

PRECISE POSITIONING FOR MASS-MARKET : OPTIMAL DATA DISSEMINATION DEMONSTRATOR

NAVISP-EL1-036 - ESA Contract No.
4000129782/20/NL/LW

24/11/2023



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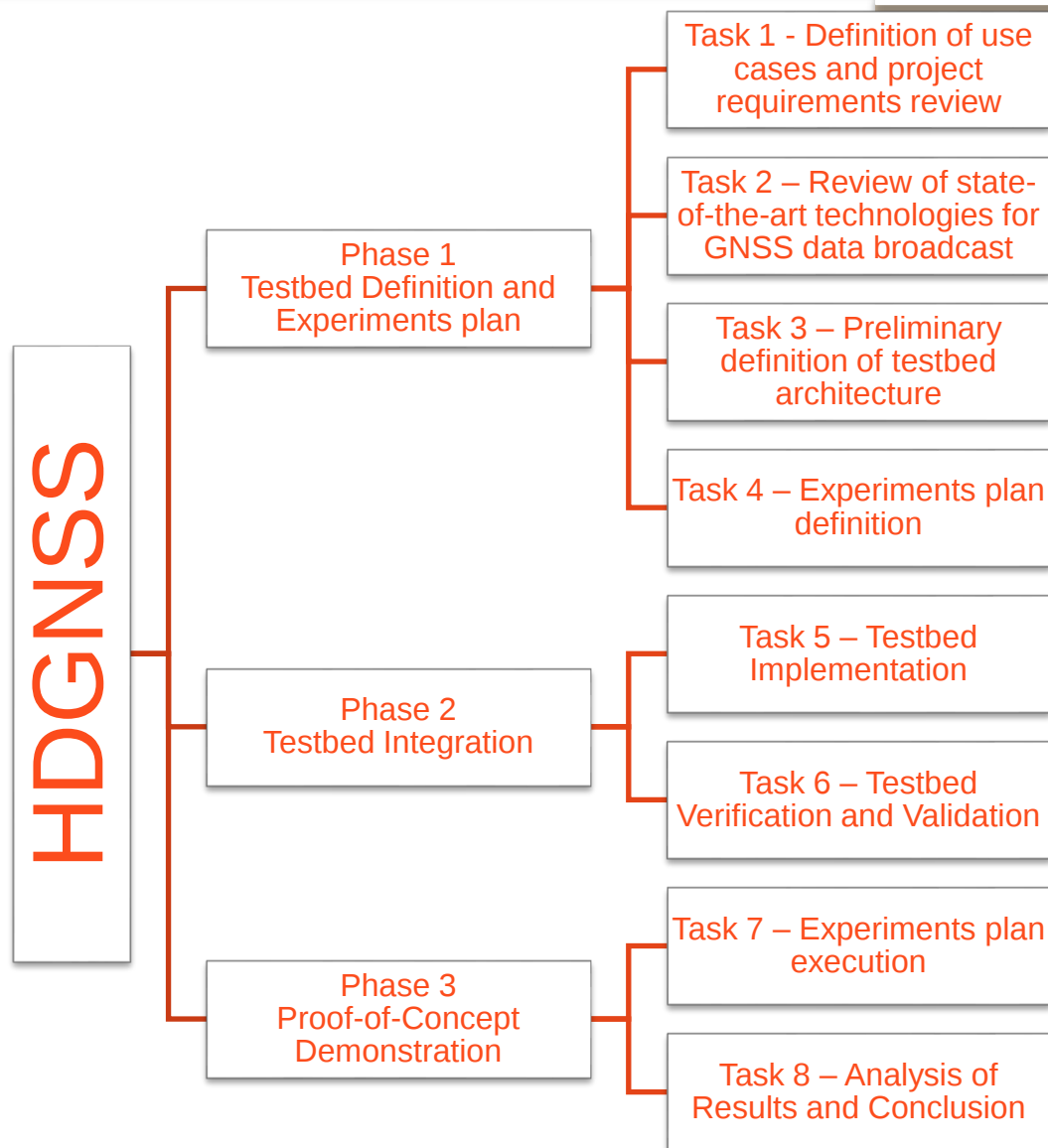
Samar Kaddouri



teria

Background and objectives of the project





Limits of the NTRIP protocol and RTCM standards

Type	Content	Size [bits] ^{*)} (upper bound)
1070	reserved	
1071	GPS MSM1 Compact GNSS Pseudoranges	$213+N_s*(10+16*N_c)$
1072	GPS MSM2 Compact GNSS PhaseRanges	$213+N_s*(10+25*N_c)$
1073	GPS MSM3 Compact GNSS Pseudoranges and PhaseRanges	$213+N_s*(10+40*N_c)$
1074	GPS MSM4 Full GNSS Pseudoranges and PhaseRanges plus CNR	$213+N_s*(18+46*N_c)$
1075	GPS MSM5 Full GNSS Pseudoranges, PhaseRanges, Doppler and CNR	$213+N_s*(32+61*N_c)$
1076	GPS MSM6 Full GNSS Pseudoranges and PhaseRanges plus CNR (high resolution)	$213+N_s*(18+63*N_c)$
1077	GPS MSM7 Full GNSS Pseudoranges, PhaseRanges, Doppler and CNR (high resolution)	$213+N_s*(32+78*N_c)$
1078	reserved	
1079	reserved	

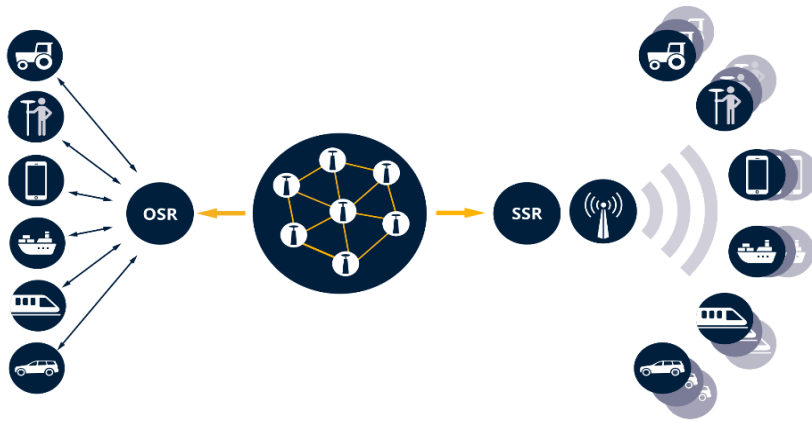
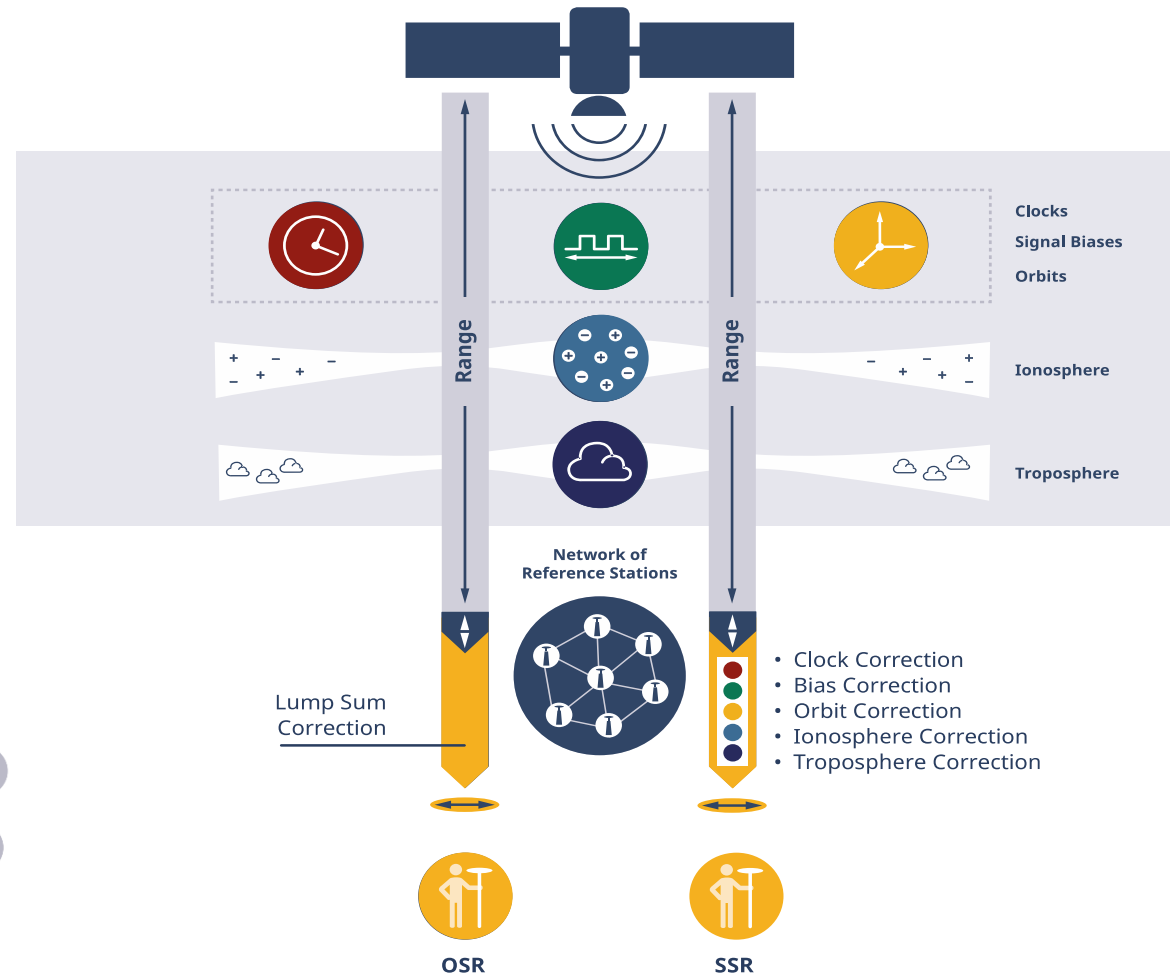
N_s : number of satellites (range: 1 ... 64)

N_c : sum of number of signals (range: 1 ... 32)

- Rover needs corrections a data stream of 8024 bits/sec
- NTRIP server will reach his limitation as soon as 125.000 requests
- So for mass market applications new methods have to be set.

OSR vs. SSR Corrections

- Observation Space Representation **OSR**
 - **lump sum of error corrections**
 - **bidirectional** communication
- State Space Representation **SSR**
 - **corrections for individual error sources**
 - intrinsically **broadcastable**



SSRZ Format - SSR models and messages

Basic SSR Parameter	SSR Models	Comments	Msg
 clock	high rate clock	related to BE	HR
	low rate clock	related to BE	LR
 orbit	orbit	related to BE; radial, along, across	LR
	velocity	related to BE; radial, along, across	LR
 bias	code Bias		LR
	phase Bias	in units of cycle	LR
 ionosphere	global VTEC	Spherical harmonics	GVI
	global STEC	Chebyshev Polynomials (per SV)	LR
	regional STEC	Chebyshev Polynomials (per SV)	RSI
	gridded STEC	native grids	GRI
 troposphere	global tropo	in preparation	TBD
	regional tropo	scale factor for wet, dry, total; Cheby. Poly	RT
	gridded tropo	native grids, scale factor for wet, dry, total	GRT

Testbed Definition, Verification and Validation



State-of-the-art - DAB+ coverage

Filter [X]

Clutter selection

☒ 0 open	☒ 10 rail
☒ 1 village	☒ 11 road
☒ 2 suburban	☒ 12 airport
☒ 3 urban	☒ 13 Tunnel
☒ 4 dense urban	☒ 14 open rural
☒ 5 forest	☒ 15 b-plester
☒ 6 hydro	☒ 16 b-brick
☒ 7 high urban	☒ 17 b-glass
☒ 8 park/wood	☒ 18 b-wood
☒ 9 building	☒ 19 border

DEM selection

minimum elevation (m)

maximum elevation (m)

Vector selection

☐ Extd station radius limited

☐ Station sector limited ...

☒ Vector polygon limited

☐ Vector polygon extended in

☐ Vector polygon extended out

☐ Vector line limited

☐ Vector path limited

Max distance (m)

Move to clutter code -1 = none

Filter selection

☐ Interference

minimum value

maximum value dBμV/m

☐ Remove pixel if neighbours are different

Range (pixel)

Area covered (%)

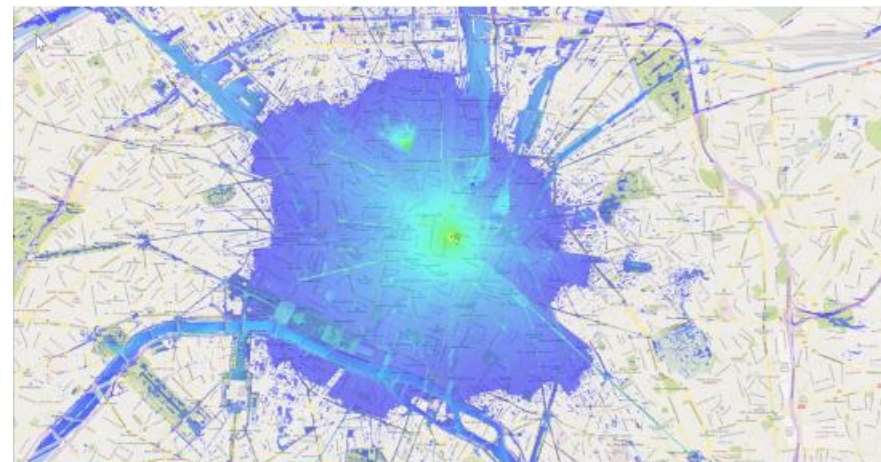
Area covered (km2)

Total area (km2)

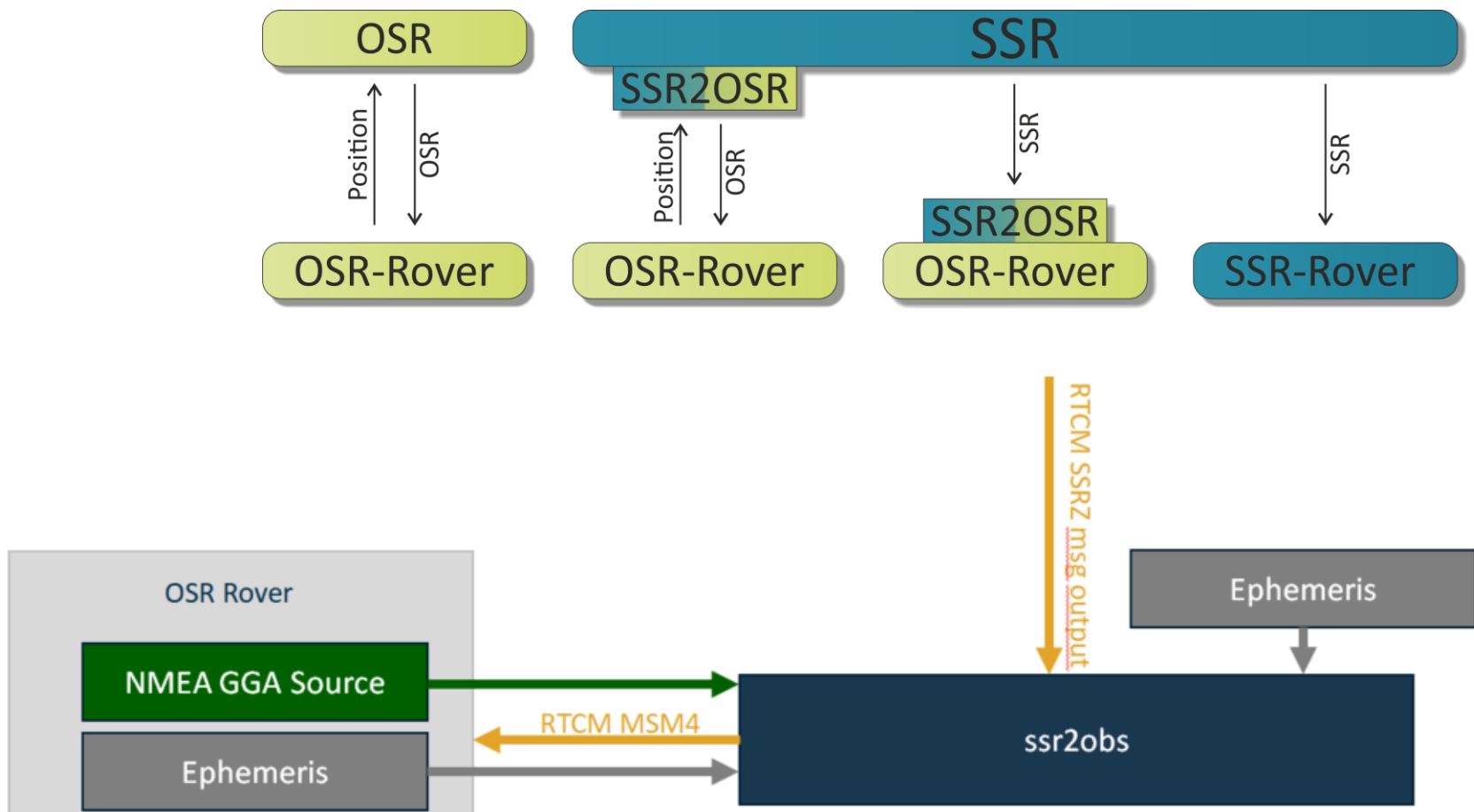
Line/Path length (km)

Mean value (dBμV/m)

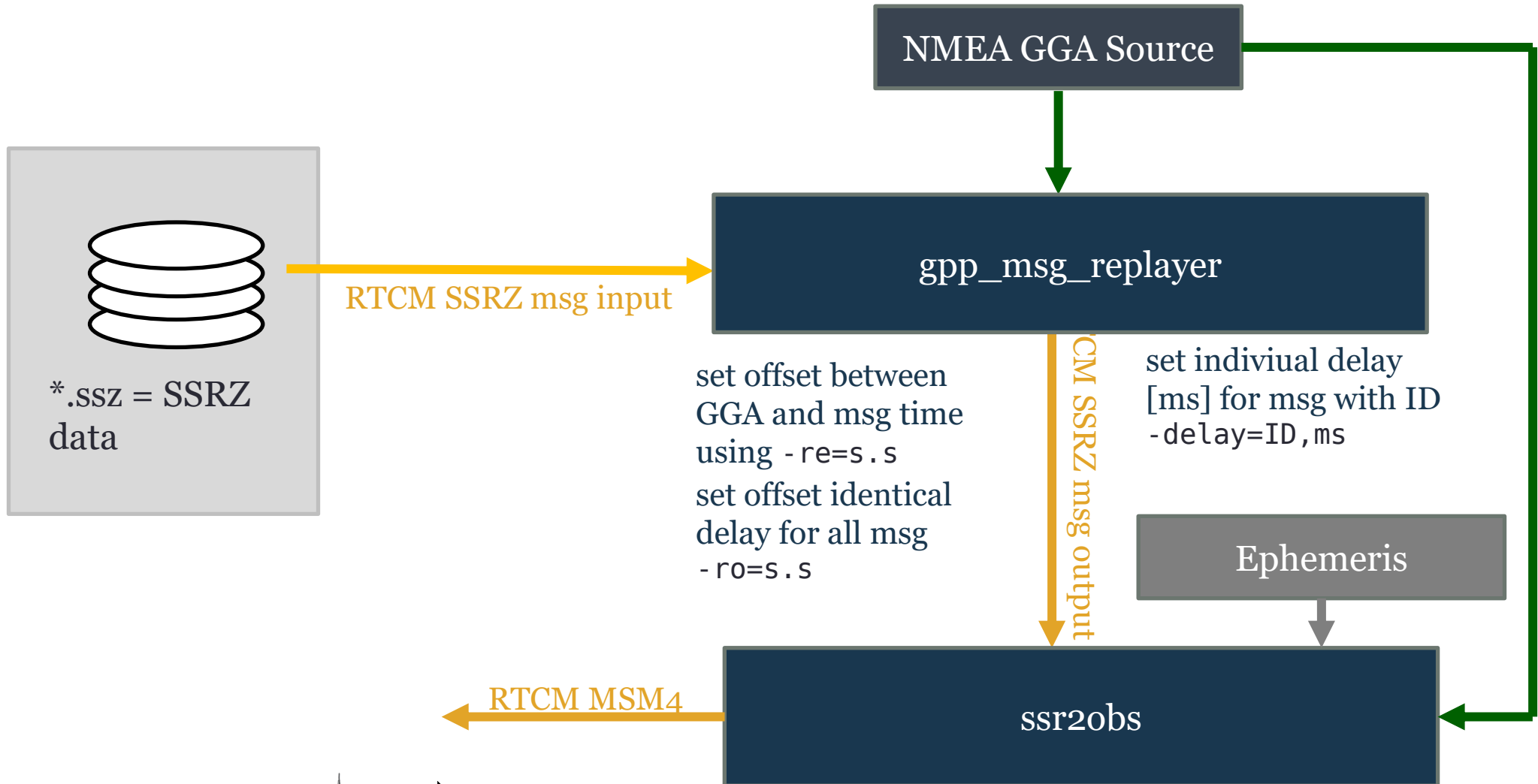
Reports



SSR2Obs

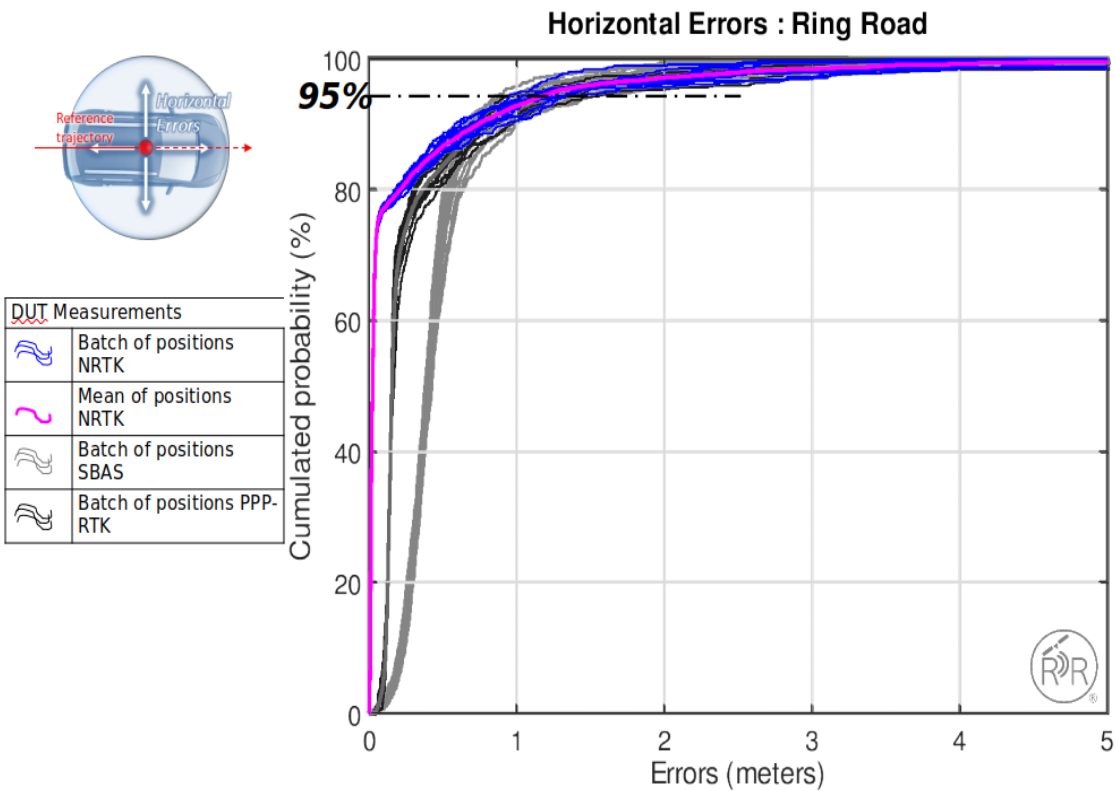


Geo++ Message Replayer Scheme



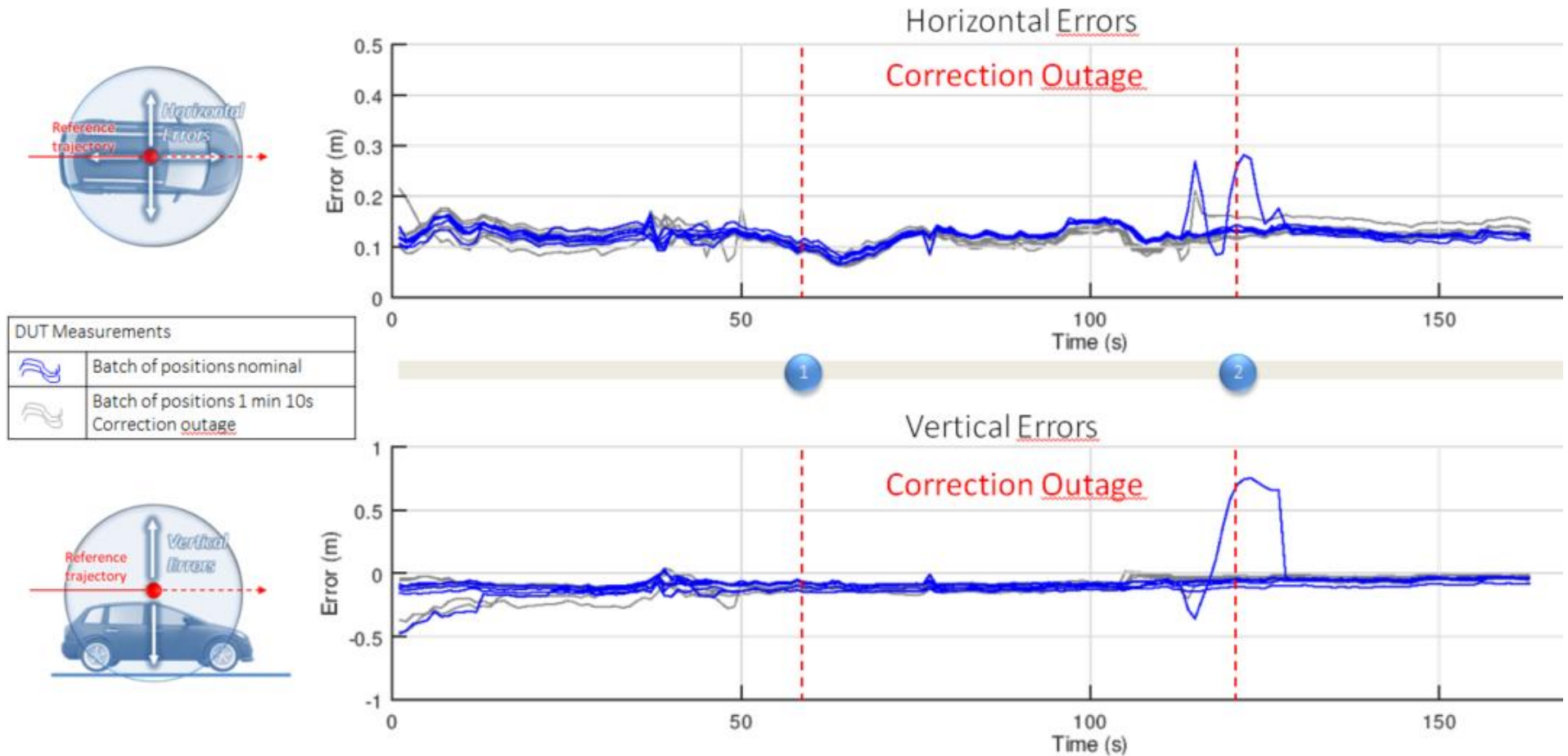
RTK vs PPP-RTK

RING ROAD – Global - Statistics – Horizontal Errors

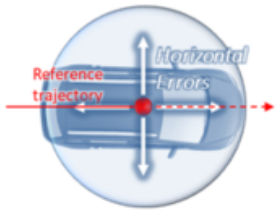


		50 %		
		Err Mean	Err Max	St Dev
Horizontal	SBAS/Stand.	0.40	0.44	0.02
	NRTK	0.03	0.03	0.01
	PPP-RTK	0.15	0.17	0.01
		75 %		
		Err Mean	Err Max	St Dev
Horizontal	SBAS/Stand.	0.52	0.58	0.03
	NRTK	0.06	0.07	0.01
	PPP-RTK	0.26	0.31	0.03
		95 %		
		Err Mean	Err max	St Dev
Horizontal	SBAS/Stand.	1.33	1.87	0.23
	NRTK	1.28	1.61	0.15
	PPP-RTK	1.34	1.65	0.18

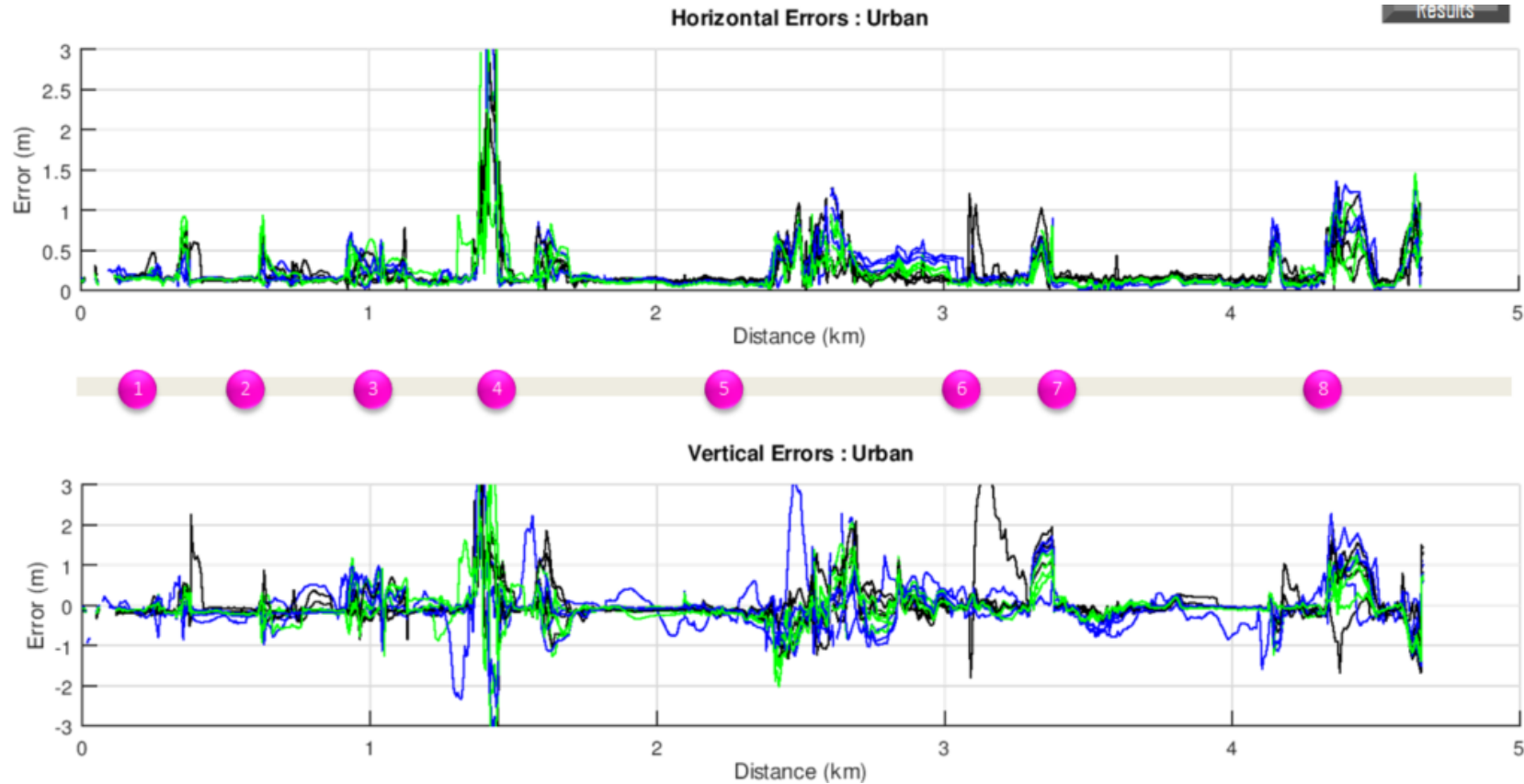
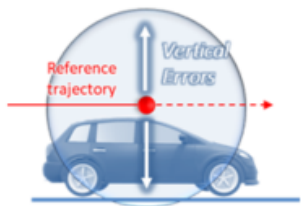
Resilience of SSRZ - Correction Outage



Resilience of SSRZ - Correction Delay



DUT Measurements	
	Batch of positions 10s delay
	Batch of positions 5s delay
	Batch of positions nominal



DAB+ Demonstrator and Experimentation

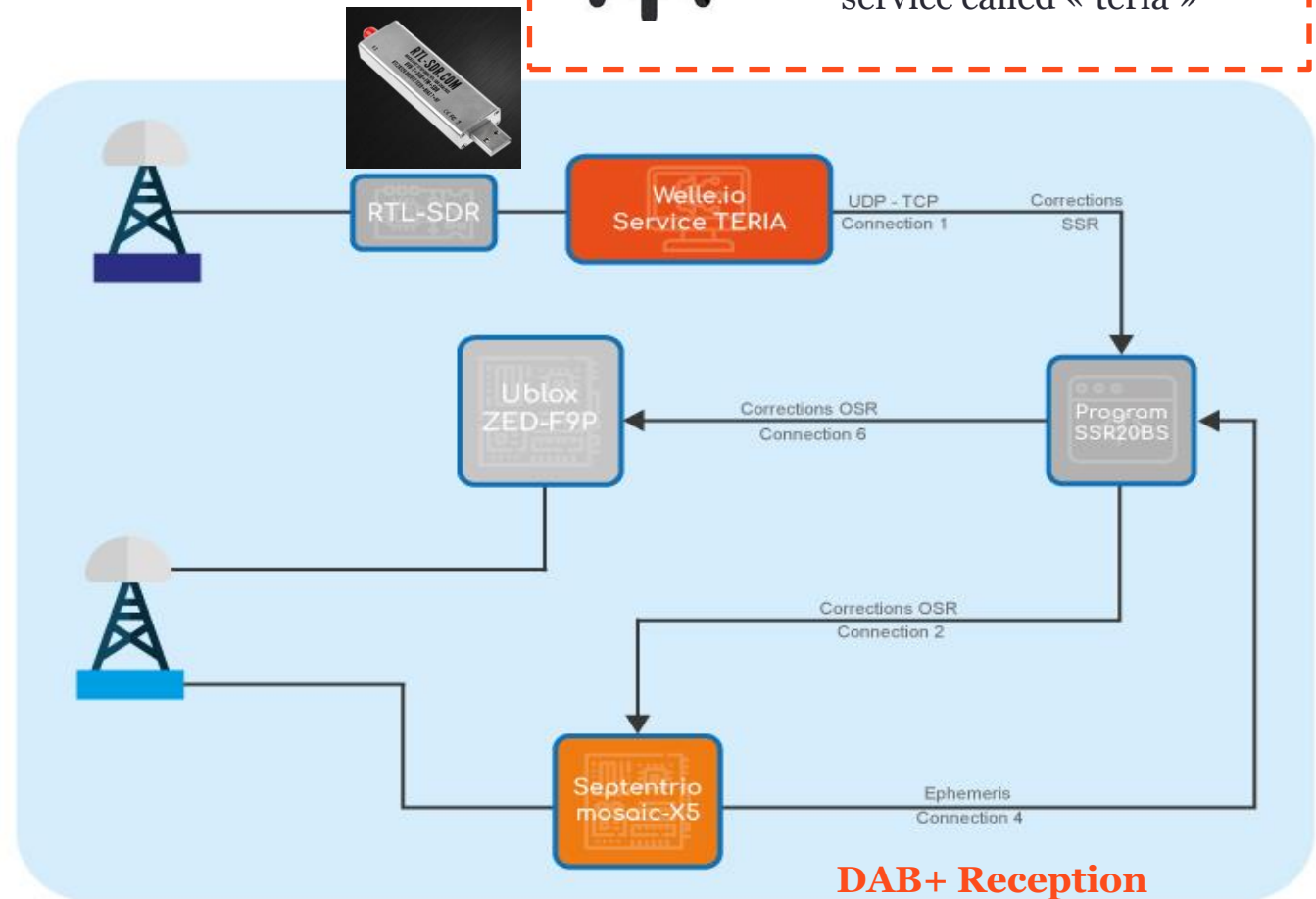


DAB + Demonstrator

DAB+ Receiver : RTL-SDR
channel 6B - 183.648 MHz

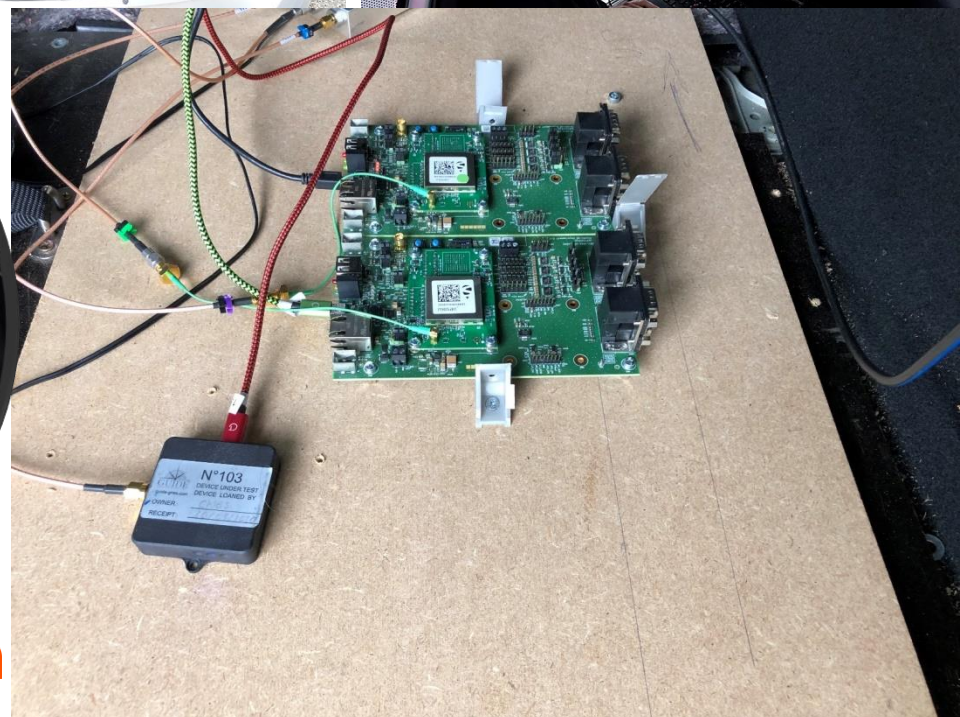
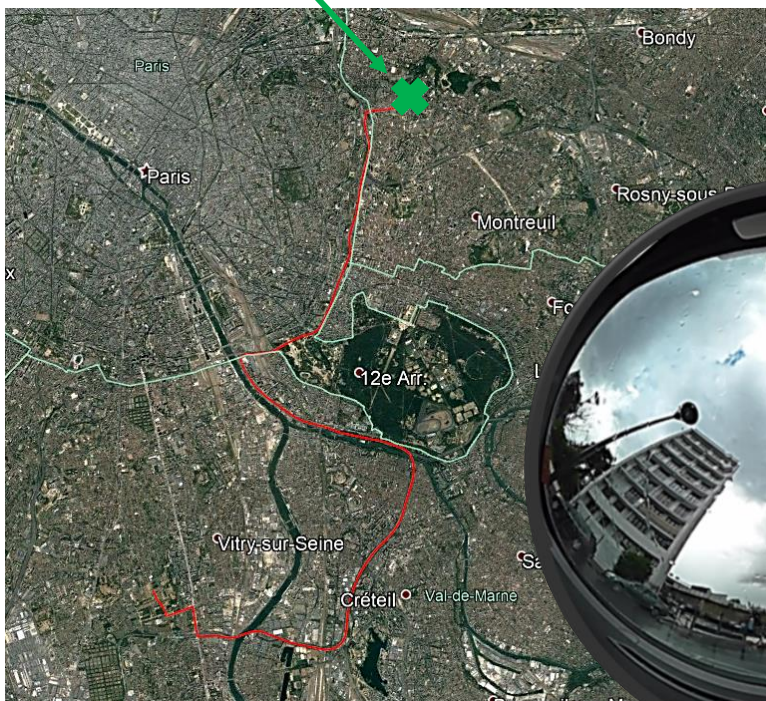
GNSS Receivers : Ublox
ZED-F9P and Septentrio
mosaic-X5

GNSS corrections : SSRz +
Ephemeris



Experimentation in Paris

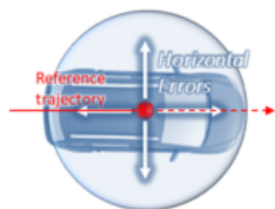
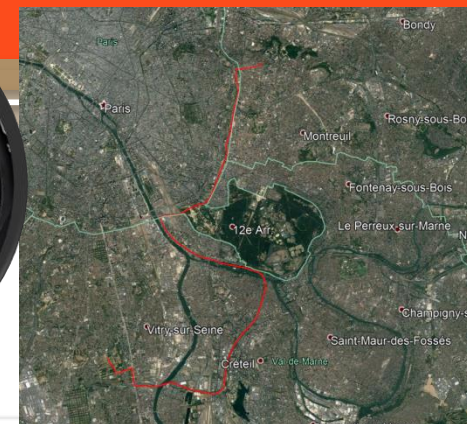
**DAB+
Transmitter**



4 scenarios

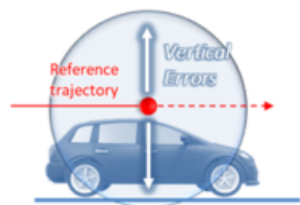
210519	1A Peripheral Roads and Highway	1B National Road	2A Urban Environment near Transmitter	2B Urban Environment away from Transmitter
Environment Profiles	RING ROAD	PERI-URBAN	URBAN ENVIRONMENT	
Vehicle	Mini Van – Renault Scenic		Mini Van – Renault Scenic	
Length	17.9km	28.2 km	5.9km	11.8 km
Duration	48 mn	106 mn	28 mn	51 mn
Loops	1	1	1	1
Height difference	No significant slopes	No significant slopes	No significant slopes	No significant slopes
Velocity	0-90 km/h; relevant traffic jam	30 – 50 km/h	0-50 km/h	0 – 70 km/h
Effects - Obstructions	Bridges	Bridges	No	No
Effects - Multipaths	No major source	Buildings on roadsides	Buildings on roadsides	Buildings on roadsides
Effects - Diffractions	No major source	Canopies	Canopies	Canopies

Scenario 1A

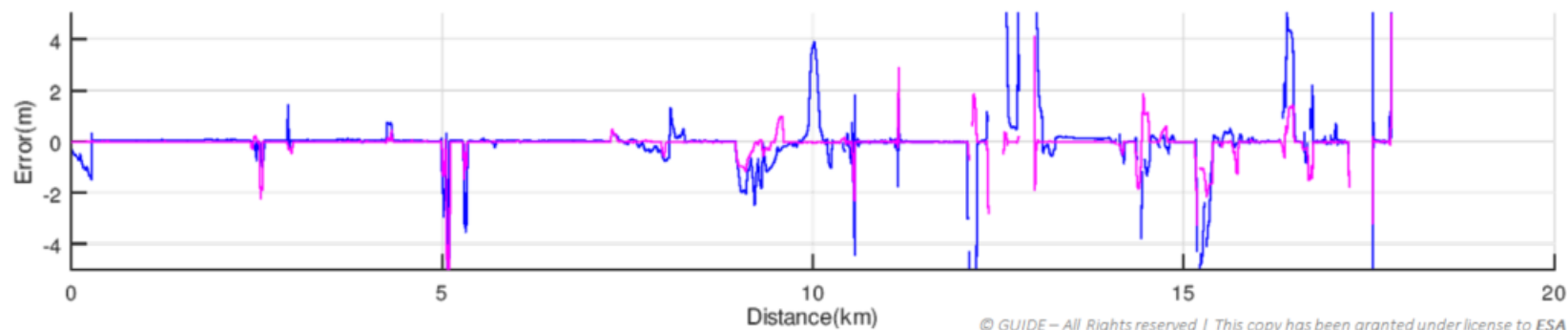


DUT Measurements	
	DAB+ PPP-RTK Corrections
	NTRIP NRTK Corrections

Horizontal Errors



Vertical Errors

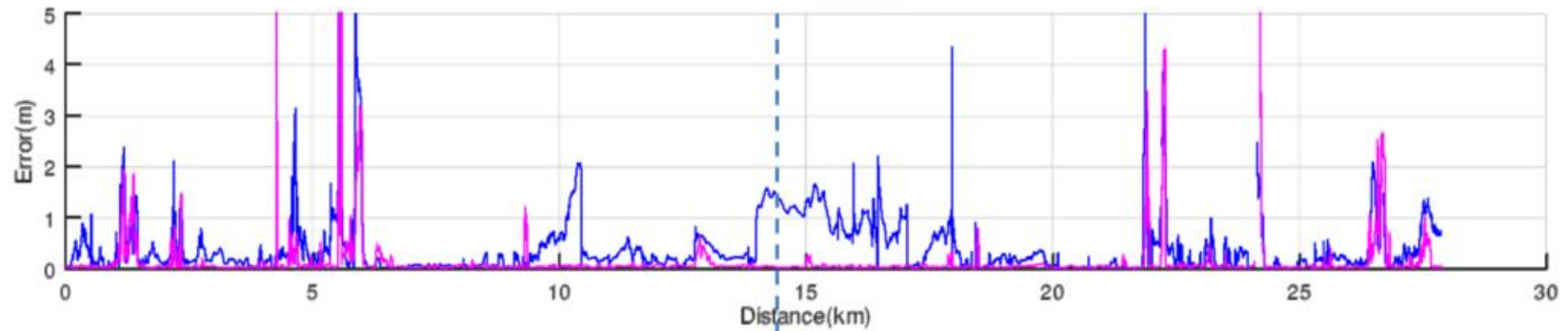


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Scenario 1B



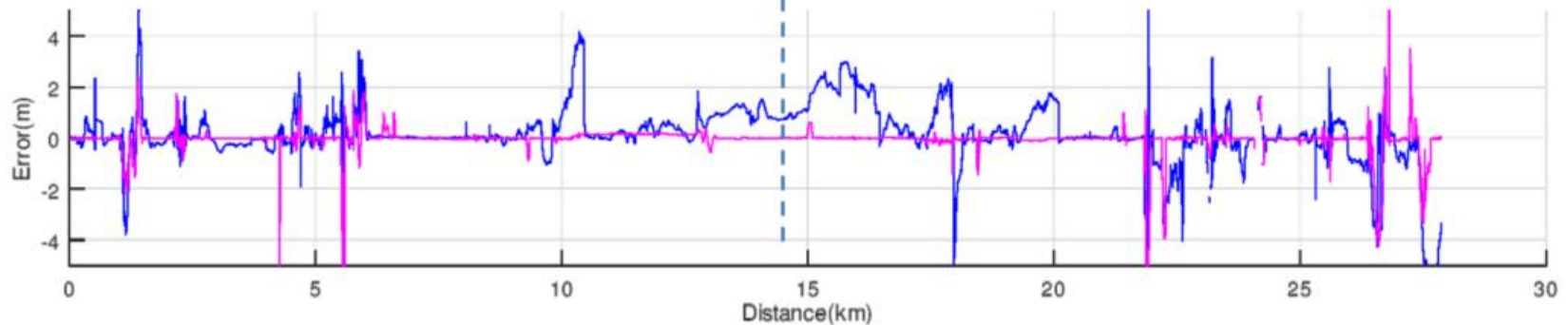
Horizontal Errors



Outbound

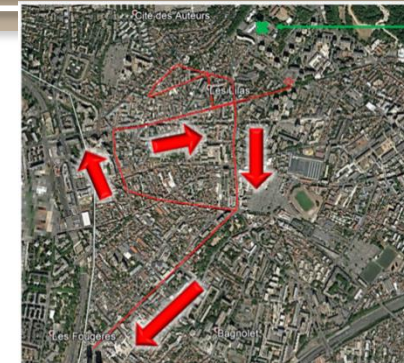
Inbound

Vertical Errors

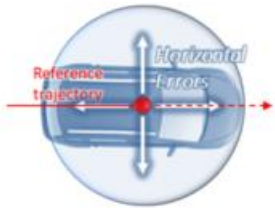


- Corrections are lost at about 10 km of distance.

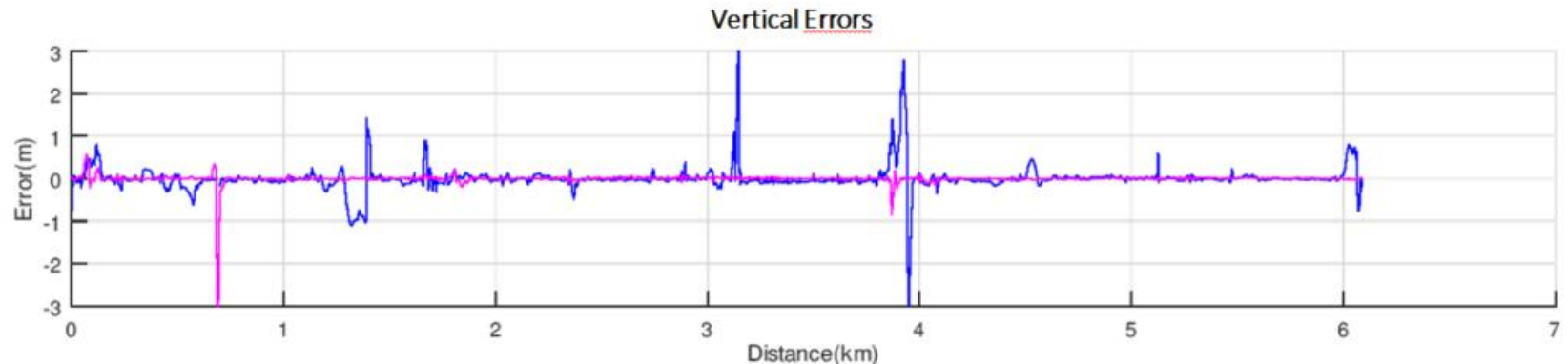
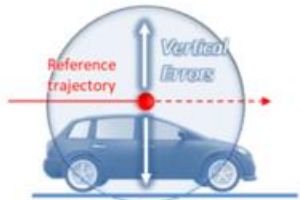
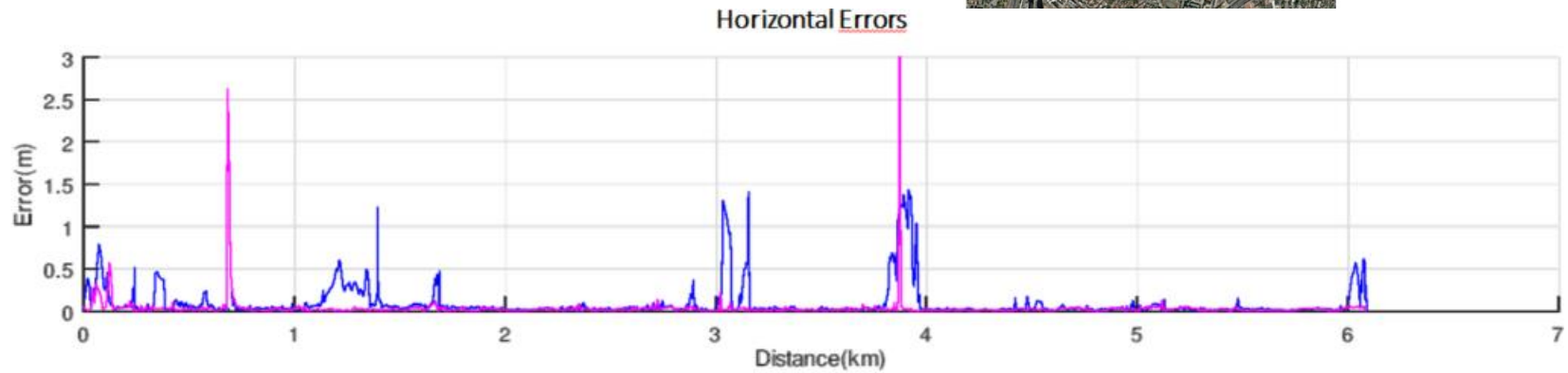
Scenario 2A



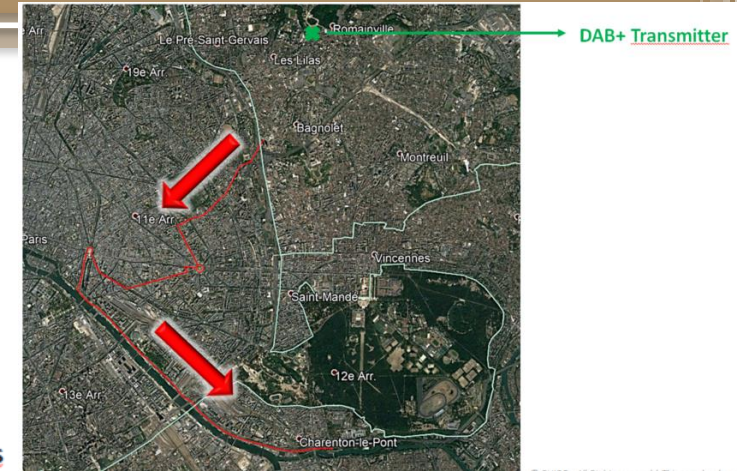
DAB+ Transmitter



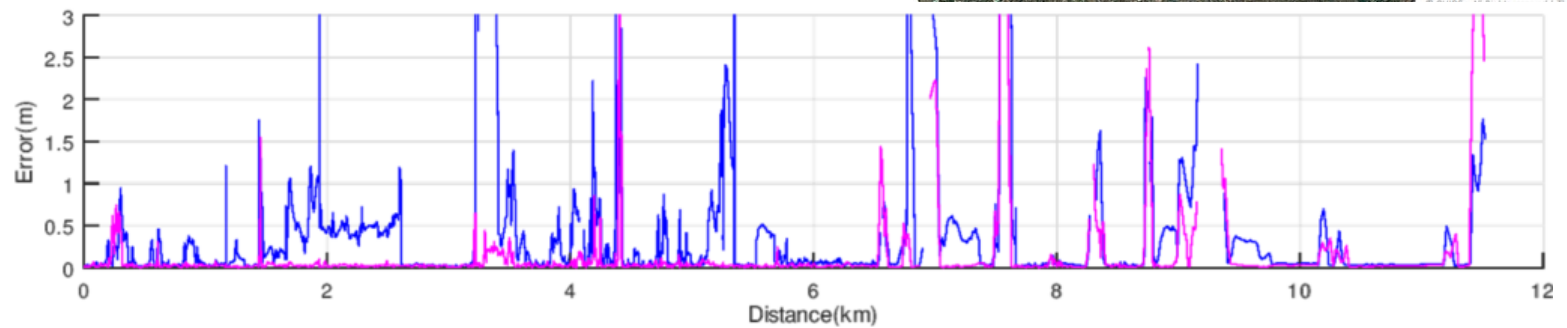
DUT Measurements	
	DAB+ PPP-RTK Corrections
	NTRIP NRTK Corrections



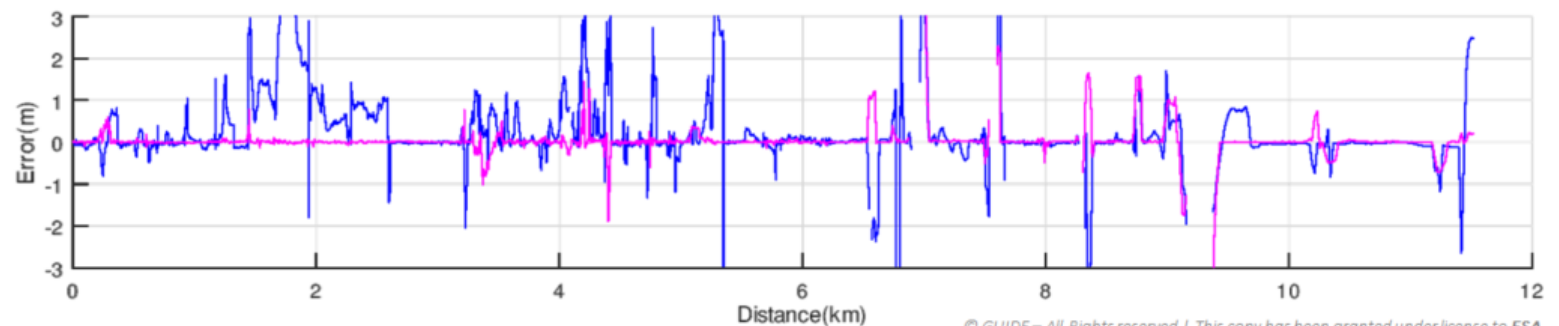
Scenario 2B



Horizontal Errors



Vertical Errors



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DAB+ Analysis

- Level of accuracy quite similar to the one of NRTK - close to the transmitter
- The reception of DAB+ signals, on all scenarios, was strongly impacted by different factors:



- The used hardware and software had purely a demonstrator scope. They were not optimized to be used in dynamic conditions and/or far from the transmitter.



- A unique transmitter only was used for the broadcast of corrections. This limited the coverage of DAB+ signals and, the quality of data once the distance was higher than 10km

Conclusions and Results



Limits of DAB +

- The DAB+ transmitter used should be more than one as in operational conditions - to extend the coverage area of the DAB+
- Poor DAB + signal availability
- Numerous outages
- Limited by environment : interferences
- Use of LTE

SSRZ resistant solution

- Accuracy near from NRTK
- Short convergence time