SECOND GENERATION STARLINK SATELLITES

Since the original license to operate the Starlink Generation 1 network was granted in March 2018, SpaceX has rapidly deployed satellites to bring internet to the hardest to reach places in the United States and abroad. Five years later, SpaceX has launched nearly 4,000 satellites and is providing high-speed internet to more than one million locations around the world, the majority of which are households. Starlink continues to grow rapidly, and SpaceX has raced to keep up with a surging demand for connectivity across the globe, especially in areas where few, if any, options for broadband connections have existed before now.

With the recent authorization of our second-generation network, or "Gen2," SpaceX will provide even faster speeds to more users. This new authorization enables SpaceX to launch additional, much-improved spacecraft with significantly more throughput per satellite than the first-generation systems. For the end consumer, this means more bandwidth and increased reliability. As a result, millions of more people will have access to high-speed internet no matter where they live.

V2 Mini

SpaceX will soon launch a new generation of satellites that are larger and more capable than earlier generations. We call these satellites "V2," and there will be two separate versions of this satellite design: one that is compatible with the Falcon 9 launch vehicle, and one that is compatible with the Starship launch vehicle. When we launch V2 satellites on Falcon 9, they won't be the full-size version that are designed to be launched on Starship. The V2 satellites launched on Falcon 9 are a bit smaller, so we affectionately refer to them as "V2 Mini" satellites. But don't let the name fool you, a V2 Mini satellite has four times the capacity for serving users compared to its earlier counterparts.

Space Sustainability and Safety

As we begin to deploy our Gen2 network, SpaceX will continue to lead the industry in creating a safe and sustainable space environment. SpaceX includes sustainability as a critical design element for its satellite operations, ensuring that no debris remains in space longer than five years, should a satellite become non-maneuverable. SpaceX adheres to, and significantly exceeds, any applicable requirements or industry best practices, and operates with full transparency, even going beyond what is required by U.S. regulations. As we've detailed in a previous update, numerous filings with the Federal Communications Commission ("FCC"), and an "Industry Best Practices" guide, SpaceX's space safety approach includes many elements that greatly enhance sustainability.

These include:

- **Design and build reliability.** SpaceX satellites are designed and built with high reliability, around 99% after the deployment of nearly 4,000 satellites.

- **Operations below 600 km.** SpaceX has chosen to operate the vast majority of our satellites at an altitude below 600 km. At these altitudes, objects will decay and reenter due to atmospheric drag within a short period of time in rare off-nominal scenarios, eliminating the risk of persistent orbital debris.

- **Deployment into low-insertion orbit below space stations.** At these low altitudes (below 400 km), any SpaceX satellites that do not pass initial system checkouts are quickly deorbited actively, or by atmospheric drag.

- **Radical transparency and data sharing with the U.S. government and other satellite owners/operators to ensure full space situational awareness.** SpaceX openly shares high-fidelity future position and velocity prediction data for all SpaceX spacecraft, along with uncertainties on those predictions. In addition, SpaceX is the only operator that provides routine system "health reports" to the FCC.

- **Advanced collision avoidance systems protect SpaceX and other satellites.** SpaceX satellites utilize an autonomous collision avoidance system that ensures spacecraft have the most up to date information to mitigate close approaches with tracked objects (including debris and active satellites). SpaceX's autonomous collision avoidance system has been scrutinized by NASA's Conjunction Assessment and Risk Analysis (CARA) program, which deemed it sufficiently trustworthy to rely on to avoid collisions with NASA spacecraft.

- **Post-mission disposal.** SpaceX satellites are propulsively deorbited within weeks of spacecraft end of mission. This vastly exceeds the international standard of 25 years.

- **Starlink spacecraft are 100% demisable**. At end of life, SpaceX satellites are designed to fully demise upon atmospheric reentry, eliminating the risk of falling debris.

- **Best Practices.** SpaceX's approach to space safety relies on extreme transparency in operations, and SpaceX has collaborated with other operators and experts in developing "Industry Best Practices" based on operational lessons learned. SpaceX encourages all operators to implement these best practices to keep space safe and sustainable.

Brightness Mitigations

SpaceX has also prioritized collaboration with astronomers and scientists to mitigate the impact of Starlink satellite streaks on their observations. For our Gen1 network, SpaceX proactively requested two license modifications from the FCC to reflect two different deployment phases to lower the operating altitude of the satellites. These modifications were a crucial mitigation for astronomers and one endorsed by the American Astronomical Society to reduce impacts on astronomy, as well as improve space safety with respect to orbital debris mitigation. More recently, the National Science Foundation and SpaceX announced an updated coordination agreement to protect astronomy and continue collaboration on mitigation practices.

As we've detailed in an earlier update, SpaceX has proactively collaborated with astronomers and the U.S. government by dedicating engineers and resources to design and deploy mitigations and run experiments to test their efficacy. Initially, for example, SpaceX experimented with a dark paint to absorb sunlight. But when in-space experiments showed this mitigation was less effective than desired, SpaceX pivoted to development of a visor—VisorSat—to block sunlight from hitting the satellite and reflecting back to the Earth. SpaceX also implemented flight configuration changes to minimize the surface area of the spacecraft from which a reflection could result—both highly effective mitigations. SpaceX also started using dielectric mirror film on many surfaces of the satellite, which reflects light away from the ground and leads to less reflectivity.

Since the first use of mirrors on our satellites, we've made significant improvements in mirror film technology and its application. We've also developed an industry leading space-qualified black paint for angled surfaces or those not conducive to mirror adhesion. SpaceX continues development with additional technologies, including a combination of dielectric mirror film (developed and made by SpaceX), which reflects sunlight away from the Earth, and the SpaceX-developed, low-reflectivity black paint, which reduces lower specular peak by a factor of five compared to the darkest available space stable paint. These improvements are implemented on our V2 satellites. With several years of experience and the ability to design, test, and field mitigation strategies, mitigations were able to be "baked into" the design of the V2 satellites from the start. Additionally, we've designed our solar arrays to allow off-pointing to reduce reflections as a satellite approaches the terminator. So, while our V2 Mini satellites are larger than earlier versions, we're still expecting them to be as dark or darker once the full range of mitigations are implemented and the satellites reach their operational orbit.

However, we want to emphasize that even though brightness component measurements, ground modeling, and analysis show effective brightness mitigations, we won't know the full efficacy of our efforts until on-orbit observations are made of the satellites and data is collected and analyzed. What we learn from early observations will help us improve and refine mitigations. These V2 Mini satellites may be somewhat bright initially, especially during orbit raising and initial operations, but as our track record demonstrates, SpaceX will work tirelessly to refine design/manufacturing/materials and operational mitigations and continue to work with astronomers toward reducing the brightness of our satellites. Critically, we will also share our insights with other operators to protect the shared space domain. To that end, SpaceX will continue to make the dielectric mirror film and dark paint we've developed available at cost to other satellite developers and owner/operators.