Orbit Determination Services

Introduction:

The Vyoma Orbit Determination Service helps obtain orbital information of space objects of interest in a timely and transparent manner. The service is based on dedicated tracking campaigns executed through the Vyoma sensor network, consisting of globally distributed telescopes covering all longitudes and orbital regimes from LEO through GEO. Next to providing an accurate estimate of the orbit itself – e.g., following orbit insertion, after a maneuver, or simply during normal operations, this service also provides a propagated trajectory as well as the uncertainty evolution of the object in the form of an Orbit Ephemeris Message (OEM). Additionally, access to Vyoma's validation service is also provided, where the solutions can be compared to other sources such as special perturbation ephemerides.

1.1 On-demand Tracking

The scope of the service is to provide customers with tracking data of space objects of interest, processed from images/data taken from a global network of sensors (see Table 1). The Tracking Data Messages (TDMs) contain angular or range/range rate information of the space object of interest. Additionally, the raw observations are made available to the Customer.

Sensor	Type	Country	Latitude	Longitude	Online
PAN2	Optical	Spain	38.2°N	6.6°W	yes
IDG	Optical	Spain	38.2°N	2.3°W	yes
SHOT	Optical	Czech Republic	50.6°N	13.8°E	yes
BAP	Optical	France	44.4°N	5.5°E	yes
OBO	Optical	Poland	52.6°N	17.1°E	yes
KRA	Optical	Poland	50.1°N	20.1°E	yes
RAN	Optical	Italy	44.4°N	10.6°E	yes
SPR	Optical	Namibia	23.5°S	18.0°	yes
ANJ	Optical	Japan	36.5°N	137.8°E	yes
SLR3	Optical	Australia	31.3°S	149.1°E	intended
BEA	Optical	USA	35.3°N	105.6°W	yes
CHI	Optical	Chile	22.9°S	68.2°W	intended

Table 1. Vyoma sensor network, enabling coverage of objects in any altitude, longitude or inclination

Vyoma performs a data quality check on the information extracted from the observations, and automatically removes false associations and outliers. A screenshot of the dashboard is given in Figure 1. In the near future, the network will be extended with further sensor stations, including laser ranging stations to further increase orbit determination accuracy.

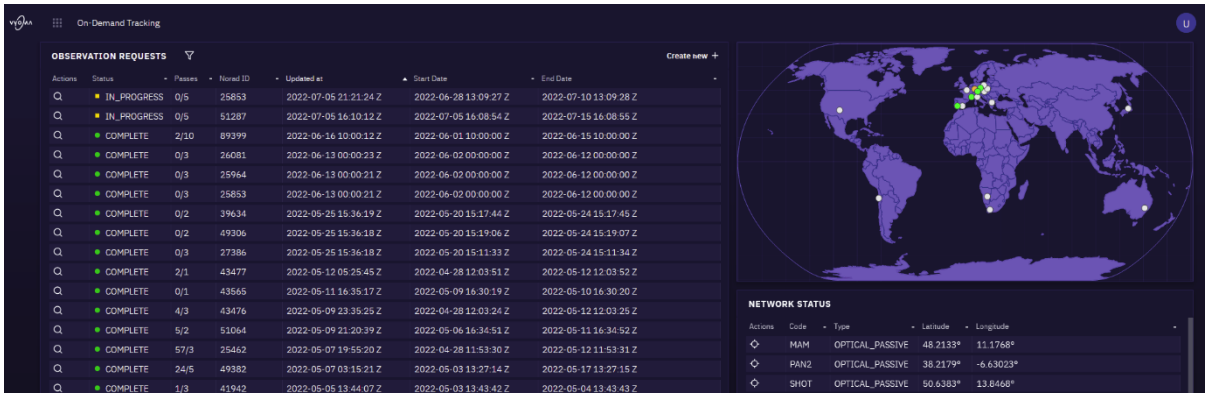

Figure 1. Dashboard of the Vyoma On-Demand Tracking Service.

Benefits to operators: Access to an independent source of data, high levels of transparency.

1.2 Orbit Determination

Based on dedicated tracking data from the Vyoma network, fused with – if available – third party data such as special perturbation ephemeris from USSPACECOM, Vyoma can provide operators with precise and timely Orbit Data Messages (ODMs). Next to the state itself, trajectory and uncertainty information is provided in the form of Orbit Ephemeris Messages (OEMs), containing the propagated mean state and covariance for 7 to 14 days into the future.

Next to providing the operator with a second opinion on the location of the satellite, the service is especially useful for obtaining an initial state rapidly after orbit insertion, or a performed manoeuvre, and to update chaser information in conjunction events.

The expected accuracy depends on the to be observed object itself (size, altitude, etc.) as well as weather conditions. For a Microsat in a 500 km circular orbit – challenging for optical sensors due to its low altitude and small size – radial and cross-track errors below 10 m are achieved with our network after a 3 – 5 day convergence period. The 3D position RMS errors (i.e., including along-track) are less than 100 m in 82% and 99% of the time for cloud coverage of 75% and 50%, respectively (see Figure 2). With the planned network expansion to space-based sensors, the equivalent tracking success rates of 50% and more shall be achievable by early 2024.

Benefits to operators: Access to an independent source of orbital information of their assets, timely provision of updated states, inclusion of uncertainty information.

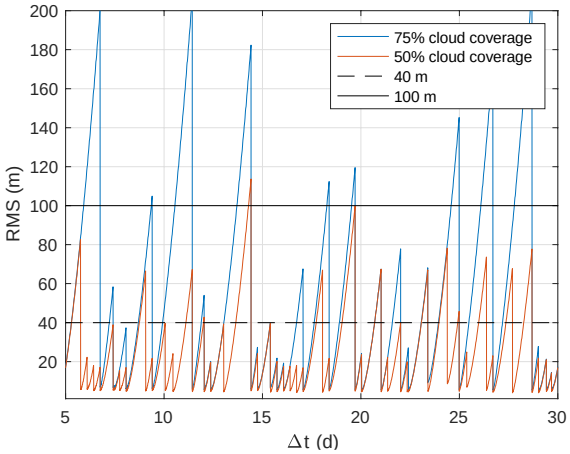

Figure 2. Representative example of the orbit determination accuracy (3D position RMS) of a Microsat in 500 km circular orbit when observed by our 12-station network under two different cloud-coverage scenarios.

Figure 3. Image taken of 2022-033N / 52169 by SHOT on the night of 3 August.