13th ITS EUROPEAN CONGRESS
FULFILLING ITS PROMISES
Brainport Eindhoven, the Netherlands | 3-6 June 2019

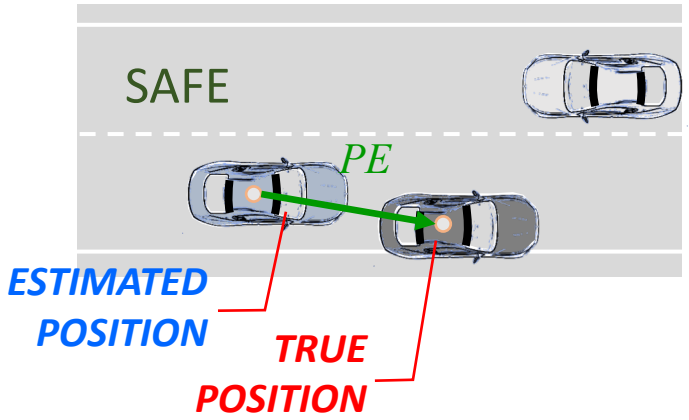
High Integrity Location and Navigation Services for Connected and Autonomous Driving

Alessandro NERI[1,2]

[1]University of ROMA TRE,
[2]RadioLabs
neri@uniroma3.it

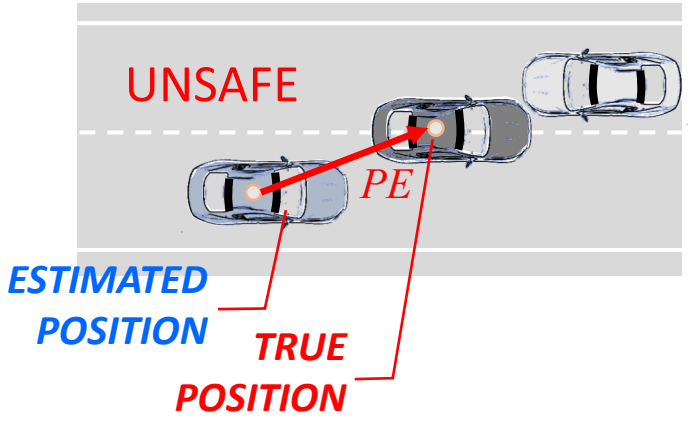
ROAD - SAFETY CRITICAL Requirements

INTEGRITY CONCEPT



ROAD - SAFETY CRITICAL Requirements

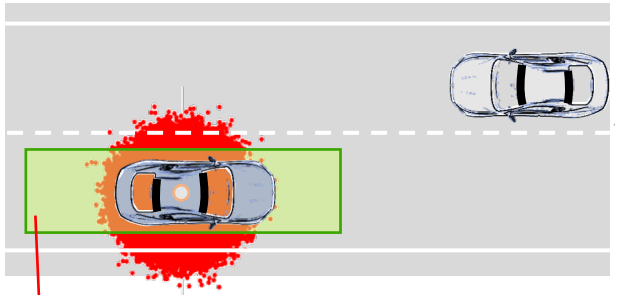
INTEGRITY CONCEPT



ROAD - SAFETY CRITICAL Requirements

KPI	Value
Lateral SAFETY LIMIT	< 25 cm
Longitudinal SAFETY LIMIT	2 m
Speed accuracy	?

INTEGRITY CONCEPT



SAFETY BOX: defines the largest position error such that the vehicle can still be safely used

The **INTEGRITY** specifies the **PROBABILITY** that the true position will fall outside the safety box and no timely warning is given.

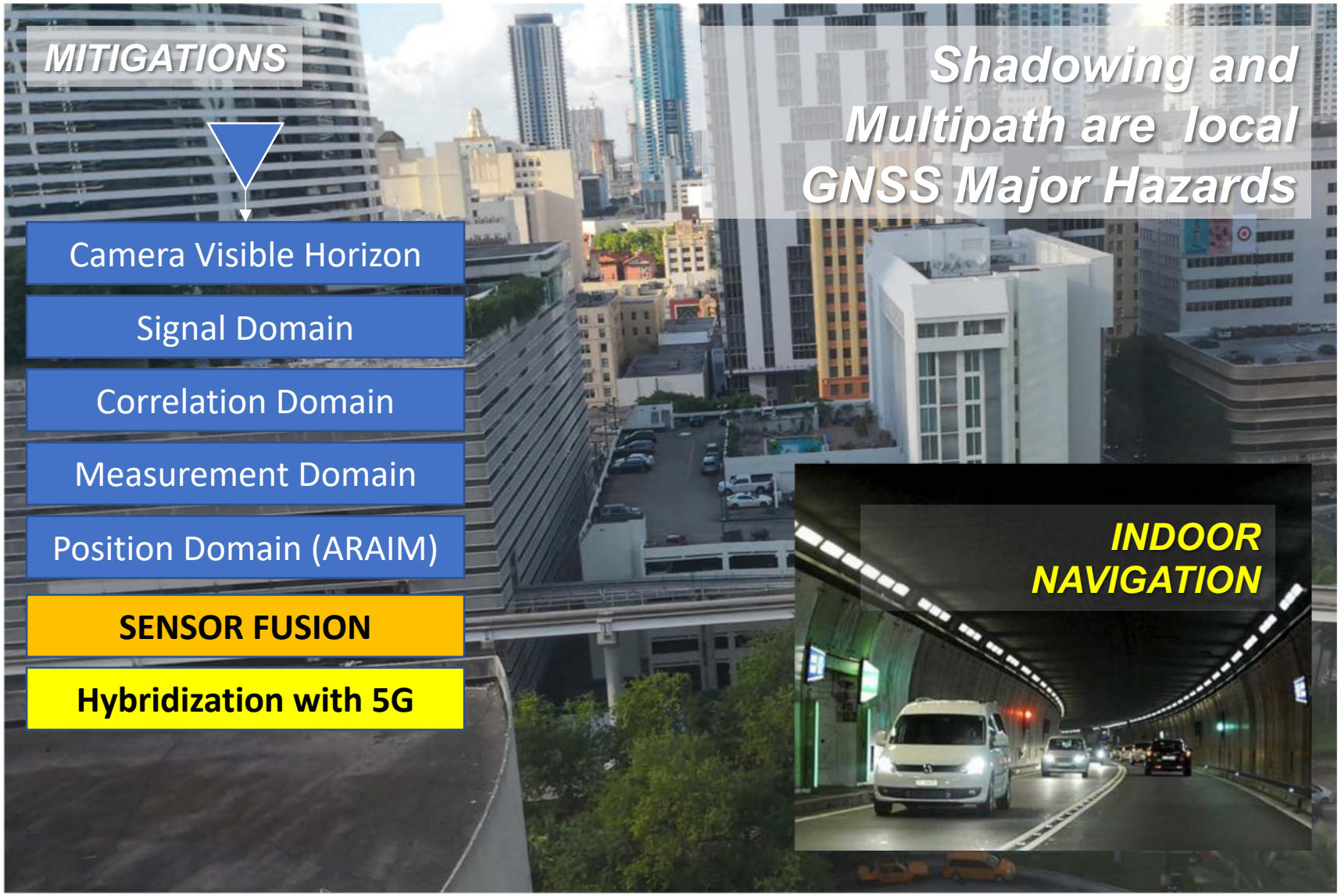
Tolerable Hazard Rate = ?

Target: 1 Death/Year
Vehicles: 45 M
Accident/Death= 50
Duty Cycle: 10%

→ **THR Computation** →

THR< 1.27×10^{-9}
Hazard/(hour x vehicle)

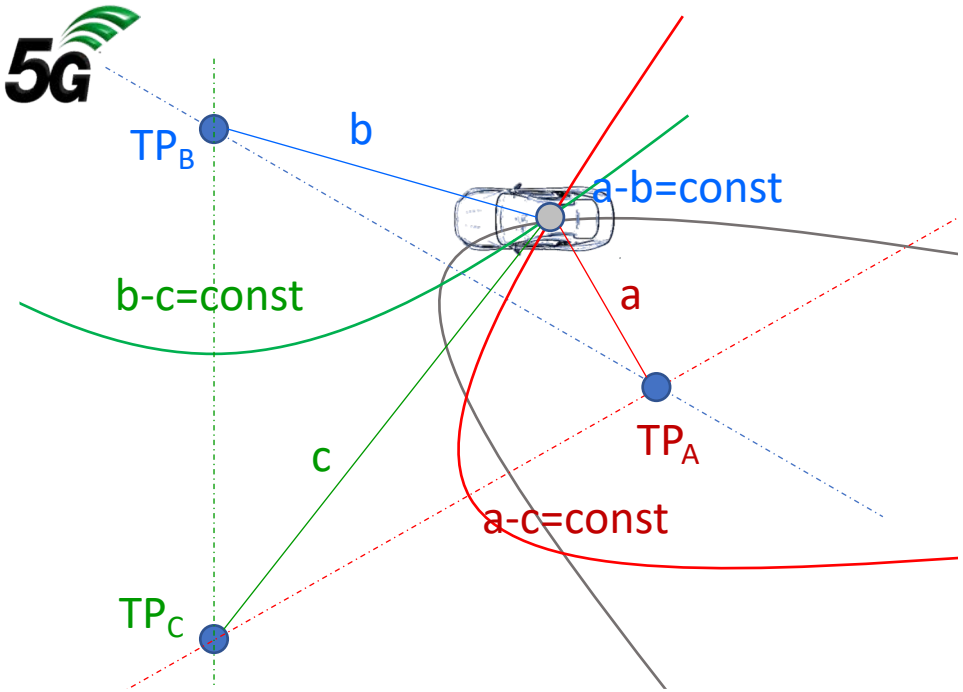
The Urban EM scenario



3GPP UE positioning methods

- **NG-RAN** Standard positioning methods:
  - **A-GNSS** network-assisted GNSS methods;
  - **OTDOA** observed time difference of arrival positioning;
  - **E-CID** enhanced cell ID methods;
  - **BAROMETRIC** pressure sensor positioning;
  - **WLAN** positioning;
  - **BLUETOOTH** positioning;
  - **TBS** terrestrial beacon system positioning.
- Hybrid positioning using multiple methods is also supported.
- Standalone mode (e.g. autonomous, without network assistance) using one or more methods is also supported.

Observed Time Difference Of Arrival



As in GNSS, several Transmission Points (TP) simultaneously transmit Orthogonal RF Positioning Reference Signals (**PRS**)

STRENGTH

- Same principle as **GNSS Relative Positioning**
- Accuracy increases with Bandwidth

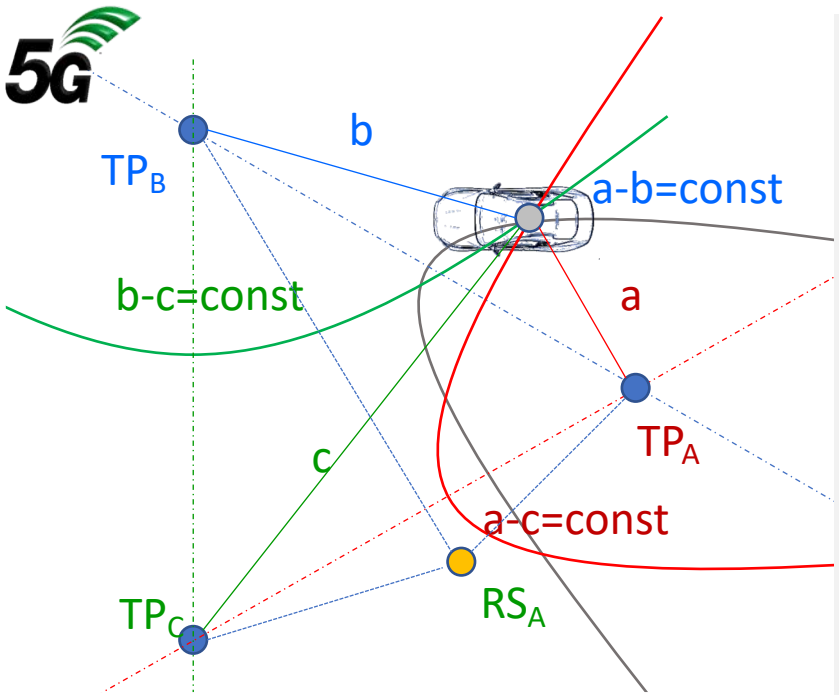
WEAKNESS

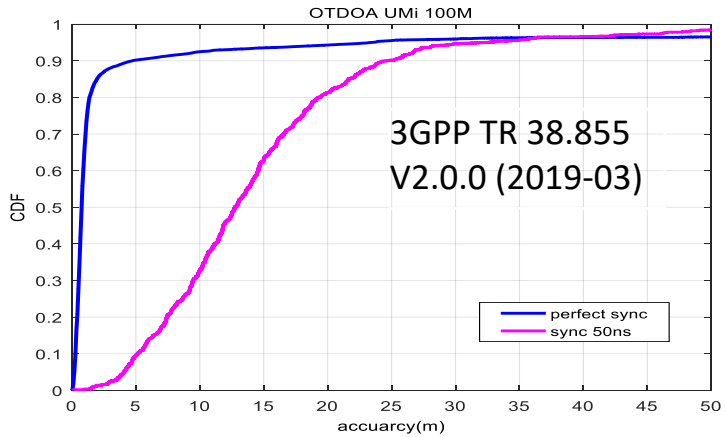
- **Synchronization**
- Coverage
- Multipath

HIGH INTEGRITY 5G POSITIONING

- Adoption of a Local Augmentation and Integrity Monitoring Network
- Receiver Autonomous Integrity Monitoring Algorithm (**OBU**)

Observed Time Difference Of Arrival

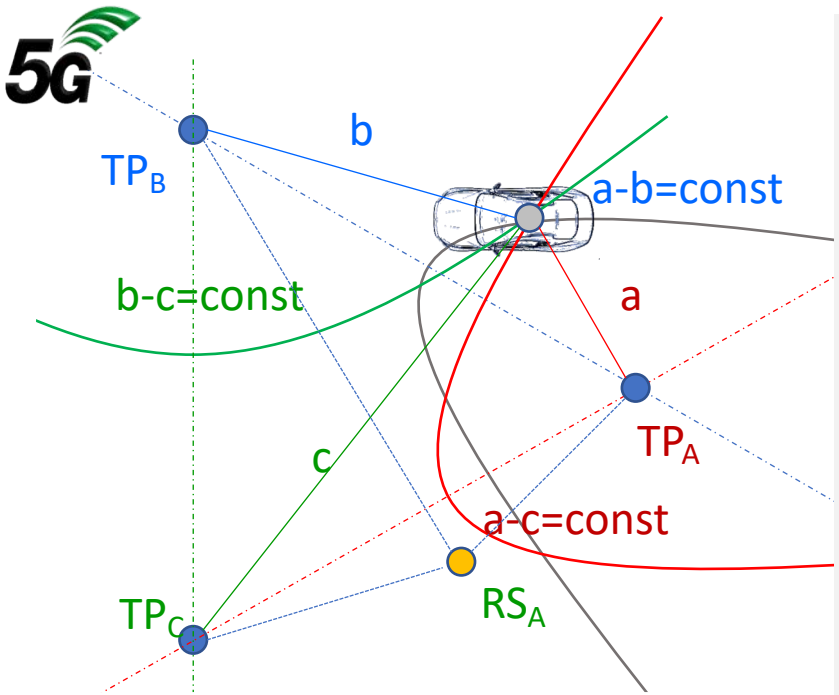


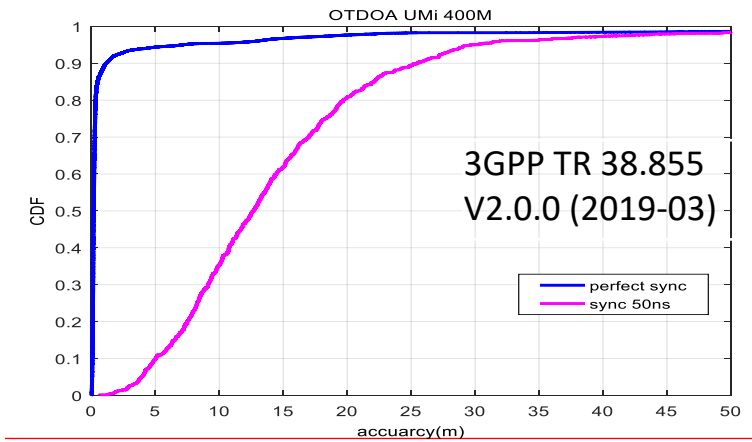


- **Reference Stations** monitoring the **Positioning Reference Signals** have to be included in the architecture
- Architectural shift from From **Network Centric** to **Vehicle Centric** positionig to guarantee the **Low Latency** required by Vehicle Control.
- **Unified** Augmentation and Integrity Monitoring Infrastructure with site sharing
- **STANDARDIZATION EFFORT** required to include both GNSS and 5G data in the Augmentation messages

  RTCM SC 134 - Integrity for High Accuracy GNSS-based Applications

Observed Time Difference Of Arrival





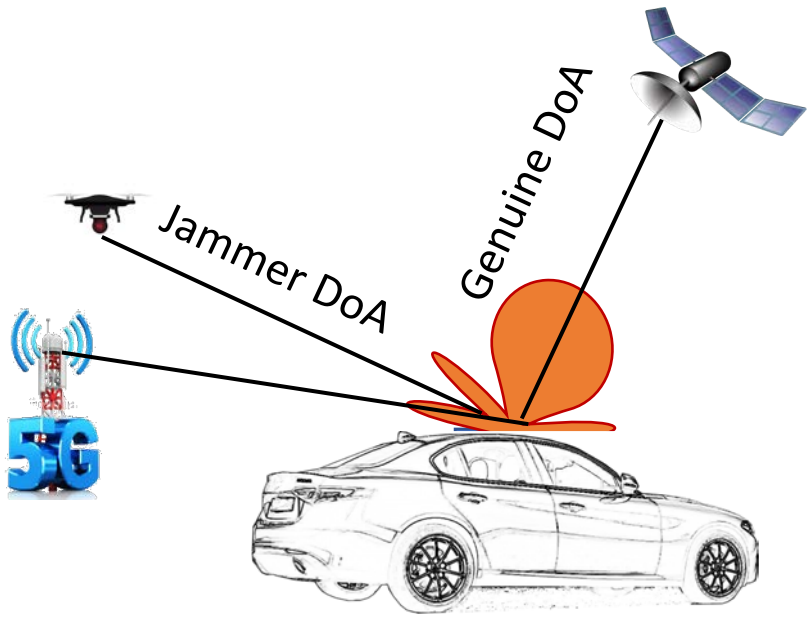
- **Reference Stations** monitoring the **Positioning Reference Signals** have to be included in the architecture
- Architectural shift from From **Network Centric** to **Vehicle Centric** positionig to guarantee the **Low Latency** required by Vehicle Control.
- **Unified** Augmentation and Integrity Monitoring Infrastructure with site sharing
- **STANDARDIZATION EFFORT** required to include both GNSS and 5G data in the Augmentation messages

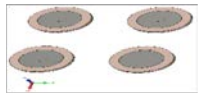
  RTCM SC 134 - Integrity for High Accuracy GNSS-based Applications

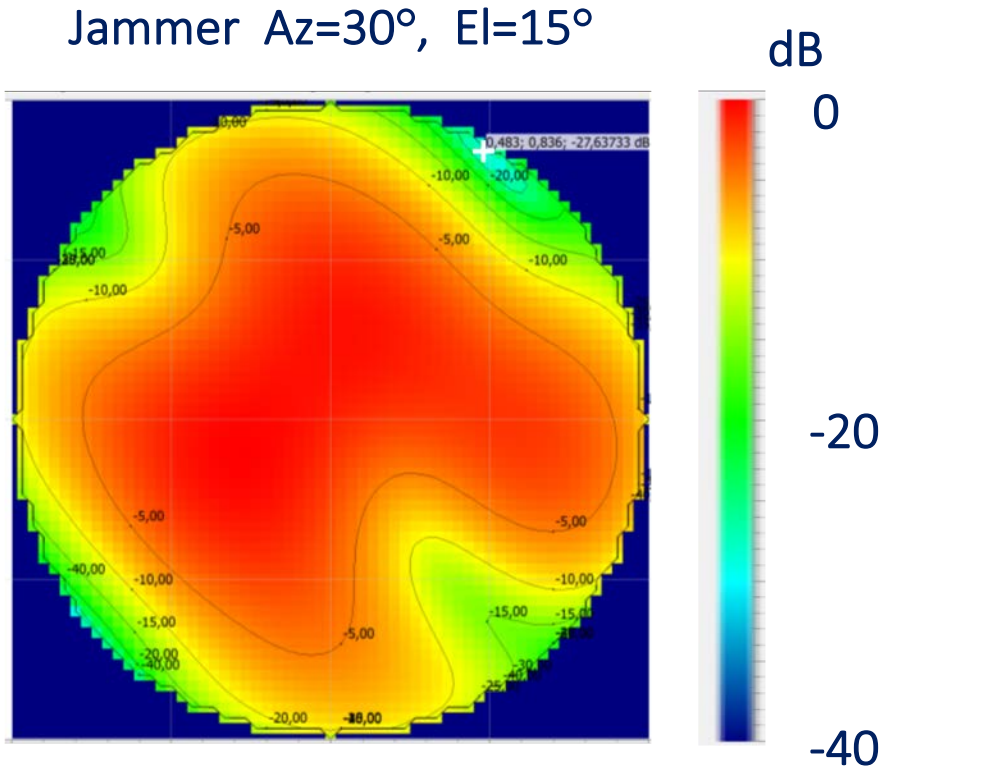
Intentional Interferences

In addition to Global Hazards and Local Hazards like **Multipath** and **RF unintentional interference,** Hazards caused by **JAMMERS and CYBER-ATTACKS (Spoofing and Meaconing)** have to be accounted for.

APPROACH: Spatial filtering based on Digital BeamFormin (ESA GSTP DB4RAIL Project)



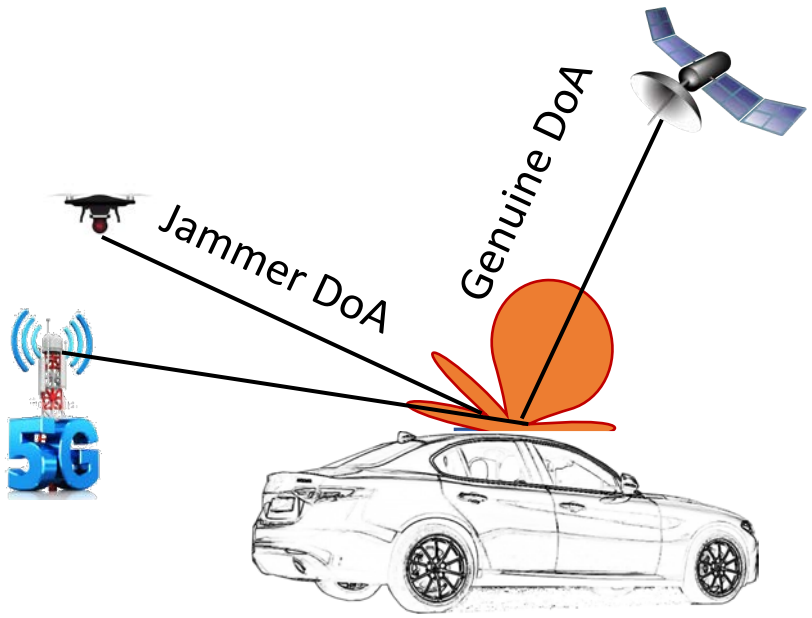


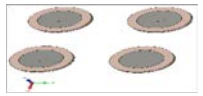


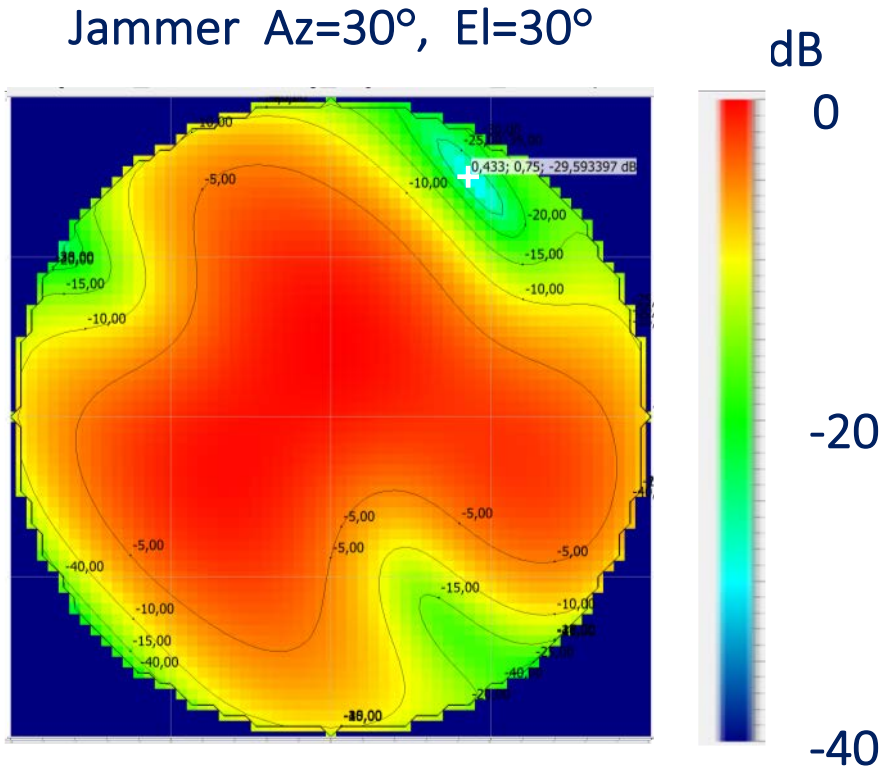
Intentional Interferences

In addition to Global Hazards and Local Hazards like **Multipath** and **RF unintentional interference,** Hazards caused by **JAMMERS and CYBER-ATTACKS (Spoofing and Meaconing)** have to be accounted for.

APPROACH: Spatial filtering based on Digital BeamFormin (ESA GSTP DB4RAIL Project)



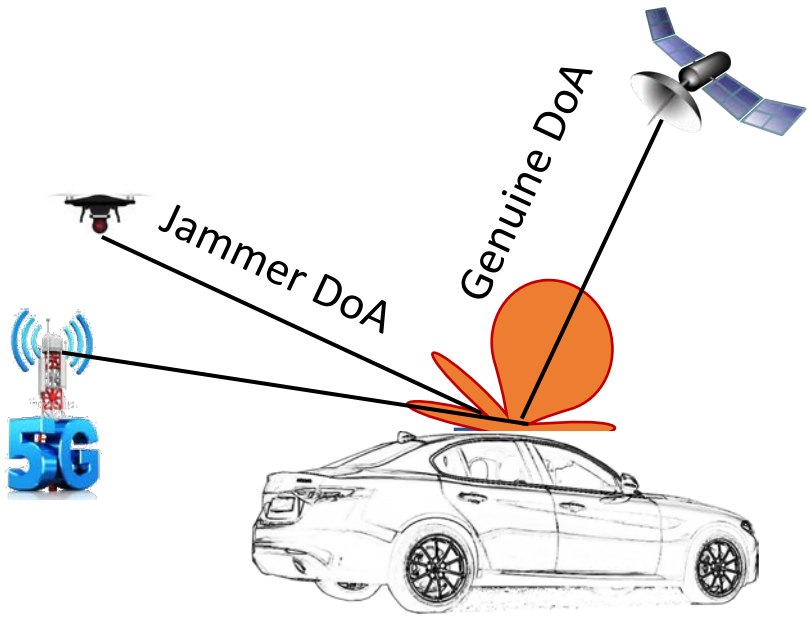


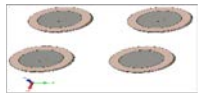


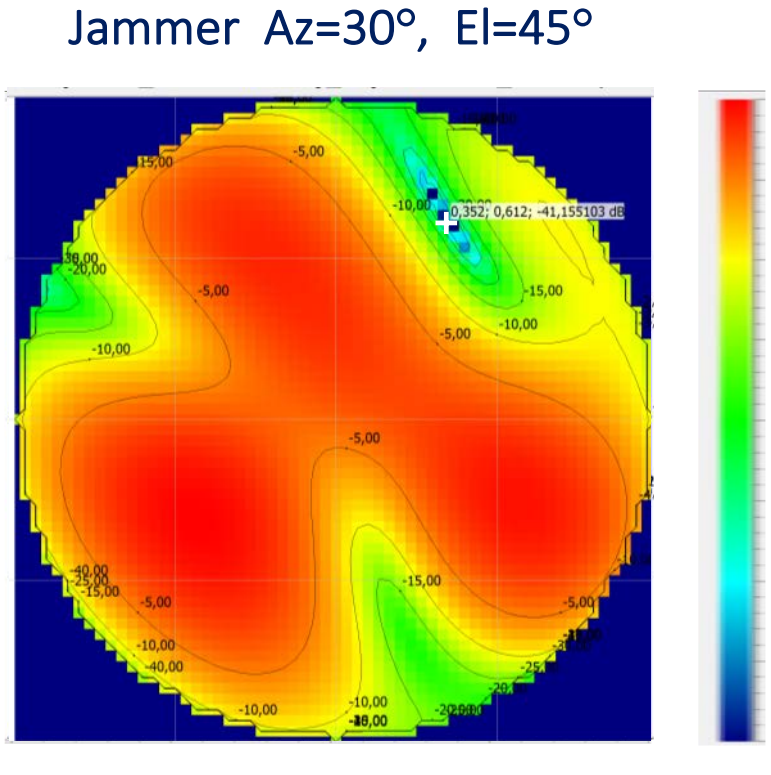
Intentional Interferences

In addition to Global Hazards and Local Hazards like **Multipath** and **RF unintentional interference,** Hazards caused by **JAMMERS and CYBER-ATTACKS (Spoofing and Meaconing)** have to be accounted for.

APPROACH: Spatial filtering based on Digital BeamFormin (ESA GSTP DB4RAIL Project)



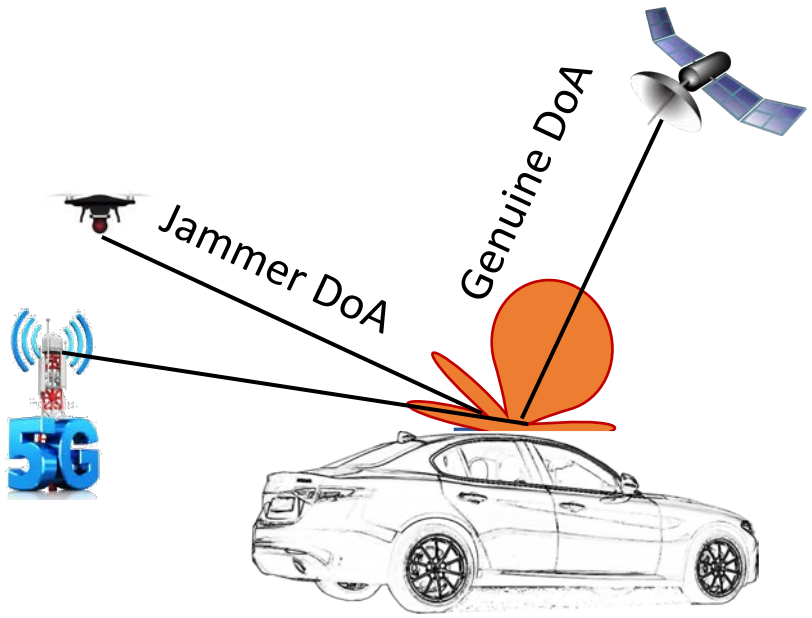


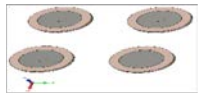


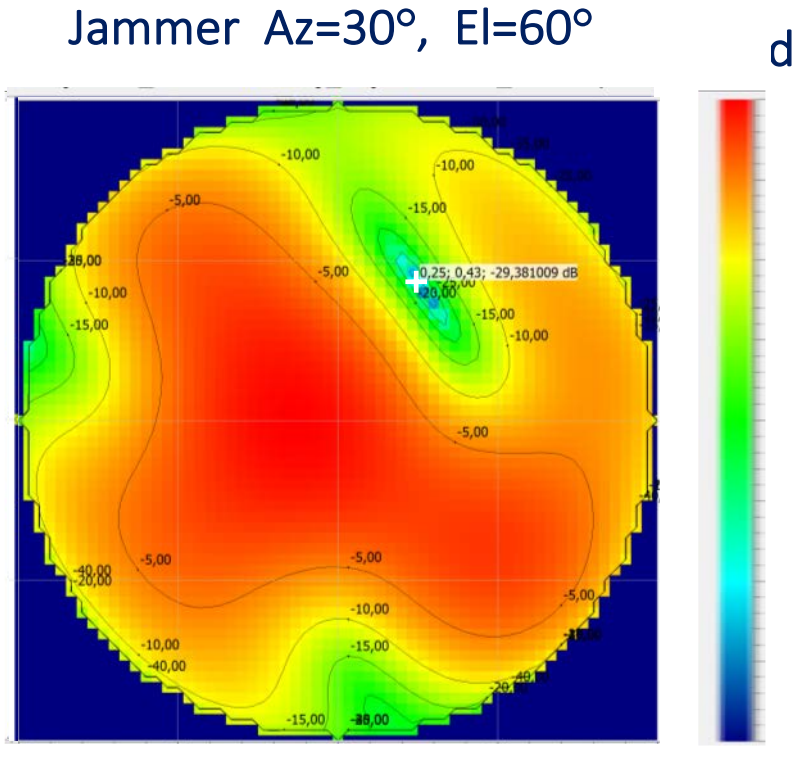
Intentional Interferences

In addition to Global Hazards and Local Hazards like **Multipath** and **RF unintentional interference,** Hazards caused by **JAMMERS and CYBER-ATTACKS (Spoofing and Meaconing)** have to be accounted for.

APPROACH: Spatial filtering based on Digital BeamFormin (ESA GSTP DB4RAIL Project)



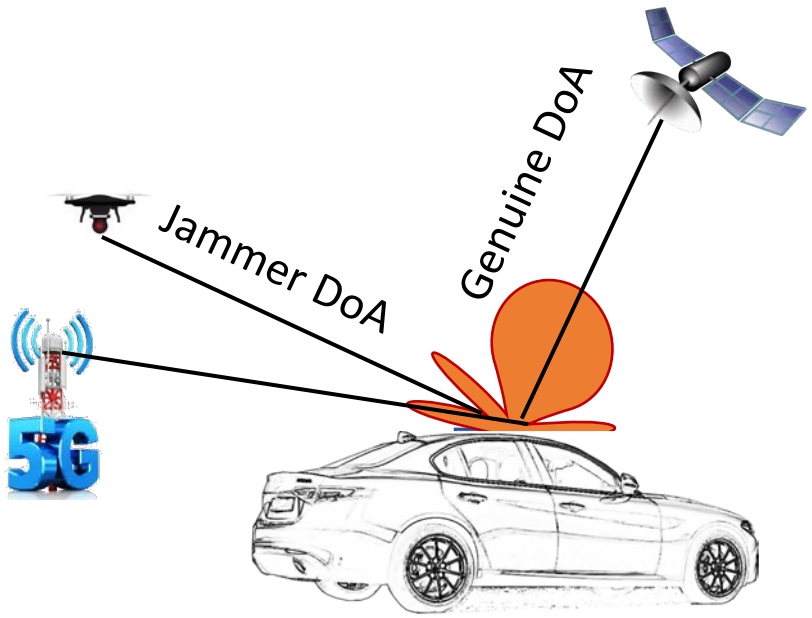


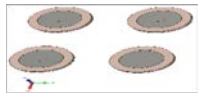


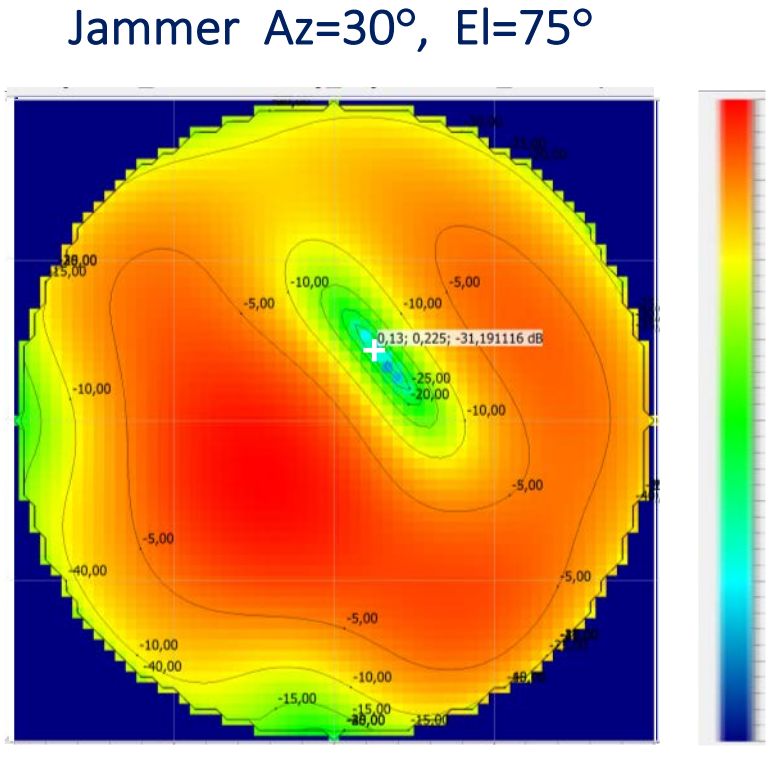
Intentional Interferences

In addition to Global Hazards and Local Hazards like **Multipath** and **RF unintentional interference,** Hazards caused by **JAMMERS and CYBER-ATTACKS (Spoofing and Meaconing)** have to be accounted for.

APPROACH: Spatial filtering based on Digital BeamFormin (ESA GSTP DB4RAIL Project)



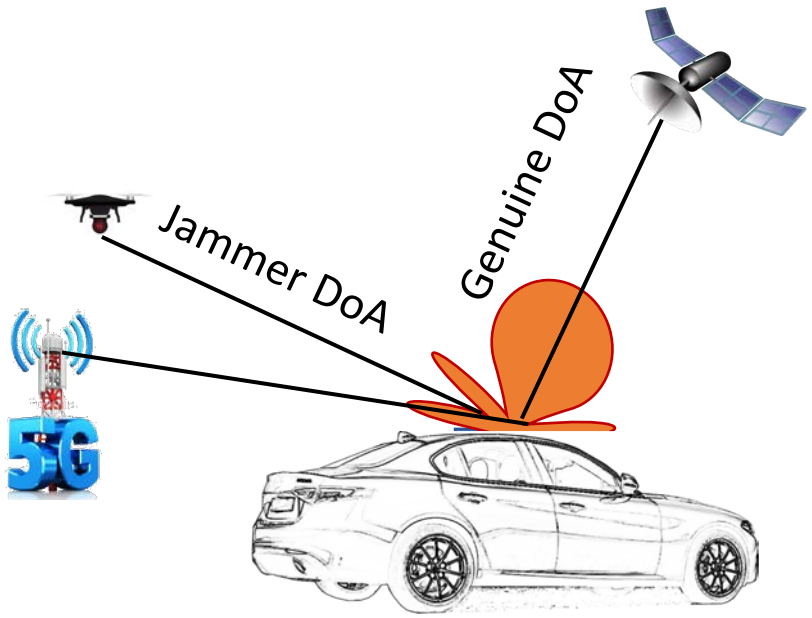


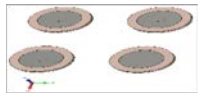


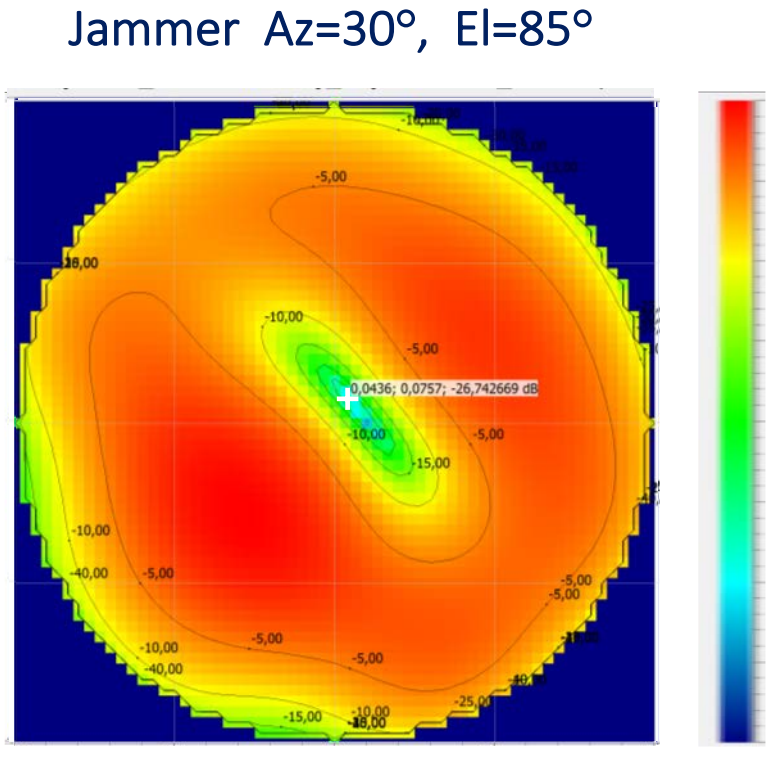
Intentional Interferences

In addition to Global Hazards and Local Hazards like **Multipath** and **RF unintentional interference,** Hazards caused by **JAMMERS and CYBER-ATTACKS (Spoofing and Meaconing)** have to be accounted for.

APPROACH: Spatial filtering based on Digital BeamFormin (ESA GSTP DB4RAIL Project)







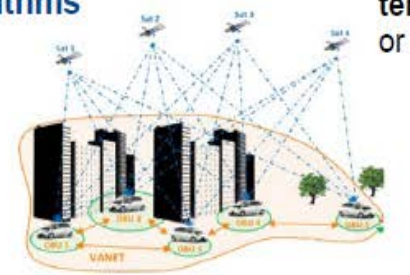
The EMERGE Ecosystem

Connected Car Positioning, TLC, Cybersecurity

SafeCOP

5G@AQ

Localization systems and algorithms



Data fusion from different technologies:

- **Satellite localization**
  GNSS, GALILEO with A-GPS/EDAS
- Visual **odometry**
- **On-board sensors**

Dynamic maps

To manage and announce events with limited temporal validity such as presence of traffic congestion or street maintenance works

V2X Communication

IEEE 802.11p protocol

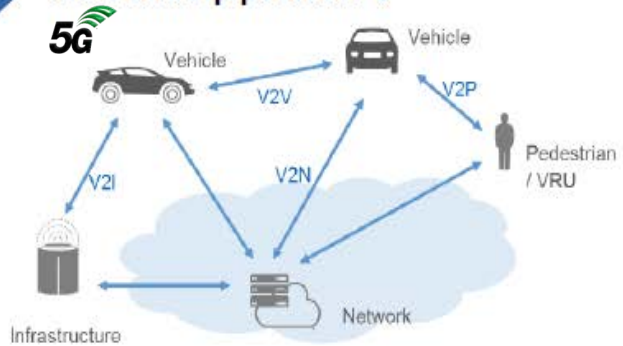


Figure 1: V2X Types.

Cybersecurity

- **Authentication** systems
- **Key distribution** mechanisms
- Cryptographic algorithms for **protecting internal and external communication channels**

Integrated Traffic Flow Management

Reduction of accidents and CO_2 emissions, management of emergency situations, improvement of driving comfort

EMERGE ecosystem

High Integrity
Positioning
Galileo based
Multi sensor

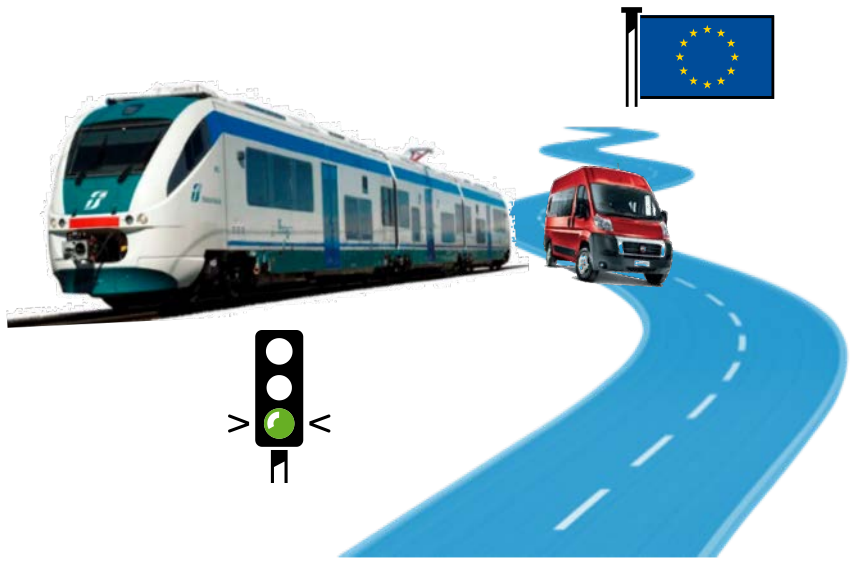
Communications
V2X
5G vs. G5
Satcom

Cybersecurity

TEST BED in l'Aquila
Center of Excellence
5G network
Validation &Certification

CONCLUSIONS

- Exploitation of **GALILEO SIS** and **5G Signal** characteristics can **boost** High **Accuracy** Location Services
- **Similar requirements** in terms of position accuracy and integrity for Rail and Automotive
- **High safety level** achieved by the **Rail** Transport Systems (ERTMS)
- **MASS MARKET** production capability of the Automotive Industry



- **SHARING** of technological and methodological effort (including **testing**, **validation**, and **certification**)
- **SHARING** of a unified **multimodal** Overlay Network for Location Services for Rail and Automotive based on GALILEO and 5G

Thank you for your attention