

The Telecommunications Regulatory Authority of Oman Builds  
First and Most Advanced Space Radio Monitoring Station (ASRMS)

**HELPS GUARANTEE RELIABLE  
AUTHORIZED SATELLITE SERVICES AND  
INTERFERENCE-FREE OPERATIONS**



**KRATOS®**

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.

## GROWTH OF TELECOM IN OMAN

Over the years Oman has undergone an extensive modernization program which has included developing a sophisticated telecommunication infrastructure. With a growing global satellite environment in the region, the Telecommunications Regulatory Authority (TRA) of Oman has been at the forefront in developing the

telecommunications infrastructure and regulating the telecom market to benefit the economy.

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

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

## FACTS ABOUT OMAN



**OLDEST**  
INDEPENDENT STATE  
IN THE ARAB WORLD

**119,500**  
SQUARE MILES



POPULATION OF ALMOST  
**5 MILLION**



TELECOMMUNICATIONS REGULATORY AUTHORITY (TRA) OF OMAN UNDERWENT A MODERNIZATION PROGRAM THAT DEVELOPED A SOPHISTICATED

**TELECOMMUNICATION INFRASTRUCTURE**



## TELECOMMUNICATIONS REGULATORY AUTHORITY (TRA)

“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 from interference, unauthorized usage and other threats, 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.

The TRA of Oman’s plan was to create a state-of-the-art Frequency Monitoring and Geolocation system, on a completely new site, with the aim of detecting, measuring, geolocating and storing all received space-based signals by covering a world-leading range of 1GHz to 40GHz. This would allow the TRA of Oman to verify authorized and licensed transmissions and identify, then locate, unauthorized transmitters to prevent harmful interference.



“Satellite spectrum is a scarce national asset that can be subject to unauthorized usage, interference and other threats.”

**Yousuf Al-Balushi,**

Vice President for Spectrum  
Management Affairs for Oman’s TRA

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," explained Yousuf Al-Balushi.

## TIMELINE FOR IMPLEMENTATION OF THE ADVANCE SPACE RADIO MONITORING STATION

**2015**

### DESIGN STAGE

- Completing the final design stage
- Commencement of civil works at the project site after obtaining the required approvals and licenses.

**2017**

### TESTING

- Final acceptance tests
- Hand over of the Advance Space Radio Monitoring Station and start of operations

**2014**

### EVALUATION

- Evaluation of offers received from suppliers worldwide.
- Contract signing with Kratos to serve as the turnkey provider to design, build and install the station.

**2016**

### INSTALLATION

- In-factory testing of the station's systems
- Completion of civil works (building construction, installation of antennas, etc)

**2018**

### OFFICIAL OPENING

- Official opening of Advance Space Radio Monitoring Station on January 17



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**Yousuf Al-Balushi,**

Vice President for Spectrum Management Affairs for Oman’s TRA

The scope of work for the ASRMS included building a fixed radio monitoring station to monitor space services in the downlink (Space-to-Earth), the provision of a drone monitoring the uplink (Earth-to-space) as well as a vehicle serving as a state of the art mobile space station to monitor radio communications in both directions. The project also included the delivery of all the systems and equipment necessary for space monitoring.

The ASRMS is a unique satellite monitoring and geolocation solution specifically developed to help the TRA of Oman identify authorized and unauthorized satellite communication signals, manage the satellite spectrum efficiently, and enable improved cooperation with other telecommunications regulatory agencies.

“Systems such as ASRMS are becoming increasingly important to satellite frequency regulators as multi-beam HTS satellites and MEO satellites make spectrum more congested, more challenging to track satellite communications (SATCOM) signals and more critical to the management of the spectrum in use in their countries,” said Bruno Dupas, President of Kratos Integral Systems Europe.

Over the next two years, Kratos worked with the TRA of Oman to build a turnkey radio monitoring station. The work included developing a new site, completing all the ground works, constructing a new building, installing the antennas and implementing and commissioning all the electronics reception and processing systems.



## STATE-OF-ART ANTENNAS FOR ADVANCED MONITORING

**The state-of-the art space monitoring station was developed according to these key milestones:**

### DESIGN PHASE

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 effort 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/CONSTRUCTION/ INSTALLATION/TESTING

Starting with a completely barren site, Kratos managed the build-out of the extensive civil works to support the ASRMS. This included delivering

the power and water from the municipality to the site and constructing a monitoring station building including the security system, back-up power generation and inter-site connectivity.

This phase also included the 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.



## SUPPORTING REGULATORY MISSIONS IN THE CONTROL AND MONITORING CENTER

### CONTROL AND MONITORING CENTER

#### The Heart of the SRMS

In the radio monitoring station, Kratos built-out a datacenter with secure servers to support the mission critical monitoring applications. The data center included advanced power management and secure redundant inter-site facilities to protect against any outages and assure connectivity.

A control and monitoring center was also constructed with several large displays to

operate the station and control all the equipment and systems.

### CENTRALIZED MANAGEMENT

In the 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 CONCEPT OF REGULATORY OPERATIONS

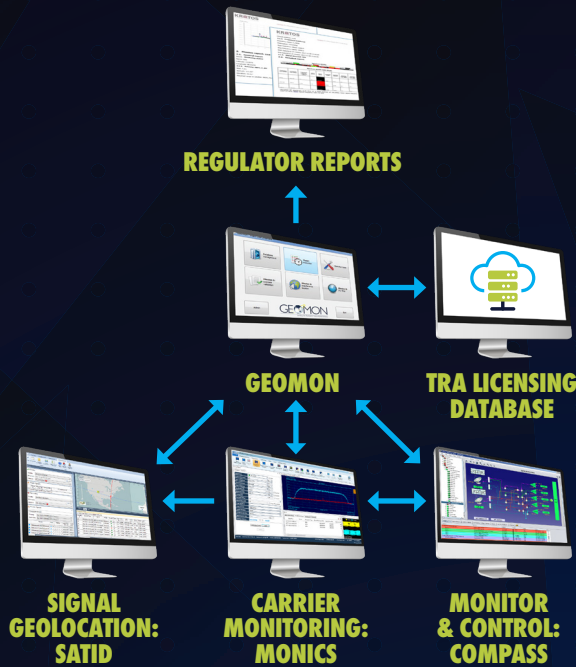
## CORE SYSTEMS

### REGULATOR LAYER

Plan and execute missions for license validation, interference resolution and ITU filings.

### MONITORING LAYER

Capabilities to detect, characterize and geolocate interference and control and assure equipment



## MOBILE SYSTEMS

### MOBILE MONITORING

RF monitoring analysis using monitoring vehicle and remote controlled drone.



DRONE



MOBILE VEHICLE

### RF LAYER

Seven multi-band antennas covering L-, S-, C-, X-, Ku- and Ka-bands

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.

## MONITOR AND SCAN

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

### Control, Monitor and Geolocate

- » 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





## MONITOR, DETECT & LOCATE INTERFERENCE

- » 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.
- » Assure uptime and service quality of its terrestrial networks by using NeuralStar Service Quality Manager (SQM)

### Signal Recording and Video Streaming Analysis

- » Record and play back signals using a spectrum recorder for further analysis

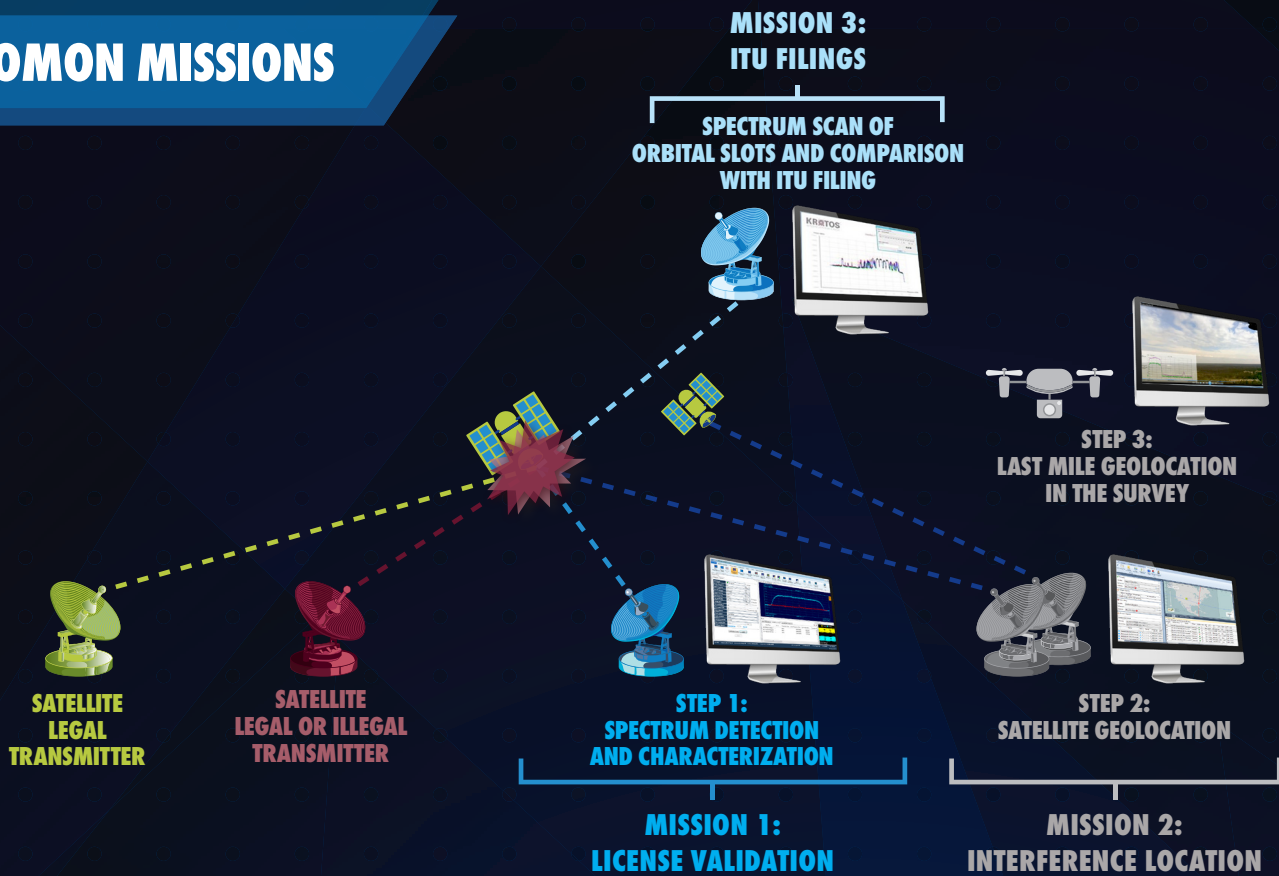
and troubleshooting, help achieve specific missions and better train staff

- » Analyze and display live video streaming using a DVB receiver to identify, analyze and trace the source of unscrambled TV channels

### Mobile RF Monitoring from the Ground and Sky

- » Determine the location of authorized or unauthorized transmissions using a vehicle with antennas and monitoring equipment to track the satellite services in the Uplink (Earth-to-Space) and the Downlink (Space-to-Earth) in all bands
- » Geolocate the unlawful usage of the spectrum and interference in the Uplink (Earth-to-Space) in any band using a remote controlled RF monitoring drone named Moscito that can overcome rough terrain and the high elevation angles of Gulf Cooperation Council earth station antennas

# GEOMON MISSIONS



## RESOLVE & REPORT

With GeoMon's graphical user interface and its integrations with all the sub systems, 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 details 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

## 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.

## STATE OF-THE-ART FREQUENCY MONITORING AND GEOLOCATION

**USING THE ASRMS, THE TRA  
OF OMAN HAS DEFINED OVER:**

**200** SATELLITES **&** **2000** TRANSPONDERS

TO MANAGE MORE THAN  
**800 LICENCES**

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



**AERIAL VIEW OF THE STATE-OF-THE-ART ASRMS**

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,” explained Yousuf Al-Balush from the TRA of Oman.

## ABOUT KRATOS

For more than 30 years Kratos has been the acknowledged leader in ground segment products and services that assure the availability, reliability, security and service quality of satellite and terrestrial networks. Kratos products and services are used by more than 80% of commercial satellite operators around the world, as well as broadcasters, service providers and government agencies, including support for 90% of U.S. space missions.

Kratos offers enterprise-grade solutions across the ground segment, including: carrier management, RF interference mitigation, network monitoring and control, service quality management, satellite command and control, signal processing and protection, tailored antenna solutions and more.

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