Resilient PNT through Interference Detection, Mitigation and GNSS Augmentation

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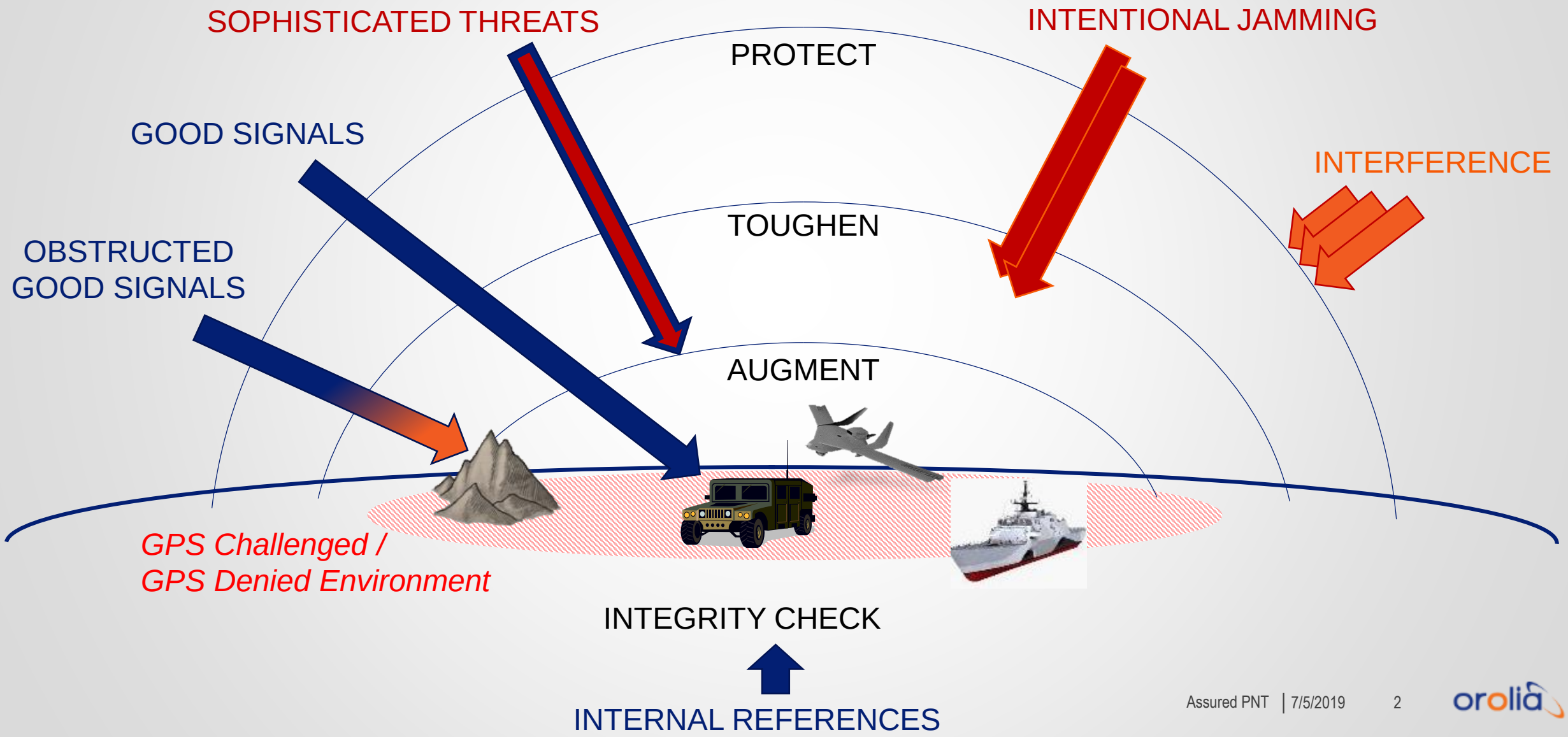
VP Advanced R&D

The Global Leader in Resilient PNT

Providing the world's most critical applications real-time, accurate, reliable positioning, navigation, and timing data.

Safety, Security and Reliability

RESILIENCY, RELIABILITY AND PROTECTION WITH INTEGRITY AND TRUST

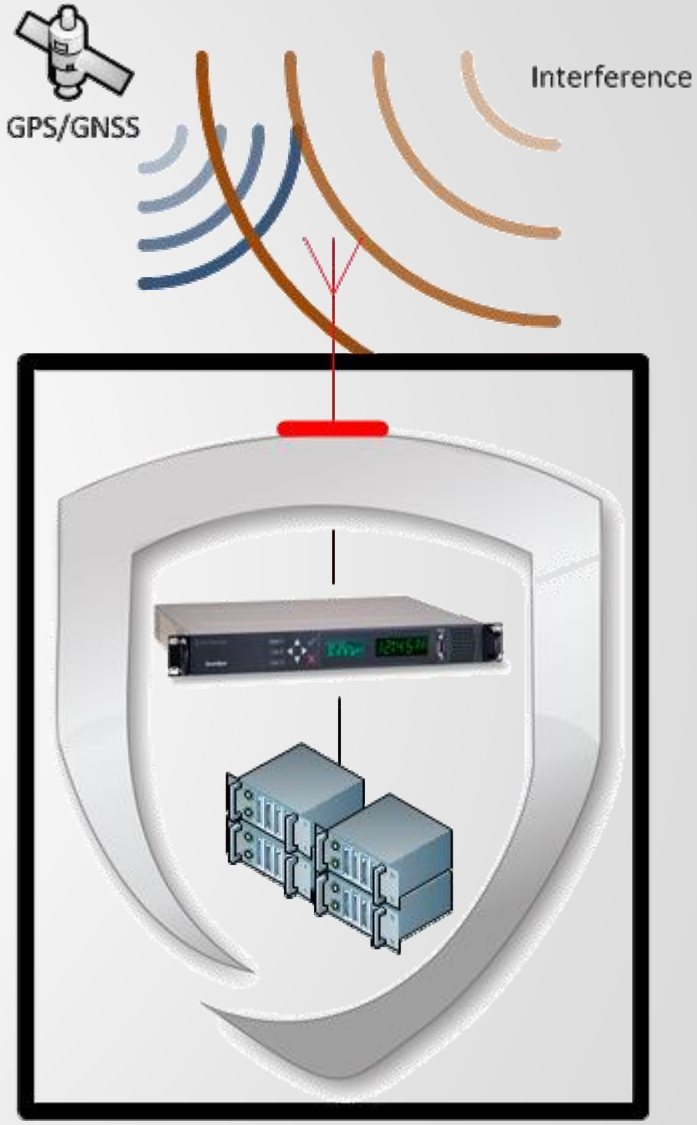



TOUGHEN

BROADSHIELD

from TALEN-X COMMUNICATE - NAVIGATE - EXCEL

Protecting GPS/GNSS critical infrastructure against emerging threats



Detects Interference / Spoofing within the GPS signal and GPS spectrum

Over 75 Jamming and spoofing detection algorithms

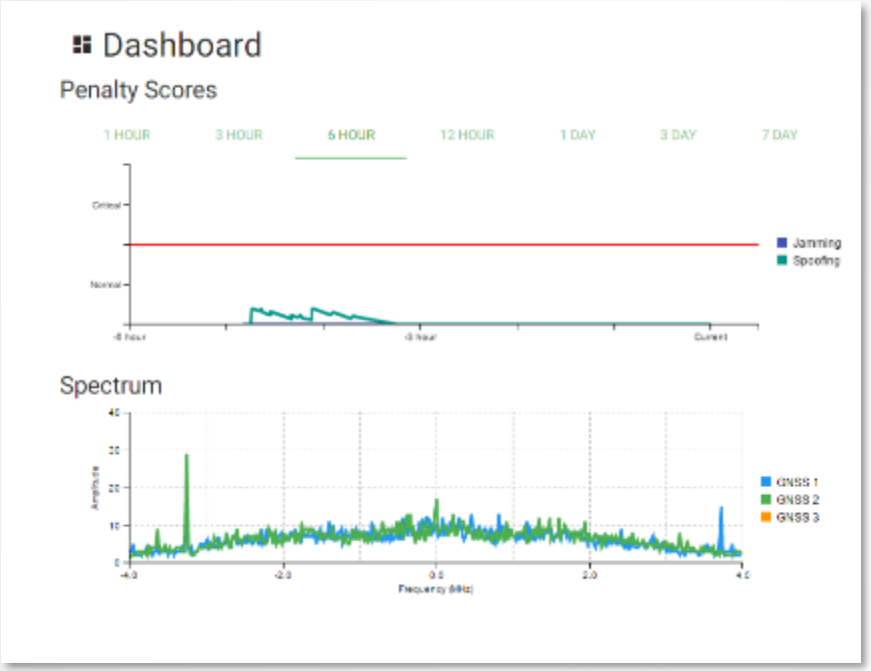
Seamlessly integrated with current products

- Works with our standard commercial GPS/GNSS receiver
- Automatic enabling/disabling of GPS during interference events
- Status information through the UI
- Integrated notifications and alarms

THE BEST JAMMING AND SPOOFING DETECTION

Detects **Jamming**

- Continuous Wave (CW)
- Swept CW
- Pulsed CW
- AWGN
- BPSK
- And more



Calibration not required

- Dynamic range based on the receiver RF front end (AGC, LNA, etc.)

Detects **Spoofing**

- GNSS simulators
- Anomalies in the GPS data
- Jumps in position and time
- And everything in between

Alerts when jamming and/or spoofing is detected

- SecureSync automatically implements user-defined counter measures
- Allowing for continuous and reliable operation in adverse environments

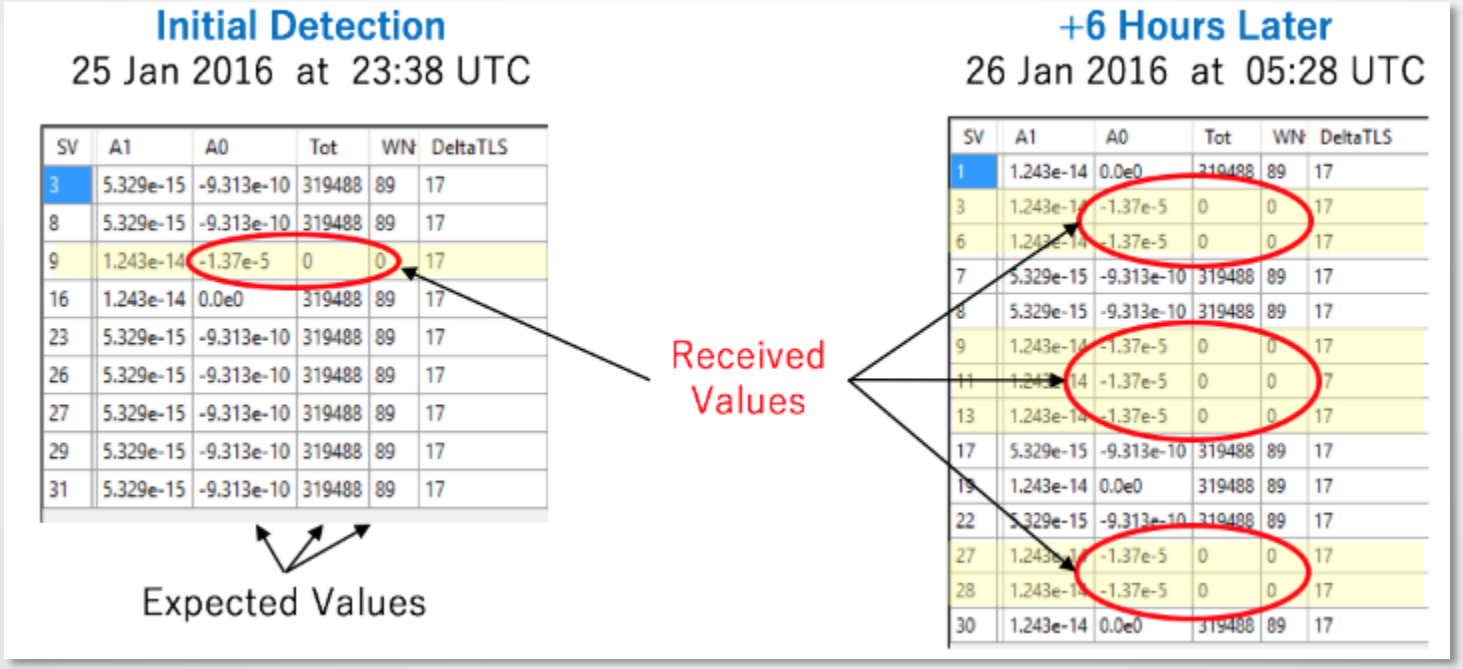
REAL-WORLD DETECTION PROVEN CASE STUDY

January 25, 2016: GPS Control Segment uploaded incorrect data to SVs (A0=13.7us, ToT=0, WN=0)

BroadShield inference and detection algorithms detected the anomaly **within 2 seconds**

Anomalies detected continuously for 12+ hours on 12 different SVs

GPS Control Segment confirmed anomaly several hours later



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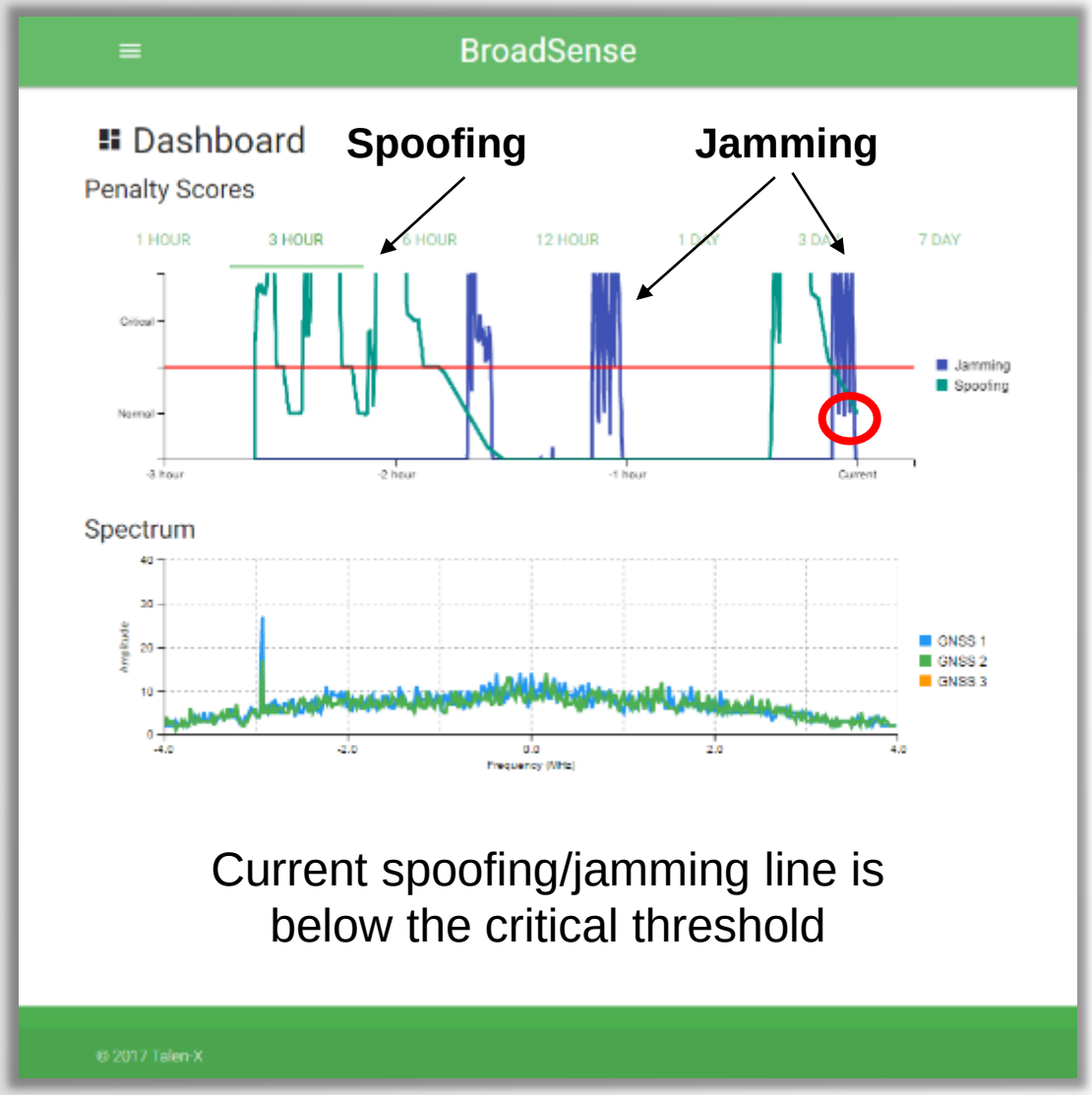
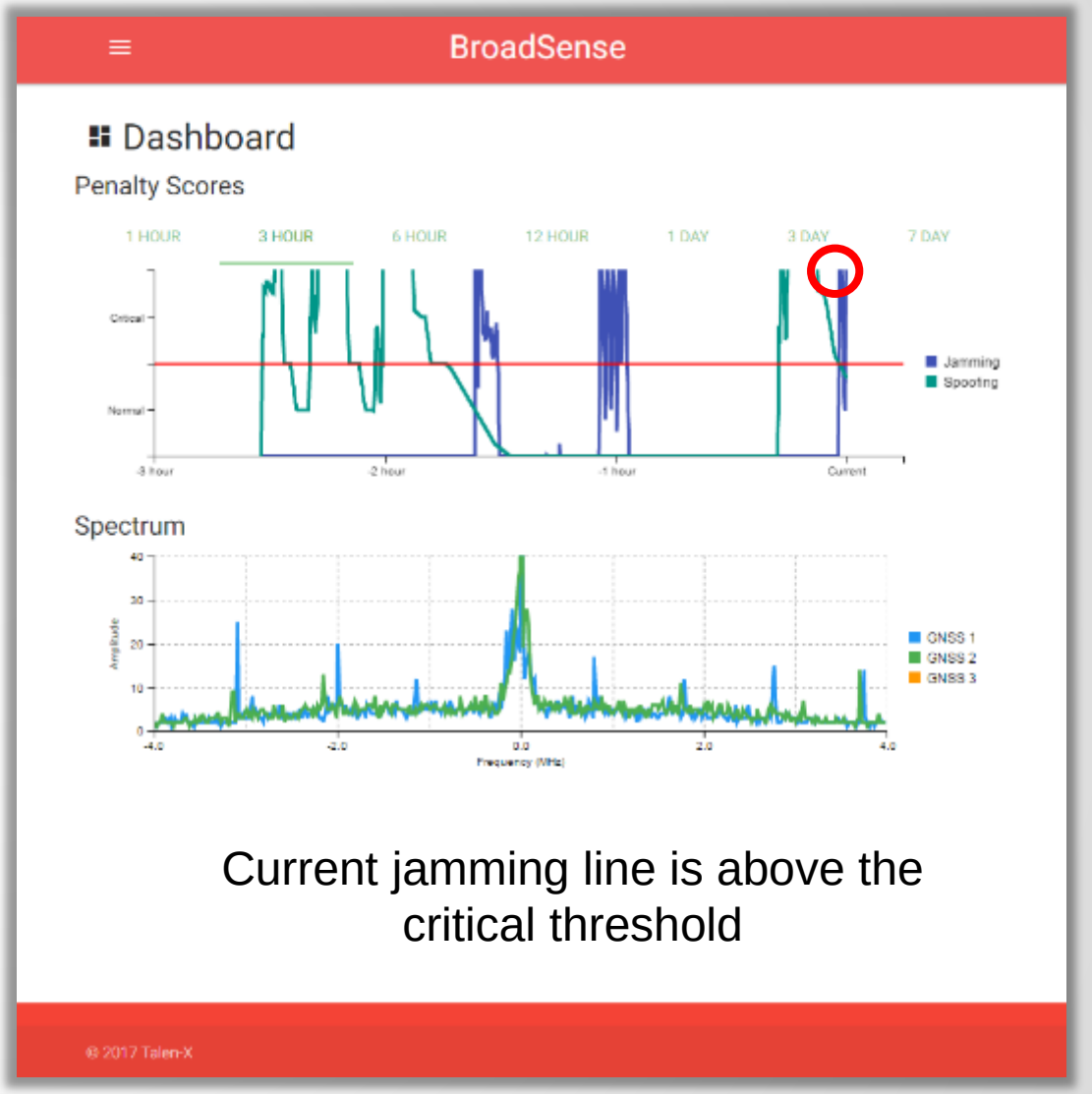


Current spoofing/jamming line is below the critical threshold



Current jamming line is above the critical threshold

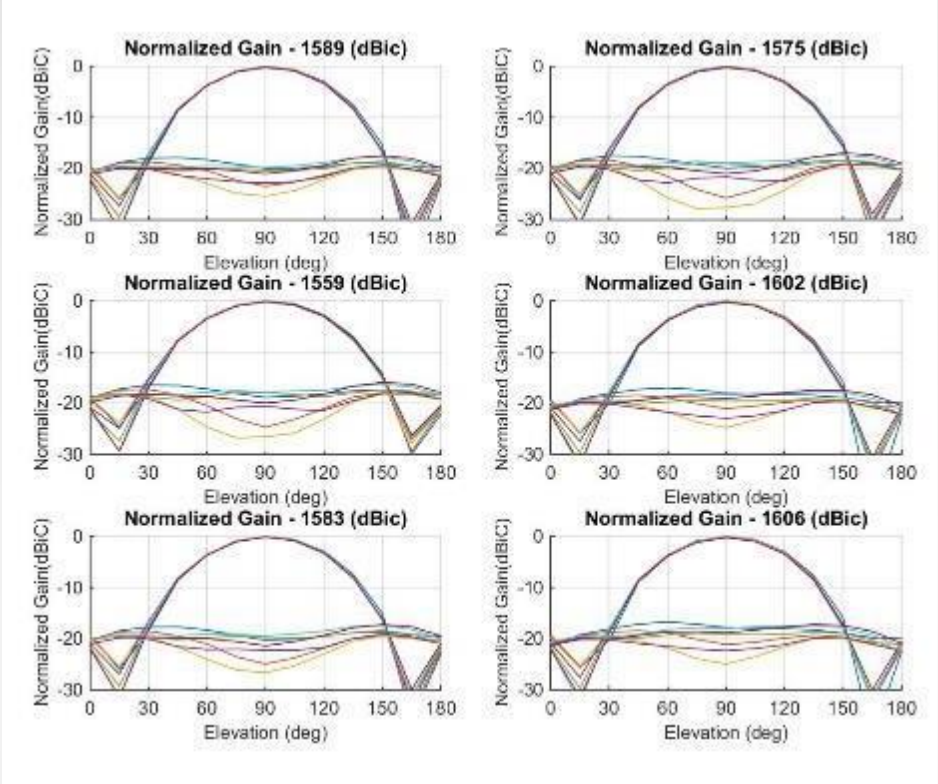
IDM ANTENNAS FOR GNSS

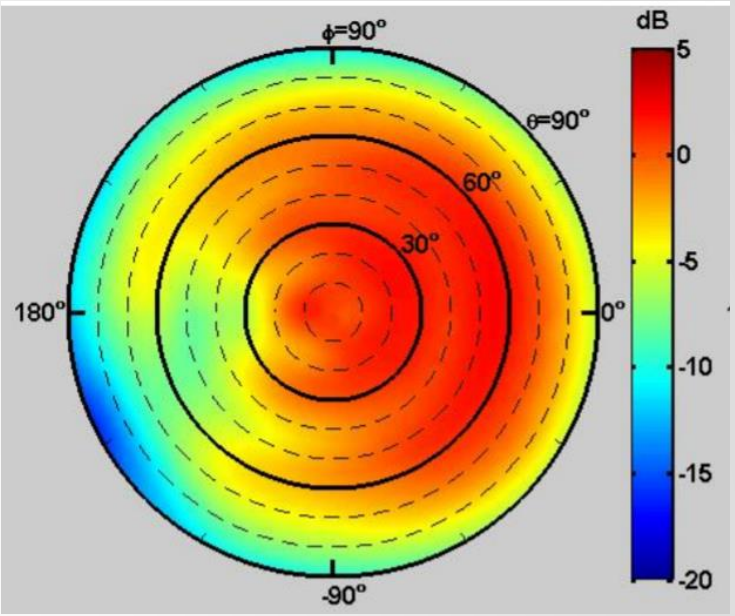
Simple

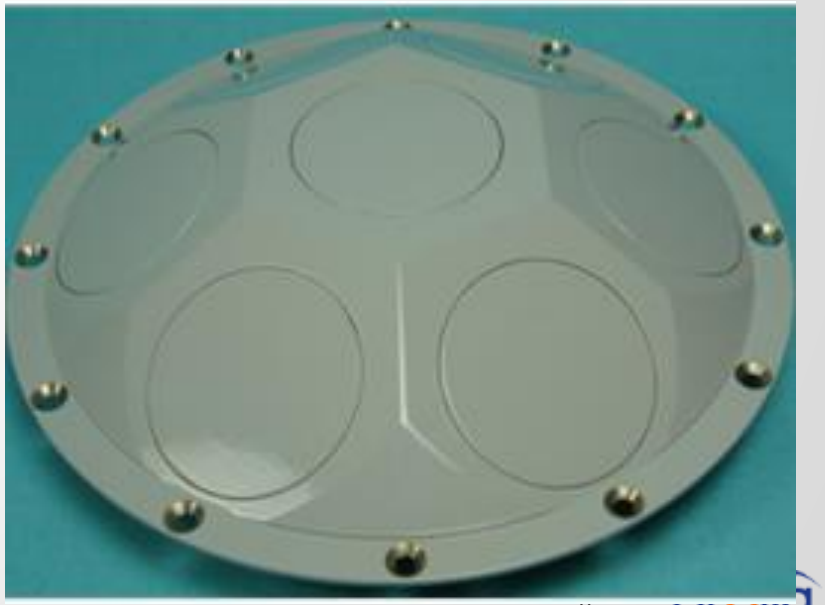
- Attenuation at the horizon where most interference comes from
- Low cost
- Timing only

CRPA

- Controlled Radiation Pattern Antenna
- Nulls steered toward interference
- Gain toward satellites
- Expensive







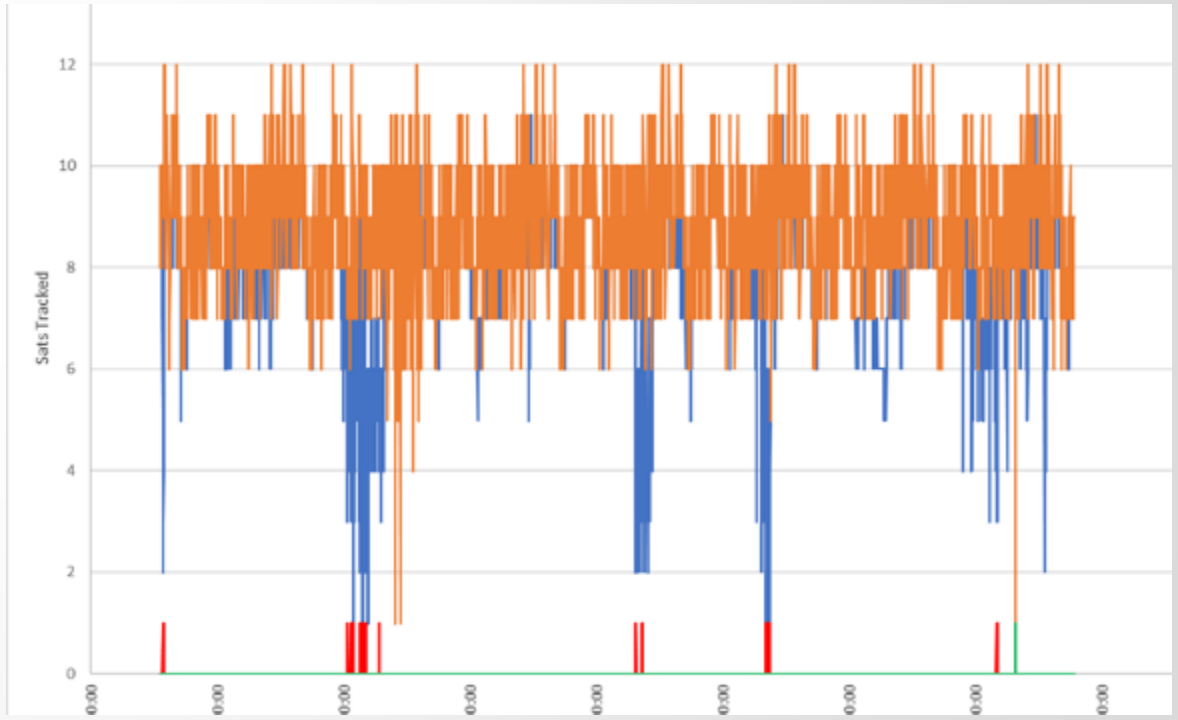
AJ TIMING ANTENNA: FIELD TEST DATA

Two GNSS Time Servers with internal Rb Holdover oscillators: side by side, one with Standard Antenna; the other with AJ Antenna

Experiencing suspected “Privacy Jammer” interference – next to a trucking company

AJ Antenna drastically reduced GNSS dropout (Holdover Events) over a one week period

	Standard Antenna	AJ Conical Antenna
Holdover events	40	4
Total time in Holdover	1 hour 32 minutes	41 seconds
Longest holdover event	14 minutes 26 seconds	17 seconds
Average holdover event	2 minutes 18 seconds	10 seconds
Satellite alarms	31	2




AUGMENT

Resilient PNT

GNSS/GPS
Weak signal but ubiquitous in open sky, most accurate

Iridium STL
Stronger than GPS, but less accurate

Cellular
Ubiquitous but inaccurate

WiFi
Spotty coverage, inaccurate; Skyhook + E911 requirements

VORTAC/DME/ILS
AIS
Traditional Nav

eLORAN/
Other special transmitters like Locata

Celestial Nav
Vision possible above the clouds, at very high altitude

Active Tx
Radar, Lidar, Sonar

Vision Systems
Inhibited by smoke, fog precipitation

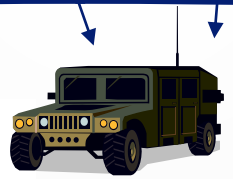
Signals of Opportunity
Not necessarily designed for navigation, but useful for determining range or bearing

Smart Antennas
CRPA / Anti-Jam

Reference Nav
Determine position in relation to other reference points

Encryption
SAASM / M-Code

UAVs



Vehicle Systems

Shipboard Systems

Autonomous Nav
No interference possible

RFID
Low cost, place sensors where needed

Crowd-Sourced
Via a network, location and proximity data is shared

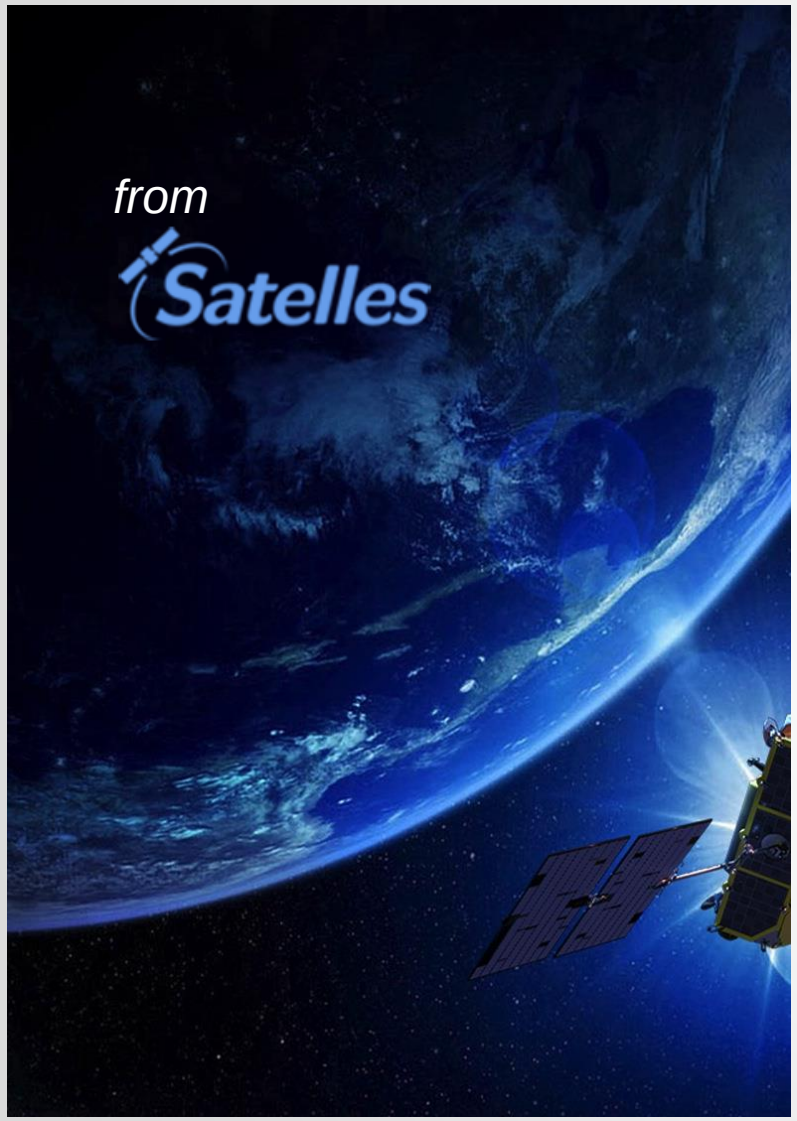
Anti-Jam Algorithms
Techniques to detect jamming/threats

Precision Clock
Atomic Clocks and others to maintain independent time

IMUs
Self contained but not accurate over the long term

Map Matching
Database must be constantly updated to be current

STL – *SATELLITE TIME AND LOCATION SIGNAL*



New signal available <u>today worldwide</u>

- Broadcast on the Iridium satellites

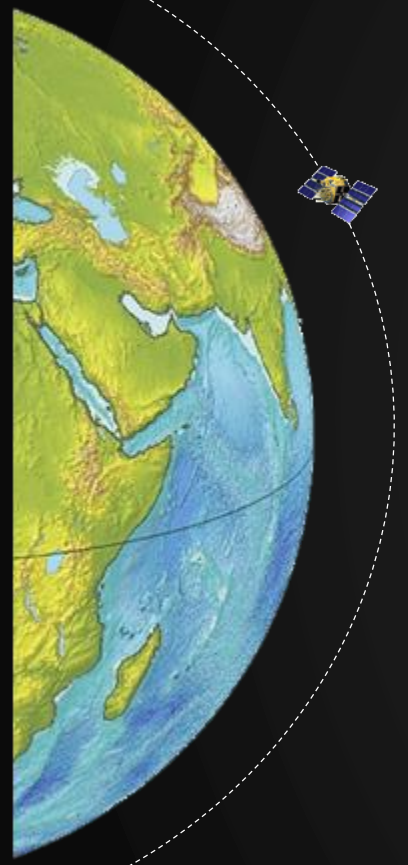
>30 dB stronger than GPS

- Higher jamming and interference resistance
- Operates indoors

Encrypted signal

- Inherently anti-spoof
- Subscription based service
- Available for civilian use

from Satelles



STL

- ✦66 Iridium Satellites
- ✦Global coverage
- ✦500 mile altitude
- ✦1000x stronger than GPS

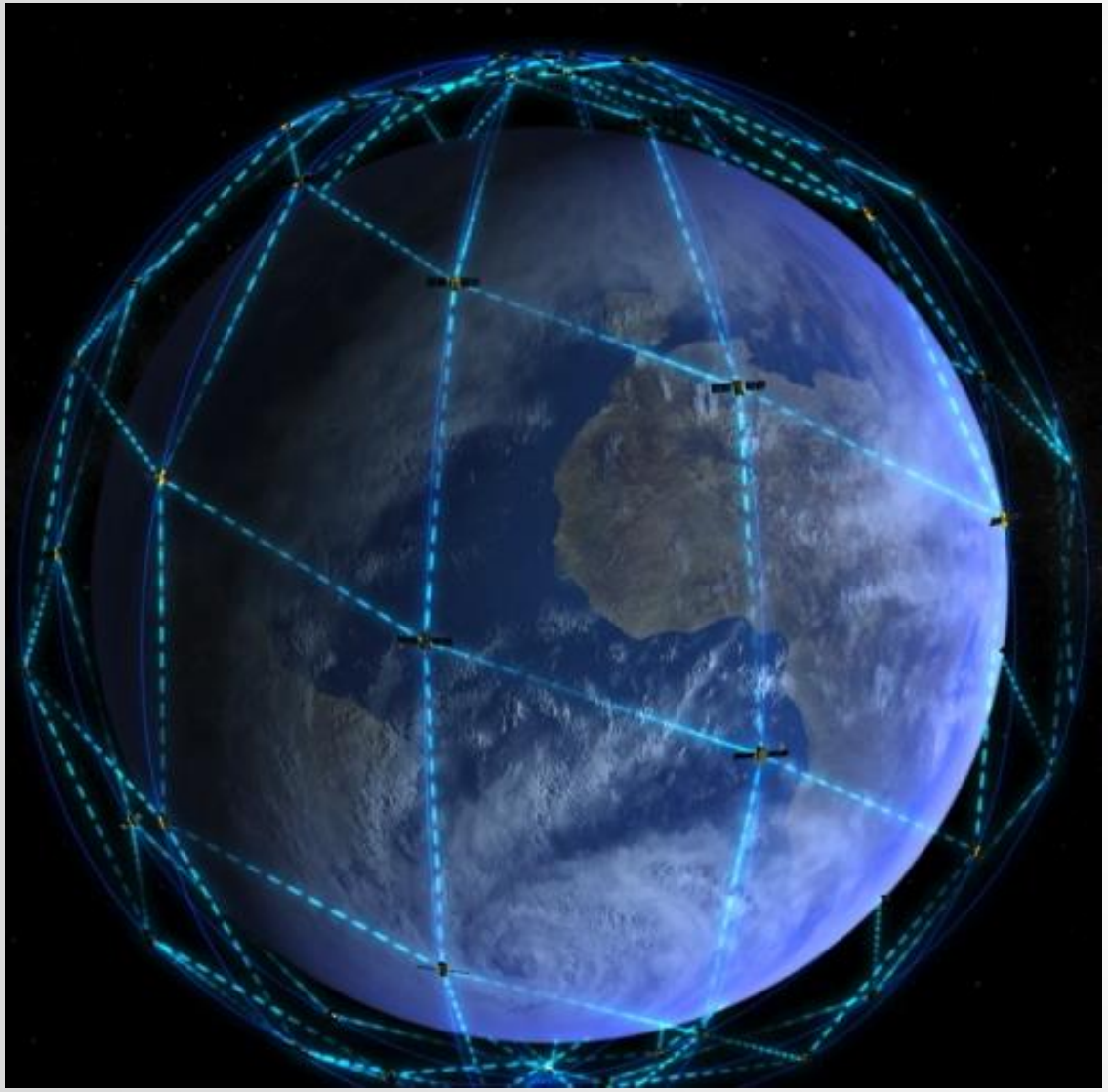
GPS

- ✦24 GPS Satellites
- ✦Global coverage
- ✦12,500 mile altitude
- ✦25x further away

SIGNAL COMPARISON TO GPS

	GPS L1	STL
Timing accuracy to UTC	~20 ns	~200 ns
Positioning accuracy	~3 meters	30-50 meters
Time To First Fix -- Timing	~100 seconds	~few seconds
Time To First Fix -- Positioning	~100 seconds	~10 minutes
Anti-spoofing	No, only for military use	Yes, encrypted signal
Coverage	Global	Global
Availability Outdoors	With view of horizon to get accurate position with low DOP	Limited view of sky lengthens convergence time
Availability Indoors	No	Yes: 30 – 40 dB stronger

TIMING SIGNAL - HOW IT WORKS



Re-purposed paging channels

1620 MHz band, 25 KHz channel, QPSK

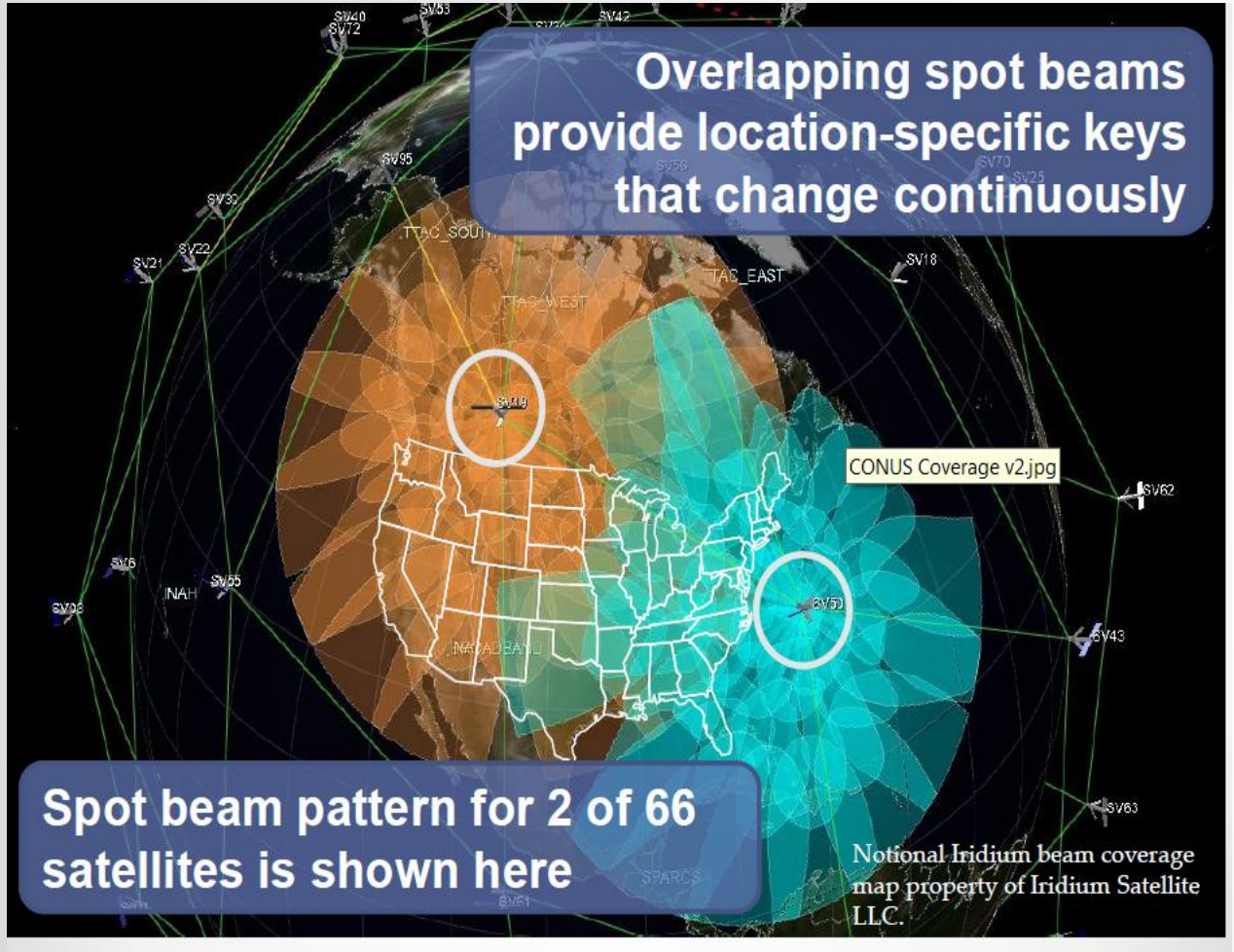
Spread Spectrum coded signal, 90 msec frame, ~1.4 sec burst on average

UTC synchronized timing

- +/- 500 nsec spec
- 100-200 nsec typical

Timing updates to a precision local oscillator for continuous time and frequency sourcing

LOW EARTH ORBIT (LEO) => STRONG SIGNAL WITH SPOT BEAMS



Iridium: ~100 minute orbit

GPS: 12 hour orbit

Encrypted signal with subscriber keys

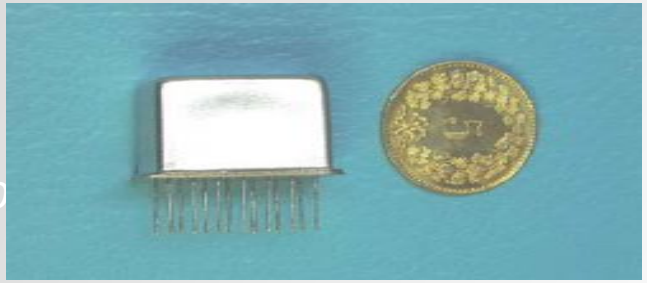
Positioning determination

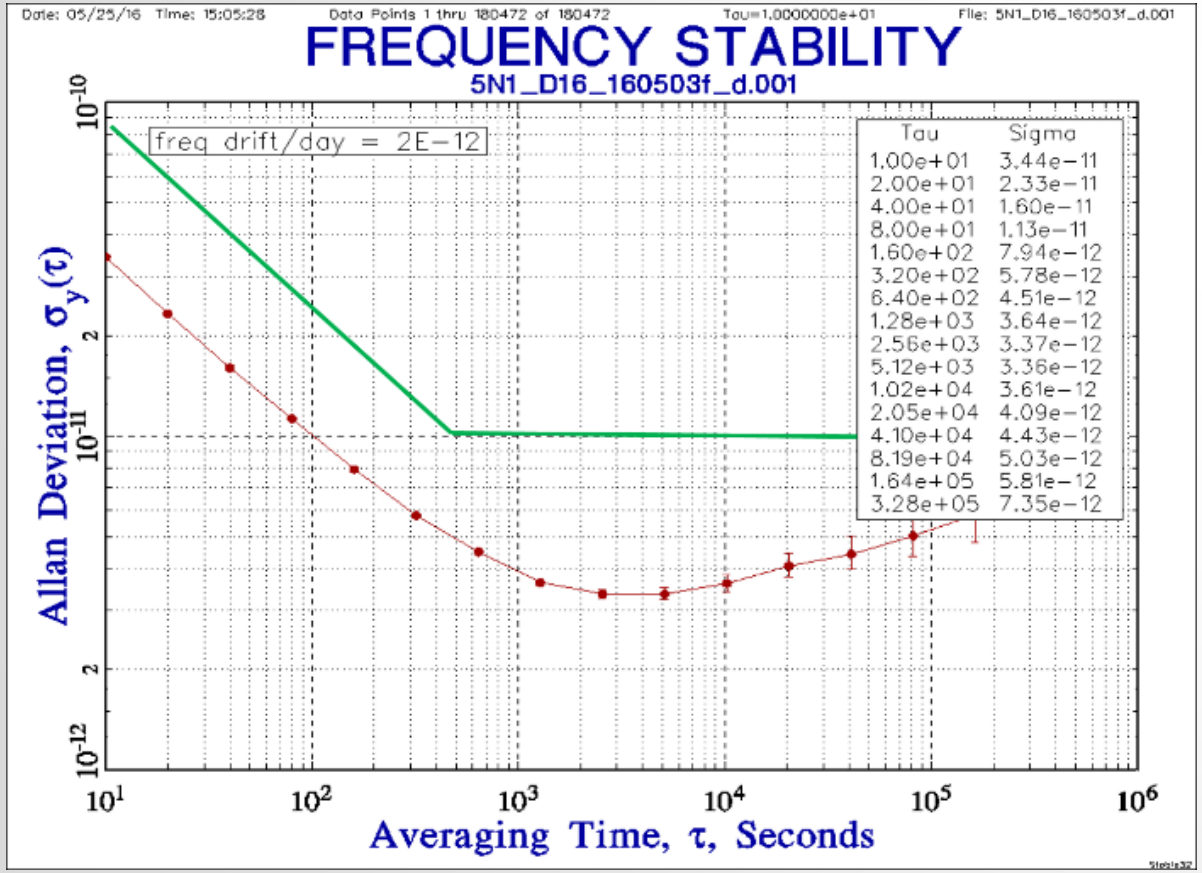
- Spot beam location (gross)
- Range and Doppler updates
- Convergence over minutes

Geo-location security

orolia

MINI –RUBIDIUM :





Extremely compact Physics Package (2 cc)

- PP power consumption < 150mW
- Hermetically sealed PP DIL14

Excellent long term stability

- Typical frequency drift : 2E-12 / day

Mid term stability

- Guaranteed < 1E-11 @ 1 day


PROTECT

CROWDSOURCED GNSS INTERFERENCE DETECTION SYSTEM

Components

1. Cell phone app reports jamming to a processing center
2. Server accepts, filters, correlates and alerts for jamming locations
3. A Prisma-like command center picture for law enforcement

CROWDSOURCING

Every cell phone can be a GPS jamming detector.
Requires a Public/Private Partnership.

INTERFERENCE REPORTING

U.S. process starts with problem report to NAVCEN, FCC or FAA:

- Different than ITU form
  - Problem Report vs. After Action Report
- Service Center triage to confirm problem
- Initial interagency conference call to provide for a coordinated government response/discussion on way forward
- Priority assigned will determine level of response and agencies involved

RICK HAMILTON
GPS INFORMATION ANALYSIS TEAM LEAD,
U.S. COAST GUARD NAVIGATION CENTER

Orolia's Prisma Command and Control Station

Used in Mission / Search and Rescue Coordination Centers