



## Protecting GNSS as the Primary Domain

leveraging out-of-domain sources of PNT to ensure resilience

*The Global Positioning System (GPS) and other Global Navigation Satellite Systems (GNSS) represent the primary domain of positioning, navigation, and timing (PNT). Out-of-domain solutions are required as an essential backup to preserve the operations of PNT-dependent systems and safeguard our national critical infrastructure.*

### What Does “Out of Domain” Mean?

The **primary domain** of PNT is made up of government-owned and operated GNSS satellite constellations which are generally in Medium Earth Orbit (MEO): GPS (United States), Galileo (European Union), GLONASS (Russia), and BeiDou (China). Alternative PNT systems capable of backing up and augmenting GNSS are considered as being **out of domain**.

The four categories of out-of-domain PNT are as follows:



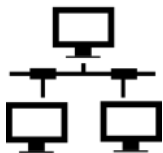
#### **Low Earth Orbit (LEO) Satellites**

timing and location from an orbit in space about 25x closer than GNSS



#### **Terrestrial Wireless Infrastructure**

timing and location from ground-based equipment and support operations across a specific geographic region



#### **Network Time Transfer**

precise timing from synchronized clocks across a high-speed computer network



#### **Signals of Opportunity**

location information derived from radio signals not intended for navigation

### The Satelles Position

We believe that the primary domain must be protected and that a heterogeneous backup is in the public interest. It is our view that the technological landscape is diverse enough to allow multiple alternatives to GPS/GNSS with varied operational characteristics to deliver against a complex and ever-expanding set of customer requirements. Robust out-of-domain solutions are available that currently support a variety of applications with secure and reliable alternative PNT. Operating a combination of these systems will ensure the highest degree of resilience for critical infrastructure and drive innovative commercial use.

There are many alternative PNT systems and services on the market — each with its own distinctive properties — that fall into the **out-of-domain categories** below:

### Low Earth Orbit (LEO) Satellites

LEO constellations have different operational features and performance characteristics than MEO systems in the primary domain, such as increased signal strength and enhanced security. LEO-based solutions are also by their very nature global, bringing coverage to every spot on the planet and offering 2D/3D positioning in addition to precise timing.

Some solutions are still in development while other technologies have been proposed by researchers. Satellite Time and Location (STL) from Satelles is the only alternative PNT solution in this category operating at technology readiness level (TRL) 9 with a multi-year track record of providing reliable service to customers.

### Terrestrial Wireless Infrastructure

This category includes technologies that require ground-based equipment and support operations across multiple regions to achieve full coverage. Metropolitan Beacon System (MBS) is a leading technology that delivers 2D/3D location and timing for indoor and urban environments where GPS is either unavailable or significantly degraded. Available in a growing number of U.S. markets, MBS provides ultra-precise 3D positioning that can pinpoint first responders within a building.

Technologies from other providers may offer alternative PNT in the future based on signals from different types of beacons, base stations, and other equipment in various topologies. For example, Enhanced Loran (eLoran) — descended from legacy LORAN technology — requires radio transmitters and antennas nationwide for timing and significant supplemental infrastructure to support 2D location.

### Out-of-Domain PNT Technologies and Solutions

#### Network Time Transfer

These technologies deliver precise timing by synchronizing clocks across a high-speed computer network, typically relying on Gigabit Ethernet or SONET. For example, Precision Time Protocol (PTP) solutions achieve clock accuracy in the sub-microsecond range. The White Rabbit Protocol (born out of research led by CERN) is capable of delivering precise timing in the sub-nanosecond range.

Network time transfer can be deployed worldwide but requires a high-speed connection to operate at any given location, meaning that this category of alternative PNT does not provide the absolute ubiquity of LEO satellites. This technology is also limited to timing applications as it does not provide location information.

#### Global Navigation Satellite Systems (GNSS)

The **primary domain** of PNT comprises these government-owned and operated Medium Earth Orbit (MEO) satellite constellations: GPS, Galileo, GLONASS, and BeiDou.

### Provide Backup and Augmentation of GNSS

#### Signals of Opportunity

Technologies in this category leverage radio signals not intended for navigation. For example, there are techniques to derive location information from signals emanating from devices all around us, such as LTE, Wi-Fi, and Bluetooth signals.

Signals of opportunity (SOOP) sources of PNT require specialized hardware that can acquire and process signals from across the radio spectrum. Some vendors not only integrate multiple radio signals but also merge SOOP with other technologies to fine tune 2D location and in some cases provide some degree of 3D positioning.

Opportunistic navigation requires a user to be in a signal-rich environment. For example, there are fewer signals in the middle of an ocean than there are in a large city, thereby making SOOP as alternative PNT most attractive in urban areas. This technology is also limited to location applications as it does not provide timing information.

### Count on Assured PNT with STL

Satelles offers alternative PNT at levels of stability, reliability, and trust required by commercial enterprises and government entities across a range of critical infrastructure applications. STL is available today, offers both urban and rural coverage, and has the operational readiness that private sector leaders and civil government officials expect when ensuring uninterrupted access to PNT sources that backup GPS and strengthen the resilience of our national critical infrastructure.

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