



Centralized GNSS Monitoring and Assurance

Mitigating GNSS jamming & spoofing utilizing artificial intelligence (AI) and machine learning (ML)

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GNSS vulnerability - known issues

NEWS Irea Made Wad UK Barres Ted Some Agent Determined & Technology GPS error caused '12 hours of problems' for companies Br Othe Barrels Recording model 0. (Parlow) 2016 Technology

News Sport Weather Shop Earth Travel N

BBC O Sign in



Several companies were hit by hours of system warnings after 16 GPS satellites broadcast the wrong time, according to time-monitoring company











Menu -

Nato holds biggest military exercise since Cold W

BBC O Sign in

Finnish Prime Minister Juha Sipila has said the GPS signal in his country's northern airspace was disrupted during recent Nato war games in Scandinavia.

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BUD CRUNCET STOP

Am I the only one been affected?

Cause	Impact
Segment error	Global/Regional
Adjacent band transmissions	Local/Regional
Spoofing	Local/Regional
Jamming	Local/Regional
Environmental	Local/Regional
Equipment failure	Local

Identifying the scale of impact can help us classify the cause



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Existing, distributed local (limited) approch

- Each GNSS receiver is working independently
- Detection of GNSS outages are done locally
- Disadvantages and weaknesses :
 - Limited/no data from external sources
 - Decision can't be made based on the "bigger picture"
 - Limited memory and compute power



Limited and sub-optimal detection & decision making



Can we do better ?

The centralized-global approch

- Relevant data is collected from all the GNSS receivers in the network
- External data is collected from independent sources
- Advantages and strengths :
 - Multiple sources of relevant data are available for analysis
 - Decision is based on the "bigger picture"
 - Unlimited memory and compute power
 - Utilize Artificial Intelligence (AI) and Machine Learning (ML)
 - Can be done remotely no dedicated HW is needed on site



Optimal detection & decision making



Centralized GNSS monitoring and assurance



Centralized GNSS monitoring and assurance



What data can we get for a GNSS receivers ?

The following data is available from most of the commercial GNSS receivers via API Can be collected remotely over secured interfaces (e.g. CLI-SSH/SNMPv3)

- Location :
 - Latitude , Longitude, Altitude
- Satellites related data
 - SV , Carrier to Noise , Health , Azimuth, Elevation

Satellite Entry Table

sv	In use	Constellation	C/No[dB- Hz]	Health	Azimuth[deg]	Elevation[deg]
2	Yes	GPS	36	OK	128	51
6	Yes	GPS	42	OK	77	42
12	No	GPS	31	OK	329	52
15	No	GPS	23	OK	205	13
17	No	GPS	41	OK	46	5
19	Yes	GPS	32	OK	42	27
24	No	GPS	26	OK	210	80
25	Yes	GPS	36	ОК	298	24
29	No	GPS	28	OK	233	20
32	No	GPS	29	ОК	316	7
78	No	GLONASS	36	NA	119	16
79	Yes	GLONASS	36	NA	77	59
80	Yes	GLONASS	17	NA	339	44
81	Yes	GLONASS	31	NA	32	46

Location

Self-survey: EnabledCoordinate Latitude: N32:11:32.094Coordinate Longitude: E34:53:8.706Coordinate Altitude: 85.3 m



What external data is available on-line ?

- GNSS related data:
 - Satellite ephemerides
 - GNSS Broadcast ephemeris files
- GNSS maintenance related info :
 - Satellite decommission
 - Satellite health
 - New Satellite
 - Special events (e.g. Leap second and GPS rollover)
- Weather and space weather data :
 - Atmospheric parameters
 - Tropospheric path delay
 - Ionospheric conditions



IGS Product Access has been moved to CDDIS and other Global Data Centers in 2017 please view the news article for details. To obtain access to the products please continue reading this article.

GPS Satellite Ephemerides (Orbits) / Satellite & Station Clocks

ftp://cddis.gsfc.nasa.gov/gnss/products,
ftp://igs.ensg.ign.fr/pub/igs/products/

Orbit and Station and satellite clock products are found in the standard product directories, the orbits in files that end in ".sp3.Z and the clocks in files that end in ".clk.Z ;.

The purpose of the APV is to provide data for software-reab developers to build safe As of March 15: 2018, the older API, based on SOAP Web Services is going to be

The REST API v1 is the bulk to transaction annual. The current sets is 1000 bench to be the set of the set of

ense kovy to get around the mounty transa • ftp://gssc.esa.int/gnss/product: When and authorized by a longer law. (All law.) To presente a unitial former law. Users are requested first to

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accellen in the instance, topace tradem (1959) in ACRAE to 20564. "All request, method used to GET, to PLR: https://www.thpo.com/sets/r/hop/effer topy: The API key (apikey) must be appended at the end of the URL as &apiKey+tyour API key)

tolowing functions are currently available.



Better decision making based on comprehensive, meaningful data



GNSS health - live network summary status





GNSS health – network historical status



C/N spectrograms (heatmap)





Things might not stay as they use to be...



Blind spot example – customer site



Poor signal from the tower direction



OSCILLOQUARTZ



High tower

Example - poor installation GNSS antenna installed near a wall N 10 urong Town Hall Rd IMPE PH 0+0 谷昌 TripZilla.com esmo Asia Ptel

Export to plot ly »



Useful data displays

Geo-map of the network



Historical display of number of satellites in view/in use





Useful data displays

Satellites usage heatmap









Site Analysis – "Good " Site





Historical view - Compare C/NO Heat Map on different time or different sites at same time



GNSS Antenna – Signal Reception

Artificial Intelligence and Applied Machine Learning | GNSS use case



... You need skilled and experienced staff to interpret imaging techniques of any kind.



The next level – Artificial Intelligence (AI) and Machine Learning (ML)

- ML and AI can help us automatically detect changes in patterns
- Safeguard GNSS signal reception in timing and synchronization networks
- Predictive maintenance through long term satellite telemetry trending and analysis
- Detect GNSS anomalies such as signal obstruction caused by trees, walls and signal interference (jamming and spoofing) etc.
- Allow early detection of protentional problems
- Can be scaled to very large networks
- Reduces OPEX



Al and ML allow automatic detection of a fault



GNSS Monitoring and Assurance using AI & ML



Machine learning in action





Example

Sky view as reported for three sites demonstrating applied machine learning to detect GNSS antenna blind spots.



Summary

- Our solution is based on centralized GNSS monitoring and assurance
- The solution can be applicable to any GNSS receivers which are capable of providing the minimal related data
- No need for additional hardware or to physically attending the site
- Provide network view of GNSS receivers health
- Allow remote in depths analysis
- Utilize ML and AI for optimal and automated detection of potential GNSS service degradation







Thank you

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GNSS vulnerability - public reports

UK Government : <u>https://www.gov.uk/government/publications/satellite-derived-time-and-position-blackett-review</u>



USA ATIS GPS vulnerability report: <u>http://www.atis.org/01_resources/whitepapers.asp</u>



