Exploring the limits of PPP High Accuracy Solution in Urban Scenarios

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Session: Urban and Indoors GNSS

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INNOVATING SOLUTIONS

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GNSS FOR AUTONOMOUS DRIVING

GNSS TECHNOLOGIES FOR ADAS

TECHNICAL BENEFITS

High Accuracy Positioning
Sub- decimeter Level

Absolute Positioning
Other technologies only provide differential positioning

Robust Safety Case
High maturity (SOTIF-like) reached and demonstrated in applications for civil aviation
Key for ISO26262 safety argumentation

Global Coverage
GNSS Availability EVERYWHERE

Independency
This technology is independent from other sensors in the car

Velocity
GNSS provides absolute velocity of the vehicle

Orientation
GNSS provides orientation values when integrated with IMU

Setup always available
Antenna and **Receiver** are already in place, due to its usage in other applications

- E-CALL
- TOLLING
- TACOGRAPH
- …

Built-In AntiSpoofing & AntiJamming

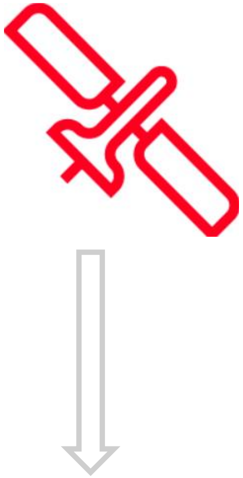
GNSS trajectory

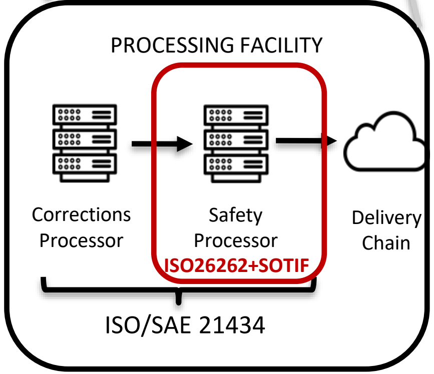
GNSS is currently a booming technology, with years of maturity, acting as the technological solutions for a wide variety of sectors. Many countries are investing on developing their own Navigation Systems, proving its worth

GMV'S POSITIONING ENGINE

PRECISE POINT POSITIONING SOLUTION

Orbit Accuracy	< 3cm
Clock Accuracy	< 0,06 ns
Convergence time	< 30 s
Integrity Risk	up to 10^-7/h
Service availability	>99,9%
Global Ionosphere	Coming Soon





EXPERIMENTATION APPROACH

PE Validation Campaign

GMV has thoroughly tested their PPP solution across several driving campaigns accomplished in the last two years.

- Tenths of Thousands of kilometers were recorded and analyzed, in dedicated driving campaigns:
  - European service area:
    - Germany
    - France
    - Spain
    - Eastern Europe
    - Netherlands
    - Scandinavia
  - Similar Campaign performed in US:
    - EAST Coast
    - NY area
    - Florida

- Some of the following Influence factors have been analyzed:
    - Mostly Highways, with frequent outages, tunnels, gantries, etc
    - Coast, Mountain routes
    - Crossing forests
    - High latitudes
    - Dedicated route in a closed driving circuit

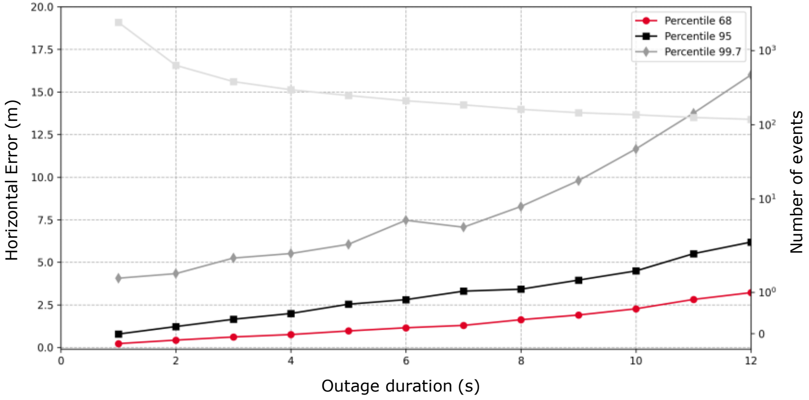
Performance Results (1/3)

Horizontal Error KPIs

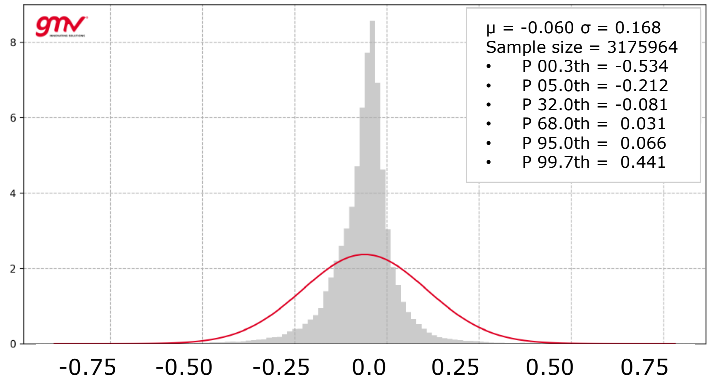
Horizontal Error Statistics	GNSS	DR after 10s
68th	0.12 m	2.50 m
95th	0.30 m	4.80 m
99.7th	0.95 m	10 m

Horizontal Error computed over ~10.000 km

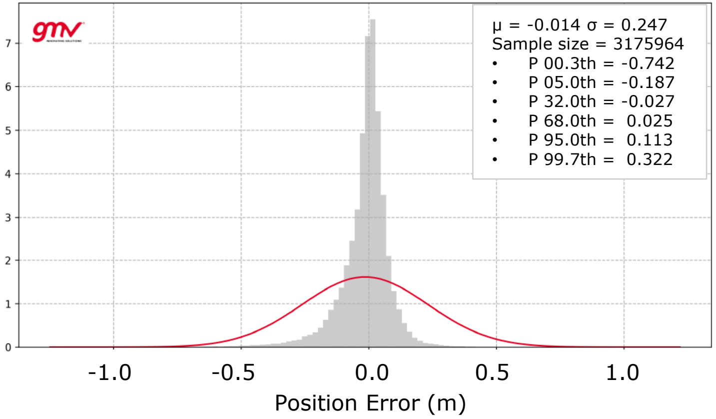
Error during horizontal outage



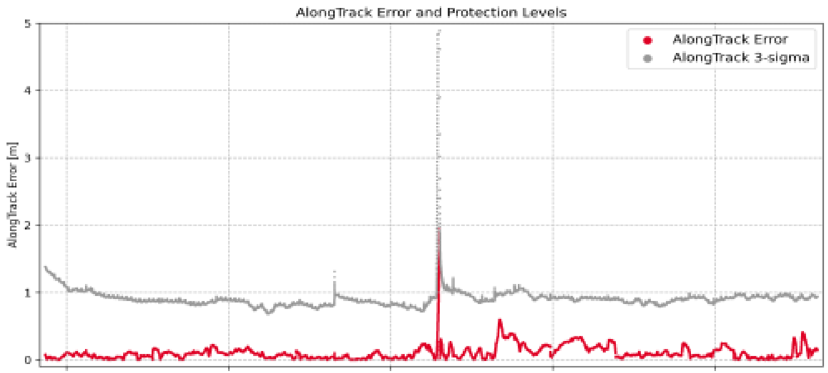
Along Track Error Distribution

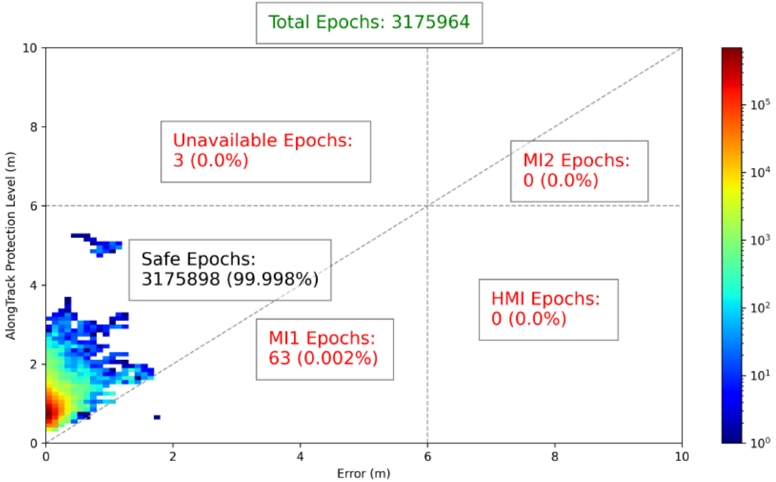


Cross Track Error Distribution



Performance Results (2/3)
Protection Level





Sample scenario: Along track and 99,7th PL
Total duration: 1.25h

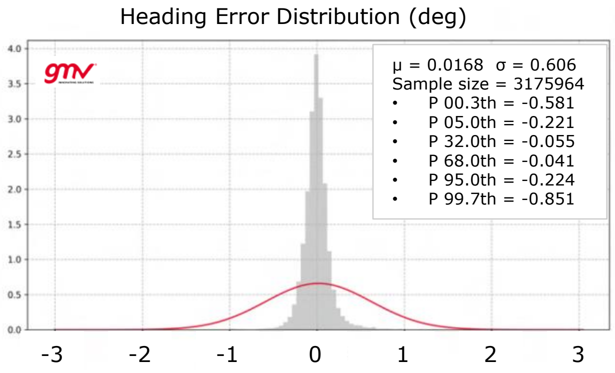
Stanford Diagram (TIR 0.03)
computed over 88.25h

Performance Results (3/3)

Heading Angle and Velocity

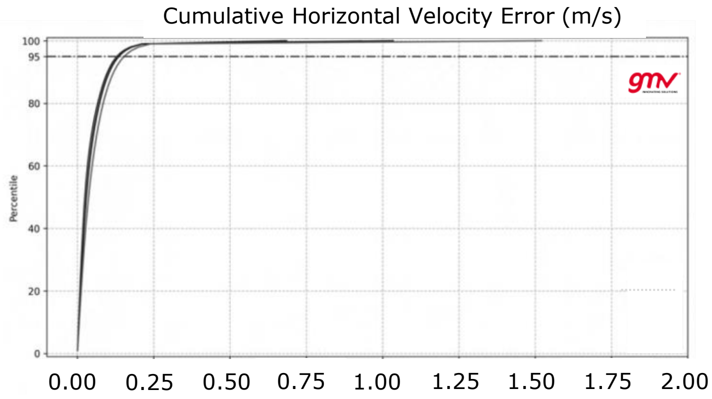
Heading Angle Error (Velocity > 10m/s)

Statistics	Heading Angle Error
68th	0.10º
95th	0.25º
99.7th	0.45º



Horizontal Velocity Error

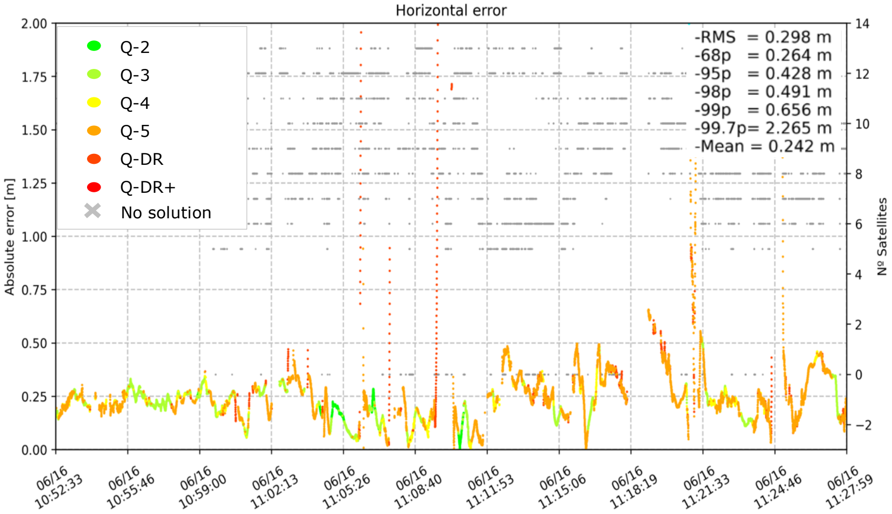
Statistics	Horizontal Velocity
Bias	0.10 m/s
Noise	0.25 m/s



Experimentation strategy for Urban Driving Tests

Experimentation strategy for Urban
Preliminary results

Our current solution shows promising results when tested in challenging scenarios such as urban canyons.

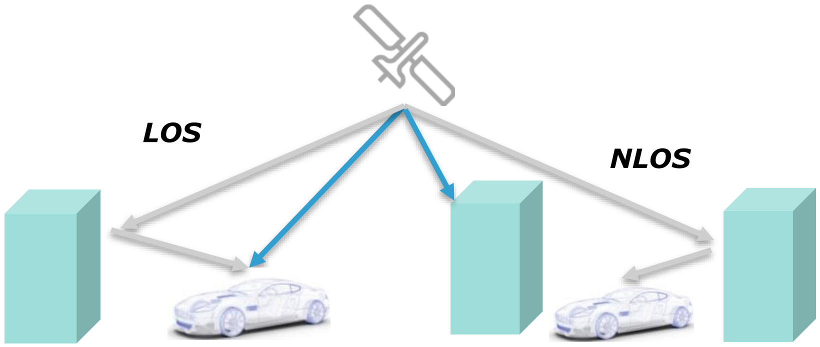


We are working to do even Better!

EVOLUTIONS FOR SUB-URBAN AND URBAN ENVIROMENTS

CHALLENGES

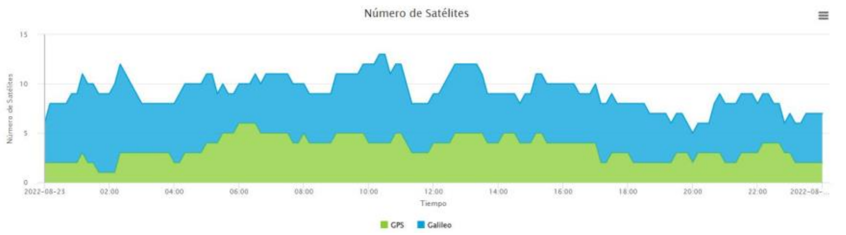
- Signal shadowing due to surrounding buildings
- Lower power strength GPS second frequency
- Cycle slips are inevitable while circulating across urban topology (intersecting streets, turns, gantries)
- LOS and NLOS multipath effects due to signal reflection in buildings

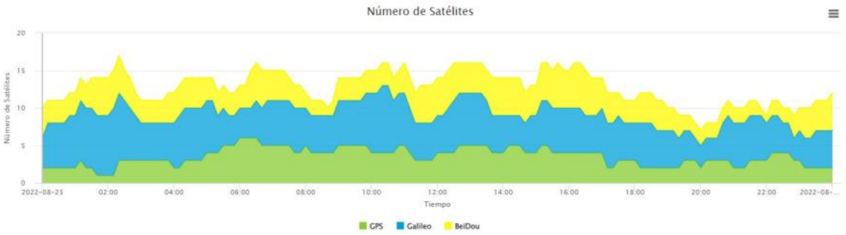


PE EVOLUTIONS (I): BeiDou

- One of the most straightforward ways to improve the quality of a GNSS solution is to increase the processing capabilities in order to include BeiDou 3 global constellation
- Evolutions in Correction Service have been focused in improving SRP and attitude models
- We are obtaining performances within the State of the Art (Wuhan University products)

	DBS3 MEO (CAST)	DBS3 MEO (SECM)
Orbit 1D RMS	4-7 cm	3-6 cm
Clock RMS	0.1-0.25 ns	0.07-0.15 ns

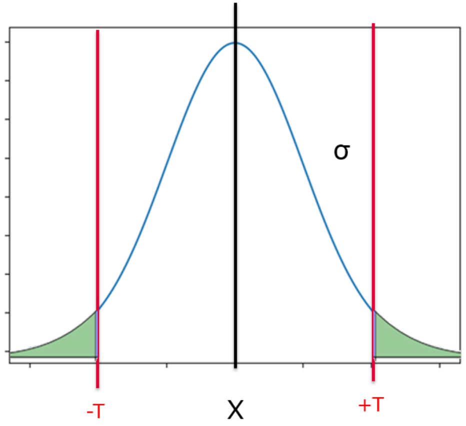


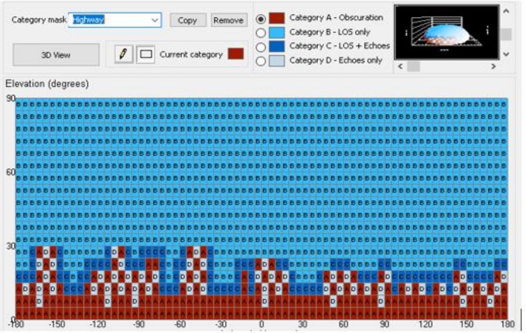


BeiDou processing increase overall satellite availability
In the image, N of sats from Galileo, GPS (IIF+III) and Beidou III, mask 20º
Source: Trimble GPS Planner

PE EVOLUTIONS (II): Multipath Characterization

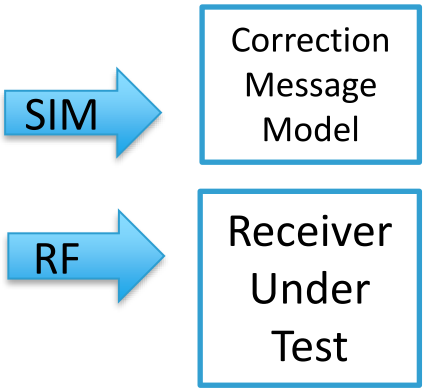
- Our current Multipath detection is based on the evaluation of the code measurements noise evolution.
- Upon the analysis of hundred of kilometers it is possible to infer reasonable levels of noise, and when the multipath can be introducing unwished effects in the solution.
- Deep testing of real scenarios + Simulation models are helping us learn about signal effects in challenging environments
- Other trends:
  - A-RAIM
  - Artificial Intelligence
  - 5G
  - LEO-PNT constellations

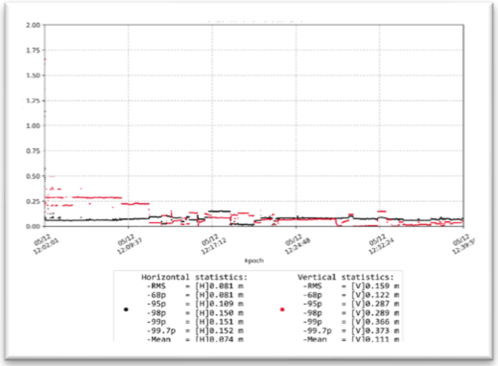


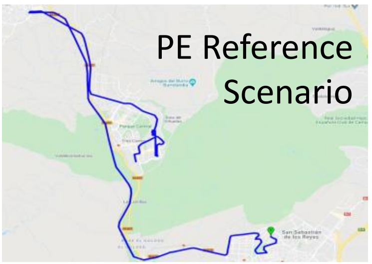


Experimentation strategy for Urban RF Simulations

- ❑ Our current validation plan involves Spirent GSS7000 signal simulator, which provide an extensive capability for testing in adverse conditions with RF signal
- ❑ Integration effort was needed in order to adapt usage of RF simulator to PE + CS system

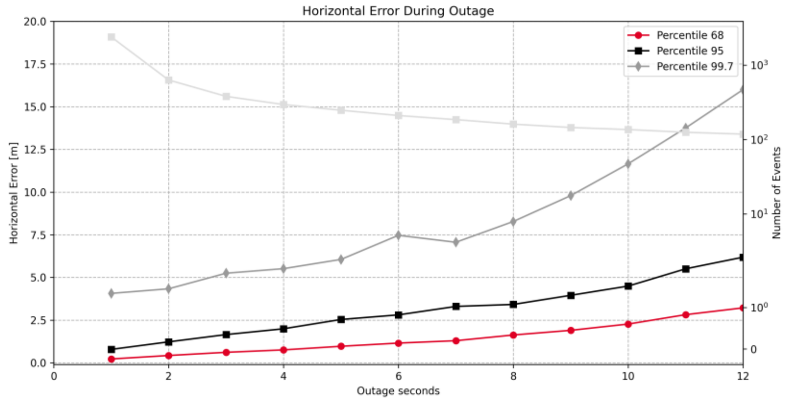


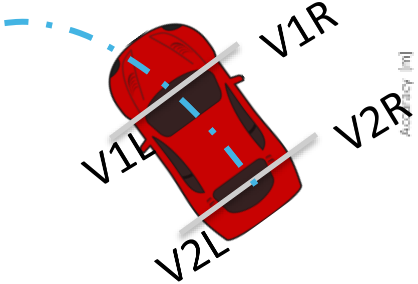


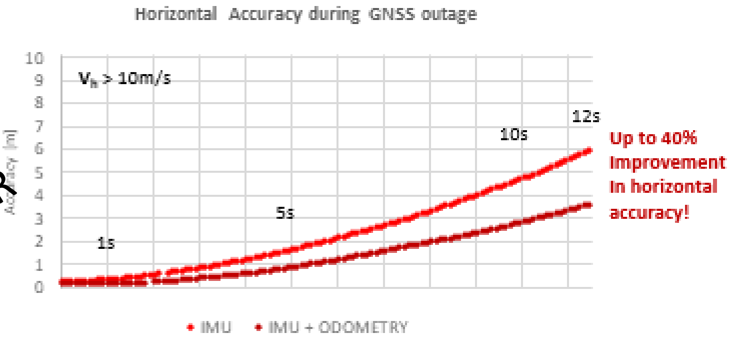


PE EVOLUTIONS (III): Sensor hybridization

- ❑ Status today
  - ➢ Estimation of IMU mounting is not perfect, and leads to error increase in long outages.
  - ➢ Dead Reckoning under 20 m after 12 secs
  - ➢ Usage of Wheel tick information provides an important improvement in DR
- ❑ Way Forward:
  - ➢ Tighter coupling (avoid DR situations)
  - ➢ Steering wheel integration
  - ➢ Visual Odometry







CONCLUSIONS

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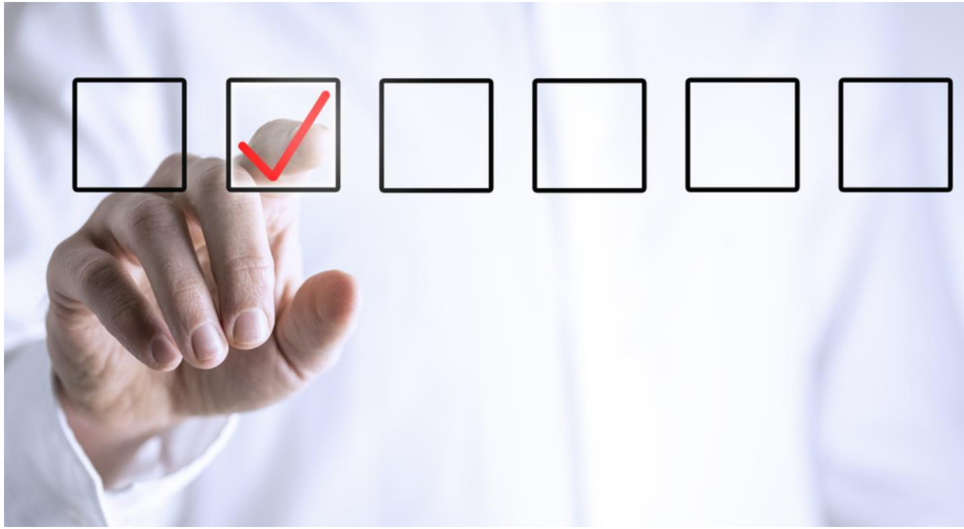
- GMV's positioning engine and correction service offer a high accuracy and reliable solution
- Strong confidence in our high accuracy solution, achieved upon thorough analysis of real life scenarios in Europe and US
- Next steps have already begun to open the way towards urban and suburban high accuracy:
  - ✓ Implementation of BeiDou processing
  - ✓ Multipath Characterization improvement
  - ✓ Sensor hybridization enhancement



Thank you!!

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