GNSS et Positionnement

Positionnement GNSS avec des récepteurs à bas coût

Clarification des performances GNSS annoncées par les constructeurs

- *mieux Acheter*
- *mieux Vendre*
- *mieux Réglementer*

COMPANY PROFILE

Overview

LEGAL ENTITY *Acronym* *Corporate Name*	 GUIDE GNSS Usage Innovation and Development of Excellence
LEGAL FORM	SCIC SA à Capital Variable *(Cooperative Community-Oriented Enterprise)*
LEGAL PURPOSE	GUIDE is a Testing Laboratory specialized in GNSS+ implementing and providing all types of services intended to assess, validate or certify geolocation performances of critical functions used by ITS applications.
PRESIDENT	Marc POLLINA
SHAREHOLDERS	**CGX** – Operator of specialized platforms and data centers; **GEOSAT** – Expert Surveyors specialized in modeling 3D maps with GNSS & LiDAR; **OKTAL-SE** – Developer of simulators based on synthetic environments: IR, Radar & GNSS; **M3 Systems** – Developer of GNSS receivers and simulators; **SILICOM** – Developer of IT solutions including GNSS test benches; **EXAGONE** – Operator of the TERIA network providing of GNSS correction services (NRTK);

SHAREHOLDERS & PARTNERS

m3 SYSTEMS GROUPEMISTRAL	*GNSS Receivers and High-end simulators*
Silicom	*GNSS Test Automation Systems*
OKTAL-SE Synthetic Environment	*3D modelling and 3D scene simulation*
GEOSAT	*3D map designs by LiDAR*
TERIA	*GNSS Augmentation Data Providers (NRTK, PPP)*
CGX	*GNSS Big Data Provider*

MARKET POSITION

BUSINESS – Know-how & Skills

The Business of GUIDE are divided into 3 types of skill :

METROLOGY Specification of methods, Performance of measurement campaigns, Interpretation of the collected data to deliver reliable numerical outcomes with managed certainties.

GEOLOCATION Expertise in precise positioning solutions based on GNSS technologies.

CRITICALITY Identification of feared situations, risk ranking and evaluation of the occurrence of phenomena.

SERVICES

Strategic Business Areas (SBA)

TEST ENGINEERING (E)

Test Report « Certifications »

- *Test specification*
- *Test planning*
- *Performance of the tests (Live testing, Simulation, Replay)*
- *Data processing and analysis*
- *Test Report*

TEST FACILITY ENGINEERING (M)

Test Scenarios and Analysis Tools

- *Definition of test facilities*
- *Design, development and distribution of test scenarios*
- *Design, development and distribution of test tools*
- *Database for the machine Learning & GNSS signal labeling*
- *Training*

PERFORMANCE ENGINEERING (P)

R&D study and technical consulting

- *Assistance to implement GNSS technologies*
- *Assistance to mastery of work*
- *Research and Development studies*

SUJET

QUESTIONS CLEFS

Boum Technologique du GNSS

Aujourd'hui, les récepteurs de haute précision (10cm) sont fabriqués en masse:

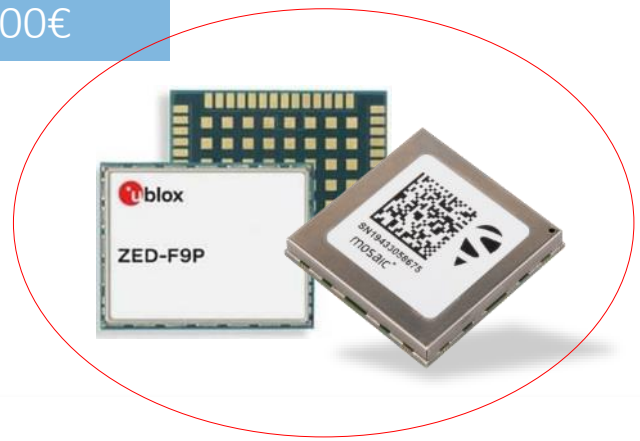
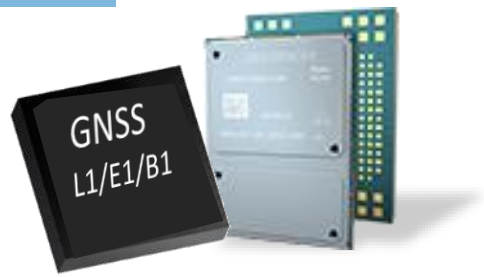
- *En 2015, budget > 4000€*
- *En 2020, budget < 200€*
- *Budget 2025 ≈ ?*

Cette « révolution » impacte t-elle **votre activité** ?

- ACHETER – Pour vous adapter, comment allez vous sélectionner **vos fournitures** et qualifier **vos solutions** ?
- VENDRE – Quels sont **vos engagements**, vis-à-vis de vos clients, conditionnés à la géolocalisation ?
- REGLEMENTER – Comment **uniformiser les informations** liées aux performances ?

LOW COST RECEIVERS

Segmentation – Assessed receivers

	CHIPSET	INTEGRATED
DESIGNED TO BE EFFICIENT	<500€ **A** 	>10000€ 
DESIGNED TO BE CHEAP	<20€ **B** 	<500€ 

APPLICATIONS A SATISFAIRE


GUIDE
Testing Lab in Geolocation
TELEPEAGES
- Autoroutiers, Urbains, Infrastructures,…

GUIDE
Testing Lab in Geolocation

PARKING & CONTROLE D'ACCES

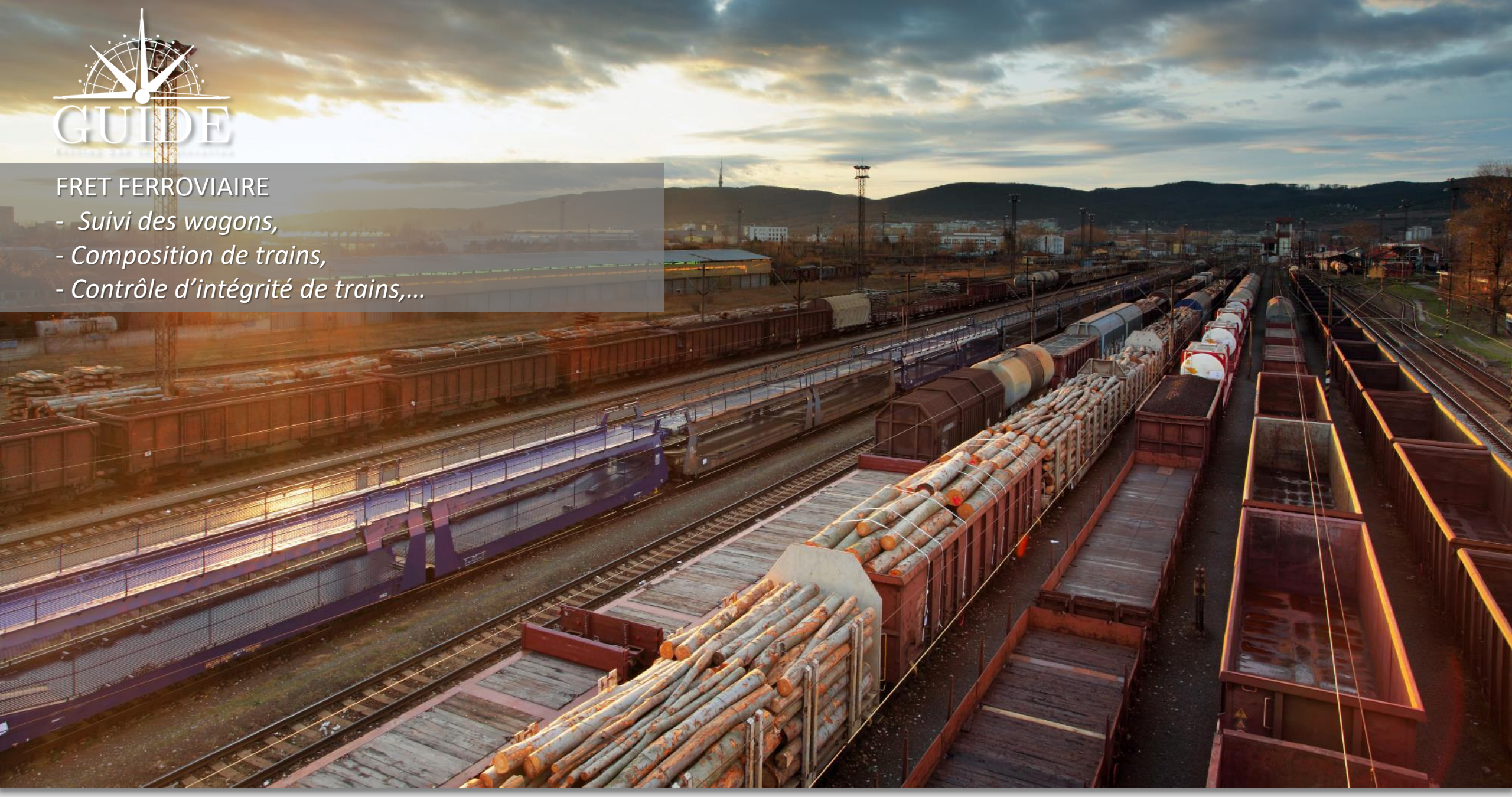
- Publics, Sites, Centres Villes, Résidences,…

GUIDE
Testing Lab in Geolocation

TRANSPORTS PUBLICS URBAINS

- Bus, Tramways,…


GUIDE
Testing Lab in Geolocation
VEHICULES AUTONOMES
- Véhicules assistés (ADAS+),..
- Robots de voierie, Engins de travaux publics, ….
- Navettes Autonomes, Convois de camions (Platooning),…
Self-Driving


FRET FERROVIAIRE
- Suivi des wagons,
- Composition de trains,
- Contrôle d'intégrité de trains,…

GUIDE
Testing Lab in Geolocation

DRONES A VOILURES TOURNANTES

- Surveillances, Inspections,

- Transports, …

ISSUES RELATED TO KEY FEATURES

1cm accuracy

Any where, any time, any condition

Have confidence in GNSS...!

KEY FEATURES

How to read the technical performances listed in data sheets

ppm

CEP

PERFORMANCE[1]

Signal Tracking[2]

GPS	L1 C/A, L1C, L2C, L2P, L5
GLONASS[3]	L1 C/A, L2 C/A, L2P, L3, L5
Galileo[4]	E1, E5 AltBOC, E5a, E5b
BeiDou	B1I, B1C, B2I, B2a
NavIC (IRNSS)	L5
SBAS	L1, L5
QZSS	L1 C/A, L1C, L2C, L5
L-Band	up to 5 channels

Horizontal Position Accuracy (RMS)

Single Point L1	1.5 m
Single Point L1/L2	1.2 m
SBAS[5]	60 cm
DGPS	40 cm
TerraStar-L™ [6]	40 cm
TerraStar-C PRO™ [6]	2.5 cm
TerraStar-X™ [6]	2 cm
RTK	1 cm + 1 ppm
Initialization time	< 10 s
Initialization reliability	>99.9%

1

Features

Receiver type	184-channel u-blox F9 engine GPS L1C/A L2C, GLO L1OF L2OF, GAL E1B/C E5b, BDS B1I B2I, QZSS L1C/A L2C	2
Nav. update rate	up to 30 Hz	
Position accuracy	RTK	< 0.2 m + 1 ppm CEP 1
ADR position error	< 2% of distance travelled without GNSS	
Convergence time	RTK	< 10 s 1
Acquisition	Cold starts	24 s
	Aided starts	4 s
	Reacquisition	2 s
Sensitivity	Tracking & nav.[1]	-160 dBm
	Cold starts	-147 dBm
	Hot starts	-158 dBm
Built-in	TCXO, RTC, flash memory, 3D accelerometer, 3D gyroscope, diplexer, SAW filters	
Supported antennas	Active	

1 Limited by firmware for best DR performance

PERFORMANCE

RTK performance[4,5,6]	
Horizontal accuracy	0.6 cm + 0.5 ppm
Vertical accuracy	1 cm + 1 ppm
Initialisation time	7 s

1

Other positioning modes accuracy

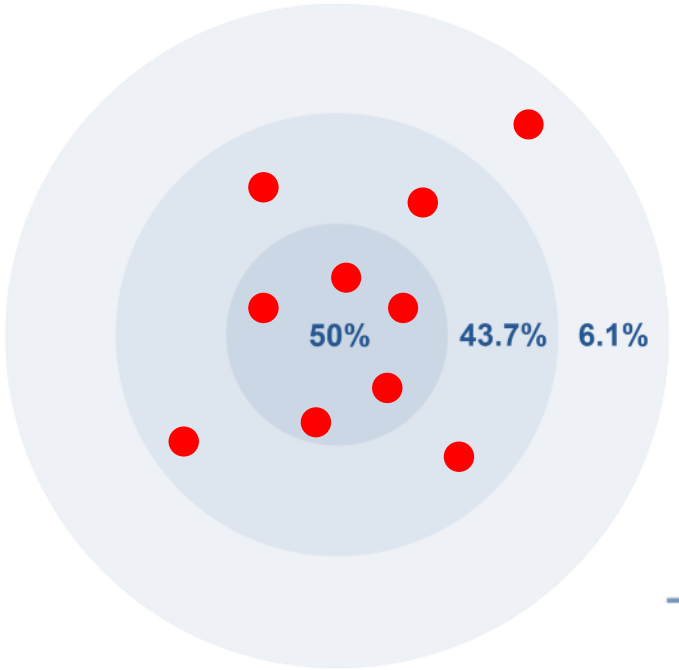
	Horizontal	Vertical
Standalone	1.2 m	1.9 m
SBAS	0.6 m	0.8 m
DGNSS	0.4 m	0.7 m
SECORX (PPP)[2,7]	0.04 m	0.06 m

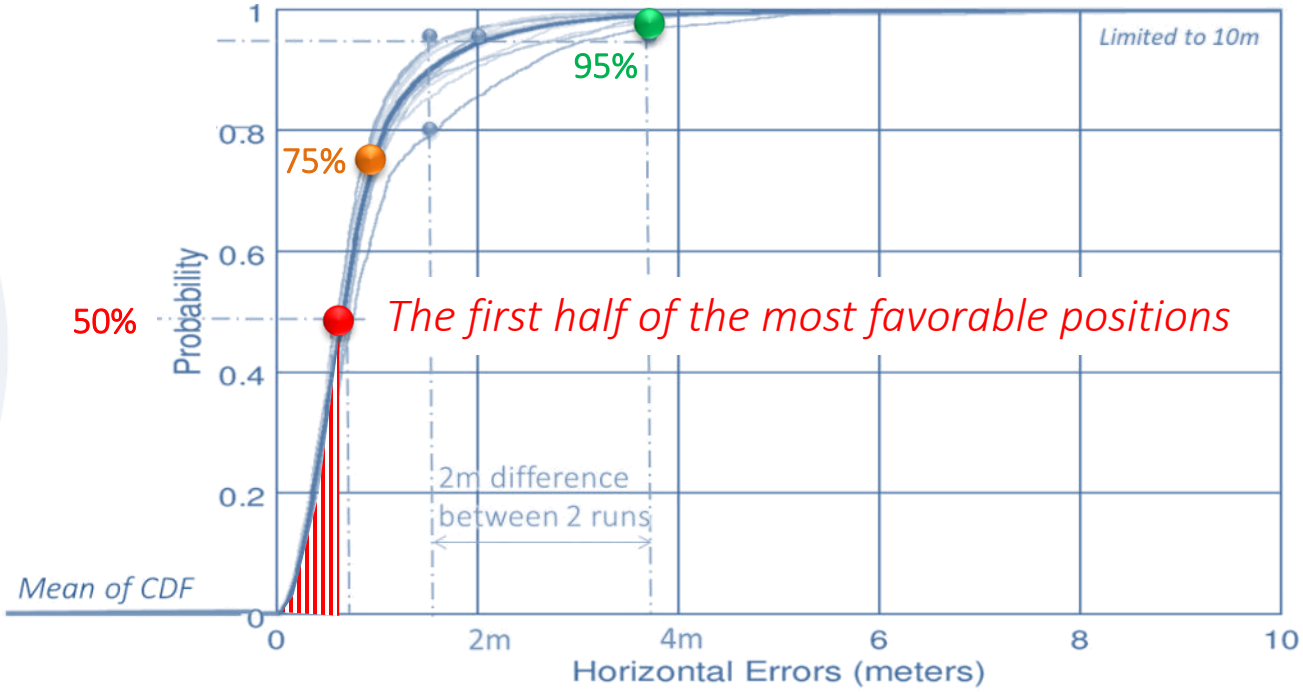
Velocity accuracy	3 cm/s
Maximum update rate	
Position	100 Hz
Measurements only	100 Hz

PERFORMANCE DEFINITIONS

Terms used in the data sheets of the GNSS receiver manufacturers

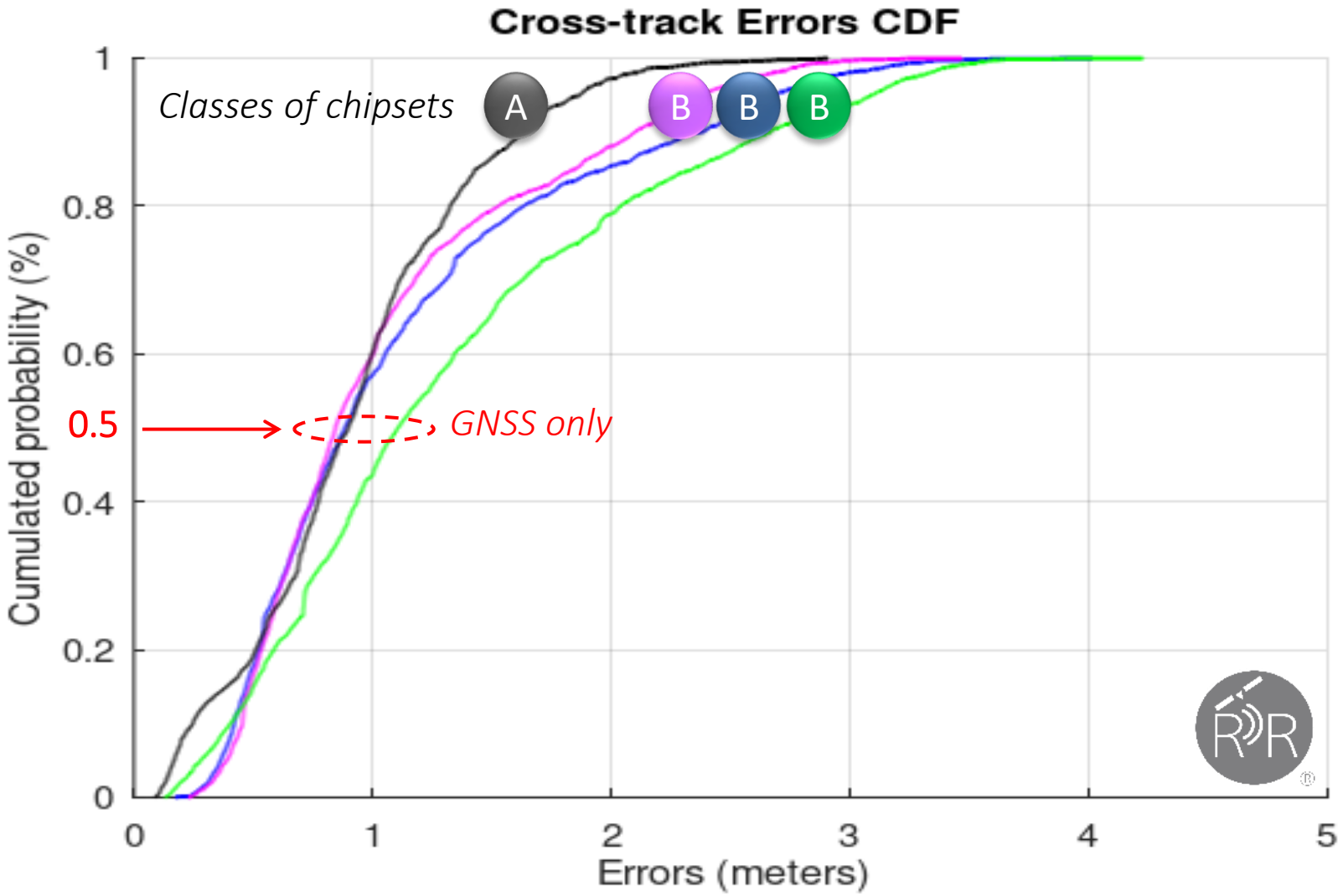
TERM	DEFINITION	ACCURACY/PROBABILITY/CONFIDENCE
CEP	Circular Error Probable	50%
RMS	Root Mean Square	63%-68%
2DRMS	Two Time the Distance of RMS	95-98%
R95	Radius 95%	95%





PERFORMANCE DEFINITIONS

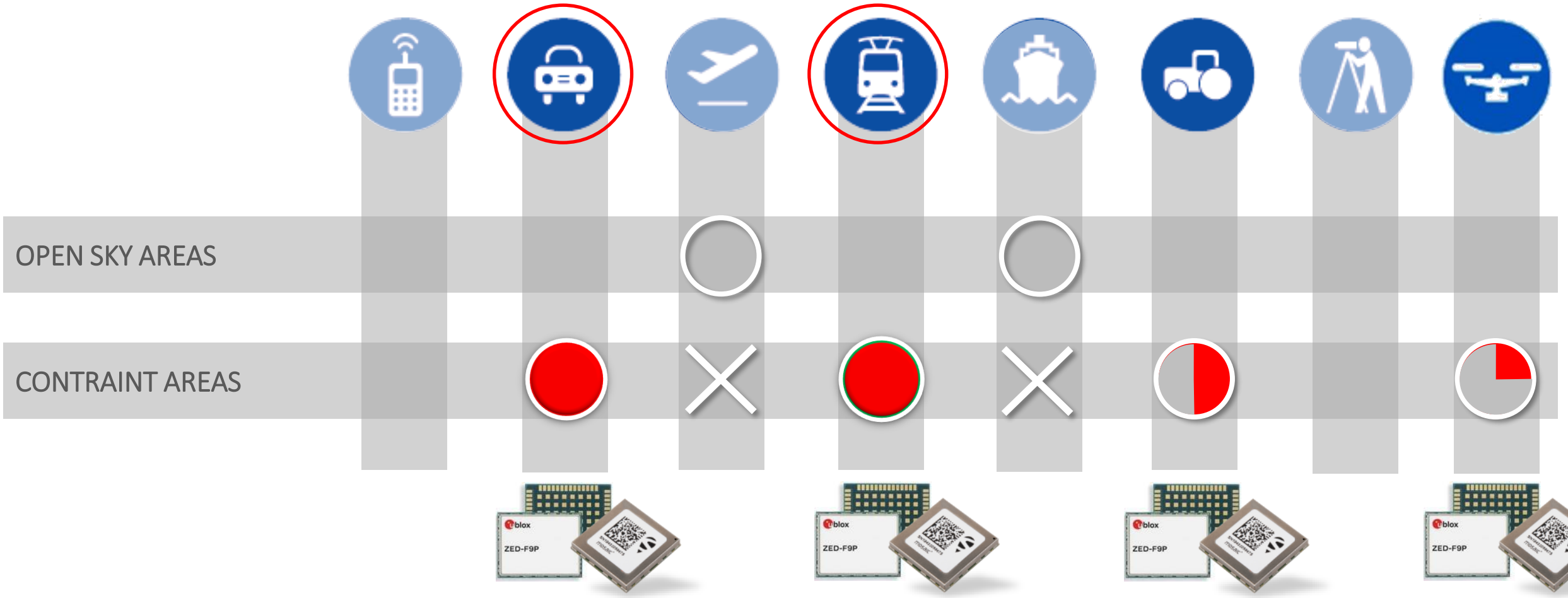
Performance assessments in Standalone (GNSS only)



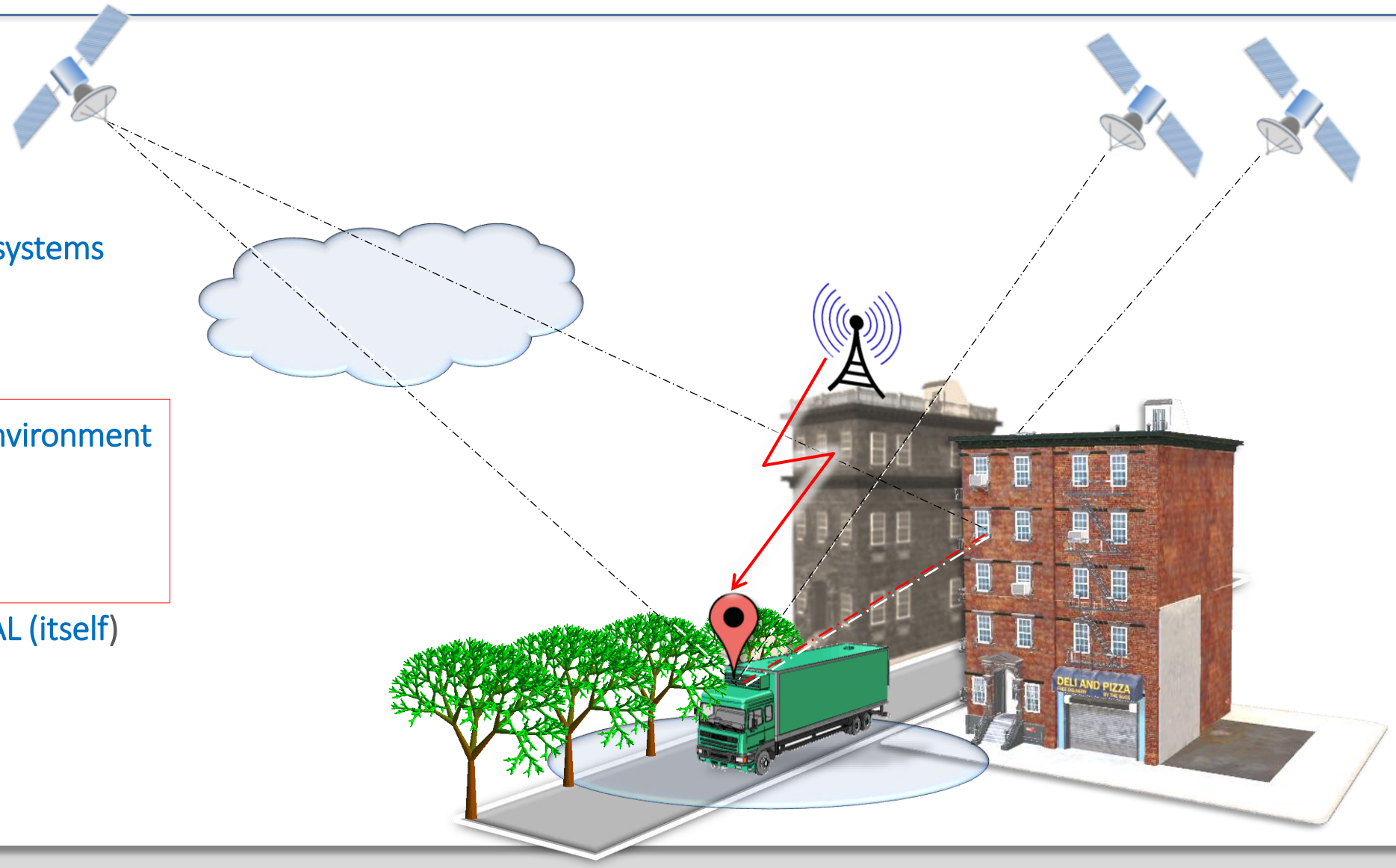
SEGMENTATION OF ENVIRONMENTS

Application – The most demanding activity sectors

The GNSS receivers in open sky all have about the same performances



SEGMENTATION OF PERTURBATIONS



Errors caused by the GLOBAL systems

- *Orbits & Clocks*
- *Geometry (DOP)*
- *Ionosphere, troposphere*

Errors caused by the LOCAL environment

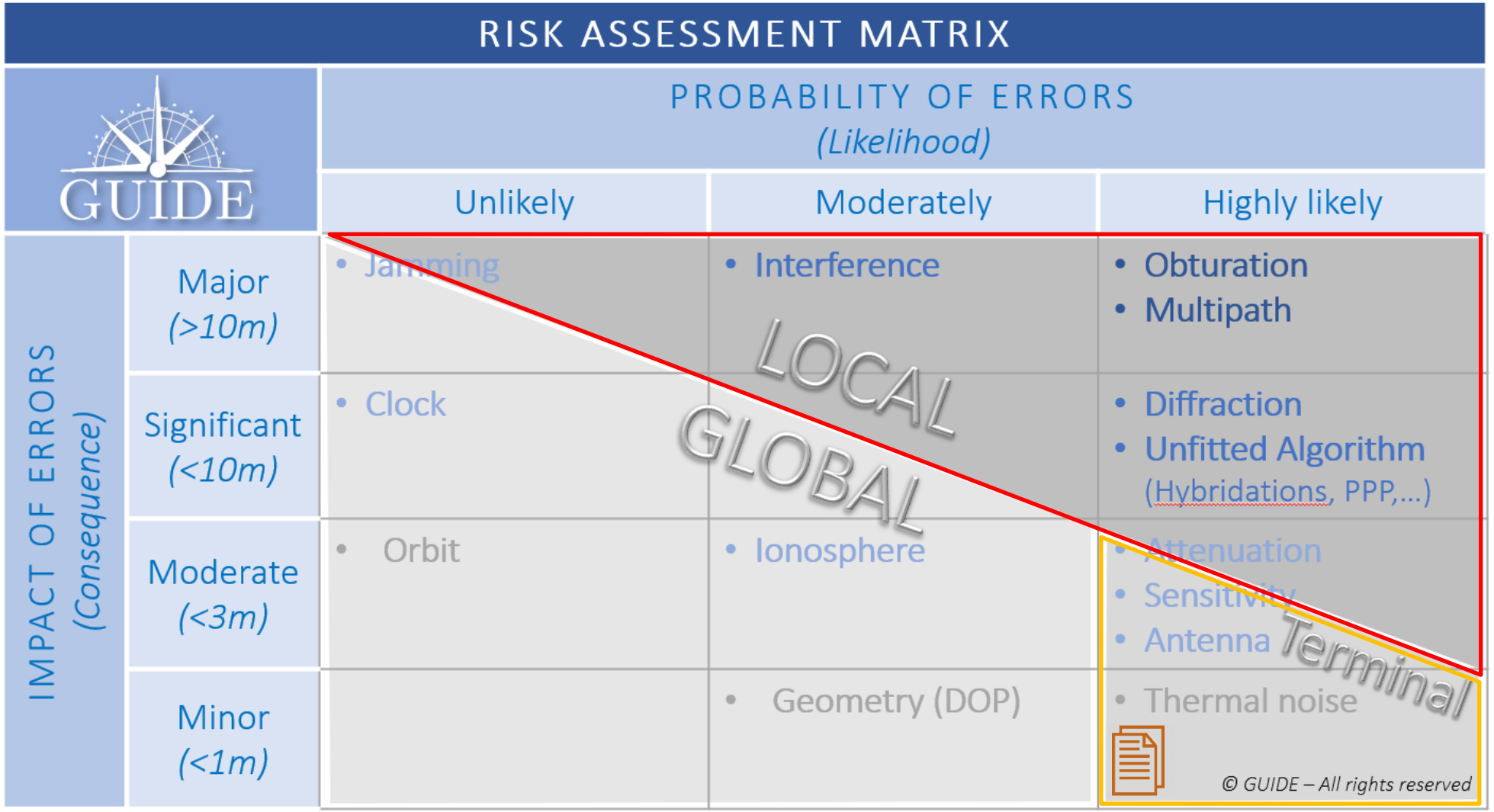
- *Obstructions, Attenuations*
- *Multipath & Diffractions*
- *Interferences, Jamming,…*

Errors caused by the TERMINAL (itself)

- *Receiving chain*
- *Algorithms & Services*
- *Additional sensors*

SEGMENTATION OF PERTURBATIONS

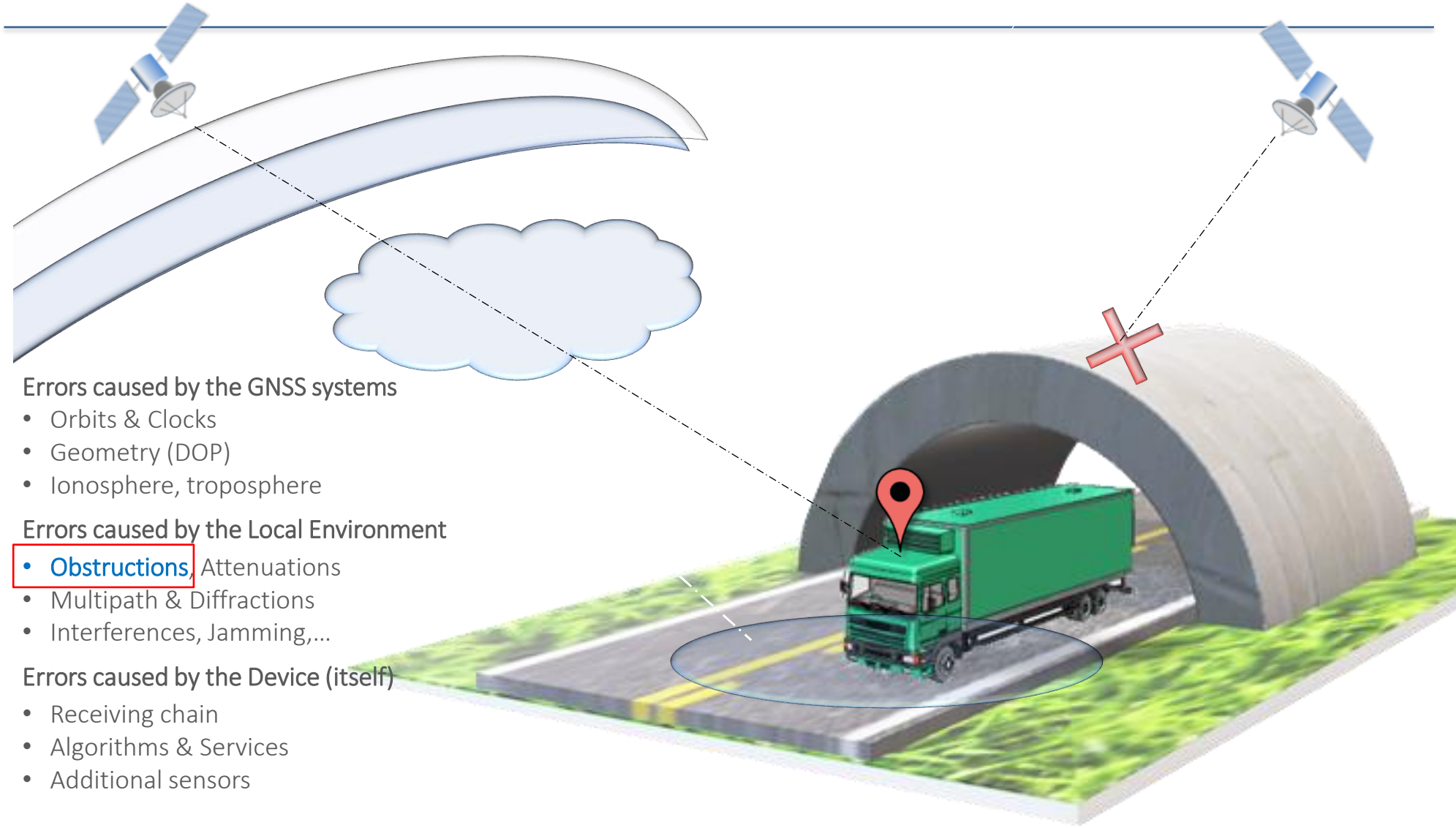
Performance Assessments for Terrestrial Environments



Current universe of the data sheet

LOCAL ENVIRONMENT

OBSTRUCTION



Errors caused by the GNSS systems

- Orbits & Clocks
- Geometry (DOP)
- Ionosphere, troposphere

Errors caused by the Local Environment

- Obstructions, Attenuations
- Multipath & Diffractions
- Interferences, Jamming,…

Errors caused by the Device (itself)

- Receiving chain
- Algorithms & Services
- Additional sensors

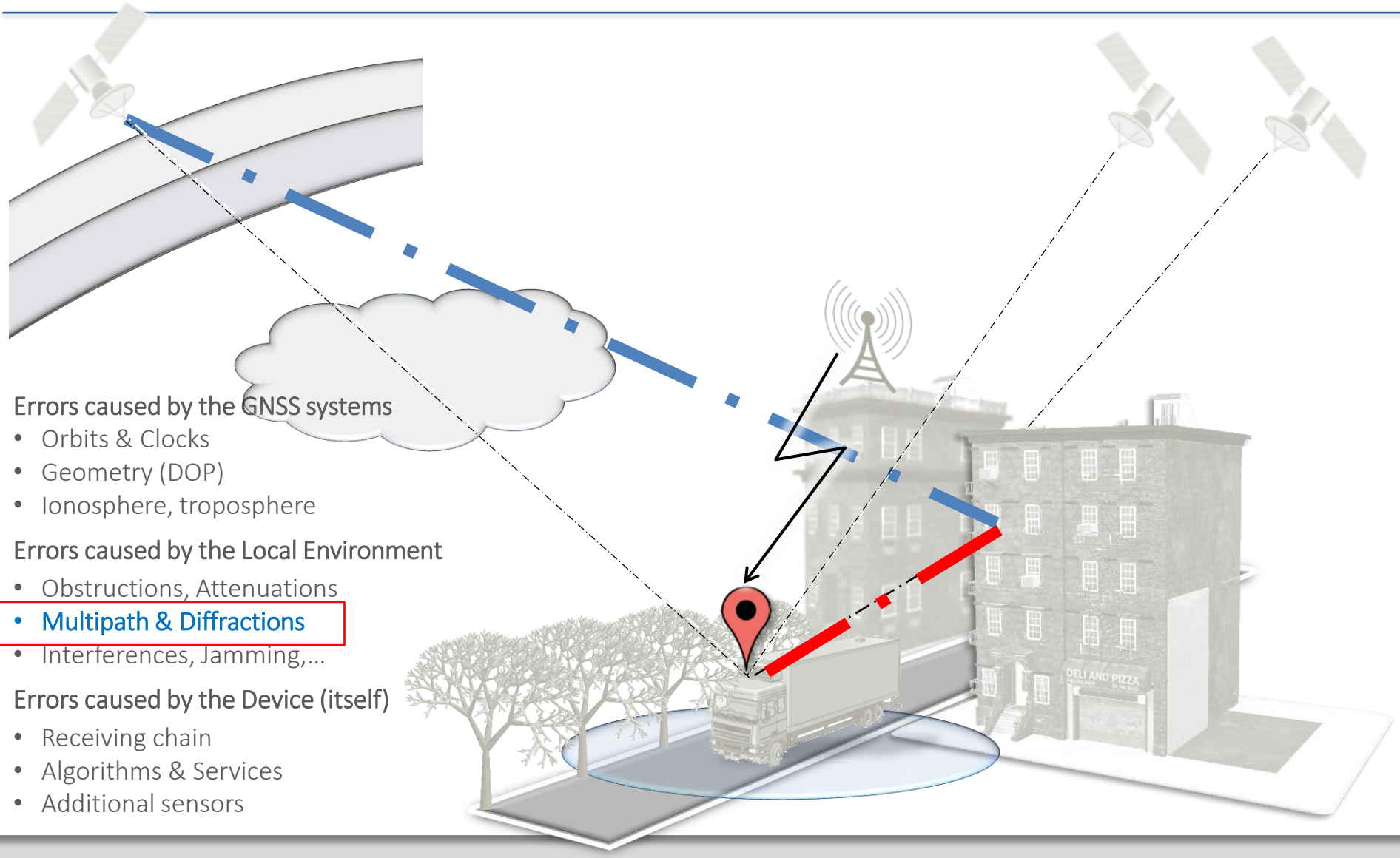
OBSTRUCTION

Passage under bridge

1. Random Dispersions of Trajectories
2. The passage of a single receiver would be insufficient to decide on its accuracy;

NB.: The trajectories are calculated by the same series of receivers on board a same vehicle

MULTIPATH



Errors caused by the GNSS systems

- Orbits & Clocks
- Geometry (DOP)
- Ionosphere, troposphere

Errors caused by the Local Environment

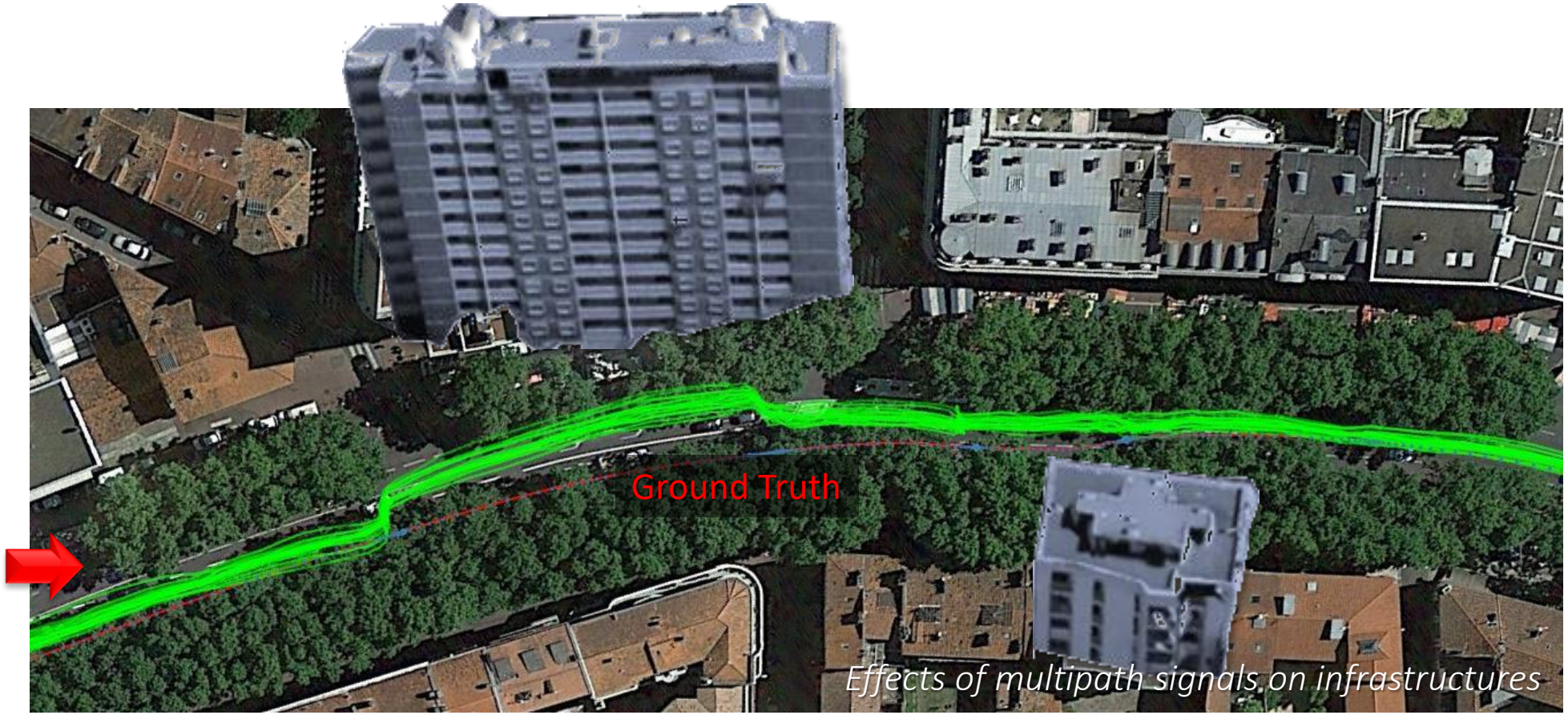
- Obstructions, Attenuations
- Multipath & Diffractions
- Interferences, Jamming,…

Errors caused by the Device (itself)

- Receiving chain
- Algorithms & Services
- Additional sensors

MULTIPATH

Positions from several identical receivers

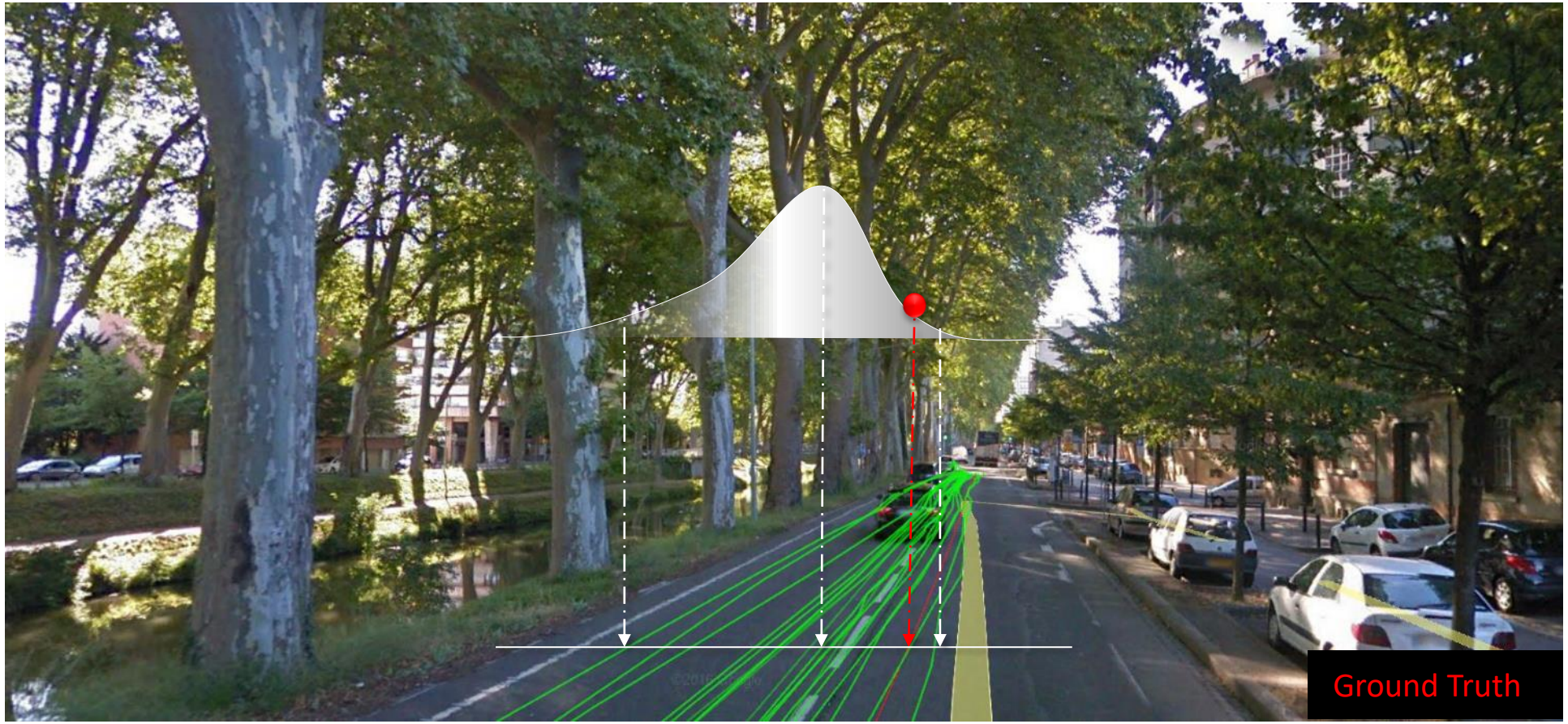


NB.: The trajectories are calculated by the same series of receivers on board a same vehicle

DIFFRACTIONS & ATTENUATIONS

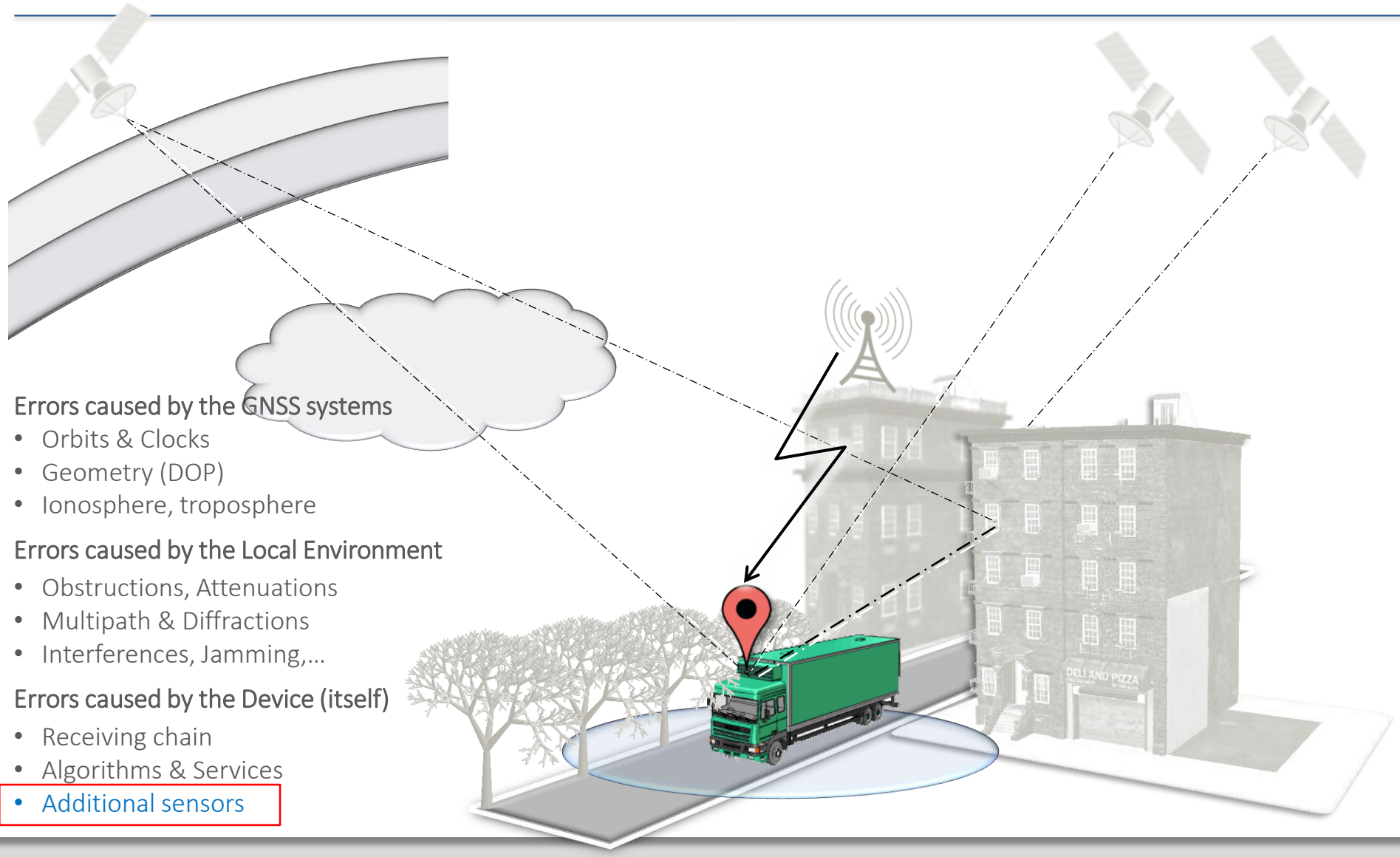
Positions from several identical receivers

1. Random dispersions of Trajectories
2. The passage of a single receiver would be insufficient to decide on its accuracy;



NB.: The trajectories are calculated by the same series of receivers on board a same vehicle

HYBRIDIZATION



Errors caused by the GNSS systems

- Orbits & Clocks
- Geometry (DOP)
- Ionosphere, troposphere

Errors caused by the Local Environment

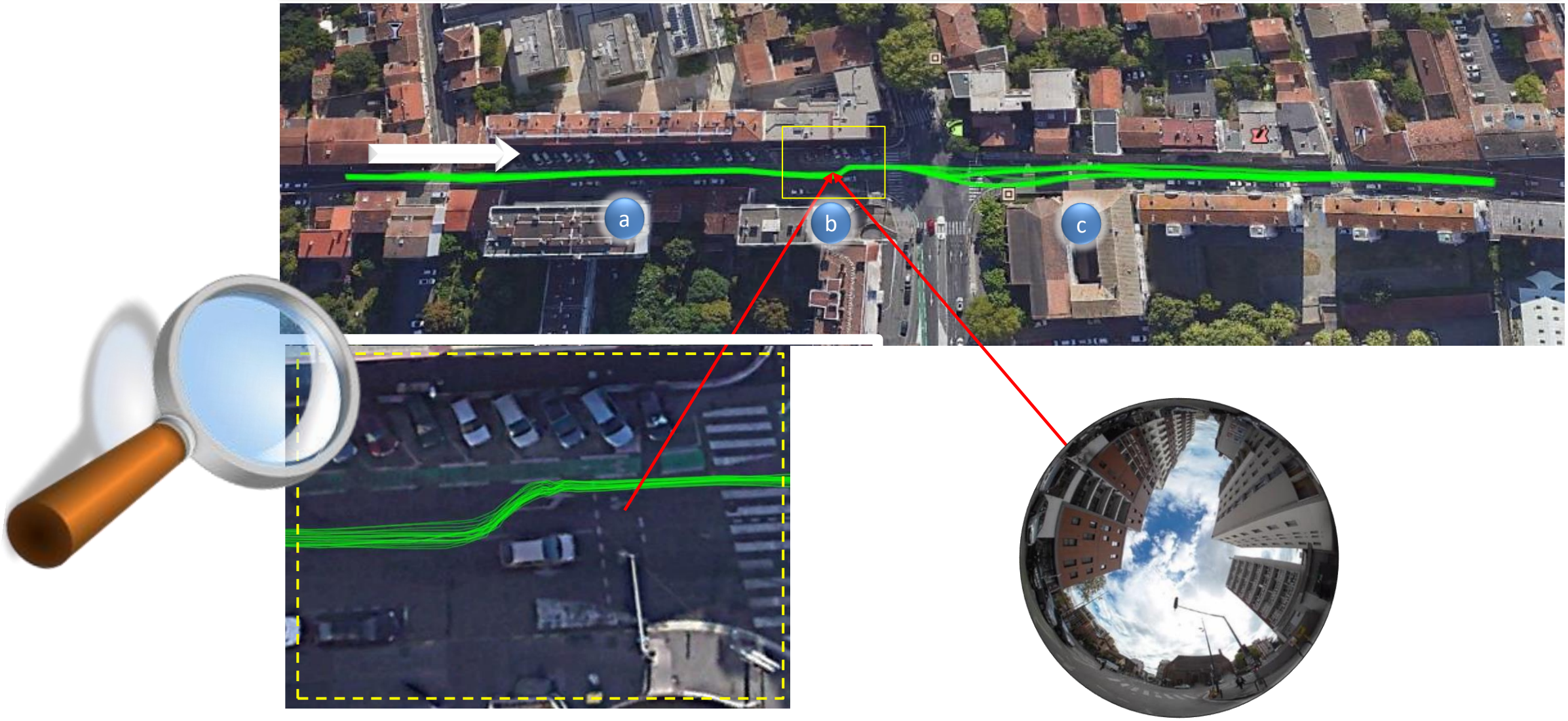
- Obstructions, Attenuations
- Multipath & Diffractions
- Interferences, Jamming,…

Errors caused by the Device (itself)

- Receiving chain
- Algorithms & Services
- Additional sensors

HYBRIDIZATION

Processing of GNSS and IMU measurements during Static Positions



HYBRIDIZATION

Processing of GNSS and IMU measurements during Restarts

NB.: The trajectories are calculated by the same series of receivers on board a same vehicle

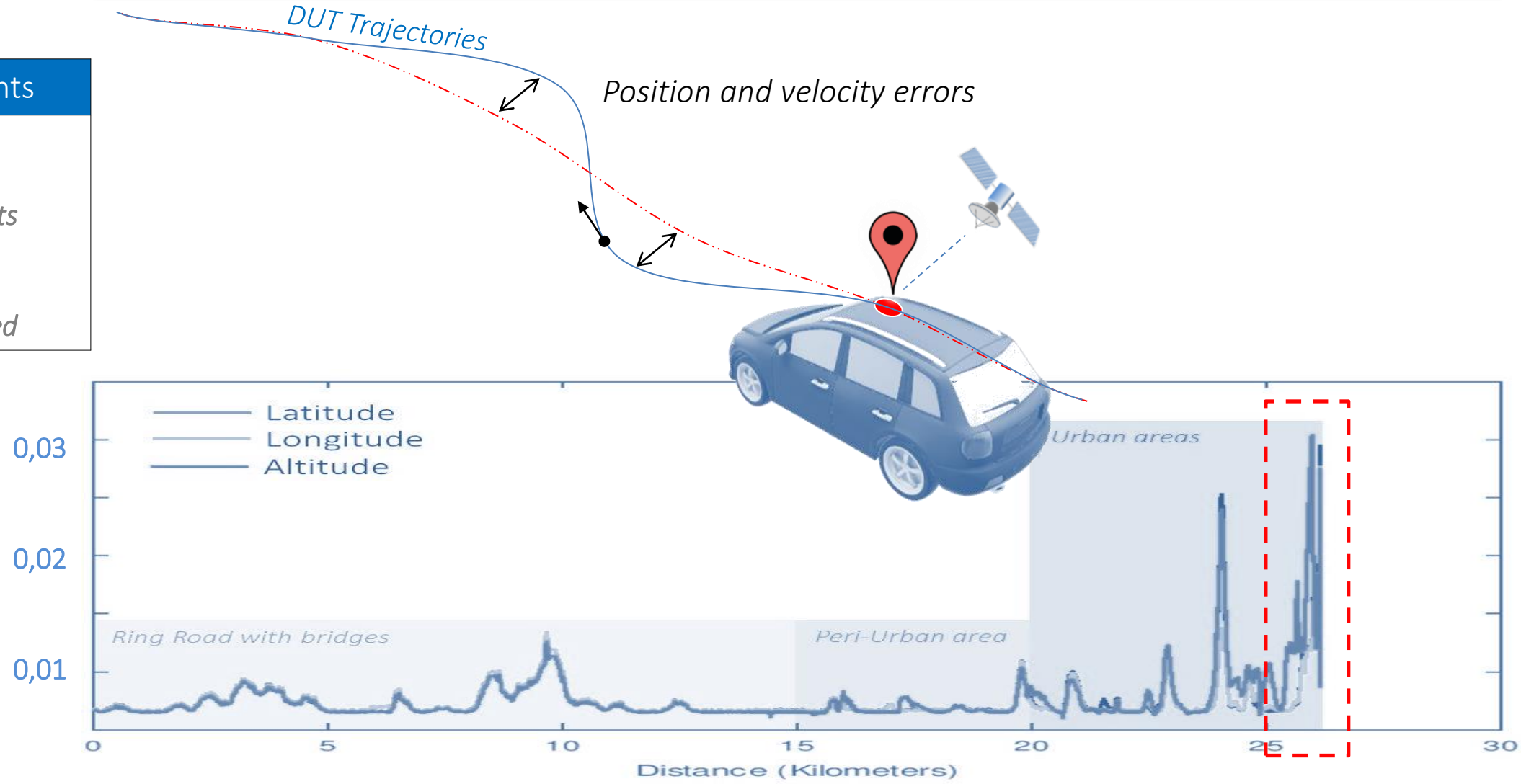
GNSS METROLOGY

GROUND TRUTH

and its measurement uncertainties

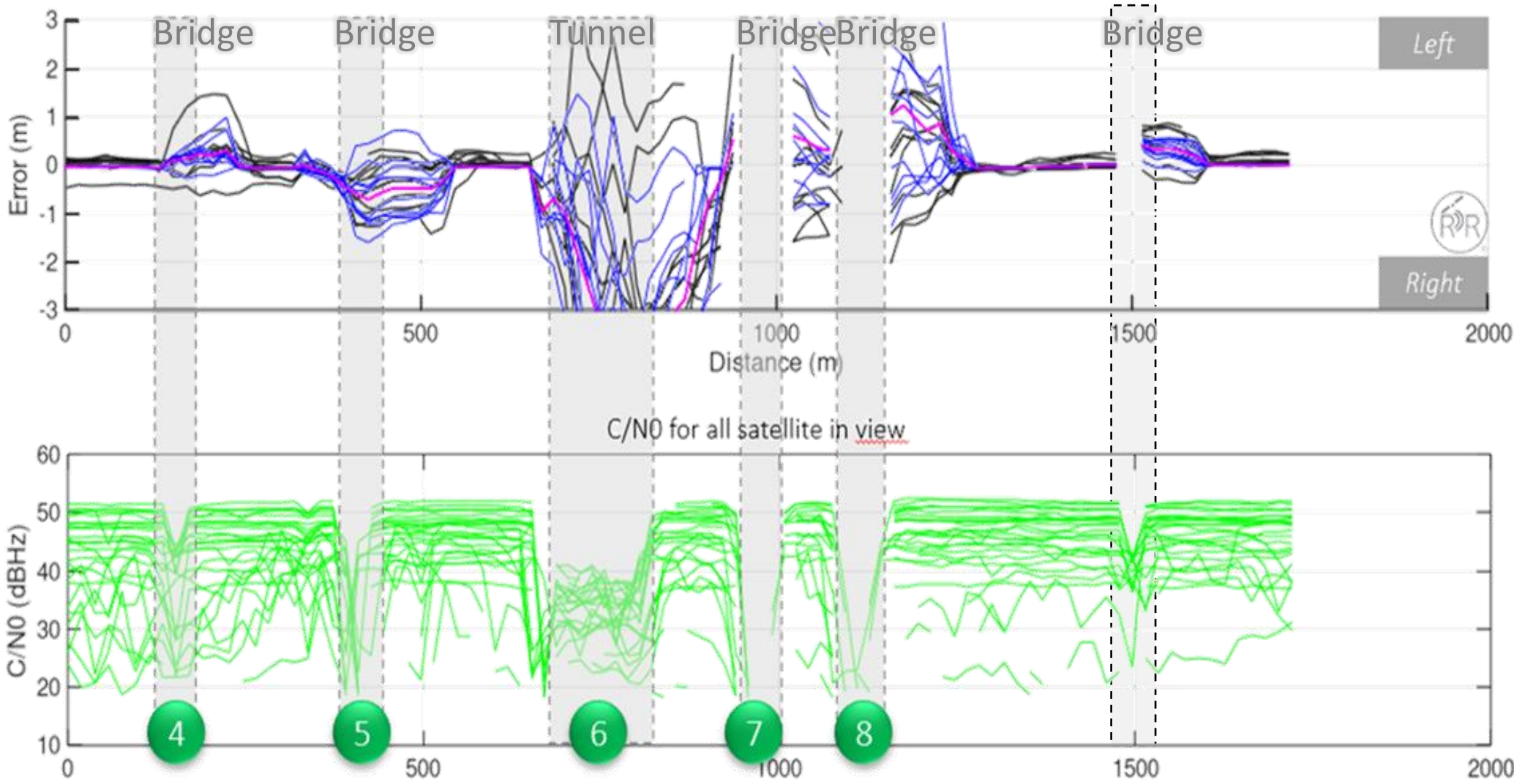
Essential Requirements

- ***Methods** applied*
- ***Operators** skilled*
- *Metrology **instruments** calibrated*
- *Measurement and uncertainties **validated***



SCENARIO (eg) – RING ROAD

Example – Error distribution over a same test trial



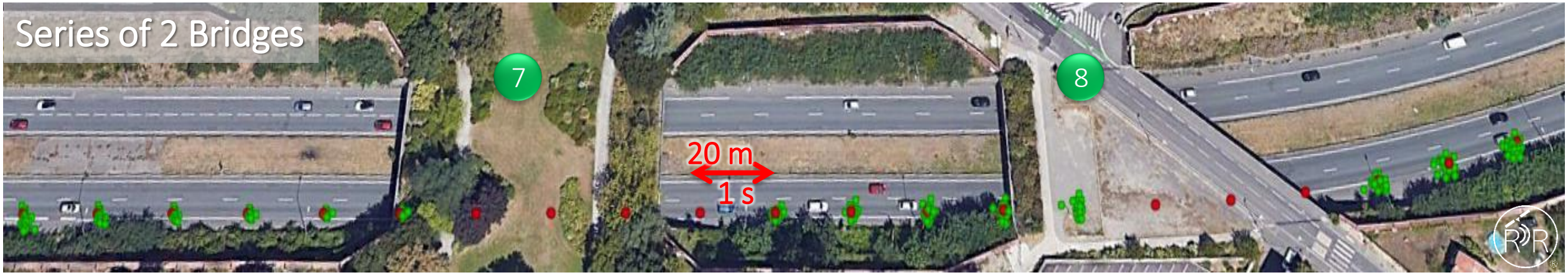
RING ROAD - #6. 7 & 8

Overview – Batches of position measurements

A VIDEO

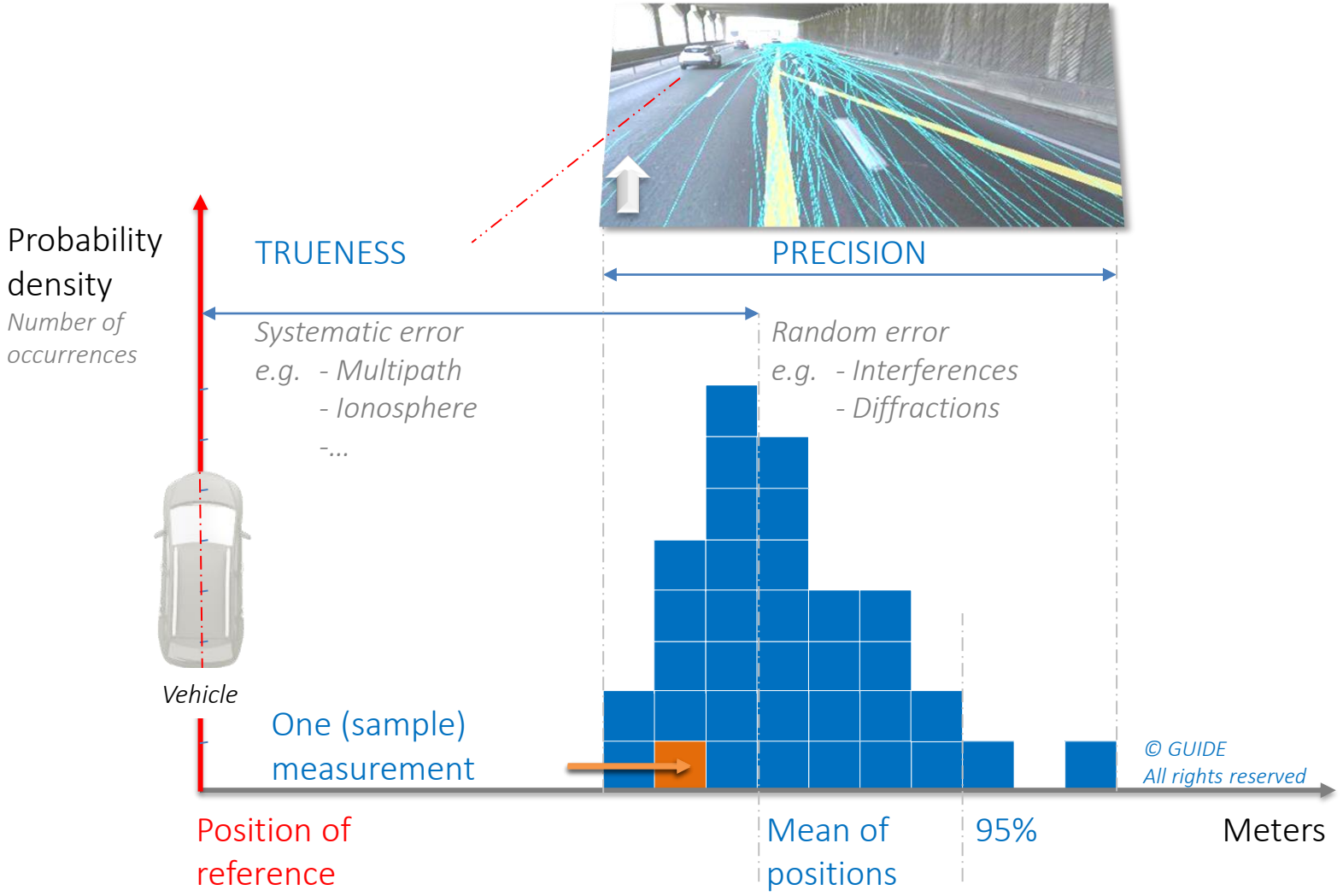
A2 KML

Results



TRUENESS & PRECISION

Metrological quality of performance assessments



It is not possible to conclude on GNSS performances of a given receiver without the signal replay technique.

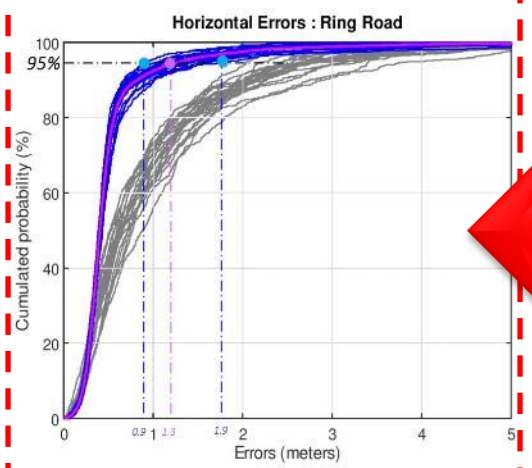
CEN/CENELEC – EN16803-2

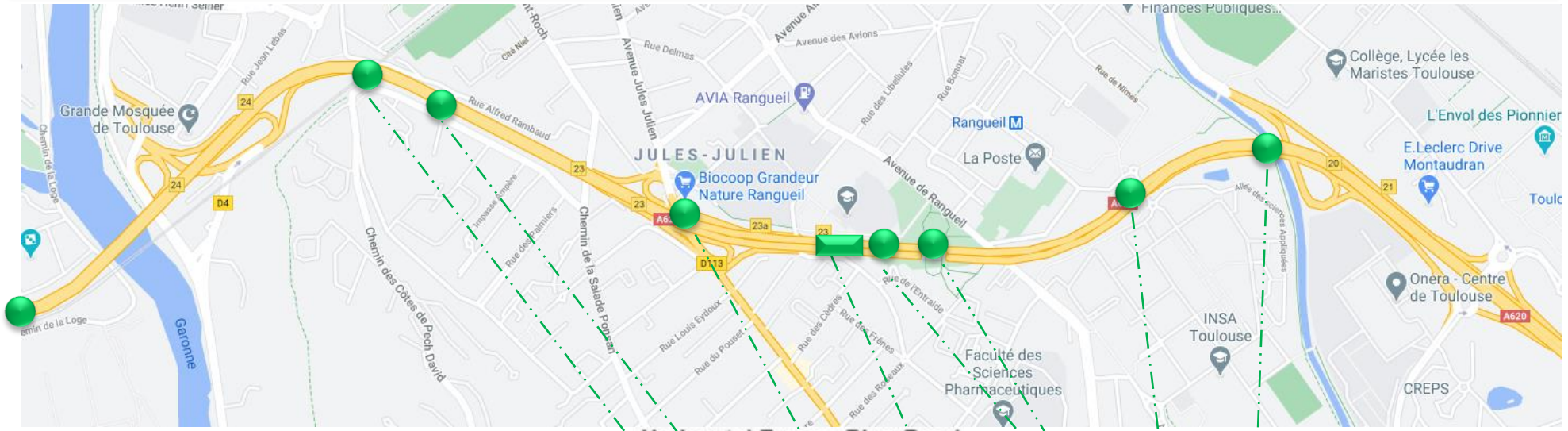
GNSS METRICS

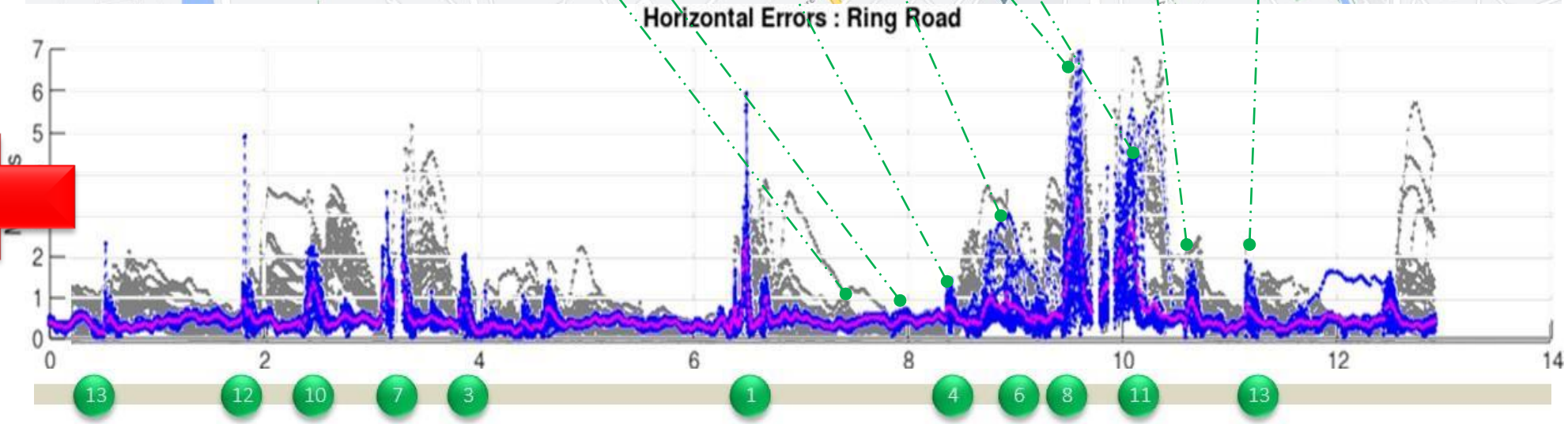
EXAMPLES

Measurements & Statistical Distributions

EN16803



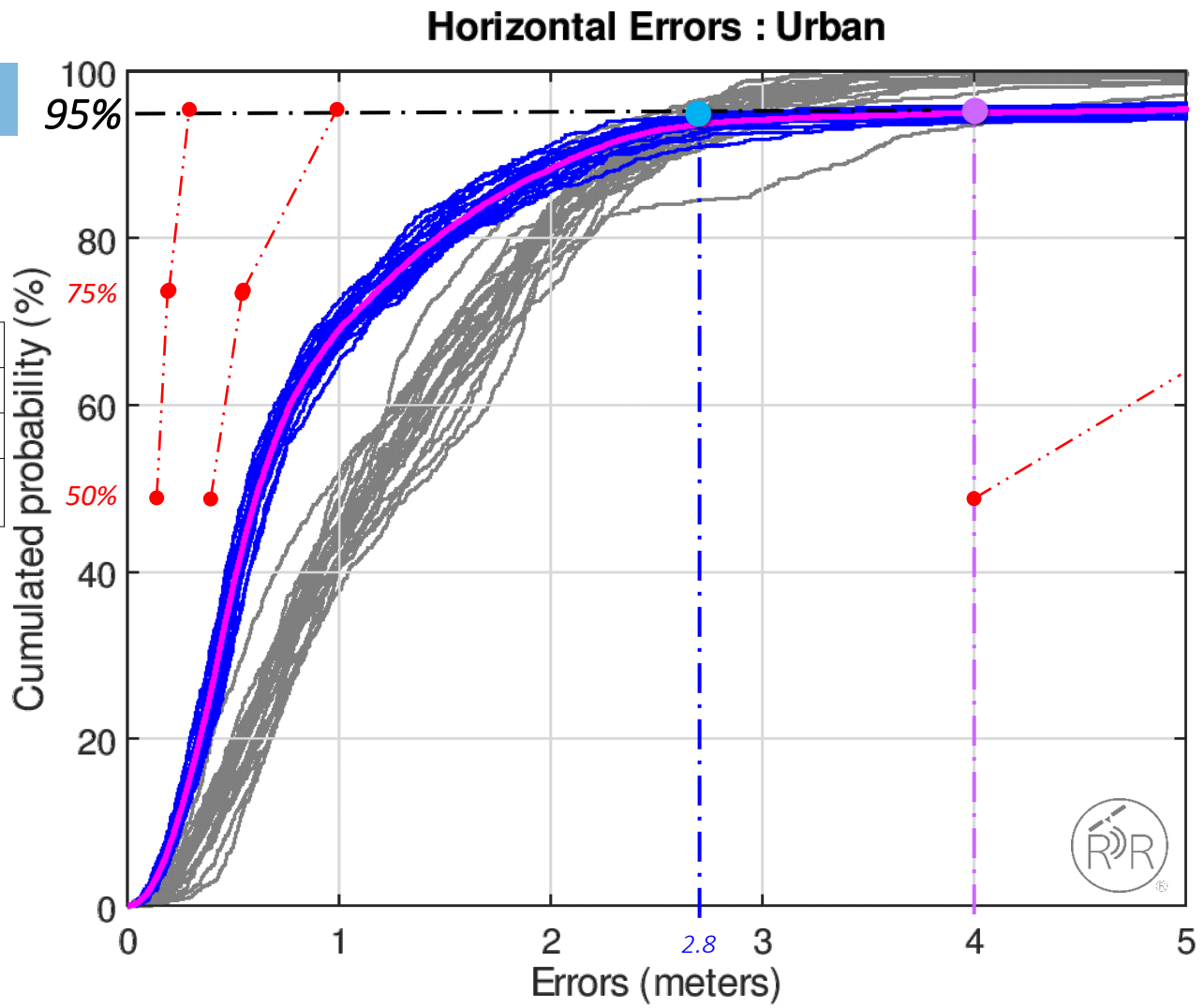




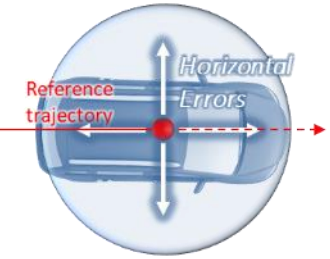
GNSS ASSISTANCE SERVICES

HPE - Comparison of performances between SBAS & Standalone

EN16803



DUT Measurements	
	Batch of positions SBAS
	Mean of positions SBAS
	Batch of positions Standalone



Results

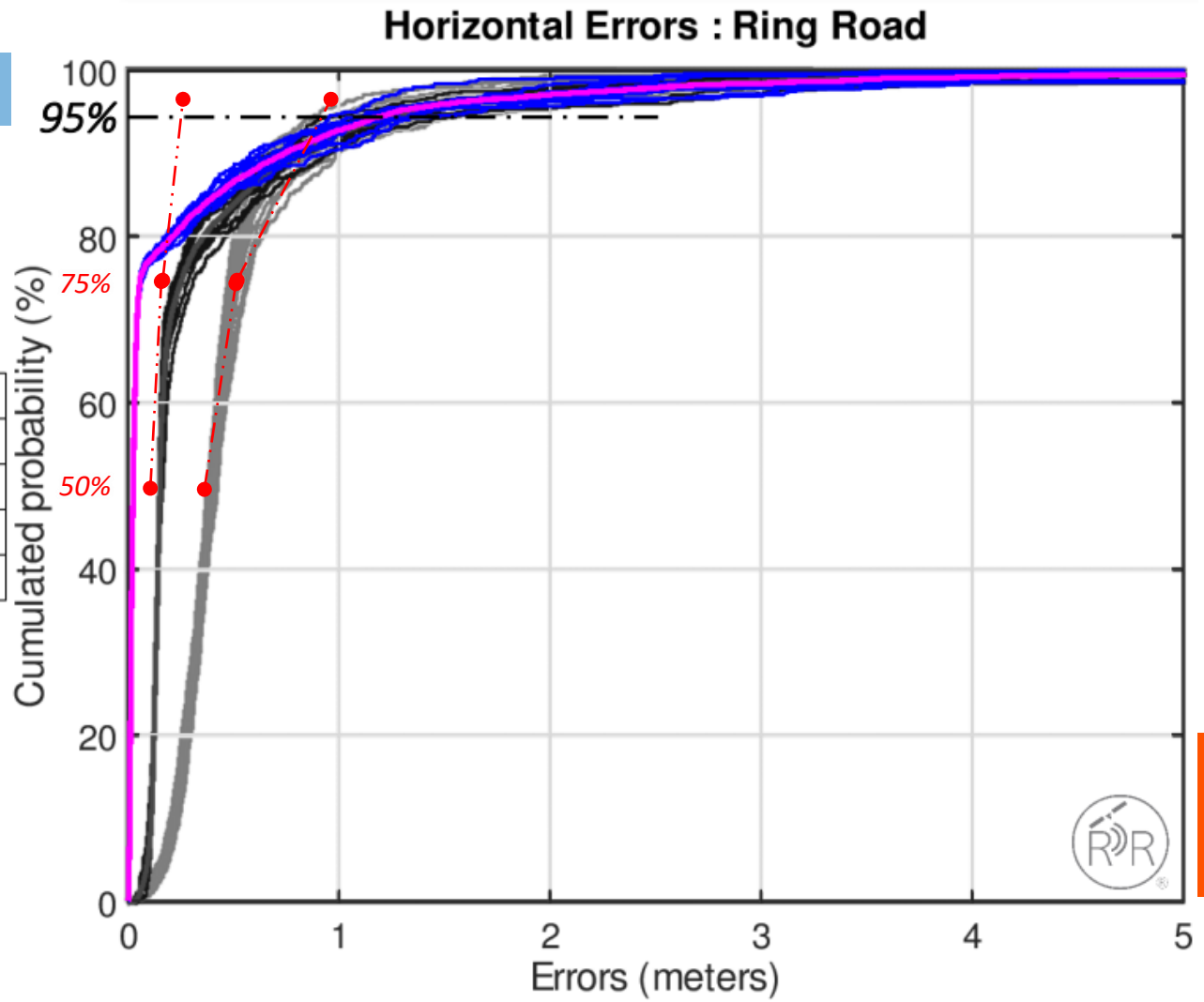
	50 %*		
	Err Mean	Err Max	St Dev
Horizontal	0.60 m	0.70 m	0.05 m
	75 %*		
	Err Mean	Err Max	St Dev
Horizontal	1.30 m	1.40 m	0.10 m
	95 %*		
	Err Mean	Err max	St Dev
Horizontal	4.00 m	6.10 m	0.10 m

**Refered to SBAS corrections active*

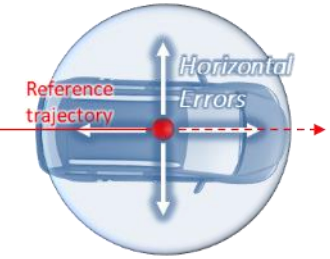
GNSS ASSISTANCE SERVICES

HPE - Comparison of performances between NRTK, PPP-RTK and SBAS

EN16803



DUT Measurements	
	Batch of positions NRTK
	Mean of positions NRTK
	Batch of positions SBAS
	Batch of positions PPP-RTK

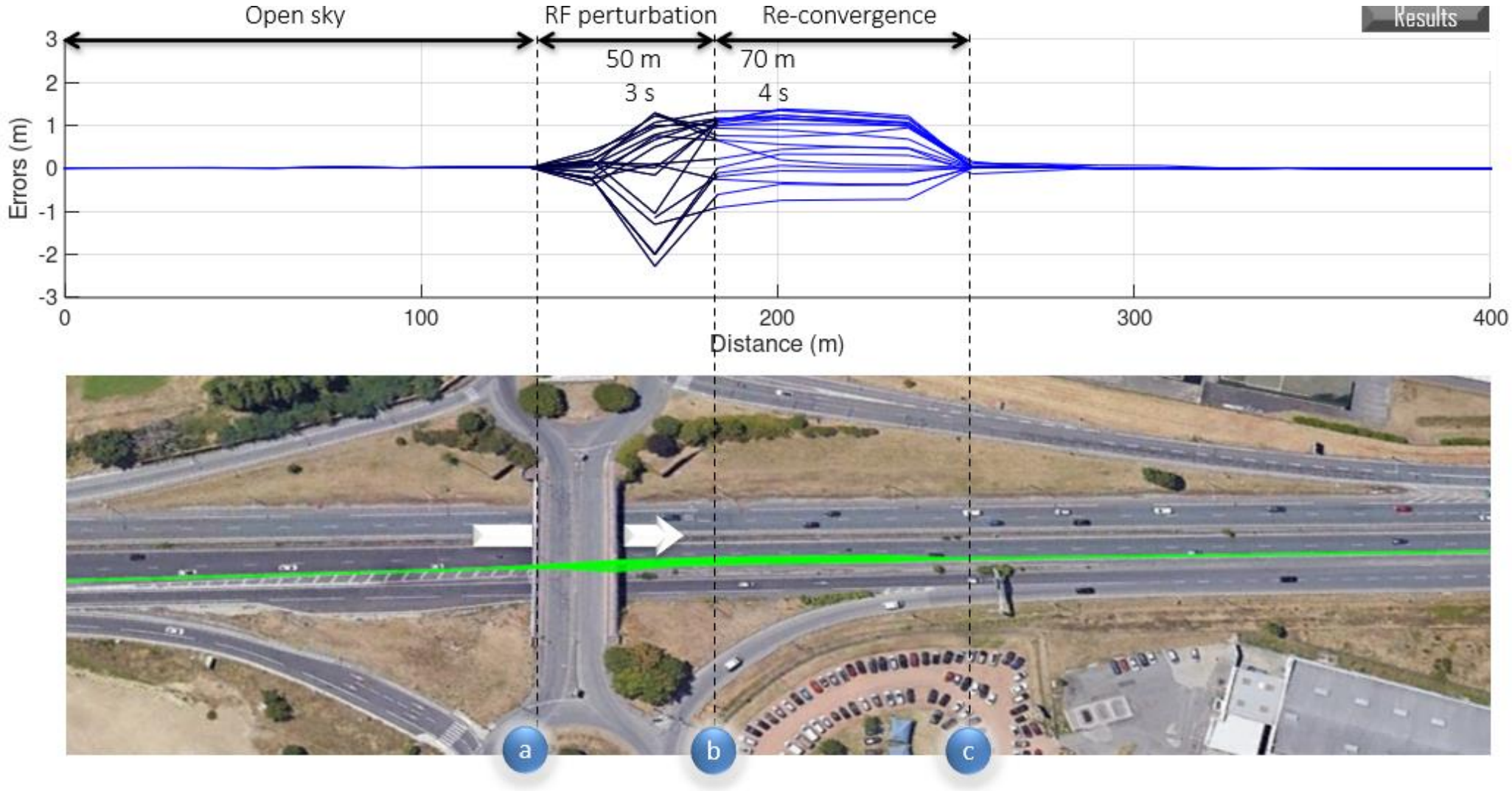


Data corrections provided by

METRICS

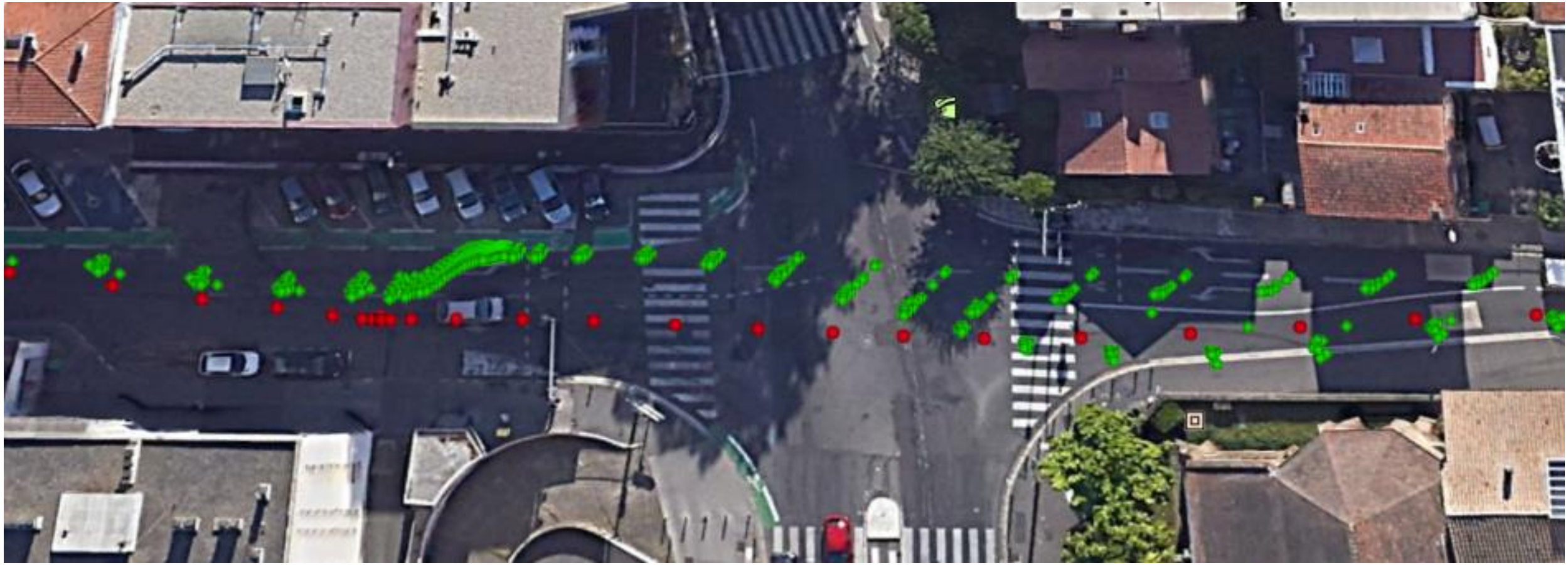
Time of Reconvergence – e.g. measurements assisted by a NRTK service

DUT Measurements	
	Batch of positions
	Batch of positions with RF pertubation



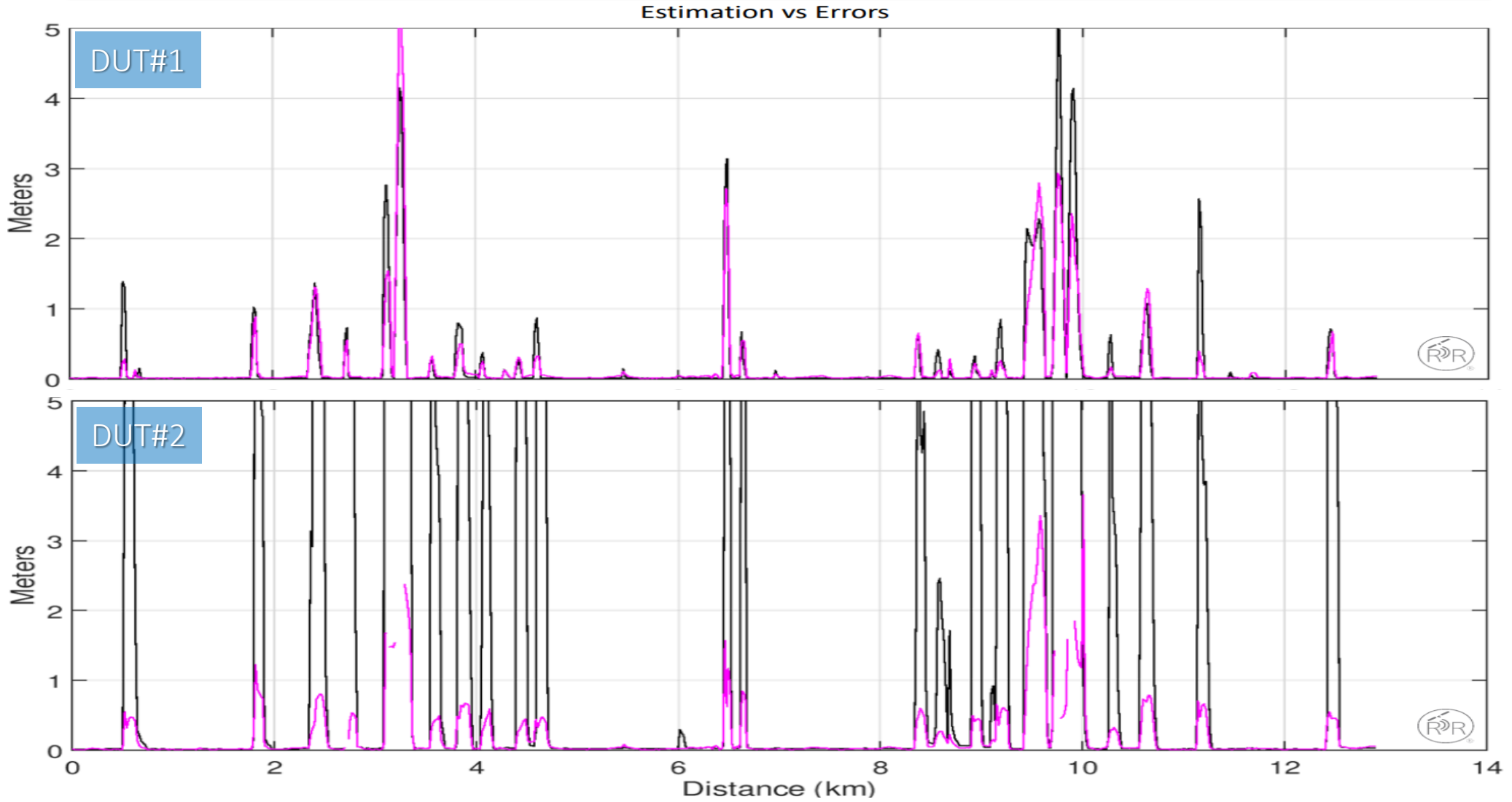
METRICS

Multipath Mitigation – Deviation of measured positions at a stop



METRICS

Self Estimation of position errors



GALILEO

GPS-Free operations

Why use signals from satellites of this European constellation?

GNSS CRITERIA TO CONSIDER		Types of Environments		COMMENTS
		Open Sky	*Constraint*	
PRECISION	STANDALONE/SBAS	○	●	The performances are sufficient with the other constellations (GPS, GLONASS, BEIDOU)
	(N)RTK/PPP-RTK	○	●●	
INTEGRITY		○	●	
AVAILABILITY		○	●●	
STRATEGIC INDEPENDENCE		**???**	**???**	**Most receivers cannot operate without GPS signals**
SERVICES				No available yet

METRICS

Measurement uncertainty

TECHNOLOGIES	POSITIONING PERFORMANCE METRICS
GNSS ONLY - STANDALONE - SBAS	• Horizontal / Vertical Position Errors • Velocity Error NB.: 50%, 75%, 95% according to characterized environments
ASSISTED GNSS - (N)RTK - PPP - PPP-RTK	• **Time of reconvergence** after a characterized perturbation (e.g.: Bridge,…) • Rate of **availability in high precision** / Standard scenarios • **Reliability** (*reproductiveness*)of calculated positions / Standard scenarios • **Multipath** mitigation • **Self estimations** of errors • **GPS-free** operations

CONCLUSIONS

CONCLUSIONS

Terminaux GNSS
- *Hardware*
- *Firmware*
- *Paramétrages*
- *Antennes*
- *Hybridation*

Corrections GNSS
- *Services*
- *Réseaux*
- *Territoires*

L'exploitation des technologies GNSS pour des applications avancées est conditionnée par une plus grande confiance dans les performances annoncées:

Il faut donc :

1. **Définir** et afficher des caractéristiques techniques-clefs;
2. **Faire valider** ces caractéristiques par des laboratoires spécialisés et indépendants;
3. **Harmoniser** les métriques de ces caractéristiques;

END OF THE TEST REPORT

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