

# GNSS Integrity Monitoring in Urban Environment

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# **GNSS INTEGRITY MONITORING** IN URBAN ENVIRONMENT

## Objective

- > The objective of this PhD thesis is to provide accurate positioning along with integrity monitoring in dense urban environments.
- Integrity monitoring consists in providing a measure of trust of the positioning information.

## Problem Statement

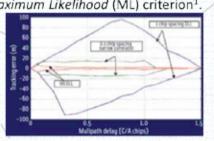
Problematic: Traditional GNSS signal processing is usually unreliable in urban environments due to typical blocking, shadowing and fading of received GNSS signals.

- The following problematic arise from the above described urban conditions:
  - Multipath: decreasing the received GNSS pseudorange accuracy;
  - GNSS satellite Outages due to:
    - Erroneous pseudorange measurements provided from one or more satellites;
    - ii. Nonfulfillment of the minimum requirement of four visible GNSS satellites in a time epoch;
  - Non-Line of Sight (NLOS) signals: significant decrease of positioning accuracy due to the non-reception of line-of-sight GNSS signals.

## Proposed Solution

#### 1. Advanced Multipath Mitigation technique (MMT)

- Objective: Multipath mitigation at the GNSS receiver correlator output.
- MMT are based on different approaches from Early - Late narrow spacing correlator to the channel estimation.
- ☐ Example: MEDLL is the 1st MMT based on the Maximum Likelihood (ML) criterion1

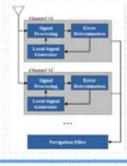


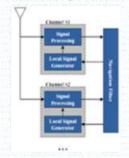
### 2. Vector Delay/Frequency Lock Loop (VDFLL)

- Objective: overcome GNSS signal outages and reacquire the blocked signals by tracking them in a joint serial approach.
- Signal Tracking and Navigation solution tasks are combined in a single step.

#### Scalar Tracking

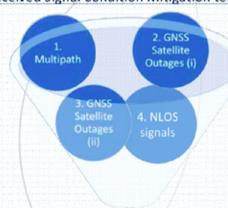
#### **Vector Tracking**





## Inaccurate Positioning with "lack of trust"

### Received Signal Condition Mitigation techniques



## Accurate Positioning with "lack of trust"

#### GNSS/INS Integrity Monitoring Algorithm

Proposed Integrity Monitoring algorithms are derived from the Receiver Autonomous Integrity Monitoring (RAIM) method.

□RAIM: an integrity monitoring algorithm developed for Civil Aviation performing the Fault Detection and Exclusion (FDE) test to remove the faulty GNSS satellite.

#### ☐Example: Isotropy Based Protection Level (IBPL)

 Protection levels are computed based on all in-view GNSS satellites without removing the degraded measurements<sup>5</sup>.

#### 3. Inertial MEMS (Micro-machined Electro-Mechanical) sensors

- Objective: Provide independent position from GNSS systems and propagation channel.
- MEMS accelerometers and gyroscopes provide by themselves the vehicle position from an initially known position.





- Advantage: low cost, small size and low power consumption
- Drawback: Relative low performance due to constantly increasing error (0.01 °/s)

## 4. GNSS NLOS Rejection techniques

□Objective: Detection & Exclusion of NLOS GNSS satellites prior to position computation aiming at an increase of positioning accuracy.

■The possible candidates:

- Fisheye camera: 180° Field of View (FOW)
  - Implementation: mounted on the vehicle roof3.
- Shadow Matching technique:
- Implementation: Takes use of the 3D city building model4.
- Drawback: Extensive computational burden.

# Accurate Positioning with "trust"

#### Conclusions

- NLOS rejection techniques were proposed and described to overcome the received signal conditions in dense urban environments.
- GNSS & INS integration employing MEMS sensors yields a low cost solution for an improved positioning performance and availability in urban canyons.
- > In this work, several Integrity Monitoring algorithms being capable of providing integrity monitoring for GNSS/INS fusion were targeted.

#### Future Work

- Advanced Multipath Mitigation techniques along with Vector Tracking and GNSS > Focus toward the implementation of advanced GNSS signal processing algorithms and exploitation of GNSS/INS hybridization techniques.
  - Definition of the Measurement Quality Indicators for our specific urban scenarios.
  - A key objective of this work will be the determination of innovative integrity monitoring algorithm suited to our measurement model.
  - Simulations and experimentations of our positioning algorithm and integrity monitoring technique will be carried out in the testing campaigns in Toulouse and Madrid.

### References

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