FY18 NDAA Section 1606 Complementary PNT Demonstration

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Demonstration Day
NASA Langley Research Center
13 Mar 2020

U.S. Department of Transportation
Volpe Center

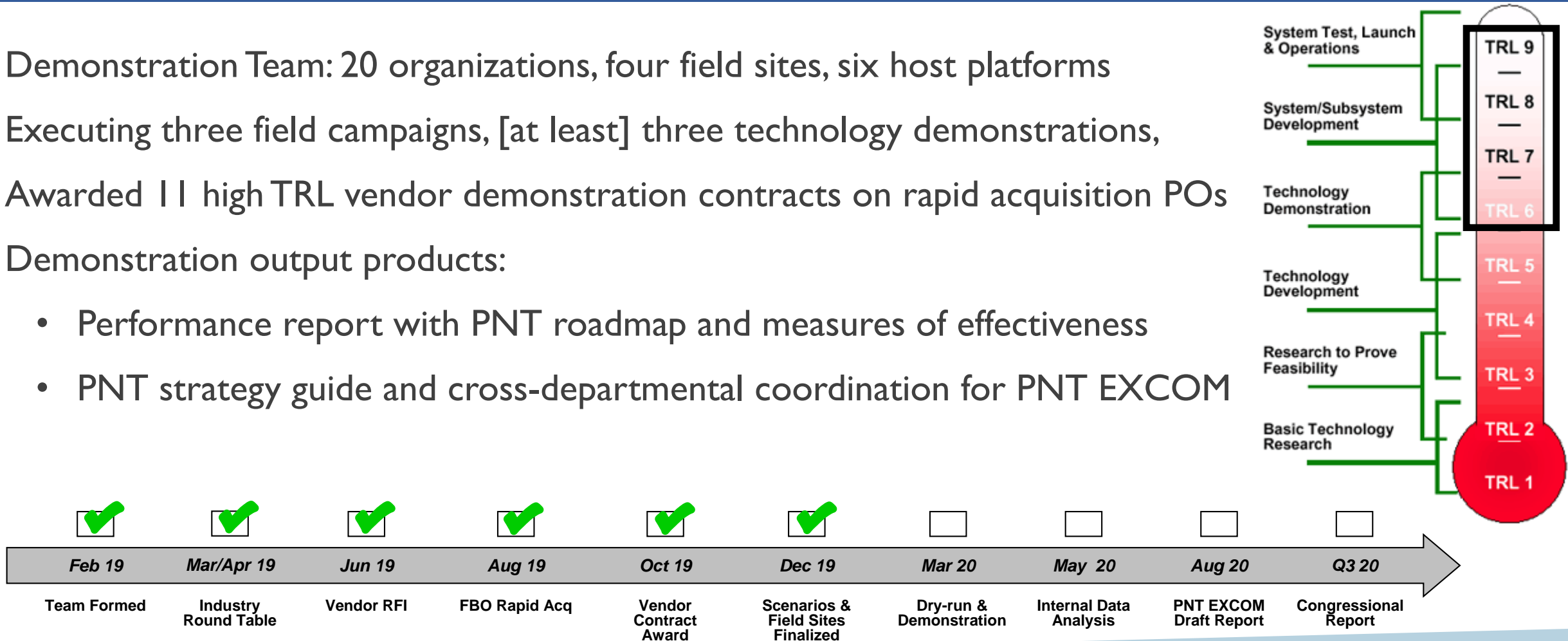*Advancing transportation innovation for the public good*

GPS Backup Demonstration Overview

High-level Demonstration Plan Developed Under FY18 NDAA

- Joint DOT/DHS/DOD congressional briefing given Nov 2018
  - Coordination and planning efforts presented
  - DOT had yet to receive funds, transportation demonstration concept presented
  - FY20 NDAA extended period of performance to Dec 2020
- DHS Science and Technology conducted timing and positioning demonstration
  - Dec 2018 at NASA Langley/Insurance Institute for Highway Safety (IIHS) Ruckersville, VA
  - Technologies demonstrated: Locata, NextNav, Satelles (those already available at Langley)
  - Results and interim report in process
- DOT Volpe Center funded to execute demonstration Jan'19 - Dec '20

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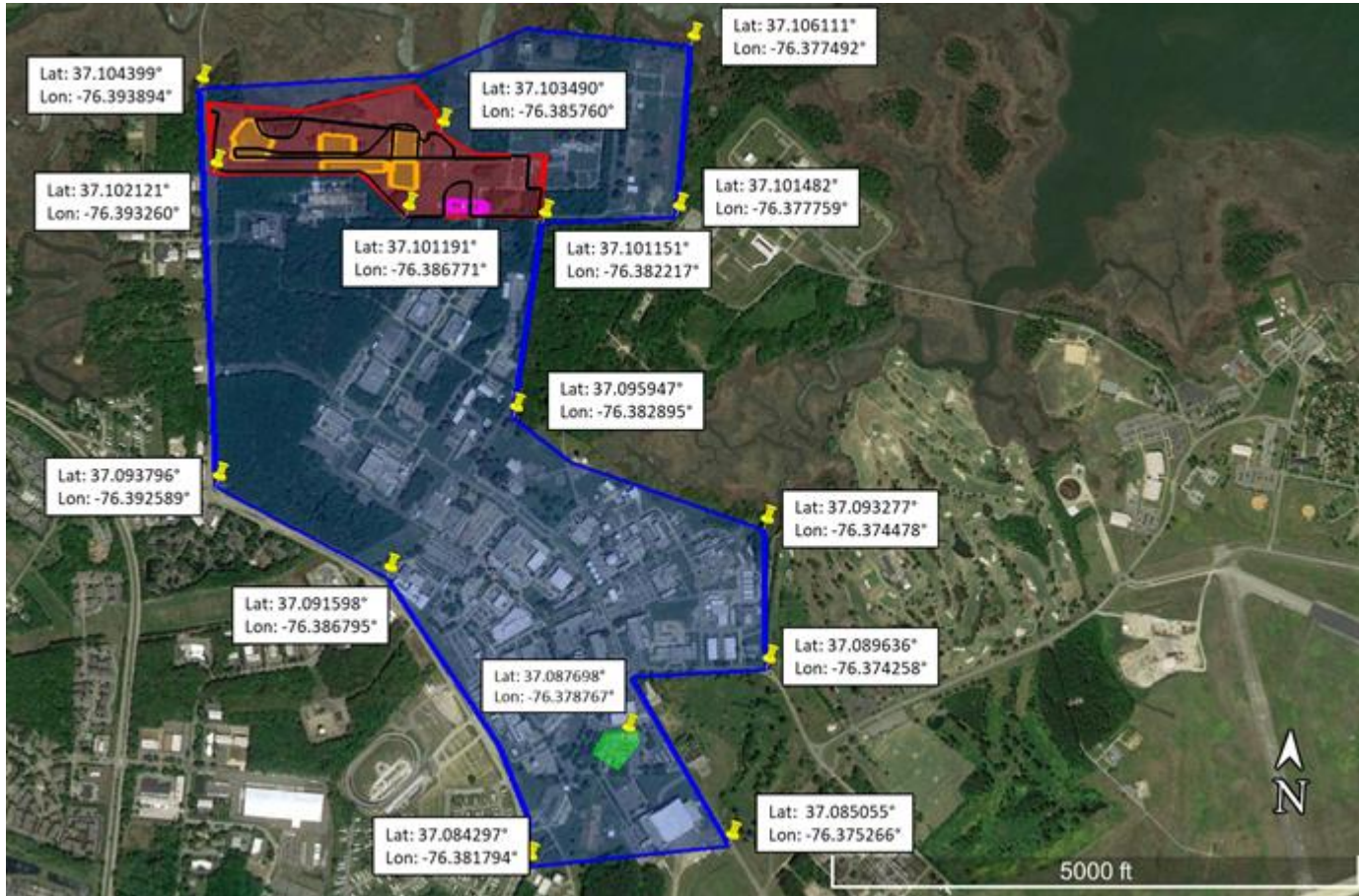# NDAA GPS Backup Demonstration Status

- Demonstration Team: 20 organizations, four field sites, six host platforms

- Executing three field campaigns, [at least] three technology demonstrations,

- Awarded 11 high TRL vendor demonstration contracts on rapid acquisition POs

- Demonstration output products:

  - Performance report with PNT roadmap and measures of effectiveness

  - PNT strategy guide and cross-departmental coordination for PNT EXCOM

System Test, Launch & Operations — TRL 9
System/Subsystem Development — TRL 8
— TRL 7
Technology Demonstration — TRL 6
Technology Development — TRL 5
— TRL 4
Research to Prove Feasibility — TRL 3
Basic Technology Research — TRL 2
TRL 1

Feb 19	Mar/Apr 19	Jun 19	Aug 19	Oct 19	Dec 19	Mar 20	May 20	Aug 20	Q3 20
✔	✔	✔	✔	✔	✔	☐	☐	☐	☐
Team Formed	Industry Round Table	Vendor RFI	FBO Rapid Acq	Vendor Contract Award	Scenarios & Field Sites Finalized	Dry-run & Demonstration	Internal Data Analysis	PNT EXCOM Draft Report	Congressional Report

Volpe Contracted PNT Vendors

NASA Langley Research Center Field Facility

- Black track used for static timing, static positioning, and dynamic positioning scenarios
- Orange areas used for static timing, static positioning, and dynamic UAS/3D positioning scenarios
- Magenta area (hangar) used for indoor timing and positioning scenarios
- The green area (test building, Lat: 37.087698, Lon: -76.378767) used for fixed and underground/degraded timing scenarios
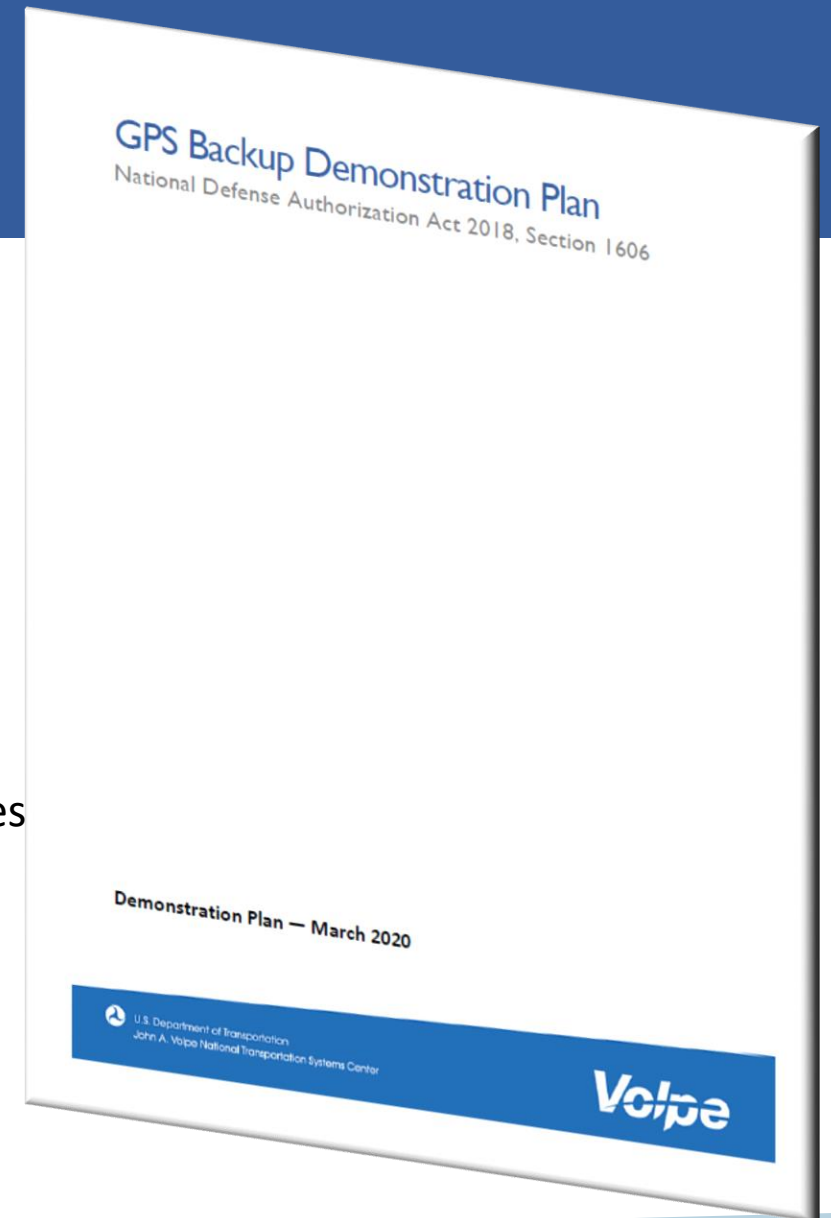
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Demonstration Plan (LaRC)

Scenario	Monday	Tuesday	Wednesday	Thursday	Friday
72-Hour Bench Static Timing	72 Hours			As Needed	
Dynamic Outdoor Positioning w/Hold		Van - 4.0 Hours (PM)		Van -As Needed	
Static Outdoor Positioning	Non-van interfaced vendors	Van - 4.5 Hours (AM)	Non-van interfaced vendors		
Static Outdoor Timing			As Needed		
Static Indoor Positioning	Van - 2.0 Hours (PM)	Non-van interfaced vendors	Van - As Needed	Non-van interfaced vendors	
Static Indoor Timing	Van - 4.5 Hours (AM)			As Needed	
Static Basement Time				2 Hours (PM)	2 Hours (AM)
Southern Campus					2 Hours (AM)
3D Pos.	4 Hours	4 Hours	4 Hours	4 Hours	

Planned Day
Make-up Day
Only for participates not interfaced with the Van reference system (deconflicted with Van scenarios for safety)

LaRC Field Campaign
- 1 Week of Scenarios
- 6 Vendor Technologies
  - Echo Ridge
  - NextNav
  - OPNT
  - Seven Solutions
  - Skyhook
  - TRX Systems

GPS Backup Demonstration Plan
National Defense Authorization Act 2018, Section 1606

Demonstration Plan — March 2020

U.S. Department of Transportation
John A. Volpe National Transportation Systems Center

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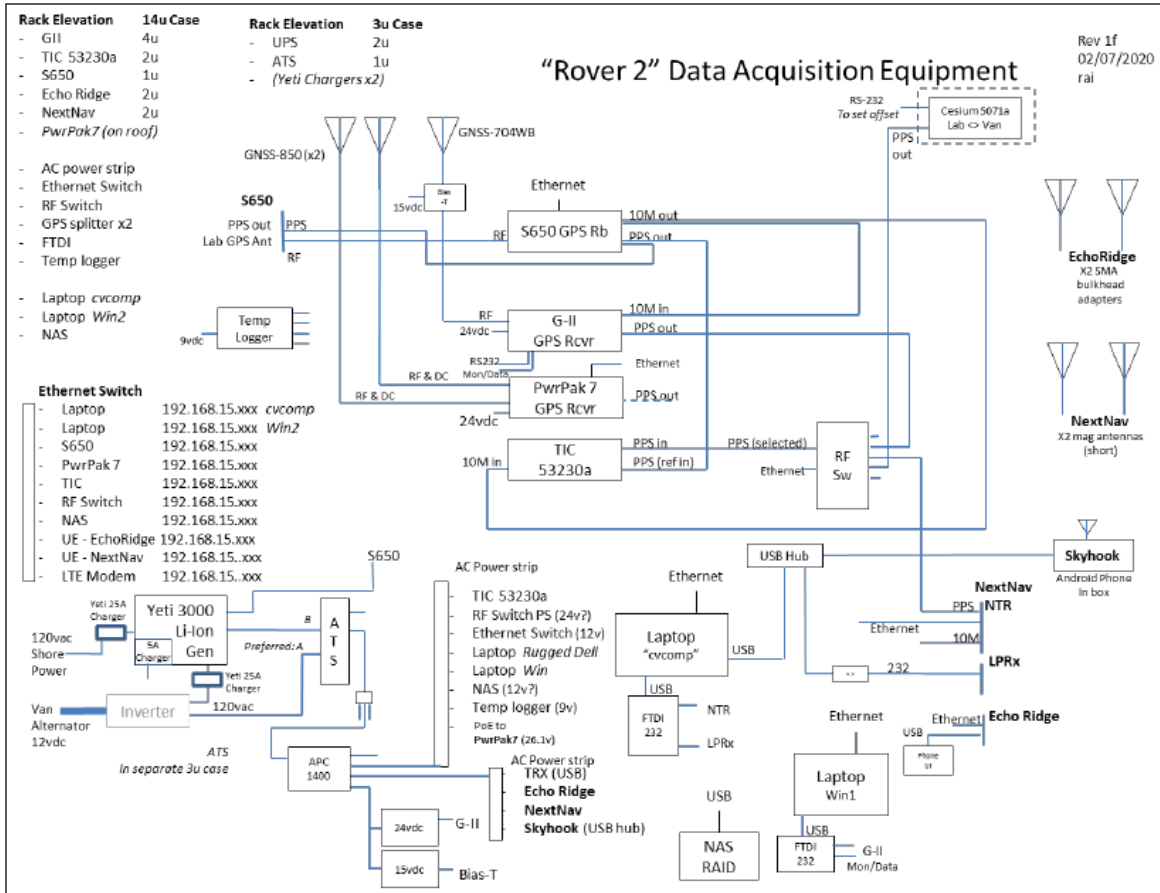# 2D Platform & Reference System (LaRC)

Figure 3: Rover Reference System Diagram LaRC "Rover 2"
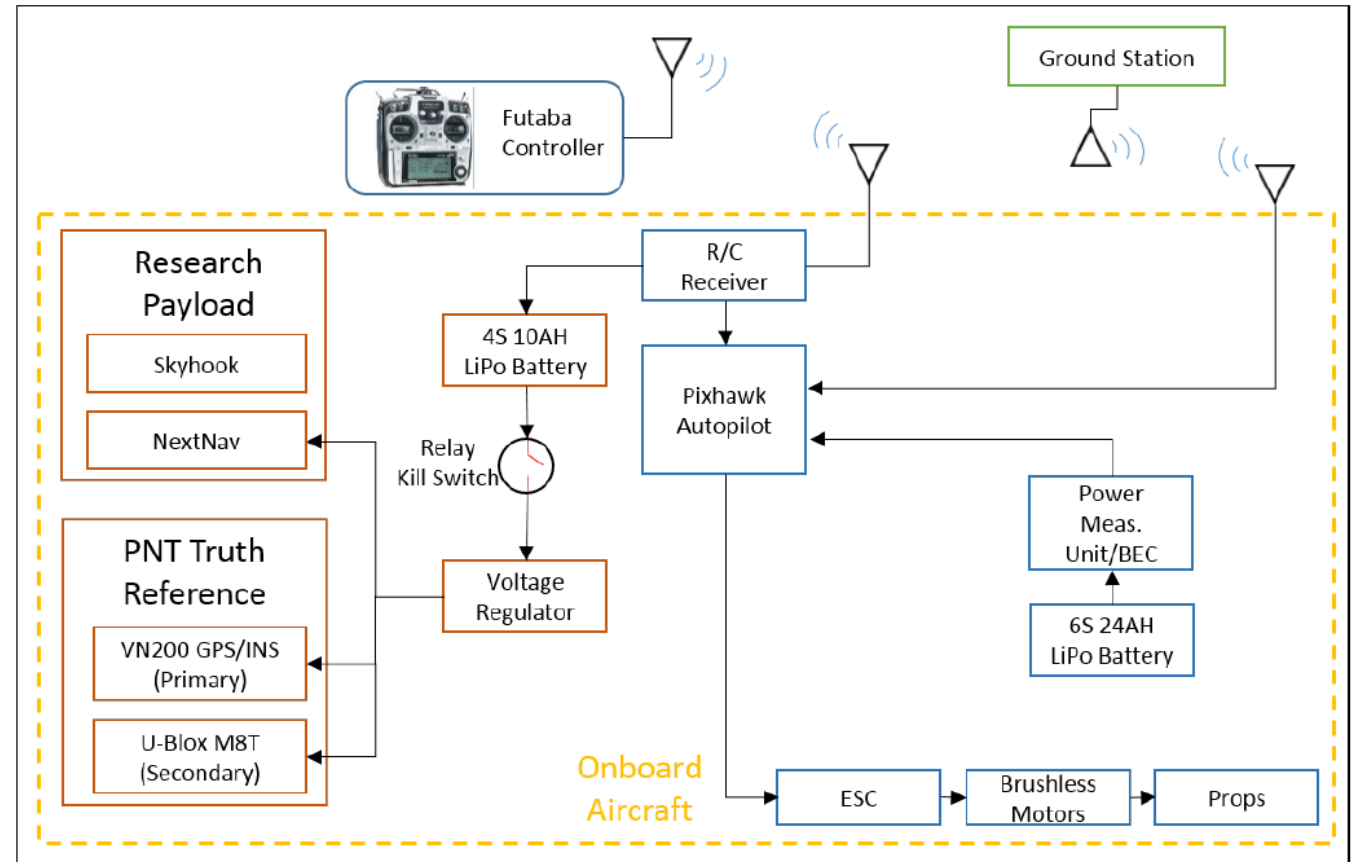
3D Platform & Reference System (LaRC)

Figure 5: R3 Reference System Diagram LaRC

Demonstration Vendor Scope and Schedule

				Technologies							Demo Platforms				
				In Situ	Terrestrial RF				Satellite	Fiber Optic	Fixed		Moving		
VIP Demo	**day**	**start**	**end**	**Map Match**	**LF (Loran)**	**MF (R-mode)**	**VHF (passive)**	**WiFi (2.4 GHz)**	**L-Band (LEO)**	**PTP**	**Outdoor**	**Indoor**	**Static**	**2D (van)**	**3D (uas)**
LaRC	13-Mar	9:00	16:00	x			x	x	x	x	x	x	x	x	x
JBCC	20-Mar	9:00	16:00		x	x		x	x		x	x	x	x	x
	Vendors			TRX	Hellen Systems	Serco	NextNav	PhasorLab	Echo Ridge	OPNT					
					UrsaNav			Skyhook	Satelles	Seven Solutions					

GPS Backup Demonstration: Vendor Travel and Deliverables Schedule - Through Demonstration

*= Travel ★ = Deliverable   Date of Award = November 4, 2019

Demonstration Outdoor Scenarios (2D LaRC)
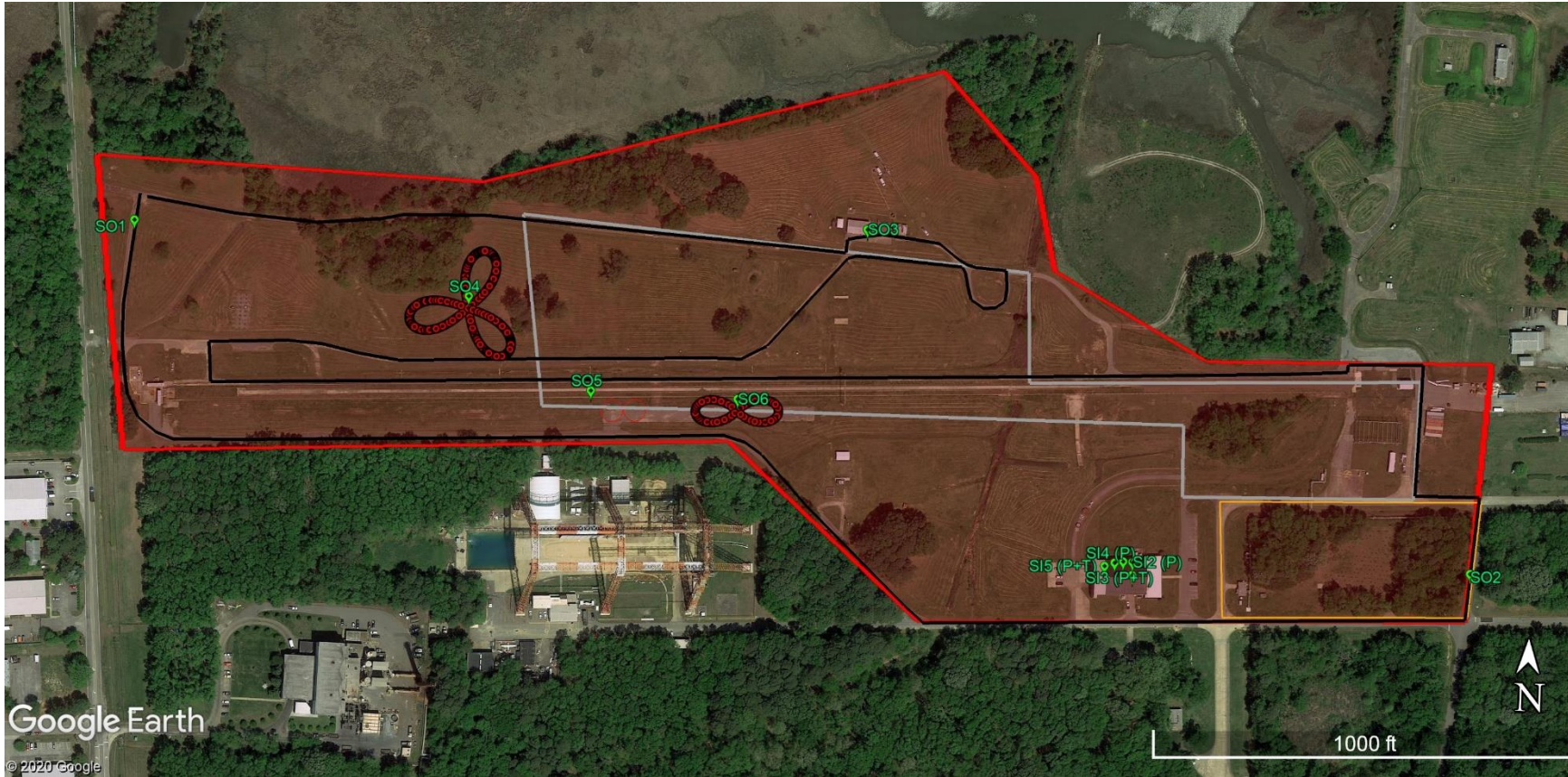
- Red area – fully instrumented
- Black track – van routes
- Green points – static points
- Grey track – UAS routes
- Red track – UAS maneuvers
- Orange box – dismount area

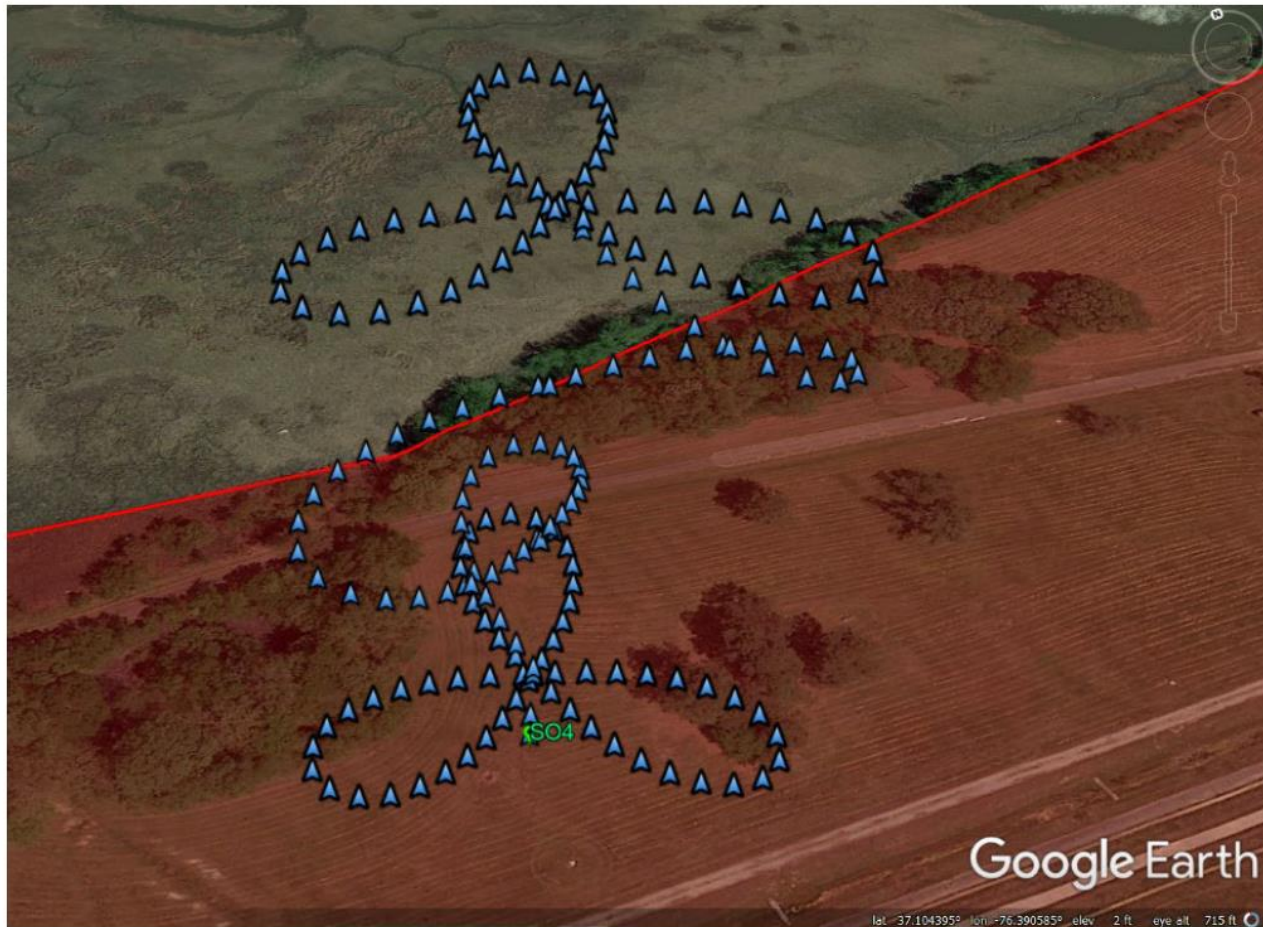# Demonstration Outdoor Scenarios (3D LaRC)

Figure 16: LaRC 3-Petal UAS Shape
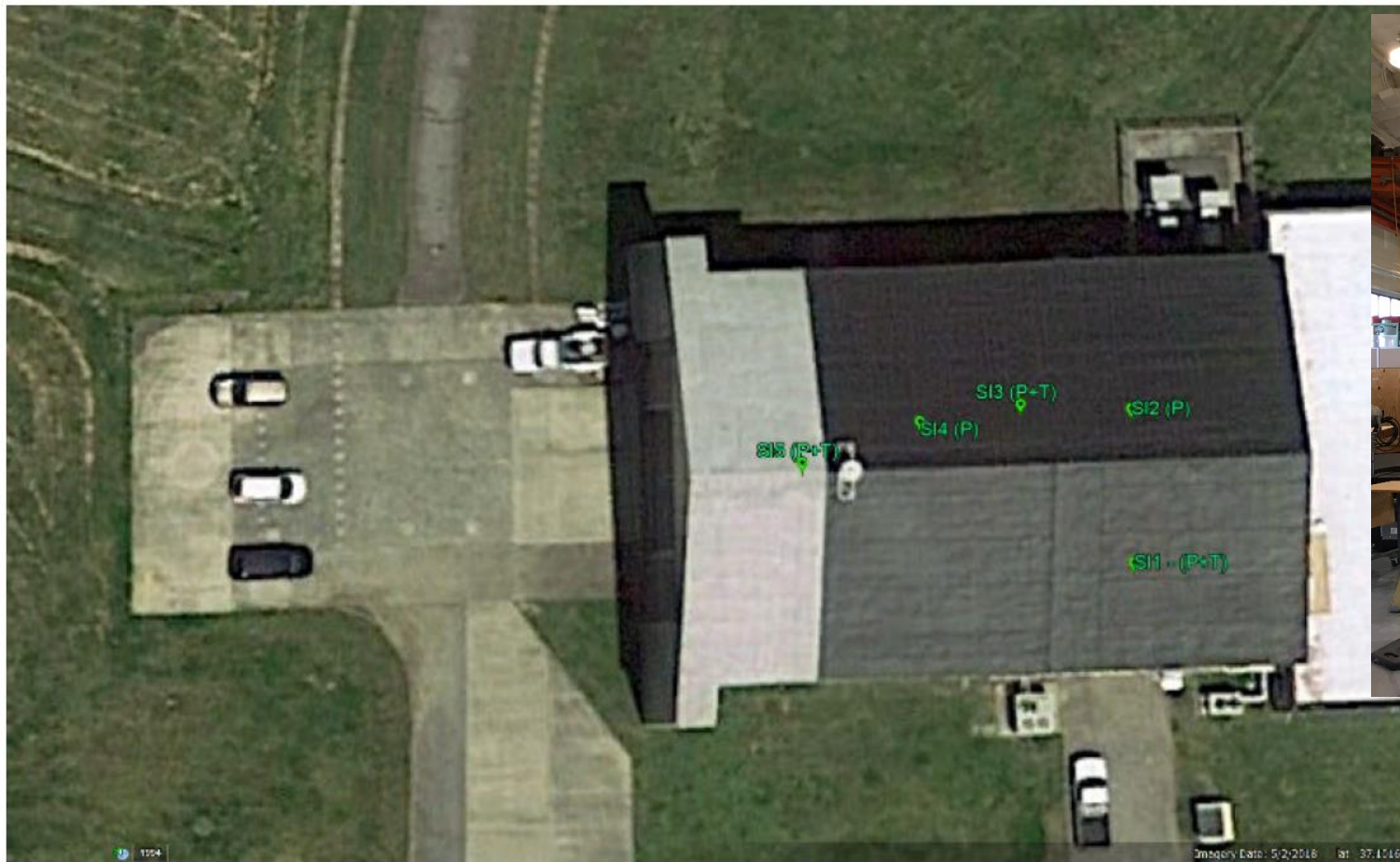
Demonstration Indoor Static Scenarios (LaRC)

Figure 11: LaRC Static Indoor Positioning and Timing Scenario

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Application: Positioning and Timing

Type of Technology: Using Globalstar Constellation of 24 LEOs as Signals of Opportunity (SOoP)

Location/Base of Operations: Sterling, VA

Partner Company(s): Globalstar

Technology Readiness Level: 9/6

RF Bands: 2483.5 – 2500 MHz downlink on S Band. Has Low Power Ancillary Terrestrial Component (ATC)

Technology Readiness Level or TRL (Transmitter/UE): 9/6

Image: Thales Alenia Space

Technology Description:

- Augmented Positioning System (APS);

- System is designed to provide PNT to support a wide range of location-dependent and timing-dependent applications;

- Can be implemented for nearly worldwide coverage, and consists of 3 segments:
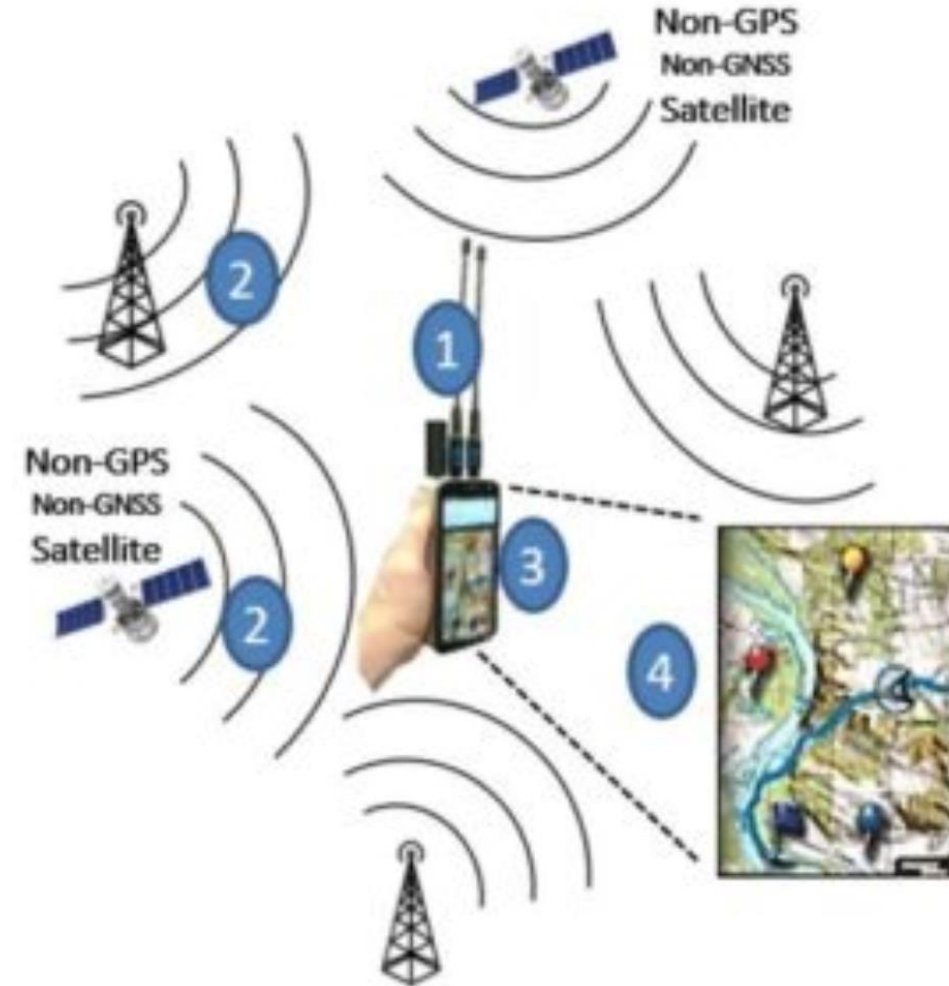
  - Space,
  - Control, and
  - User Equipment (UE)

Image: Echo Ridge

Application: **Positioning and Timing**

Type of Technology: **Metropolitan Beacon System transmitting GNSS Compatible waveforms**

Location/Base of Operations: **McLean, VA / Sunnyvale, CA**

Partner Company(s): **N/A**
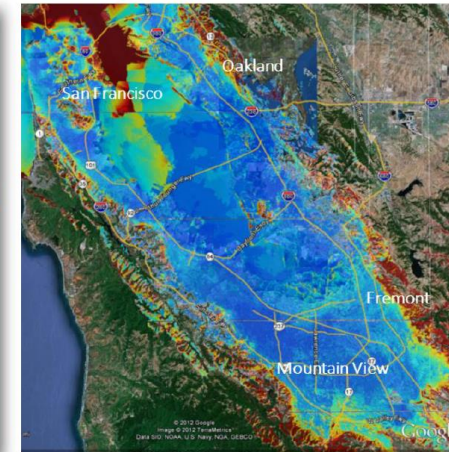
RF Bands: **920-928 MHz**

Technology Readiness Level or TRL (Transmitter/UE): **6/6**
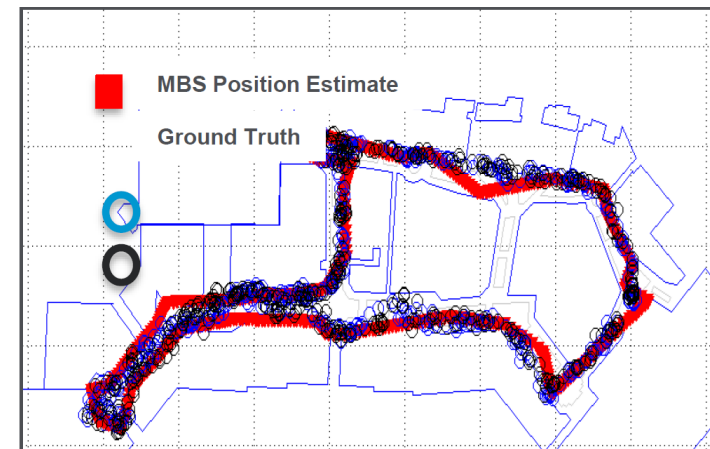
Managed Terrestrial Network

Spectrum licenses cover 95% of urban U.S. POPs

Pervasive Market Coverage

900 sq. miles coverage in San Francisco/San Jose Market

Accurate Horizontal (X-Y) Positioning

MBS Position Estimate

Ground Truth

Technology Description: The Metropolitan Beacon System (MBS) Network consists of:

- A network of long-range, low-cost broadcast beacons that transmit Global Navigation Satellite System (GNSS) compatible waveforms on NextNav's 920-928MHz near-nationwide licensed spectrum

- High accuracy in urban and indoor environments

- High reliability, high yield and pervasive coverage in a market

- Low variability of results

- Low time to first fix

- Reduced power consumption

- On-device location computation

Application: Timing

Type of Technology: White Rabbit Precision Time Protocol (WR-PTP)

Location/Base of Operations: Amsterdam, The Netherlands

Partner Company(s): N/A

RF Bands: N/A (Fiber-Based Solution)
Wireless Transmitters: 3.5 GHz/CBRS, unlicensed 5 GHz, ISM bands

Technology Readiness Level (Transmitter/UE): 8/8

Technology Description: OPNT's solution provides any existing network with a unique synchronization feature which distributes a uniform time base that is under your own control. Simply place OPNT's timing switches in those locations where timing is needed (base stations, datacenters, subways, power plants and synchrophasors). Connecting only one of the nodes to a reference clock will result into exact replicas of the reference clock in each timing node – fully automatic and maintenance-free.

- Based on CERN's White Rabbit protocol

- Versatile like Ethernet yet more accurate than GPS

- Leave your data network untouched. OPNT's solution works side by side with existing telecommunication equipment, independent of communication protocols

- Sub-nanosecond accuracy, any time, any place. OPNT's solution provides the most accurate network timing currently available on the market, providing sub-nanosecond accuracy in any network, from local to long haul (long distance)

Application: Timing

Type of Technology: White Rabbit Precision Time Protocol (WR-PTP)

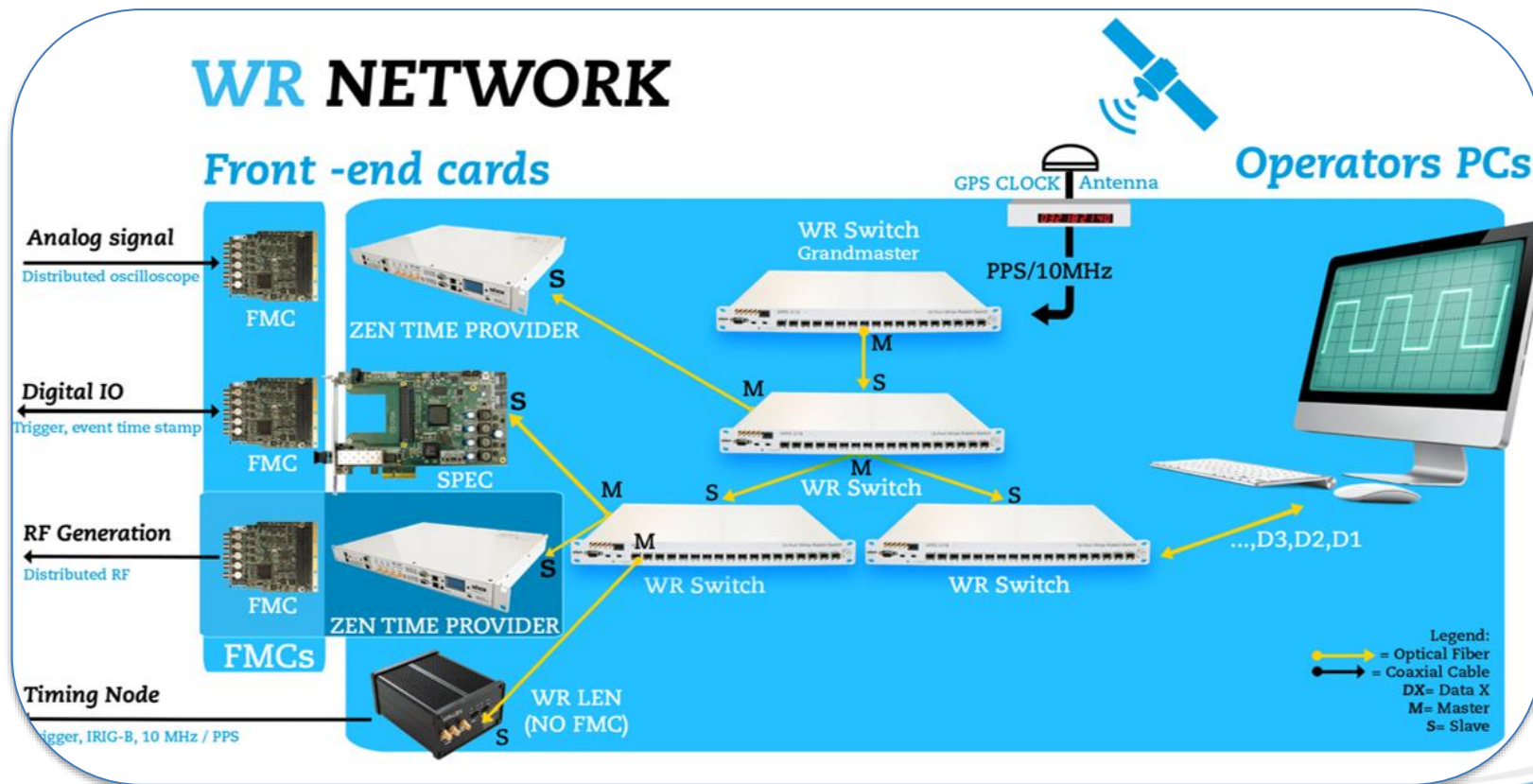**Location/Base of Operations: Granada, SPAIN**

Partner Company(s): N/A

RF Bands: N/A (Fiber-Based Solution)

Technology Readiness Level (Transmitter/UE): 9/9

Technology Description: The Seven Solutions offering is a timing only solution. This unique technology uses a standard based, new IEEE 1588-2008 v2, for distribution of time and frequency with sub-Nano-second accuracy. The physical infrastructure of this time transport mechanism is hack proof.

SKYHOOK°

Application: Positioning

Type of Technology: Wireless Positioning System (WPS)

Location/Base of Operations: Boston, MA

Partner Company(s): N/A

RF Bands: 900 MHz (902 to 928 MHz)
2.4 GHz (2.4 to 2.4835 GHz)
5 GHz (5.15 to 5.35 and 5.725 to 5.825 GHz)

Technology Readiness Level (Transmitter/UE): 9/9

SKYHOOK°

Technology Description: Skyhook's WPS locates devices using:

- Wi-Fi, GNSS and Cell signals, ensuring that all devices can be located in all environments

- Provides the ability to locate devices even when offline, in an extremely power efficient manner

- Enables Skyhook to provide the most accurate and precise location available no matter the platform, operating system, CPU or battery capacity

5.1 Billion
+ Wi-Fi access points

650
+ Patents

200 Million
+ Cell Towers

20 Million
+ Actionable Venues
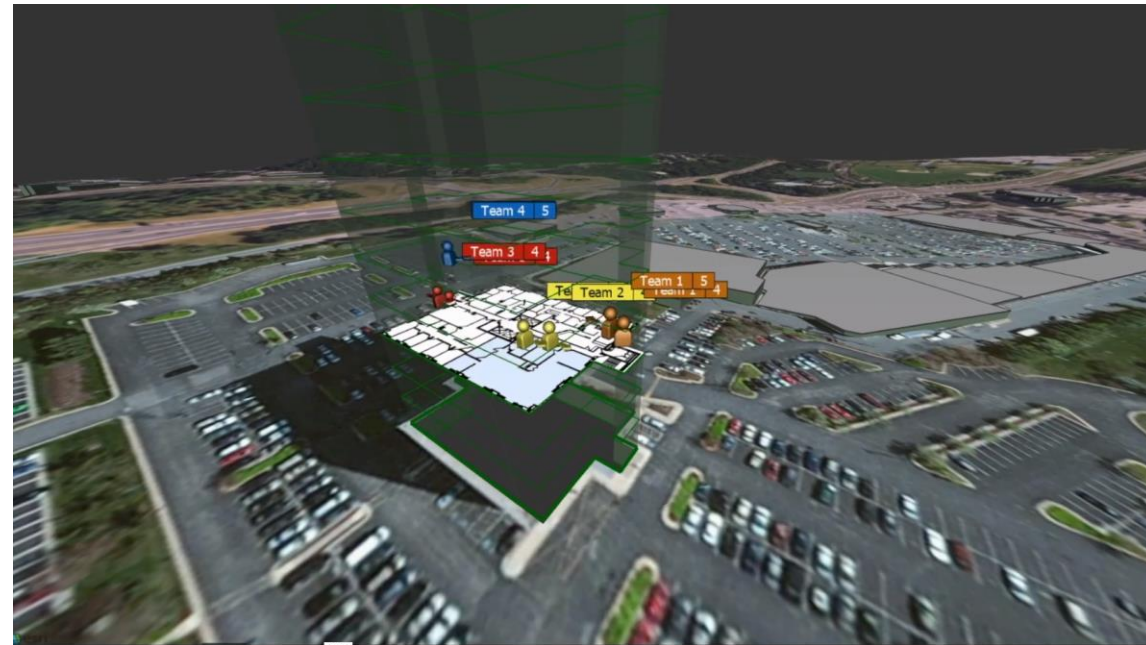
Application: Positioning

Type of Technology: TRX Systems GPS-Denied Location and Mapping Technology **(**IMU & UWB Based Map Matching)

Location/Base of Operations: Greenbelt, MD

**Partner Company(s): N/A**

RF Bands: N/A

Technology Readiness Level (Transmitter|UE): N/A | 9

Technology Description:

- NEON® location solutions geolocate sensor data and track personnel indoors, underground and anywhere GPS is not available using TRX's patented sensor fusion, ranging, and mapping technologies.

- NEON is deployed on each person being tracked with an Android phone (running the NEON app) and a bodyworn accessory (NEON Tracking Unit)

- Automatic 3D geo-referencing and mapping of signal and sensor data for test and measurement applications. Seamless 3D coverage indoor and out.
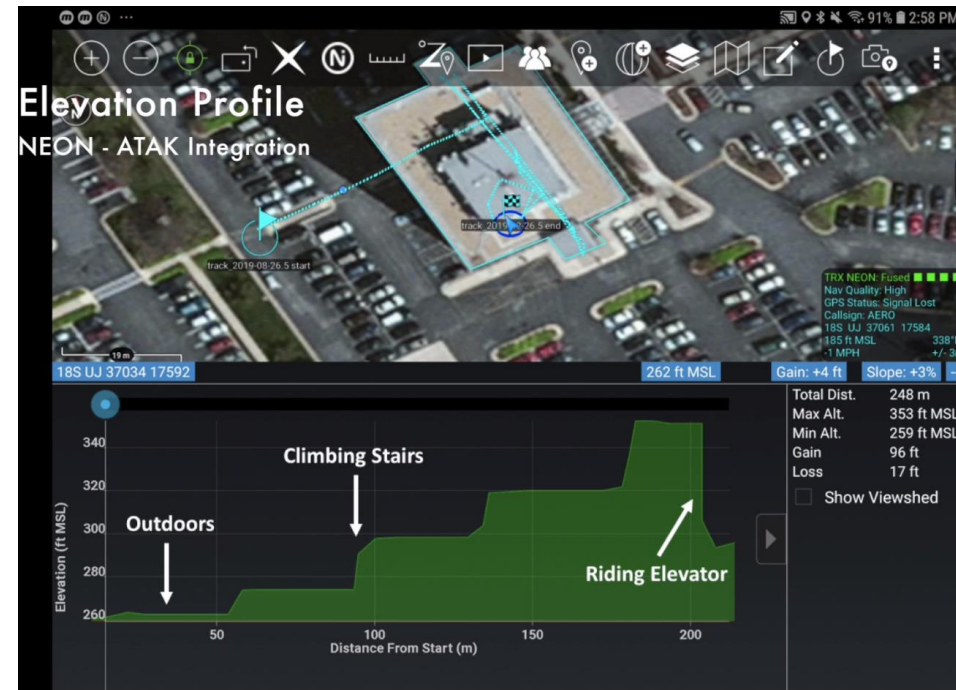
Technology Description(s) Continued:

- 3D mapping and GPS-denied personnel tracking for warfighters, first responders, security and industrial personnel that operate indoors, underground, and in areas without GPS.

- Delivering resilient location for dismounted warfighters operating in urban, subterranean, and indoor areas including intentionally GPS-denied environments. Offline operation designed for situational awareness applications including ATAK.

- Enterprise-class 3D mapping and tracking solution that improves safety, situational awareness, and operational efficiency for security, public safety and industrial users.