



Satelles Alternative PNT WSTS 2021

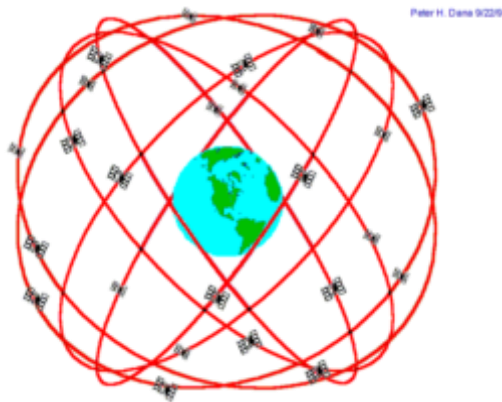
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The World Relies on GPS

Since the launch of GPS, time and location have found their way into practically **everything** we do.



A Global Utility

“Since the United States made the Global Positioning System available worldwide, positioning, navigation, and timing (PNT) services provided by space-based systems have become a largely invisible utility for technology and infrastructure.”

source: Executive Order on Strengthening National Resilience through Responsible Use of Positioning, Navigation, and Timing Services (February 2020)



Diverse Industry Requirements

16 Critical Infrastructure Sectors and Sector-Specific Agencies (SSAs)

- Communications (DHS)
- Energy (DOE)
- Financial Services (USDT)
- Information Technology (DHS)
- Transportation Systems (DOT, DHS)
- Defense Industrial Base (DoD)
- Emergency Services (DHS)
- Food and Agriculture (USDA, HHS)
- Chemical (DHS)
- Government Facilities (DHS, GSA)
- Nuclear Reactors, Materials, and Waste (DHS)
- Critical Manufacturing (DHS)
- Dams (DHS)
- Commercial Facilities (DHS)
- Healthcare and Public Health (HHS)
- Water and Wastewater Systems (EPA)

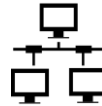
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- timing precision – microsecond, sub-microsecond
- positioning – 3D, 2D, none
- positioning precision – 10 meters, 5 meters, 1 meter
- motion – static, dynamic
- breadth of coverage – national, regional, local
- environment – outdoors, indoors, underground, urban, rural, mountains, oceans

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**Multiple
Technologies**



“Precise time is crucial to a variety of economic activities around the world. Communication systems, electrical power grids, and financial networks all rely on precision timing for synchronization and operational efficiency.”

– 2019 Federal Radionavigation Plan





Wireless and Cable Market Needs

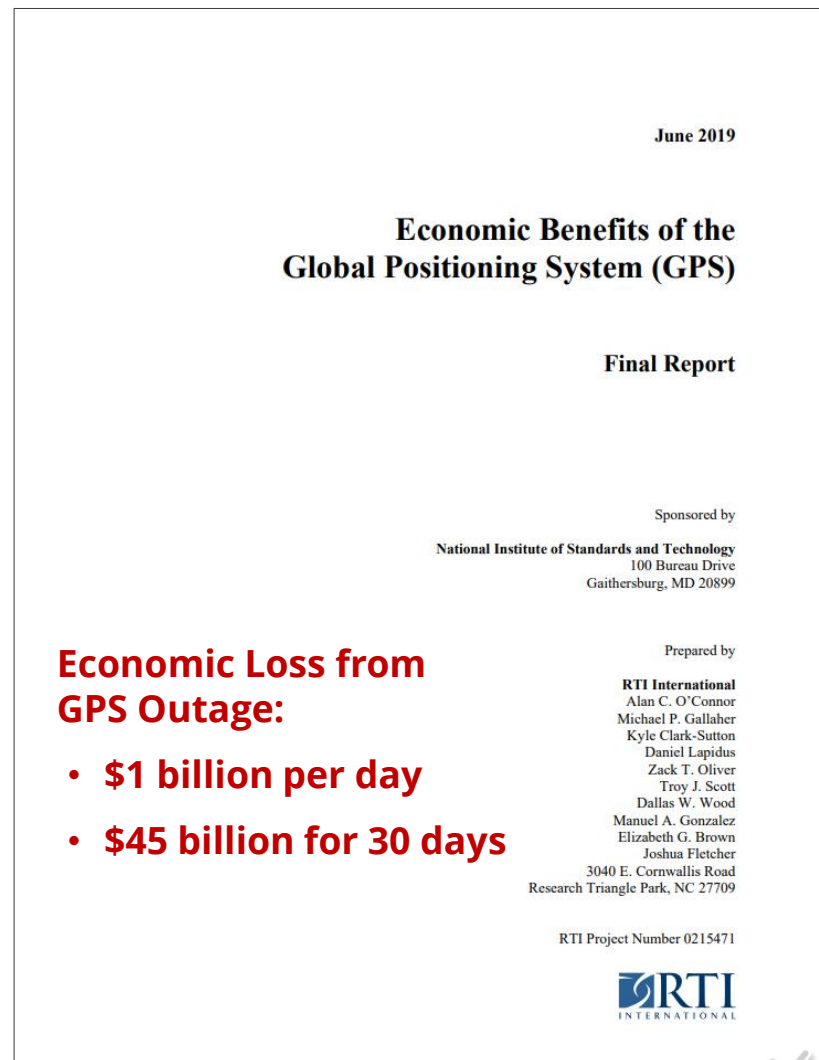
- **Wireless Carriers rely on timing in all aspects of their network. 5G requires 5-10x increased number of RAN nodes compared to 4G, and the majority of these will be indoors where GPS is challenged.**
 - Macro Towers and indoor/outdoor small cells (especially TDD type)
 - Femtocells-enterprise & residential broadband
 - PTP edge master routers
- **Wireless carriers and Cable providers are both focused on capturing the very sizable and critical enterprise & residential broadband market. Covid has made this segment more critical to our economy as our workforce will forever be more work from home employees.**
 - Requires timing (& location for E911 for residential)
 - Significant issues w GPS coverage as these are all indoor installations
 - Requires low cost, ubiquitous solution for consumer self-install



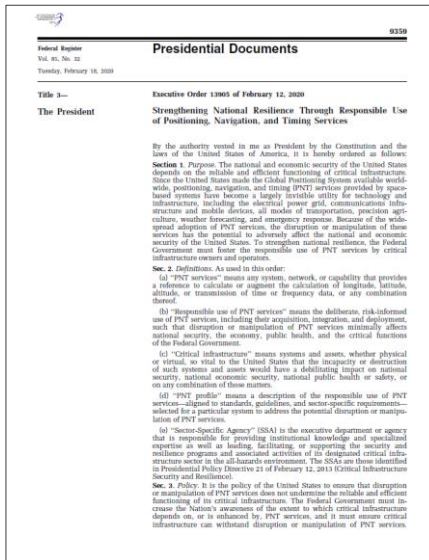


But GPS is Vulnerable

- Weak Signal
- Unintentional Events
- Deliberate Attacks
- Value of GPS ➡

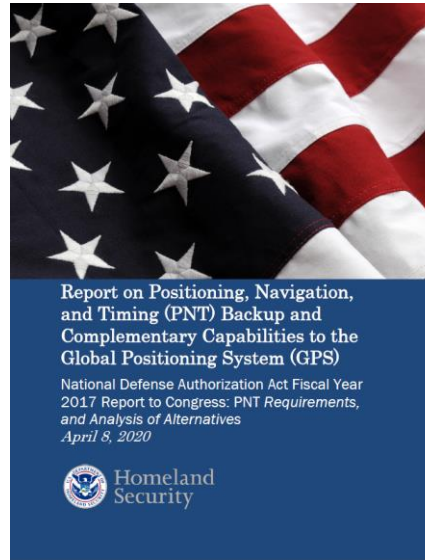


Alternative PNT is needed now



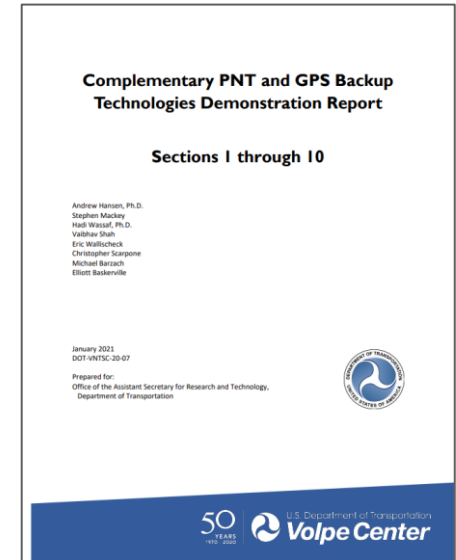
Executive Order 13905 (2/12/2020) – Strengthening National Resilience Through Responsible Use of Positioning, Navigation, and Timing Services

- critical infrastructure PNT protection policy
- implementation roadmap
- DOC, DOE, DOT, and DHS



DHS Report (4/8/2020) – Report on Positioning, Navigation, and Timing (PNT) Backup and Complementary Capabilities to the Global Positioning System (GPS)

- urgency for GPS backup
- multiple technologies for diverse needs
- common requirement for precision timing (65-240 ns)



DOT Report (1/14/2021) – Complementary PNT and GPS Backup Technologies Demonstration Report

- “suitable, mature, and commercially available technologies” exist to back up or complement GPS for timing
- varied requirements for critical infrastructure “necessitates a diverse universe of positioning and navigation technologies”
- of 11 providers evaluated, STL is the ONLY one that is nationally and globally scalable
- in addition, STL was one of only two technologies for time and location that is commercially available today (TRL 9)



Alternative PNT from Satellites

STL

Satellite Time and Location

- Exclusive use of the Iridium constellation for PNT
- Provides precision timing independent of GPS
- Provides location information independent of GPS
- Augments GPS measurements when not enough GPS satellites are in view or are obstructed or denied





Strong Satellites Signals from Iridium



***1,000 times stronger signals from nearby Iridium satellites
penetrate indoors and into places where GPS does not reach***



Unique Value Derived from Iridium

(custom signals provide secure time transfer and location capabilities)

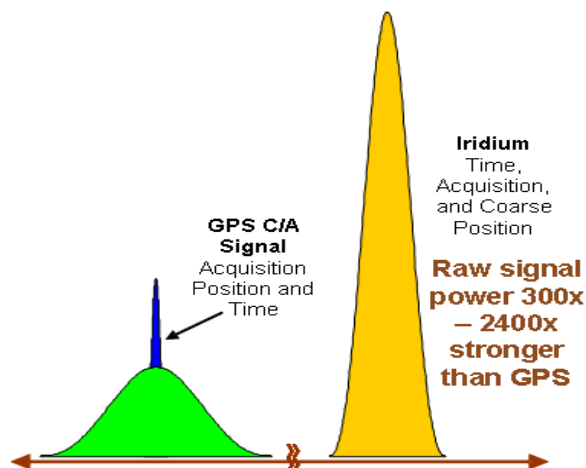
Worldwide Coverage

No local infrastructure



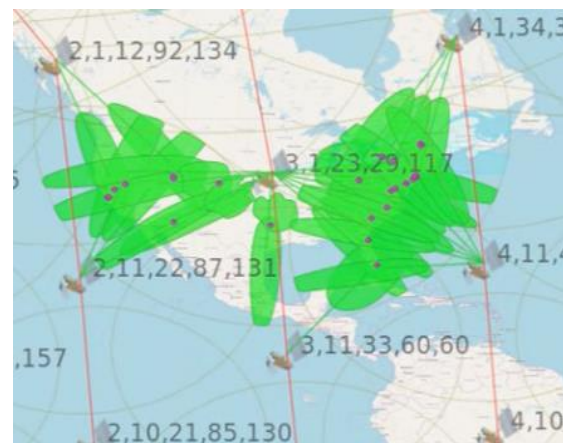
High Power Broadcasts

Signals penetrate buildings



Localized Spot Beams

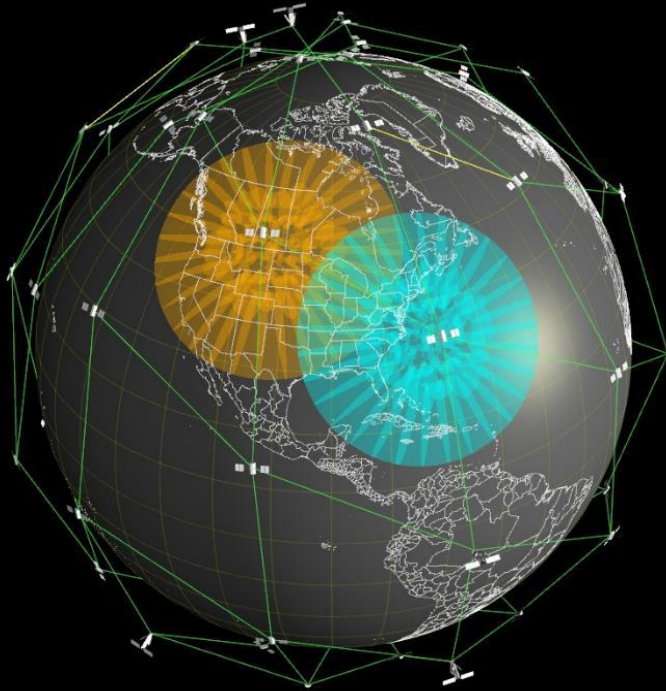
Enables proof of location



No other space asset provides this key combination of features



We Cover the Planet



Cross-links provide continuous orbit and time information on the entire constellation even when most are not in view of ground systems.

Overlapping **spot beams** provide location-specific keys that change every second to support location-based authentication.



STL Service Attributes

Powerful Signal	• LEO satellite constellation • Broadcast signal is 1,000 times (30 dB) stronger than GPS
Global Coverage	• No geographic restrictions • Available today
Secure Delivery	• In building penetration where GPS can't reach • Authentication used so signal cannot be spoofed
Accurate PNT	• UTC accuracy typ. 60 nSec 1-sigma with max error < 500 nSec • Meets timing requirements for FCC/3GPP/ITU 50 ppb and 1500 nS
Proven Technology	• Customers around the world



DOT Demonstration of PNT

- In March 2020, the U.S. Department of Transportation organized a demonstration of positioning, navigation, and timing (PNT) technologies from 11 providers.
- The technology demo was fair to all participants, the evaluation of the results was thorough, and the report itself is comprehensive, data-driven, accurate, and expertly written.
- The report summarizes that multiple forms of PNT are needed to meet wide-ranging performance specifications and operational requirements of critical infrastructure providers that must back up or augment GPS.

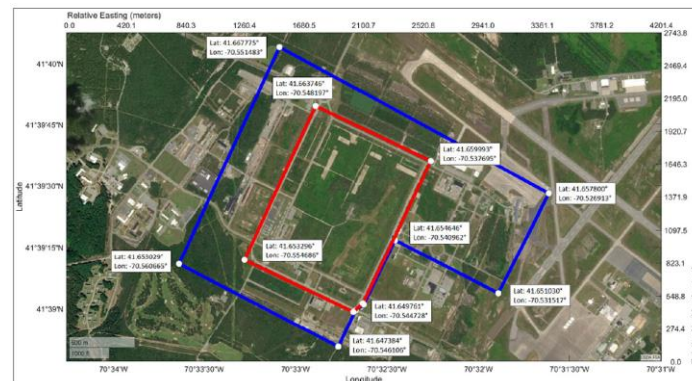


Figure 2. JBCC: Area Used for Demonstration



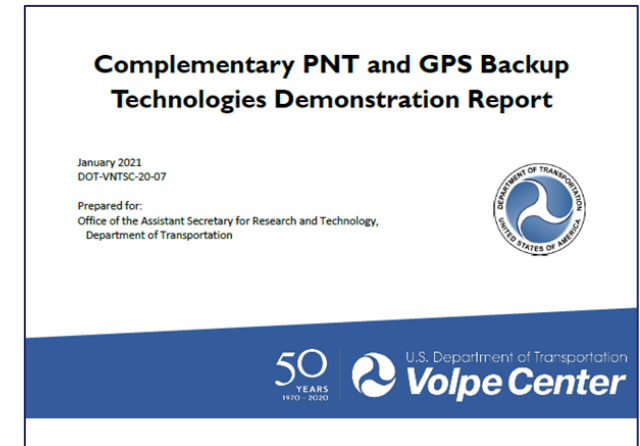
Figure 10. LaRC Rover Transport Van, with GPS/IMU Mounted Top Center Rear of Van Roof

PNT Technology Vendor	Demo Site	72-Hr Batch Static Timing	Static Outdoor Timing	Static Indoor Timing	Static Basement Timing	Reference Station Offset (w/ Demo Timing)	Dynamic Outdoor Positioning with Hubs	Static Outdoor Positioning	Static Indoor Positioning	Airborne Positioning
Echo Ridge LLC	LaRC					N/A		8		
Hellen Systems, LLC	JBCC	8			8	8				
NextNav LLC	LaRC	9	9	9	9	N/A	9	9	9	9
OPNT B.V.	LaRC	9				N/A				
PhasorLab Inc.	JBCC	8	8	8		N/A	7	7		7
Satelles, Inc.	JBCC	9	9	9	9	N/A		9		
Serco Inc.	JBCC					N/A	5	5		
Seven Solutions S.L.	LaRC	9				N/A				
Skyhook Wireless, Inc.	LaRC					N/A	9	9	9	9
TRX Systems, Inc.	LaRC					N/A	7	7	7	
UrsaNav Inc.	JBCC	9		9	9	9				
GPS (SPS PS)	All	9	9			9	9	9		9

Figure ES.1. MoE-1: Technical Readiness–System Government Consensus Scorecard

Alternative PNT solutions available now

- The top results in the DOT demonstration came from commercially developed solutions.
- The testing showed that only 3 of the 11 demonstrated technologies are ready and able to provide both timing and position:
 - **Satelles** – a commercial solution based on low Earth orbit (LEO) satellites that are globally available and independent of GPS
 - **NextNav** – a commercial solution that provides precision PNT based on metropolitan-area transmitters
 - **PhasorLab** – a commercial solution that provides PNT based on local transmitters



DOT Testing Results

(Complementary PNT and GPS Backup Technologies Demonstration Report)

PNT Technology Vendor	Demo Site	72-Hr Bench Static Timing	Static Outdoor Timing	Static Indoor Timing	Static Basement Timing	Reference Station Offset (eLoran Timing)	Dynamic Outdoor Positioning with Holds	Static Outdoor Positioning	Static Indoor Positioning	Airborne Positioning
Echo Ridge LLC	LaRC					N/A		333.2		
Hellen Systems, LLC	JBCC	114.9			failed to close	3.4				
NextNav LLC	LaRC	23.1	7.1	5.8	17.5	N/A	15.6	6.7	8.9	3.8
OPNT B.V.^	LaRC	0.2				N/A				
PhasorLab Inc.	JBCC	9.4	17.4	18.7		N/A	11.7	7.4		8.6
Satelles, Inc.	JBCC	75.5	75.0	9.0	117.0	N/A		9.0		
Serco Inc.	JBCC					N/A	DNQ	39.4		
Seven Solutions S.L.^	LaRC	0.1				N/A				
Skyhook Wireless, Inc.	LaRC					N/A	7.6	1.8	23.5	14.6
TRX Systems, Inc.	LaRC					N/A	9.7	6.2	9.8	
UrsaNav Inc.	JBCC	80.1		57.4	failed to close	9.7				
GPS (SPS PS)	All	30	30			30	5	5		7

Rubric:

positioning: max 95%{runs} (m)

1.8

to

333

timing: max 95%{runs} (ns)

0.1

to

117

^ 1PPS from USG at measurement node

Figure ES.2. MoE-3: Timing and Positioning 95% Accuracy Government Consensus Scorecard

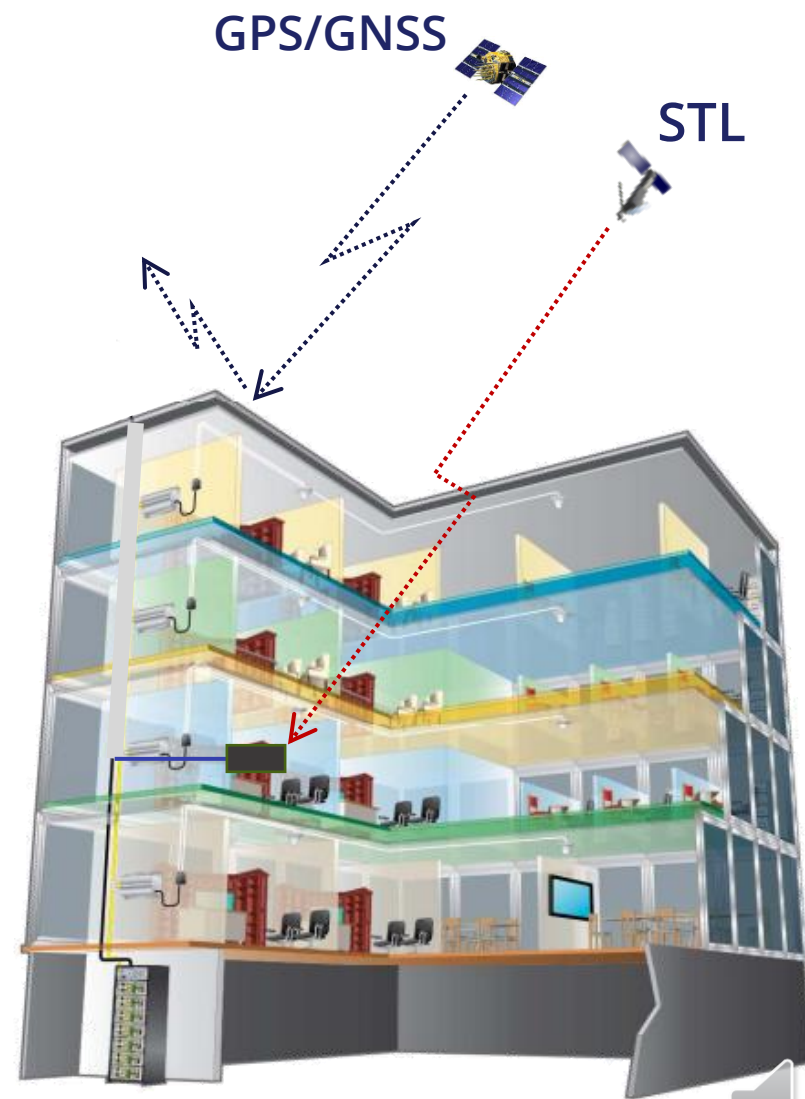
Indoor Timing & Positioning Solutions

- **Indoor timing installations are growing**
 - Indoor wireless carrier solutions
 - Data centers / global databases
 - Financial services
- **Network time synchronization currently requires GPS**
- **GPS roof antennas are difficult and costly**

In-building STL receiver eliminates the need for a GPS roof antenna

see additional detail in 3-Feb-2020 *Inside GNSS* article: "Test Confirms Timing Resilience of LEO Time Service Underground, Indoors"

<https://insidegnss.com/test-confirms-timing-resilience-of-leo-time-service-underground-indoors/>





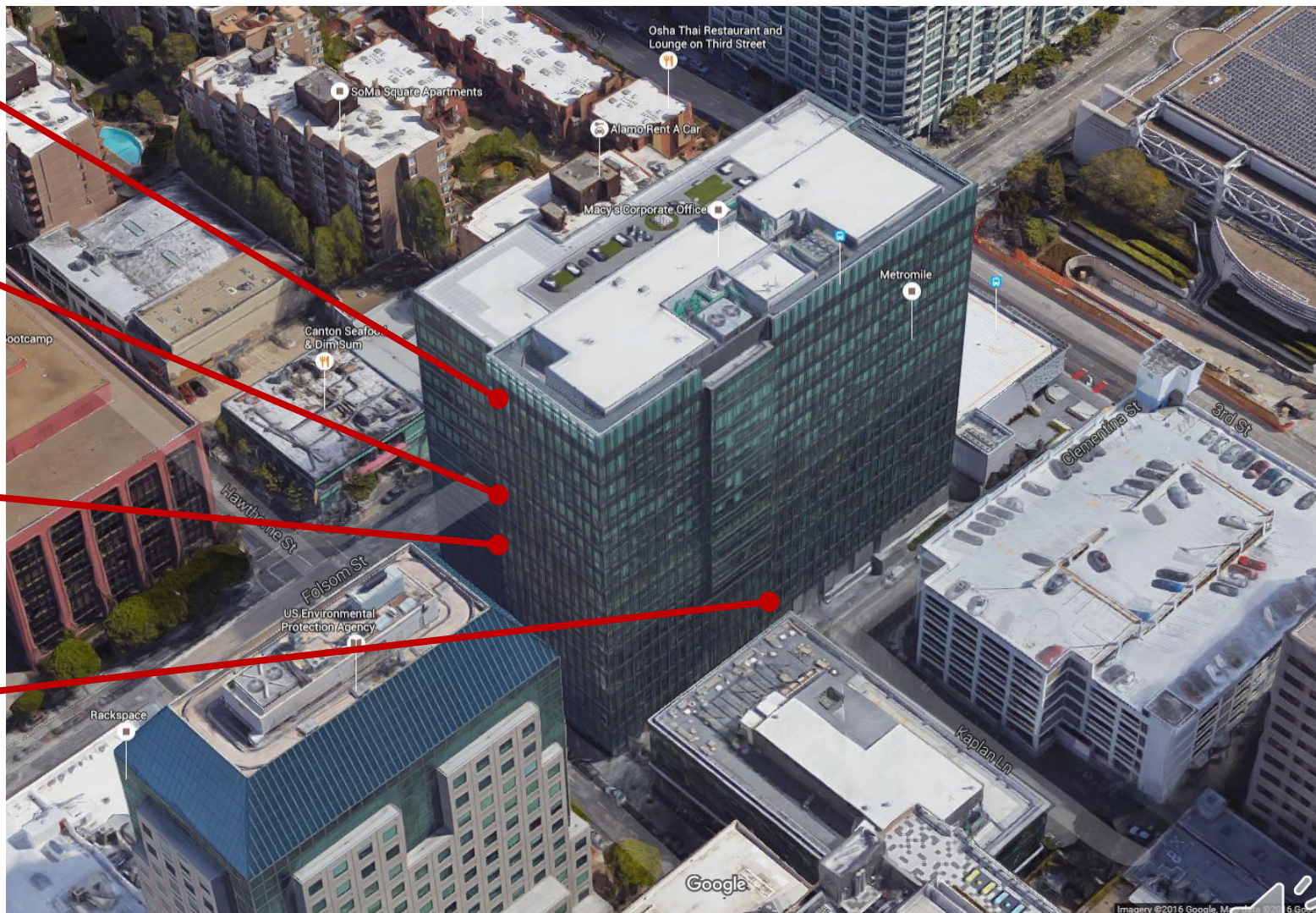
San Francisco Validation

Sites #1-2
13th Floor

Sites #3-4
9th Floor

Site #5
6th Floor

Site #6
2nd Floor





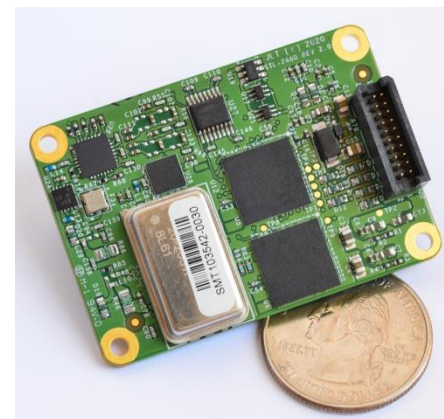
Carrier Testing – Indoor Validation Results

Test Site	Description	Bluetooth GPS (unassisted)	Smart Phone GPS (assisted)	STL-1 (unassisted)	STL-2 (assisted)
1	13 th floor	NO FIX 1-2 sats	NO FIX 1-2 sats	Strong Signal SNR ~45-60	Strong Signal SNR ~35-60
2	13 th floor	NO FIX 0 sats	NO FIX 0 sats	Strong Signal SNR ~45-55	Strong Signal SNR ~35-55
3	9 th floor	NO FIX 0 sats	NO FIX 1-2 sats	Strong Signal SNR ~45-60	Strong Signal SNR ~35-60
4	9 th floor	NO FIX 0 sats	NO FIX 0 sats	Strong Signal SNR ~45-55	Strong Signal SNR ~35-55
5	6 th floor	NO FIX 0 sats	NO FIX 0 sats	Strong Signal SNR ~45-55	Strong Signal SNR ~35-55
6	2 nd floor	NO FIX 0 sats	NO FIX 0 sats	Strong Signal SNR ~45-55	Strong Signal SNR ~35-55

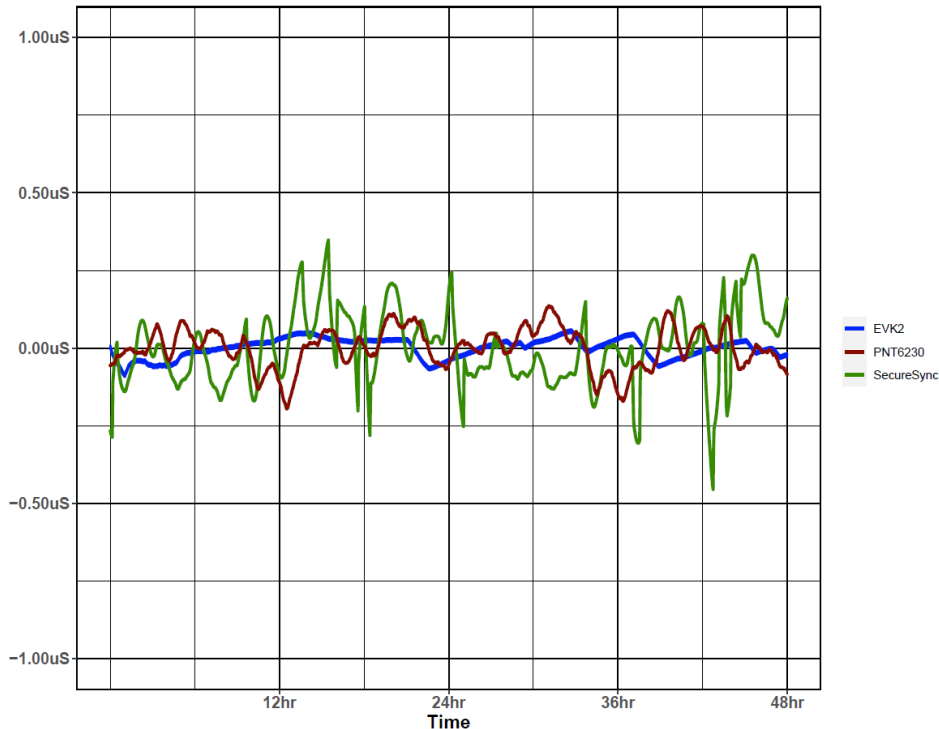


STL Solutions are Available Today

- **Subscription-based model** – directly with service providers
- **Manufacturing partners** – support STL service
- **Multiple form factors** – receivers available from ASICs and module boards to test equipment and PTP Edge Grandmasters
- **Demo Kits available** – for evaluation purposes



Test Results – STL Receiver Performance



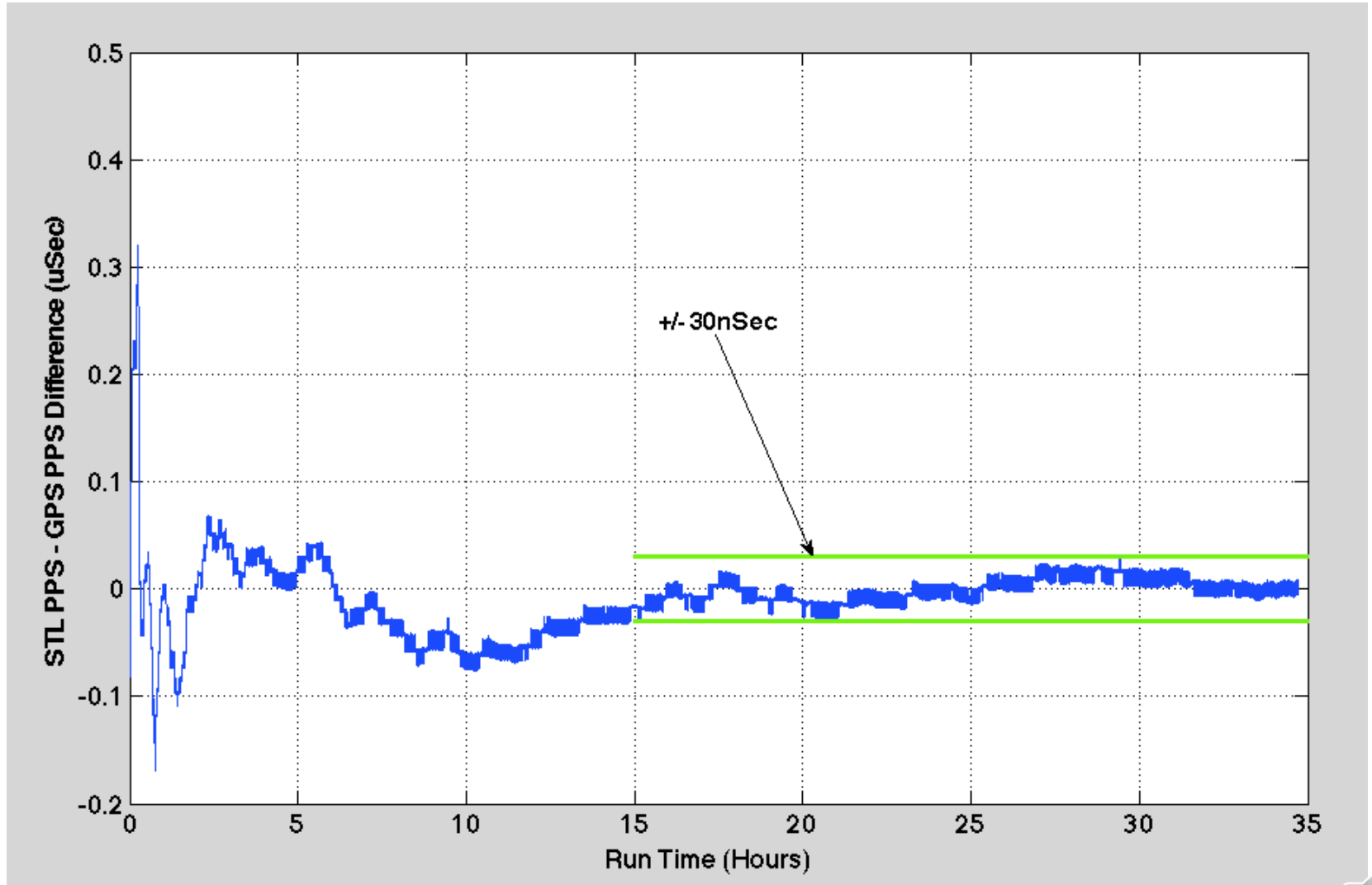
STL Performance: 1PPS with Satelles EVK2,
Orolia SecureSync, and Jackson Labs PNT-6230

Satelles EVK2	The error from the PPS reference for the EVK2 receiver with rubidium clock was ± 78 ns.
Orolia SecureSync	The error from the PPS reference for the SecureSync receiver with STL and rubidium clock options was ± 402 ns. <i>NOTE: Orolia has stated that a future software release will increase the accuracy further, but it was not available when the tests were conducted for this study.</i>
Jackson Labs PNT-6230	The error from the PPS reference for the PNT-6230 receiver with STL and DOCXO options was ± 166 ns.

see details in 26-Jan-2021 *Inside GNSS* article: “LEO PNT Performance Report: STL”

<https://insidegnss.com/leo-pnt-performance-report-stl/>

STL Disciplined Rubidium Clock Timing Performance (Repeatable <100nsec Timing Error)





STL Capabilities

Time Synchronization

Independent of GPS

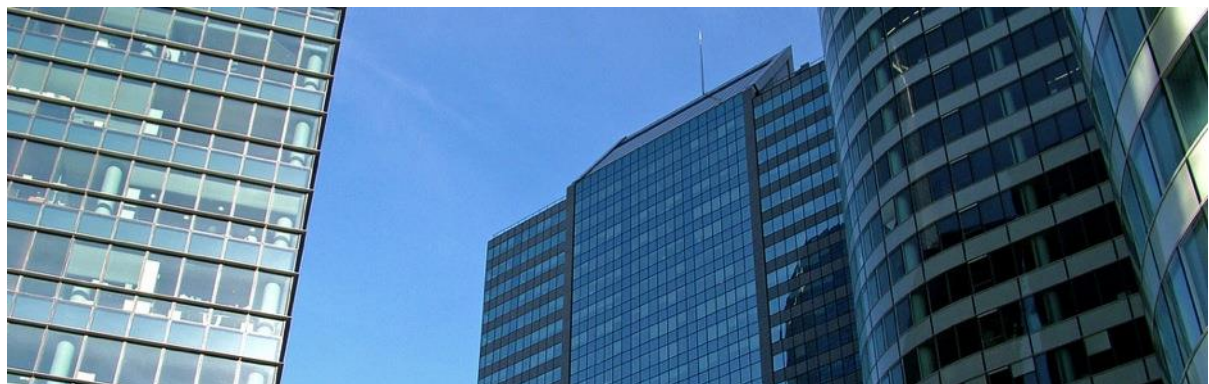
< 1 μ Sec



via: Mumbai	AI116	Gate opens 11:20
13:30 Belgrade	AI130	Gate opens 11:40
13:30 Moscow	JU381	Gate opens 12:15
13:35 Houston	SU2579	Gate opens 12:50
14:00 Algiers	UA971	Gate opens 12:30
14:05 Atlanta	AH2055	Gate opens 12:05
14:05 Abu Dhabi	DL9	Gate opens 13:00
14:15 Doha	KM2137	
14:50 Bucharest		

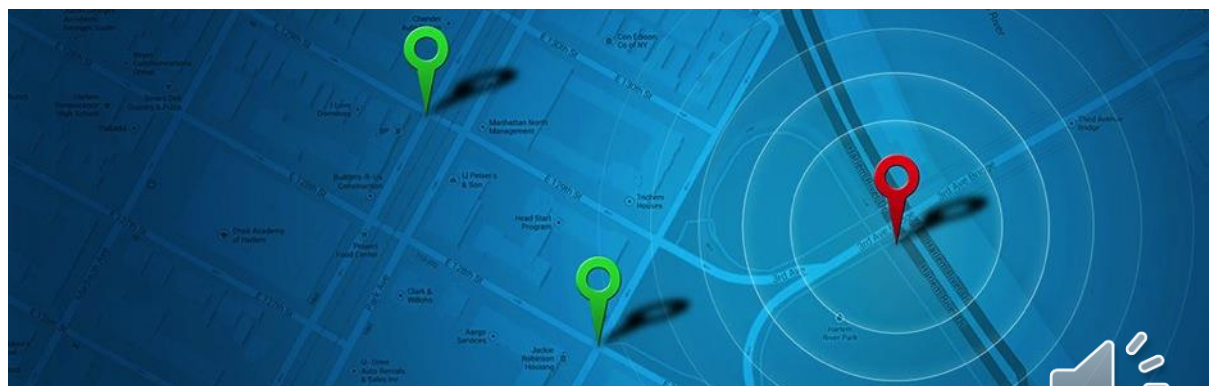
Deep Indoor Penetration

With no local infrastructure



Trusted Location

20-50m





Applications

Cyber Security



Communications



Data Centers



Energy Grid





Thank You



Artist depiction of an Iridium LEO satellite in space.