AEROSPACE

# SPACE THREAT AND RISK DETECTION AND REPORTING

Space threats are changing at an incredibly rapid pace. Spacecraft, ground systems, mission operations centers, and links are at risk for all space stakeholders—from national security and intelligence stakeholders to commercial and civil government organizations. During a conflict, adversaries may seek to deceive, deny, disrupt, degrade, or destroy any space assets critical to the national interest.

Detecting, identifying, attributing and avoiding space threats is a complex challenge, and time is of the essence. Traditionally, satellite operators have either relied on specialized flight hardware or software to detect threats or monitored mnemonics on state-of-health telemetry to see if they exceeded thresholds. This can require significant time, resources, and mature space domain awareness insights that may not be readily available to detect anomalies or counter fast-moving threats.

Drawing on more than 20 years of applying machine learning (ML) techniques to satellite telemetry, The Aerospace Corporation (Aerospace) has developed the Detection and Reporting System (DARS), to quickly mitigate risks. Using DARS provides early indications of potential threats, enabling space operators and defenders to take responsive actions nearly in realtime, before spacecraft, space systems, or space missions are compromised.

## Multi-Mission Anomaly Detection and Reporting Capabilities at Scale

Using a combination of artificial intelligence (AI) and physics on spacecraft telemetry, DARS covers significant ground, providing situational awareness of threat environments and status of sizable satellite constellations. DARS detects and characterizes a range of threats in near realtime, including:

- GPS interference and spoofing
- Command receiver interference
- Optical threats and “lasing” events
- Cyber intrusions

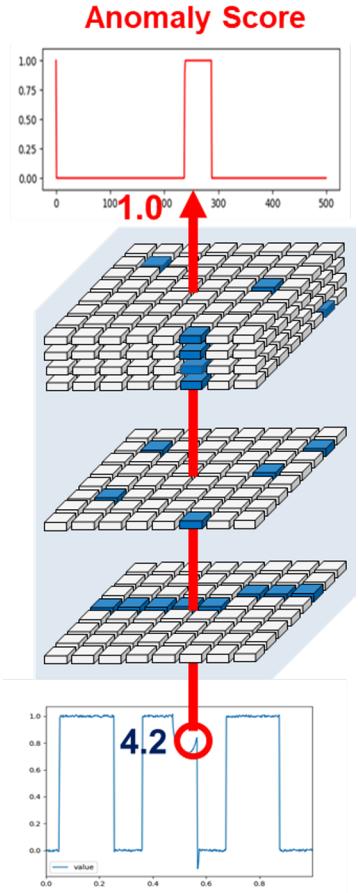
DARS is also currently being expanded to predict hardware failures.

**TRL:** 6

**MISSIONS:** Multi-Mission

### Contact Aerospace

› For more information or to license this technology, please contact ip@aero.org.



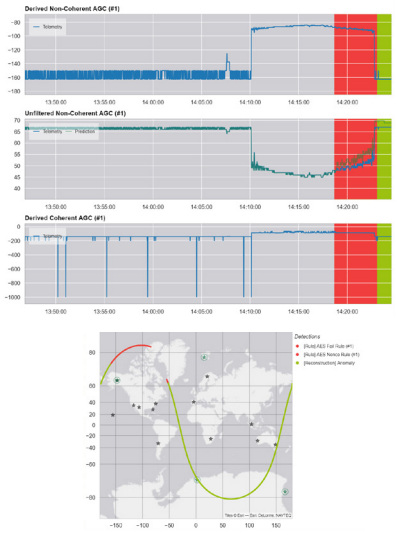

DARS combines human-machine teaming with multiple detection models to improve resilience and minimize false anomaly positives.

Designed as a cloud-native, scalable end-to-end enterprise system comprised entirely of open-source, industry-standard tools, DARS can run continuously on constellations of spacecraft with tens of thousands of mnemonics—checking them all with little or no operator effort—and can automatically adapt to ageing spacecraft and the changing space environment. DARS then populates both interactive visual displays and machine-readable reports for characterizing threats up the command chain. While its enterprise value increases within a multiple-mission scope, this can be built out incrementally, starting with a single mission and adding missions and additional detection models as needed over time.

## Human-Machine Teaming Framework

DARS uses a variety of techniques—including rules-based and expert-system approaches, statistical models, and state of the art AI/ML techniques (including random forest and transformer neural network models). The tool produces its detections by incorporating Machine Learning Operations (MLOps) with a cloud-based data system to efficiently ingest, store, and analyze spacecraft state of health telemetry and sensor data records (for laser threats). DARS leverages common infrastructure and customized ingest processes for each telemetry format, using an ensemble of detection models to distinguish real anomalies from false positives.

DARS' human-machine teaming and automated model artifact storage and training allow for rapid sustainment, creating a trusted framework for AI-enabled threat reporting. While DARS is able to detect threats that human operators may miss, it learns by incorporating human feedback into its own training parameters to further minimize false positives. This multi-staged learning process enables DARS to learn initial policy and concepts model in low-risk, human-guided environments, gradually increasing its exposure to risk before learning online in a live environment.




Example of a command receiver interference detection. DARS monitors spacecraft telemetry using AI/ML to populate interactive visual displays and machine-readable reports to detect and characterize threats. The top image displays are affected mneumonics; at bottom, a geospatial representation of detections in reference to approved and known ground stations (stars). Colors indicate the type of model that detected the interference, leading to quick attribution.

### CASE STUDY: IN-SPACE DEMONSTRATIONS

DARS' capabilities have been successfully demonstrated on-orbit as part of the NOAA-20 and NOAA-21 missions within the Joint Polar Satellite System (JPSS). Aerospace's team supporting this mission combined experts in spacecraft subsystems, space weather, optical, and microwave instruments with data scientists and software engineers to train DARS models on JPSS satellite data and characterize anomalies detected by the tool. Current DARS models are trained on the telemetry from NOAA-21 (prelaunch designation JPSS-2).

Photo courtesy NOAA/NASA.

## The Aerospace Corporation

The Aerospace Corporation is a national nonprofit corporation that operates a federally funded research and development center and has more than 4,600 employees. With major locations in Chantilly, Virginia; El Segundo, California; Albuquerque, New Mexico; and Colorado Springs, Colorado, Aerospace addresses complex problems across the space enterprise and other areas of national and international significance through agility, innovation, and objective technical leadership. For more information, visit www.aerospace.org.

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