Advanced Monitoring and Troubleshooting of Large Scale GNSS Antennas Installations

WSTS 2021

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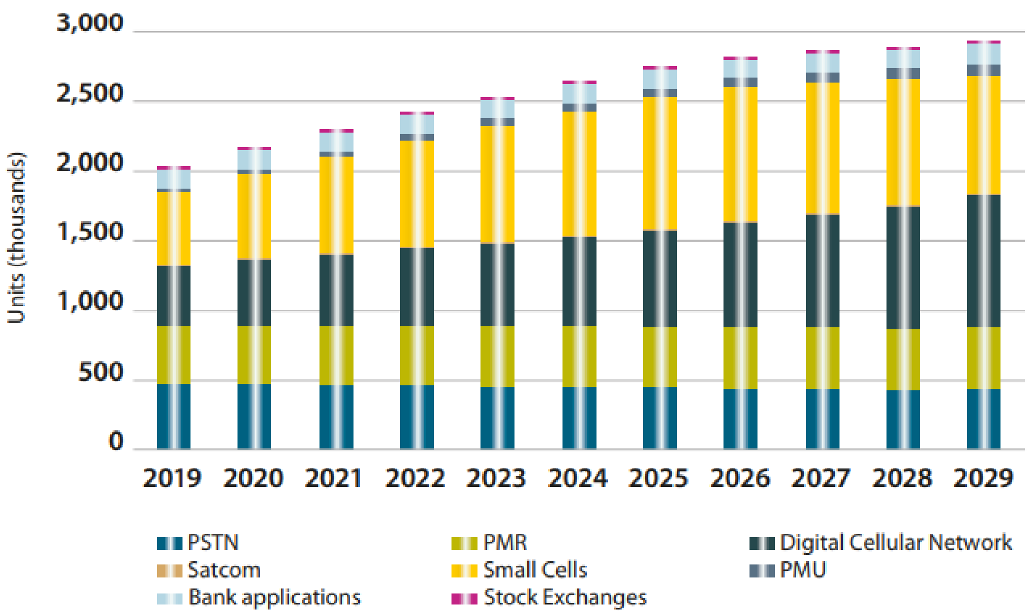
Over two million GNSS timing receivers in use…

Installed base of GNSS devices by application



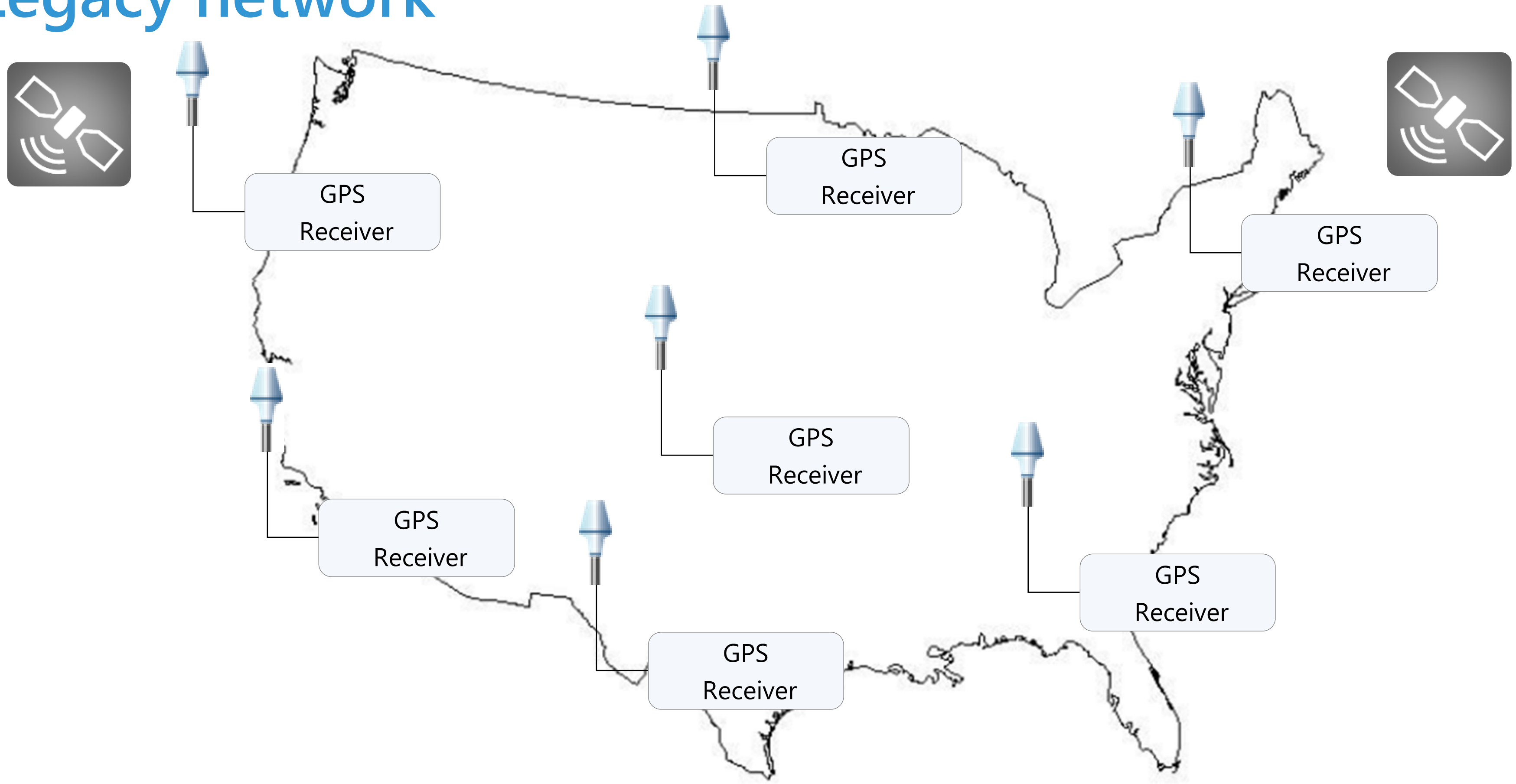
GNSS applications

- **Telecommunication applications:** Telecom operators require accurate time and a consistent frequency at distant points of their networks to meet increasingly demanding broadband requirements.
  - **Digital Cellular Network (DCN):** GNSS is used to provide consistent frequency and time alignment between all base stations within the network.
  - **Public Switched Telephone Network (PSTN):** GNSS is usually a back-up to atomic clocks to provide time slot management.
  - **Professional Mobile Radio (PMR):** GNSS is used for synchronisation of time slots and handovers between base stations.
  - **Satellite Communication (SATCOM):** GNSS is typically used in Satellite Control Stations and Telecommunications Gateways, mostly for frequency control.
  - **Small cells:** GNSS is used to provide frequency and phase alignment in small cell networks.
- **Energy applications:** Energy operators require an accurate time source to monitor the energy flow of their networks.
  - **Phasor Measurement Units (PMU):** GNSS is used to provide a precise timing marker at nodal points of the networks to ensure monitoring and protection against failure.
- **Finance applications:** Financial institutions are legally required to trace operations within a consistent and accurate time scale.
  - **Bank applications:** GNSS is used for time-stamping functions to log events in a chronological manner, and therefore be able to establish causal links.
  - **Stock Exchanges:** GNSS is used by Stock Exchange servers to apply time-stamps to the trades they execute and to the quotes they establish.

Number of GNSS timing receiver in use increases significantly

Source: https://www.gsa.europa.eu/system/files/reports/market_report_issue_6_v2.pdf

Legacy network



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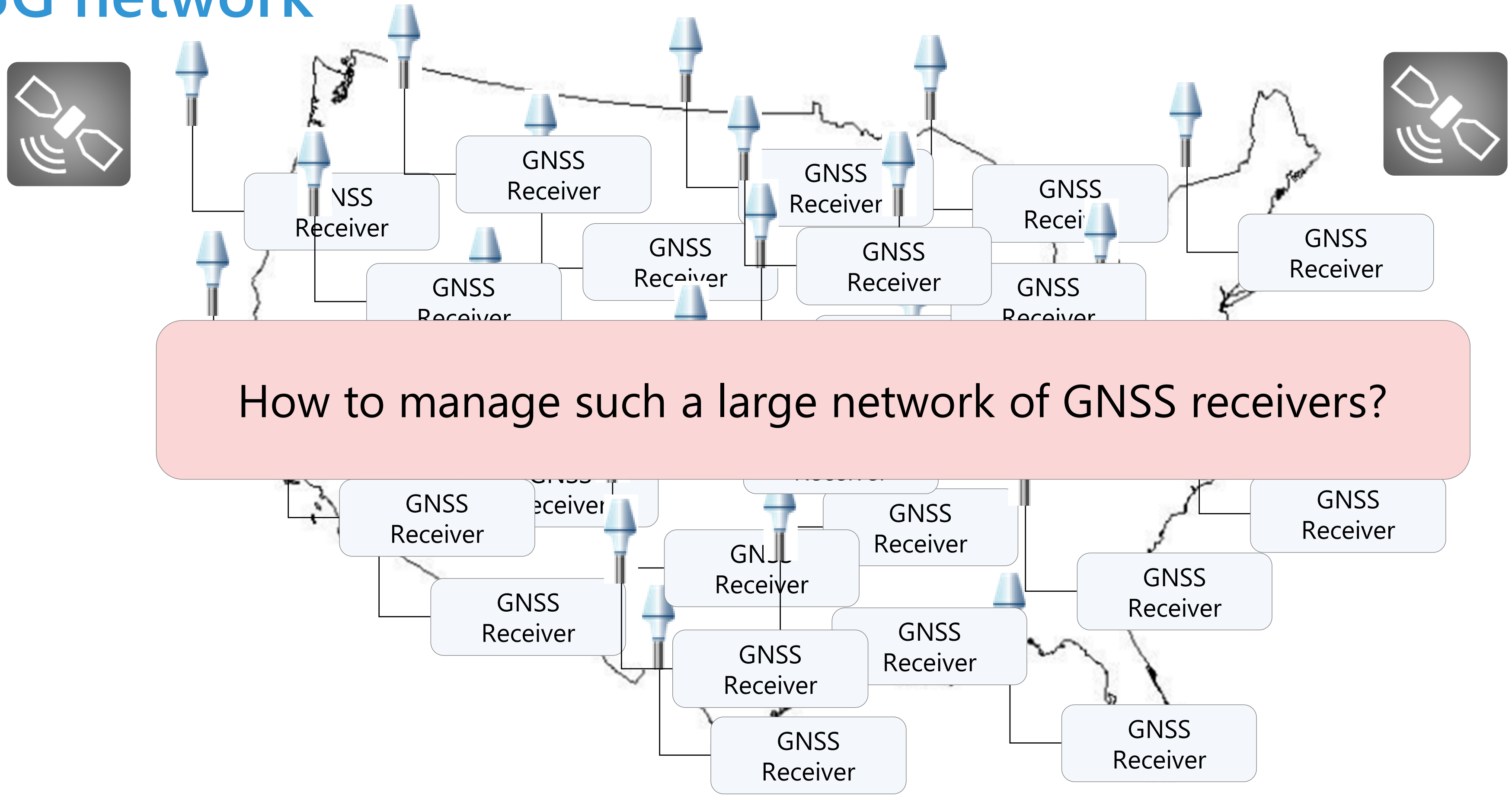
5G network



How to manage such a large network of GNSS receivers?

Example from mobile network

Legacy Networks

- GPS used mainly in core location
- Single constellation (GPS) , single band (L1)
- Loose frequency accuracy (16ppb)
- Frequency distribution from core using physical layer (T1/Sync-E) or PTP (e.g. G.8265.1)
- Few tens of GNSS receiver in large network
- Jamming and spoofing not very common

Next generation Networks

- Uses GNSS in core , aggregation and cell sites
- Multi constellation (GPS/GALILEO/GLONASS/BEIODU) , multi band (L1/L2/L5) options
- Synchronization requirements are becoming tighter (sub 1usec)
- Phase and time distribution from PTP GM or GNSS directly connected to the end application
- Few thousands of GNSS receiver in large network
- Jamming and spoofing becoming a real threat

Networks are becoming more dependent on GNSS

GNSS vulnerability - known issues


Technology

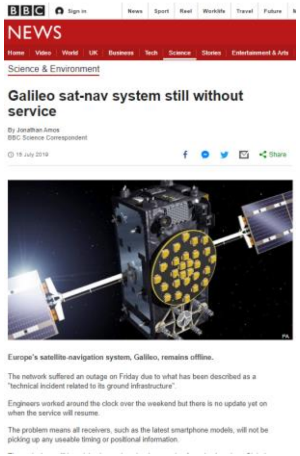
GPS error caused '12 hours of problems' for companies

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 15 GPS satellites broadcast the wrong time, according to time-monitoring company


Science & Environment

Galileo sat-nav system still without service

By Jonathan Amos
BBC Science Correspondent

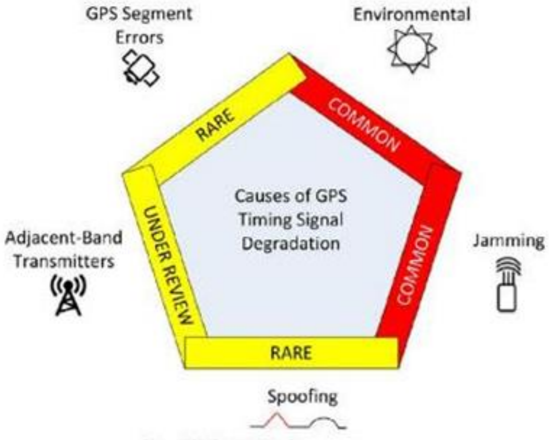
15 July 2019

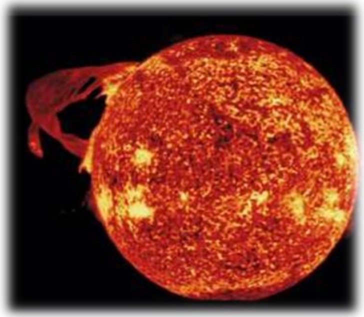
Europe's satellite-navigation system, Galileo, remains offline.

The network suffered an outage on Friday due to what has been described as a "technical incident related to its ground infrastructure".

Engineers worked around the clock over the weekend but there is no update yet on when the service will resume.

The problem means all receivers, such as the latest smartphone models, will not be picking up any useable timing or positional information.






Technology

Russia denies role in Israeli airport GPS jamming

27 June 2019

GPS signals have been unreliable for weeks, said officials

Russia has denied Israeli suggestions that it is behind disruption of GPS signals at Israel's Ben Gurion airport.

Since early June, GPS signals at the airport have been unreliable for pilots and planes using the location.

The missing navigational data has had a "significant impact" on airport operations, said Israel's Airports Authority.

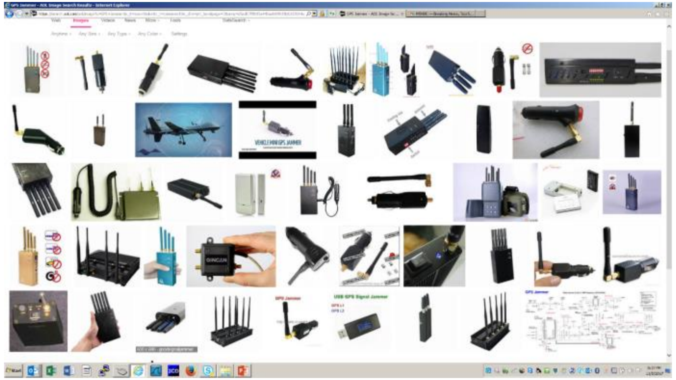

World

Russia suspected of jamming GPS signal in Finland

12 November 2018

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.



Real world challenges

Installation challenges

1. Find suitable location with good sky view
2. Getting roof top access
3. Routing long RF cable to the roof
4. Lightning protection
5. GNSS installation is done by subcontractor with limited knowhow
6. **Validating the antenna was installed properly before been used**

Operational challenges

1. Dynamic condition around the antenna
   - Trees , new buildings , new equipment installed nearby
   - Intentional and unintentional jamming and spoofing
2. Antenna failures (lightning , long outdoor exposure)
3. GNSS constellation operational problems affecting the receiver
4. **Monitoring the antenna and receiver health + efficient troubleshooting of possible problems**

Centralized GNSS receivers monitoring and assurance

The **centralized** approch

- Relevant data is collected from all the GNSS receivers in the network
- 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

Questions to be answered …

- Which sites are affected?
- Location of the sites (urban/rural)?
- Was the same problem reported in nearby sites?
- When reported issue started?
- What were the conditions on site after installation (day 1)?
- From which “direction” GNSS reception is poor ? Any nearby objects?
- Periodic pattens or sporadic ?
- Which GNSS constellation are affected? (all/only one)

Centralized GNSS assurance NMS can answer these questions!

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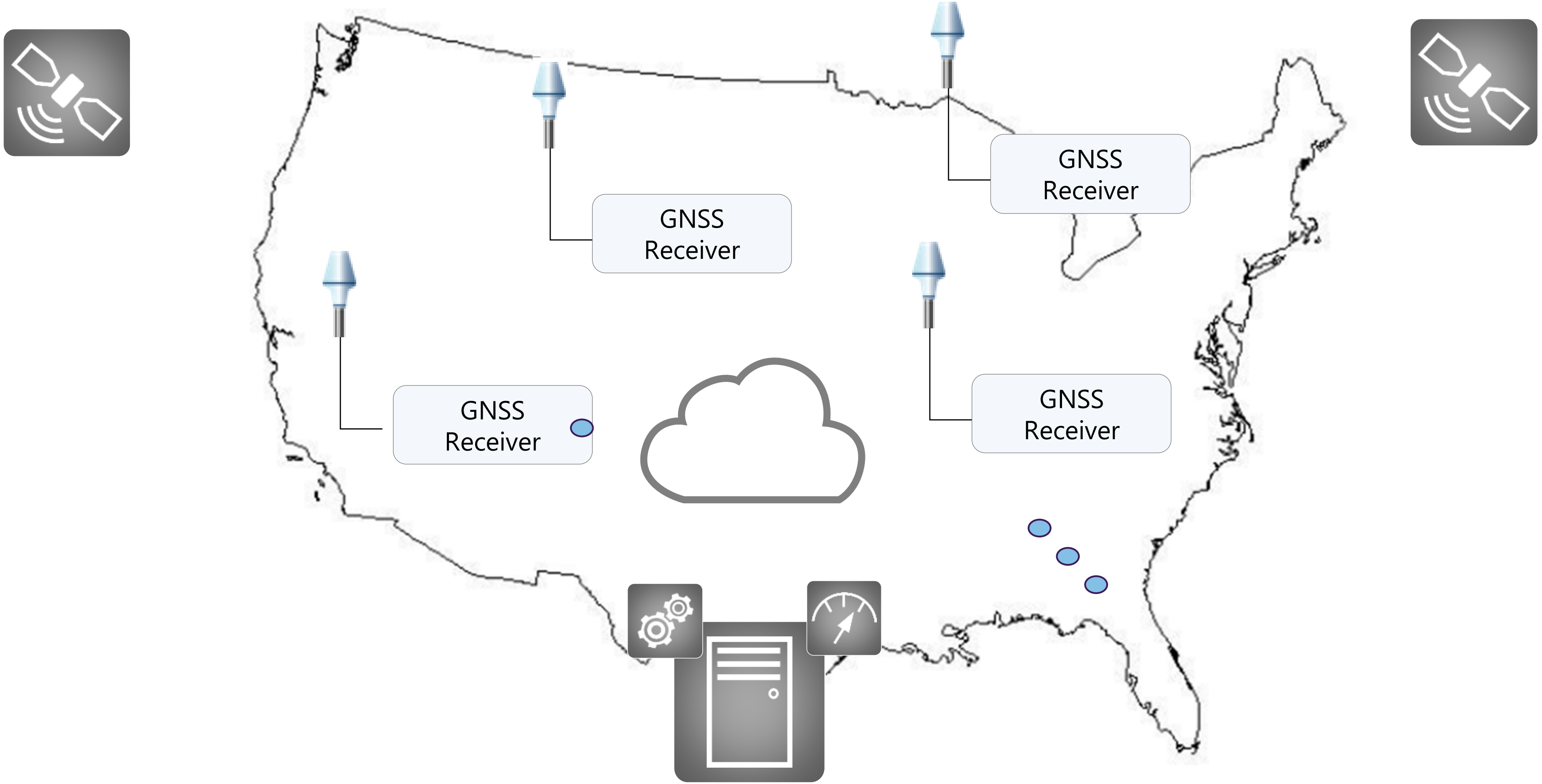
Centralized GNSS monitoring and assurance



GNSS monitoring and assurance

What data can we get for a GNSS receivers ?

The following data is available from most of the commercial GNSS timing 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 ,AGC

Location

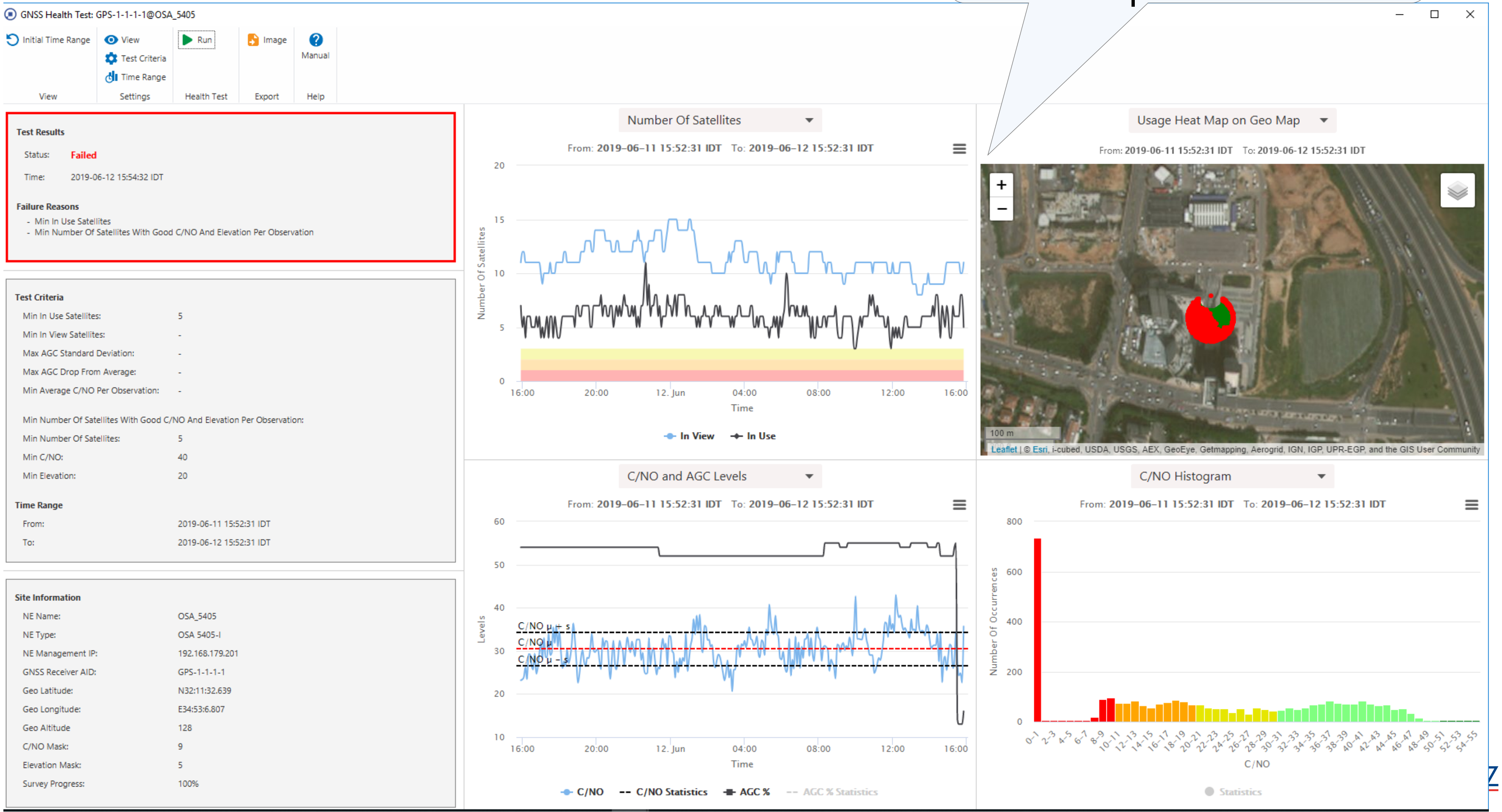
Self-survey : Enabled
Coordinate Latitude : N32:11:32.094
Coordinate Longitude : E34:53:8.706
Coordinate Altitude : 85.3 m

Satellite Entry Table

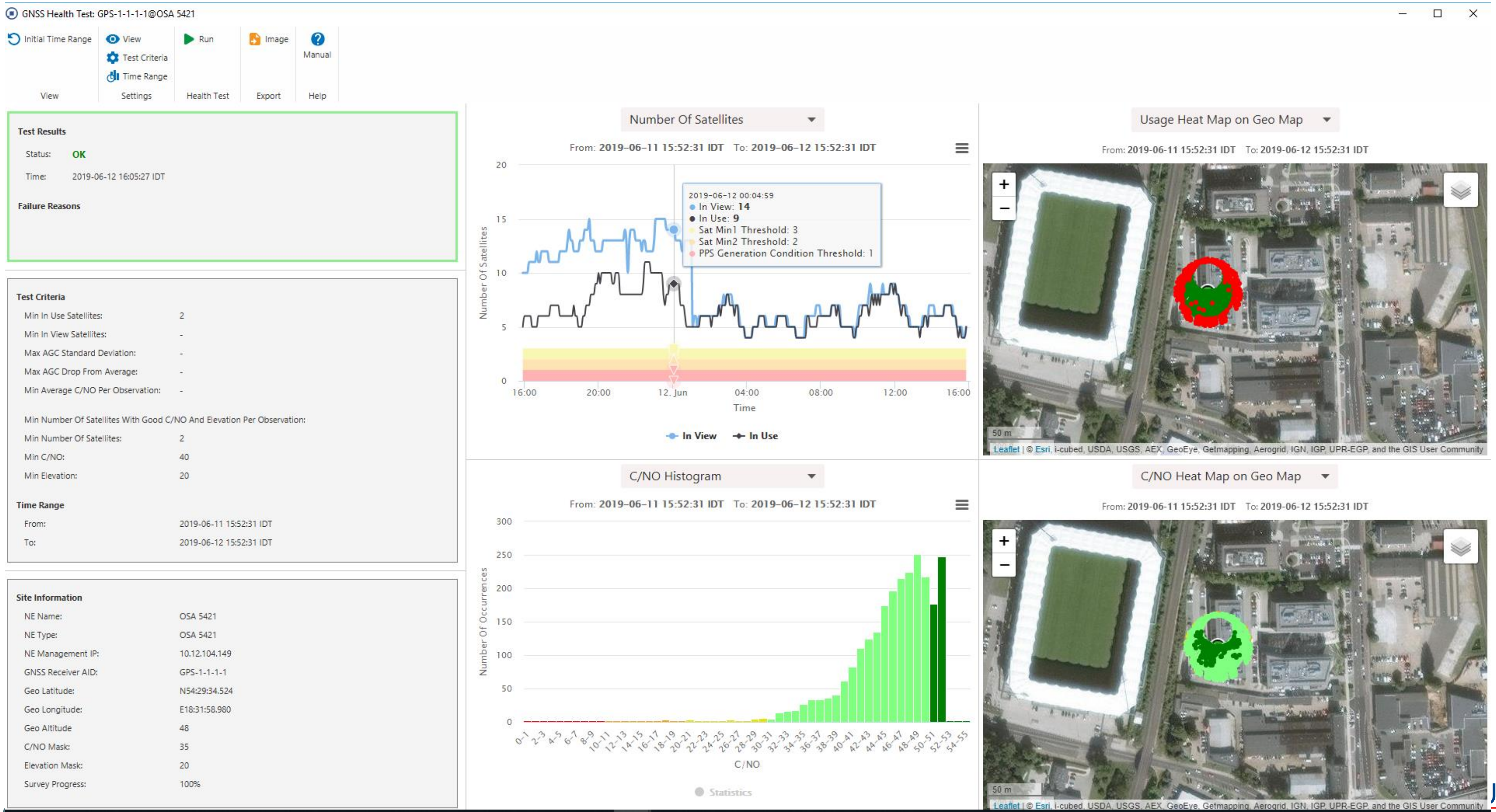
SV	In use	Constellation	C/No[dB-Hz]	Health	Azimuth[deg]	Elevation[deg]
2	Yes	GPS	36	OK	128	51
6	Yes	GPS	42	OK	77	42
12	No	GPS	31	OK	329	52
15	No	GPS	23	OK	205	13
17	No	GPS	41	OK	46	5
19	Yes	GPS	32	OK	42	27
24	No	GPS	26	OK	210	80
25	Yes	GPS	36	OK	298	24
29	No	GPS	28	OK	233	20
32	No	GPS	29	OK	316	7
78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

Remote Health test – bad site

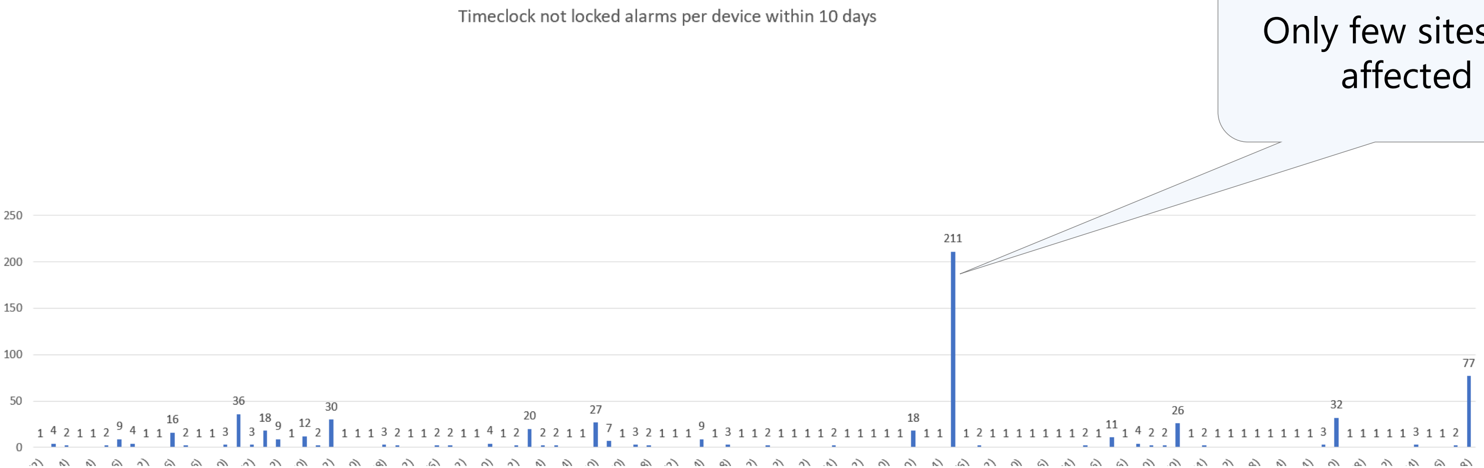
Help identify local reception issue



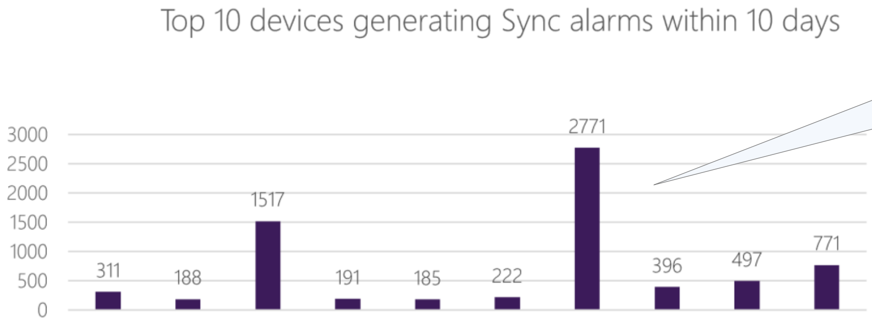
Remote Health test – good site



Identifying affected sites

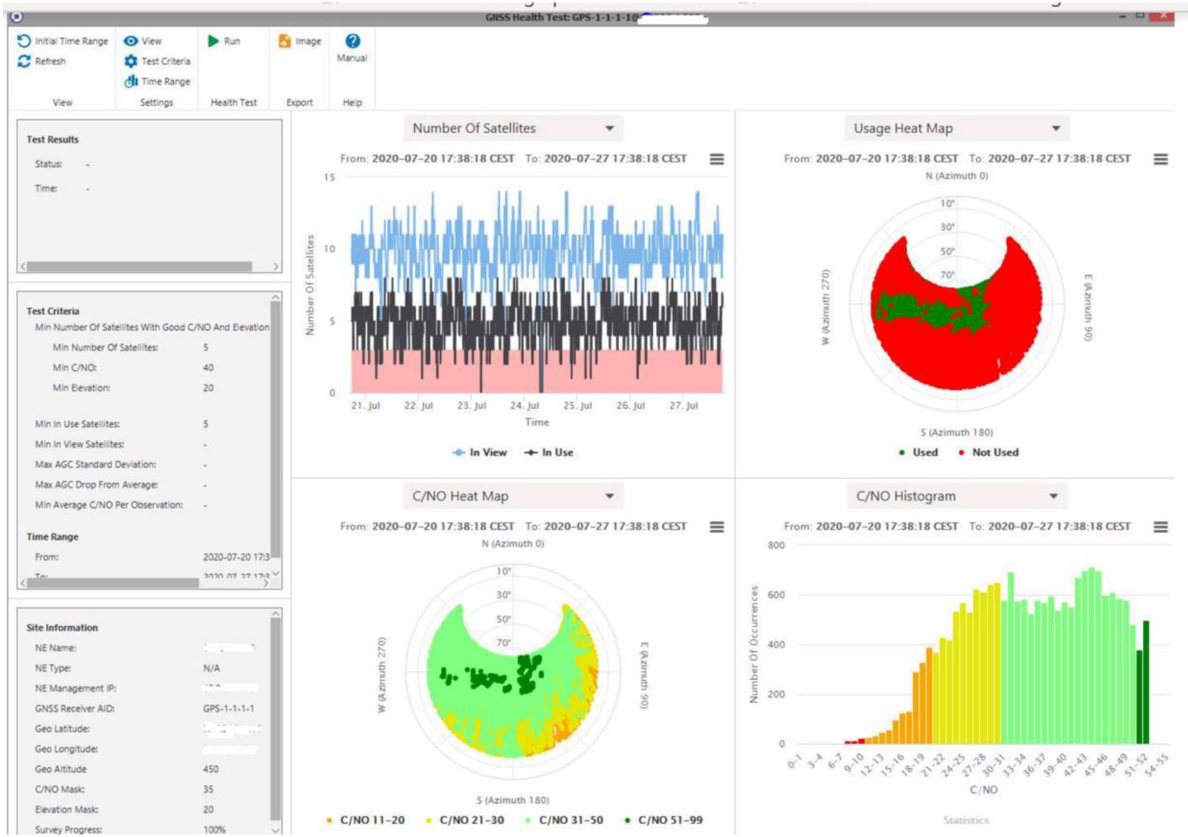


Only few sites are affected



Focusing on relevant sites

Case study - GNSS assurance analysis –Site X



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Case study - Site X reality check and recommendations

Cause:

GNSS receiver under OBSTRUCTION condition

Antenna has been installed in worst case condition

GNSS blocked from multiple directions (house/roof/mast)

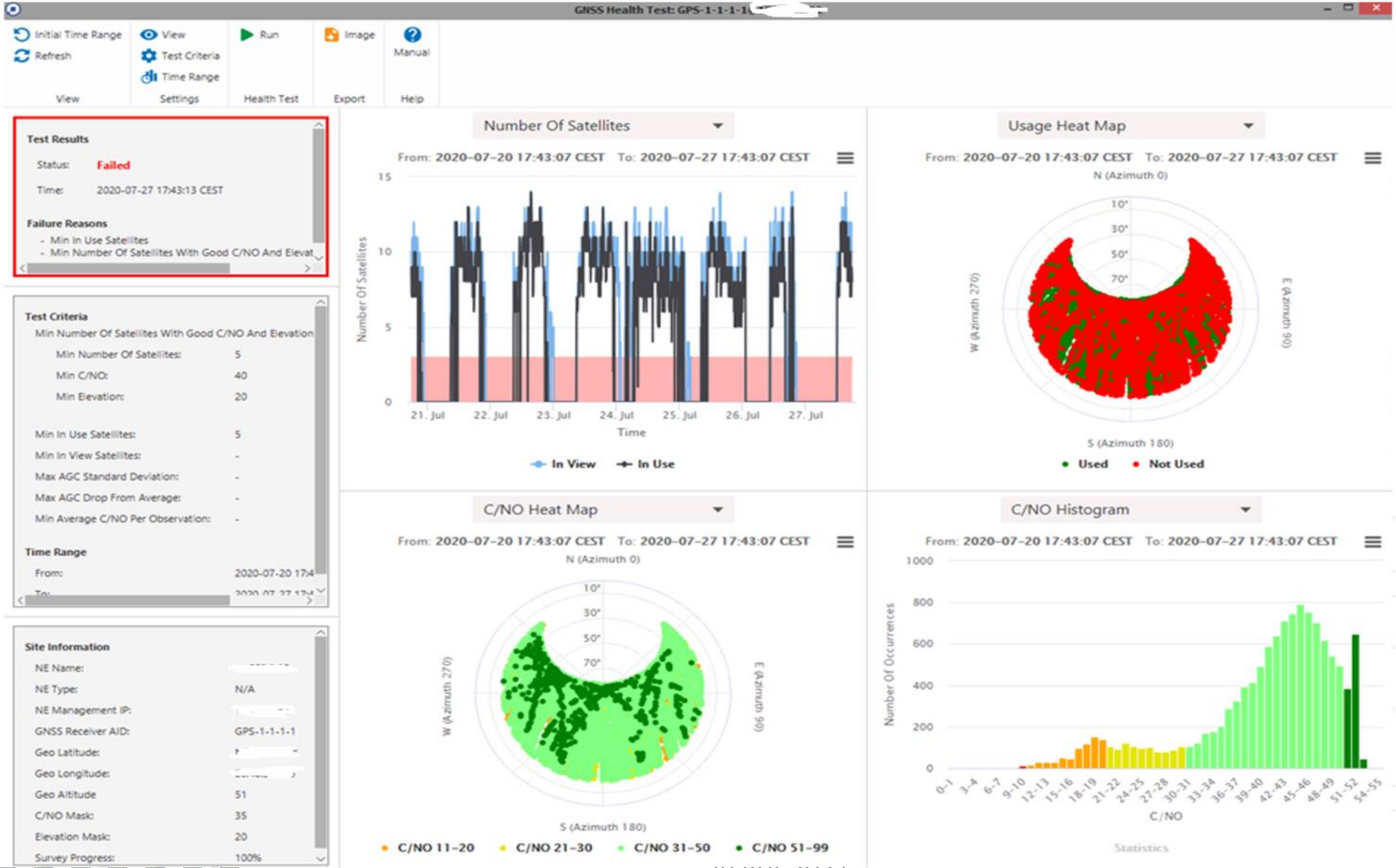
Result:

2538 alarms

Recommendation:

Re-install antenna

Case study - GNSS assurance analysis –Site Y



Case study - Site Y reality check and recommendations

Cause:

GNSS receiver under OBSTRUCTION condition

Antenna has been installed in worst case location

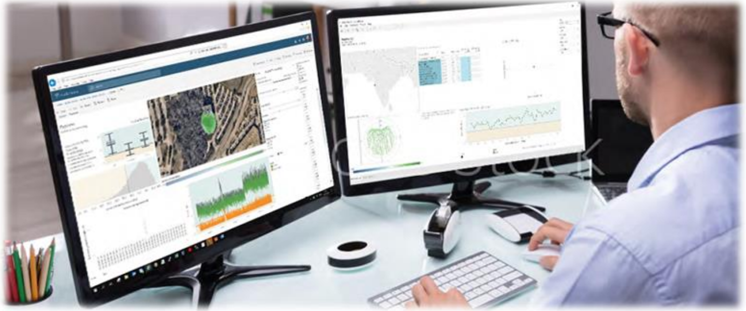
GNSS blocked from multiple directions (tree/mast)

Recommendation:

Re-install antenna/ remove tree/ lower SNR-Mask to 20 and elevation angle to 10

Summary

- The number of GNSS timing receivers in use is growing significantly
- Networks are becoming more dependent on GNSS
- Ideal solution should be based on centralized GNSS monitoring and assurance
- The solution can be applicable to any GNSS timing 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 during installation and in operation
- Allow remote in depths analysis of spoofing and jamming events,
- Utilize ML and AI for optimal and automated detection of potential GNSS service degradation events



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Thank you

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