a vastly expensive rocket that is supposed to take astronauts back to the Moon later this decade. More generally, it could help NASA scientists boldly go—faster, better, and more cheaply than they have ever gone before.

3. SpaceX History & Vision

SpaceX was founded in 2002 to expand access to outer space. Not just for government or traditional satellite operators, but for new participants around the globe. Today, we're flying at an unprecedented pace as the world's most active launch services provider. SpaceX is safely and reliably launching astronauts, satellites, and other payloads on missions benefiting life on Earth and preparing humanity for our ultimate goal: to explore other planets in our solar system and beyond.[3]

Starship is paramount to making that sci-fi future, along with a growing number of U.S. national priorities, a reality. It is the largest and most powerful space transportation system ever developed, and its fully and rapidly reusable design will exponentially increase humanity's ability to access and utilize outer space. Full reusability has been an elusive goal throughout the history of spaceflight, piling innumerable technical challenges on what is already the most difficult engineering pursuit in human existence. It is rocket-science, on ludicrous mode.

[3] Updates, SpaceX, https://www.spacex.com/updates/#eva-suit

Every flight of Starship has made tremendous progress and accomplished increasingly difficult test objectives, making the entire system more capable and more reliable. Our approach of putting flight hardware in the flight environment as often as possible maximizes the pace at which we can learn recursively and operationalize the system. This is the same approach that unlocked reuse on our Falcon fleet of rockets and made SpaceX the leading launch provider in the world today.

To do this and do it rapidly enough to meet commitments to national priorities like NASA's Artemis program, Starships need to fly. The more we fly safely, the faster we learn; the faster we learn, the sooner we realize full and rapid rocket reuse. Unfortunately, we continue to be stuck in a reality where it takes longer to do the government paperwork to license a rocket launch than it does to design and build the actual hardware. This should never happen and directly threatens America's position as the leader in space.

***Mission:** "You want to wake up in the morning and think the future is going to be great - and that's what being a spacefaring civilization is all about. It's about believing in the future and thinking that the future will be better than the past. And I can't think of anything more exciting than going out there and being among the stars." -Elon Musk*[4]

Author's comment: SpaceX has an excellent site. Click through some of the links below and explore it for a while.

3.1. Dragon

The Dragon spacecraft is capable of carrying up to 7 passengers to and from Earth orbit and beyond. It is the only spacecraft currently flying that is capable of returning significant amounts of cargo to Earth, and is the first private spacecraft to take humans to the space station.[5]

3.2. Starship

Starship is the fully reusable spacecraft and second stage of the Starship system. The vehicle offers an integrated payload section and is capable of carrying passengers and cargo to Earth orbit, planetary destinations, and between destinations on Earth.[6]

Since 2020, SpaceX has performed multiple sub-orbital test flights of Starship from Starbase. These tests successfully demonstrated an unprecedented approach to controlled flight, during which the vehicle orients itself for a controlled aerodynamic descent, belly-first like a skydiver, accomplished by independent movement of two forward and two aft flaps on Starship, before lighting engines and flipping itself to a vertical configuration for landing.

Flying like this removes the need for wings and a tailplane, protects the vehicle from the extreme heat of orbital entry and minimizes the propellant needed for landing. It also enables missions to destinations across the Solar System where runways do not exist.

[4] https://www.spacex.com/mission/
[5] https://www.spacex.com/humanspaceflight/
[6] https://www.spacex.com/vehicles/starship/assets/media/Starbase%20Overview.pdf

3.3. Starshield

Secured Satellite Network for Government Entities: *Starshield leverages SpaceX's Starlink technology and launch capability to support national security efforts. While Starlink is designed for consumer and commercial use, Starshield is designed for government use, with an initial focus on three areas:*[7]

- *Earth Observation: Starshield launches satellites with sensing payloads and delivers processed data directly to the user.*
- *Communications: Starshield provides assured global communications to government users with Starshield user equipment.*
- *Hosted payloads: Starshield builds satellite buses to support the most demanding customer payload missions.*

Security: *Starlink already offers unparalleled end-to-end user data encryption. Starshield uses additional high-assurance cryptographic capability to host classified payloads and process data securely, meeting the most demanding government requirements.*

Interoperability: *Starlink's inter-satellite laser communications terminal, which is the only communications laser operating at scale in orbit today, can be integrated onto partner satellites to enable incorporation into the Starshield network.*

Rapid Development and Deployment: *With the proven ability to iterate rapidly, SpaceX's unique full-stack approach in developing end-to-end systems, from launch vehicles to user terminals, enables the deployment of capabilities at scale with unprecedented speed.*

Resilient and scalable capability: *The Starshield low-Earth orbit architecture provides inherent resiliency and constant connectivity to on-orbit assets, while SpaceX's proven rapid launch capability provides expedient and economical access to space.*

[7] https://www.spacex.com/starshield/