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## Multi-mission Ground Segment as a Service

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### Abstract

As the satellite industry grows increasingly complex, operators face mounting challenges in managing mission operations efficiently while maintaining high reliability and scalability. KSAT’s integrated multi-mission operations service addresses these challenges by unifying ground network services, satellite operations, and mission planning into a seamless, highly automated platform. Operated by a highly trained multi-mission team, this approach minimizes operational complexity, reduces risk, and ensures mission resilience, allowing satellite owners to focus on maximizing the value of their data rather than managing infrastructure.

By leveraging automation, event-driven anomaly detection, and a globally distributed ground segment, KSAT delivers a highly available and scalable solution tailored to both commercial and government missions. This whitepaper explores the benefits of a fully integrated operations model, detailing how KSAT’s approach—combined with expert operators—enhances efficiency, improves responsiveness to anomalies, and enable mission success in an increasingly dynamic space environment.

**Keywords:** multi-mission operations, ground-segment-as-a-service, satellite operations, mission operation service

### Acronyms/Abbreviations

Anomaly Response and Resolution Protocol	ARRP
Artificial Intelligence	AI
Concept of Operations	ConOps
Ground-Segment-as-a-Service	GSaaS
Kongsberg Satellite Services	KSAT
Mean Time to Acknowledge	MTTA
Mean Time to Resolve	MTTR
Mission Control Systems	MCS
Mission Operations Team	MOT
Multi-Mission Monitoring System	MMS
Satellite Operations Engineers	SOE

### 1. Introduction

Kongsberg Satellite Services (KSAT), known as the world leading Ground Network and Earth Observation service provider, has over the last few years expanded its service portfolio into Satellite Operations, enabling satellite owners to focus on downstream data, connectivity, or other services, instead of operations. KSAT provide satellite owners with a fully integrated Ground-Segment-as-a-Service (GSaaS) through the Mission Operations Service, which currently supports twelve spacecraft in orbit, a number that will exceed twenty satellites by the end of 2025. The service is based on the expertise of trained operations teams, adept in the technical difficulties of mission management, and with experience from different missions.

Operating a satellite involves far more than its launch into orbit. Traditionally, satellite owners have had to establish and maintain their own operations centers, needing to invest in personnel, infrastructure, and software. The management of a single satellite – or a constellation of them – requires continuous monitoring of telemetry, command sequences, mission control, flight dynamics data handling and a methodical approach to address emerging challenges.

As satellite constellations expand and missions grow in complexity, the demand for efficient, scalable, and automated satellite operations increases.

KSAT’s multi-mission operations service provides a comprehensive and integrated solution for satellite management, incorporating ground network services, satellite control, mission control, flight dynamics, and data management. The structure improves scalability and predictability of the system. Reliable and secure operations are crucial for protecting downstream revenue by guaranteeing consistent satellite performance and uninterrupted data delivery.

Through the integrated mission operations service, satellite owners can concentrate on generating downstream value from payload data, while all aspects of satellite operations – from integration with ground network services and data management to mission planning and flight dynamics – are managed by KSAT.

Whether supporting the ESA Arctic Weather Satellite or GHGSat’s methane-monitoring constellation, KSAT has a proven history of operational excellence and remains committed to ensuring optimal satellite performance.

## **2. Challenges of Mission Operations**

Performing multi mission, multi bus operations in a scalable manner have some significant challenges from both a technical and operational perspective. These vary from the implementation and utilization of mission specific singularities such as the protocol stack, mission specific flight software, telemetry and telecommands definitions, automation of routine activities, among others.

On the operational side, challenges are related to onboarding the mission specific Concept of Operations (ConOps) into a multi-mission operational team, which requires a comprehensive understanding of the mission specific bus, its modes of operations, procedures, anomaly recovery processes and escalation routines.

These challenges can limit a satellite owner’s capability to change bus providers while going from one generation of spacecraft to the next as it puts a significant load onto in-house resources. KSAT is enabling, through the Mission Operations service, to reduce such industrial lock-ins and provide a flexible solution suitable for most bus manufacturers with a single operational interface.

Operating a spacecraft needs a variety of specialized resources. It includes operators trained for the mission, system engineers proficient in data management and customized software solutions, a flight dynamics team that understand the complex orbital physics, and engineers with knowledge about ground networks and their integration with spacecraft.

Satellite owners often need customized solutions to solve their problems, using fragmented service providers. KSAT helps satellite owners to manage the process and simplifies it. Through an extensive process, KSAT’s Mission Operations Team (MOT) have identified effective operational procedures, what alerts to escalate on, and the information and methods most suitable for different mission types.

KSAT’s service ensures that the health, orbit adjustments, communication, and functionality of satellites are all consistently monitored and maintained throughout their entire lifecycle, ensuring secure, efficient, and reliable operations at all stages. The integrated approach allows customers to shift focus to market impacts, leaving the complexities of satellite operations to be managed by a dedicated team. KSAT is fully multi-mission operational and is not limited to specific satellite buses or Mission Control Systems (MCS).

## **3. Technical Architecture**

The Mission Operations service delivers a modern and scalable solution by integrating KSAT’s specialized operations teams, global ground network, and multi-mission control system. This approach provides an adaptive



The Satellite Control System manages mission-specific configurations, including protocol stacks, telemetry, and telecommand definitions. Meanwhile, the Mission Planning System automates and orchestrates operational components to streamline execution.

A key objective of the architecture is reusability across missions while simplifying payload control for end users. The solution enables satellite owners (or the payload planner) to manage payload prioritization through a standard interface. Through this interface, the payload planning entity can provide tasking input such as Areas of Interest (AOIs), payload configurations, among others. KSAT’s system then automatically translates these requests into executable commands, ensuring efficient uplink scheduling. This allows satellite owners to optimize asset utilization without needing to manage day-to-day Mission Operations.

To further enhance scalability, KSAT has developed an in-house monitoring system that collects and analyzes data from all operational systems. This system automates service monitoring, anomaly detection, and recovery processes, reducing the need for manual intervention.

#### **4. Event-Driven Operations Concept**

KSAT’s Mission Operations service is designed to minimize the need for human intervention and utilize automation both for planning, execution, and system monitoring, leaving manual resources to be focused on edge cases.

At the core of operations lies the internally developed Multi-Mission Monitoring System (MMS), which continuously monitors the health and performance of all missions on orbit, enabling an automated cross system workflow which retrieves data, analyzes it and initiate routine and recovery actions.

The data collection process is done continuously for assets which can be monitored in real-time but is also triggered by events such data availability after downlinking spacecraft data. The system collects data from any asset that could impact the operations of the spacecraft to perform a quality assessment of the mission status. These data sources include, among others:

- Spacecraft telemetry and on-board events
- Ground network performance
- Conjunction detection messages
- Data and files transfers
- Infrastructure performance
- Log files

After data collection, the MMS analyzes the performance of the system. This is done based on pre-defined thresholds and long-term trending. If an anomaly is identified, the system automatically escalates it, and an anomaly state is established, which kicks off a workflow that checks if there exists an automated recovery action for this anomaly. If it does, an anomaly ticket is generated, and the automated recovery is initiated.

If the automated recovery fails, or there does not exist a pre-defined recovery action, the anomaly will be escalated to our MOT. The MOT is a global team of trained and experienced professionals consisting of Satellite Operations Engineers (SOE), System Engineers, Project Engineers, among others.

The escalation of an anomaly from the MMS will notify the SOE on duty of the ongoing anomaly. From there the SOE will follow an established protocol for each mission to confirm the spacecraft is in a safe state and initiate the pre-defined Anomaly Response and Resolution Protocol (AARP) to initiate recovery from the anomaly.

As the anomaly is resolved and the root cause is identified, KSAT will close out the incident ticket and perform a lesson learned to improve future operations. In this process, concise communication with the customer is key.

Figure 3 presents a distribution of the anomaly recovery from the Mission Operations service during the preceding months, showing that two out of three anomalies are automatically recovered by the system today. This percentage is

under continuous development as automatic recoveries are deployed after manual recoveries have been tested and validated by the MOT.

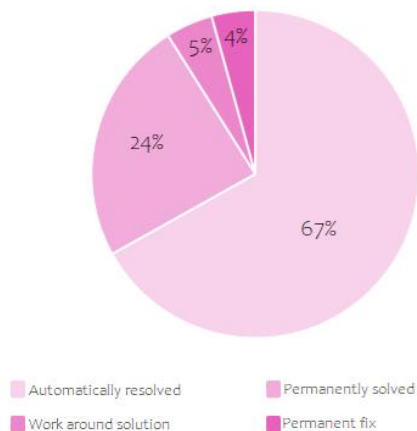


Figure 3 – Anomaly recovery distribution from the MMS

Although the service is provided in an automated manner, resilient operations team with specialized skills are available when anomalies occur to prevent operational unavailability of the platform and the payload. To ensure this resilience, KSAT has established geo-redundant operations centers in Tromsø, Norway and Denver, Colorado, providing follow-the-sun capabilities as well as operational resilience.

The team utilizes a core set of standardized operational processes and procedures for operations across missions and platforms. These procedures are adapted to accommodate the mission-unique elements of day-to-day operations, thus enabling mission specific adaptations while maintaining a standardized framework. Furthermore, this cross-mission exposure provides the MOT with unique operational expertise where the experience of an anomaly of a given mission can provide insight into how to best solve or work around an issue with a different bus.

Since the recovery of an ongoing anomaly depends heavily on mission-specific elements such as upcoming ground station contacts, anomaly severity, mission ConOps, among others, KSAT has chosen to measure anomaly response times based on:

- Mean Time to Acknowledge (MTTA) which is:  
The interval from anomaly detection on ground to acknowledgment by SOE. The SOE will initiate the Anomaly Response and Recovery Protocol.
- Mean Time to Resolve (MTTR) which is:  
The interval from anomaly detection on ground to confirmed recovery of the anomaly.

The KSAT MOT is highly efficient and dedicated to restoring nominal operations and has operated over the preceding 4 months with an average MTTA of 6 minutes and an average MTTR of 1 hour and 38 minutes. Figure 4 and Figure 5 illustrate the overall trend of MTTA and MTTR over the past 4 months.

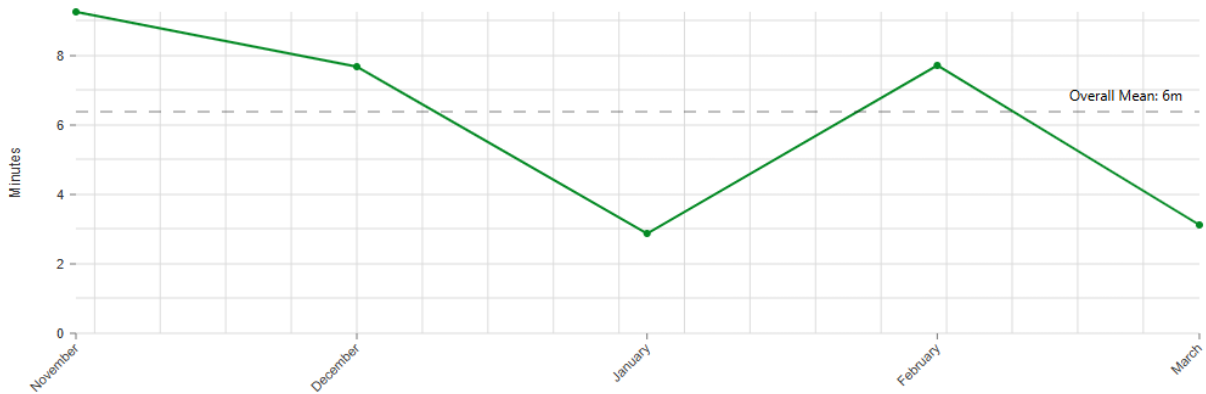


Figure 4 – MTTA from 01.11.24 (extracted 17.03.2025)

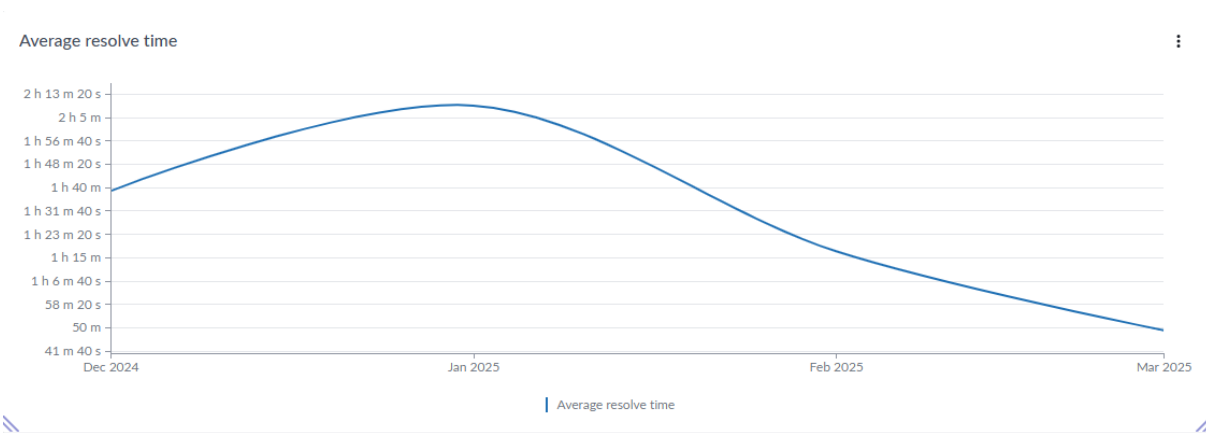


Figure 5 – MTTR for the past three months (extracted 18.03.2025)

## 5. Modular Service Offering

KSAT has implemented a modular service model designed to accommodate the diverse operational needs of satellite owners. At its core, a standardized baseline service ensures cost-efficient mission operations, which can be tailored with optional enhancements to meet specific service level requirements.

Routine operations are conducted from two operations centers, strategically located in different time zones, eight hours apart. This setup enables a "follow-the-sun" model, providing 16 hours of on-console support during standard working hours and ensuring continuous mission oversight.

By integrating in-house Ground Network, Satellite Operations, and Flight Dynamics capabilities, KSAT delivers a seamless and highly responsive mission management solution. This unified approach enables rapid diagnosis and troubleshooting, reducing downtime and operational complexity while maximizing mission efficiency. The streamlined data flow and close coordination between ground network and satellite operations significantly enhance overall reliability and responsiveness.

In day-to-day operations, the MOT is responsible for executing all on-console tasks. Each team member undergoes comprehensive training and certification, combining KSAT's standardized Mission Operations onboarding with mission-specific training plans. To maintain operational excellence, MOT members follow a strict certification and recertification process. This process, developed in collaboration with satellite owners, ensures that all operators meet the necessary qualifications to manage each mission safely and effectively manage each mission. Recertification follows a structured schedule, ensuring all team members remain up to date and fully certified for ongoing mission needs.

## **6. Into the future of Mission Operations Services**

The Mission Operations service has experienced significant growth over the last few years from handover of on-orbit assets, to performing LEOP and commissioning of ESA’s Arctic Weather Satellite, through standardization of the service and development and integration of the MMS.

Customer focus has been essential for KSAT for more than 50 years of facilitating solutions. Open discussions about challenges together with the spacecraft owners and manufacturers have led to better solutions, and customer feedback helps optimize satellite operations for everyone involved.

Moving forward, the focus will be on identifying areas for expansion and improvement. KSAT is eager to collaborate with both existing and new clients to enhance service offerings and broaden knowledge in new fields. The focus areas will be to improve scalability, reduce costs, ease of use, and find new ways to manage increased data load from an increasing number of missions.

One identified area is Artificial Intelligence (AI), which has the potential to proactively address incidents on spacecraft. AI can be deployed and used to make the Mission Operation service more effective by continuously assessing trends, correlations and to detect system issues before they become anomalies, and take corrective actions automatically, reducing the need for human intervention. These technologies enhance autonomous operations, improve situational awareness, and improve decision making processes. This will reduce the workload on operators, making the system more scalable with less investment in resources.

On the programmatic level KSAT plans to continue to automate testing for onboarding, which significantly reduces the time required to integrate new mission. This streamlined process ensures that each mission meets rigorous quality standards from the outset, allowing for rapid deployment and minimizing the variability typically associated with customized onboarding. As a result, satellite owners can transition more quickly from setup to full operational status, accelerating mission readiness while maintaining high levels of reliability and performance.

## **7. Conclusion**

Satellite operations have evolved into a specialized and complex field, requiring not only significant infrastructure but also the expertise to manage increasingly sophisticated missions. As satellite constellations grow and the demand for efficiency rises, the need for a comprehensive and scalable operations solution becomes ever more critical.

KSAT’s multi-mission operations service provides a streamlined, adaptive solution that integrates satellite control, flight dynamics, data management, and mission planning. By leveraging KSAT’s expertise and global ground network, satellite owners can focus on their core mission objectives, knowing that every aspect of satellite operations is in capable hands.

The integration of a unified user interface, automation, and standardized processes ensures seamless, efficient, and reliable operations, allowing satellite owners to utilize a multi-mission service offering and focusing on generating value from their payload data, instead of building in-house capacity and operational systems.