

Test Results from an Operationally Deployed Iridium- Based Secure Timing Solution

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Numerous Applications can Benefit from Time and Location Augmentation of GNSS



Mobile Indoor Location / E-911



Indoor Timing for Data Centers



Small Cell Time & Location



Emergency Services

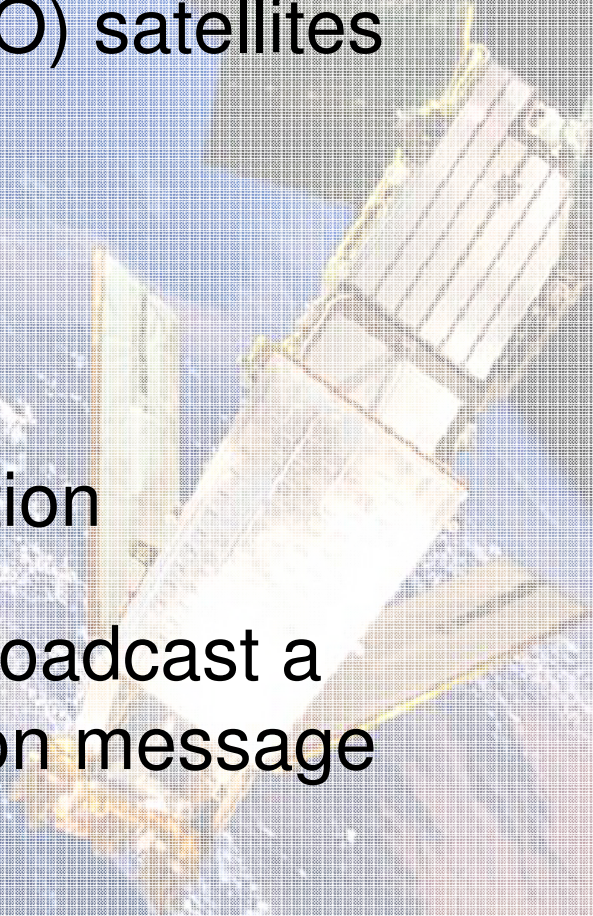


Intentional Jamming

Time and location is frequently needed in environments where GNSS is not available

The Iridium Satellite Constellation

- Low Earth Orbiting (LEO) satellites
 - 66 satellites
 - 6 orbit planes
 - 780 km altitude
- Actively used for high-availability communication
- Recently modified to broadcast a secure time-and-location message



Satelles Time and Location (STL)

LEO-satellite-based secure time and location signals designed to augment GNSS in certain circumstances

Augmentation #1

Improved Availability

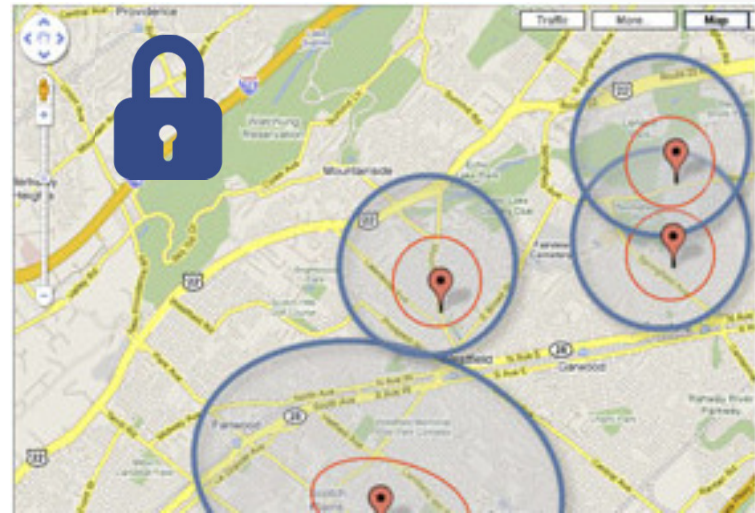
without local infrastructure



Augmentation #2

Stronger Security

extremely difficult to spoof



Strong Signals from Low Earth Orbit



66 Iridium Satellites

Global coverage

780 km altitude

**~30dB stronger
receive signal**



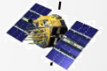
GPS

24+ GPS Satellites

Global coverage

20,200 km altitude

25x farther away



**Stronger signals from nearby Iridium satellites can
penetrate indoors and in places where GPS does not reach**

STL User Equipment Implementations



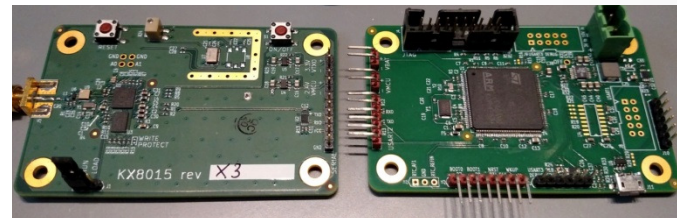
Ettus Research USRP N200



Custom Board



NooElec NESDR Mini 2 USB Stick



CSR SiRFstarV-XP

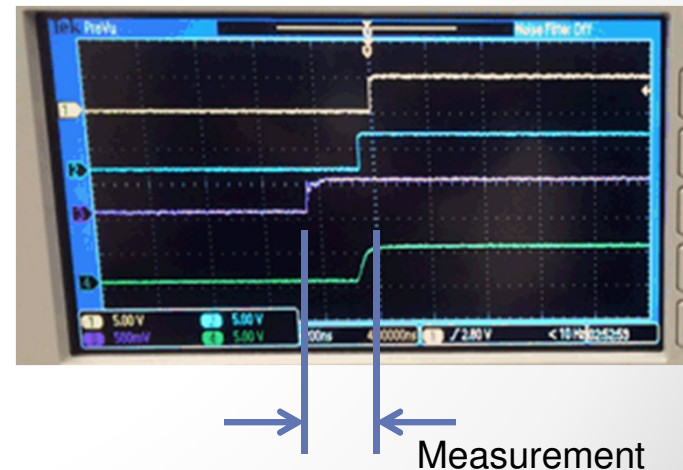
Timing Solution Evaluation

- A STL-based timing solution was implemented and tested
- Custom receiver based on:
 - Standard GNSS RF chip
 - Xilinx Spartan-6 FPGA
 - TI dual-core DSP chip
- Satellite receiver and antenna both inside a single-story home
- TCXO disciplined to STL burst timing measurements

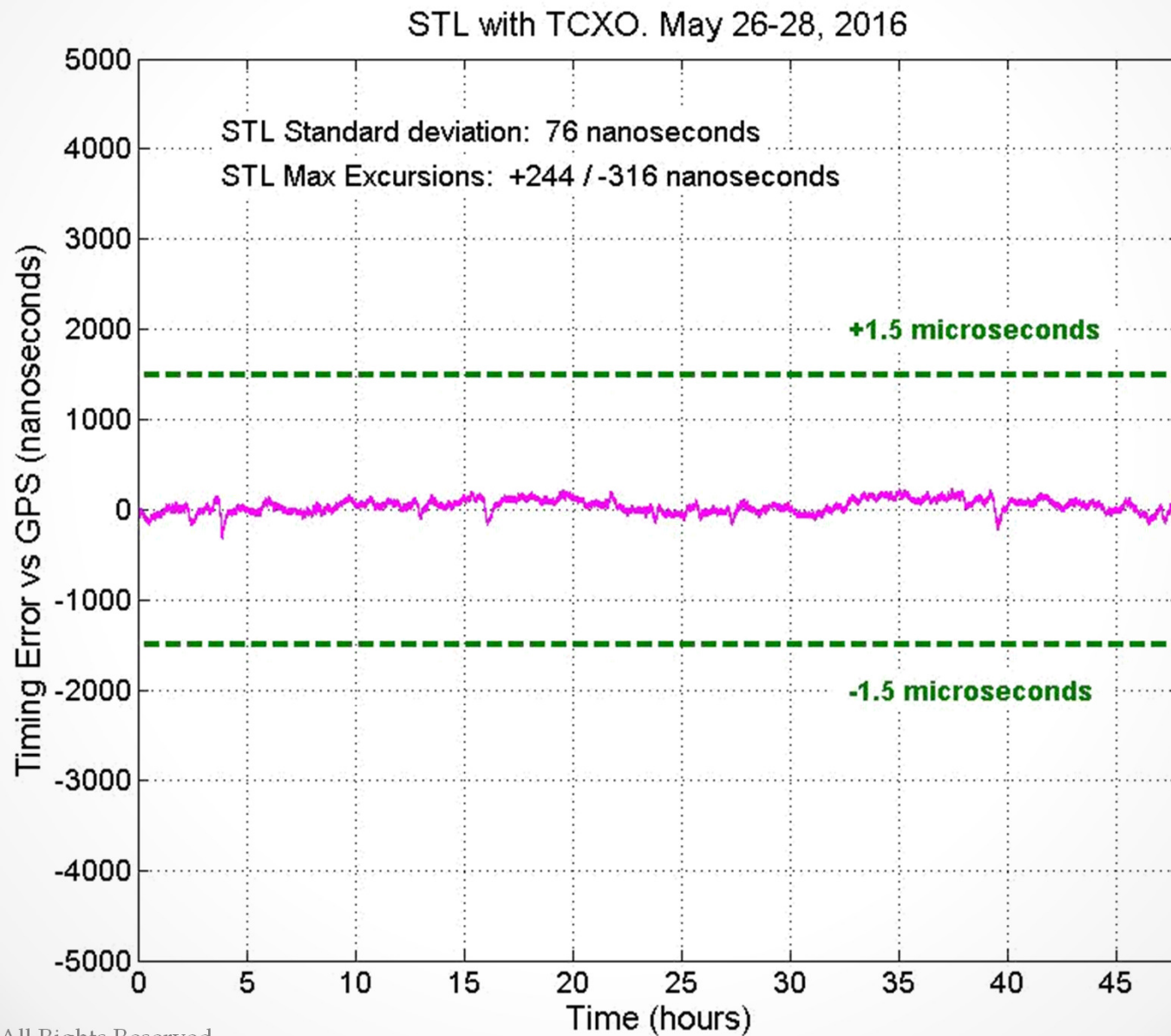


Timing Data Collection

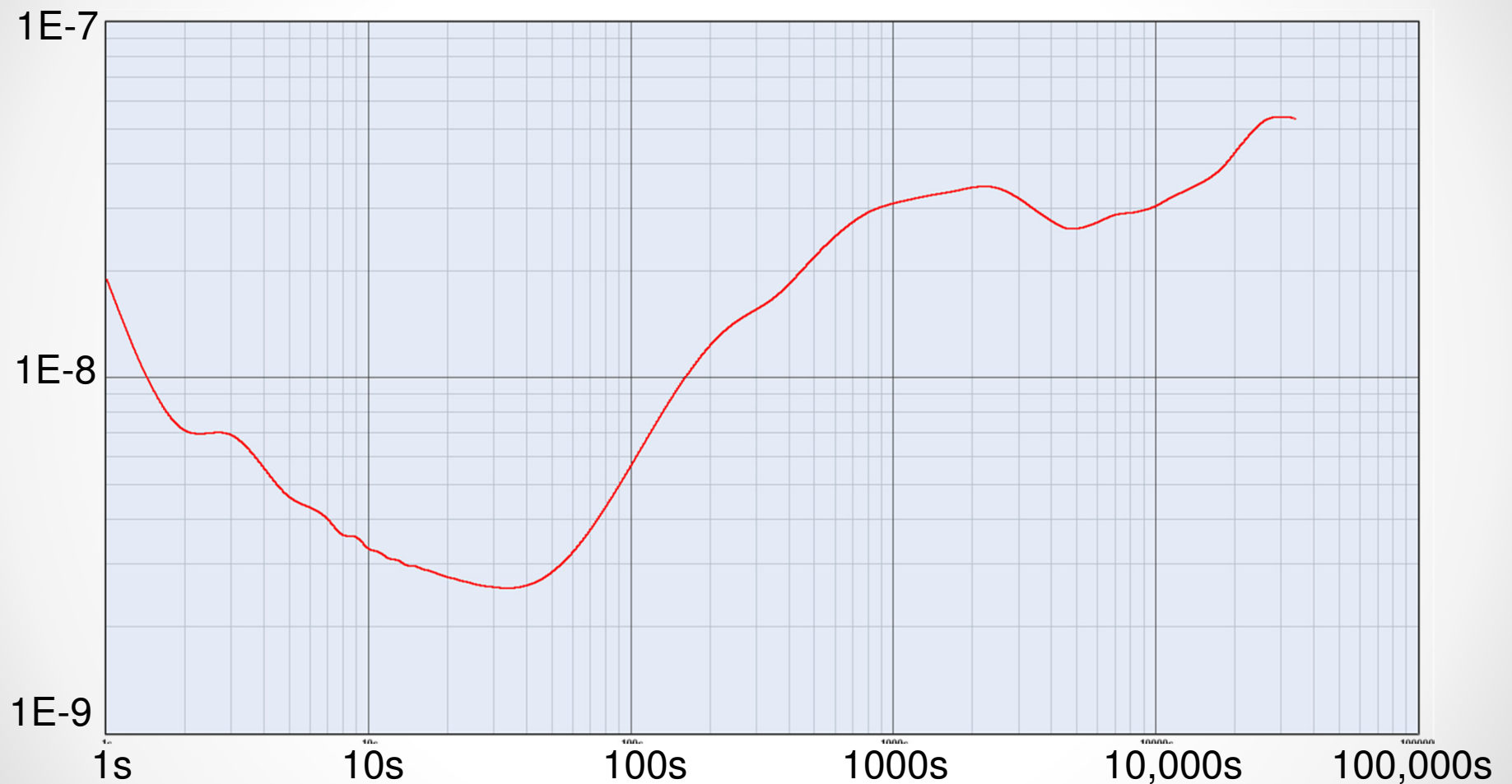
- Trimble Thunderbolt receiver with outdoor GPS antenna used as “truth” reference
 - ~10ns PPS accuracy
- STL PPS and GPS PPS compared and measured
- Data collected for 48 hours
 - HP 5334B Universal Counter disciplined to Thunderbolt clock
 - Prologix Ethernet interface to laptop
 - TimeLab Software running on laptop



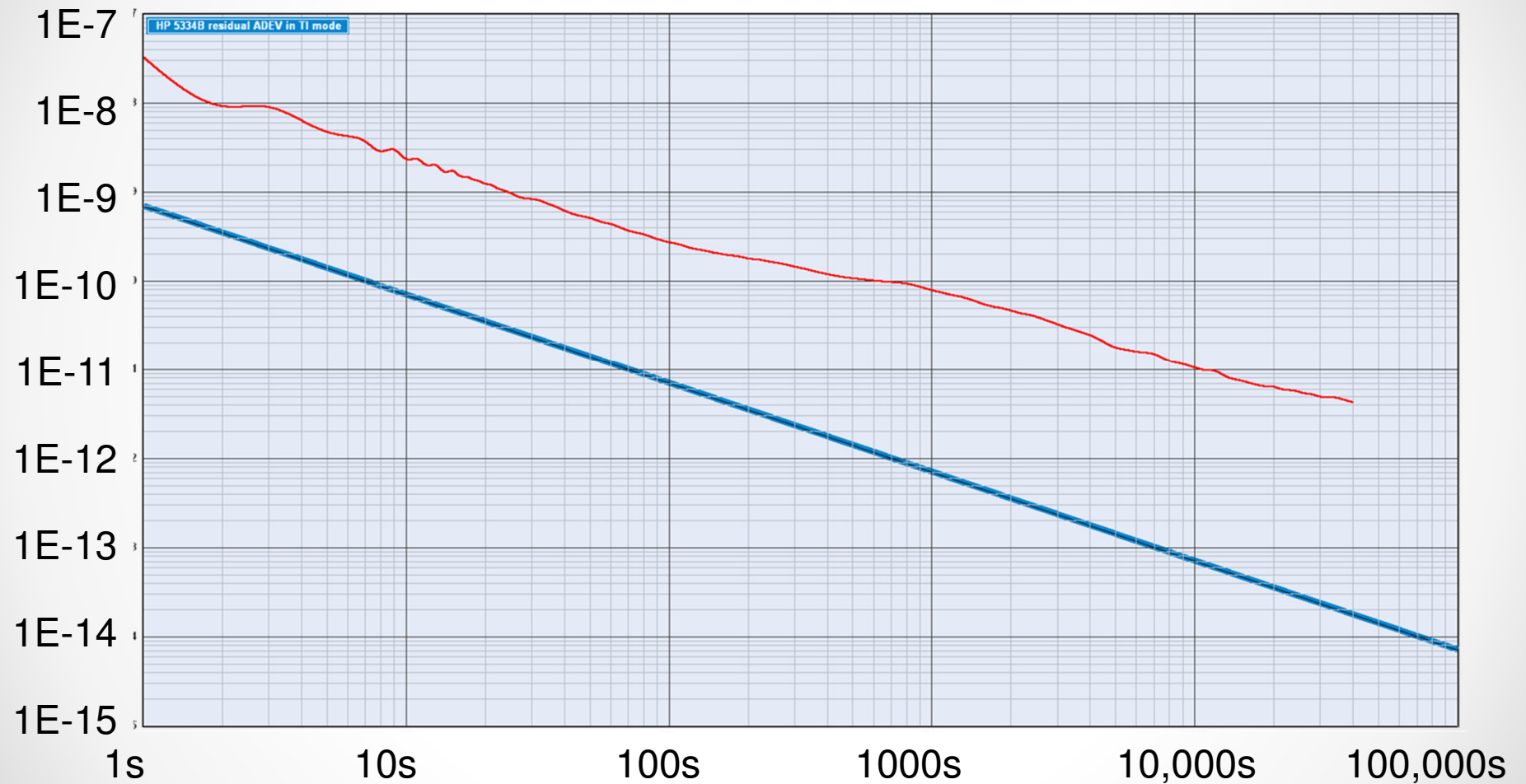
TCXO-based STL Timing – 48 hours



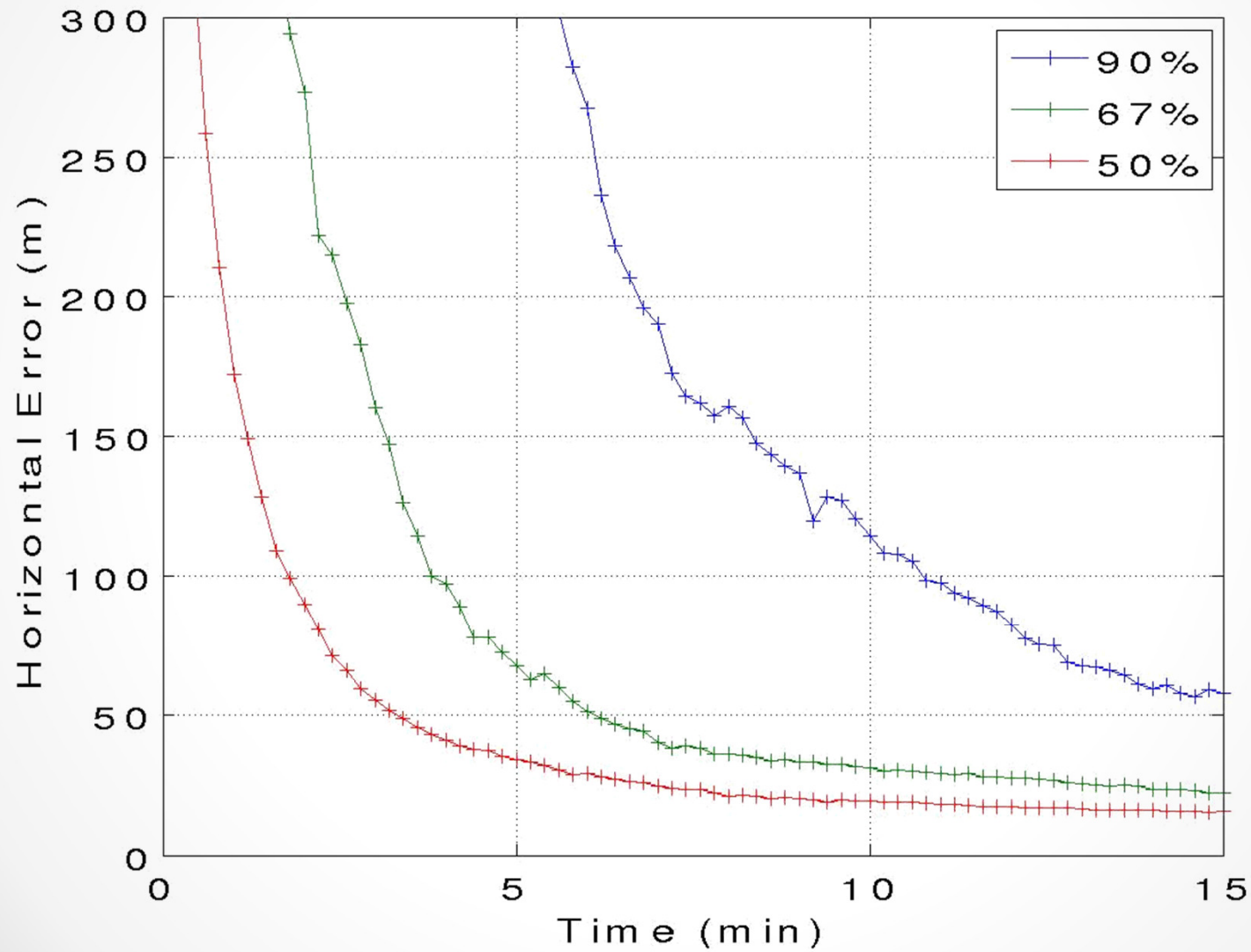
TCXO-based STL Timing – TDEV



TCXO-based STL Timing – ADEV



Indoor STL Geolocation Results



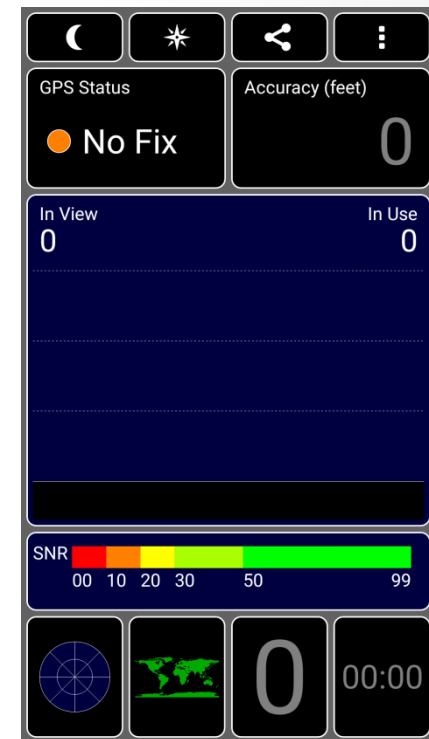
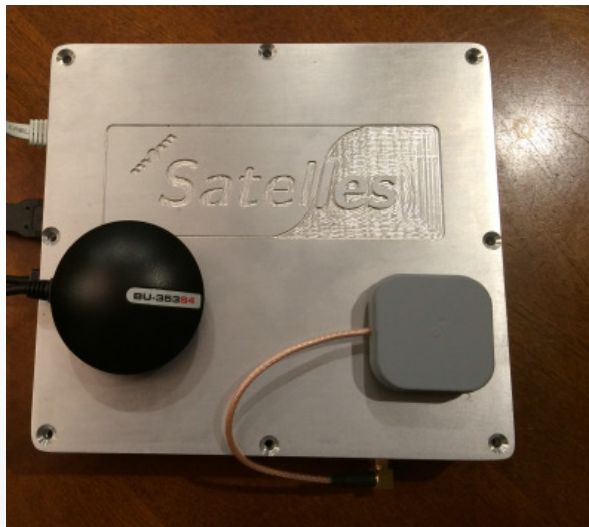
Deep Indoor Signal Evaluation

- Iridium tracking was implemented and tested in a GNSS-denied environment
- STL receiver and antenna both inside a concrete room within a steel building (indoor hockey rink)
- Same basic receiver design as timing test

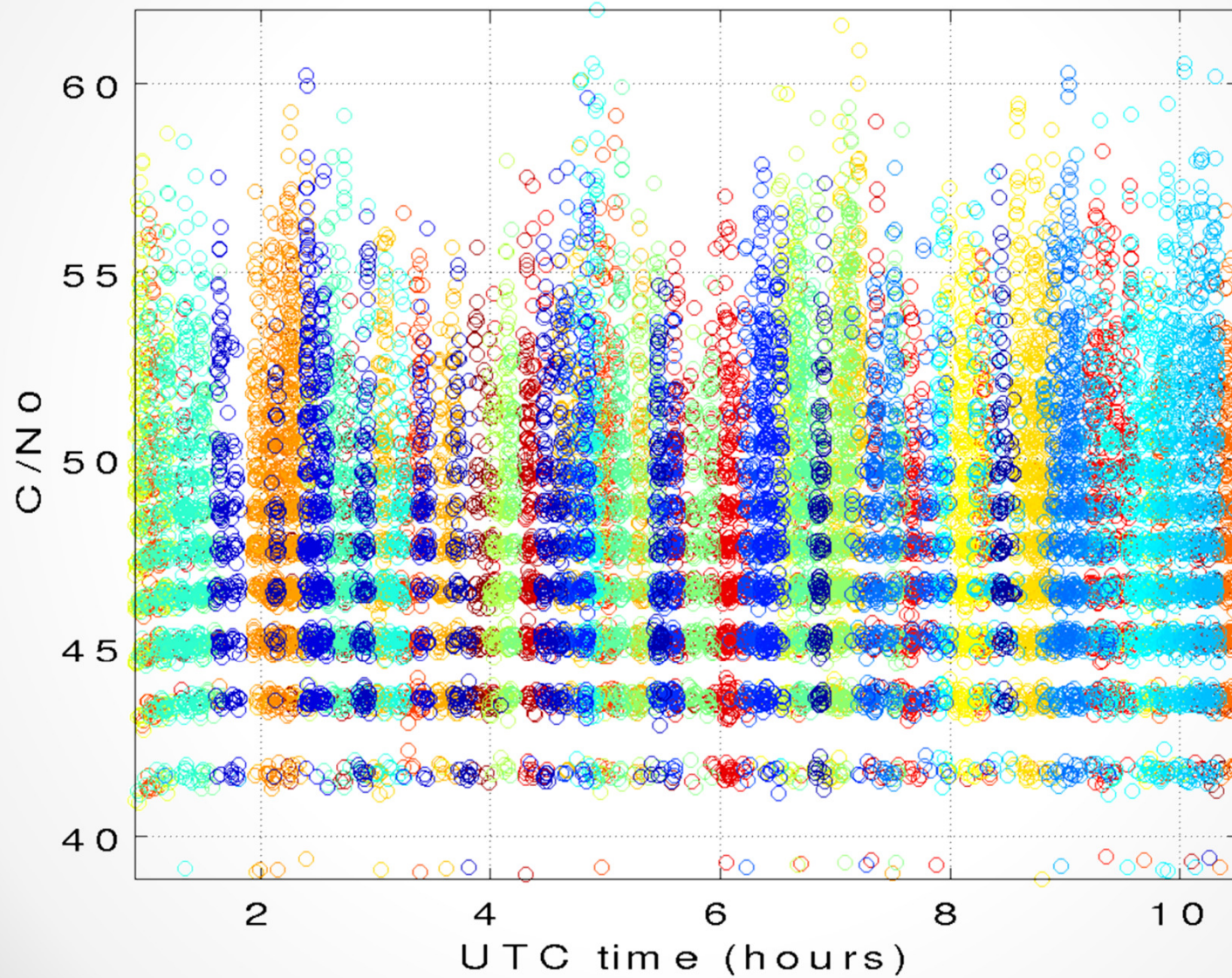


Deep Indoor Signal Data Collection

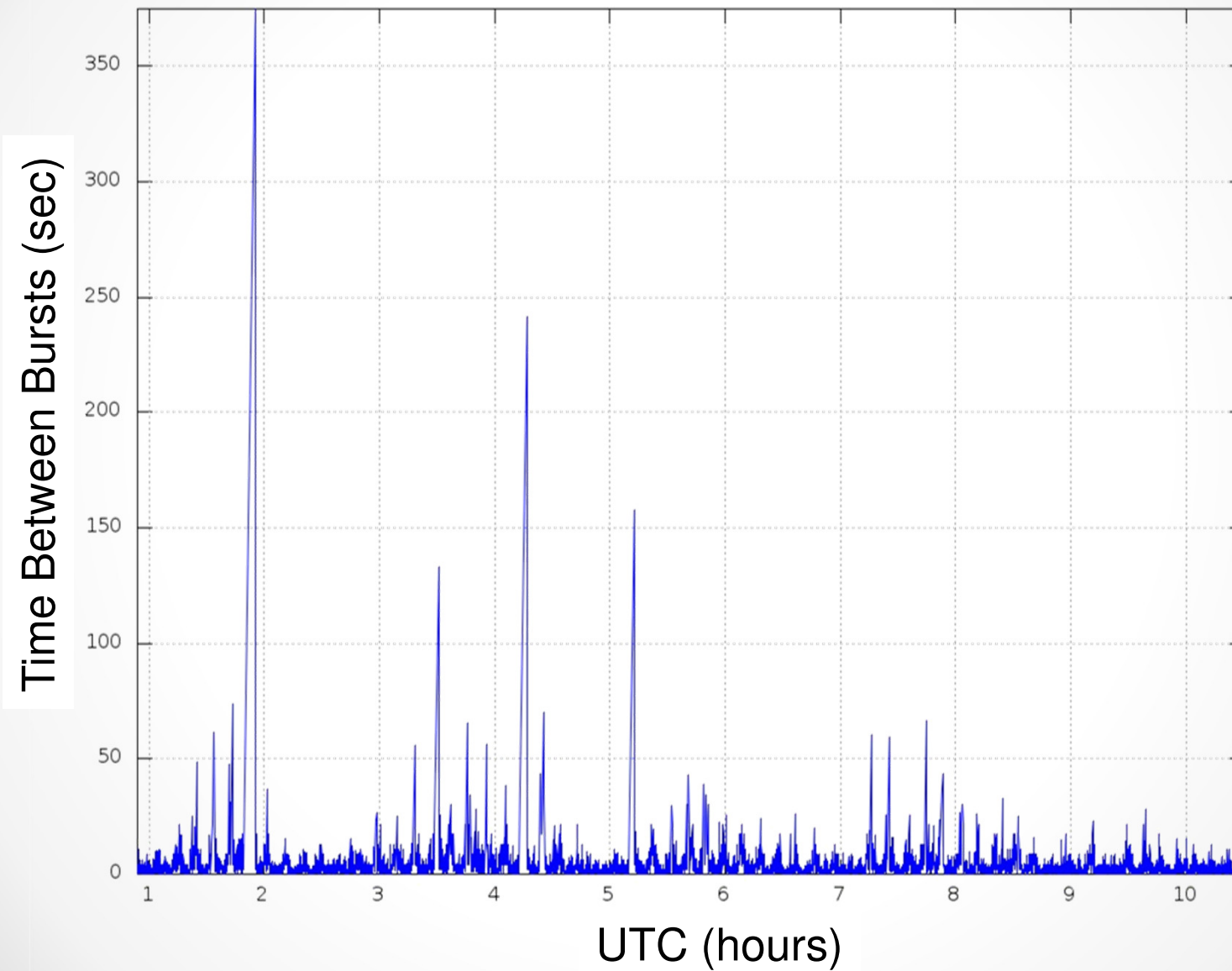
- Simultaneous STL and GNSS data collected overnight (~10 hours) during low activity at the facility
- Unable to track GNSS satellites at any time, on mobile phone or GNSS puck



Deep Indoor Signal Tracking

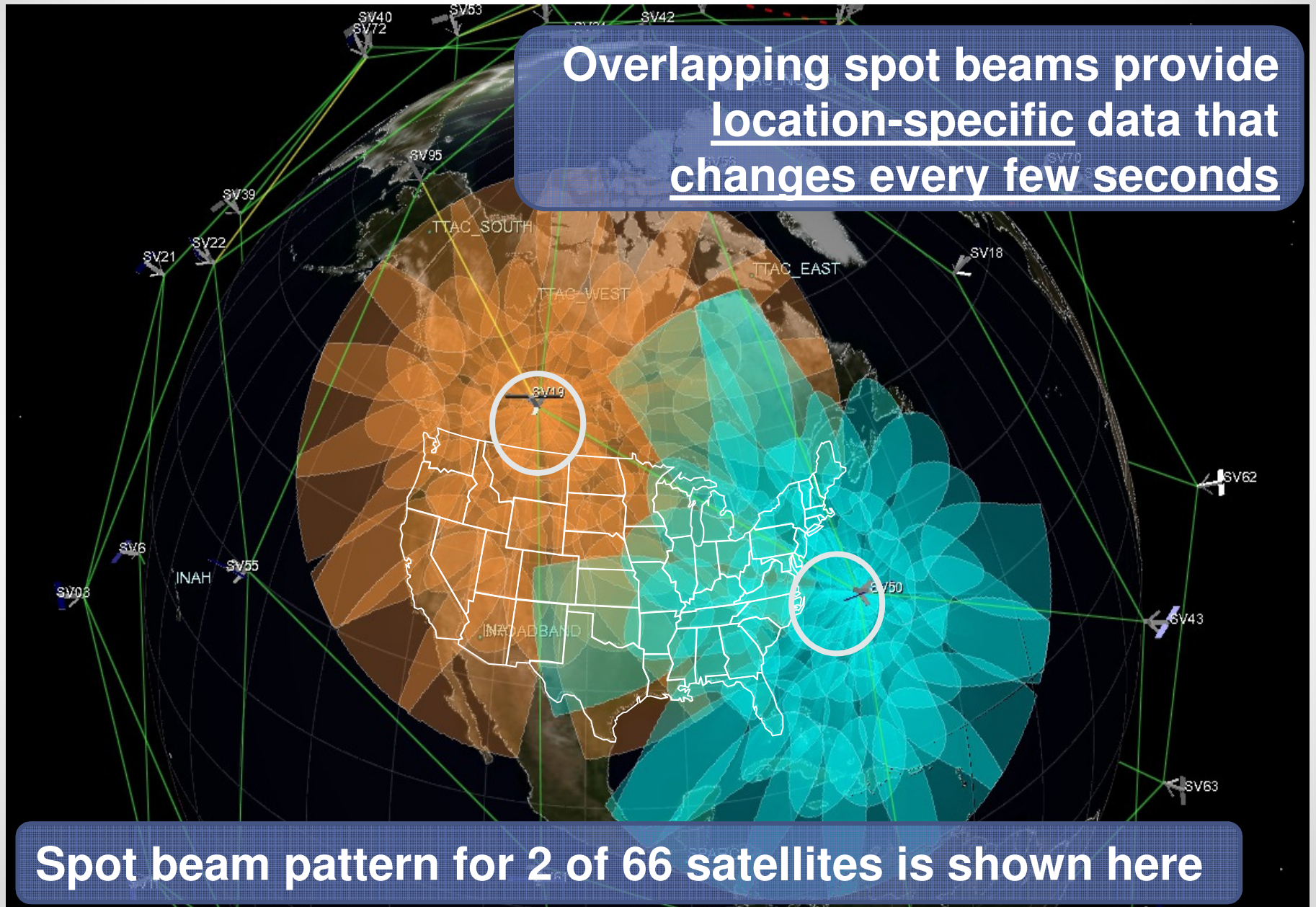


Deep Indoor Time Between Bursts



Random Numbers from Space

Overlapping spot beams provide location-specific data that changes every few seconds



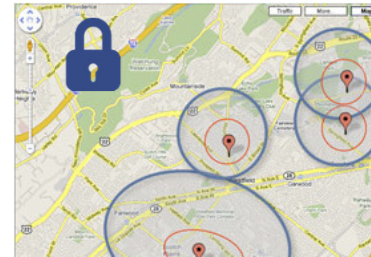
Spot beam pattern for 2 of 66 satellites is shown here

A Securely Augmented GNSS Solution can also Enable New Applications



IT Security

BYOD, Enterprise authentication,
Secure financial transactions



Secure Geofencing

Location-restricted data (ITAR, HIPAA)
and applications (encryption, gaming)



Secure Time Transfer

Critical Infrastructure
Trading compliance, Financial services



Automated Vehicles

Secure validation of vehicle
time and location

Verification of GPS Time and Location

The unique signal structure and high power of STL make it highly secure and resistant to spoofing

GPS Spoofing



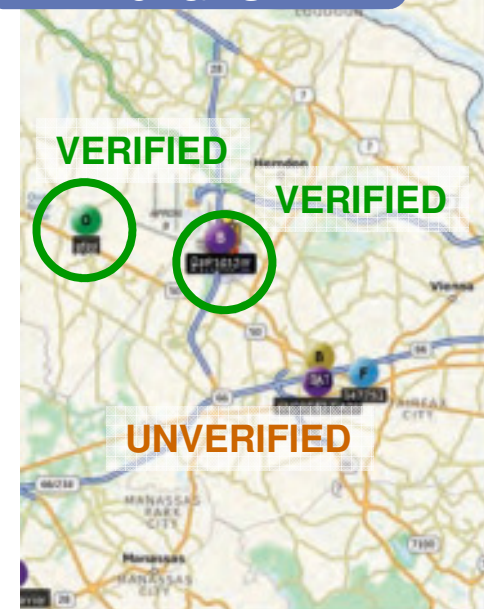
GPS Spoofing



GPS is vulnerable to spoofing

STL provides secure, independent verification of GPS

STL Verification of GPS



STL is exceptionally difficult to spoof

Summary

- Numerous applications can benefit from time and location augmentation of GNSS
- Low Earth Orbit satellites complement GNSS solutions
 - High-power signals reach environments where GNSS does not
 - Unique signals offer increased security in the presence of spoofing
- Sub-microsecond time transfer accuracy demonstrated
- Indoor positioning accuracies of ~20m
- Deep indoor signal penetration where GNSS is not available
- Iridium's unique signal structure enables secure validation and/or authentication of user location

Thank You Questions?

