

First and Most Advanced Space Monitoring Station in the Middle East Assures Reliable and Authorized Satellite Services



Case Study: The Telecommunications Regulatory Authority of Oman



Located at the mouth of the Gulf at the south-east corner of the Arabian Peninsula is Oman—one of the oldest states in the Arab world. The country is bordered by the United Arab Emirates, Saudi Arabia, and Yemen. With a population of almost 5 million, Oman covers an area of 119,500 square miles, making it slightly smaller than Poland, or about twice the size of the US state of Georgia.

Growth of Telecom in Oman and Rising Threats to Spectrum

With a growing global satellite environment in the region, the Telecommunications Regulatory Authority (TRA) of Oman has been at the forefront of modernizing its telecommunications infrastructure and regulating the telecom market to benefit the economy.

The TRA of Oman was well aware that with the rapid rise in the number of radio communication networks and wireless devices an increasingly dense signal environment was emerging. This raised concerns that the frequency spectrum would become congested leading to potential increases in interference and that illegal transmissions would occur more frequently.

Yousuf Al-Balushi, Vice President for Spectrum Management Affairs for Oman's TRA, explained "Satellite spectrum is a scarce national asset that can be subject to unauthorized usage, interference and other threats."

Foreseeing this issue and to protect the satellite spectrum, the TRA of Oman put a plan in place to develop a one-of-a-kind satellite monitoring station in the region with the goal of guaranteeing reliable licensed satellite services and interference-free operation.

Building the Most Advanced Space Radio Monitoring Station (ASRMS)

In 2014, after evaluating offers from multiple vendors, the TRA of Oman selected Kratos to implement a turnkey Advanced Space Radio Monitoring Station (ASRMS).



The Kratos solution has been selected because of Kratos' extensive experience in the arena of space radio monitoring systems. The ASRMS will enable us to better manage the satellite spectrum used in the Sultanate and provide for improved cooperation with other

telecommunications regulatory agencies.

Yousuf Al-Balushi, Vice President for Spectrum Management Affairs for Oman's TRA

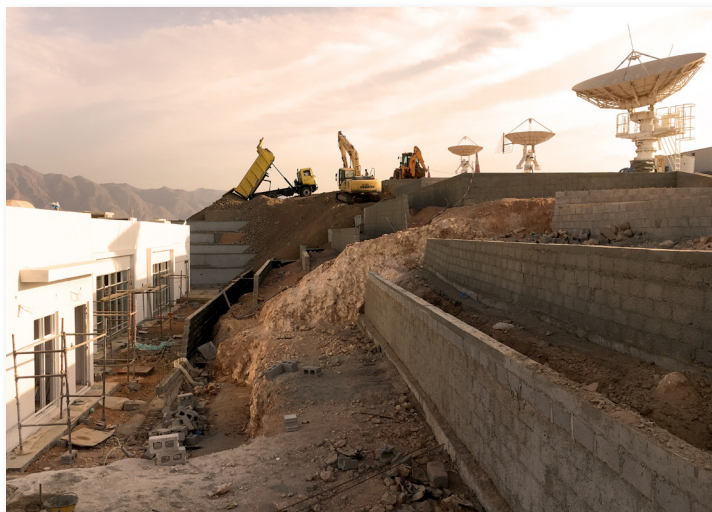
Over the next few years, Kratos worked with the TRA of Oman to build a turnkey radio monitoring station.

Design

In the engineering phase of the project, the TRA of Oman led the effort with the support of Kratos in completing the Critical Design Review (CDR). The completion of this phase demonstrated that the design would exceed the requirements of the project and that the team could move to the full-scale fabrication, assembly, integration and testing of the ASRMS.

Build Out

Starting with a completely barren site, Kratos managed the build-out to support the ASRMS. This included the



Large-scale build out of the ASRMS.

installation of the antennas—one of the most critical parts of the implementation. The TRA of Oman wanted to monitor signals from geostationary satellites in the orbital arc covering an extremely wide area from Europe to Asia. The challenge was to cover all available extended frequency ranges with all polarizations using full motion antennas or large antennas with very advanced and reliable tracking systems. To meet this need, seven separate multi-band antennas developed by Kratos ranging in diameters from 3.7M, 6.2M to 7.3M and covering L-, S-, C-, X-, Ku-, Ka-bands were installed successfully. This enabled the ASRMS to cover a world-leading range of 1GHz to 40GHz.



Kratos' state-of-the-art antennas for advanced monitoring.

Control and Monitoring Center

Kratos also constructed a data center, control and monitoring center including the security system, back-up power generation and inter-site connectivity to protect against any outages and assure connectivity.

In the control and monitoring center, Kratos deployed its GeoMon—geographical monitoring solution specifically designed to simplify spectrum and licensing operations for regulators. GeoMon enables the TRA of Oman to identify authorized and unauthorized satellite communication signals, manage the satellite spectrum, and enhance cooperation with other telecommunications regulatory agencies.



TRA of Oman's monitoring staff performing regulatory missions.

GeoMon Architecture

GeoMon is an end-to-end regulator solution with a graphical user interface and centralized database that displays satellite and ground views. GeoMon integrates with the TRA of Oman's frequency management system to access spectrum license information and Kratos' industry leading monitoring products to direct operations and collect measurement data. All the data from these systems is consolidated into GeoMon's centralized database for analysis and reporting.

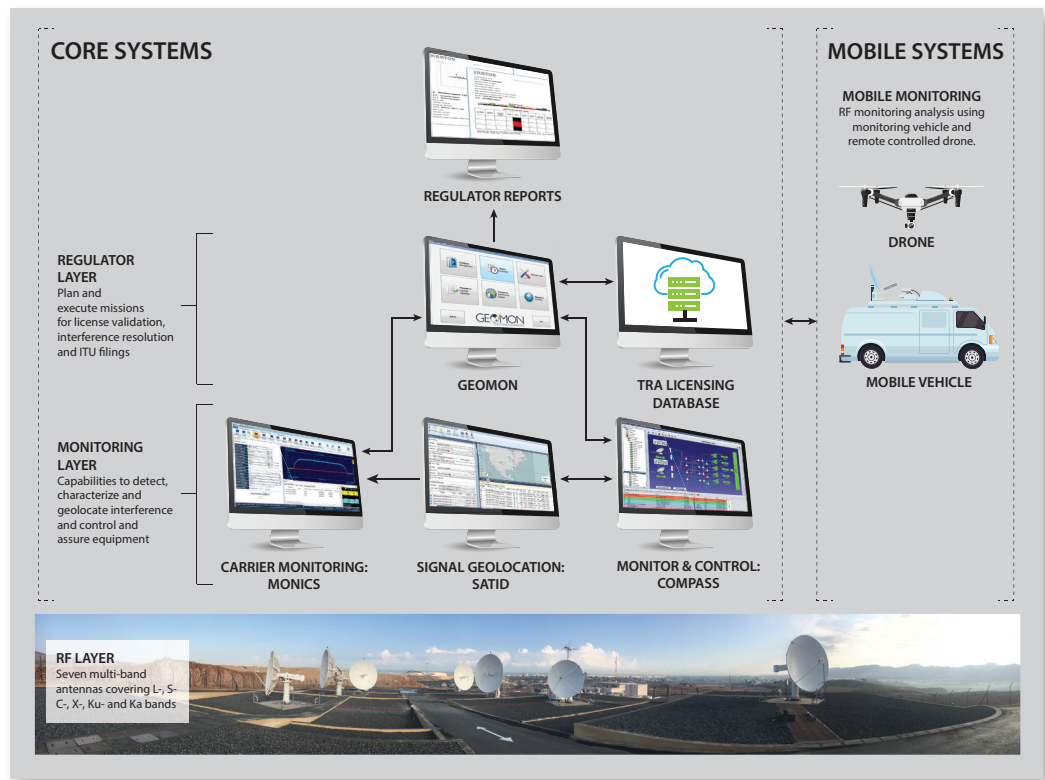
Regulator Operations: Detect, Locate and Resolve

Using GeoMon as a centralized management system, the TRA of Oman operations staff is able to:

- Command Compass, a monitoring and control product to direct antennas to satellite orbital positions including paths, polarizations and the flow of signals. The team is also able to control and monitor all the radio equipment and view alarms indicating problems or the malfunction of equipment
- Send measurement requests to Monics, the carrier monitoring software that detects and analyzes radio signals received from satellites and delivers the frequency and time domain measurements to provide the most advanced interference protection
- Geolocate the signals received in the downlink (Space-to-Earth) using the satID product to determine the location of unlawful usage and transmissions originating from Oman and the location of the radio signals that cause interference

Mobile RF Monitoring

Beyond fixed site monitoring, Kratos delivered mobile RF monitoring capabilities for the TRA of Oman. This included using a vehicle with antennas and monitoring equipment to track the satellite services in the Uplink (Earth to-Space)



TRA of Oman's Concept of Regulatory Operations Using GeoMon.

and the Downlink (Space-to- Earth) to determine the location of authorized or unauthorized transmissions. In addition, in areas with rough terrain and high elevation, Kratos provided a remote controlled RF monitoring drone named Moscito that performed last mile geolocation to identify unlawful usage of the spectrum and interference in the Uplink (Earth-to- Space).



TRA of Oman's staff in the RF monitoring vehicle locating the source of interference.

Optimizing Regulatory Missions

With GeoMon's powerful capabilities, the TRA of Oman's operators plan, schedule, execute and automate missions as well as create reports for license validation, interference

resolution and ITU filings. With a few clicks TRA of Oman's operators can generate results and reports that:

- Validate carriers or licenses by automatically checking expected EIRP, center frequency and bandwidth based on a RF downlink measurement
- Locate interference by collecting interference events and booking antenna resources to perform a geolocation mission to pinpoint the source
- Perform ITU filing or orbital slot scanning by automatically performing a blind scan and comparing the spectrum measurements with all known satellites in this specific space position to identify any issues



GeoMon performs three main missions to protect the RF spectrum effectively for the TRA of Oman

ASRMS: Final Acceptance Tests and Handover

After the final acceptance tests, Kratos completed the ASRMS and handed over authority to the TRA of Oman in May 2017. The official opening of the station occurred on January 17th 2018 with the presence of Houlin Zhao, Secretary-General of the International Telecommunication Union (ITU).

"With this launch, the Sultanate has been placed on the world map in the field of spectrum management", said Yousef bin Abdullah al Balushi. The station is the first of its kind in the Middle East and the ninth in the world according to the ITU.

The ASRMS is capable of monitoring an extremely wide area from Europe to Asia. Kratos continues to work closely with the TRA of Oman sharing spectrum monitoring expertise and supporting the Sultanate in running the most advanced regulatory operation in the region.



Aerial view of TRA of Oman's ASRMS.

State-of-the-Art RF Monitoring and Geolocation

Using the ASRMS, the TRA of Oman has defined over 200 satellites with 2000 transponders to manage more than 800 licenses. This allows the TRA of Oman to effectively safeguard the RF spectrum as a national resource and to:

- Control the use of frequency spectrum and space resources by verifying that existing uses are compatible with the radio licenses granted by the TRA
- Monitor and measure satellite signals within the Sultanate and in neighboring countries, with the capability of verifying cases of interference at the regional, national and international level
- Detect and resolve accidental and intentional interference by identifying and then geolocating the source from within the country or from neighboring nations
- Coordinate with the ITU and other regulators by providing monitoring services and satellite data to minimize cases of interference
- Support national projects and activities related to space services such national satellite launches and allocations of orbital positions and frequencies in accordance with the ITU



The A.S.R.M.S. has exceeded all our expectations, and we are very pleased with Kratos' ability to deliver on time and within budget on such a large scale effort. They were uniquely positioned in the industry to deliver on this project.

Yousef Al-Balushi, Vice President for Spectrum Management Affairs for Oman's TRA