Communication & Situational Awareness

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MASTERING THE ELEMENTS

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



Five facilities in the world











Partner of the Spacefaring Nations







isro



JAXA









These lists are not comprehensive

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Cutting Edge Technologies Serving Aerospace



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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
 - \checkmark 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 checkout



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
 - \checkmark 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
 - $\checkmark~$ 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 \checkmark
 - Europe & Asia coverage
 - ✓ USA (end 2017)
- Defined Software 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.

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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
ts	Snapshots Geo-Mapping of transponder traffic.	Avaibility of top class satellite ephemerides allowing street/block class 2-sat geolocation.	Satellite Orbital position enforcement.
chievemen	Comprehensive TDMA traffic identification and geolocation.	Close circuit spectrum recording for interference prosecution.	100% succes rate CID.
Ă	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

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SATCOM Monitoring Carrier ID

Carrier ID

Carrier ID Scenario by ZODIAC DATA SYSTEMS CID tests

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

Carrier ID analysis										
File Help										
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INFO : BR high> Cha INFO : BR high> Cha INFO : BR high> Data	-67.6192 dB FS	1354501 kF	lz 0x00	:12:B4:FF:FF:00	:12:D6 51°08'59	'N 4°11'2	23"E	Bad B	ѹ	_
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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

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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

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02.400	7.04	100.00	-404 9606 0.419	2 1404 5000	0.0022	E 77	(15,717,0,5002) (20,54,1,40,6,75) Done		CSA::init()	Resolution = 6.10e+02 Hz, mi							
20.219	7.91	100.00	-455 2004 0.210	4 1004.3550	0.0000	11.90	(15.022 -2.081) (10.15 1.61 7.20) Done		FIR::init() [: CSA::detect() [:	Method:oas, types: f, F, 10 Starting with base std = 0.8	Ser	rvers pool					Ξ×
.29.310	7.91	100.00	400.0005 0.005	4 1596.1155	0.0021	11.00	(15.052, -2.961)(19.15, 1.61, 7.20) Done		CSA::detect()	Computing SGS kernels							
.4/0.566	7.55	100.00	-492.0325 0.065	2 1636.0221	0.0087	0.00	(18.435, 1.429) (17.79, 1.70, 8.06) Done	U)	CSA::detect() [CSA::detect()]	First frequency domain split Iterate on frequency domain	em	note metho rver IP a	ddre rietary sei	ver Timeoul	t Selection	Busy	Test result
100.010	7.23	100.00	-444.0443 0.060	/ 1592.5441	0.0067	9.22	(14.526, -4.063)(18.66, 1.63, 7.27) Done		Sonogram::get_sonogram() [Sonogram valid, used former	No	ne 127.0.0.	1 7900	1800.0	<	False	Server ready
.29.318	7.78	100.00	-479.1425 0.278	9 1651.4890	0.0025	8.81	(19.478, 0.860) (17.32, 1.68, 8.23) Done		sonogram() (estimate optimum sampling zc-	No	ne 127.0.0.	7901	1800.0	•	False	Server ready
09.055	7.63	100.00	-476.9180 0.039	6 1661.1379	0.0025	24.55	(20.272, 1.000) (16.52, 1.49, 7.63) Done		1 ·	carrier 0	No	ne 127.0.0.	1 7902	1800.0	•	False	Server ready
2819.138	16.81	100.00	-339.0180 0.045	5 1871.1554	0.0060	10.36	(39.496, -0.478)(2.24, 1.72, 81.90) Done		<	4	No	ne 127.0.0.	1 7903	1800.0	•	False	Server ready
54.316	7.83	100.00	-659.2748 0.053	3 1763.3634	0.0011	65.87	(31.779, 35.294 (33.60, 1.45, 7.54) Done				No	ne 127.0.0.	1 7904			False	
384.750	7.73	100.00	-660.3476 0.131	9 1403.4384	0.0025	11.15	(0.451, 9.433) (37.58, 1.36, 3.89) Done		Sampler monitor daemon (1Fo1P ¥2 (through sampler service	e)) 🗹 📕	No	ne 127.0.0.				False	
380.051	7.61	100.00	-842.0300 0.036	9 1398.3794	0.0034	17.68	(0.348, 32.748) (82.18, 1.42, 2.01) Done		Started		No	ne 127.0.0.				False	
'9.880	9.31	100.00	-270.6758 0.114	0 1700.1720	0.0014	22.42	(22.575, -14.344 (11.10, 2.69, 15.43) Done		Task 9: "Geolocation of all carriers in a transponder"		No	ne 127.0.0.				False	-
'8.964	7.32	100.00	-439.4131 0.026	4 1617.3738	0.0011	151.69	(16.433, -3.675)(18.04, 1.45, 6.74) Done		 Completed 		A	Actions					
32.626	10.25	100.00	-286.4272 0.070	4 1747.4276	0.0012	42.86	(26.734, -11.694 (8.25, 3.31, 23.92) Done					aunch local selected	servers				
382.797	8.45	100.00	-730.5539 0.021	7 1341.4985	0.0020	42.20	(-4.287, 15.338)(49.25, 1.50, 2.99) Done		Task 8: "Geolocation of all carriers in a transponder"			est selected servers butdown selected se	ivers				
311.508	9.04	100.00	-660.2830 0.115	6 1403.7814	0.0023	14.13	(0.451, 9.427) (37.55, 1.36, 3.89) Done		► Completed								
.81.503	6.73	100.00	-736.8106 0.394	1 1469.4136	0.0031	5.06	(5.725, 19.126) (43.28, 1.32, 3.81) Done				Tas	sk monitor					Ξ×
.34.811	9.29	100.00	-292.9908 0.034	9 1711.0258	0.0011	74.61	(23.488, -12.759 (10.44, 2.77, 16.75) Done					ask name: Geolocat	on of all carrier	is in a transpor	nder		
.34.811	9.17	100.00	-300.9649 0.066	3 1742.3121	0.0013	35.54	(26.240, -11.162 (8.67, 3.16, 22.09) Done					Status:Ready					
.40.305	9.66	100.00	-309.2403 0.042	9 1740.9529	0.0012	55.96	(26.156, -10.540 (8.79, 3.08, 21.37) Done						Start			Stop	
.41.220	9.35	100.00	-293.3414 0.051	6 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 0.041	3 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 0.076	7 1719.1029	0.0012	35.53	(24.125, -13.337 (9.96, 2.94, 18.30) Done	-									
•							4										
Signal PSD a	nd detected o	arriers					•	×	Global map	🗆 🗙 Selected ca	arrier d	details					Π×
									Latitude = 38.3417 deg, longitude = 7.5586 deg Make measur	res Zoom level (4.0)	Map	Measures Phase	ath				
-80 [ZH//UBD] GSd -100	Province transfer of the second secon							Chad Juget Charge Content of the server									
SHOW MIT	a ardinaponde	ə. 💌							opuare map			~~~		- And All			exect TIBINA /

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Geo-Mapping scenario by ZODIAC DATA SYSTEMS Automated geolocation of SCPC carriers

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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.

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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
 - o 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

