

WHITEPAPER - UNCLASSIFIED

Understanding Satellite Maneuver Intent for Real-Time Predictions and Alerts

Problem: Within current Space Domain Awareness (SDA) tools there is an inability to identify, observe, analyze, and predict Patterns of Maneuvers (PoM) for Resident Space Objects (RSO) to protect high-value space assets from proximity operations and safely conduct Orbital Engagement Maneuvers (OEMs). Current SDA software tools lack a near real-time, intuitive, and informative user interface for rapid, accurate, and informed assessments of historical, current and predictive RSO pattern activity. Current capabilities are workforce intensive, subject to human bias, and confined to networks with limited access by personnel with a need to know.

Need for Pattern of Maneuver Analysis Tool (PoMAT): USSPACEFORCE Deltas Two, Seven, and Nine and the National Space Defense Center all have the need to:

- Observe and document the full spectrum of activities and interactions of all RSOs
- Maintain a robust understanding of RSO associations and behaviors
- Determine RSO onboard-technologies to develop an understanding of potential vulnerabilities for Intelligence Preparation of the Battlespace.

None of the current orbital analysis, maneuver and anomaly detection software services label, catalog and utilize Artificial Intelligence classification services to identify satellite activity patterns of interest nor predict RSO maneuvers based on Pattern of Life behaviors.

PoMAT Description: PoMAT (*Figure 1*) was built under an AFWERX Phase II Small Business Innovative Research (SBIR) contract (FA864921P0784) from MAR 21 – JUN 22. Originally built for Delta Nine on an unclassified network, PoMAT was designed to ingest satellite location data (e.g., Two Line Element Sets) and provide a rapid, accurate, and intuitive decision tool for OEM planning, asset protection and advanced warnings (up to seven-days) of foreign proximity operations.

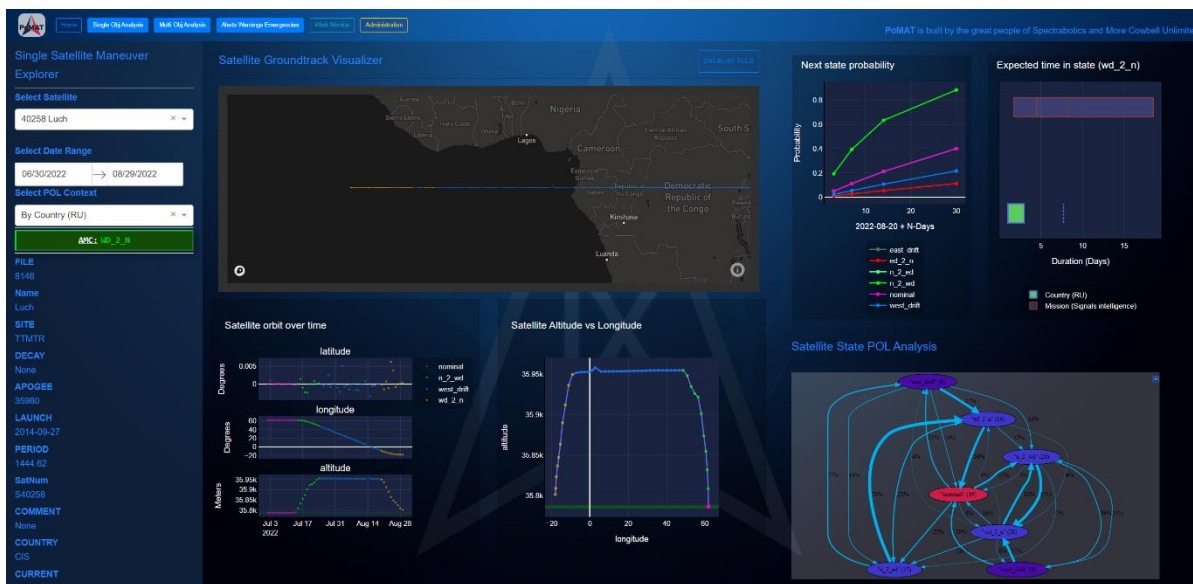


Figure 1 - PoMAT User Interface for Single Object Analysis

PoMAT utilizes a Deep Learning altitude-based pattern classifier to identify maneuver pattern activity and provide alert notifications for RSO maneuvers and location changes within the GEO Belt. The impact to Delta Nine is a reduced workload for prioritization, additional planning time

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for mission preparation, an *enhanced* Space Domain Awareness (eSDA) of foreign satellite activities of interest, and an understanding of future satellite behaviors for threat assessments and resource planning. PoMAT automates the detection, classification, and prediction of space maneuvers and provides Space Operators and Analysts with key insights into space activities and emergent patterns that inform rapid decision-making.

PoMAT In

Action: *Figure 2* is an example detection of a 14-day orbit station keeping cycle performed by the Ground Station.

The two spikes found by PoMAT identify successive thrusts, frequency, and timeline over the lifetime of the satellite. PoMAT maneuver predictions use this POL to derive actionable statistics and determine prioritization for alert activities.

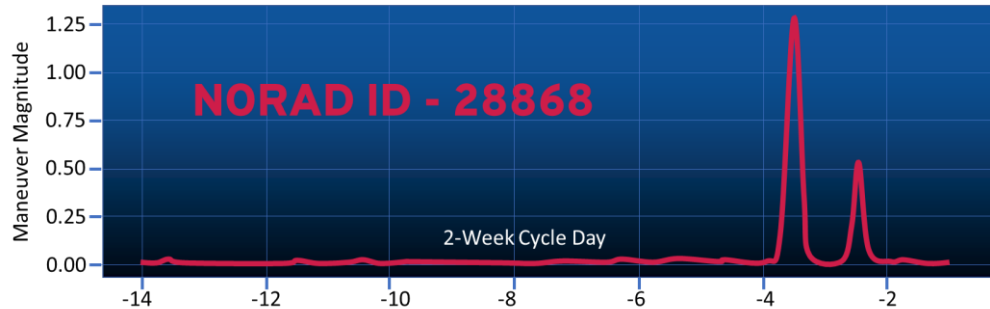


Figure 2 - Routine RSO Station Keeping Maneuvers

PoMAT Experimentation: Spectrabotics demonstrated PoMAT during the Joint Commercial Office (JCO) Sprint Advanced Concept Training (SACT) 22-3. PoMAT responded to both simulated and real-world space information requirements using a variety of commercial and Government satellite location services and data formats. During the SACT, PoMAT highlighted the benefits of close collaboration with data providers (Kratos, ExoAnalytics) and how pattern classification identifies foreign RSO intentions. Spectrabotics was invited to pitch PoMAT at the AUG 22 Delta Innovation Collaborative Exchange (DICE) and Delta Innovation MAT Exchange (DIME).

Sustainment: PoMAT is a SaaS model and requires developer and Subject Matter expertise to sustain and expand its services. At a minimum and in its current state PoMAT can be managed by five to seven personnel with expertise in Artificial Intelligence, mathematics, software development, and space subject matter expertise. Expanding PoMAT will require additional personnel to build further services and derive added intelligence value from data stores and analytic services. These services include additional pattern classifiers that identify on-board technologies, Tactics, Techniques and Procedures (TTPs) for maneuvers mapped to space missions, vulnerability assessments, maneuver predictions, and Ecosystem analysis for advanced indications and warnings of threat activities. Additional funding is needed to transition to classified networks.

Spectrabotics, LLC is a Colorado Springs, Colorado, based, Veteran-owned small business that uses Artificial Intelligence, Machine Learning, and Pattern of Life Analysis to explain Resident Space Object (RSO) behaviors for enhanced Space Domain Awareness (eSDA). CEO/Founder is a 21-year DoD Space professional.