

SATELLITE REFLECTION MITIGATIONS

August 2023

Making A Difference!

- SpaceX was founded to revolutionize space technology towards making life multiplanetary
- Starlink is making a huge positive impact for million+ people worldwide, while advancing space sustainability
 - Supporting connectivity to numerous communities, Tribes, school districts, etc.
 - Supporting enterprise and small businesses
 - Serving remote, rural communities with un/underserved households and schools
 - Helping to close the digital divide in the U.S. and around the world...one terminal at a time
- We're deeply committed to protecting human spaceflight and ensuring space is safe, sustainable & accessible for everyone
 - SpaceX is safely operating 4,800+ satellites in Low Earth Orbit despite intentional debris surge and non-cooperatives
 - Unwavering commitment to reduce the brightness of our satellites and ensure there are accurate ephemerides and TLEs available

Elon Musk's satellite internet flies under the radar at public schools nationwide



What a difference high-speed internet can make! Our children can participate in remote learning, residents can access #healthcare. We felt like we'd been paddling up-river with a spoon on this.@SpaceX Starlink made it happen overnight. Thanks @WAStateCommerce for introduction. 1:59 PM · Oct 7, 2020



FSET Information Technology provides SpaceX Starlink Internet to Pikan... The Internet has shaped the 21st Century by connecting the entire planet to a variety of resources, including virtual healthcare, education, and ... & # termanian comes.

E 🔰 🖂

WEATHER > HURRICANE

SpaceX donates Starlink satellite kits to assist in Hurricane Ian recovery efforts

More than 1,100 rescues have been made so far



Happy to have the support of @SpaceX's Starlink internet as emergency responders look to help residents rebuild the town of Malden, WA that was overcome by wildfires earlier this month. #wawildfire



Current Starlink Deployment Status

4,800+ satellites launched into low Earth orbit

1,500,000+ customers on all seven continents

200 Mbps (improving to 1 Gbps) speeds far exceed other satellite systems and are competitive with some terrestrial systems

Gen-2 system critical to fulfilling customer orders and scaling Starlink service approved in 2022, as part of license SpaceX completed a coordination agreement with the US National Science Foundation





Mechanism for Satellite Reflections



Mitigations in Three Areas

Hardware and satellite design

- Shade the reflective surfaces
- Specular materials can scatter light away from Earth
 - Dielectric Bragg mirror film
- Dark materials can be used to absorb light •
 - Pigmenting solar arrays and black paint
- Other accommodations
 - Oversize solar arrays so they can off-point to reduce reflections •
 - Robust thermal design to accommodate more absorbed heat energy

Satellite Operations

- Off-pointing solar array during orbit raise
- Autonomous attitude adjustments as satellite approaches terminator
 - Off-pointing solar array
 - Biasing bus pointing to reduce likelihood of light reflections toward Earth's surface

Satellite position predictions

- Publish accurate ephemeris predictions that include planned maneuvers and make them publicly available
- Publish Two Line Elements (TLEs) with planned maneuvers included



Thermal Considerations



Material

Initial v1 Inter-Cell Darkened v1 Inter-Cell Material





Reflection Mitigation Best Practices

- Take reflection mitigation seriously
- Design w/ Criteria-Build-Measure-Model-Launch/Operate-Measure-Feedback to Design
- Reflect, Darken, Shade and Avoid
- Continuously seek to understand and address edge cases
- Be transparent

Conclusion

- Starlink is making a huge positive impact around the world, while keeping space safe, sustainable and accessible
- Through coordination with astronomers and following industry-leading best practices on space sustainability, SpaceX continues to innovate and implement mitigation solutions
- We welcome collaboration with other operators, and are making in-house products available to other companies
- We agree with NSF that our coordination agreement and collaboration should be a model moving forward!