Richard P. Feynman Center for Innovation

Technology Snapshot

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Los Alamos NATIONAL LABORATORY

Spacecraft Speedometer: Satellite Velocity Detection

Compact, Rugged, and Low-Power Detector for Real-Time Spacecraft Velocity Measurement

Fig. 1. The Spacecraft Speedometer flight unit featuring the dual-sensor head laminated electrostatic analyzer (ESA). This compact design enables precise velocity measurements for spacecraft without relying on GPS.

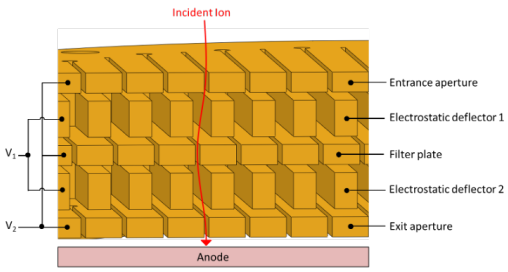

Fig. 2. Cross-sectional schematic of the laminated ESA design. The layered structure optimizes charged particle filtering, enhancing velocity determination accuracy in space environments.

Overview

The Spacecraft Speedometer provides real-time velocity measurements for satellites without relying on GPS, which can be unreliable at low altitudes, in high-radiation environments and during geomagnetic storms. Using a dual-sensor head electrostatic analyzer (ESA), it determines velocity by analyzing ambient space plasma charged particles, offering a self-contained, compact, and power-efficient solution for better orbital tracking and space weather monitoring. Designed as a small size, weight, and power (SWaP) payload for small satellite platforms, this system fills a critical gap in spacecraft navigation, improving operational efficiency while reducing reliance on external tracking systems.

As spacecraft and probes travel to planets and moons where GPS isn't available, the Spacecraft Speedometer provides a critical navigation solution for deep-space missions. By enabling precise velocity measurements in these GPS-denied environments, it supports autonomous spacecraft operations, improves mission planning, and ensures accurate trajectory control for planetary exploration and interplanetary travel.

Applications

- Small satellites and CubeSat operators for tracking
- Space weather monitoring and forecasting
- Satellite manufacturing and system integration

Partnership Opportunities

LANL is seeking a licensee for the technology for deployment in space applications.

Technology Readiness

A prototype has been developed and deployed to demonstrate the technology.

IP Information

This technology is currently patent pending.

Contact Information

Kathleen McDonald
kathleen_h@lanl.gov
505.413.3732

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NNSA National Nuclear Security Administration

Advantages

- **Velocity Measurement**: Directly measures spacecraft speed in situ, improving orbit prediction and maneuver planning.
- **Compact & Low-Power Design**: Optimized for CubeSats and small satellites, making it cost-effective and scalable.
- **Enhanced Space Weather Monitoring**: Provides real-time data to mitigate space weather disruptions that impact spacecraft performance.
- **Increased Accuracy for Satellite Tracking**: Reduces reliance on GPS, which struggles at low altitudes and certain latitudes, especially during intense space weather events.
- **Space Deployment**: Successfully tested on the International Space Station (ISS), validating its accuracy and effectiveness.

Technology Description

Unlike traditional satellite velocity tracking, which relies on GPS or ground-based radar, the Spacecraft Speedometer provides direct, onboard velocity measurements using a dual-sensor laminated-head electrostatic analyzer (ESA). This system detects and analyzes charged particles in space, filtering them based on energy and trajectory to determine spacecraft velocity in real time. The laminated-head design enhances measurement accuracy and efficiency by optimizing particle detection and reducing noise. Because it does not depend on external signals, it remains effective in GPS-limited environments, such as low-altitude or high-radiation regions. Its compact, low-power design makes it well-suited for CubeSats, small satellites, and larger spacecraft, improving orbital prediction and mission planning while reducing reliance on external tracking systems.

Market Application

- **Small Satellite & CubeSat Operators**: Enhances tracking for satellites where GPS is unreliable.
- **Space Weather Monitoring & Forecasting**: Provides critical velocity data to predict space weather disruptions.
- **Government & Defense Agencies**: Supports space domain awareness and collision avoidance.
- **Satellite Manufacturers & System Integrators**: Can be easily integrated into commercial and defense satellite systems.

With the space weather forecasting market projected to grow to $2.8B by 2032, this technology offers a low-cost, scalable alternative to traditional tracking methods, enabling more autonomous, cost-effective space operations.

Next Steps

The technology has been successfully tested in space and is ready for scaling and commercialization. We are seeking a manufacturing partner or system integrator to refine production and deploy this technology into commercial and defense satellite markets.

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