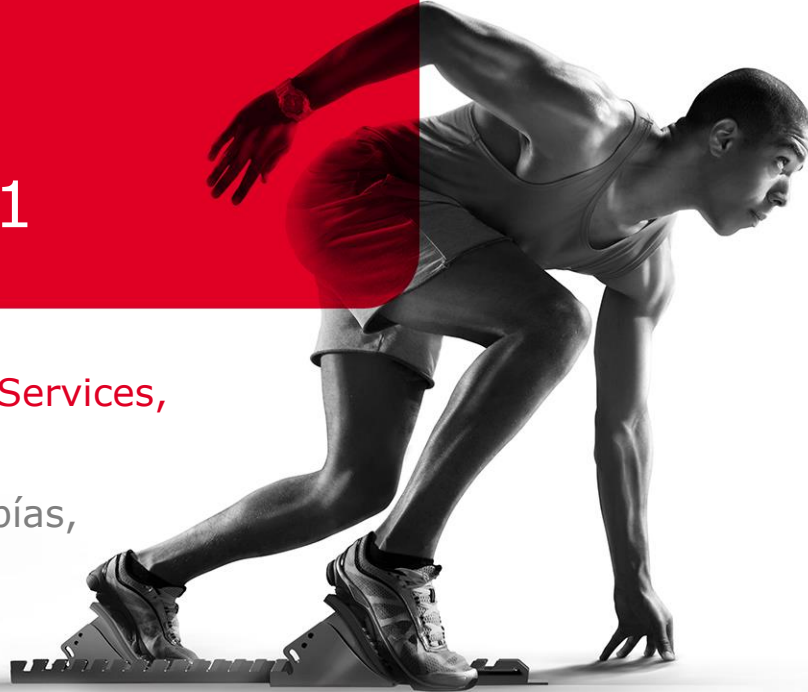


PPP AUGMENTATION BASED ON GEO-E5B SIGNAL

September 2021

ION GNSS+ 2021



Session A2a: Augmentation Services,
Integrity and Authentication

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GMV - Spain

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CONTEXT

THE E5B

HA SERVICES

HA SERVICE ON E5B

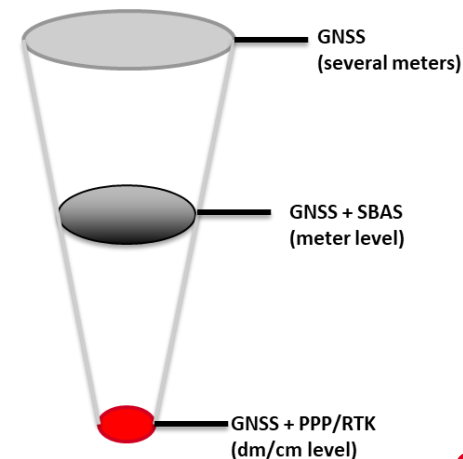
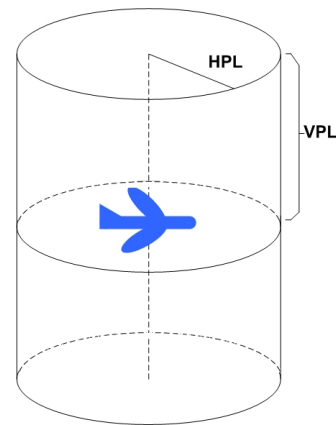
PERFORMANCE TESTING RESULTS

CONCLUSIONS

CONTEXT

SBAS Services

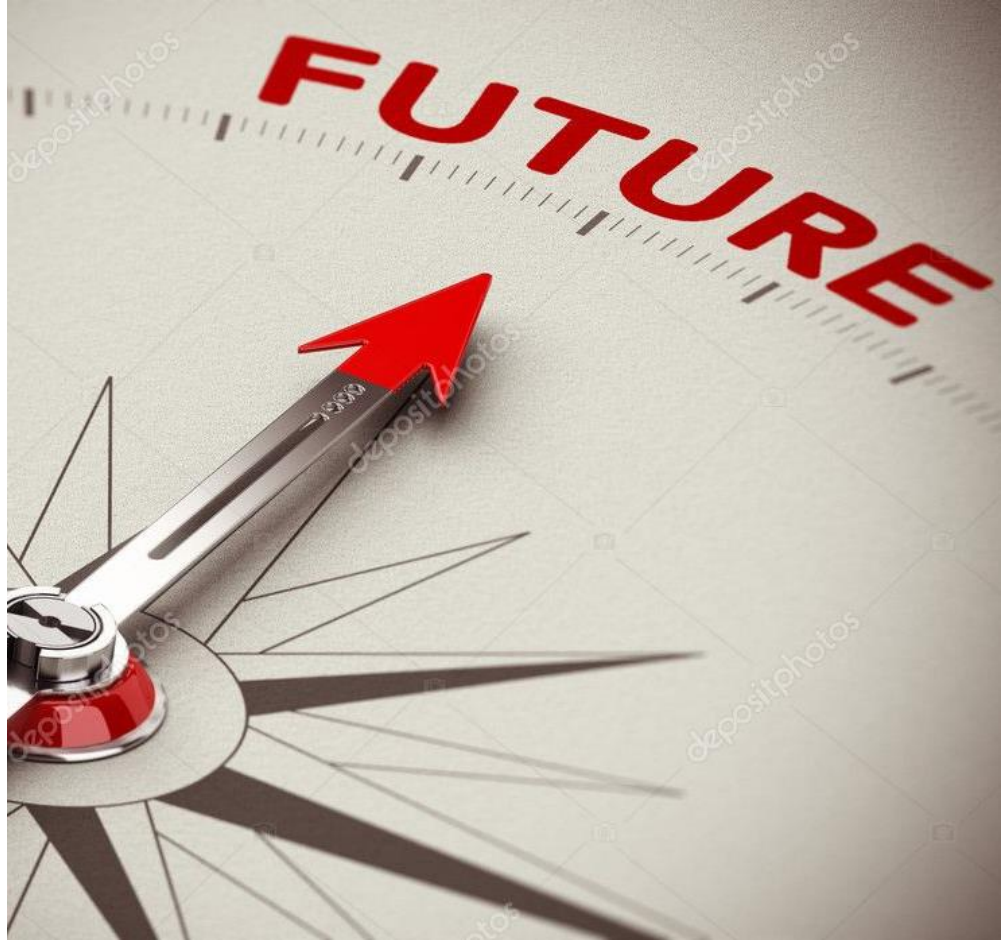
- Existing SBAS Services born to provide augmentation and integrity for aviation services (e.g.: EGNOS SoL on L1)
- New target users are being considered to the services (e.g.: users targeted by EGNOS OS)
- Ground transmission channels are considered (e.g.: EGNOS EDAS)
- And also evolutions for existing services to exploit new SIS frequencies, in particular L5 for DFMC services.
- Current services both on EGNOS, WAAS, SDCM, GAGAN... are providing services reaching the meter/sub-meter level.
- But how the services can be expanded/improved to engage new users?



CONTEXT

Potential evolutions of SBAS

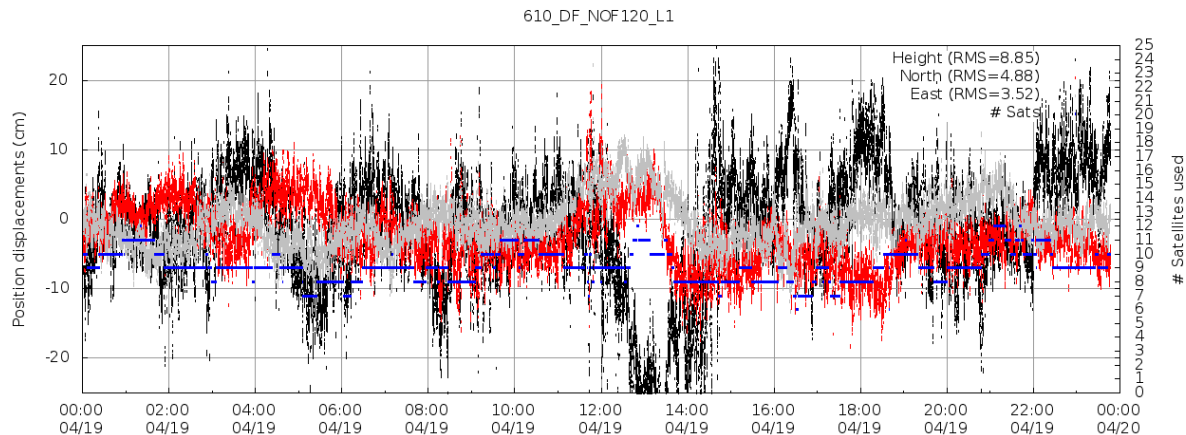
- Authentication, to improve the reliability and integrity of existing and new services
- High accuracy, to improve performance
- Others: High accuracy + integrity, Timing, ...



CONTEXT

SBAS L1 for SoL and OS

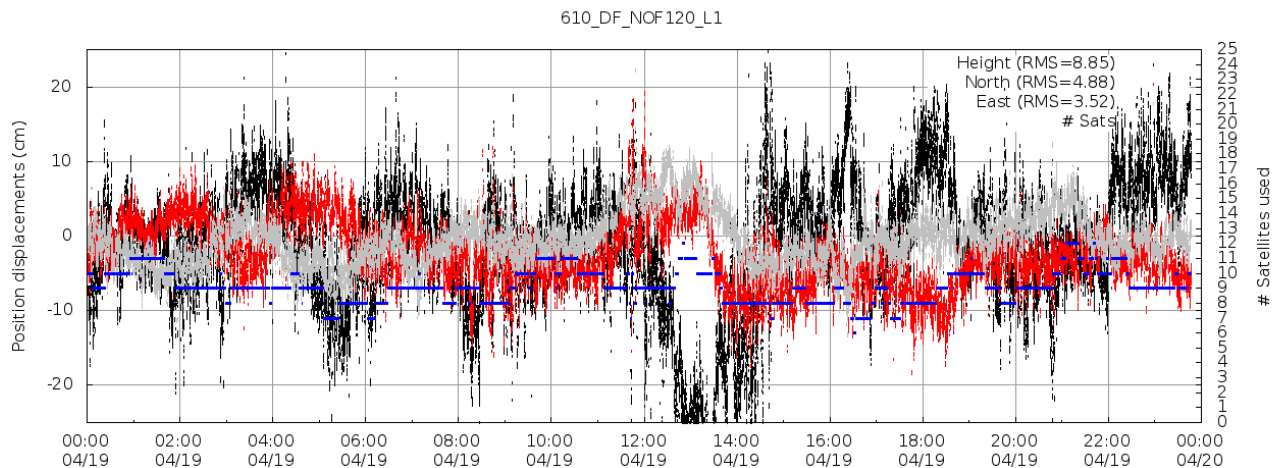
- No available space in the SIS to broadcast new messages/data.
- Lockheed Martin and GMV demonstration in AUS/NZ testbed used part of reserved information to improve the corrections accuracy and user performances.
- Convergence time is not so good (+30mins), performance after convergence look reasonable.



CONTEXT

SBAS L5 for DFMC

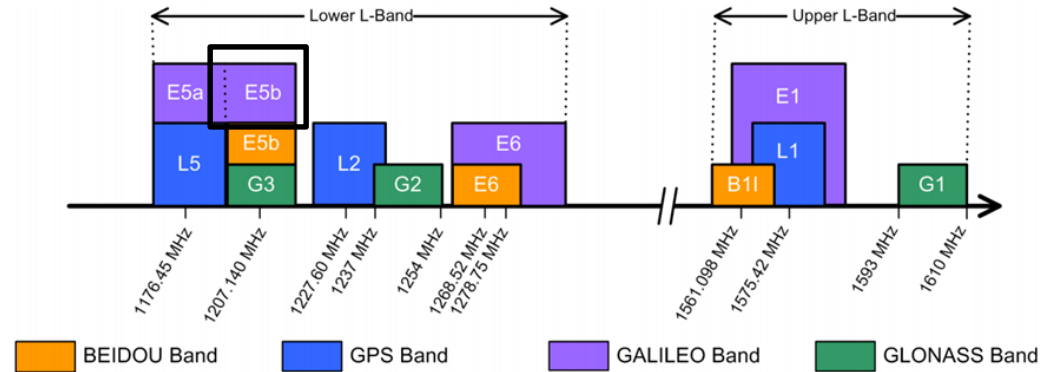
- DFMC has higher resolution in the orbit/clock corrections, and some room to increase the corrections rate.
- Still difficult to add new information such as biases or accurate atmospheric models.



THE E5B

New SIS transmission channels

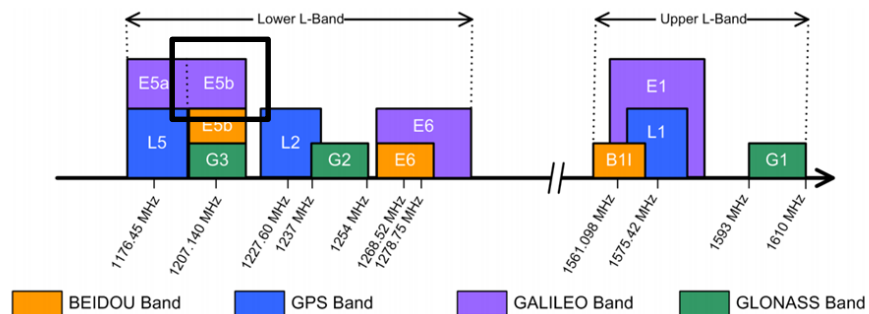
- The E5b (carrier 1207.14MHz) which is already used for Galileo OS, is being explored for extended SBAS services
- Different studies and publications done in the last years in the frame of EGNOS evolutions.
- EGNOS Satellites already include an E5b transponder.
- Mentioned as future service in future SBAS in AUS/NZ.
- Modulation and format is not defined for SBAS-E5b.



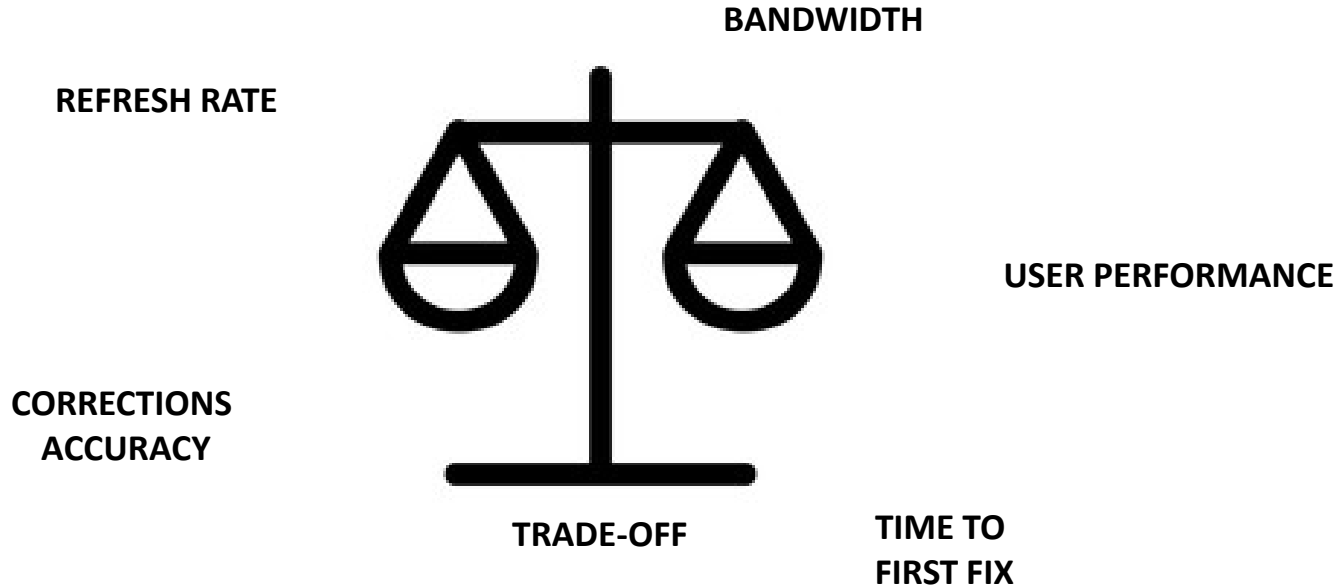
THE E5B

Signal and potential adopters

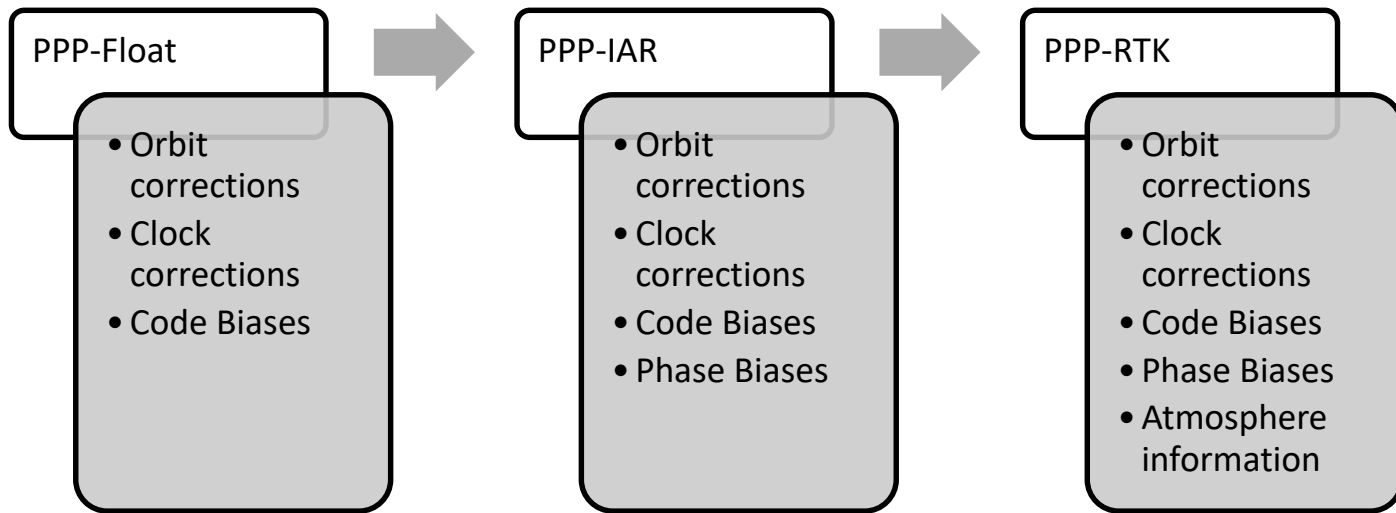
- Already present in Galileo and BeiDou, expected for future GLONASS CDMA.
- Many receivers high-grade and mass-market/automotive grade already support E5b.
- The range of quick/early adopters could be really high. Probably a Firmware change would allow supporting the new service.
- But early stage of service definition.



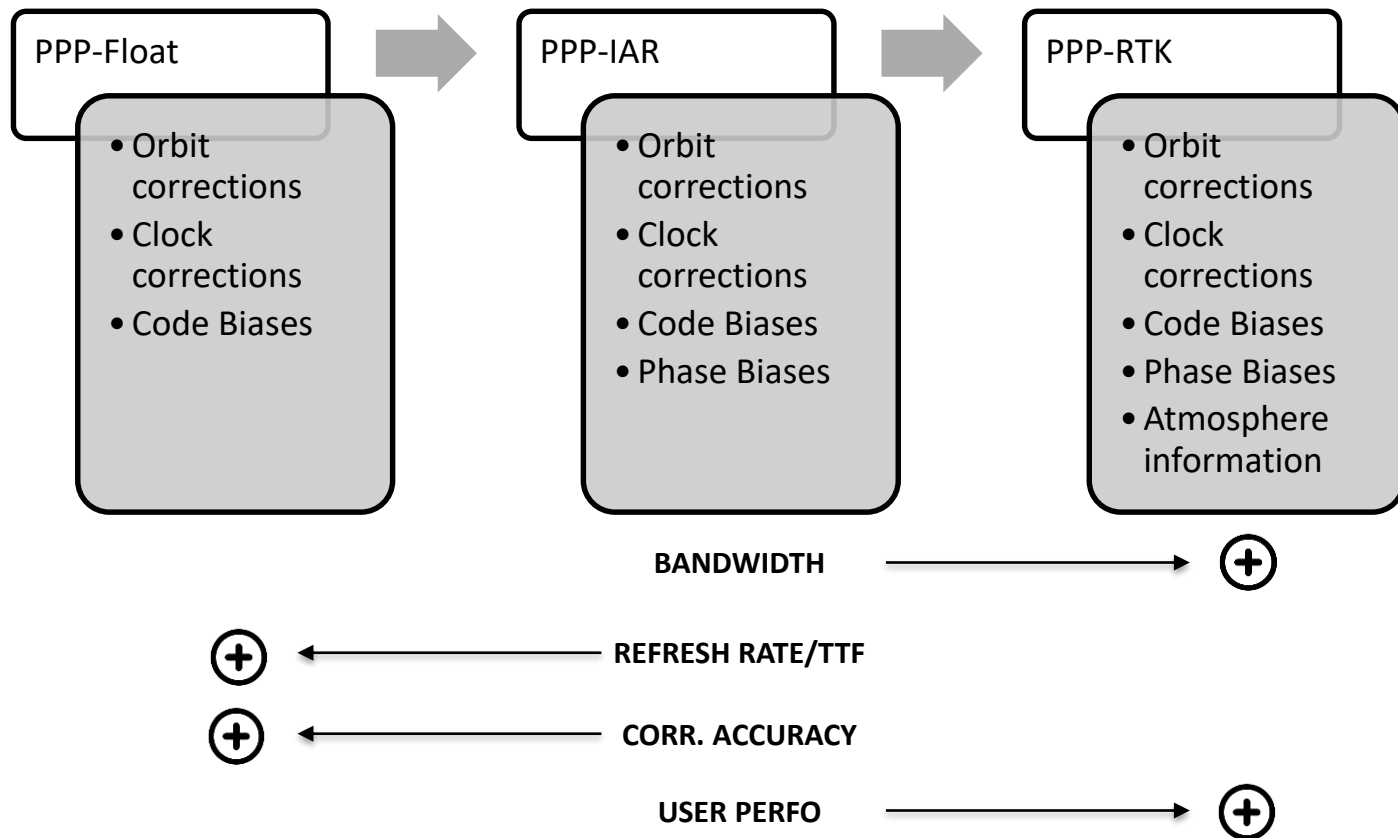
HA SERVICES



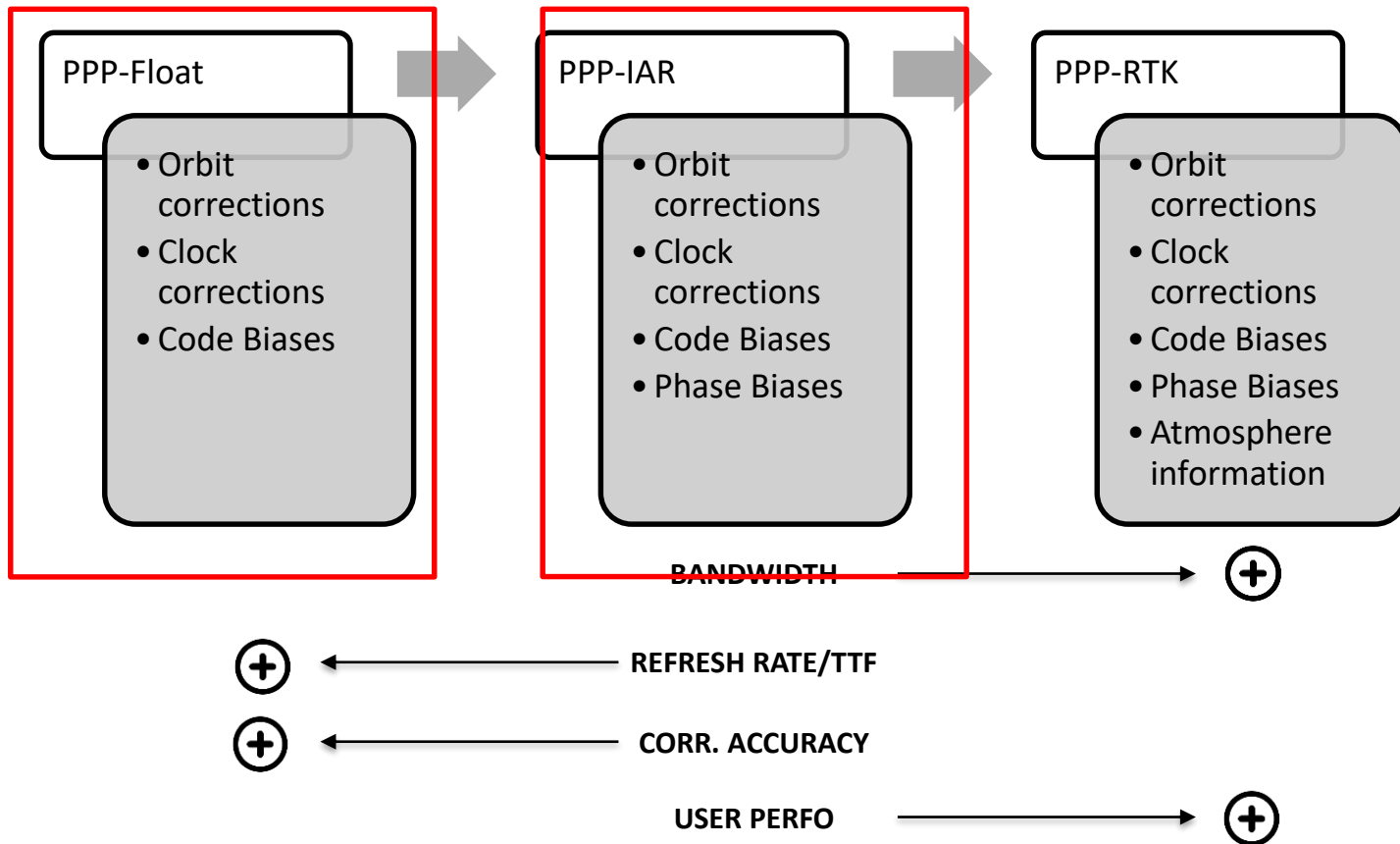
HA SERVICES



HA SERVICES



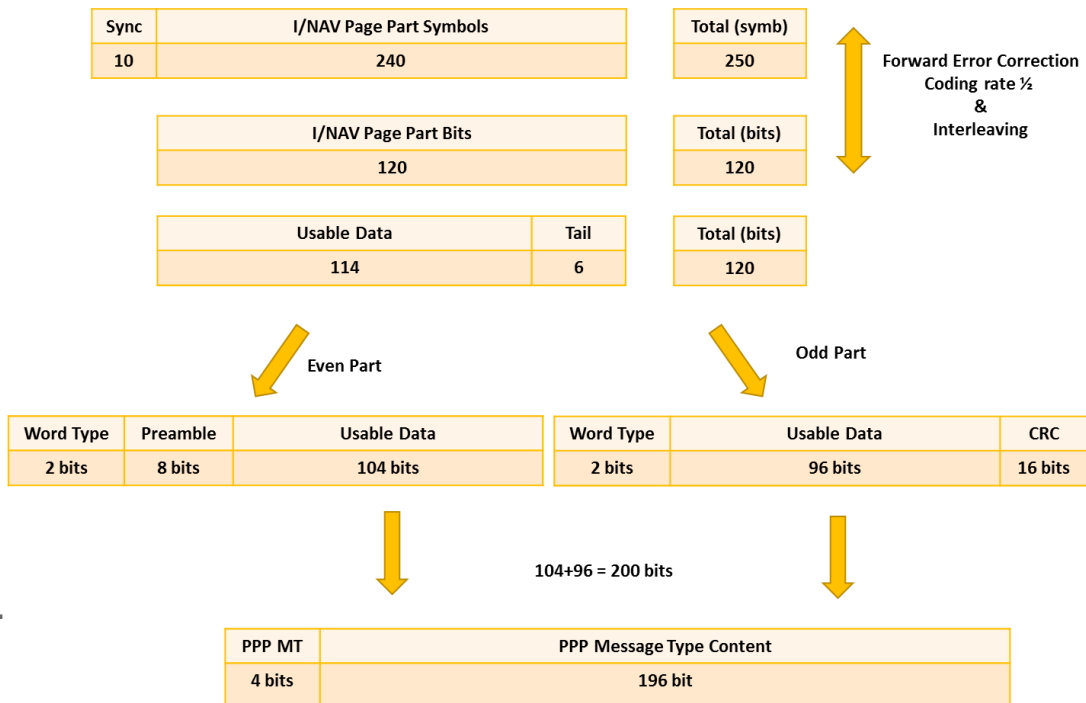
HA SERVICES



HA SERVICE ON E5B

Paging scheme based on Galileo approach:

- 1 page comprises 2 seconds (subpages)
- 200 usable bits per page (excluding WT, Preamble CRC)
- 4 bits for Message Type
- 196 for Message Content
- Optimized resolution for each field really required. Mainly based on CSSR.



HA SERVICE ON E5B

Paging scheme based on Galileo approach:

Expected rates:

- PPP Float (refresh rate of ~40 seconds)
- PPP IAR (refresh rate of ~50 seconds)

Empirical Analyses:

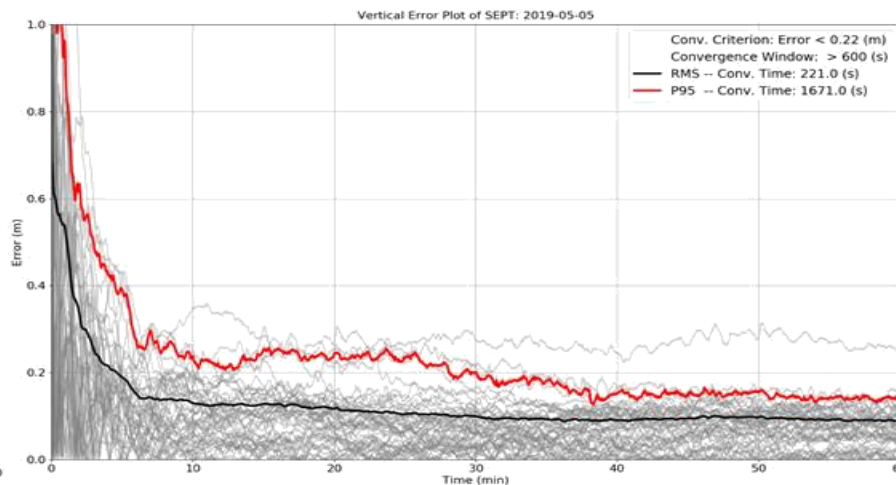
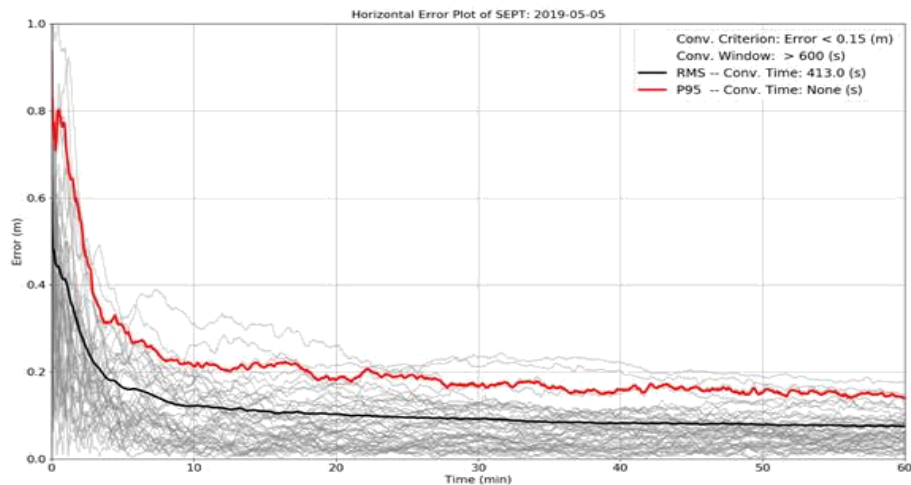
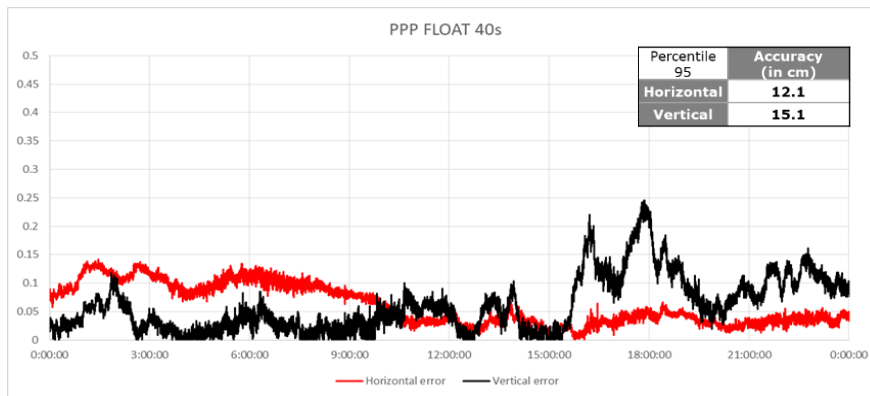
- Accuracy and convergence with proposed messaging schemes
- Considering both options
- PPP Float
- PPP IAR
- COTS receiver used in the analyses:
Septentrio ASTERX-U

Message Type	Name
0	General Info / Satellite bitmap
1	Orbit Correction
2	Clock Correction
3	Code Biases
4	Phase bias
5-15	Reserved

PPP PERFORMANCE

PPP Float analyses

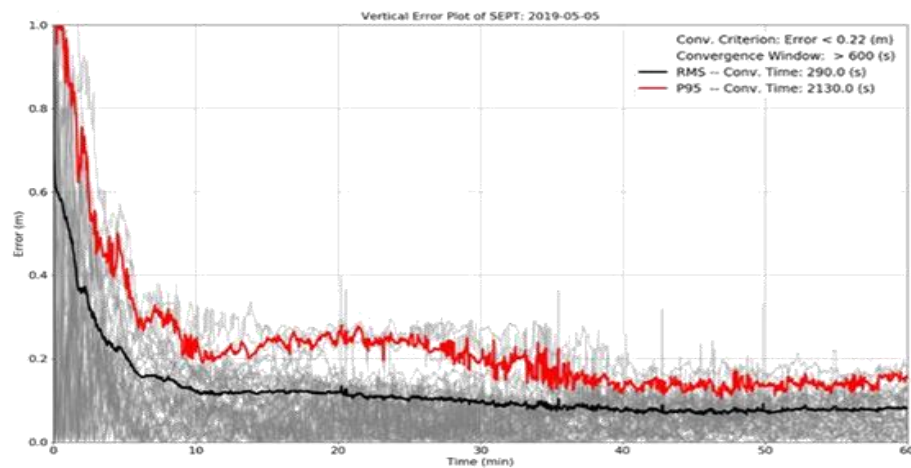
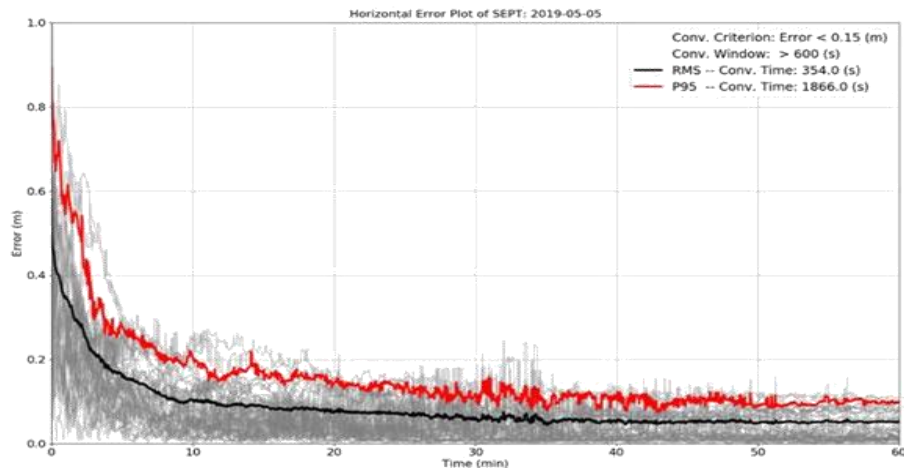
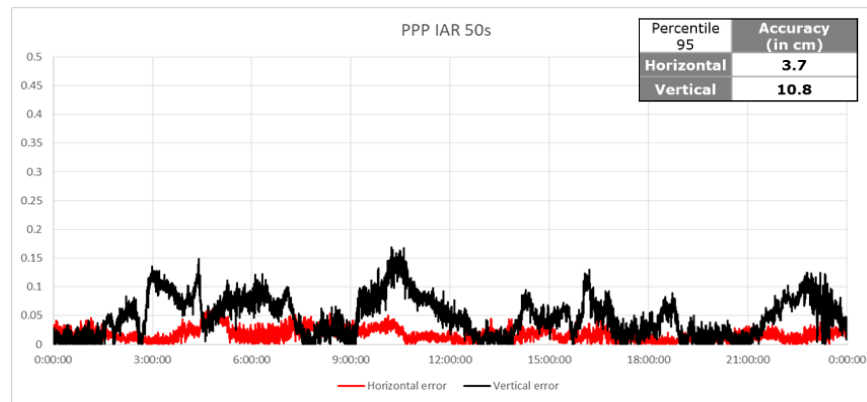
- Accuracy: 24 Hours analysis for solution accuracy in static mode
- Convergence Time: 48 scenarios in one day (each 30 min). Measured time needed to achieve the requirement thresholds



PPP PERFORMANCE

PPP IAR analyses

- Accuracy: 24 Hours analysis for solution accuracy in static mode
- Convergence Time: 48 scenarios in one day (each 30 min). Measured time needed to achieve the requirement thresholds



PPP PERFORMANCE

Bonustrack: PPP IAR+Atmospheric analyses

- Atmospheric information requires a relevant amount of info.
- But... we might consider other modulations and header/tailing strategy such as the one used for the EGNOS. It would allow to send all the information + atmospheric information at 60seconds rate.

PPP PERFORMANCE

Bonustrack: PPP IAR+Atmospheric analyses

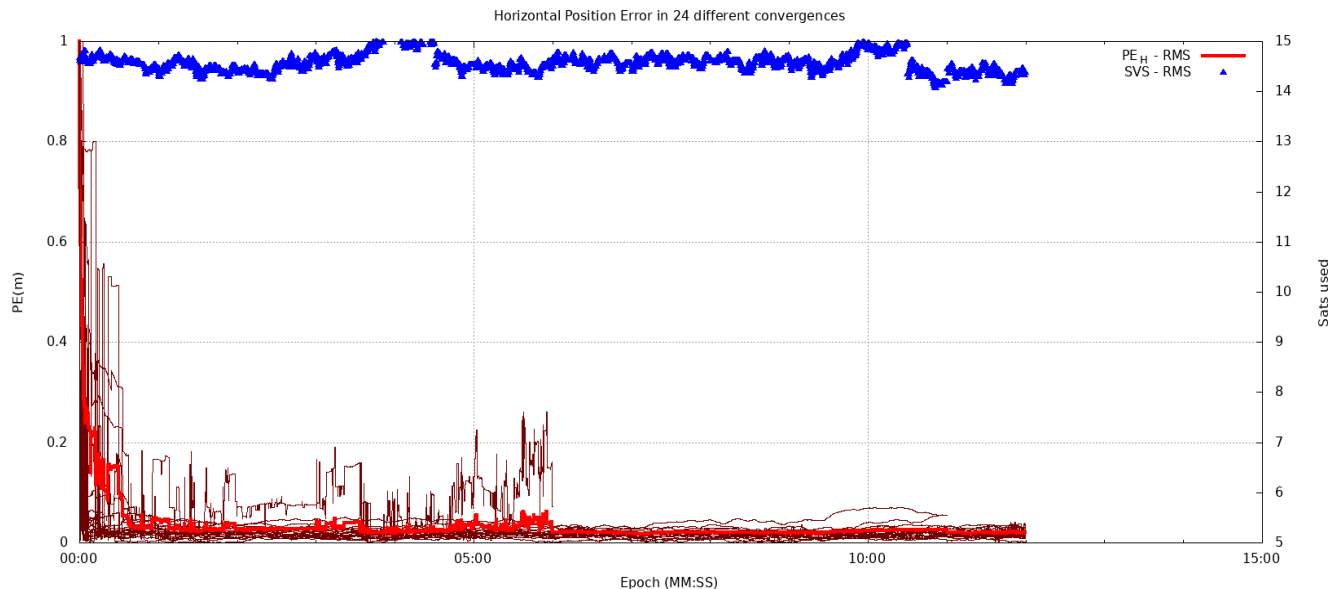
- Atmospheric information requires a relevant amount of info.
- But... we might consider other modulations and header/tailing strategy such as the one used for the EGNOS. It would allow to send all the information + atmospheric information at 60seconds rate.

E5-B messages contains 250 bits
Preamble following SBAS ICD is considered
Message type following SBAS ICD is considered
CRC-24 as per SBAS ICD is considered
The resulting messages have an usable payload of
212 bits.

PPP PERFORMANCE

PPP IAR+Atmospheric analyses

- Atmospheric information requires a relevant amount of info.
- But... we might consider other modulations and header/tailing strategy such as the one used for the EGNOS. It would allow to send all the information + atmospheric information at 60seconds rate.



CONCLUSIONS

- The performances obtained when using SBAS-L1 or DFMC for HA are not state-of-the art, especially due to the long convergence time.
- Following the Galileo E5b modulation and similar encoding for the GEO-E5b, the performance analyses show that the PPP float and PPP-IAR solution achieve performance aligned to a similar commercial services.
- Following an SBAS-like modulation, a PPP-RTK solution is possible with really good performances both for convergence and accuracy.



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Thank you!!