The TSIS-2 Mission

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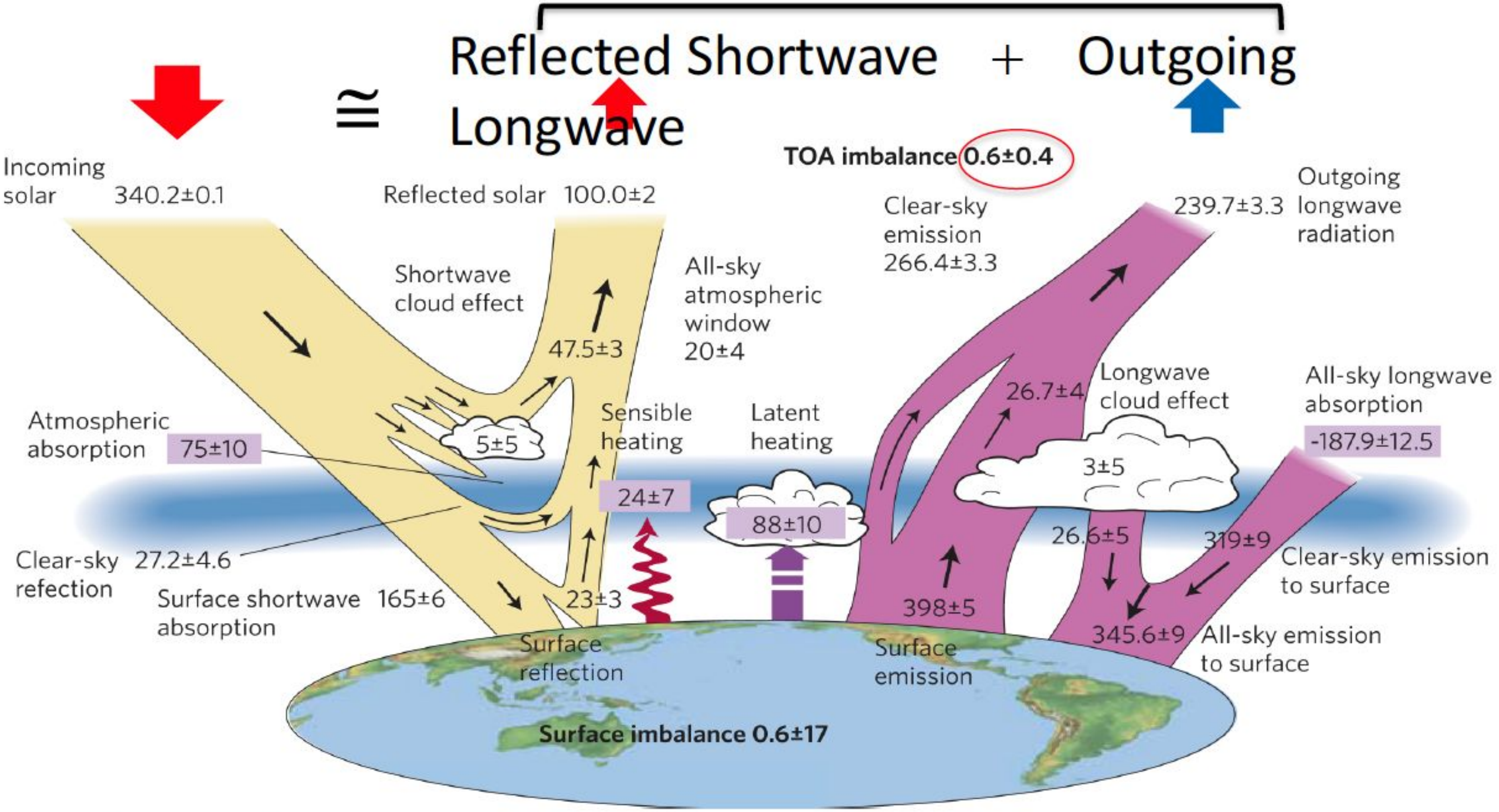
TSIS-2 Mission Objectives

- Acquire total solar irradiance (TSI) and spectral solar irradiance (SSI) measurements to determine the direct and indirect effects of solar radiation on climate
- Extend a more than 40-year uninterrupted measurement record of TSI beyond ISS/TSIS-1
  - Maintaining solar irradiance data continuity is one of the "Most Important" objectives in the 2017 Decadal Survey.
  - Overlapping TSIS-2 with TSIS-1 is a high priority in NASA Earth Science Division mission development.
- Provide accurate SSI measurements for better understanding of wavelength-dependent solar energy deposition in Earth's atmosphere and surface

Global Energy Budget

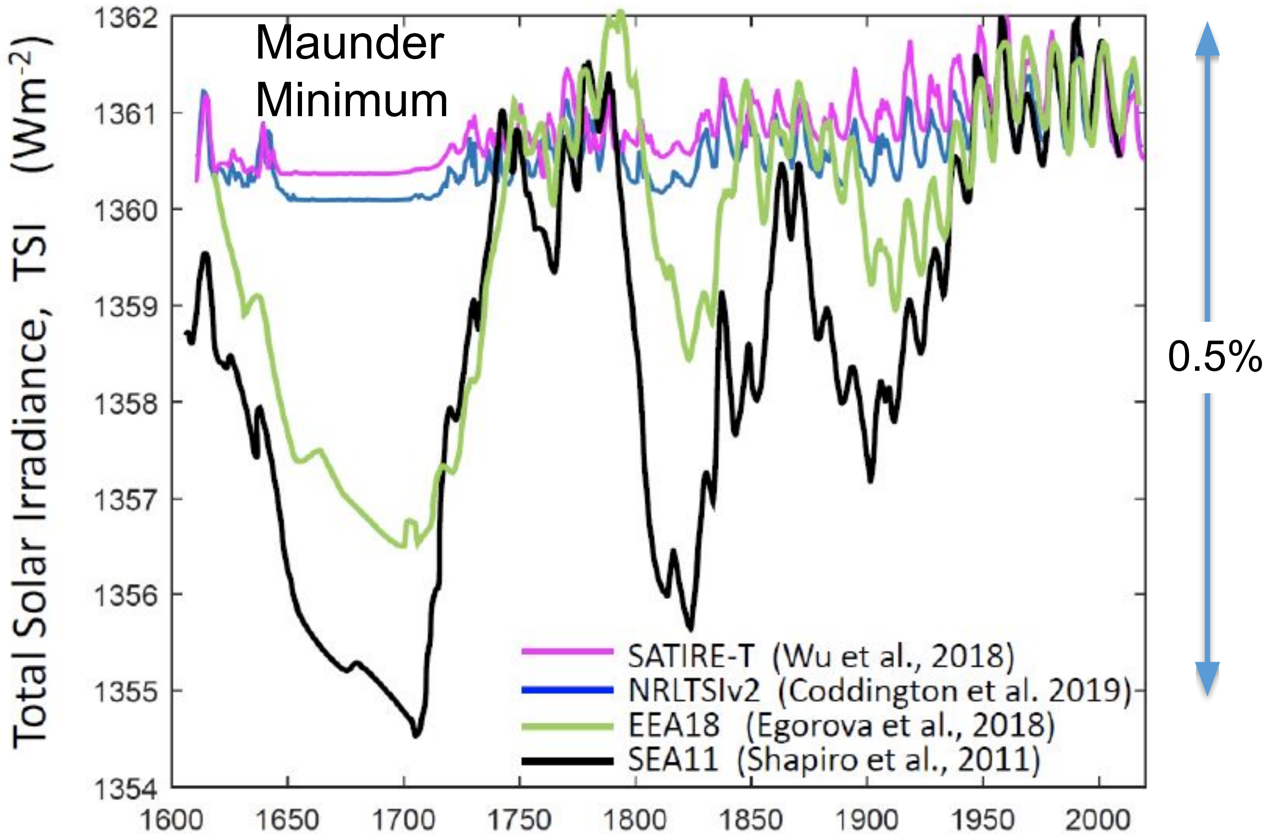
The 2017 National Academy of Sciences Decadal Survey for Earth Sciences and Applications from Space recommended that NASA sustain a multidecadal global measurement of solar irradiation



Stephens et al., Nature Geo., 2012

How Much Does TSI Vary?

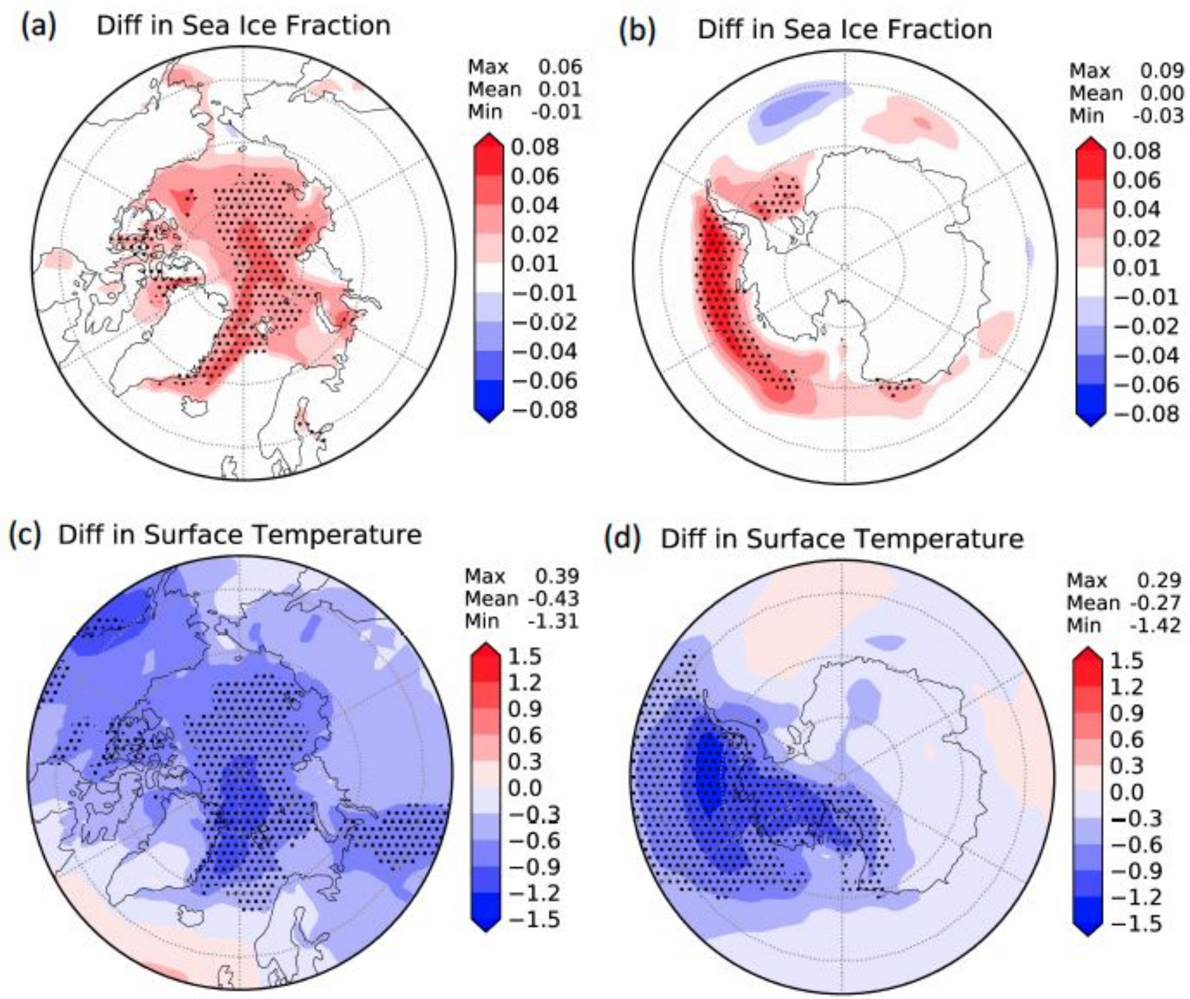
- Large uncertainty remains in the reconstructed total solar irradiance (TSI) for quiet Sun back in the Maunder Minimum;
- Variations could give significant changes to solar power input to Earth's climate;
- Good consensus found between TSI observations since 1995 supports higher stability of the Total Irradiance Monitor (TIM) data.



Lockwood and Ball (2020)

SSI Impact on Arctic Sea Ice

Arctic sea ice absorbs more solar radiation in near infrared (NIR) wavelengths than in visible (VIS) wavelengths => Importance of SSI distribution in wavelength

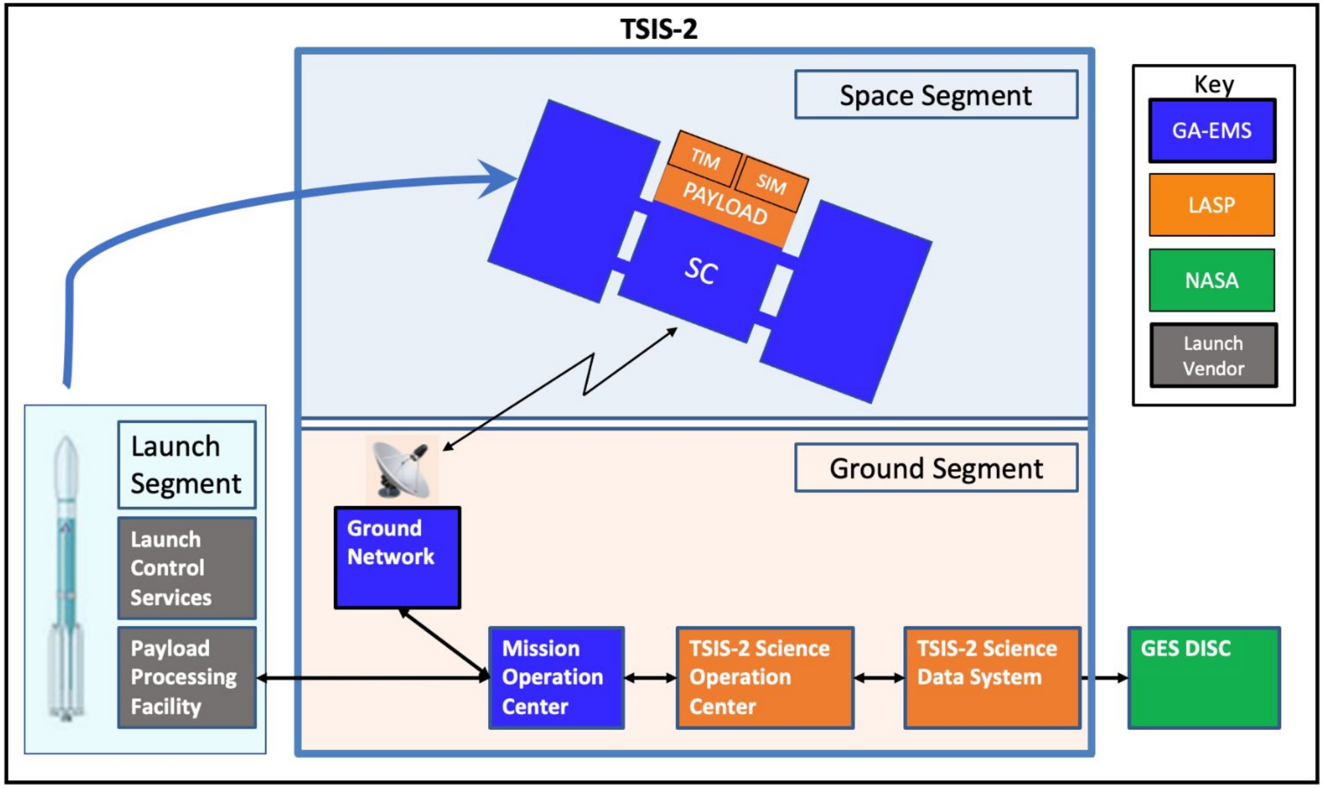


Method: The recent TSIS-1 mission has provided more accurate SSI observations than before. The SSI difference in a given VIS or NIR band can be as large as 4 W m^{-2}.

Impact: The results show that, due to different spectral reflectance of sea ice and water surfaces in the VIS and NIR, the set of simulation with more SSI in the VIS has less solar absorption by the high-latitude surfaces, ending up with colder polar surface temperature and larger sea ice coverage.

Mission Concept/Overview

- Lessons learned from SORCE and TSIS-1 missions
- Stand-alone spacecraft in LEO for solar irradiance observations
- Same TSI and SSI measurement quality as TSIS-1
- 3-year mission lifetime



Level 1 Science Requirements

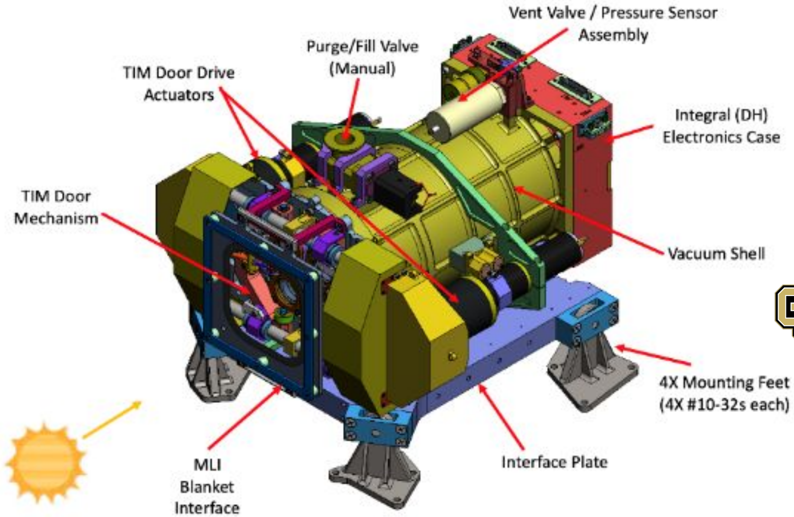
- Provide continuity of TSI measurements and maximize the chance of overlap and intercomparison with existing on-orbit climate sensors
  - TSI requires 3-month minimum overlap with TSIS-1 with a goal of 6 months
  - SSI requires 6-month minimum overlap with TSIS-1 with a goal of 12 months
- Put all measurements that make up the record on the same calibration scale

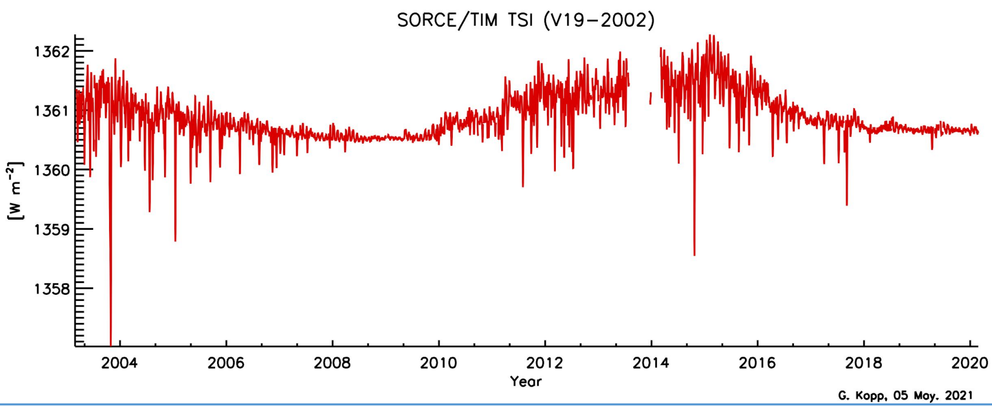
Parameter	TSI Requirement		SSI Requirement	
	Baseline	Threshold	Baseline	Threshold
Spectral Range	Total Integrated Spectrum		200 – 2400 nm	
Accuracy	≤200 ppm	≤350 ppm	≤1.0% (200 – 400 nm) ≤0.5% (>400 nm)	≤1.0% (over full spectral range)
Stability	≤10 ppm/yr	≤20 ppm/yr	≤0.05%/yr (<400 nm) ≤0.01%/yr (>400 nm)	≤0.1%/yr (<400 nm) ≤0.02%/yr (>400 nm)
Spectral Resolution	Not Applicable		≤2 nm (<280 nm) ≤5 nm (280 – 400 nm) ≤45 nm (>400 nm)	
Reporting Frequency	4 six-hourly averages per day		2 spectra per day, sampled every 12 hours	

NOTE: 1 ppm – 0.0001%

Total Irradiance Monitor (TIM)

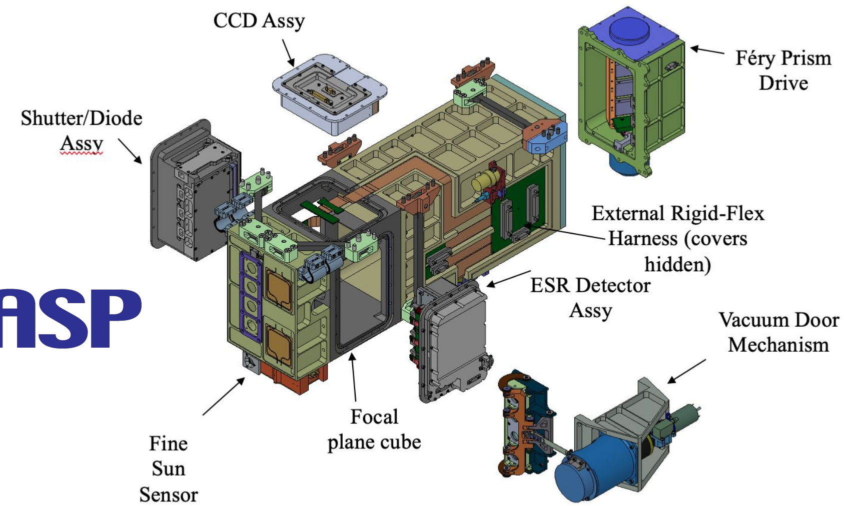
- TSI is Earth's predominant energy source
- TSIS-2 TIM will extend a 40-plus year uninterrupted measurement record of TSI

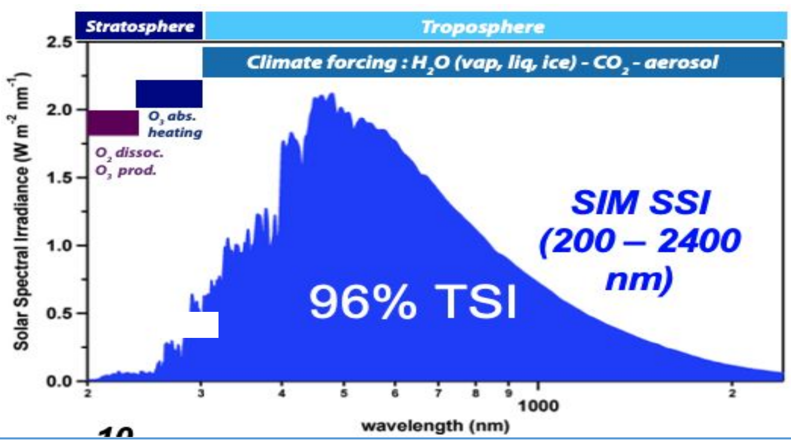




Spectral Irradiance Monitor (SIM)

- High accuracy solar irradiance spectra for radiative transfer applications in climate research enables more realistic climate model simulations.





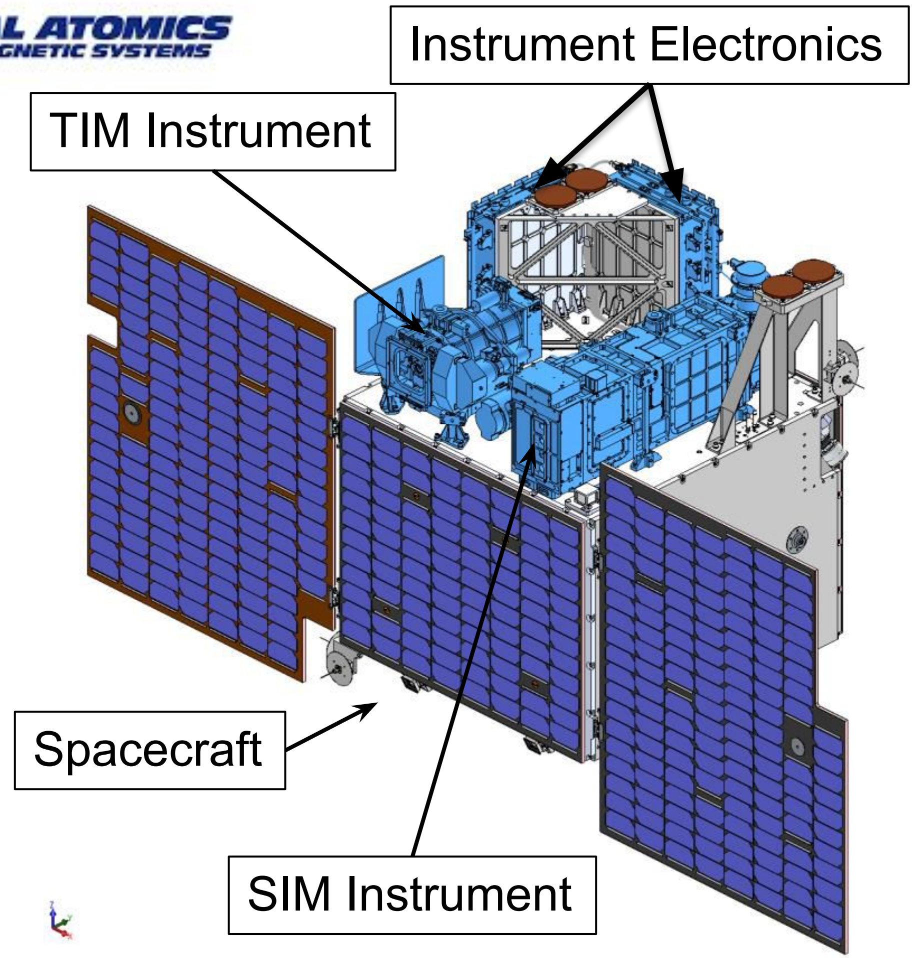
Observatory

GENERAL ATOMICS ELECTROMAGNETIC SYSTEMS

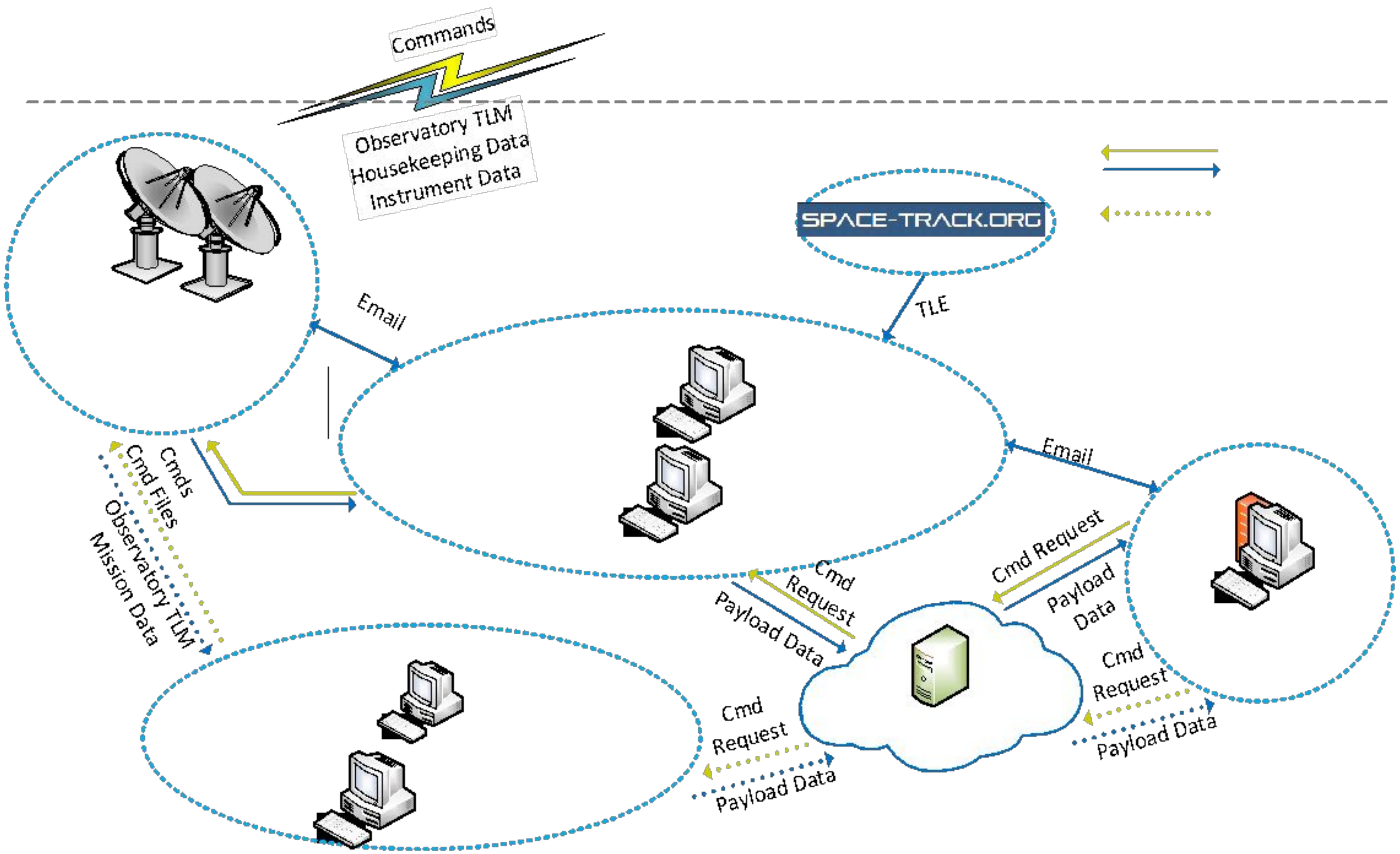
Instruments and instrument electronics are mounted on +Z deck of the spacecraft

Spacecraft Key Features

- 3-axis stabilized attitude control
    - Actuators: Reaction wheels, magnetorquers
    - Sensors: Star Trackers, Sun Sensors, Magnetometers, Gyros
- S-Band Communications
- Power generated by 4 solar panels
    - 2 deployable
    - 2 body mounted (1 for tumble only)
- Passive and active thermal control
- Payload, battery, and –z deck heaters
- No propulsion



Ground System



Nominal Operations

- Sun/Dark Pointing for Day-to-Day Operations
  - Tracking the sun for payload observations when in sunlight
  - Pointing to dark space for dark field calibration when in eclipse (or once per orbit if no eclipse conditions exist)
    - Instruments pointed anti-velocity direction
- Intermittent Payload Calibrations
  - Cruciform Calibration for SIM and Field of View Map for TIM
  - Sensor calibrations occur every 6 months
    - Step and stare processes over several orbits
- Transition to Safe Mode When Necessary
  - Power and thermally safe Y-Thomson spin when a component fails or out of limit condition is triggered

TSIS-2 Status

- Planned working launch date Aug. 2024
- Laboratory for Atmospheric and Space Physics (LASP)
  - SIM is fully integrated and has begun calibration testing
  - TIM assembly is nearing completion
  - TSIS-2 Science Operations Center (TSOC) and and TSIS-2 Science Data Center (TSDS) updates from TSIS-1 are on-going
- General Atomics (GA)
  - Spacecraft and Ground System CDR completed Apr. 2022
  - All major subcontracts are in place
    - Avionics—Surrey Satellite Technology, Ltd.
    - Solar Arrays—Sierra Nevada Corp.
    - Battery—Saft America
    - Ground Station—Kongsberg Satellite Services (KSAT)
- Launch Vehicle
  - To be procured by Kennedy Space Center