Micropositioning Signals as Augmentation of GNSS for PNT for Autonomous Vehicles

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

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From ADAS[1] to Autonomy

2020

High functioning ADAS

- Anti-lock brakes/traction control,
- Lane assist, Automatic parking
- Emergency braking, obstacle avoidance
- Driver wake-up/attention control

State of the Art: Level 3 Autonomy

- Environmentally and contextually carefully controlled Autonomy
- Driver intervention on demand.
- Severely gated test environments
- Fatalities … !

2030 (goal)

High Functioning Autonomy (Level 4/5)

- Zero fatality
- Zero emissions
- Zero congestion

Requirements:

- Ubiquitous, fast, continuous access to high precision positioning information
- Relative = sensors
- Absolute = GNSS

1: Advanced Driver Assistance Systems,

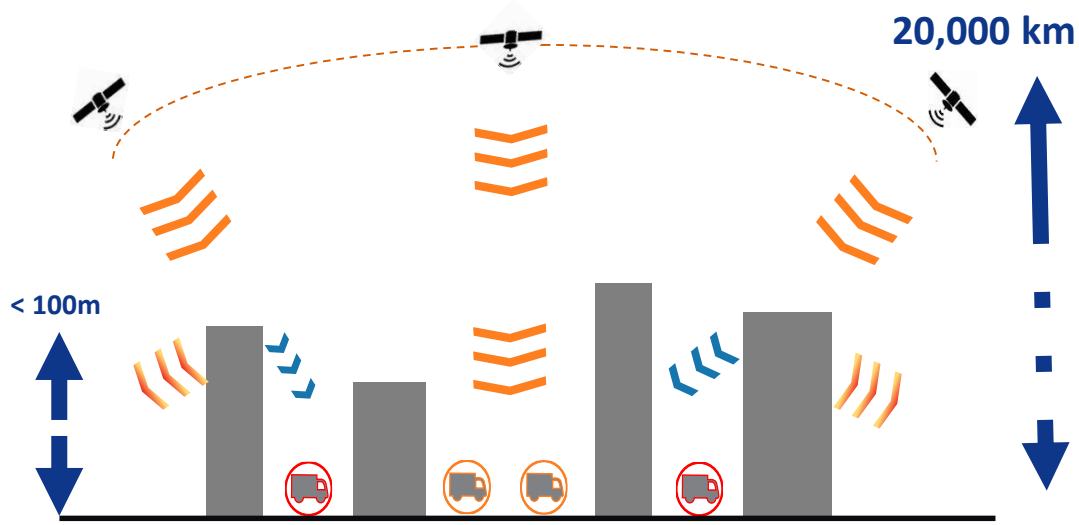
AV Requirements: GNSS is Critical

- **AV are effectively Mobile Mapping Platforms that use**
  - High performance IMU
  - Accurate odometer data
  - Accurate pre-defined route network definition files (RNDF)
  - map-matching & Feature Extraction

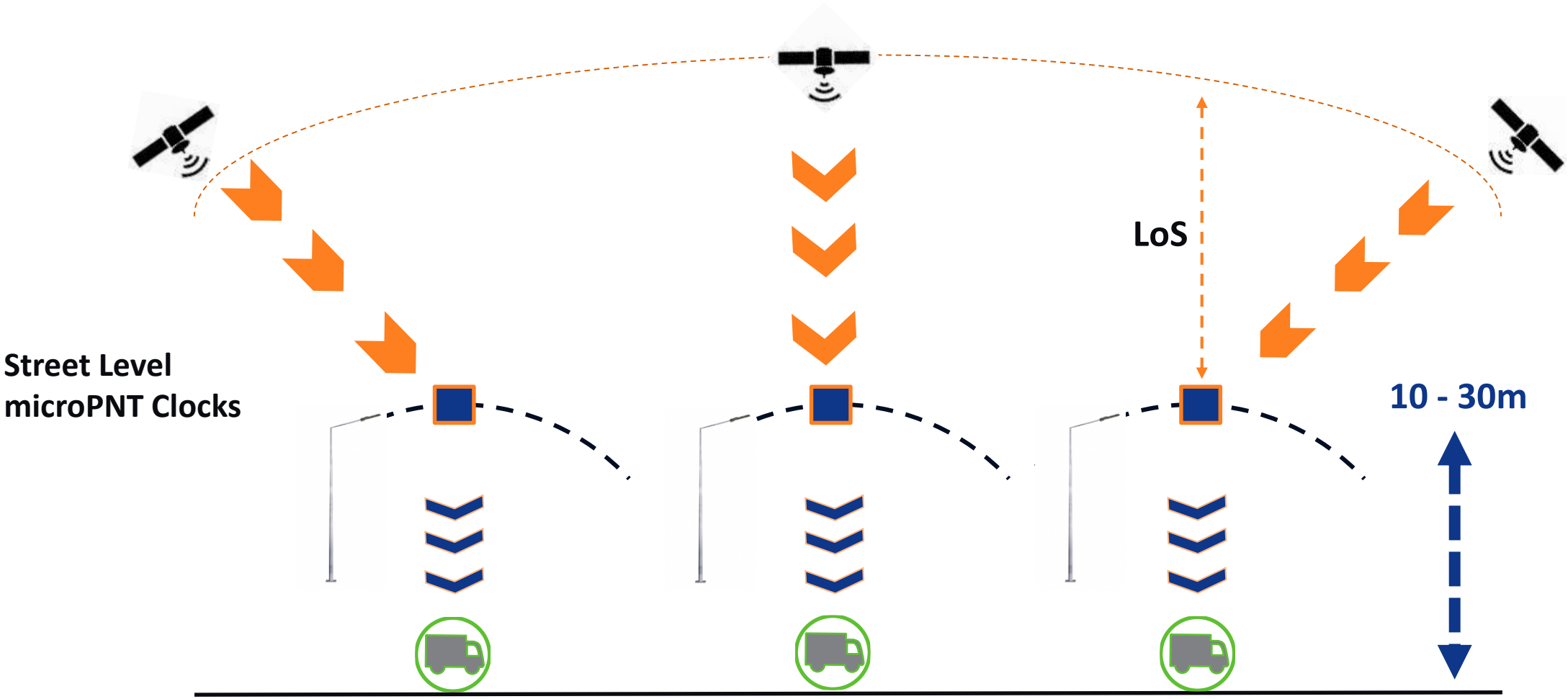
- **Must Have**
  - High positional self awareness for accurate Initial Pose Estimate
  - +/-10cm “absolute” location in 10s of usec
  - Uninterrupted Access to PNT information

- **Problem: Urban Canyon**
  - +/-2 to >+/- 5 meters, 10’s of seconds
  - “Extremely accurate uninterrupted geospatial information and real-time interpretation is essential for Autonomous Vehicle operation”. *

*DARPA Challenge, 2005-2010



microPNT System Provides Ubiquitous Signal



Micro PNT Navigation Node System

- **Time Error Mitigation**
  - Time Error between Navigation Nodes is a critical component impacting position uncertainty
  - To support PNT services as a vehicle moves through Navigation Node system boundaries the Time Error must be maximally constrained

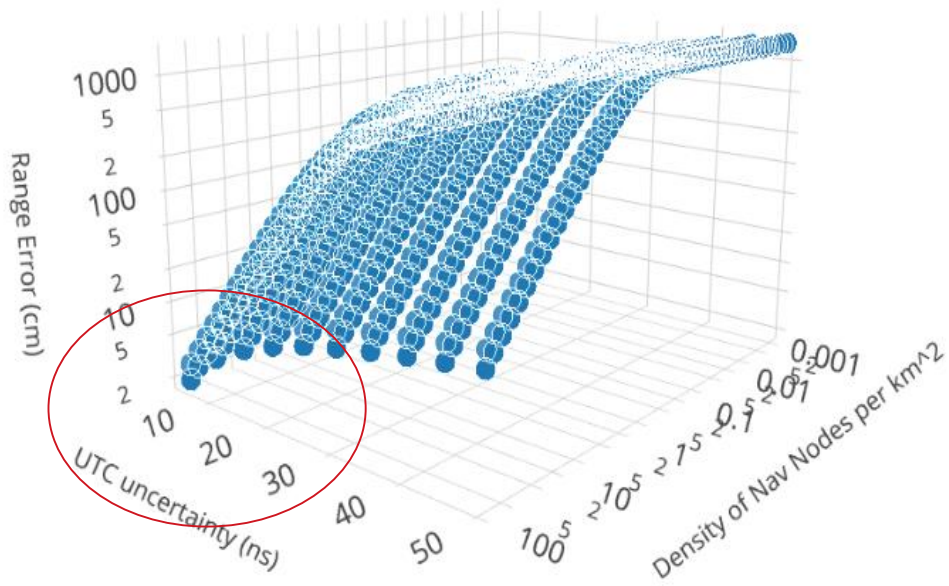
Key metrics:

- **UTC traceability**
  - UTC reference is needed to support multiple PNT systems using TOA/TDOA, TOF, etc
  - To provide a baseline to mitigate time uncertainty (Time Error) of each Navigation Node in the system

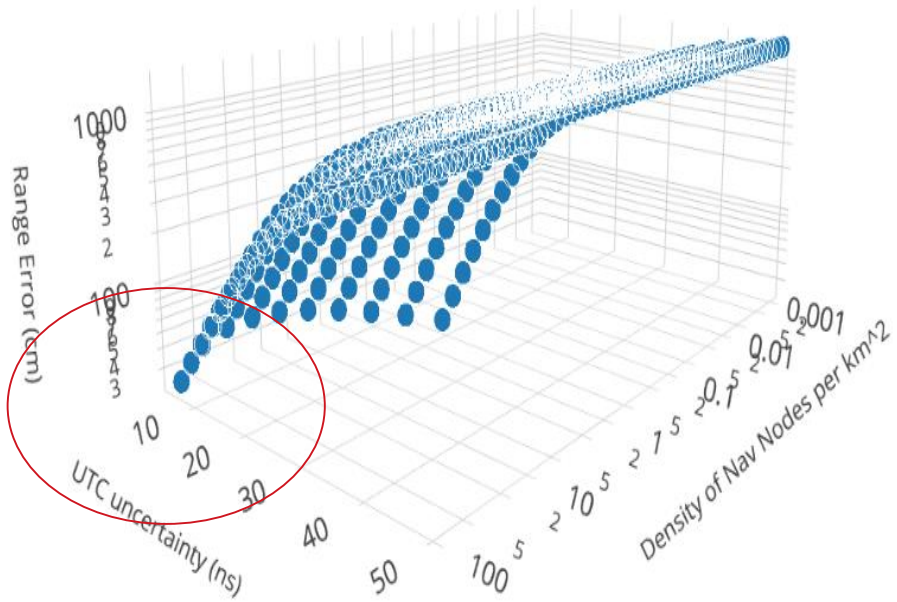
- **Navigation Node Density**
  - As the baseline between Navigation Nodes and vehicles increases, position uncertainty increases.
  - Desirable to ensure that Time Error between neighboring Navigation Nodes is closely correlated to maximize the common mode component
  - Increasing the Navigation Node density enables low spatial de-correlation between the Nodes and minimizes the Time Error in the system

Spatial Decorrelation & Navigation Node Synchronization

Simple model confirms that higher density = less uncertainty & less range error

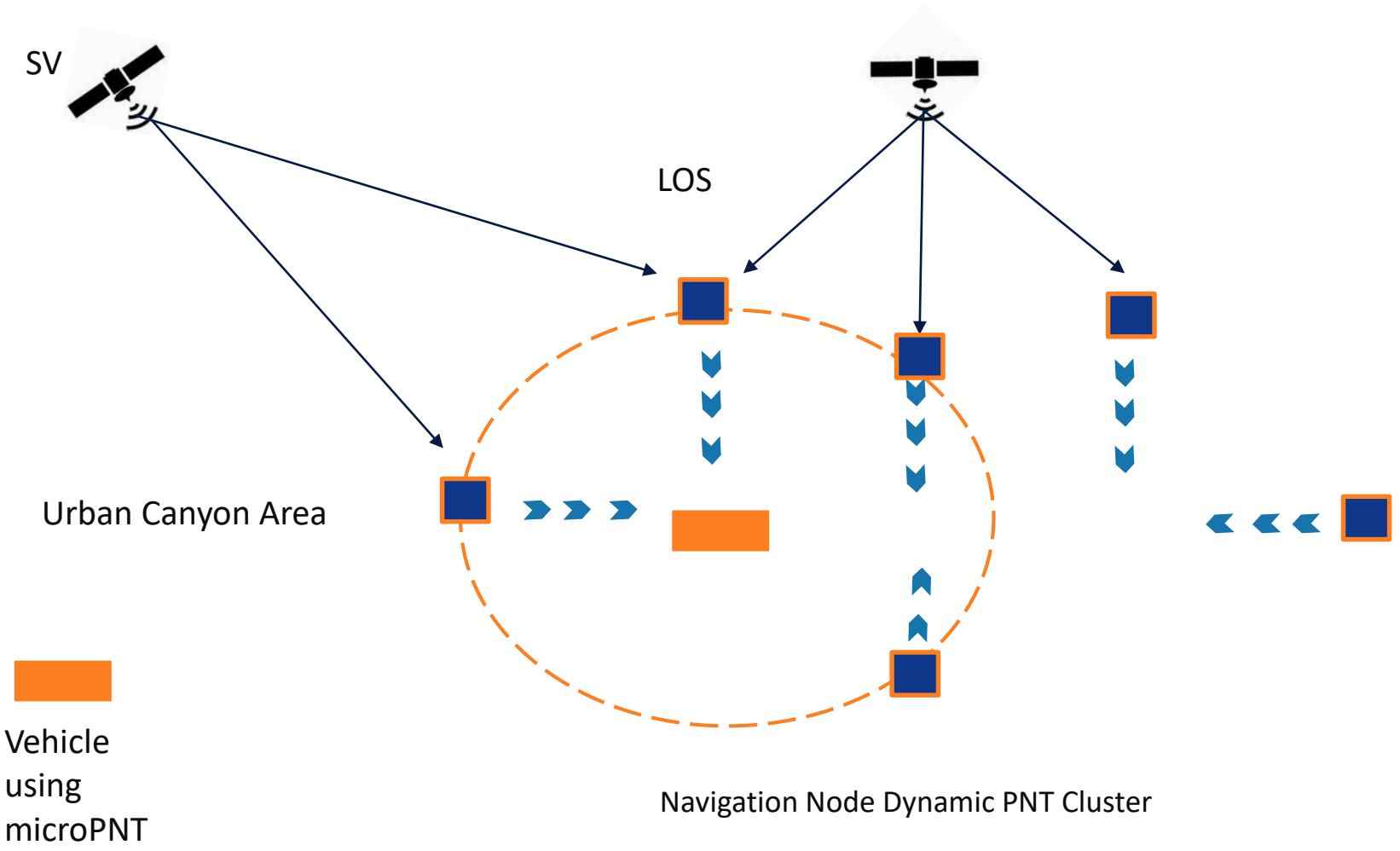


Ranging Performance: Open Sky GNSS



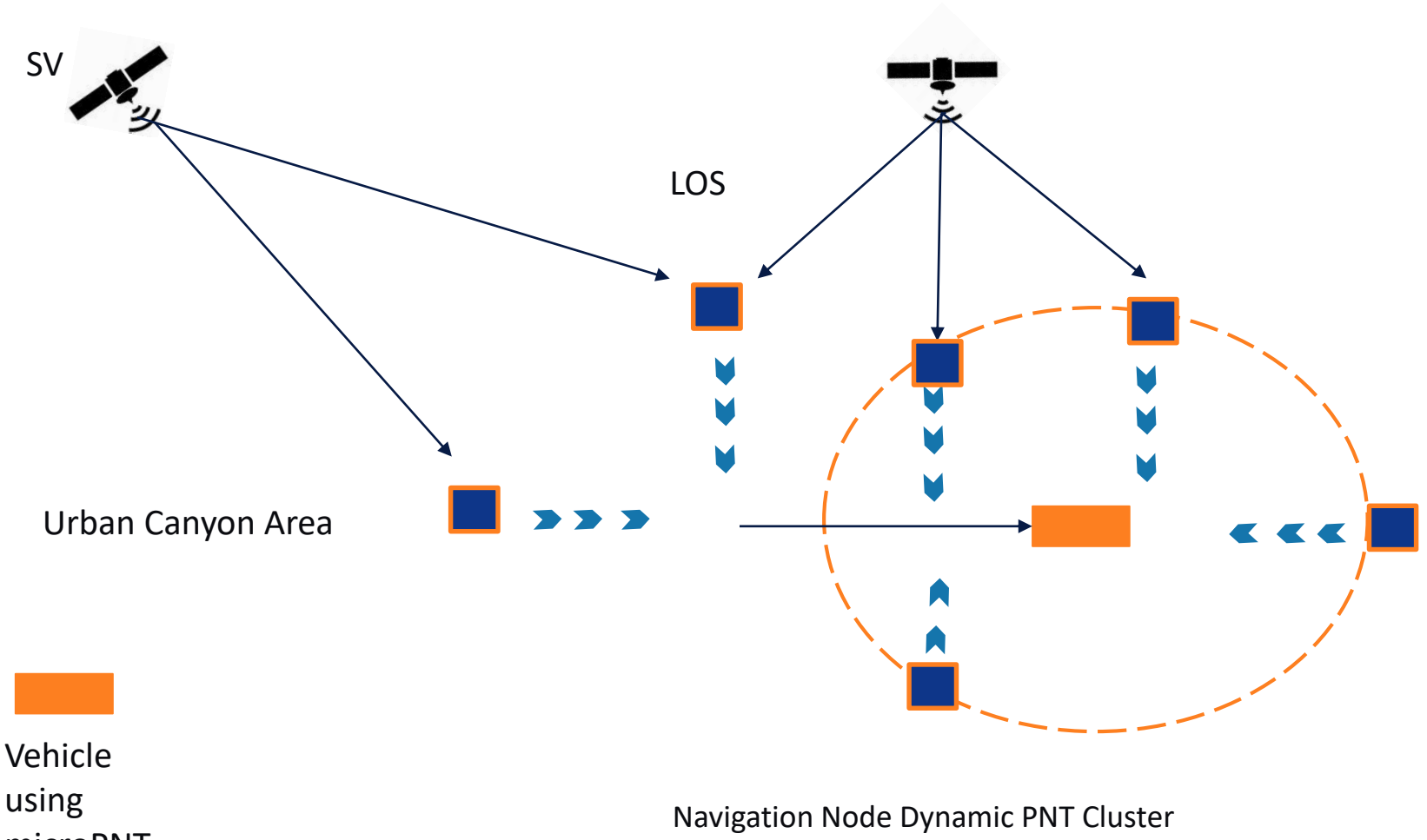
Ranging Performance: Degraded GNSS

mPNT Cluster as “Single” Terrestrial Navigation Node



- Navigation Node Densification Lowers spatial de-correlation

mPNT Cluster as “Single” Terrestrial Navigation Node



- Mitigation of Time Error as vehicles traverse Node boundaries enables system to become a dynamic “single clock”

microPNT Canopy : Complements & Improves GNSS & AI

1. **Enhances Existing GNSS**
    1. Brings PNT information closer to the vehicle
    2. Enables precise ubiquitous location data
    3. Consolidates UTC Global Time Reference
    4. Enables granular Time Error management

2. **Enhances AV onboard AI systems**
    1. Enables high accuracy Initial Pose Estimates
    2. Facilitates fast accurate Feature Extraction
    3. Enables Extremely Accurate Geo-fencing

3. **Provides Security Layer for GNSS signals**
    1. Much harder to jam or spoof 100 clocks than an SV