OSCILLOQUARTZ
An ADVA Company

70 YEARS
TIMING EXCELLENCE

Centralized GNSS Monitoring and Assurance

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

Nir Laufer , Senior Director Product Line Management , Oscilloquartz

March 2019 , WSTS 2019

GNSS vulnerability - known issues


BBC Sign in News Sport Weather Shop Earth Travel
NEWS
Home Video World UK Business Tech Science Magazine Entertainment & Arts
Technology

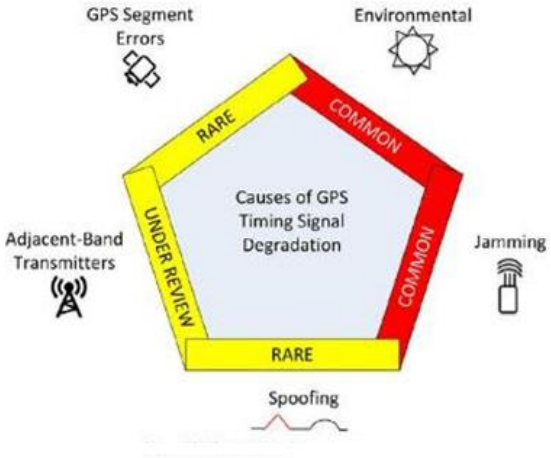
GPS error caused '12 hours of problems' for companies

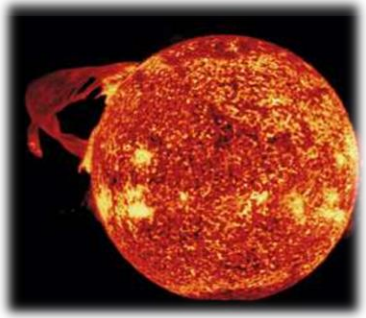
By Chris Baraniuk
Technology reporter

4 February 2016 Technology

System engineers were "called out of bed" over the problems

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





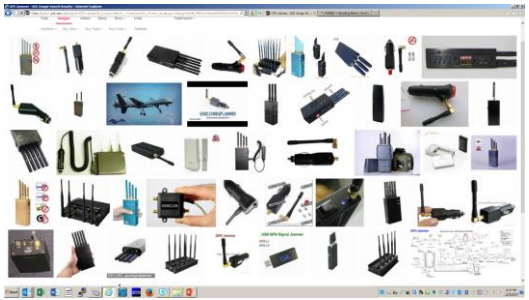

BBC Sign in Menu
NEWS
Home Video World UK Business Tech Science Stories Entertainment & Arts
World Africa Asia Australia Europe Latin America Middle East US & Canada

Russia suspected of jamming GPS signal in Finland

12 November 2018 Share

Nato holds biggest military exercise since Cold War

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.



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

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 ?

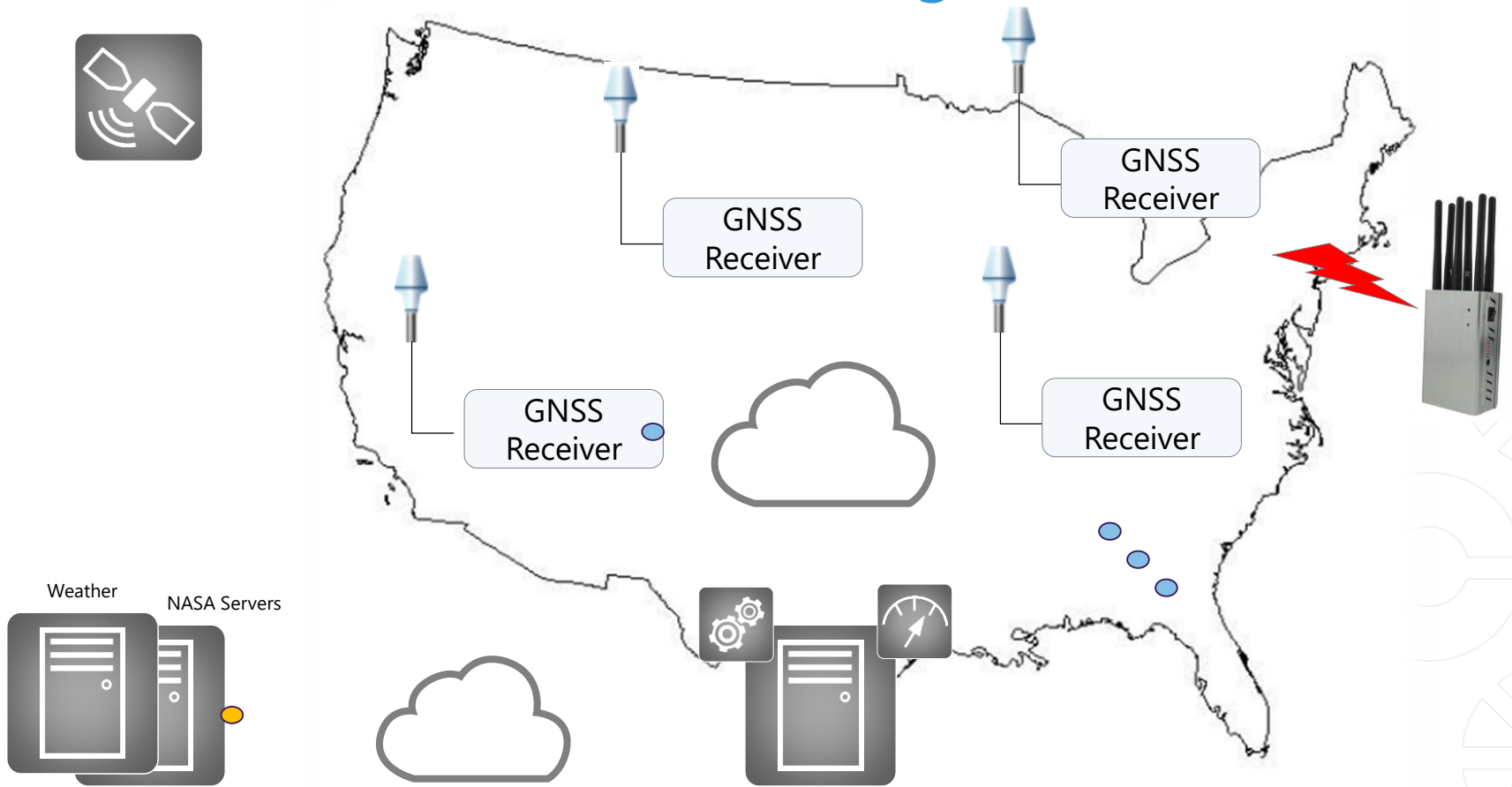
The c**entralized-global** approch

- 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

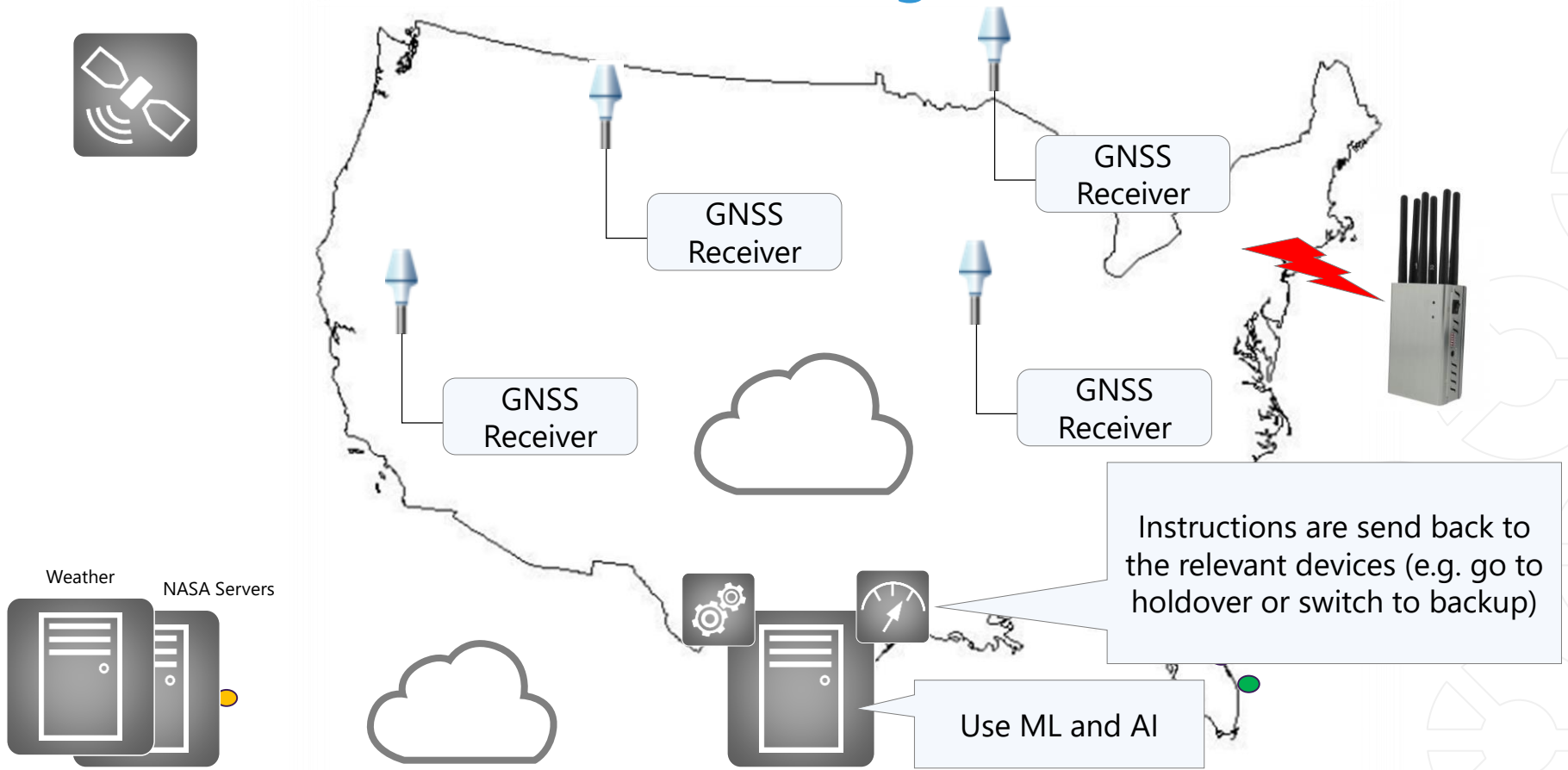
Optimal detection & decision making

Centralized GNSS monitoring and assurance



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

Location

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

Satellite Entry Table

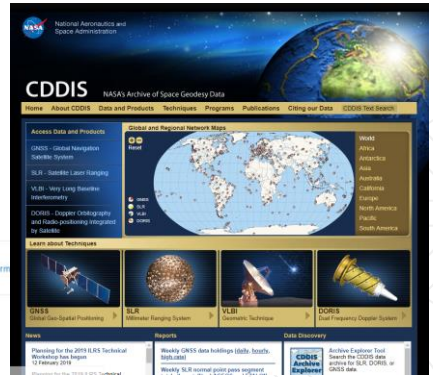
SV	In use	Constellation	C/No[dB-Hz]	Health	Azimuth[deg]	Elevation[deg]
2	Yes	GPS	36	OK	128	51
6	Yes	GPS	42	OK	77	42
12	No	GPS	31	OK	329	52
15	No	GPS	23	OK	205	13
17	No	GPS	41	OK	46	5
19	Yes	GPS	32	OK	42	27
24	No	GPS	26	OK	210	80
25	Yes	GPS	36	OK	298	24
29	No	GPS	28	OK	233	20
32	No	GPS	29	OK	316	7
78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

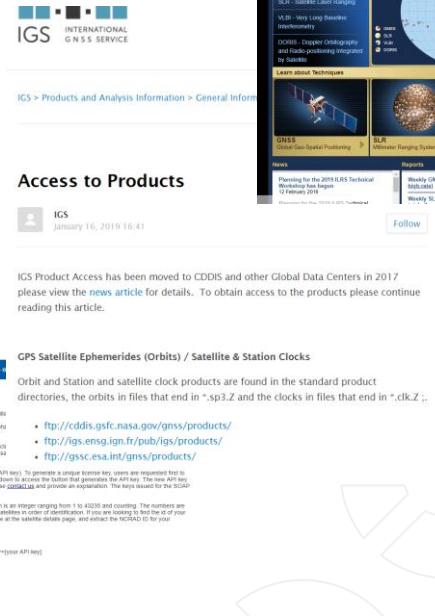
What external data is available on-line ?

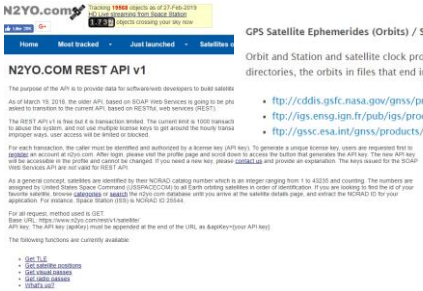
- GNSS related data:
  - Satellite ephemerides
  - GNSS Broadcast ephemeris files

- 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

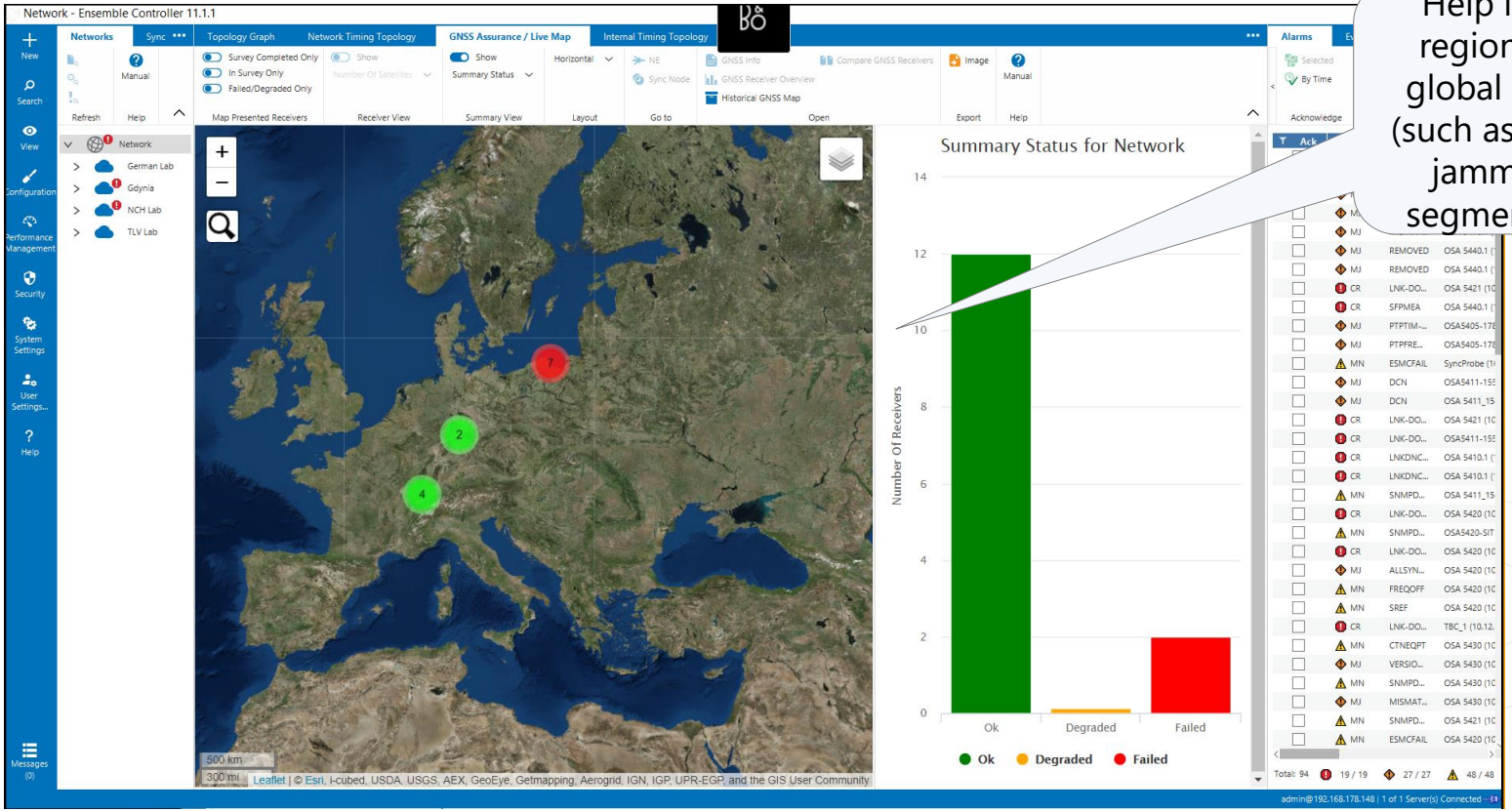




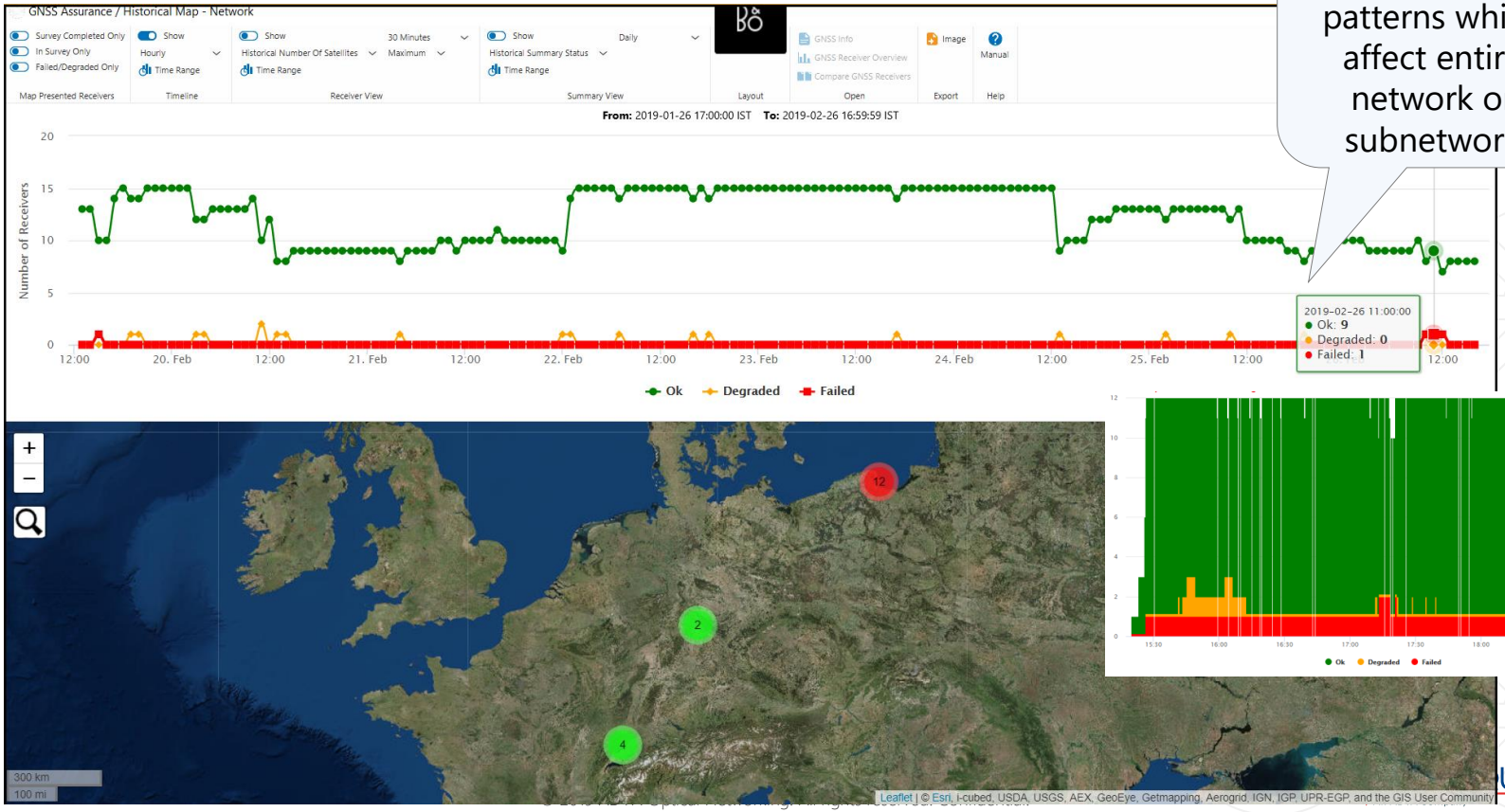


Better decision making based on comprehensive, meaningful data

GNSS health - live network summary status

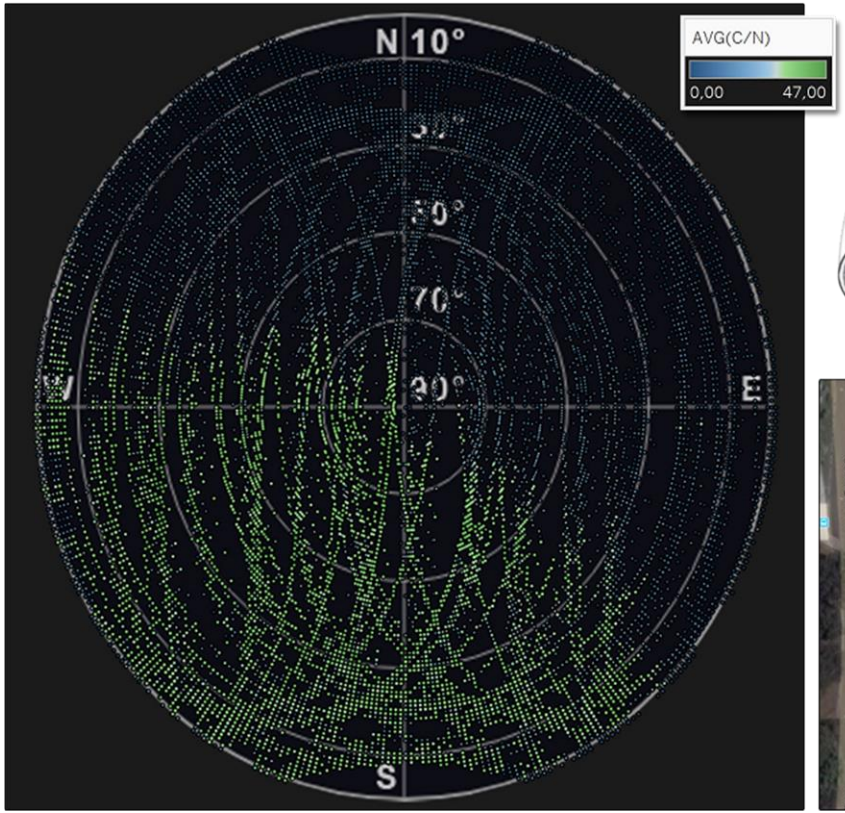


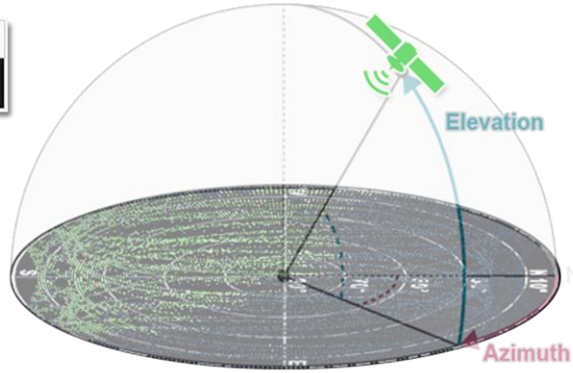
GNSS health – network historical status

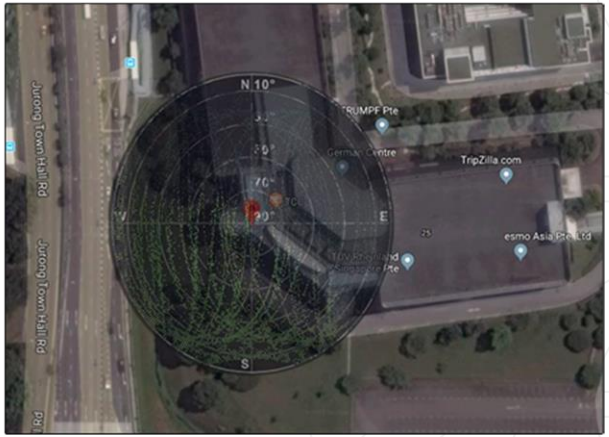


Help identify periodic patterns which affect entire network or subnetwork

C/N spectrograms (heatmap)

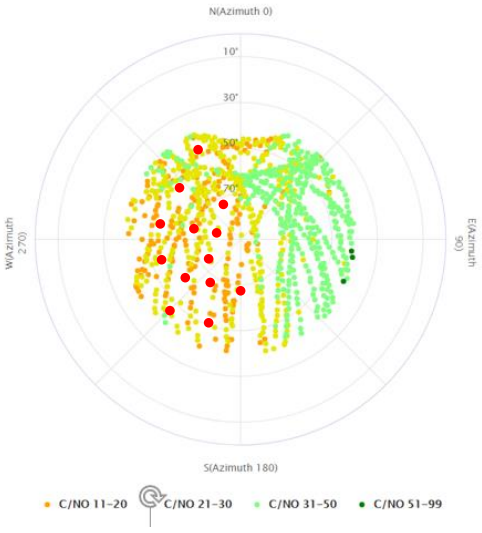


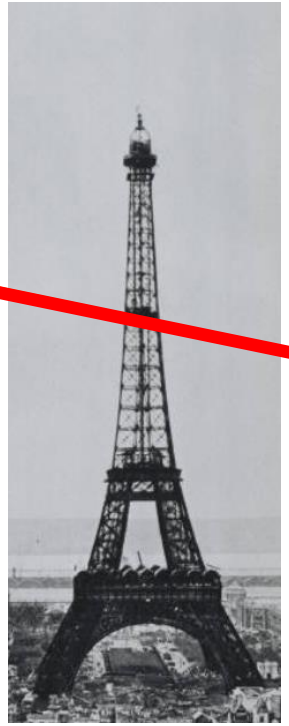


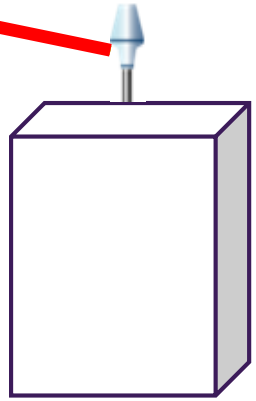


Things might not stay as they use to be…

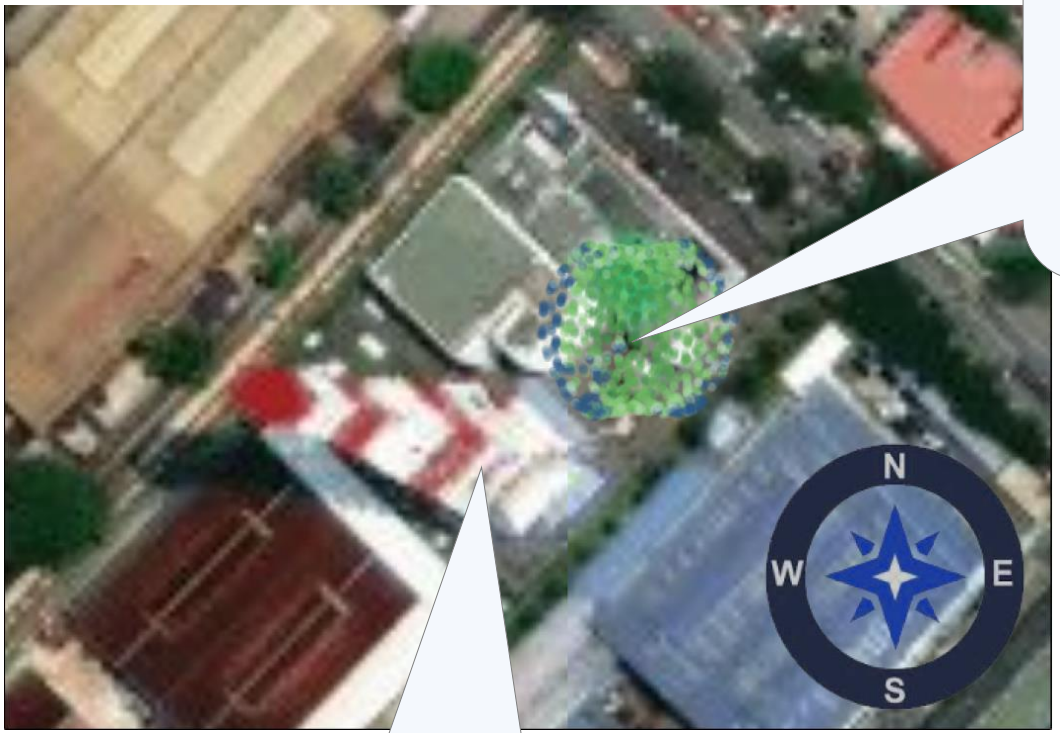
How can we automatically detect changes in site conditions?



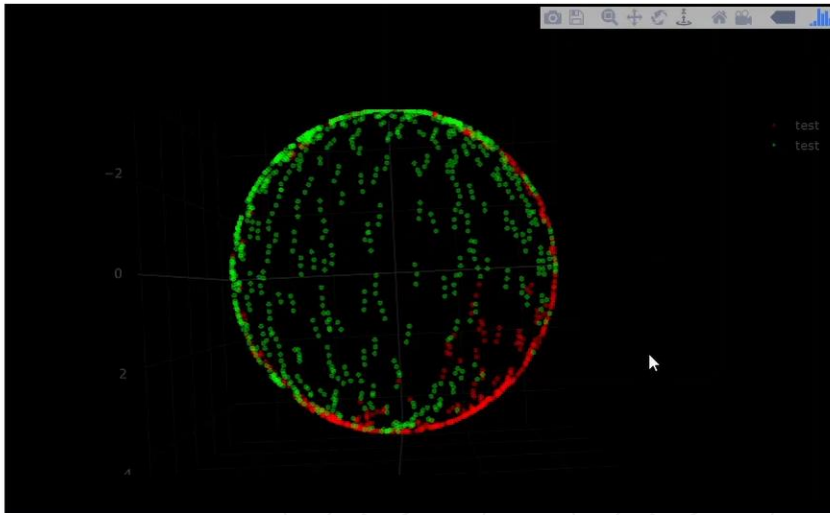




Blind spot example – customer site

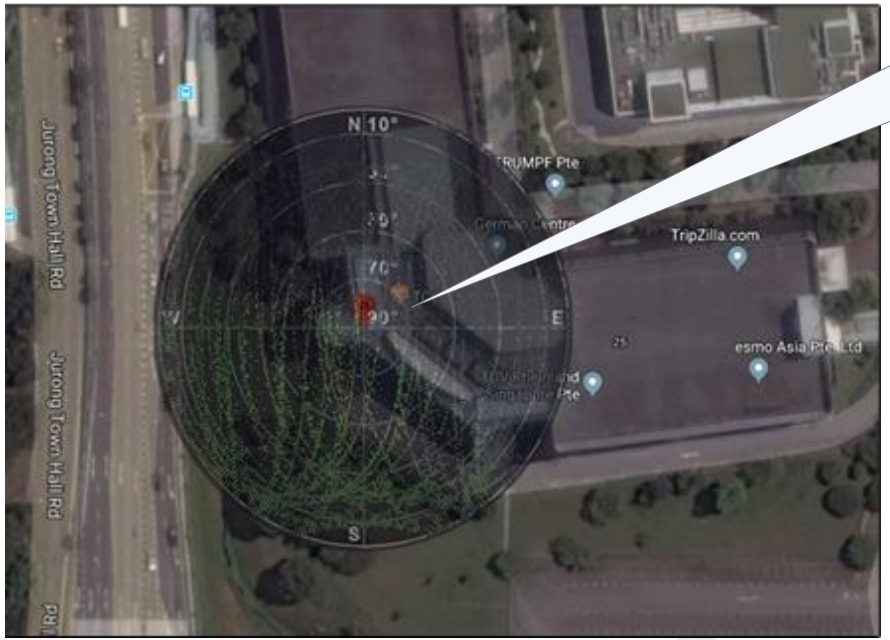


Poor signal from the tower direction

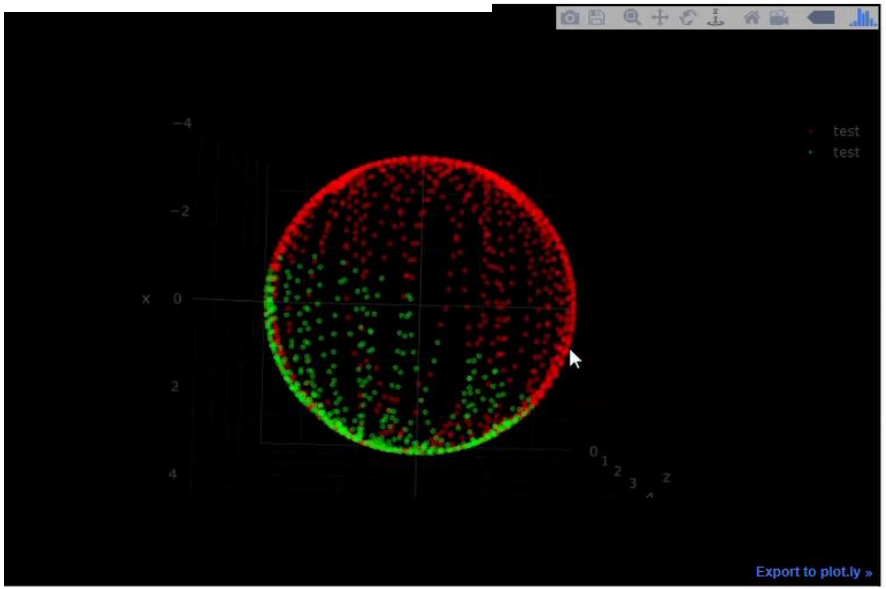


High tower

Example - poor installation



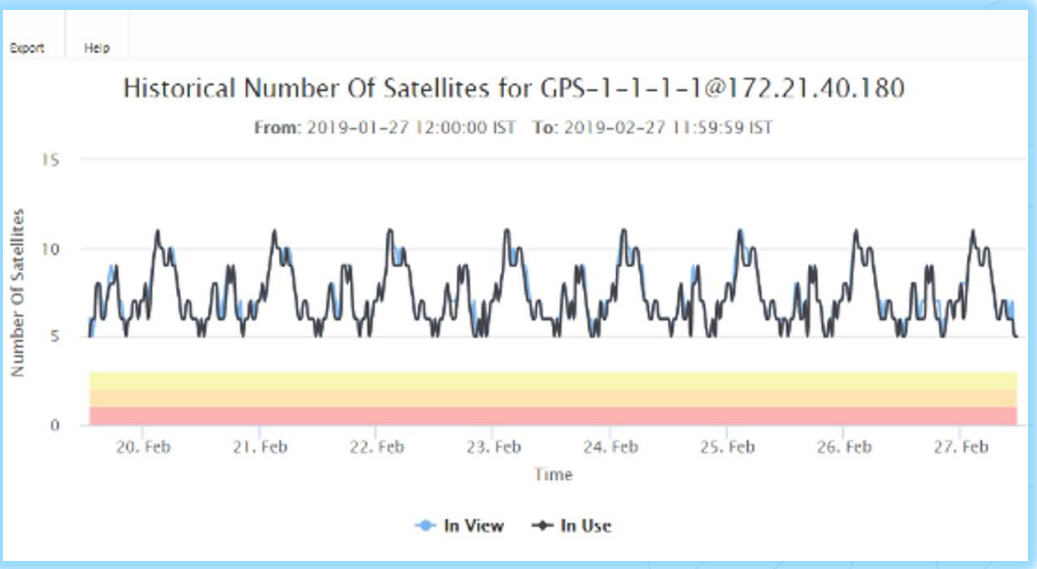
GNSS antenna installed near a wall



Useful data displays

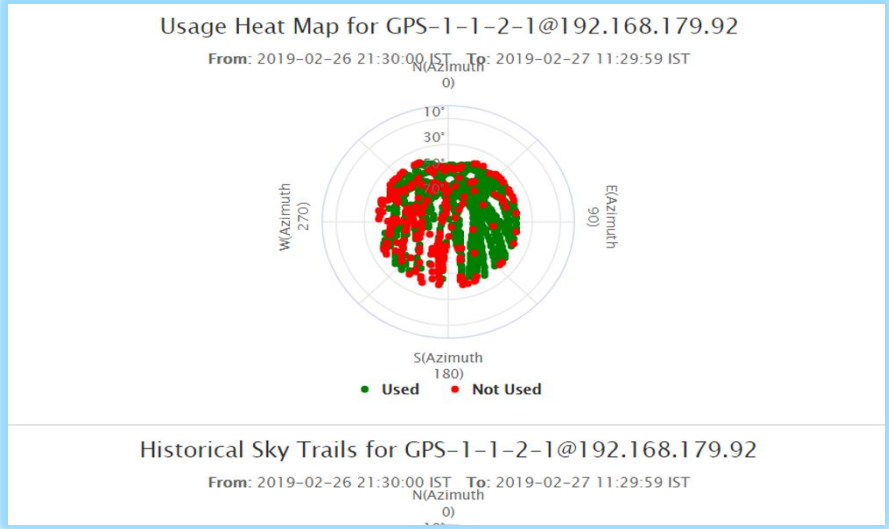
Geo-map of the network

Historical display of number of satellites in view/in use

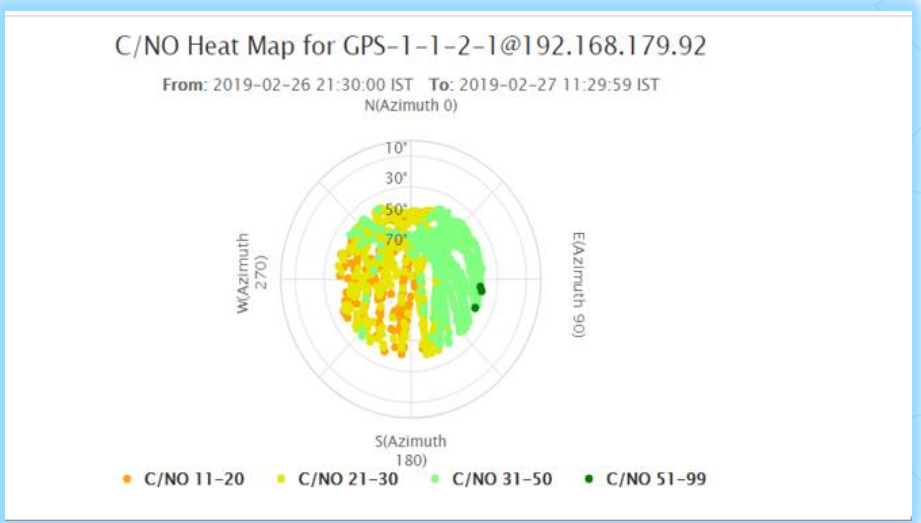


Useful data displays

Satellites usage heatmap

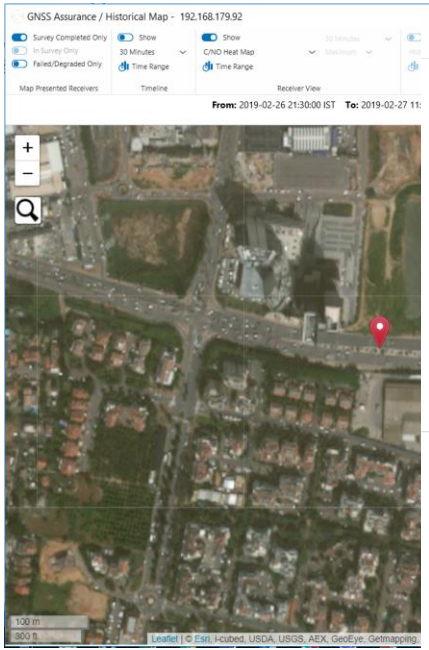


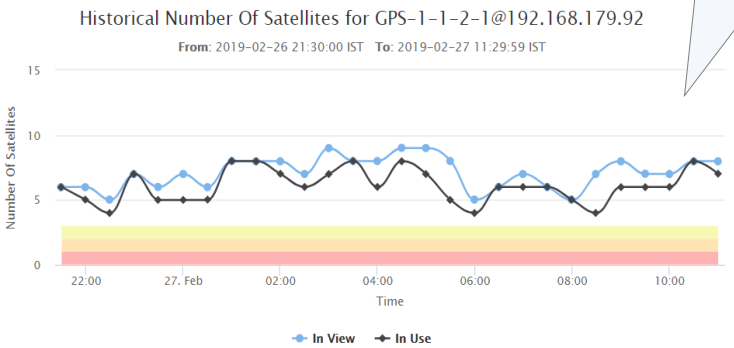
C/N heatmap (indication of directional GNSS signal strength).

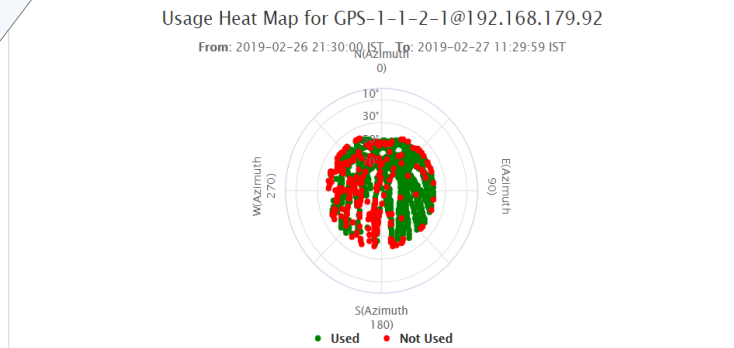


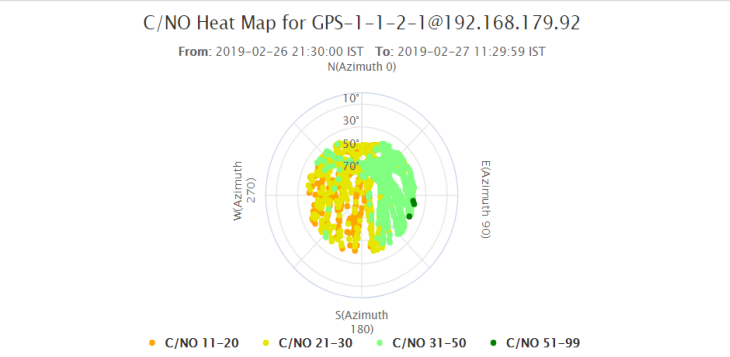
Site Analysis – "Bad" Site

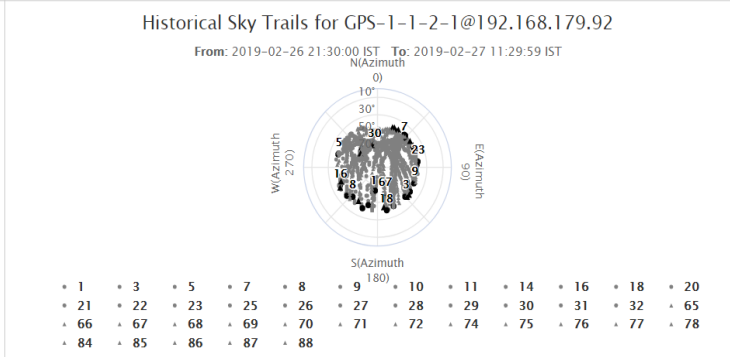
Help identify local reception issue



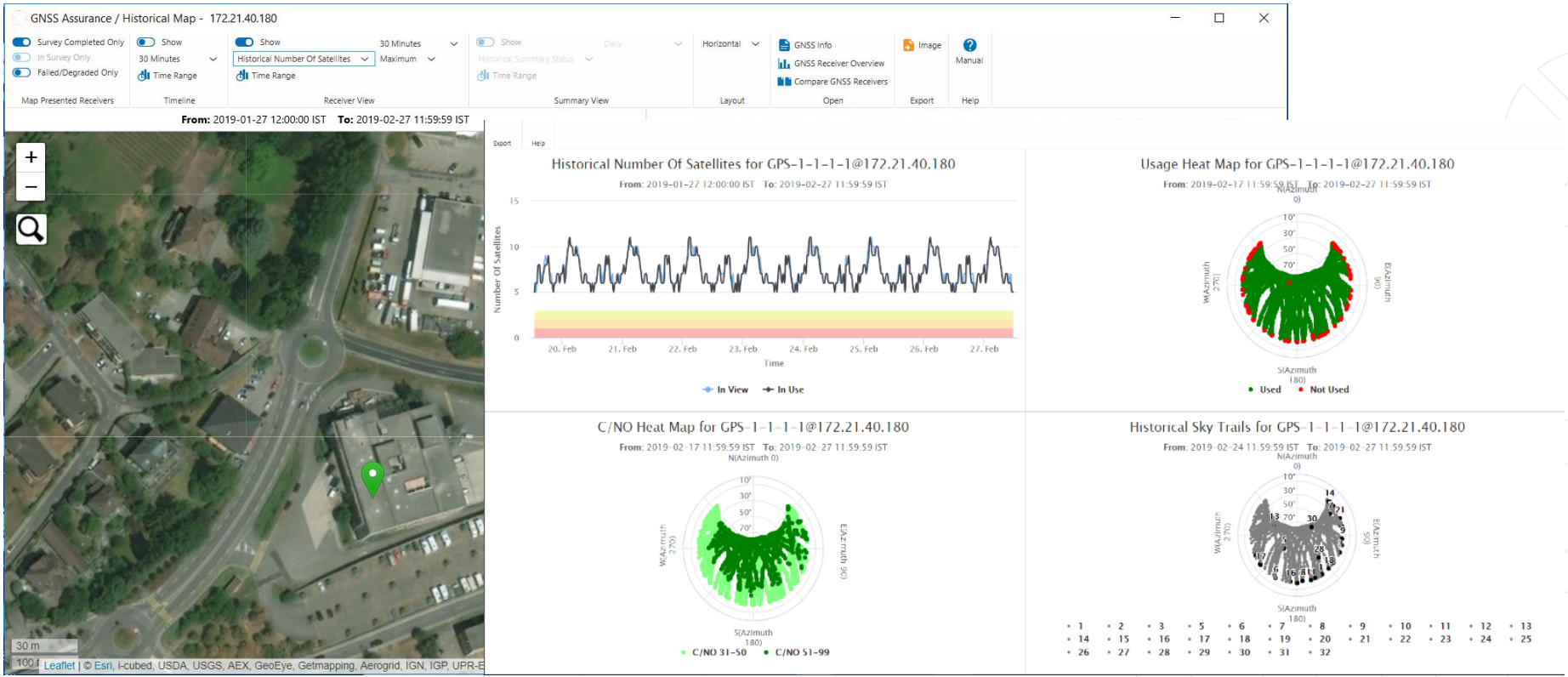








Site Analysis – “Good ” Site



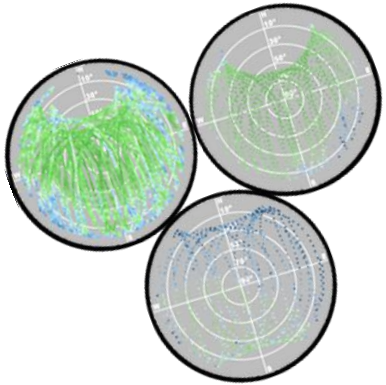
Historical view - Compare C/NO Heat Map on different time or different sites at same time

GNSS Antenna – Signal Reception

Artificial Intelligence and Applied Machine Learning | GNSS use case

Reading these …

… is like reading these



ML can assist here …

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

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

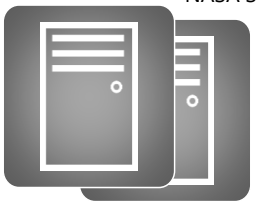
- ML and AI can help us automatically detect changes in patterns
- Safeguard GNSS signal reception in timing and synchronization networks
- Predictive maintenance through long term satellite telemetry trending and analysis
- Detect GNSS anomalies such as signal obstruction caused by trees, walls and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

AI and ML allow automatic detection of a fault

GNSS Monitoring and Assurance using AI & ML

Weather

NASA Servers



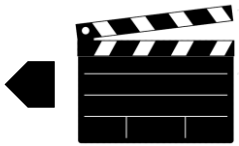
AI Server

Automatic detection of abnormal patterns

Alert

React

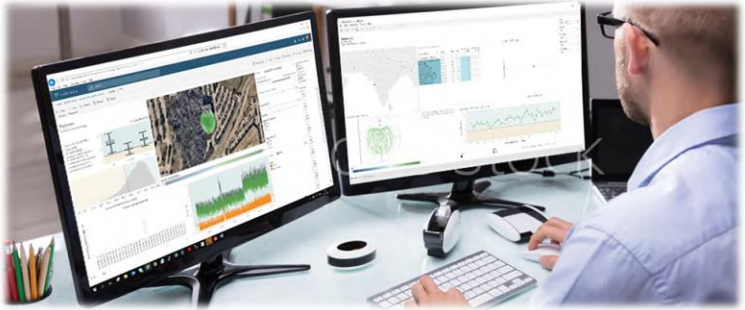
Machine learning in action



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



OSCILLOQUARTZ
An ADVA Optical Networking Company

Thank you

Nlaufer@advaoptical.com

GNSS vulnerability - public reports

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

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