Life on the ISS:

The Challenges Faced by the TSIS-1 Mission Due to Observing Onboard the ISS

Keira J. Brooks, Michael Chambliss, Stéphane Béland, Luke A. Charbonneau, Odele Coddington, Cody Folgmann, Charles Labonde, Robby Mendoza, Courtney L. Peck, Steven V. Penton, Jason Price, Erik Richard, Lucas Sackrison

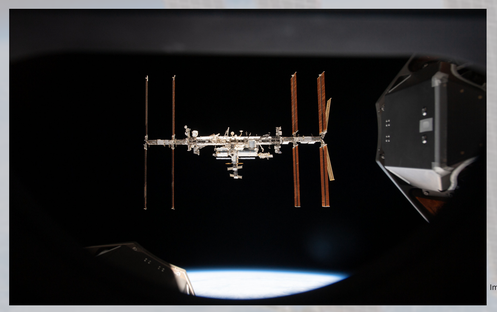
LASP (Laboratory for Atmospheric and Space Physics) – University of Colorado at Boulder

For the last five years, TSIS has collected data from its observing platform on the ISS. The location of the instrument has presented a unique set of challenges to the operations, systems engineering, and data analysis that is required in order to continue the solar irradiance data record and provide the highest quality data.

Early in the mission, learning how the seasonal changes in the length of time the instruments are sun-lit during an orbit and different solar viewing windows impact scheduling was particularly challenging, while the continued and frequent changes to the ISS schedule, requires constant attention and adjustment by the Operations team.

Additionally, recent leaks in docked vehicles, ISS power outages, and debris from ISS activities have all affected the TSIS-1 team from recovering the instruments to adding processing steps to ensure data quality.

The daily solar observing success rate for TSIS prime mission was 86% for TIM and 85% for SIM. While for space-based most missions, this is less than optimal, for TSIS, given the scheduling challenges, this is quite impressive.



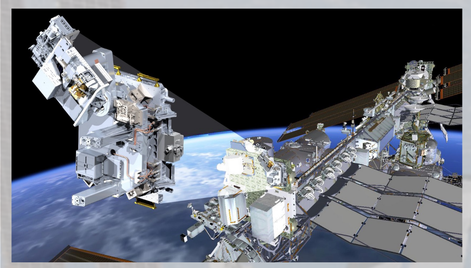
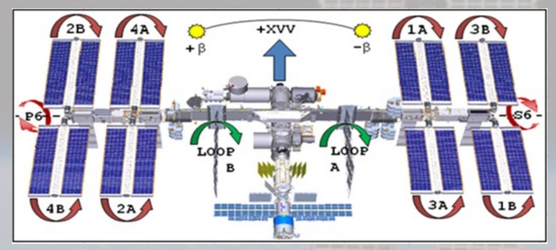


Image Credits: NASA

Impacts to Operations: Scheduling

One of the main challenges of having the ISS as the TSIS-1 platform is that due to the position of TSIS-1 on the ISS, there are times of the year in which it is impossible to take science data due to obstructions, glints, and other impacts of the hardware around the instruments. This was discovered very early on in the mission, and adjustments to scheduling had to be made to ensure optimal science data collection.



Due to the location of TSIS-1 on the ISS, there are many obstructions that block the sun, and how much they block the sun can depend on the time of year and other factors. In the figure above, we see how an angle, β, is used to indicate the viewing window of the TSIS-1 instruments. In the figure to the right, this angle is shown on the y-axis and we see a mapping of ISS components in the TSIS-1 field of view. Outside of β +/- 40 degrees, our viewing window, and therefore the ability to take all scans as expected, decreases.

If, at any point, additional ISS components, for example the Candarm, are moved into the field of view of TSIS-1, this also impacts the scheduling window and the amount of science data we can take.

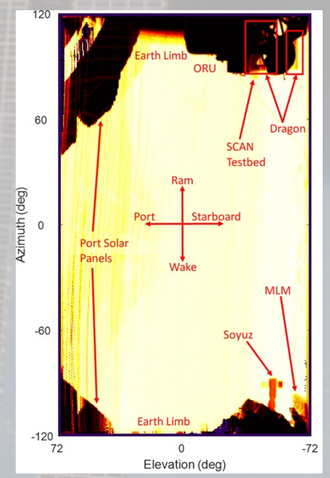


Image Credit: Brown, P., Gathright, G., "TSIS-1 Pointing System Performance after 5 Years on ISS", IEEE Aerospace Conference, 2024 (submitted)

Impacts to Operations: Outages

Planned Outages

Two main reasons for planning TSIS outages: concern for contaminants and ISS required outages for safety

Contaminant concerns arise when:

1. A vehicle docking or berthing/capture
2. A vehicle is undocking or unberthing/release
3. A vehicle relocate
4. ISS maneuver of any kind
5. ISS vents substances
6. EVA that involves risk of contaminant release or foreign object debris risks

ISS safety outages:

These occur when there is a safety risk to the crew or hardware. At these times TIM & SIM are powered off and are powered on immediately after their conclusion.

1. EVA activity in the vicinity of ELC3
2. Robotics activity in the vicinity of TSIS

Unplanned Outages

In the event of unplanned outages, TIM & SIM are shuttered as soon as Ops is aware of the event. Such events have included leaks and unexpected power loss.

Major unplanned events that have impacted TSIS operations:

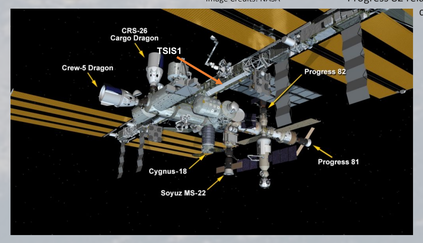
- December 2022: Soyuz (MS-22) coolant leak
- February 2023: Progress 82 cargo ship coolant leak
- August 2023: Unexpected loss of ELC-3 (where TSIS is located) power
- October 2023 (ongoing): MLM coolant leak

Outage tracking

The TSIS-1 operations team has an internal ISS Dynamic Ops Log which tracks events (both planned and unplanned)

Soyuz MS-22 coolant leak

Image Credits: NASA



Locations of Soyuz MS-22 and Progress 82 relative to TSIS coolant leak

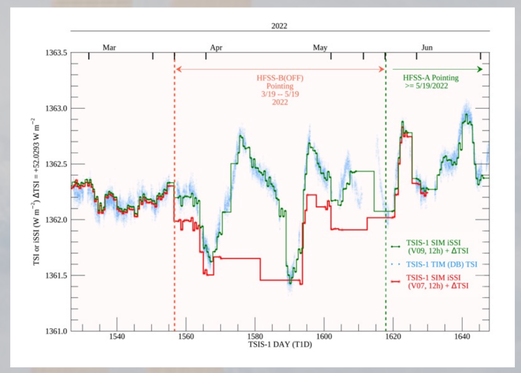
Impacts to Data Processing

A recent example of the ISS impact to the TSIS-1 data processing is that on or around March 19th, 2022, the High-rate Fine Sun Sensor (HFSS)-B, the primary sun sensor for the SIM instrument was contaminated by some debris, which has remained on the sensor since that time.

The HFSSs are comprised of four quadrants (see illustration below) and when, while looking at the Sun, the measured irradiance in all four quadrants is equal, the HFSS is considered pointed at the Sun.

After March 19th, the TSIS-1 SIM data processing team discovered that SIM had been measuring a drop in irradiance at all wavelengths due to this contamination that had resulted in a ~1 arcmin off-pointing. The team switched to the redundant HFSS-A around May 19th, 2022.

After several months of analysis, the team settled on a correction at each wavelength during the two months in which HFSS-B was being used while off-pointing. The figure to the right illustrates the impact of this correction on the integrated SSI as compared to the TSI measured by TIM during that same time period.



In the plot above, the blue data points indicate the TSI measured by TIM, the red data points indicates the SIM integrated SSI before the correction to the data taken during the period of time when the HFSS-B was off-pointing (V7), the green data points indicate the corrected SIM data (V8) during that two month period

Additional updates made as a result of this event:

- Added quality flags
- Adjustment to the pointing flags
- Adjustments made to the HFSS-B so that if used in the future, it will be pointed correctly