Communication & Situational Awareness

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ZODIAC DATA SYSTEMS
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Zodiac Data Systems

Agenda

- Company presentation
  - Activities overview
- SATCOM Monitoring Facts
  - Mission and Tasks
  - Technology trends
  - Market trends / Achievements
- SATCOM Monitoring solutions
  - Tool set
  - COMSAT Ephemeris Estimation
  - SATCOM QoS Monitoring
    - Carrier ID
    - Geo-mapping
    - Interference Mitigation scenario
- Q&A, Conclusion

Zodiac Data Systems

Five facilities in the world

- Turnover: >120M€
- R&D: 15%
- Staff: 600p
- Growth: 7%

Turnover Share

50% Europe

50% Export

Products

60% Ground

40% Airborne

Applications

45% Space

40% Flight Test

15% Missions

Zodiac Data Systems

Partner of the Spacefaring Nations

These lists are not comprehensive

Zodiac Data Systems

Partner of the Aerospace Industry

Communication Satellite Operators

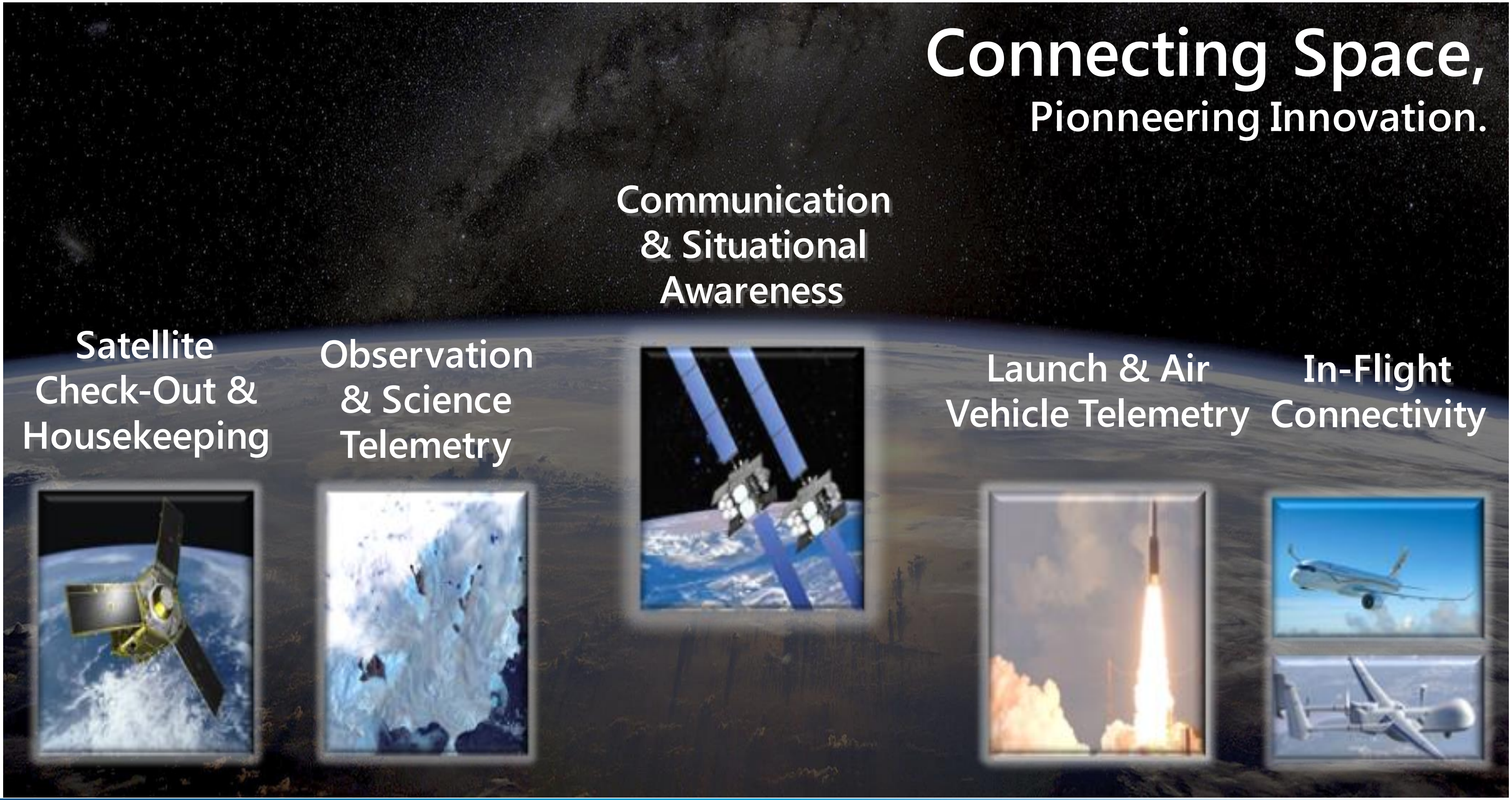
Earth Observation Service Providers

System Manufacturers

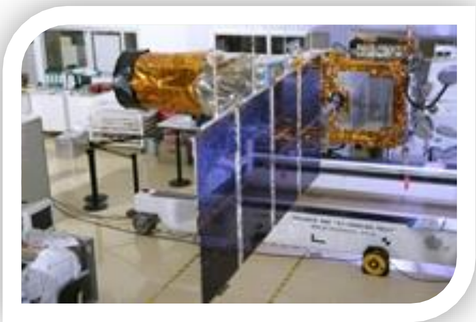
These lists are not comprehensive

Zodiac Data Systems

Cutting Edge Technologies Serving Aerospace



Satellite Check-Out & Housekeeping



Use case

- Ground design & validation
- LEOP, IOT & Emergency recovery
- In-Orbit Command & Control
- Co-located satellite operations
- Constellation operations

Technology

- TT&C (H/W & S/W)
- Ranging / Semi-Active Ranging
- Passive ranging / WeTrack Services
- Direct Sequence Spread Spectrum
- Transmission Security (TranSec)
- Encryption / Cyphering
- Enterprise Network Distributed Architectures

Benefits

- Quality Assurance
  - ✓ Reliability & Accuracy
  - ✓ Product sustainment
  - ✓ Proven track-record
- Upgrade-ability
  - ✓ Widest supported fleet
  - ✓ Asset re-usability

Observation & Science Telemetry

Use case

- LEO Scientific Satellites
- Commercial & defense E/O
- Space exploration
- Data-relay satellites
- Laboratory design
- Transmitters & Satellites check-out

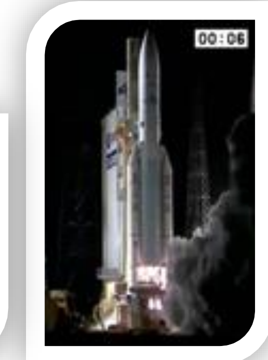
Technology

- S/X/Ka concentric feeds
- Monopulse & S/W Autotracking antennas
- Transportable antennas
- FPGA high speed signal processing (6Gbps)
- Variable Coding & Modulations
- Cross polarization cancellation
- Powerful FEC (LDPC, Turbo…)

Benefits

- Versatility & Scalability
  - ✓ Not tuned to only one mission
  - ✓ Field & time upgrade-able
- At technology forefront
  - ✓ Most advanced solutions

Launch & Air Vehicle Telemetry



Use case

- Launch pad tracking
- Downrange tracking
- Re-entry vehicles
- Injection on orbits

- Aircraft & Helicopter Flight Tests
- UAV datalinks

Technology

- Shipborne, transportable & fixed antennas
- Single Channel Monopulse tracking
- RF & IF direct recording & playback
- Link margin improvement (LDPC / Equalizer)
- CCSDS, CH10 & CH4 data handling & display
- CH7 and legacy datalinks
- C-OFDM error-free datalink

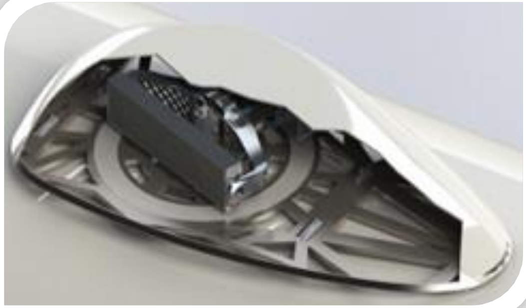
Benefits

- State-of-the-art solutions
  - ✓ Arianespace + many

- Data availability & recovery
  - ✓ Best-in-class link availability

- One-Stop-Shop
  - ✓ From antenna to display
  - ✓ Airborne FTI & datalink

In-Flight Connectivity



Use case

- Linefit & retrofit commercial IFC
- Military airborne communications
- UAV high speed datalinks

Technology

- Ka-band active micro-horns array
- 3-axis stabilization system
- Composite & alloy materials
- In-house multi-standards modems

Benefits

- Worldwide service
  - ✓ Zodiac Aerospace support
- Equator crossing service
  - ✓ Use of 3rd axis

Communication & Situational Awareness

Use case

- Space situational awareness
- Spectrum awareness
- Communication & Signal Intelligence
- Interference identification & geolocation
- Cooperative traffic identification (CID)

Technology

- Passive RF satellite triangulation
  - ✓ Europe & Asia coverage
  - ✓ USA (end 2017)
- Software Defined Radio (SDR) architecture based on state of the art hardware and a software suite for signals Display, Detection, Recording, Characterization, Monitoring and Geolocation
- Automated/scheduled full transponder geolocation
- Close circuit spectrum recording

Benefits

- Easy to get
  - ✓ ITAR free technology
  - ✓ Off-the-shelf products
  - ✓ Online ephemeris service
- Easy to integrate
  - ✓ LibDiapason DSP libraries

SATCOM Monitoring

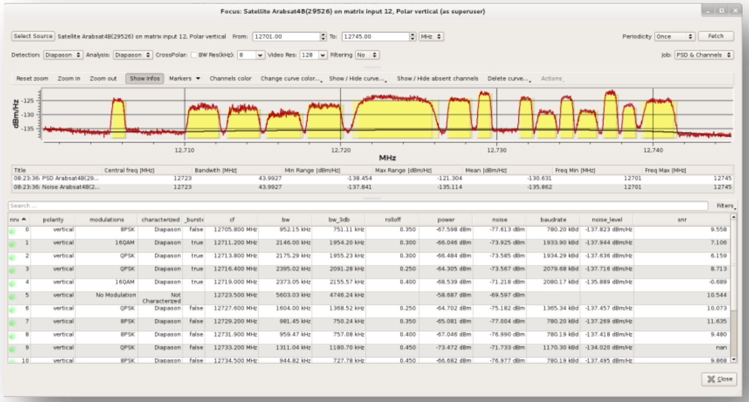
Facts

Geolocation & Monitoring

Missions and Tasks

Mission and Tasks of Space Radio Monitoring

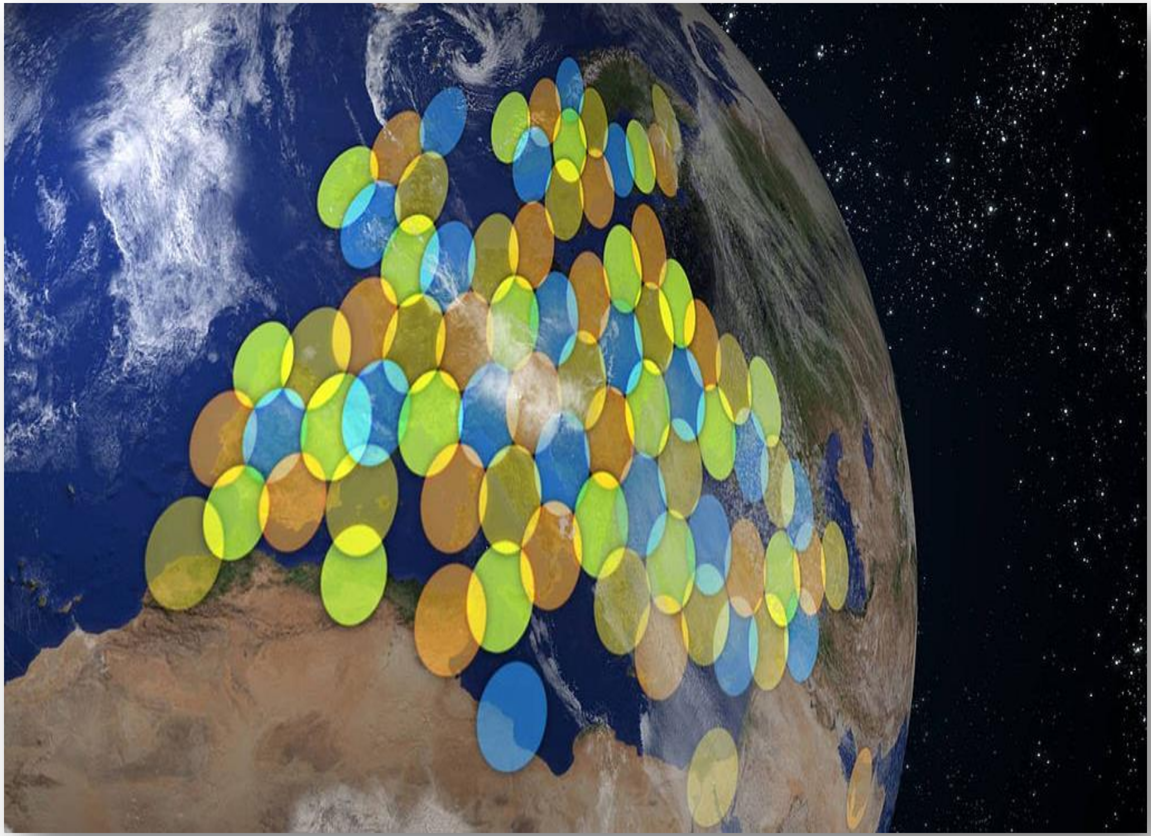
- Spectrum efficiency evaluation
  - Spectrum occupancy measurement
  - Knowledge of the real spectrum usage
  - GSO Satellite Orbit usage evaluation
- Signal parameter inspection
  - RF & Digital parameters characterization
  - Data recording for real-time and/or post-processing
- Signal Monitoring
  - Policing the rules;
  - Verification of orbital and spectral parameters;
  - Search for interferers or for unauthorized.



Geolocation & Monitoring
Technology trends

Latest technologies to comply with:

- HTS
  - Ka band;
  - Spotted beams.
- TDMA/MF TDMA
  - Burst signal;
  - Frequency hopping.
- Flexibility
  - Frequency Switching;
  - On board Processing;
  - Cross-strapped Transponders.
- Active Arrays
  - Antenna Beam Shaping;
  - Steerable Beams.
- Mobility
  - Mobile transmitters;
  - In-Flight Connectivity.



- Constellations
  - LEO/MEO/HEO constellations

Geolocation & Monitoring

Market Trends / Achievements

Market trends	Search for increase of beams and spectrum efficiency	Increase of interferences in complex and elusive contexts	Demand for policing and higher QoS
Achievements	Snapshots Geo-Mapping of transponder traffic.	Avaibility of top class satellite ephemerides allowing street/block class 2-sat geolocation.	Satellite Orbital position enforcement.
	Comprehensive TDMA traffic identification and geolocation.	Close circuit spectrum recording for interference prosecution.	100% succes rate CID.
	Sharp interference discrimination using carrier cancellation.	1-sat geolocation for lack of RF compatible mirror satellite.	Continuous monitoring of the traffic and quick detection and reports on events.

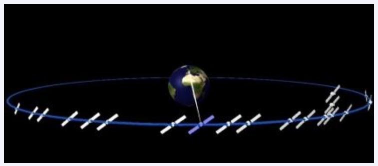
SATCOM Monitoring
Tool set

Geolocation & Monitoring

by ZODIAC DATA SYSTEMS

Solutions & Services

Services



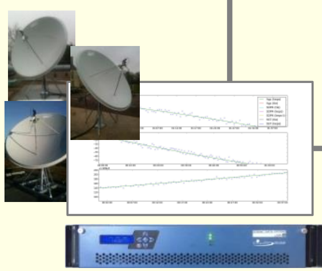
Ephemeris and TDOA services

Geolocation and mapping services

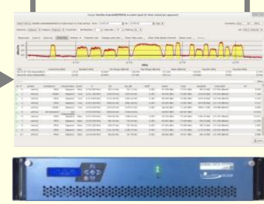
Markets:

- Satellite Operators
- Regulatory Bodies
- Defense Agencies
- System Integrators

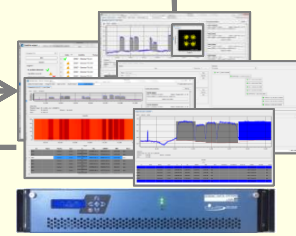
Systèmes & Solutions



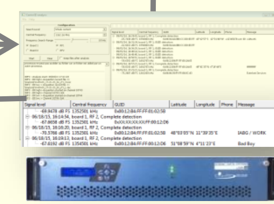
Satellite Ephemeris Estimation



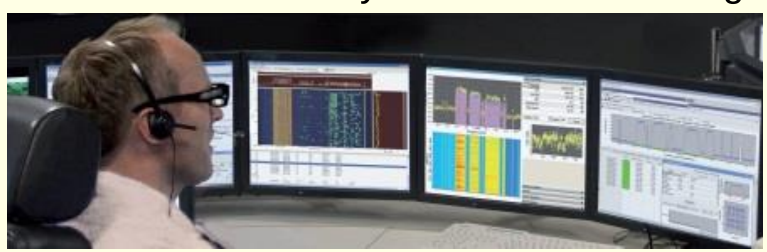
Geolocation systems



Monitoring systems



Carrier ID

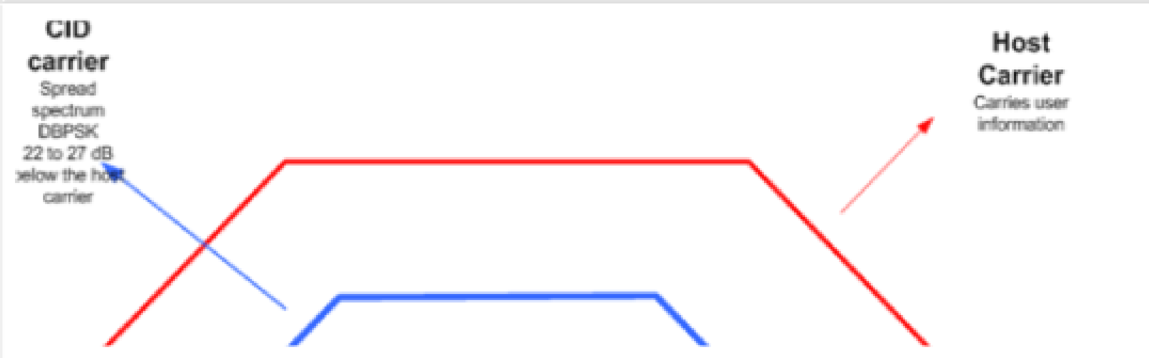


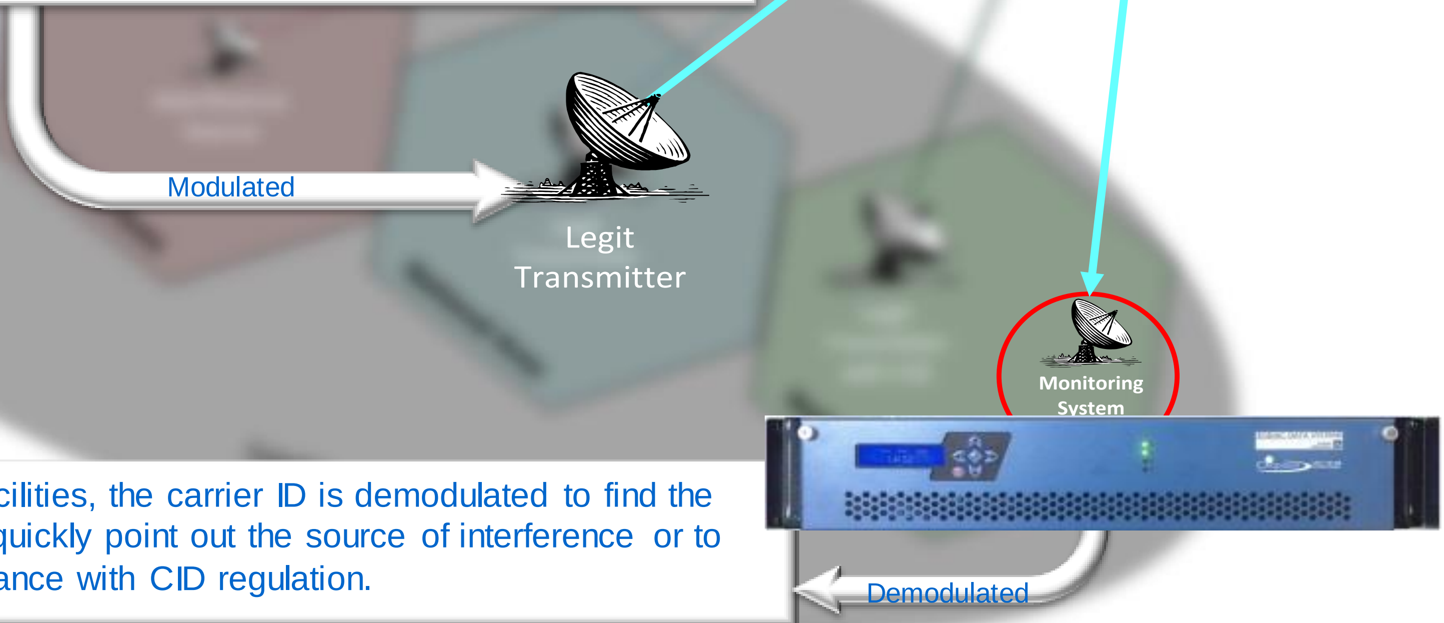
SATCOM Monitoring

Carrier ID

Carrier ID

The Carrier ID is transmitted using spread spectrum technique.





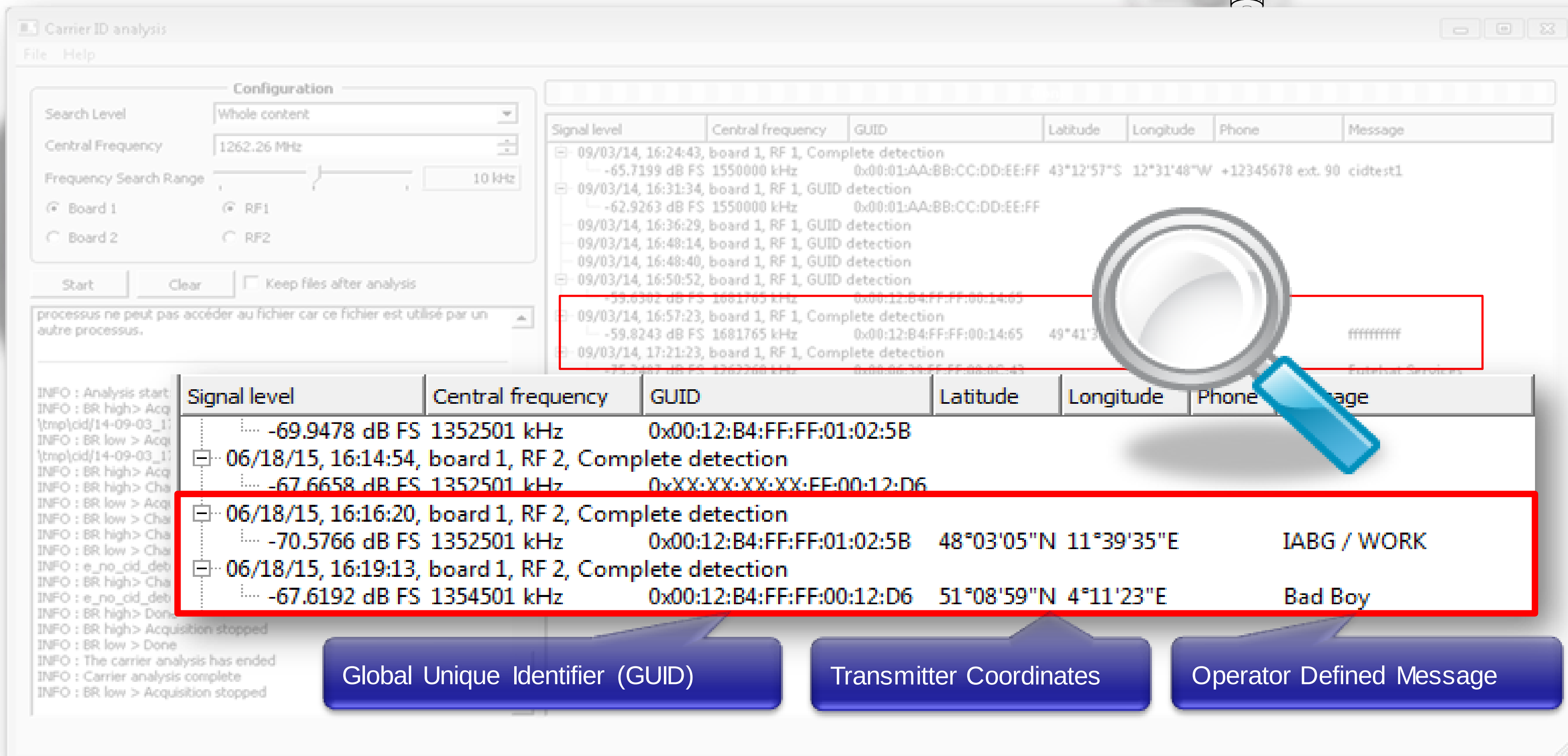
At Satellite Monitoring facilities, the carrier ID is demodulated to find the contact information and quickly point out the source of interference or to check transmitter compliance with CID regulation.

Carrier ID Scenario

by ZODIAC DATA SYSTEMS

CID tests

Tests organized with the courtesy of Eutelsat and Work Microwave for the SIRG



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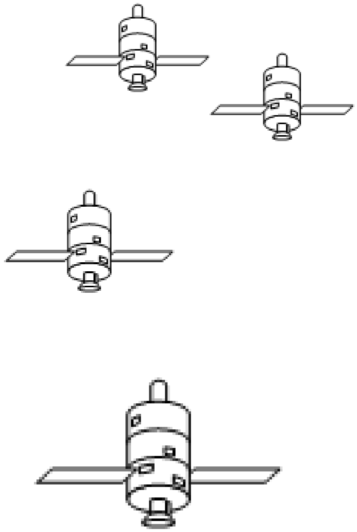
SATCOM Monitoring
COMSAT Ephemeris Estimation

Monitoring satellite orbital position



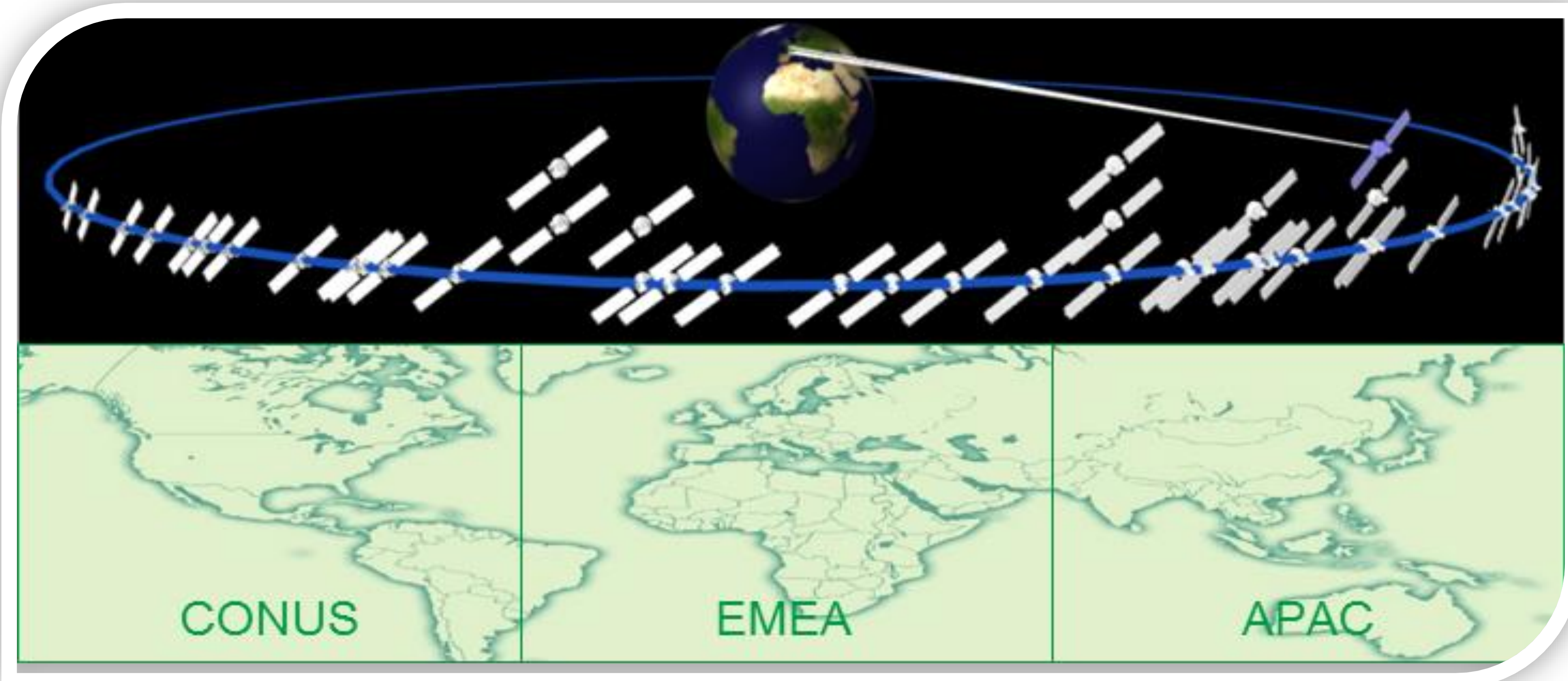
Purposes:

- To do passive ranging;
- To improve geolocation accuracy ;
- To retrieve measurements quickly after manoeuvre;
- To secure the satellite with the surrounding environment;
- To do big antenna pointing;
- To preserve performances, interoperability and quality of satellites communications…

WeTrack Service 24/7

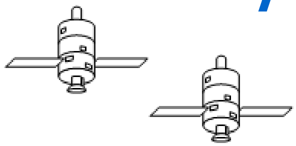
by ZODIAC DATA SYSTEMS

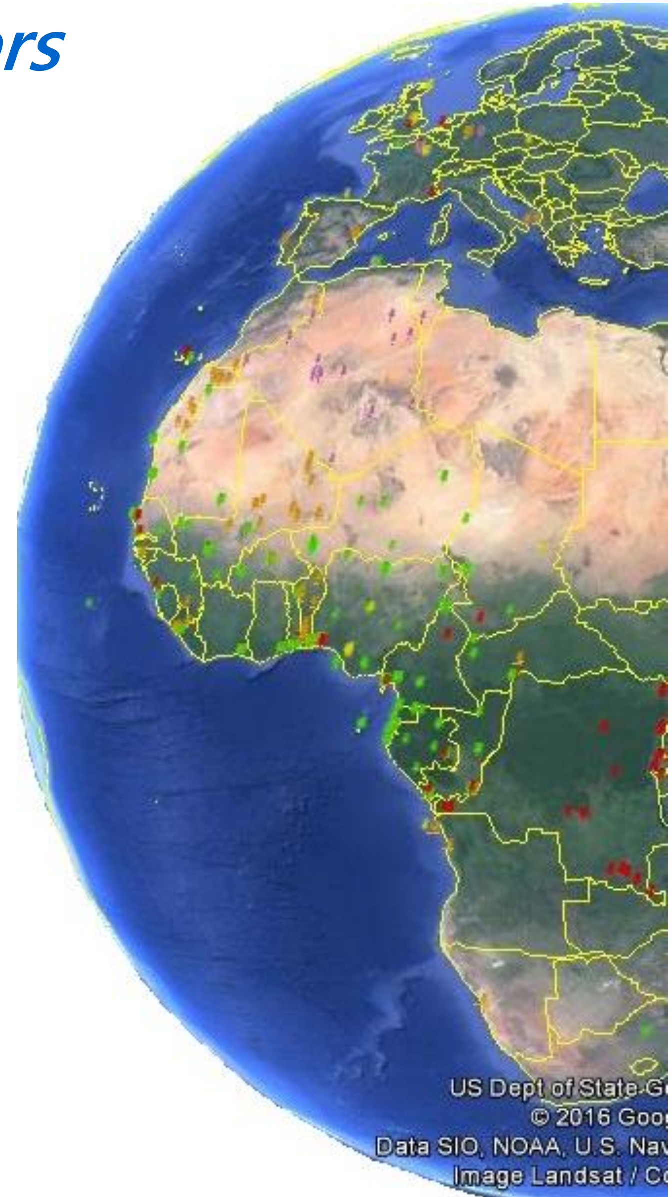
ZDS provides TDOA and Ephemeris based on Passive Ranging



SATCOM Monitoring
Geo-mapping

Geo-Mapping SATCOM transmitters

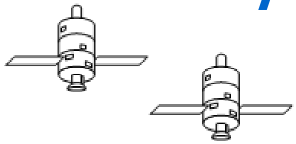


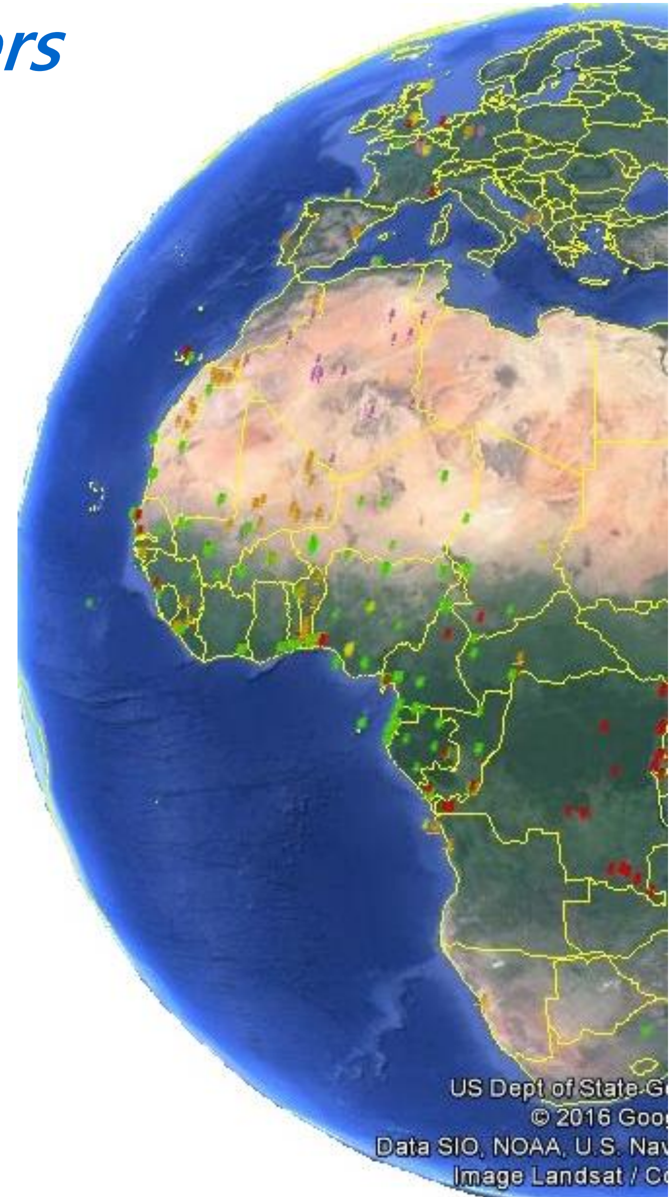


Purposes:

- **To facilitate rapid identification of interference**
- **To check registered transmiters location;**
- **To catalog transmitter positions before satellite transition (global beam to spot beams)**
- **To Maximize Quality and Availability of Service**

Geo-Mapping SATCOM transmitters





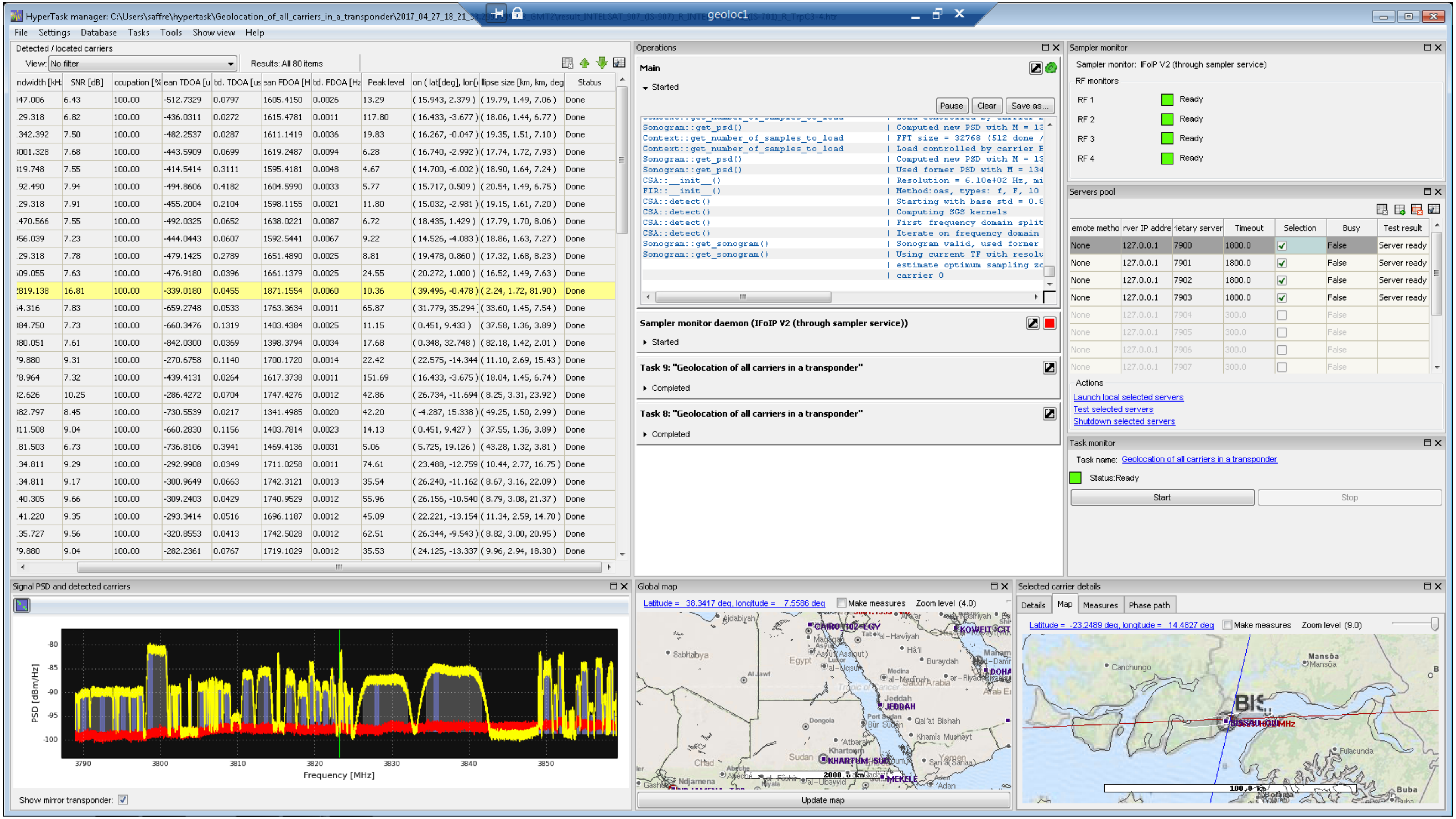
Method:

- **Two satellites geolocation using TDOA/FDOA measurements;**
- **Automated geolocation process;**
- **Simultaneous geolocation (up to 32 at the time);**
- **On events recording capabilities ;**
- **Clean cancellation of adjacent satellite or interfering signal for a better signal sensitivity.**

Geo-Mapping operation

by ZODIAC DATA SYSTEMS

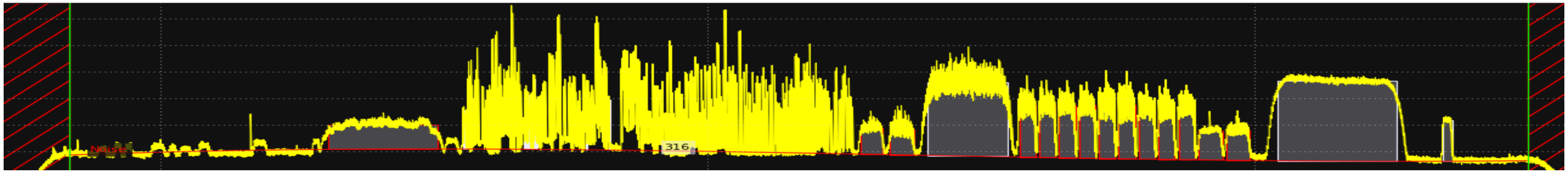
Target Manager

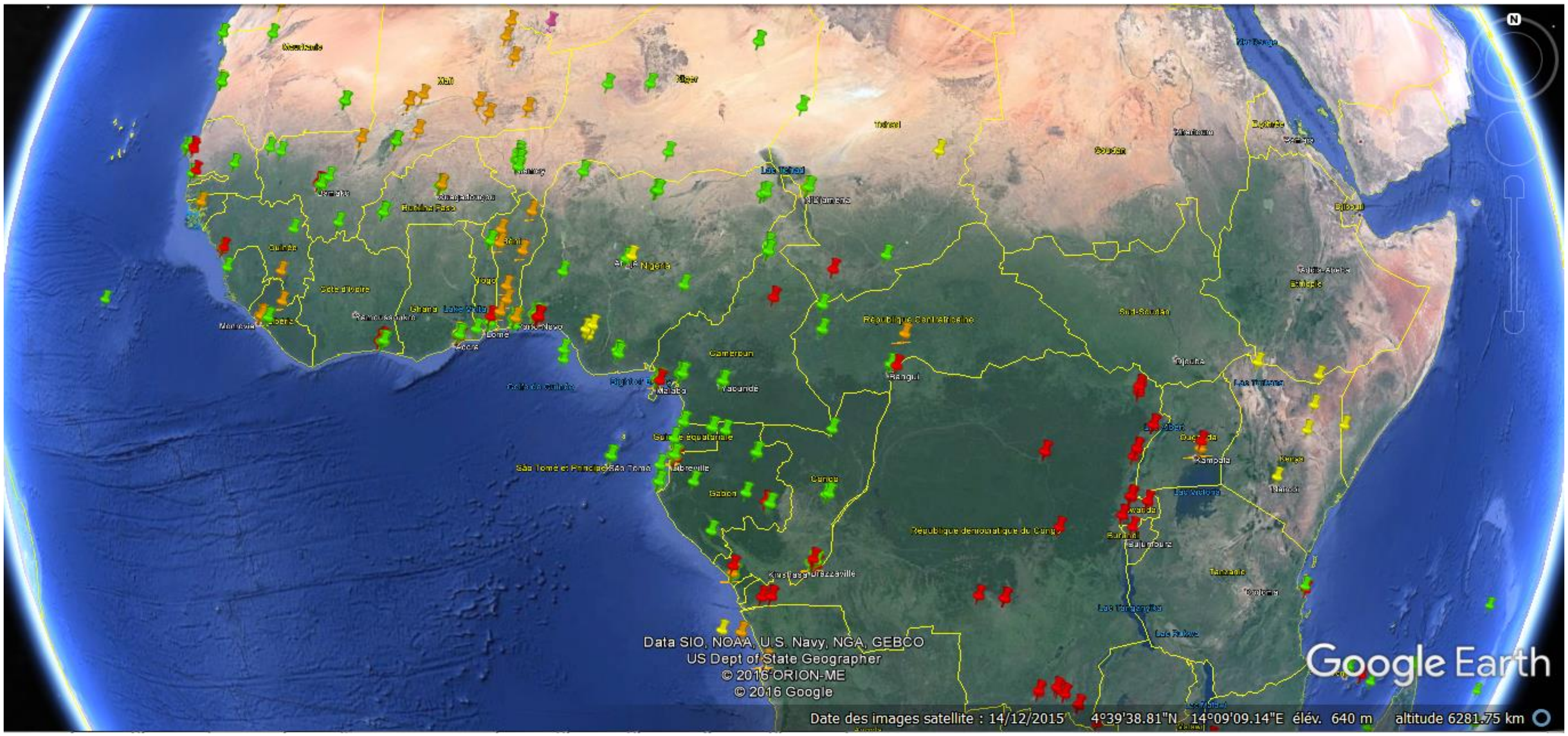


Geo-Mapping scenario

by ZODIAC DATA SYSTEMS

Automated geolocation of SCPC carriers

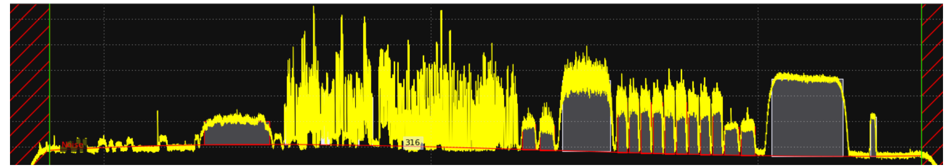


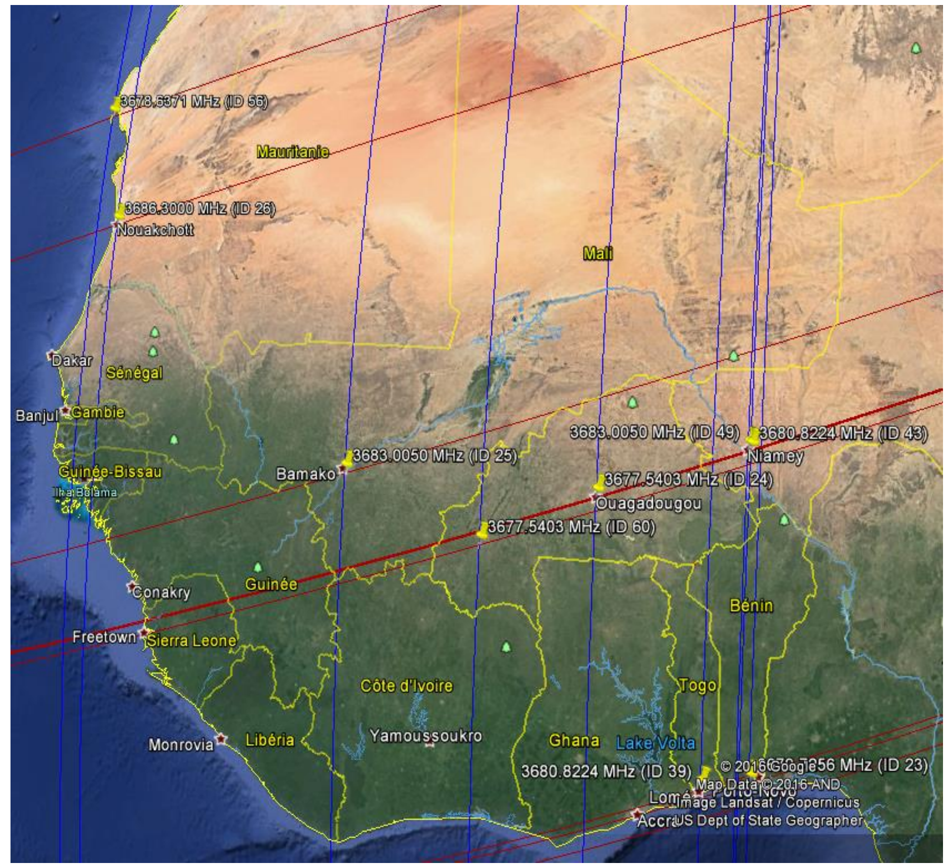


Geo-Mapping scenario
by ZODIAC DATA SYSTEMS
Geolocation of TDMA carriers

Example Case:

- **Geolocation of transmitters active at time of record**
- **Possibility to associate the position with the transmitter ID in case the geolocation system is interfaced with an ID extractor**
- **Accuracy better than 5 km**





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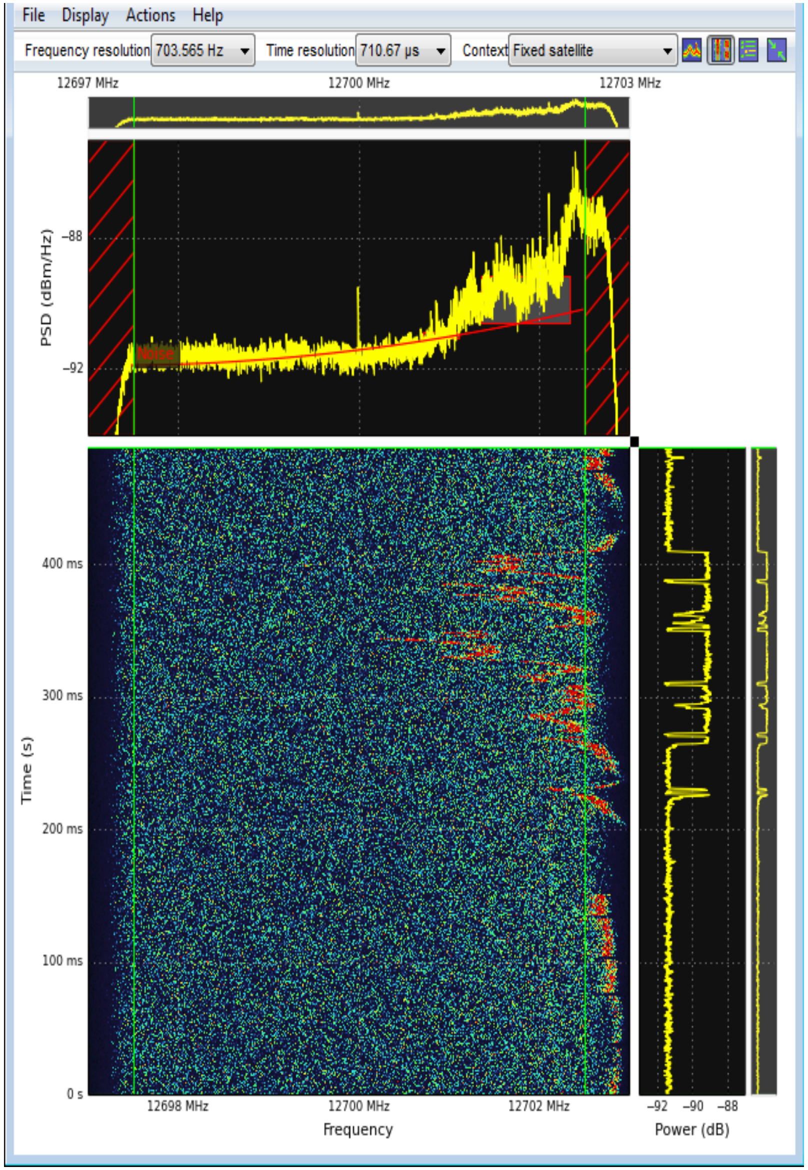
SATCOM Monitoring
Interference Mitigation

Interference Mitigation

by ZODIAC DATA SYSTEMS

Interference description

1. **The interference has been around several weeks, interfering with several transponders, uplinking and disturbing a spectrum range spreading at least between 14180 MHz and 14240 MHz**
2. **Signal is both sweeping, bursted, alternating extremely narrow (close to CW) to fairly consistent bandwidth (>400kHz), alternating frequency hopping and somewhat frequency steady (a few seconds long) presence**
3. **Signal Analysis gives no conclusive modulation hint. Burst period seems quite consistent.**
4. **Spectral occupancy and frequency stability being very erratic, defining a central frequency to the interference may be quite challenging and sometimes prone to uncertainty.**



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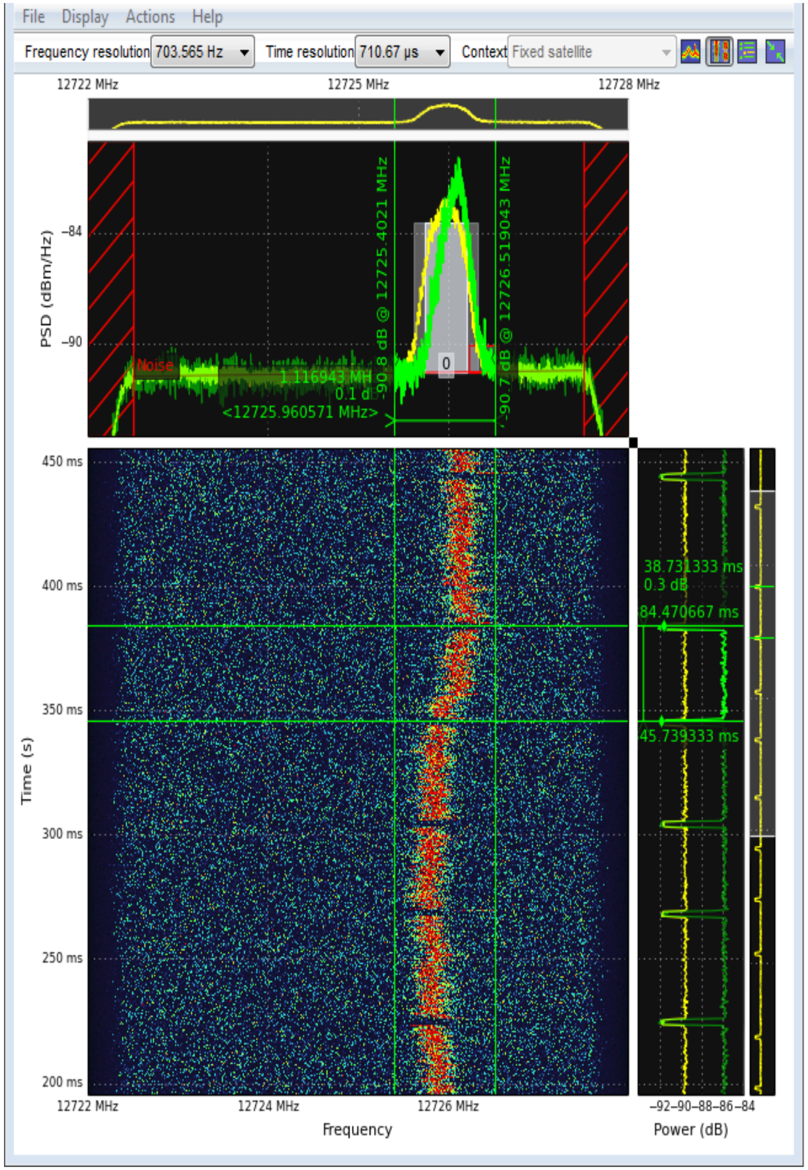
Interference Mitigation

by ZODIAC DATA SYSTEMS

Interference recording

Measurements could be performed by taking advantage of ZODIAC DATA SYSTEMS CGL Geolocation Recording capabilities, by using moments when the interference was coarsely stable. For most cases, recordings of 16 seconds duration over 5 MHz of bandwidth. This increases the chance of catching a sufficiently long presence time of the signal of interest, while giving also sufficient bandwidth to perform carrier cancellation on potential blocking carriers on the mirror satellite.



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Interference Mitigation

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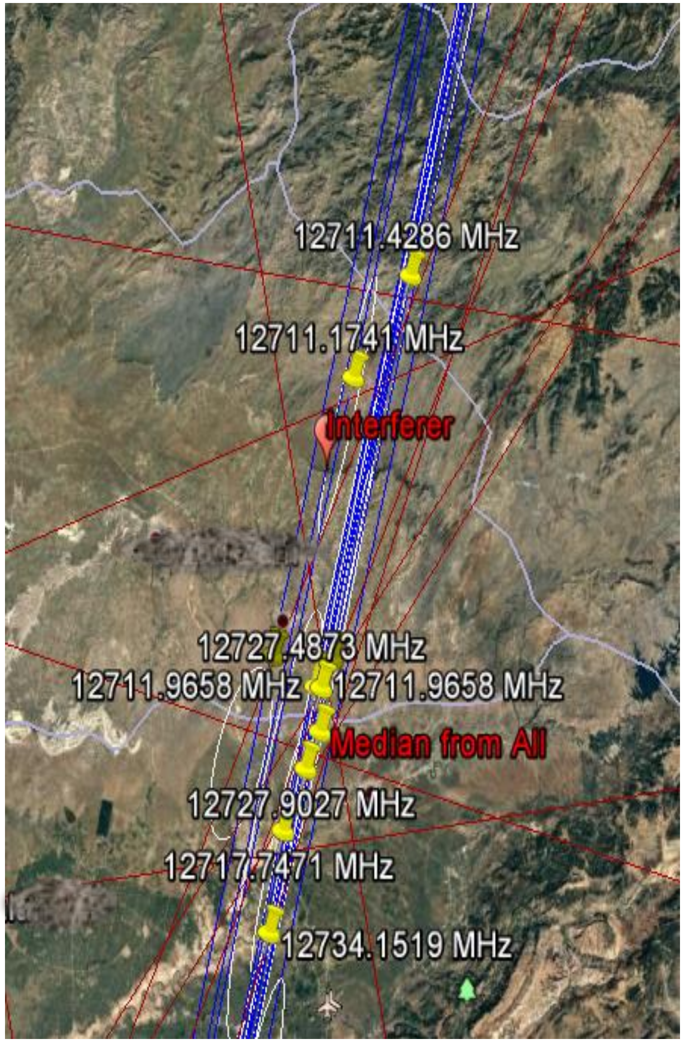
Geolocation result

Measurements were performed regularly over several days

Several points should be noted:

1. The measurements consistently fall on the same TDOA line. Interference source is therefore very likely to be along this line.
2. The previous fact rules out the possibility to have a moving target.
3. The uncertainty on the center frequency explains the diversity along the line.
4. When the signal is present over several seconds, it is fairly easy to get a Main-Mirror signal correlation, which, in this configuration, should be the sign of a relatively small size transmitter.
5. As a result, the displayed FDOA lines (Doppler difference effect - in red) have some diversity across measurements.



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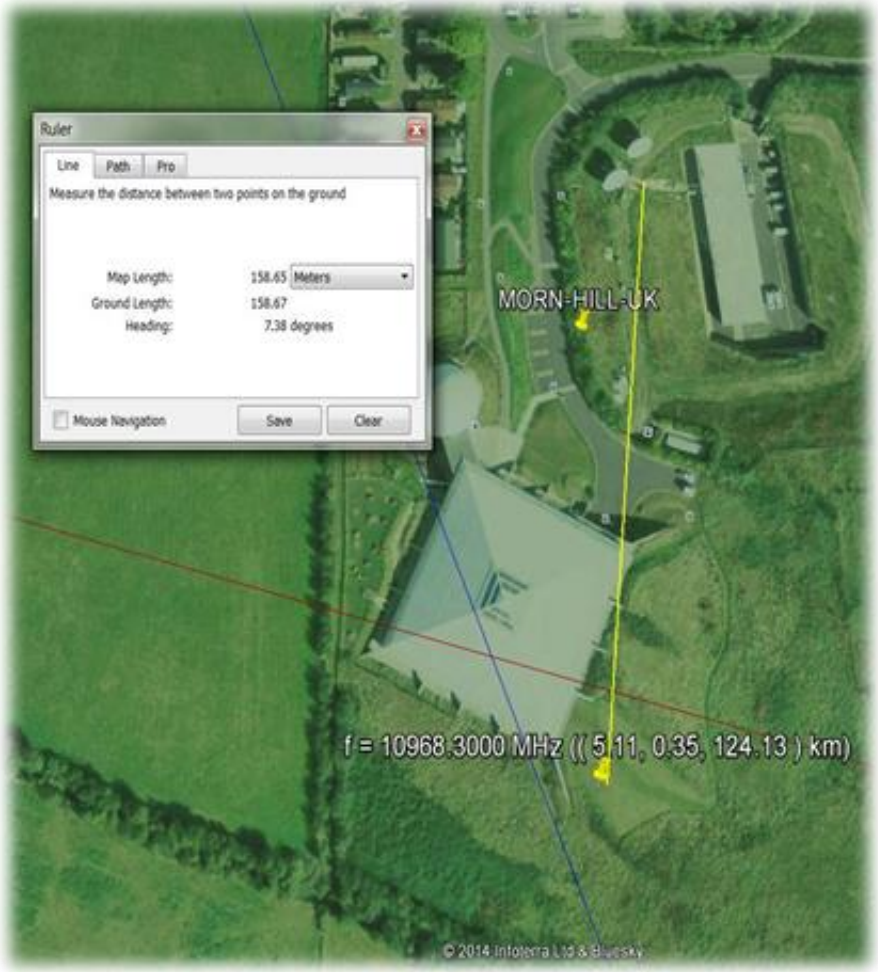
Geolocation

by ZODIAC DATA SYSTEMS

Conclusion

The data feeds into the geolocation system makes the difference on the interference location success and accuracy.

- **Interference records**
  - **Automatically detected and recorded by CSM**
- **Ephemeris**
  - **Automatically feed into the system**
- **Mirror satellite selection**
  - **Automatically selected by the system**
- **Reference carriers**
  - **Constantly checked**
- **Carrier cancellation on mirror satellite**
  - **Automatically cancel in case there is a carrier on mirror satellite**
- **ID extraction for TDMA/MF TDMA carrier**
  - **Automated geolocation in order to catch all users at the time they are transmitting.**



Any questions ?

Thank you for your attention