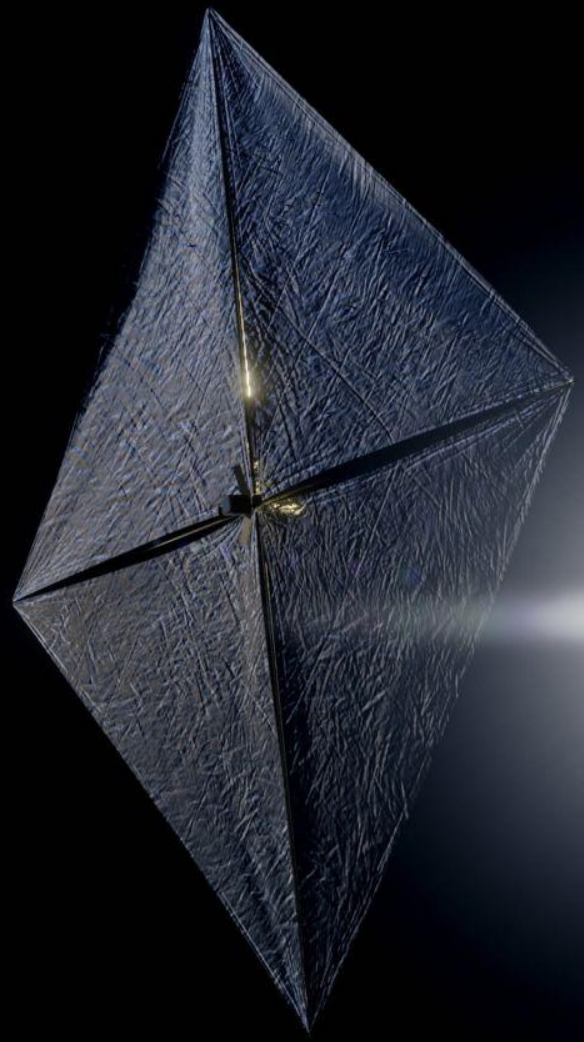
Space Storm Solar Sail Sentinel (S5) Mission Overview



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08/31/2026

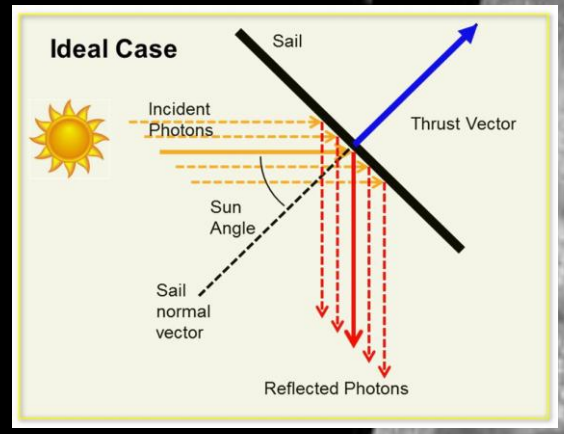
Filling a Sail with Light

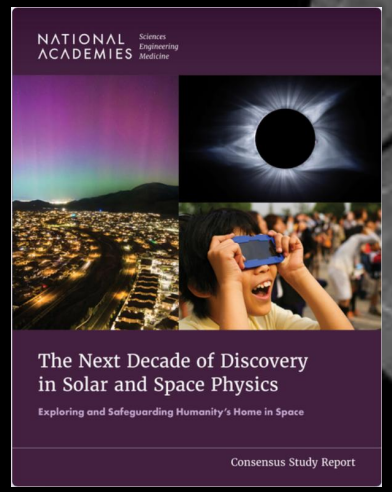
- Produces thrust with solar radiation pressure on a thin, lightweight reflective "sail"
- Creates a propellent free constant acceleration, enabling nearly unlimited propulsive capability

Heliophysics Decadal Survey:

- "Assess science-enabling instrument and flight system technology needs for the next generation, including next-generation radioisotope thermoelectric generators and solar sails"
- "Solar sails, for example, are a potential multispacecraft enabling technology, and demonstrations of their use and other relevant technologies for heliophysics applications would be of considerable benefit in the long-term vision of multipoint observation feasibility."

S5 serves as the next step for enabling solar sail missions.





1653 m^2 (>17,000 ft^2)
2.5 microns thick
(thinner than a human hair)

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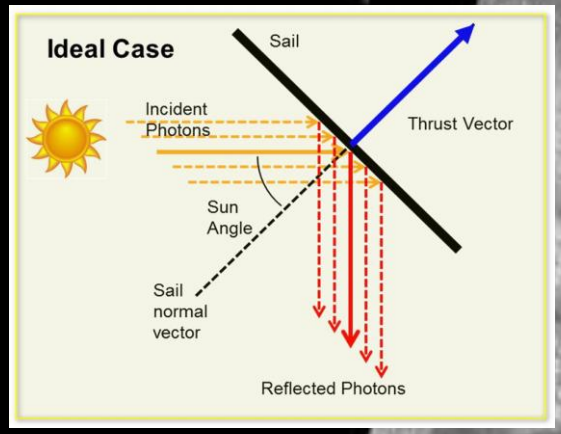
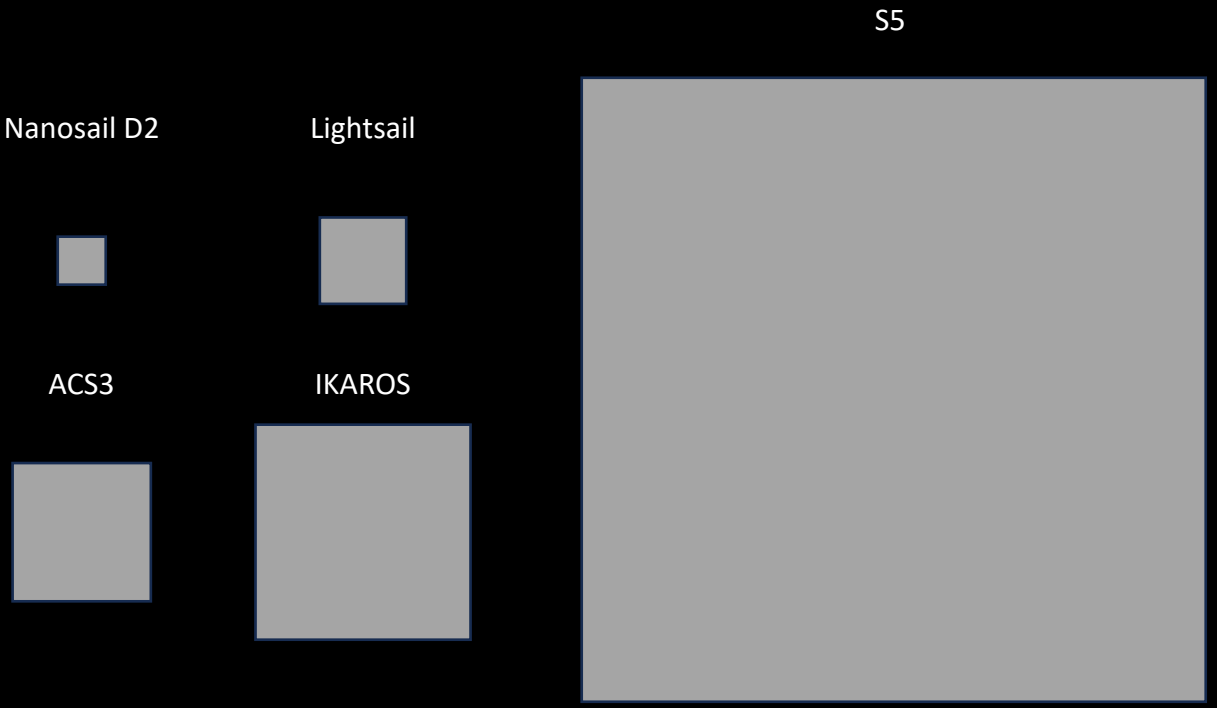


Solar Sail Missions to Scale:



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S5 Project Overview and Key Players

Project Description: 7120.8 Technology Demo

Validate core solar sail technologies in a space environment for extensibility to next Generation solar sail platforms.

1. Demonstration of **Navigation** with a Solar Sail System.
   Demonstrate how a Gen 1 solar sail can be controlled and maneuvered for navigation.
2. Verification of **Performance** of a Magnetometer onboard a Sailcraft.
   Understand how well magnetometers works in the space environment aboard a solar sail spacecraft.

NASA MSFC Roles:

- Project Management
- Systems Engineering (Sailcraft & SSS)
- Thermal and Structural Integrated Analysis
- Active Mass Translator (AMT) DDT&E
- AMT Electronics Design & Integration
- Mission FSW planning and oversight
- Solar Sail System (SSS) AI&T
- SSADCS[1] Development and Delivery
- Mission Design and Planning

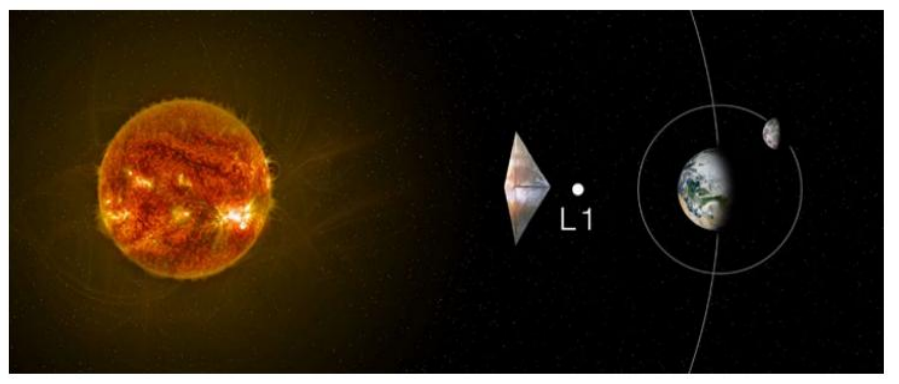
[1]SSADCS – Solar Sail Attitude Determination and Control System

Customers:

- National Oceanic and Atmospheric Administration (NOAA)
- Science & Technology Mission Directorate (STMD) – GO Domain Program Office

Partners:

The team also completed a 60-day spacecraft bus study with two providers. A provider has not been officially downselected between the two providers



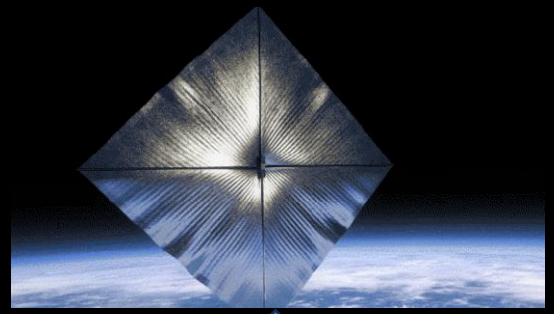
Mission Assumptions:

- Using **existing 1653m²** sail design and interfaces - NOAA funded and in progress
- Manifested to NOAA provided launch (SOL-A) as ESPA secondary payload
- NOAA provided Instrument (magnetometer)
- Using NASA ARC FO IDIQ for S/C Bus, Sailcraft AI&T & Mission Ops.

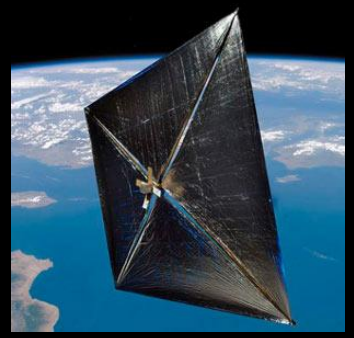
Mission Objectives:

- Demonstrate control of sailcraft up to 15 degrees Sun Incidence Angle and a predictable manner
- Characterize sail characteristic acceleration performance from solar radiation pressure
- Capture imagery of the sail deployed in space
- Characterize magnetometer performance pre and post sail deployment for use as a solar weather monitor

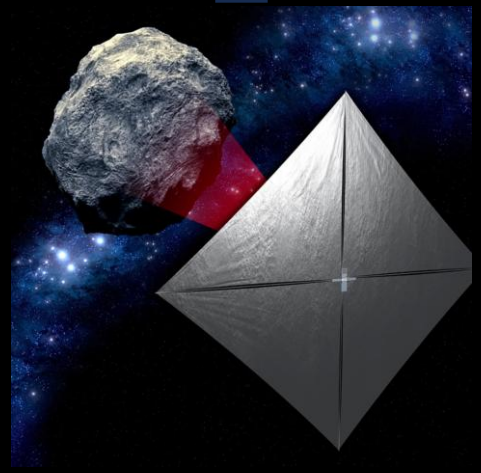
Mission Heritage of S5



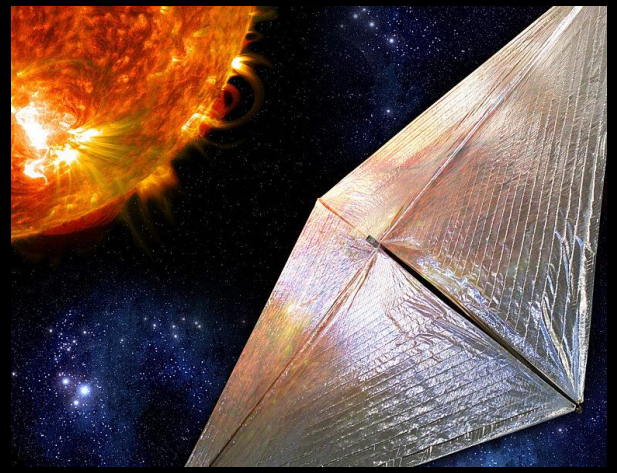
ACS3 was a Langley 12U Cubesat mission which flew in 2024 and successfully deployed its sail in LEO



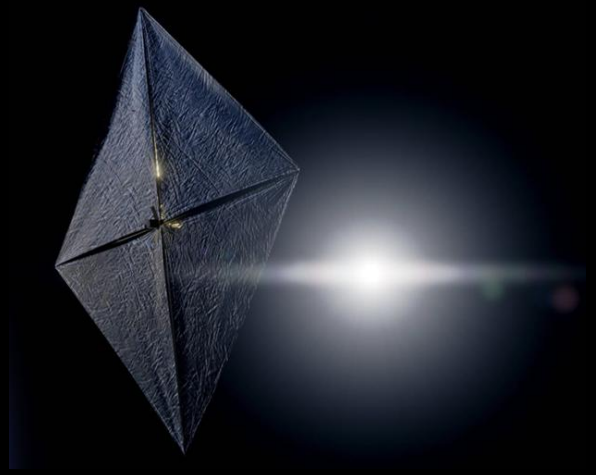
NanoSail-D2 was a 3U Cubesat flown in late 2010 and deployed its sail successfully in LEO



NEAScout was a 6U Cubesat flown on Artemis I but no radio contact was made



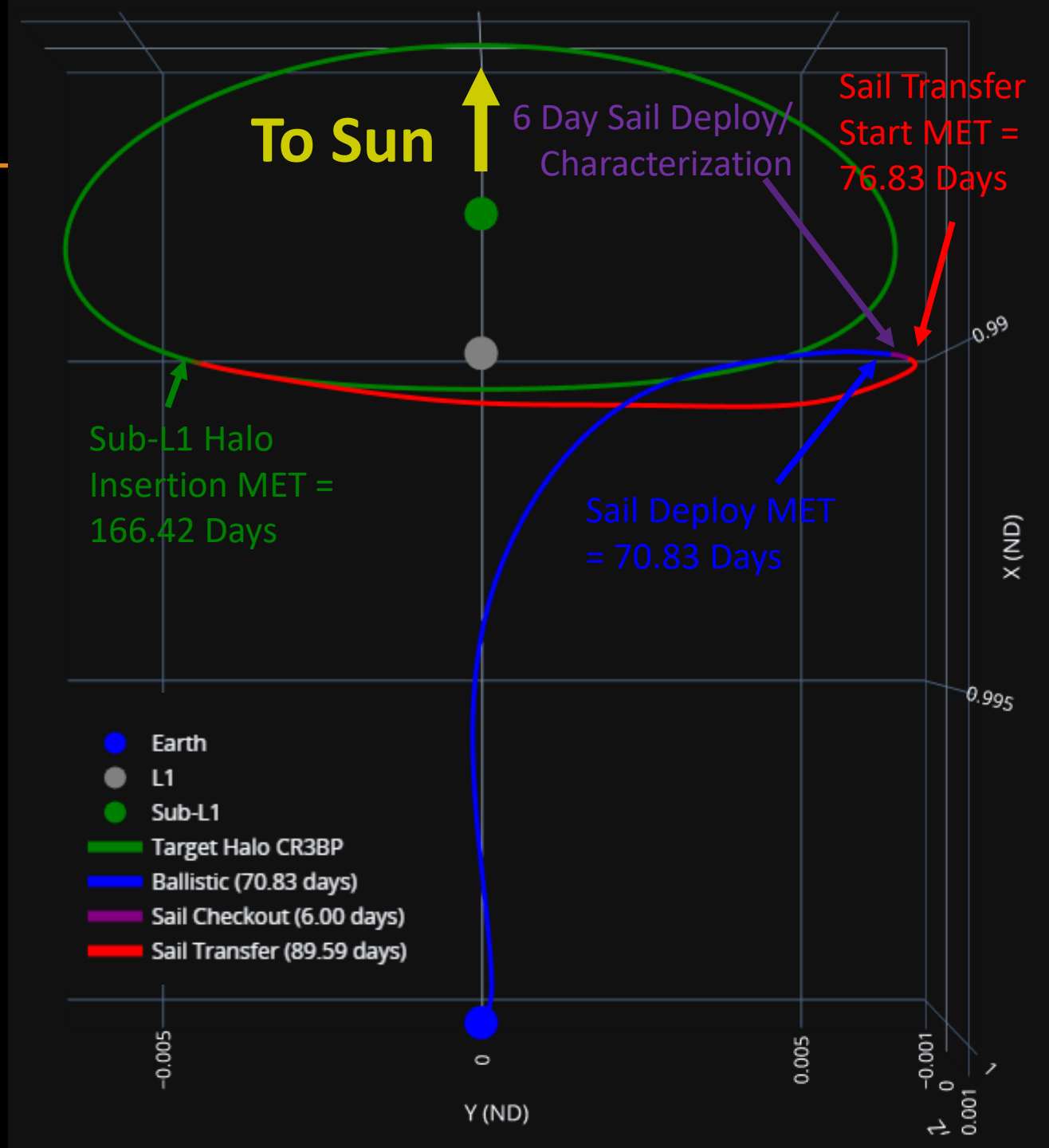
Solar Cruiser was a 1653 square meter solar sail discontinued at KDP-C in 2022



S5 builds off the previous missions and reuses the sail membrane originally destined for Solar Cruiser. Leverages lessons learned from all the missions presented here

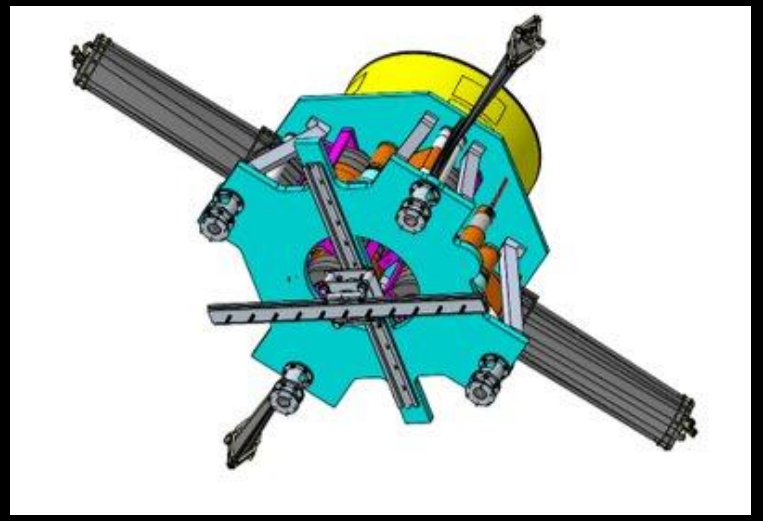
Mission CONOPS

- Ballistic Transfer – Following deployment from the launch vehicle, S5 will check out instruments, and ensure spacecraft is working correctly
- Sail Deploy/Characterization – Sail deployment will occur approximately over an hour with a 48 hour attitude hold and a series of maneuvers to characterize the sail and its behavior
- Sail Transfer – Solar sailing phase from initial ballistic transfer to reach the target Sub-L1 halo orbit
- Sub L1 Halo – Target Sub-L1 halo orbit allowing a closer approach to the Sun in comparison to a traditional L1 Halo orbit which enabled increased warning time of solar weather events

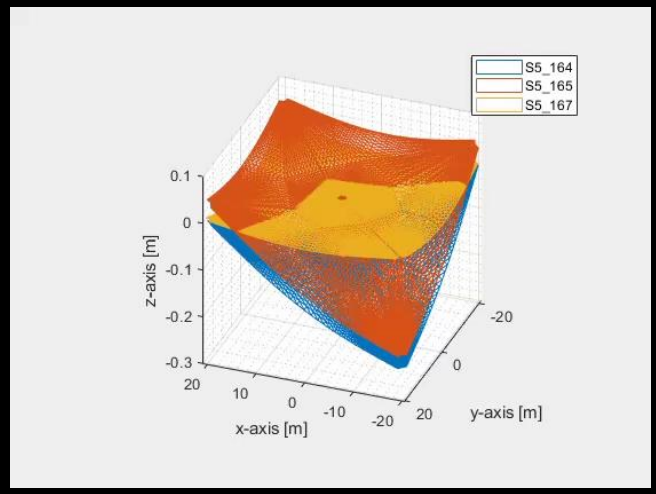


Current Status – Sailcraft Design

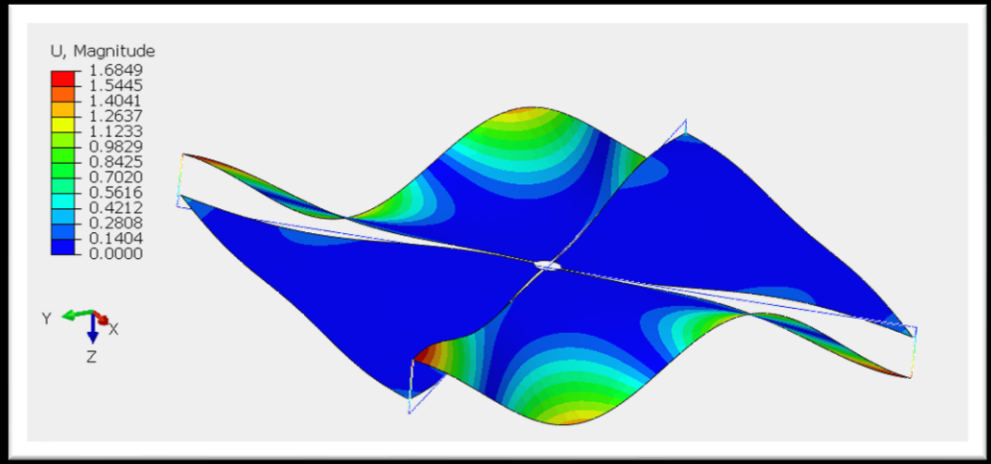
- The S5 Team recently completed the first major design analysis cycle with teams conducting initial analysis of the sail system
- Spacecraft bus study was conducted with two vendors: bus award will be occurring in the near future



CAD Model of AMT and SSDS Design



Sail Shapes Generated

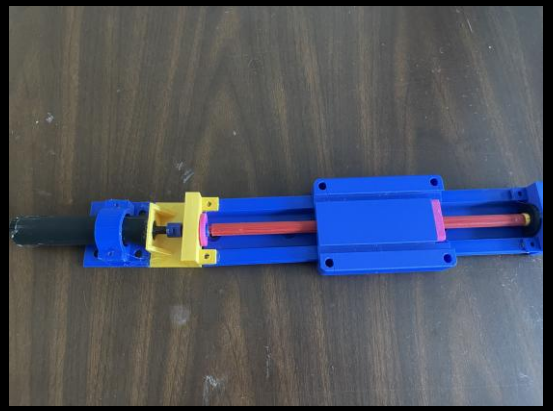


Flex Body Analysis

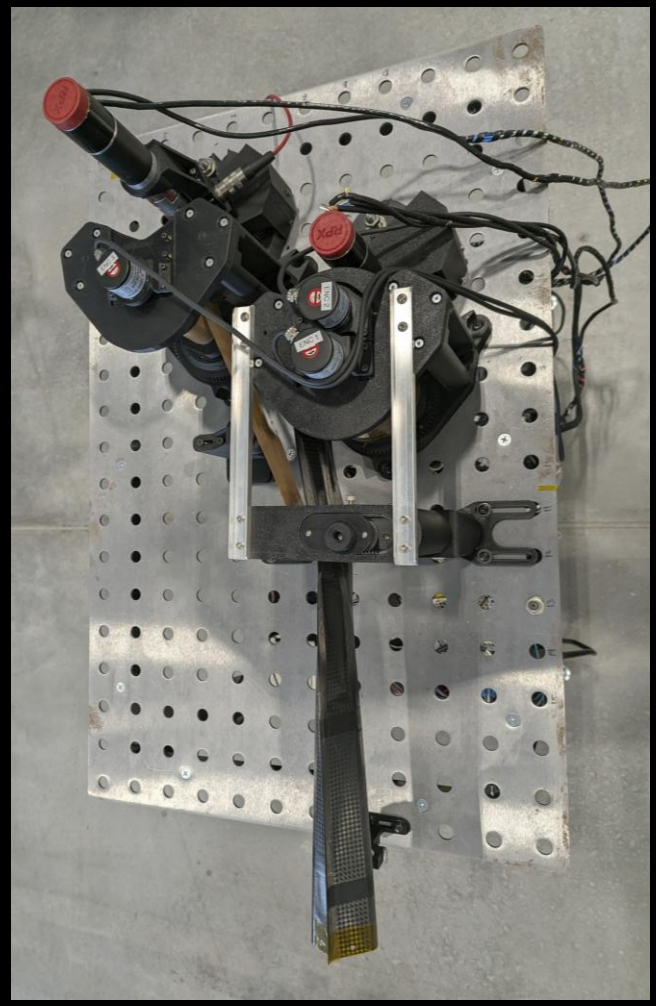
Current Status – Hardware Built

All four quadrants of the flight S5 sail membrane have been built and folded with a fifth under construction

Full-scale 3D-printed Active Mass Translator



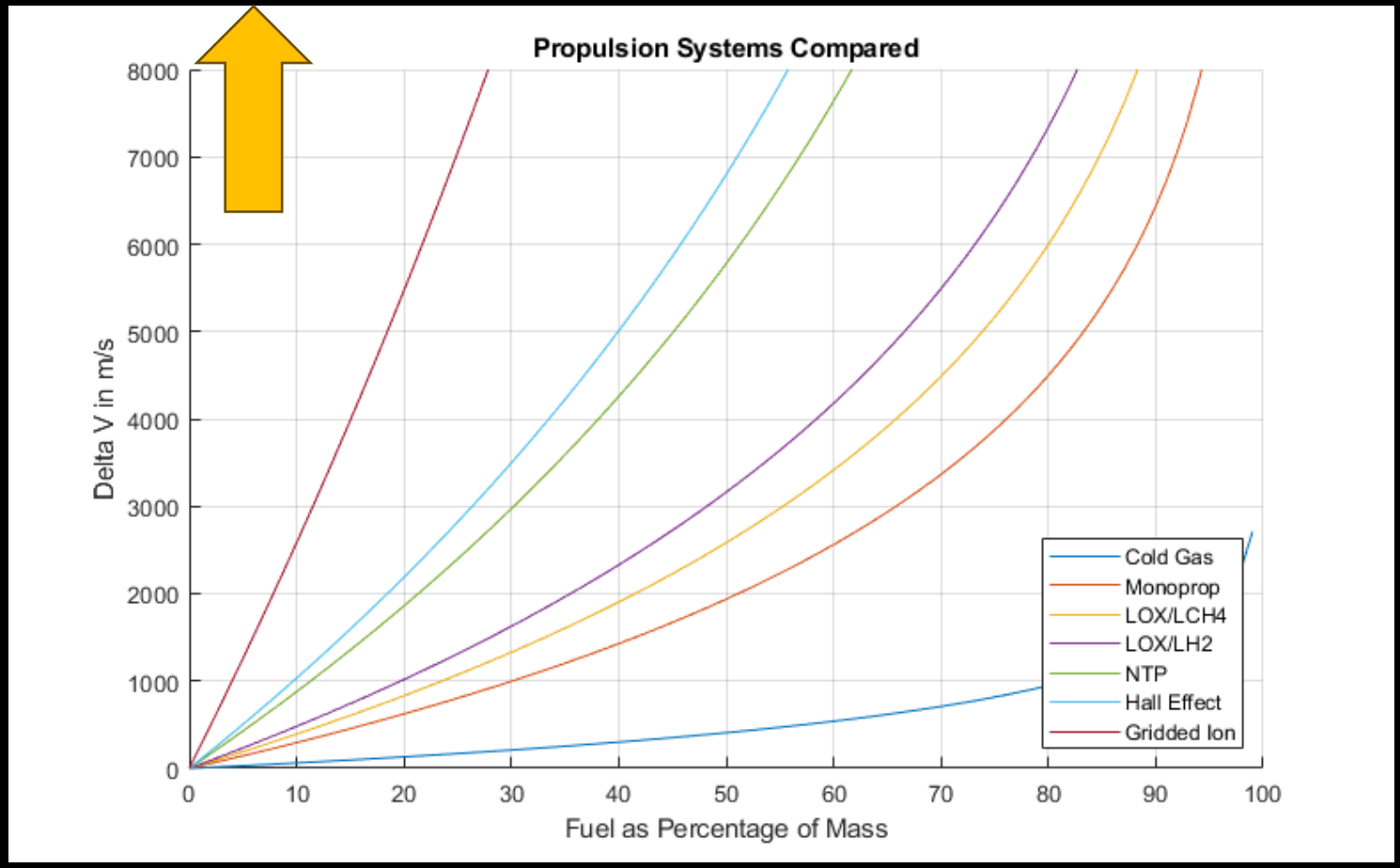
Boom structure is being tested along with a breadboard deployment system for the booms and sail membrane



Solar Sails vs Conventional Propellant Systems

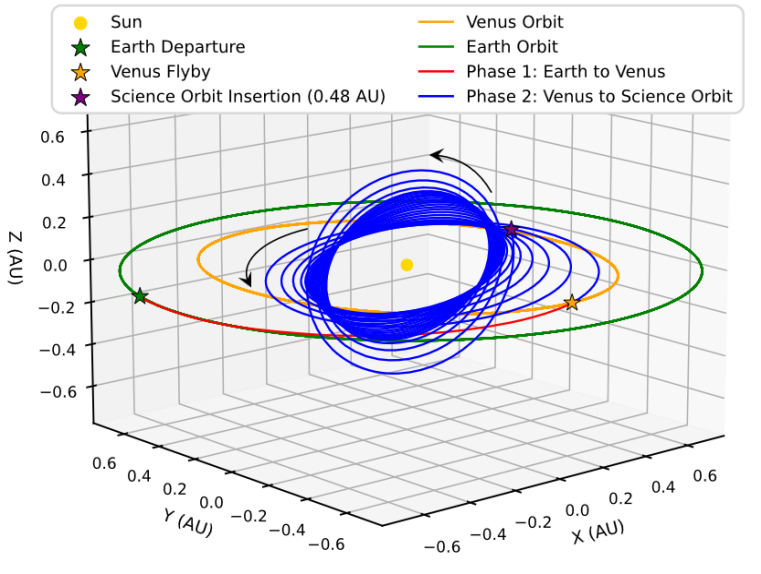
Solar sails provide a nearly limitless form of propulsion capability which enables hard to reach and non-Keplerian orbits inaccessible via use of chemical or electrical propulsion

Solar Sails off the chart with “infinite” delta V capability



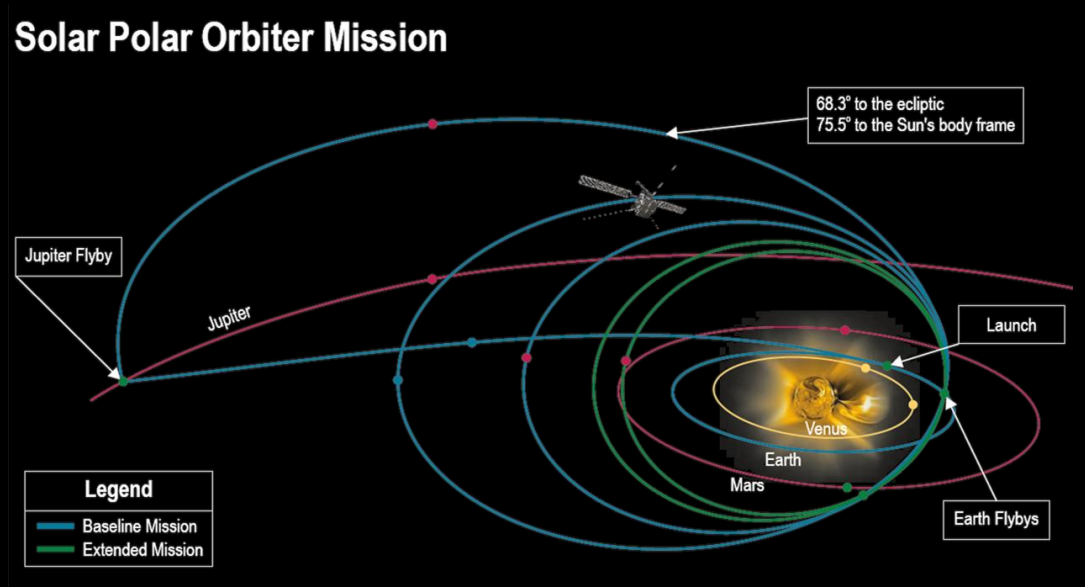
Future Missions Enabled – High Solar Inclination

Solar Polar Imager



Solar sail technology enables Solar Polar Imager missions with constant observation capabilities of the Sun while targeting final orbits in 7 years. Conventional propulsion can not achieve the same profile.

Solar Polar Orbiter



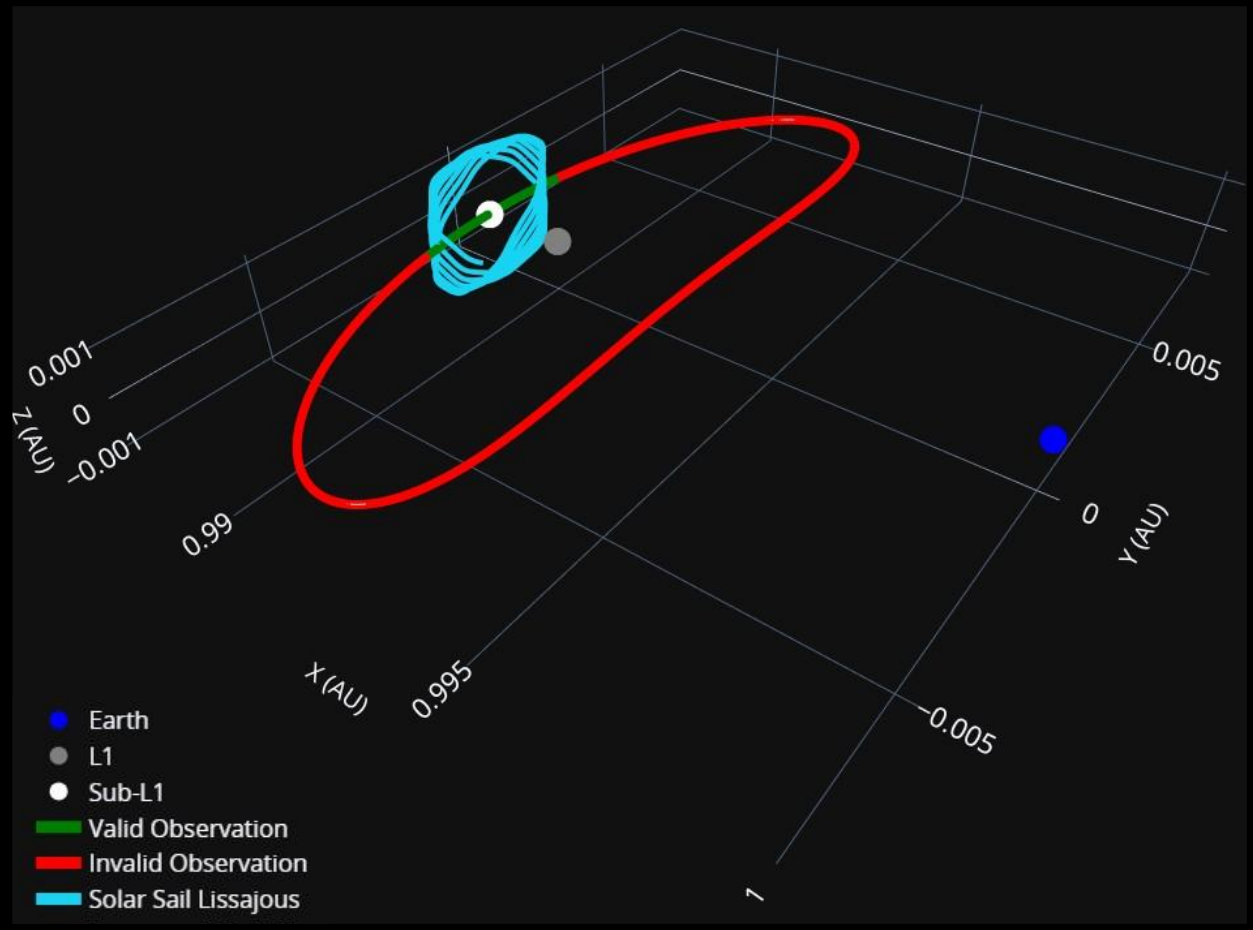
Current proposed solution is to use a Jupiter flyby to reach a high inclination. Solar Polar Imager not only reaches the final orbit faster but also enables science to be done during the transit to the final orbit.

Future Missions Enabled – Solar Weather

Sailing Space Weather Monitoring

Utilizing the constant acceleration from SRP, a solar sail can dive even closer to the Sun than the Sun-Earth L1 and provide advance warning time on solar weather events with the sail remaining within 50 Earth radii on the Sun-Earth line

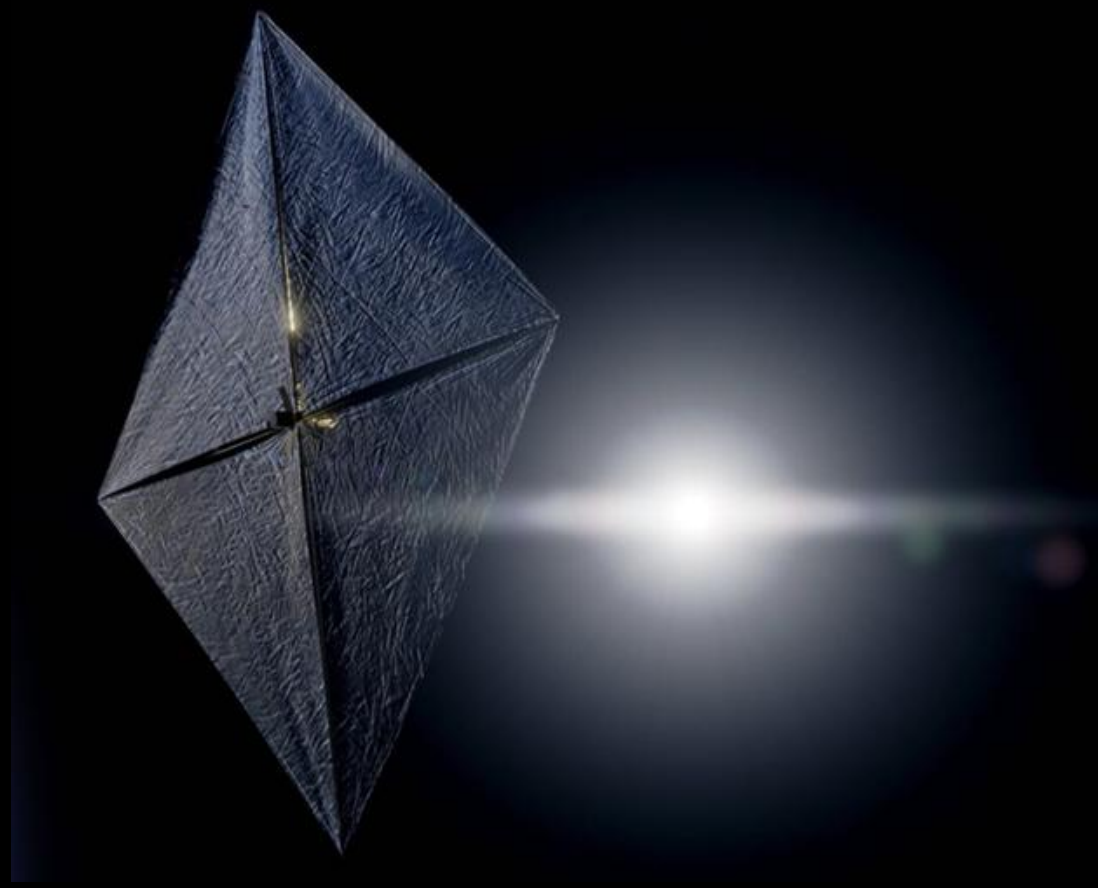
Solar Weather Monitor Constellation



To create the same effect as the solar sail, consistently Sub L1 and within 50 Earth radii of the Sun-Earth line, would require 13 satellites in a Lyapunov orbit constellation instead of a singular solar sail to achieve the same end effect

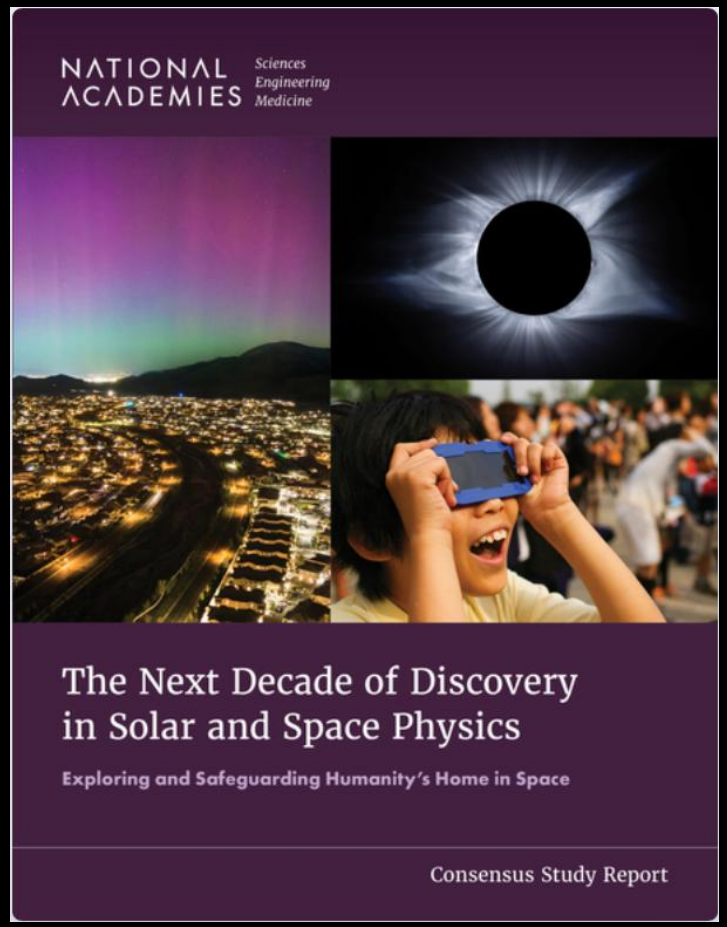
S5 Next Steps

- Bus contract award to bring spacecraft provider onboard
- Initial Design Review (IDR) scheduled for mid 2027
- Final Design Review to be scheduled after IDR



Conclusions

- S5 serving as the next major development step for Solar Sail technology which enable key heliophysics missions
- S5 will immediately enable follow on missions to leverage this technology for both in the heliophysics domain and beyond



"Technology demonstration to raise the TRL of solar sail technology as a means to obtaining more inner heliospheric observations at a variety of locations along the Sun–Earth line." – Page 504 of 2024 Heliophysics Decadal Survey

Space Storm Solar Sail Sentinel (S5)

Questions?