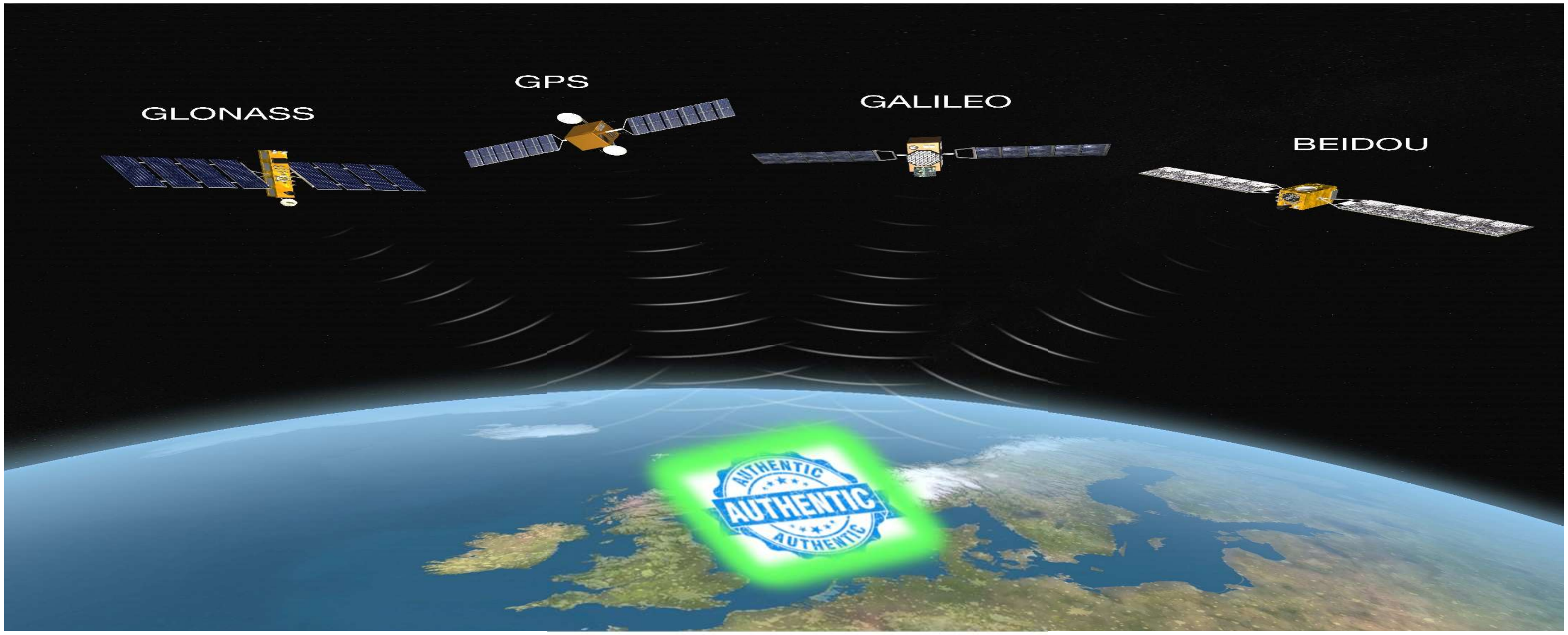


Jamming and Spoofing mitigation

Hydro 2025, Liverpool
30 October

Hans.visser@fugro.com
Product Manager: Jamming and Spoofing(Satguard)
Fugro Satellite Positioning, The Netherlands

Marinestar
- thousands of active users globally


Dredging


Hydrographic Survey


Research


Cable Lay


Windfarm installation/support


Coast guard

Unmanned Survey

https://www.fugro.com/expertise/satellite-positioning/marinestar

Infrastructure

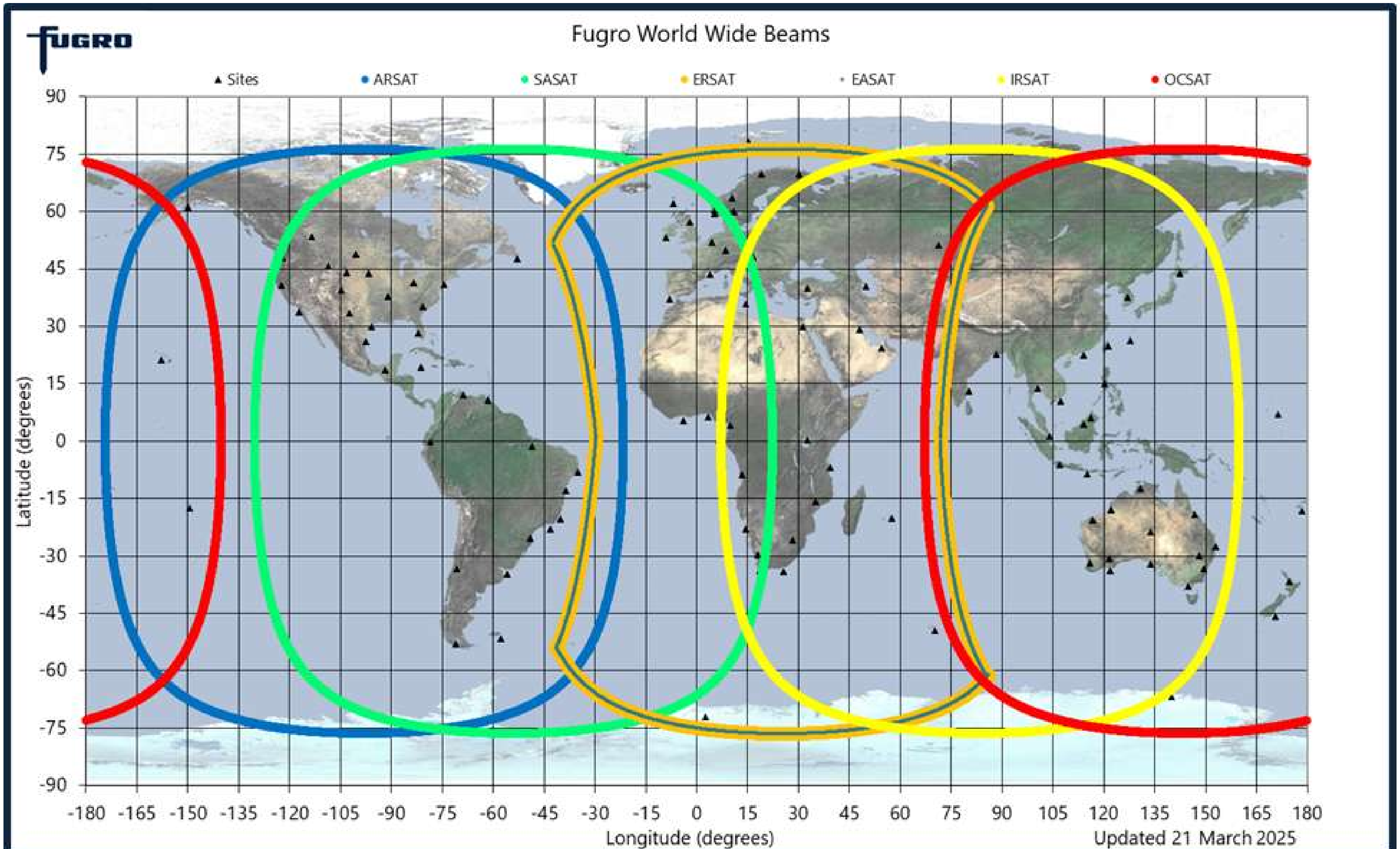
100+ reference stations

6 global L-band GEO broadcast satellite beams

2 fully redundant Network Control Centers (NCCs)

Using Orbit and Clocks From G4 We calculate precise Positions

centimetre accurate worldwide



https://fsp.support/marinestar/

Different sources of Jamming. E.g.

Unintentional Interference

Local Electronics

Iridium/Globalstar

1610-1630 MHz

Legal radio Amateur

Secondary user 1240-1300 Mhz

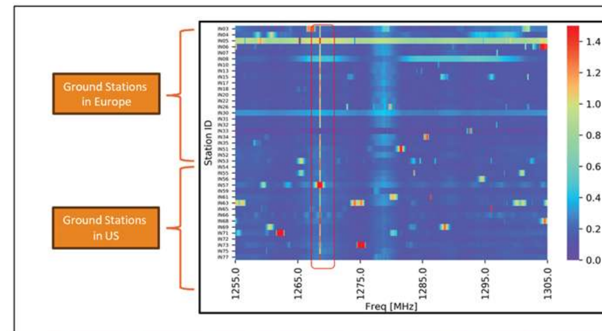


FIGURE4 Received Power Variation in the B3-E6 Spectrum Across all Stations on February 3,

GNSS Satellites from space

e.g. BeiDou C57 in the past.

Airport Radar

Ship radar if direct in radio path!

GPS Jammer

Taxi drivers

Illegal activity

GNSS

Re-Radiating KIT. (Meaconing)

Military Jamming radar

GNSS Frequencies

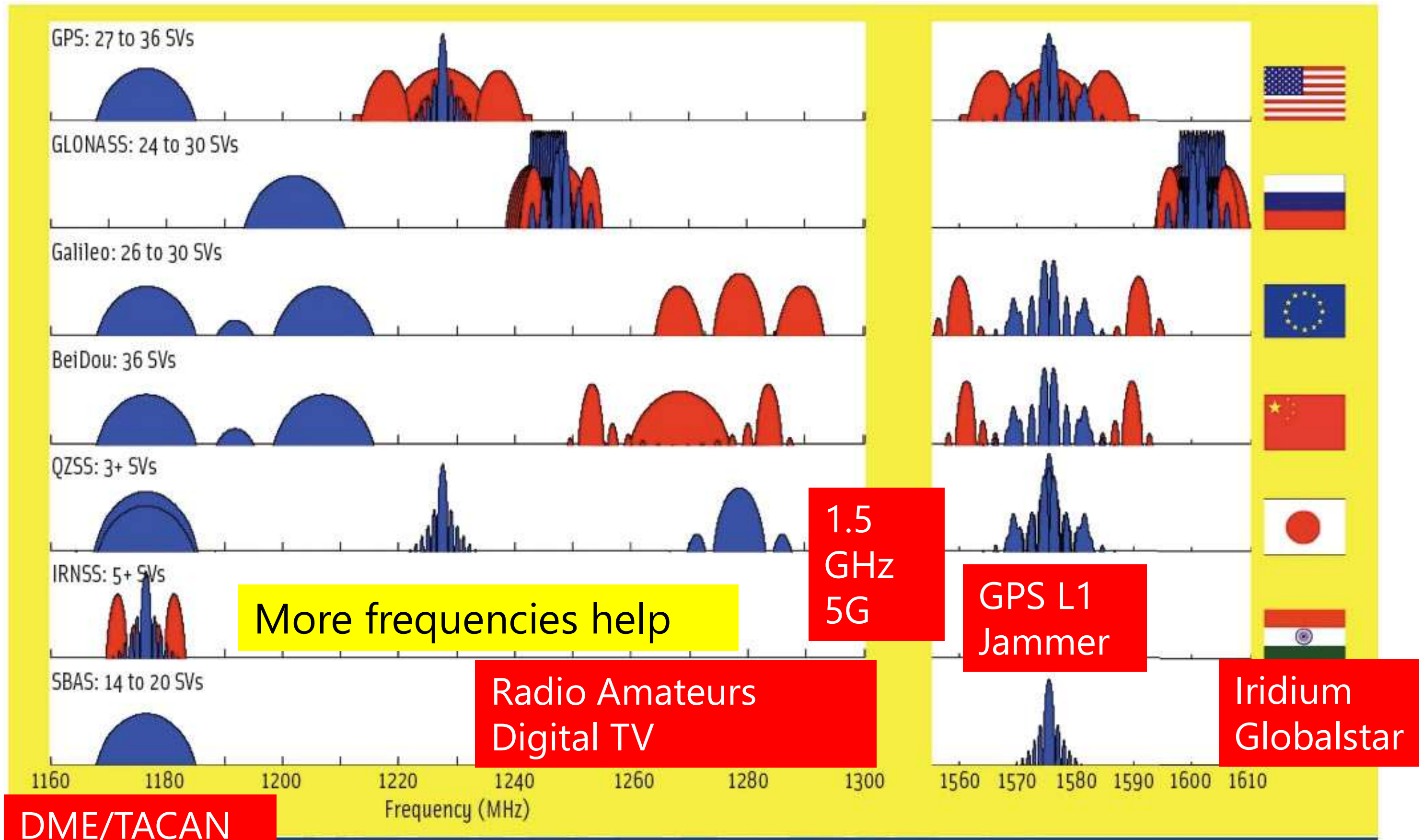


FIGURE 1 Prospective satnav signal structures, with open signals in blue and restricted signals in red

More frequencies
Improve robustness.

Improve convergence
time.

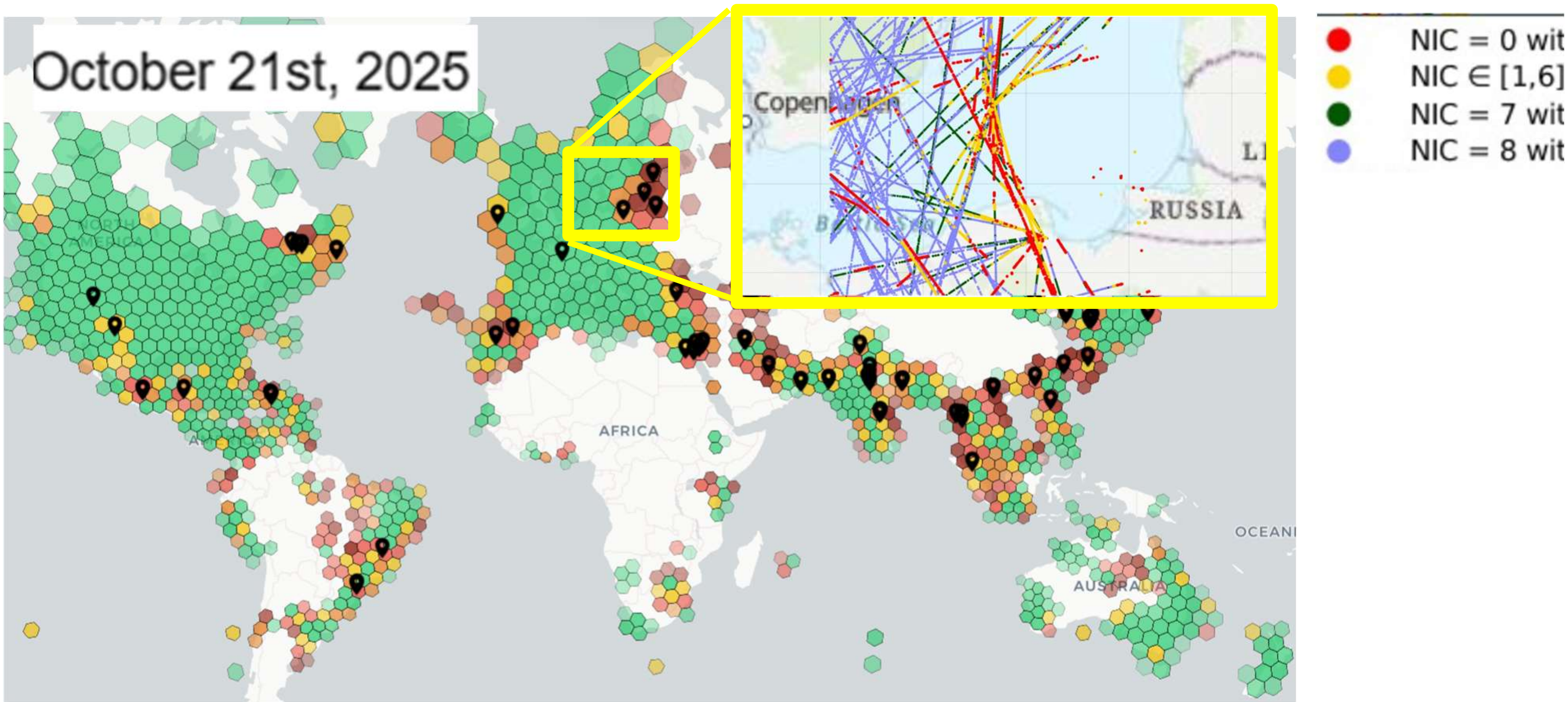
New signals are
stronger and more
robust.

More frequencies help.

In war zone areas
All frequencies are
jammed!

http://insidegnss-com/figure-2-tables-1-2-something-old-something-new/ (2013)

Aircraft Jamming according to rfi.Stanford

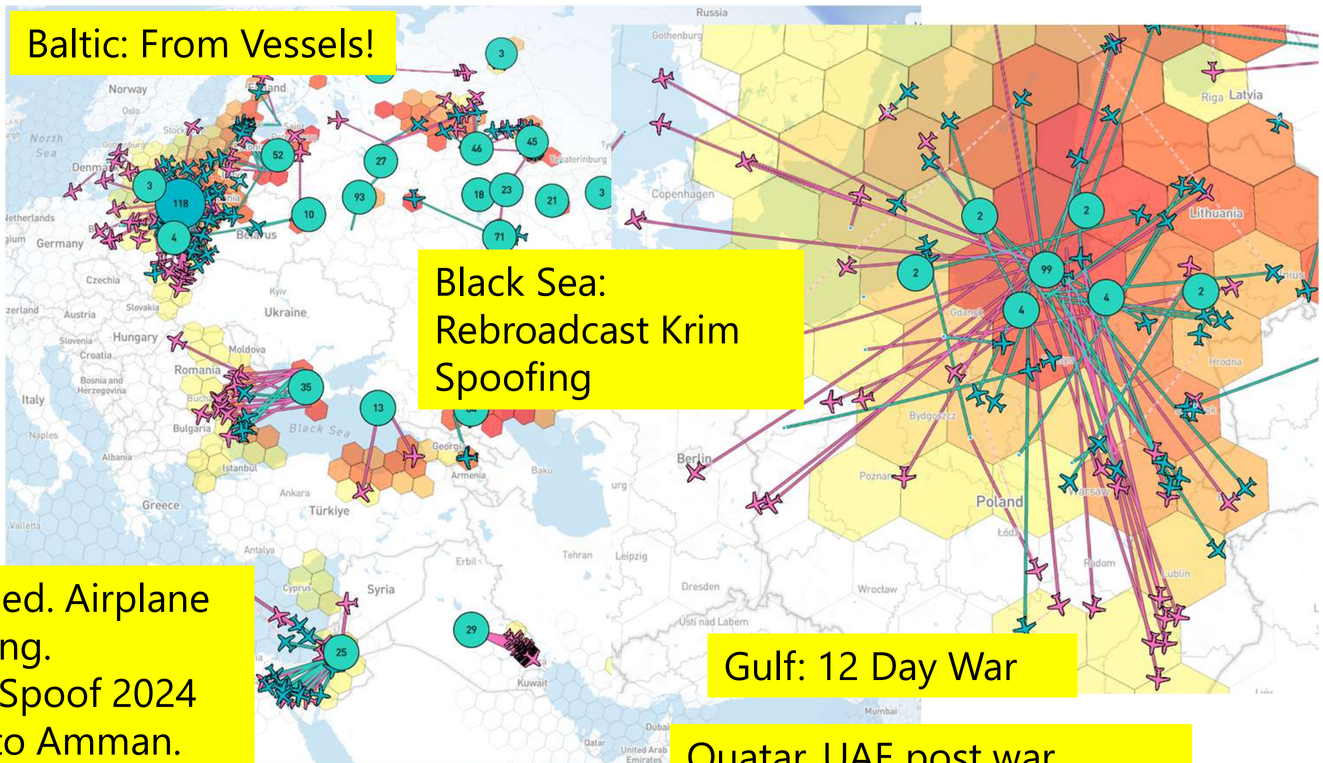


https://rfi.stanford.edu/

Aircraft jamming and spoofing 21-Oct-2025 GPSwise

Aircraft are on purpose jumping to false positions.

Baltic: From Vessels!

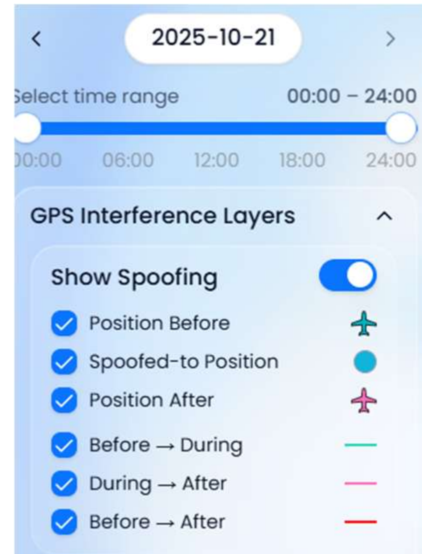


Black Sea: Rebroadcast Krim Spoofing

East Med. Airplane Spoofing.
Beirut Spoof 2024
Jump to Amman.

Gulf: 12 Day War

Quatar, UAE post war

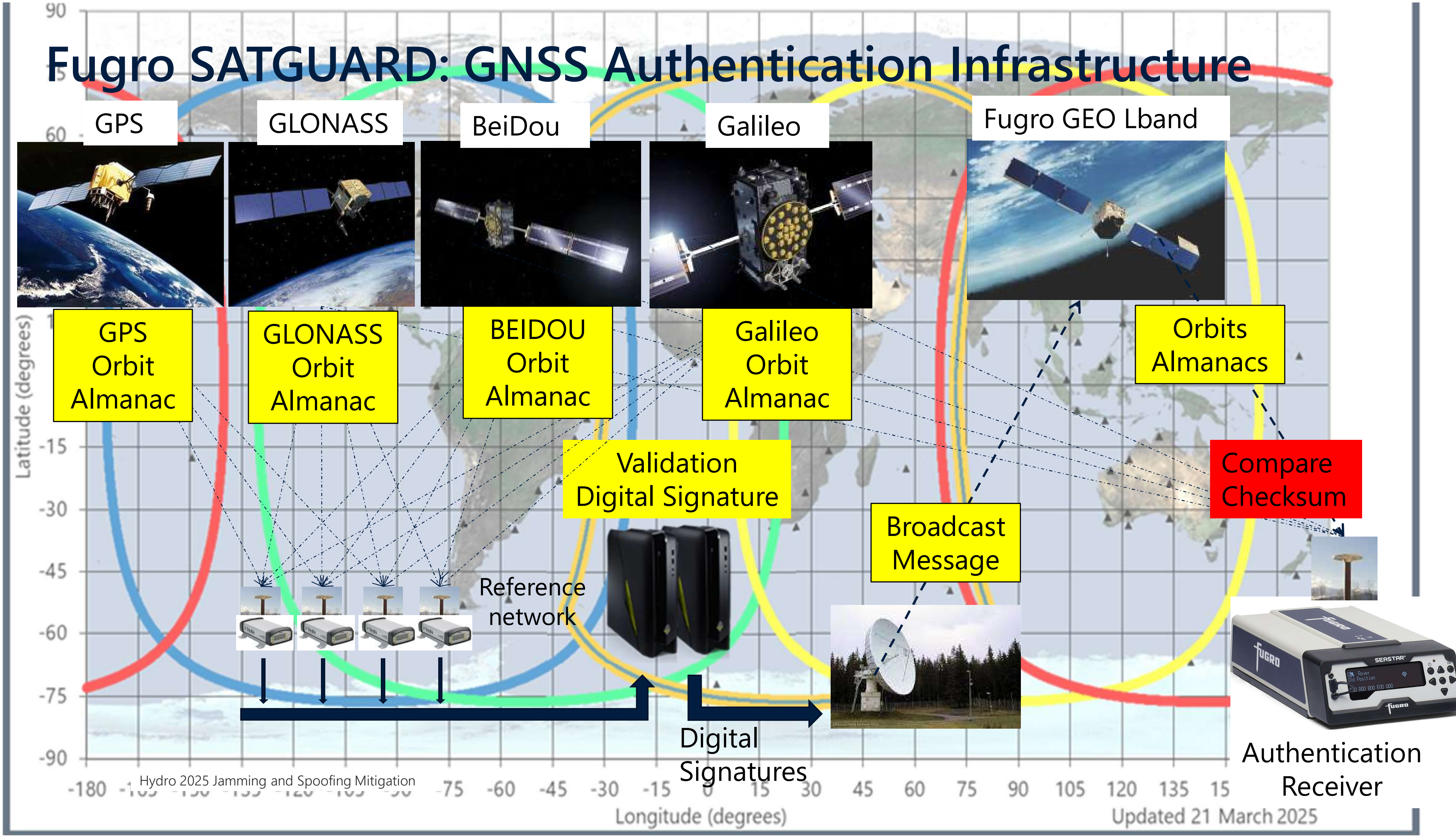


Aircraft up 10 km: 350 km radius
Ship up 10-50 m: 40-80 km range

https://gpswise.aero/

FUGRO

Fugro SATGUARD: GNSS Authentication Infrastructure



Fugro NMA

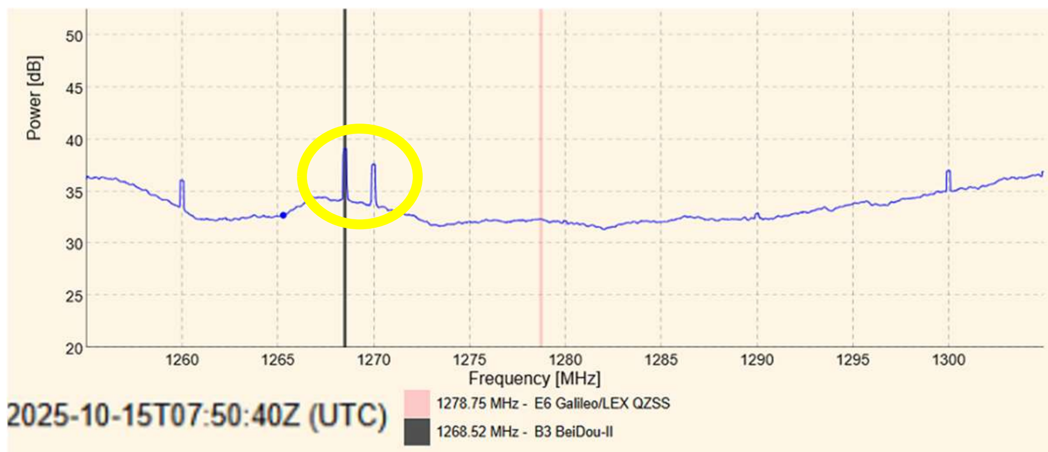
Baltic Spoofing Attack

Implemented in StarPack 2

Navigation Message

GPS Nr	GPS Status	GLONASS Nr	GLONASS Status	Galileo Nr	Galileo Status	BeiDou Nr	BeiDou Status
Almanac	N/A	2	OK	4	N/A	Almanac	Alert
10	N/A	3	OK	5	OK	[illegible]	OK
12	N/A	4	OK	6	OK	14	OK
13	N/A	11	OK	9	N/A	21	OK
14	N/A	12	OK	13	OK	26	OK
15	N/A	13	OK	23	N/A	27	OK
17	N/A	20	OK	24	OK	29	OK
19	N/A	21	OK	31	OK	30	OK
22	N/A	22	OK			36	OK
23	N/A					40	OK
24	N/A					42	OK
32	N/A					45	OK
						56	N/A

Baltic : Spoofing. Fast changing attack:
All constellations, all frequencies. Very minor signal increase



Satguard NMA

Modes:
Strict: Only use Authenticated SV.
Relaxed: Start Position if no NMA.
Flag: Report Status in Display

See movie on the Fugro stand

Spatial Integrity Analysis

Spatial integrity analysis for meaconing detection

- When Meaconing is present all antennas will have the approximate same position.

Anti-jam Antenna examples.

Hexagon GAJT-710MS

- GPS L1/L2,
- Galileo E1.
- 6 Nulls

Accuracy <20 cm Height
Since Sep 2025:No ITAR regulations
Market is developing.

Tualcom 8300-D

GPS L1/L2/L5,
GAL E1/E5a/E5b,
BEI B1

7 Nulls

Calian
CR8894SXF+

- GPS L1/L2/L5, GLO G1/G2/G3, GAL E1/E5b,
- BEI B1/B2/B2a/B2b
- 4 Nulls

Calian AJ977XF

GPS L1/L2/L5,

GLO G1/G2/G3,

GAL E1/E5b,

BEI B1/B2/B2a/B2b

20° Elevation Mask

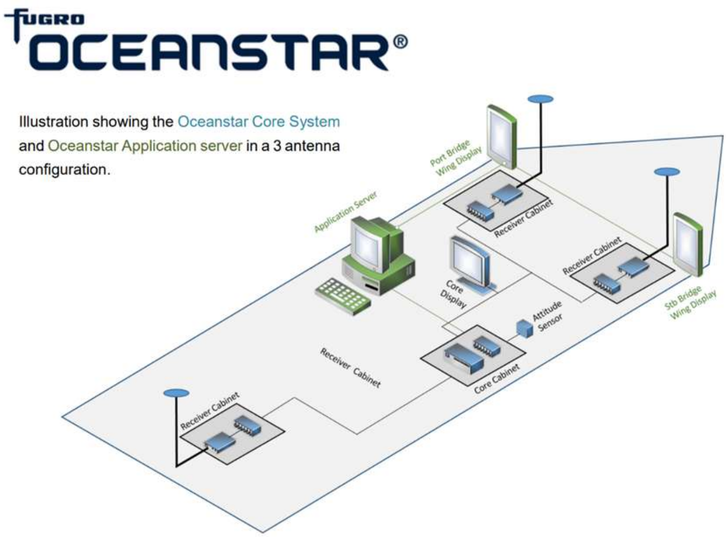
Metal object blocking Interference source
Use more antennas. Front Bow, Starboard, Port, Top Mast

Ship construction can block jamming signals. With 4 constellations(G4) and >30 Satellites one can afford blockage

Seen Offshore

Bad for phase multipath

Satguard capable receivers



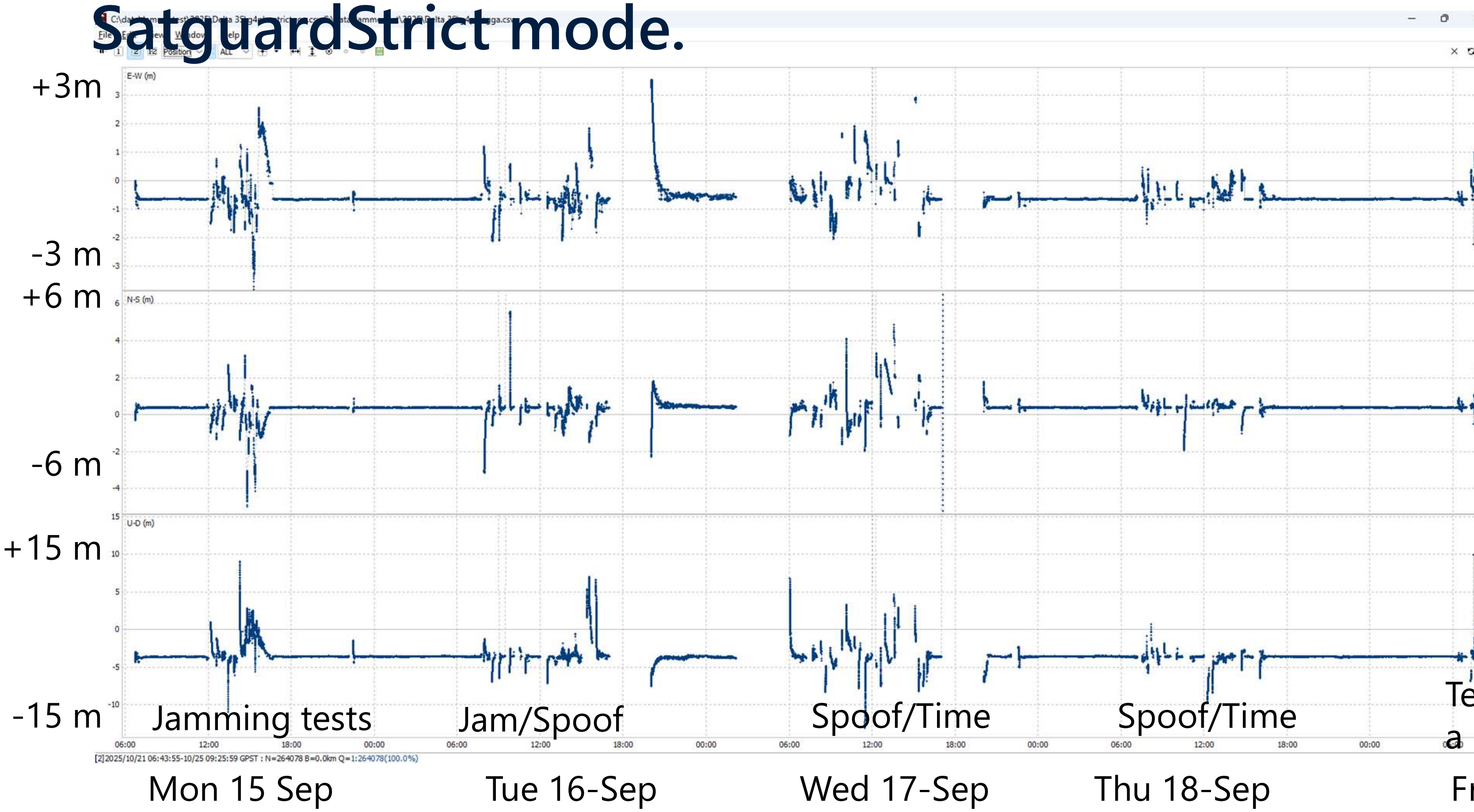
- Oceanstar multi receiver multi antenna system
- Multi-Antenna protects against spoofing.
- Spoofing flag raised if baselines do not fit.
- Spoofing flag raised if Navigation Message Authentication fails

- Fugro 9410AUT

- Fugro Starpack II,

- Septentrio
- Mosaic-T Chip
- (For timing)

One week time overview : PPP Replay SatguardStrict mode.



During 200 jamming and spoofing tests.

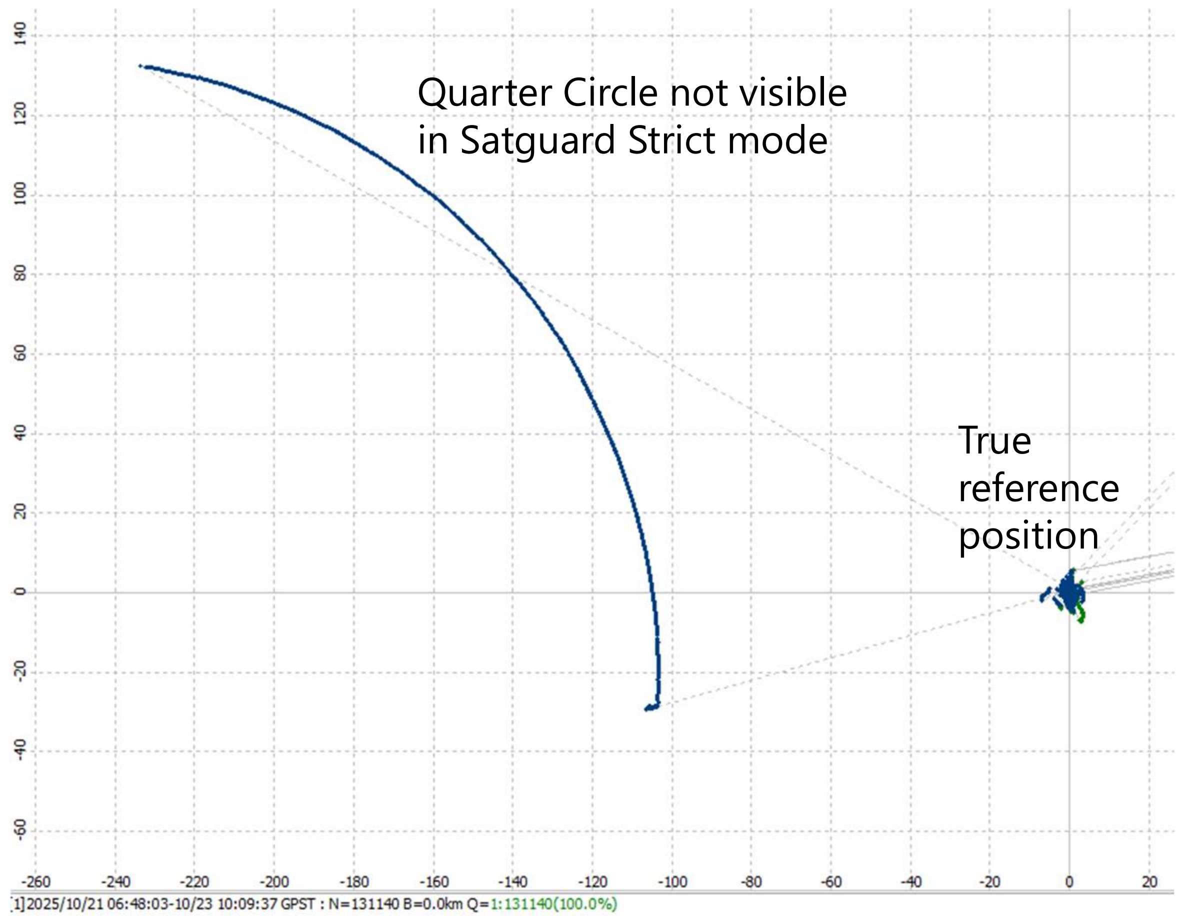
Many restarts with standard converge

Starting at 3, 4, 10-meter max

Normal behavior: Fast convergence

FUGRO

Satguard Navigation Message Authentication works.



Jammertest 2025: 15 receiver, 7 manufacturer

•Use GPS, Galileo, BeiDou, Glonass (G4) for redundancy.
•Operate on multiple frequencies to mitigate jamming.
•Anti-jamming antennas required for 10–50 W power jammers.
•Low-power jamming (<300 mW) often survive.
•Watch out for rebroadcast signals. (Meaconing)
•GNSS receivers can be spoofed—positions may be wrong.
•Enable G4 Navigation Message Authentication in strict mode.
•Keep firmware updated—manufacturers improve anti-spoofing algorithms.

•Add alternative sensors: INS, radar, depth, laser, terrestrial navigation.

Alternatives are less precise than PPP Marinestar.

Unlocking **Insights** from **Geo-data**

Questions: Hans.visser@fugro.com