

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



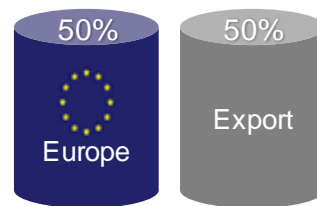
Turnover:
>120M€

R&D: 15%

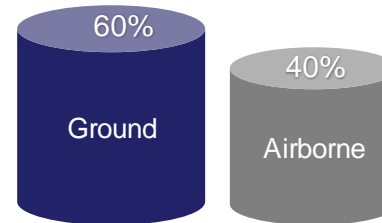
Staff: 600p

Growth: 7%

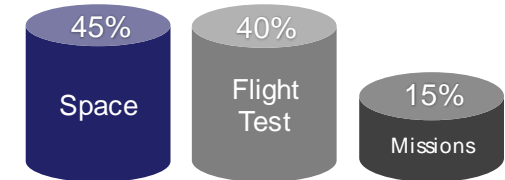
Turnover Share



Products

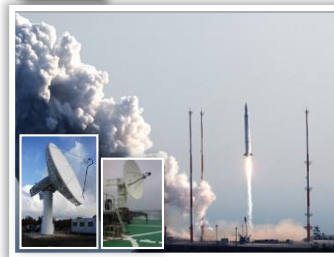


Applications



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

Connecting Space,
Pioneering Innovation.

Communication
& Situational
Awareness

Satellite
Check-Out &
Housekeeping



Observation
& Science
Telemetry



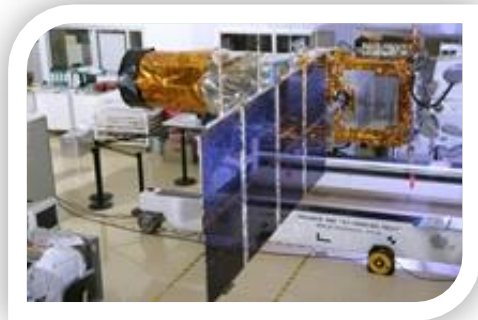
Launch & Air
Vehicle Telemetry



In-Flight
Connectivity



Satellite Check-Out & Housekeeping



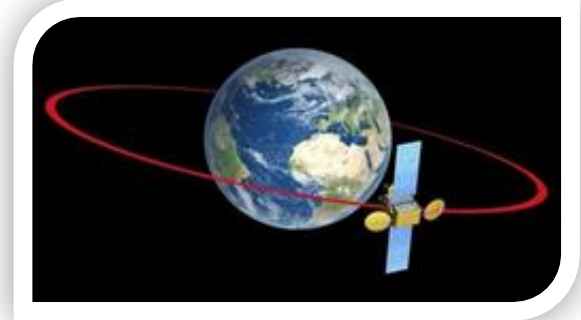
Use case

- 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



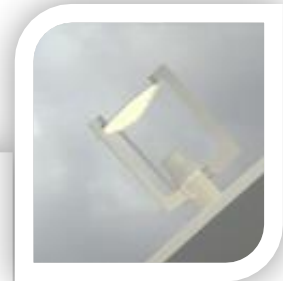
Use case

- 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

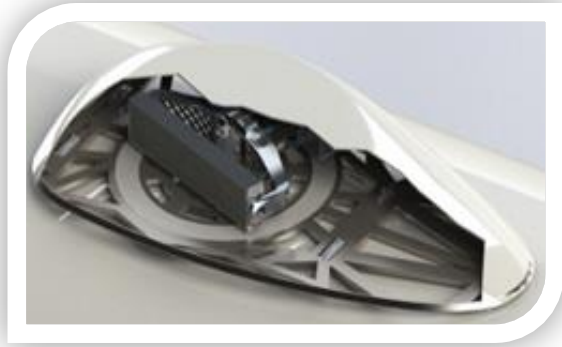
- State-of-the-art solutions
 - ✓ Arianespace + many
- Data availability & recovery
 - ✓ Best-in-class link availability
- One-Stop-Shop
 - ✓ From antenna to display
 - ✓ Airborne FTI & datalink

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

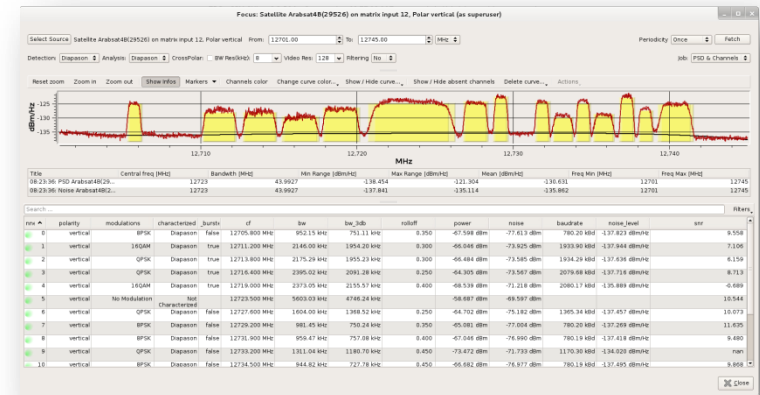
SATCOM Monitoring Facts

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.

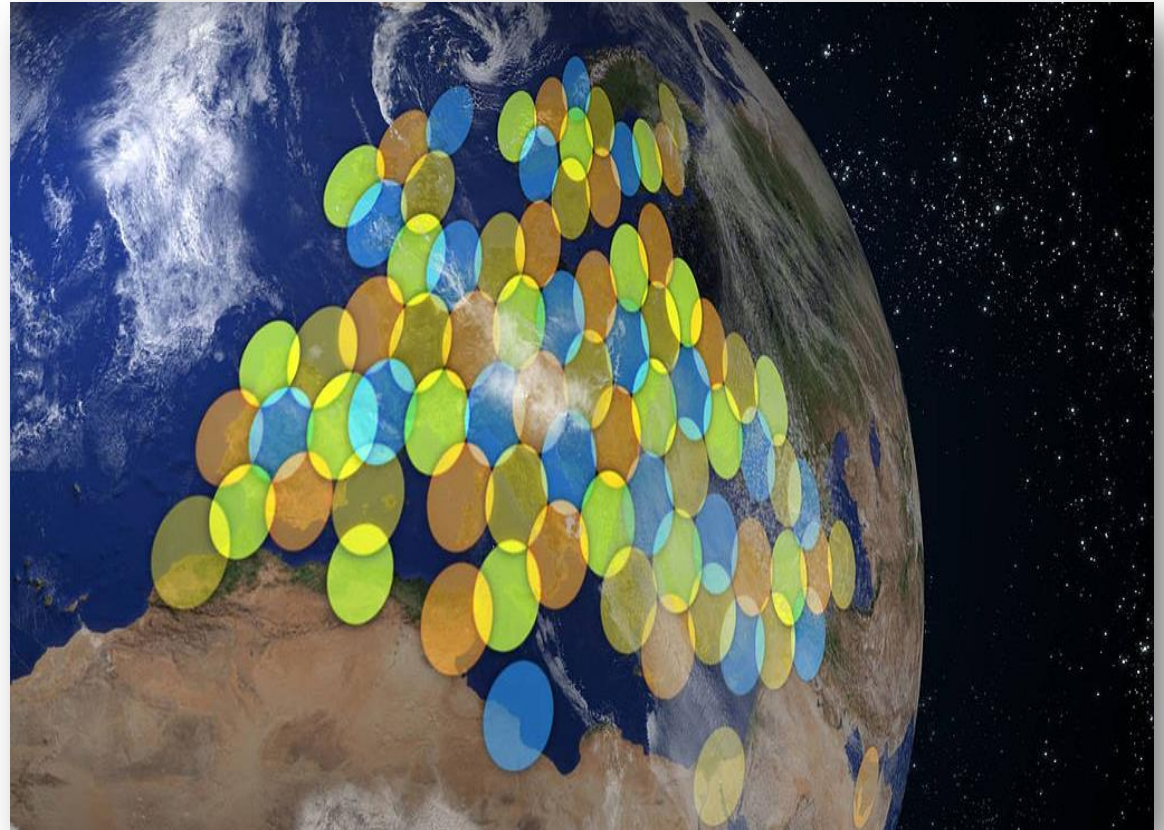


Geolocation & Monitoring

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

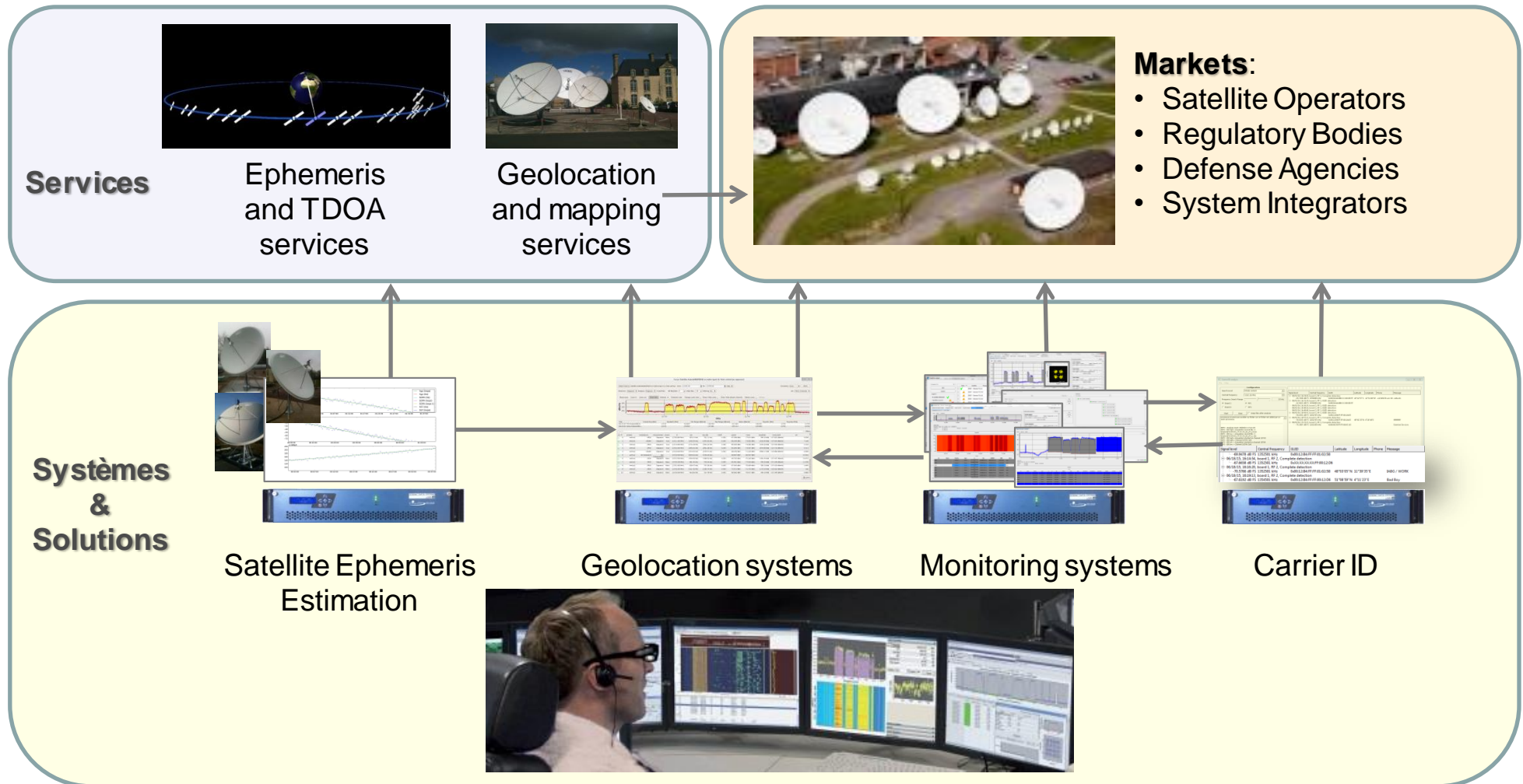
Market trends	Search for increase of beams and spectrum efficiency	Increase of interferences in complex and elusive contexts	Demand for policing and higher QoS
Achievements	Snapshots Geo-Mapping of transponder traffic.	Availability of top class satellite ephemerides allowing street/block class 2-sat geolocation.	Satellite Orbital position enforcement.
	Comprehensive TDMA traffic identification and geolocation.	Close circuit spectrum recording for interference prosecution.	100% success 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

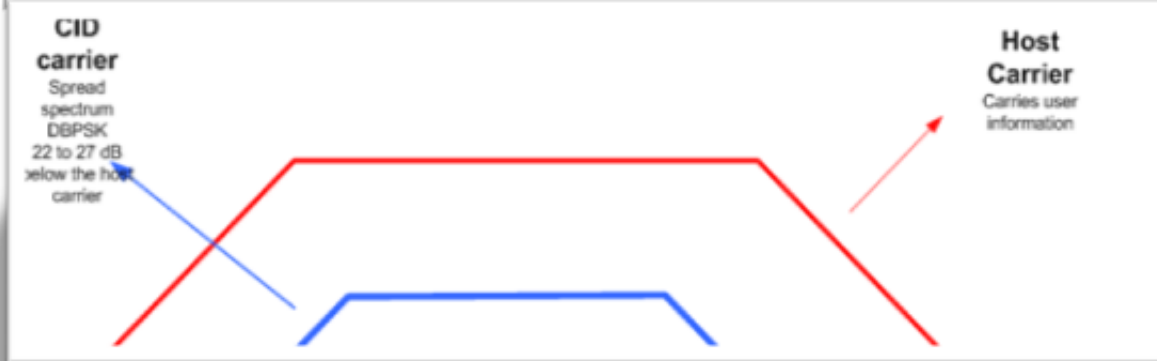
Solutions & Services



SATCOM Monitoring Carrier ID

Carrier ID

The Carrier ID is transmitted using spread spectrum technique.



Modulated

Legit
Transmitter

Monitoring
System

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.

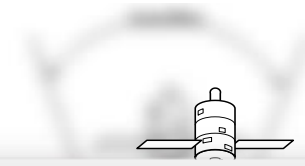
Demodulated

Carrier ID Scenario

by ZODIAC DATA SYSTEMS

CID tests

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



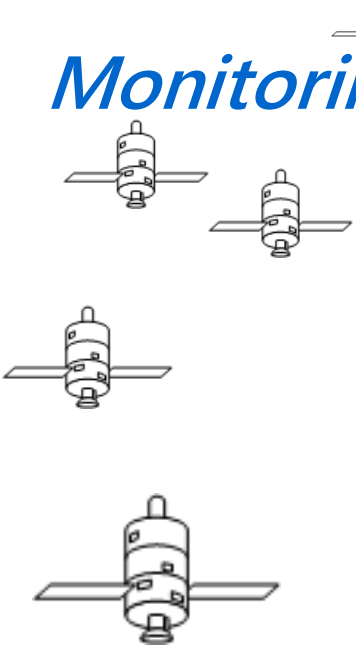
The image shows a screenshot of the 'Carrier ID analysis' software interface. The window title is 'Carrier ID analysis' and it has a menu bar with 'File' and 'Help'. On the left, there is a 'Configuration' panel with fields for 'Search Level' (set to 'Whole content'), 'Central Frequency' (1262.26 MHz), and 'Frequency Search Range' (10 kHz). Below this are radio buttons for 'Board 1' (selected) and 'RF1' (selected). There are 'Start', 'Clear', and 'Keep files after analysis' buttons. A status bar at the bottom left shows an error message: 'processus ne peut pas accéder au fichier car ce fichier est utilisé par un autre processus.' The main area displays a list of signal detections with columns for 'Signal level', 'Central frequency', 'GUID', 'Latitude', 'Longitude', 'Phone', and 'Message'. A magnifying glass icon is overlaid on the table, focusing on a specific row. Below the table, three blue callout boxes point to specific columns: 'Global Unique Identifier (GUID)', 'Transmitter Coordinates', and 'Operator Defined Message'. The table data is as follows:

Signal level	Central frequency	GUID	Latitude	Longitude	Phone	Message
-69.9478 dB FS	1352501 kHz	0x00:12:B4:FF:FF:01:02:5B				
06/18/15, 16:14:54, board 1, RF 2, Complete detection						
-67.6658 dB FS	1352501 kHz	0xXX:XX:XX:XX:FE:00:12:D6				
06/18/15, 16:16:20, board 1, RF 2, Complete detection						
-70.5766 dB FS	1352501 kHz	0x00:12:B4:FF:FF:01:02:5B	48°03'05"N	11°39'35"E		IABG / WORK
06/18/15, 16:19:13, board 1, RF 2, Complete detection						
-67.6192 dB FS	1354501 kHz	0x00:12:B4:FF:FF:00:12:D6	51°08'59"N	4°11'23"E		Bad Boy



SATCOM Monitoring COMSAT Ephemeris Estimation

Monitoring satellite orbital position



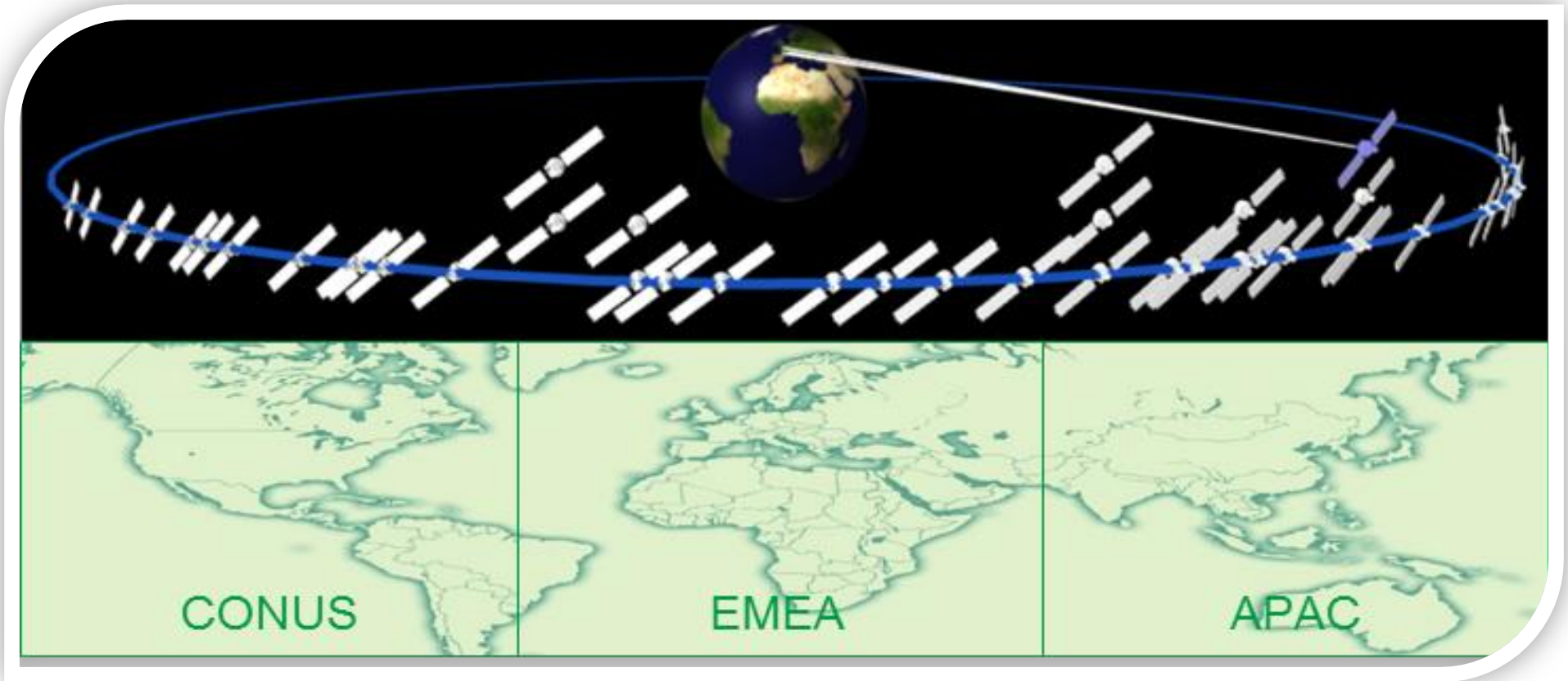
Purposes:

- 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

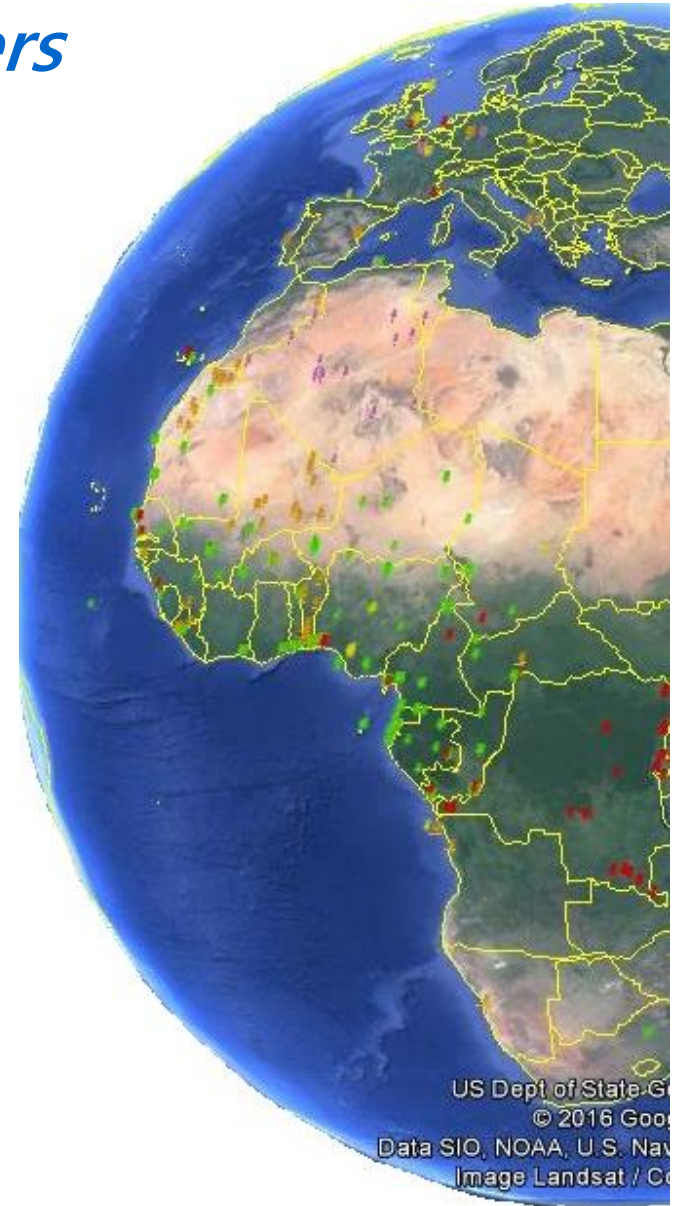
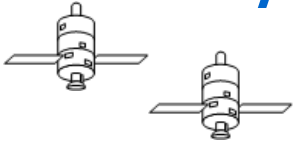
by ZODIAC DATA SYSTEMS

ZDS provides TDOA and Ephemeris based on Passive Ranging



SATCOM Monitoring Geo-mapping

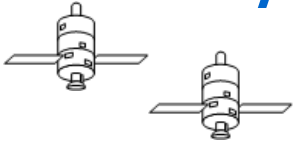
Geo-Mapping SATCOM transmitters



Purposes:

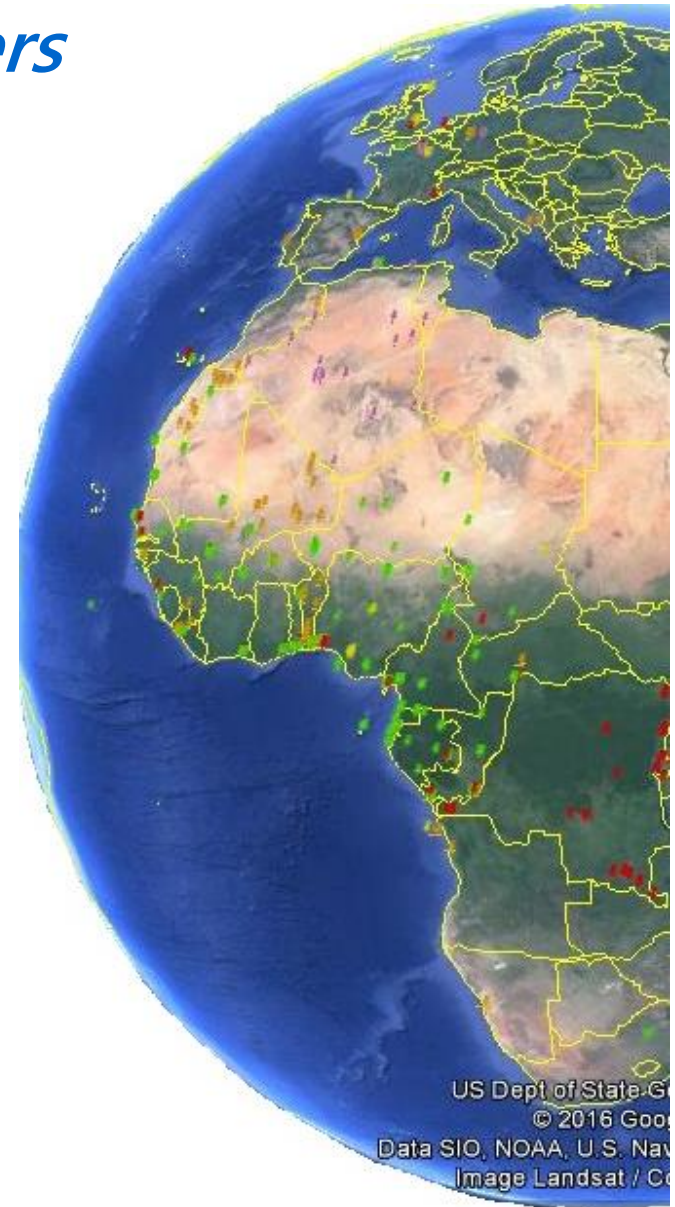
- To facilitate rapid identification of interference
- To check registered transmitters location;
- To catalog transmitter positions before satellite transition (global beam to spot beams)
- To Maximize Quality and Availability of Service

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

The screenshot displays the HyperTask manager interface for a geolocation task. The main window is titled "HyperTask manager: C:\Users\saffre\hypertask\Geolocation_of_all_carriers_in_a_transponder\2017_04_27_18_21_...".

Detected / located carriers table:

ndwidth [Hz]	SNR [dB]	ccupation [%]	ean TDOA [u]	td. TDOA [u]	san FDOA [Hz]	FDOA [Hz]	Peak level	on (lat[deg], lon[deg])	llipse size (km, km, deg)	Status
147.006	6.43	100.00	-512.7329	0.0797	1605.4150	0.0026	13.29	(15.943, 2.379)	(19.79, 1.49, 7.06)	Done
29.318	6.82	100.00	-436.0311	0.0272	1615.4781	0.0011	117.80	(16.433, -3.677)	(18.06, 1.44, 6.77)	Done
342.392	7.50	100.00	-482.2537	0.0287	1611.1419	0.0036	19.83	(16.267, -0.047)	(19.35, 1.51, 7.10)	Done
8001.328	7.68	100.00	-443.5909	0.0699	1619.2487	0.0094	6.28	(16.740, -2.992)	(17.74, 1.72, 7.93)	Done
119.748	7.55	100.00	-414.5414	0.3111	1595.4181	0.0048	4.67	(14.700, -6.002)	(18.90, 1.64, 7.24)	Done
92.490	7.94	100.00	-494.8606	0.4182	1604.5990	0.0033	5.77	(15.717, 0.509)	(20.54, 1.49, 6.75)	Done
29.318	7.91	100.00	-455.2004	0.2104	1598.1155	0.0021	11.80	(15.032, -2.961)	(19.15, 1.61, 7.20)	Done
470.566	7.55	100.00	-492.0325	0.0652	1638.0221	0.0087	6.72	(18.435, 1.429)	(17.79, 1.70, 8.06)	Done
956.039	7.23	100.00	-444.0443	0.0607	1592.5441	0.0067	9.22	(14.526, -4.083)	(18.86, 1.63, 7.27)	Done
29.318	7.78	100.00	-479.1425	0.2789	1651.4890	0.0025	8.81	(19.478, 0.860)	(17.32, 1.68, 8.23)	Done
109.055	7.63	100.00	-476.9180	0.0396	1661.1379	0.0025	24.55	(20.272, 1.000)	(16.52, 1.49, 7.63)	Done
819.138	16.81	100.00	-339.0180	0.0455	1871.1554	0.0060	10.36	(39.496, -0.478)	(2.24, 1.72, 81.90)	Done
14.316	7.83	100.00	-659.2748	0.0533	1763.3634	0.0011	65.87	(31.779, 35.294)	(33.60, 1.45, 7.54)	Done
884.750	7.73	100.00	-660.3476	0.1319	1403.4384	0.0025	11.15	(0.451, 9.433)	(37.58, 1.36, 3.89)	Done
880.051	7.61	100.00	-842.0300	0.0369	1398.3794	0.0034	17.68	(0.348, 32.748)	(82.18, 1.42, 2.01)	Done
9.880	9.31	100.00	-270.6758	0.1140	1700.1720	0.0014	22.42	(22.575, -14.344)	(11.10, 2.69, 15.43)	Done
78.964	7.32	100.00	-439.4131	0.0264	1617.3738	0.0011	151.69	(16.433, -3.675)	(18.04, 1.45, 6.74)	Done
12.626	10.25	100.00	-286.4272	0.0704	1747.4276	0.0012	42.86	(26.734, -11.694)	(8.25, 3.31, 23.92)	Done
882.797	8.45	100.00	-730.5539	0.0217	1341.4985	0.0020	42.20	(-4.287, 15.338)	(49.25, 1.50, 2.99)	Done
111.508	9.04	100.00	-660.2830	0.1156	1403.7814	0.0023	14.13	(0.451, 9.427)	(37.55, 1.36, 3.89)	Done
81.503	6.73	100.00	-736.8106	0.3941	1469.4136	0.0031	5.06	(5.725, 19.126)	(43.28, 1.32, 3.81)	Done
34.811	9.29	100.00	-292.9908	0.0349	1711.0259	0.0011	74.61	(23.488, -12.759)	(10.44, 2.77, 16.75)	Done
34.811	9.17	100.00	-300.9649	0.0663	1742.3121	0.0013	35.54	(26.240, -11.162)	(8.67, 3.16, 22.09)	Done
40.305	9.66	100.00	-309.2403	0.0429	1740.9529	0.0012	55.96	(26.156, -10.540)	(8.79, 3.08, 21.37)	Done
41.220	9.35	100.00	-293.3414	0.0516	1696.1187	0.0012	45.09	(22.221, -13.154)	(11.34, 2.59, 14.70)	Done
35.727	9.56	100.00	-320.8553	0.0413	1742.5028	0.0012	62.51	(26.344, -9.543)	(8.82, 3.00, 20.95)	Done
9.880	9.04	100.00	-282.2361	0.0767	1719.1029	0.0012	35.53	(24.125, -13.337)	(9.96, 2.94, 18.30)	Done

Operations: Shows logs for tasks like "Task 9: 'Geolocation of all carriers in a transponder'" and "Task 8: 'Geolocation of all carriers in a transponder'".

Sampler monitor: Shows status for RF monitors (RF 1-4) and Servers pool.

Signal PSD and detected carriers: A plot showing PSD [dBm/Hz] vs Frequency [MHz].

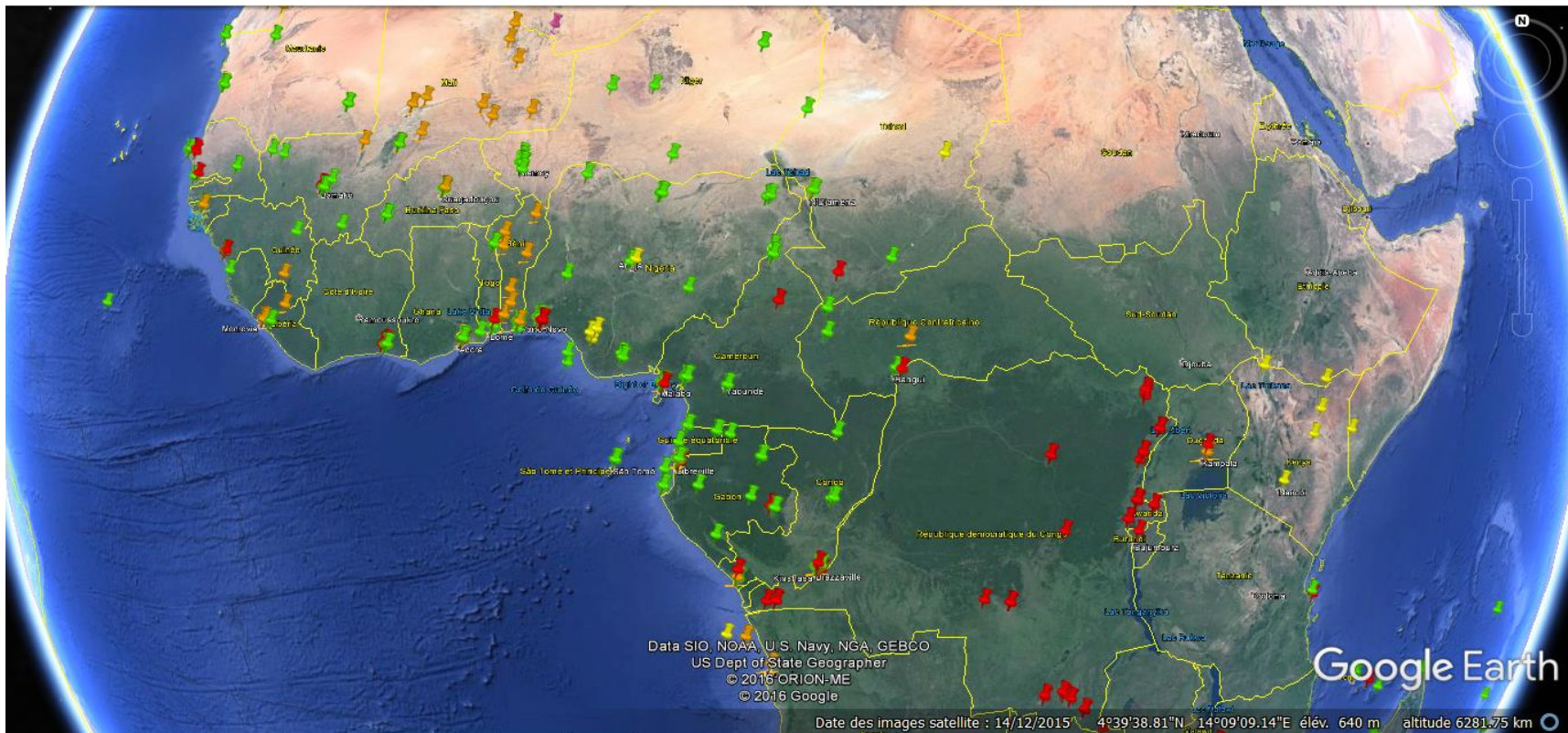
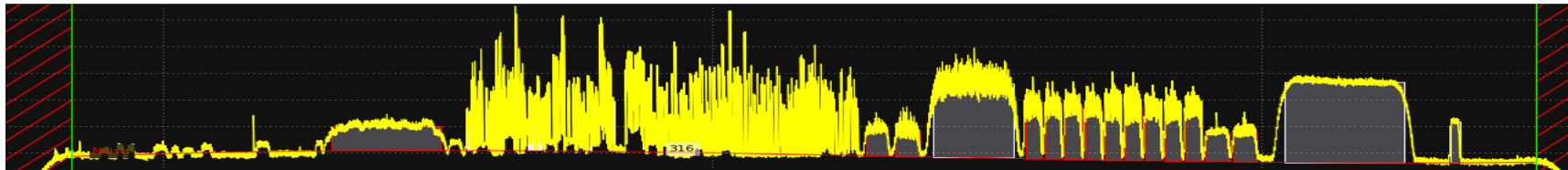
Global map: A map showing the location of detected carriers in the Middle East region.

Selected carrier details: Shows details for a specific carrier, including its location (Latitude = -23.2489 deg, Longitude = 14.4827 deg).

Geo-Mapping scenario

by ZODIAC DATA SYSTEMS

Automated geolocation of SCPC carriers



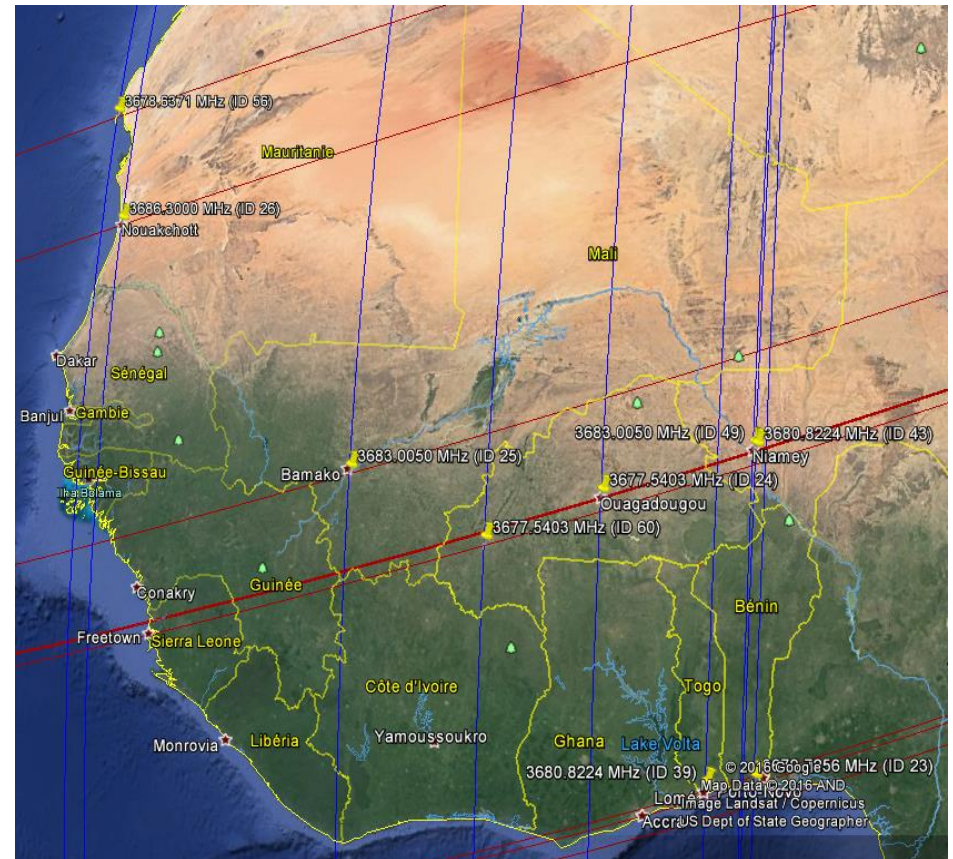
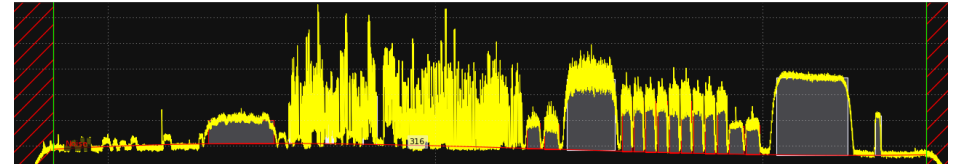
Geo-Mapping scenario

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



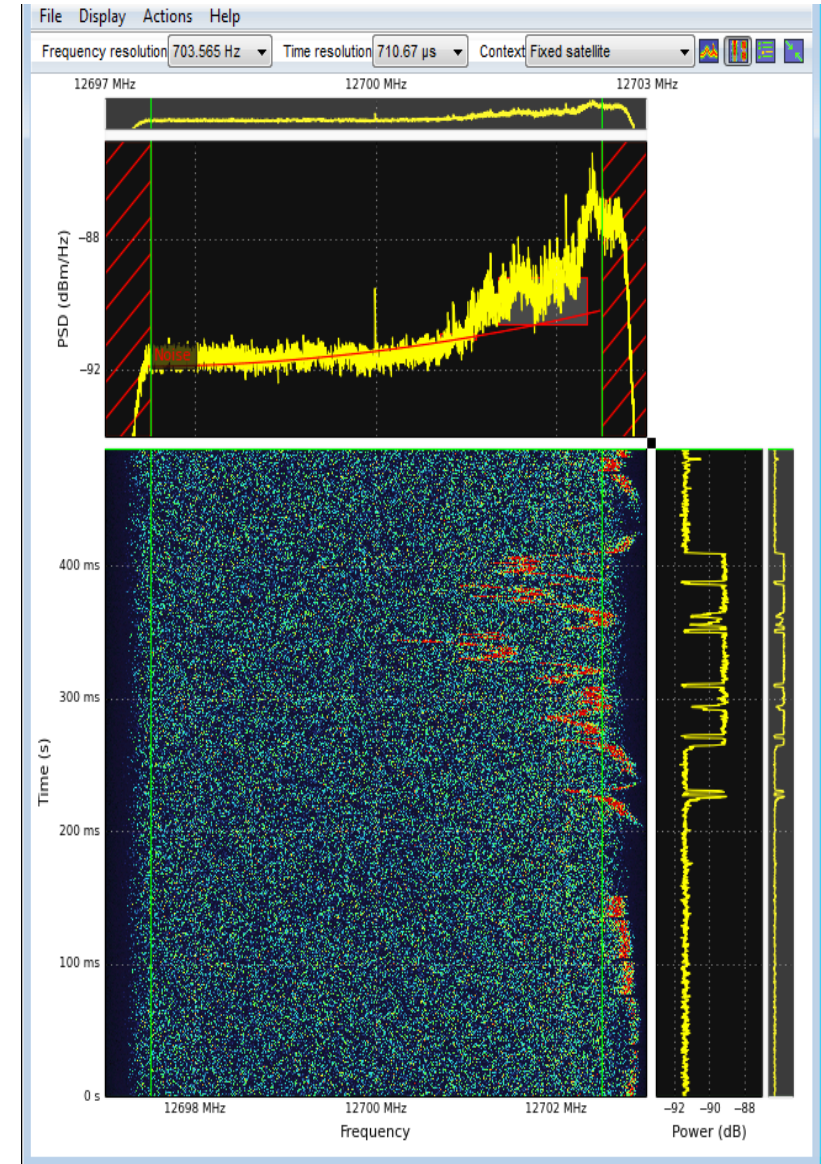
SATCOM Monitoring Interference Mitigation

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.

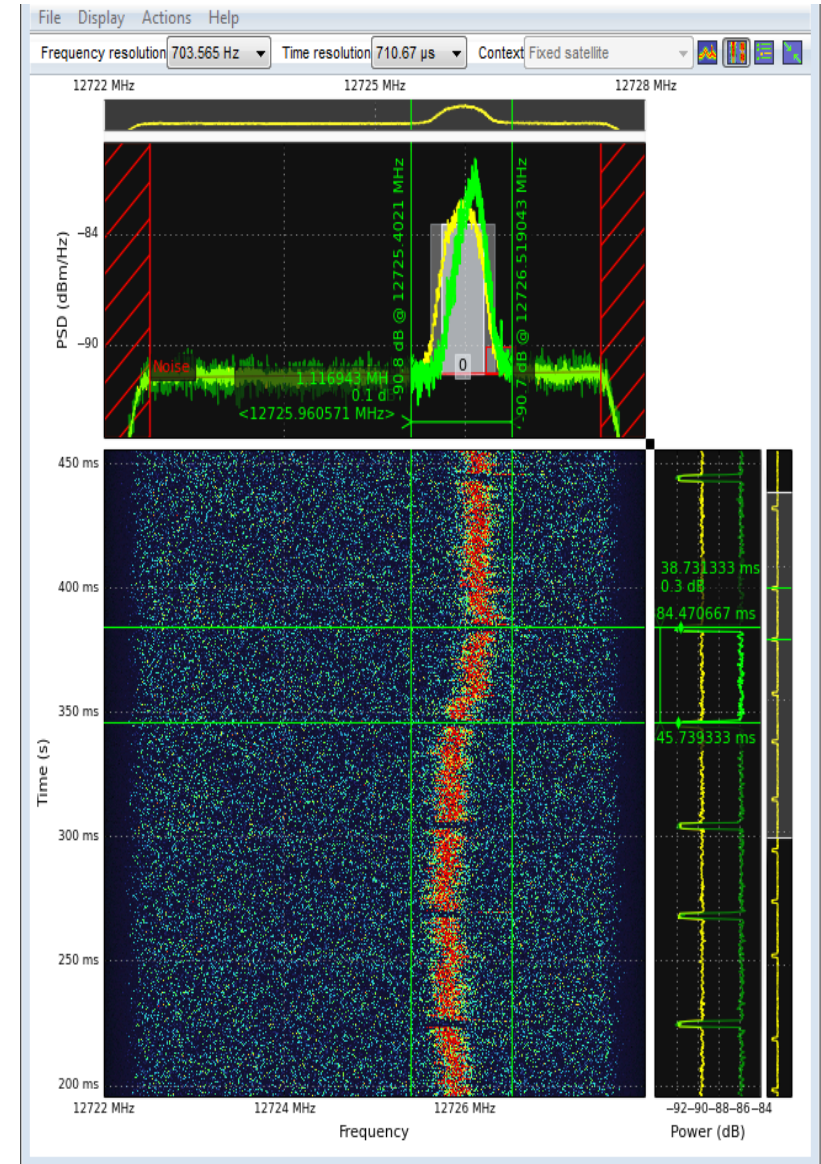


Interference Mitigation

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.



Interference Mitigation

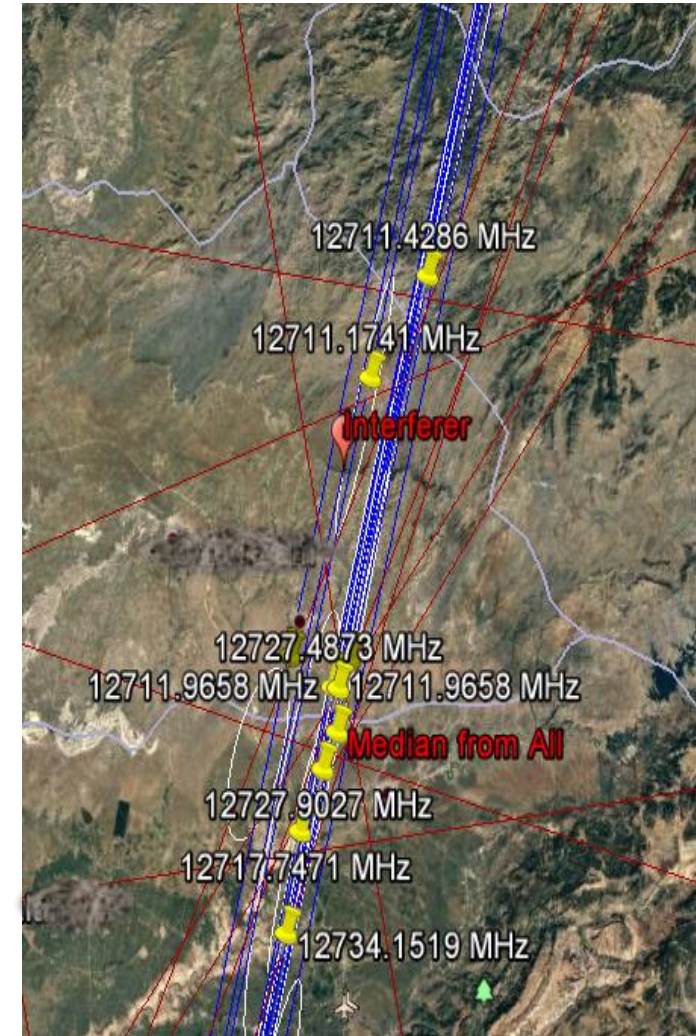
by ZODIAC DATA SYSTEMS

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.



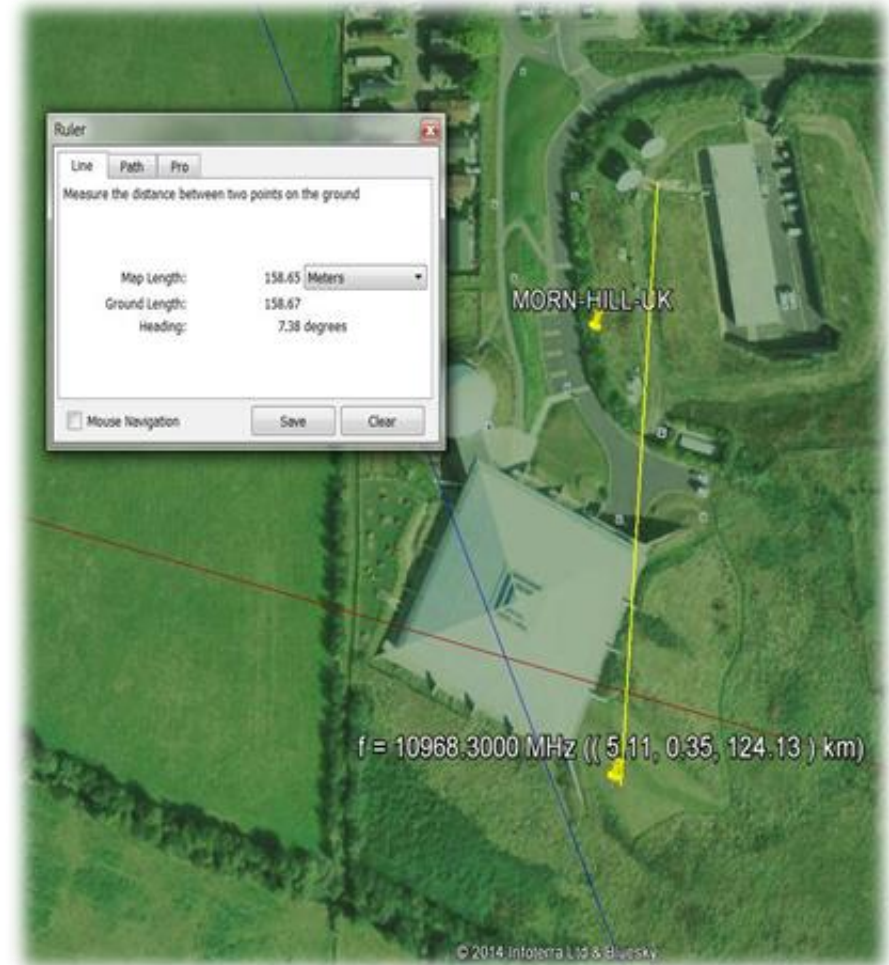
Geolocation

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