AGU Poster 2727

The Module for Event Driven Operations on Spacecraft: Applying MEDOS to Science Data

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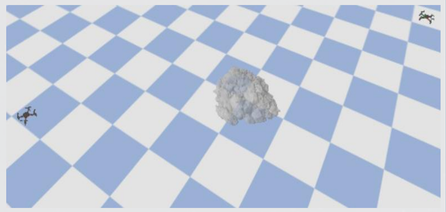
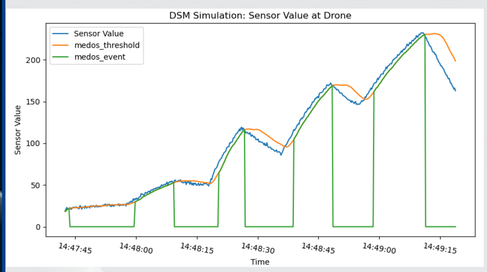
Autonomous Searching: Locating a Plume

Image Credit: JPL/Caltech

Source location assists in studying some of the most exciting events on other worlds, like Enceladus and Europa's oceanic plumes

MEDOS assists in guiding simulated drones to a gas source, using sensor data to detect whether the drone is moving towards or away from the source





An adaptive peak finding algorithm uses a window of previous sensor readings to detect local slope increases which result from the drone moving closer to the source

RAW TELEMETRY (blue)

Real-time sensor readings (variable length buffer size)

Buffer weighted mean and weighted std. deviation

DERIVED TELEMETRY

KEY FEATURES (orange)

Combine mean & std. dev to generate threshold for new values

Value above threshold → moving closer
Value below threshold → not moving closer

EVENT DETECTION (green)

Motivations: Why Event Driven Operations?

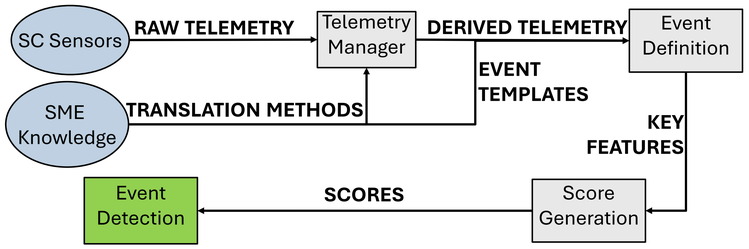
- Deep space missions require robust, autonomous real time operational control driven by subject matter expert (SME) knowledge
- In-situ telemetry can yield high level data products which drive decision making
- MEDOS is a science-driven decision engine based on real-time event detection

Logo Design: Luke Berger

Methods: Putting the Scientist on the Spacecraft

Raw telemetry is converted to a few physically meaningful high-level derived telemetry

SMEs define mission-specific in-flight events based on available derived telemetry



Based on each event's score, return those events currently in progress

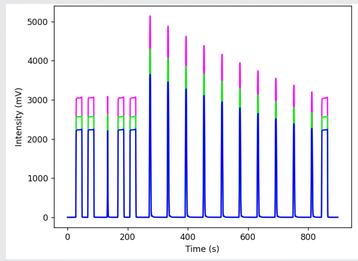
Scores generated per event based on the mathematical distance between current state and event numerical definitions

Ocean Worlds: Mass Spectrometry Data Classification

Future missions to ocean worlds like Enceladus and Europa may yield answers to planetary decadal survey questions

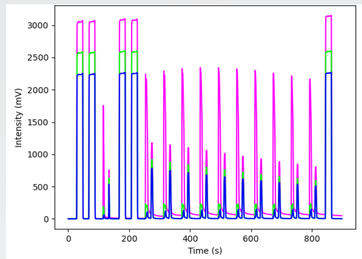
Image Credit: Mark Garlick

NOMINAL IRMS SAMPLE



OW missions often make use of mass spectrometers to analyze planetary environments. MEDOS classifies these samples immediately after collection for data prioritization, instrument health, and anomalies

IRMS SAMPLE TO CLASSIFY



RAW TELEM → Peak Intensity, Fractionation, Peak Timing… (**600+ datapoints**)

DERIVED TELEM → Fractionation Statistics, Peak Trends, Relative Intensities… (**20 features**)

KEY FEATURES → **Peak Number** > Nominal
Extra Peaks Intensity ≈ Constant

EVENT DETECTION → **Anomaly Detected**: Contamination from Sample-External Source

MEDOS detections inform follow-up actions like resampling, instrument diagnosis, or requesting higher complexity algorithms for further sample analysis, based on available power, mission health, and science objectives.

Heliophysics: Boundary Crossings in MMS Data

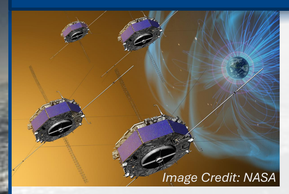
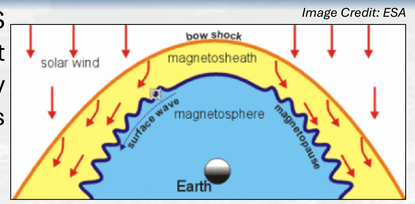


Image Credit: NASA

MEDOS has been verified on MMS historical data to detect spacecraft region changes (boundary crossings), which have implications for both science and operations

Image Credit: ESA



RAW TELEMETRY

Plasma flux, electron counts, magnetic field, GPS coords

Plasma velocity and density, radial position, mag field variance

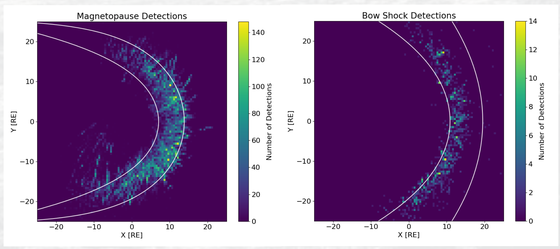
DERIVED TELEMETRY

KEY FEATURES

Classify current state as magnetospheric region

When detected region changes, record a crossing

EVENT DETECTION



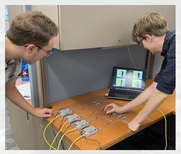
Historical data is fed into MEDOS in real time to run a "cutout" of the MMS mission synthetically, covering 4 years of data

79.6% and **88%** accuracy on bow shock and magnetopause crossings within 10 minutes of SitL detections

Results from MMS study, showing MEDOS changes in detected region, compared to model predictions for bowshock and magnetopause

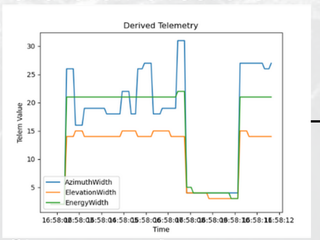
Synthetic Missions: Prioritizing Science Objectives in Early Design

MEDOS's use of SME knowledge makes it usable from the early stages of conceptual mission design to test detection algorithms and follow-on actions

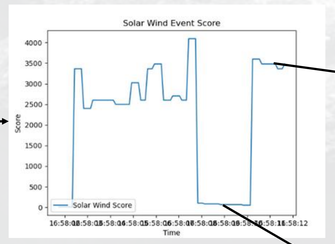


Simple Raspberry Pi sensors (mag field, light) are used as proxies for more complex telemetry like plasma skymaps:

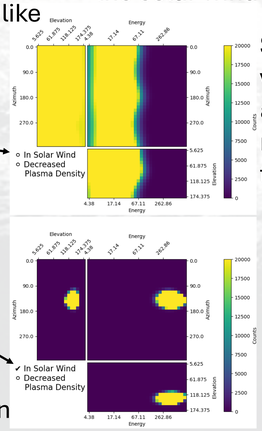
MEDOS can detect flight-like events through proxy data, like detecting if the spacecraft is in the solar wind



Skymap features are compared to SME definitions of solar wind, and combined into a score



Events are detected as the score nears zero, with a defined threshold for detection



Synthetic data visualizations are powerful mission design tools

Low cost and easy-to-iterate demos show capability without high investment

Background image credit: ESO/L. Calcada