Galileo High Accuracy Service and its importance for mobility applications

INTERGEO Frankfurt 16 Oct 2018
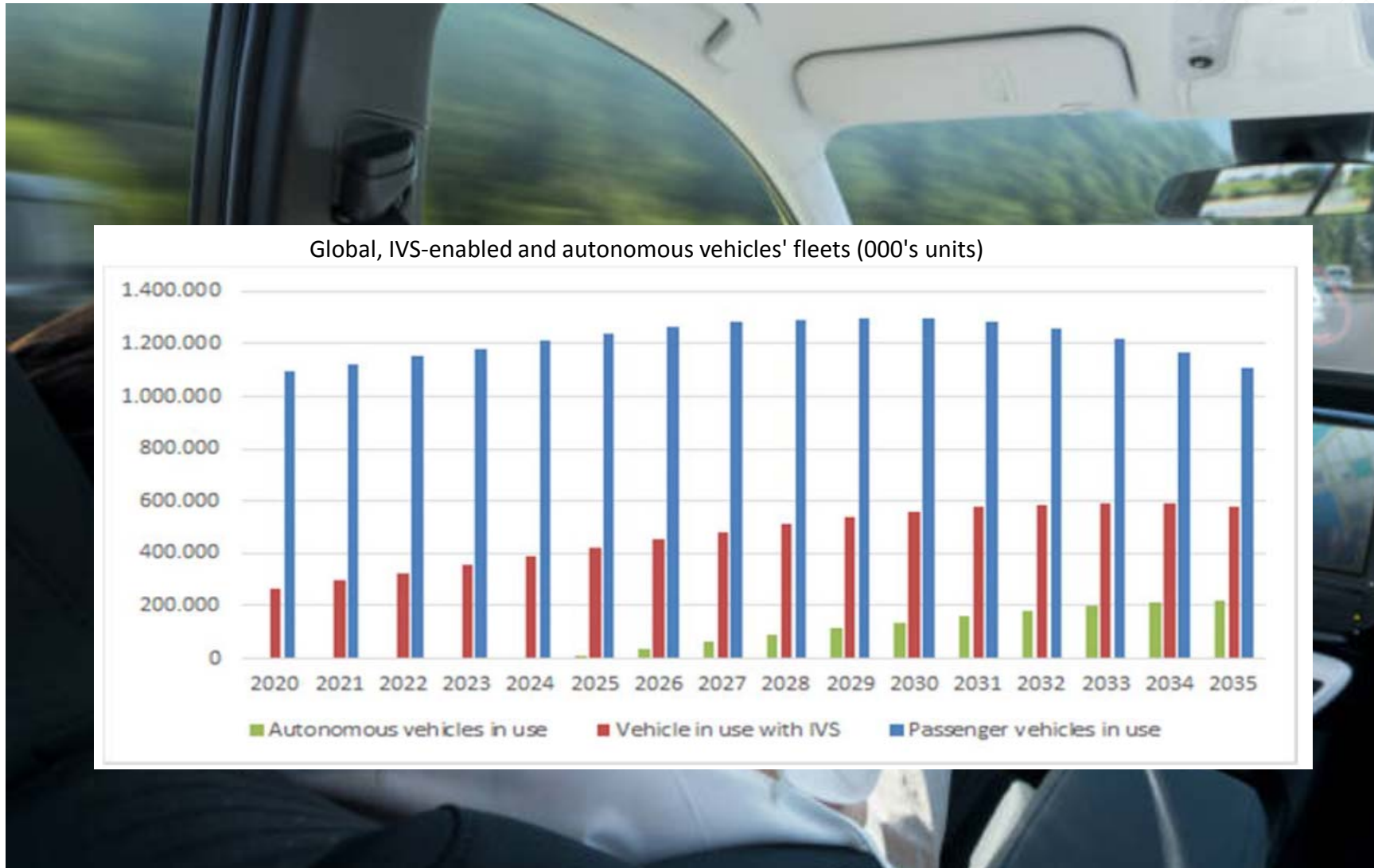
Ignacio Fernández Hernández

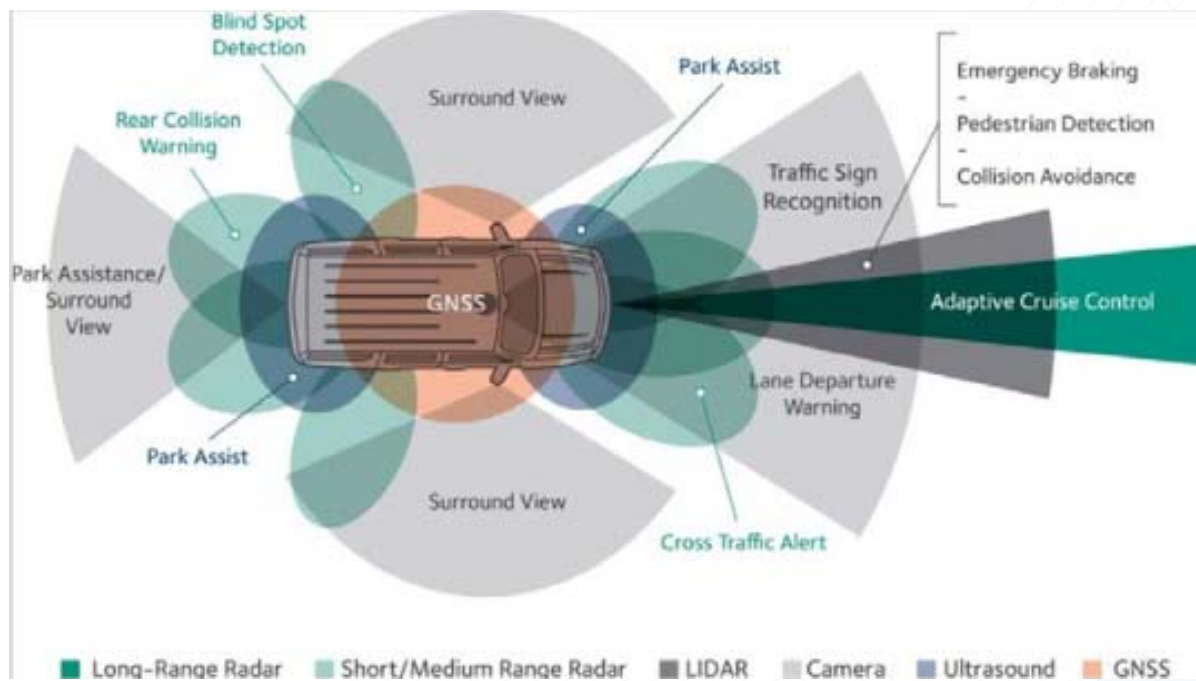## TABLE OF CONTENTS

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- HAS Status and Service Definition
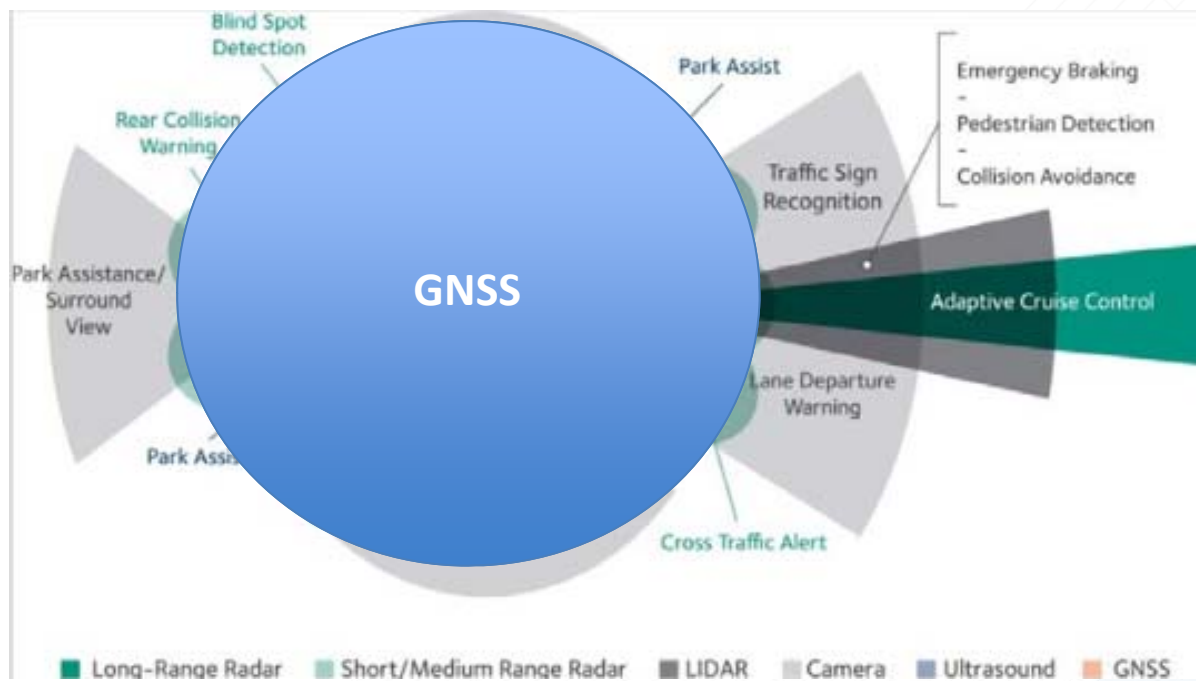- HAS Prospective Performance
- Roadmap
- Conclusions

GALILEO EGNOS

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Global, IVS-enabled and autonomous vehicles' fleets (000's units)

IVS = in-vehicle systems

Source: http://insidegnss.com/assets/webinar/201611/Inside-GNSS-Webinar_Safety-Critical-Positioning-for-Automotive-20161103.pdf

Long-Range Radar   Short/Medium Range Radar   LIDAR   Camera   Ultrasound   GNSS

Source: http://insidegnss.com/assets/webinar/201611/Inside-GNSS-Webinar_Safety-Critical-Positioning-for-Automotive-20161103.pdf
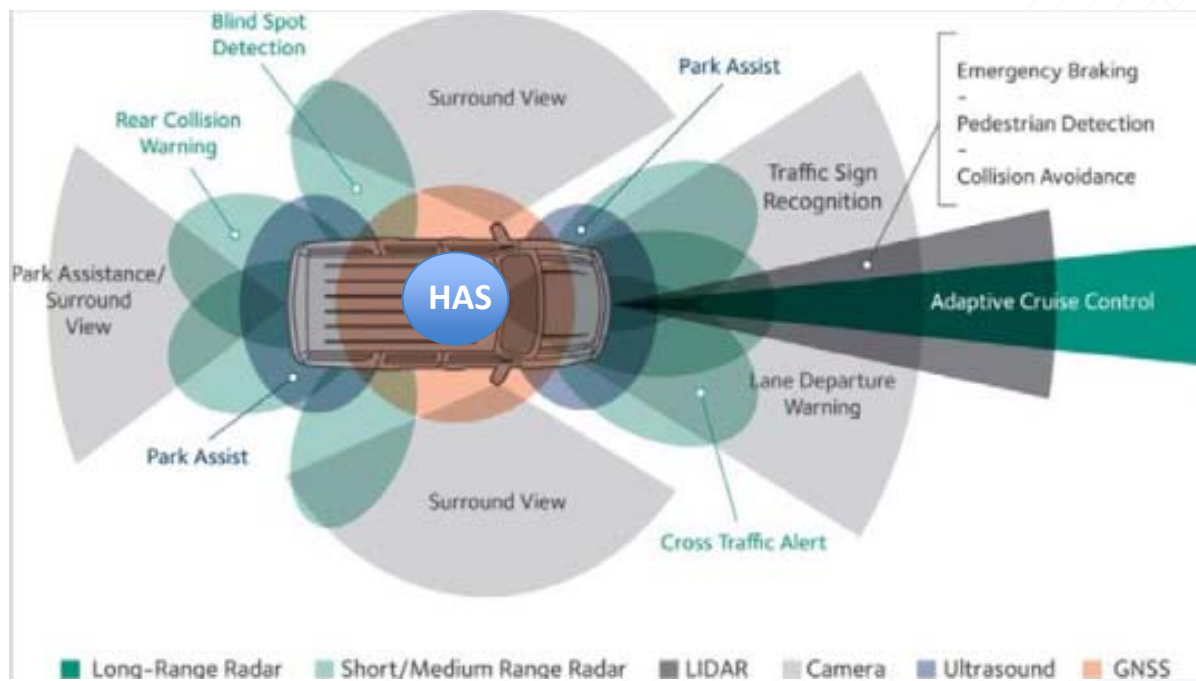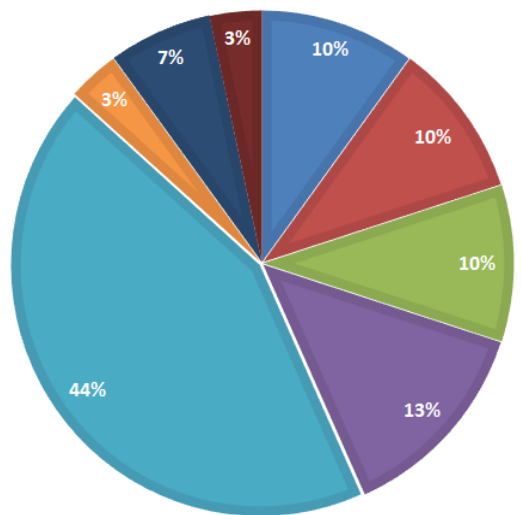
STAKEHOLDER CONSULTATION

- 2017 Nov-Dec: GSA launches a **stakeholder consultation** on the free HA.
- 31 participaints, incl. main HA commercial providers, research institutes, manufacturers.

Left pie chart legend:
- GNSS Chipset Manufacturer
- HA Services Provider
- GNSS Devices Manufacturer
- R&D Centre
- GNSS Devices Manufacturer + HA Services Provider
- Space Agency
- GNSS Solutions Provider
- University

Left pie: 10%, 10%, 10%, 13%, 44%, 3%, 7%, 3%
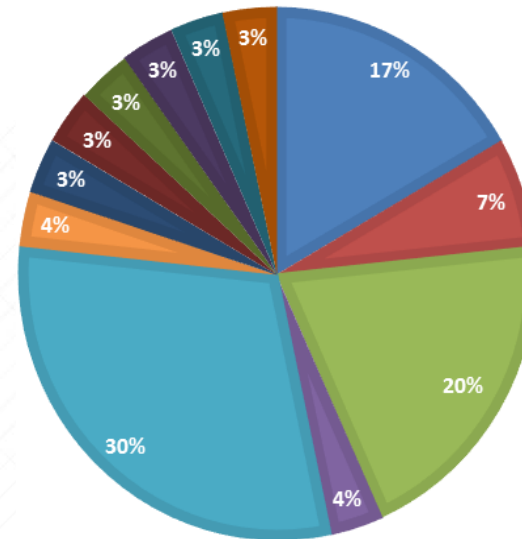
**Right pie chart legend:**
- All
- Governamental
- LBS
- Maritime
- Professional
- Professional and LBS
- Professional, Aviation, Rail and Maritime
- Professional, Governamental and Aviation
- Professional, Governamental, Road, and LBS.
- Professional, Road and Aviation
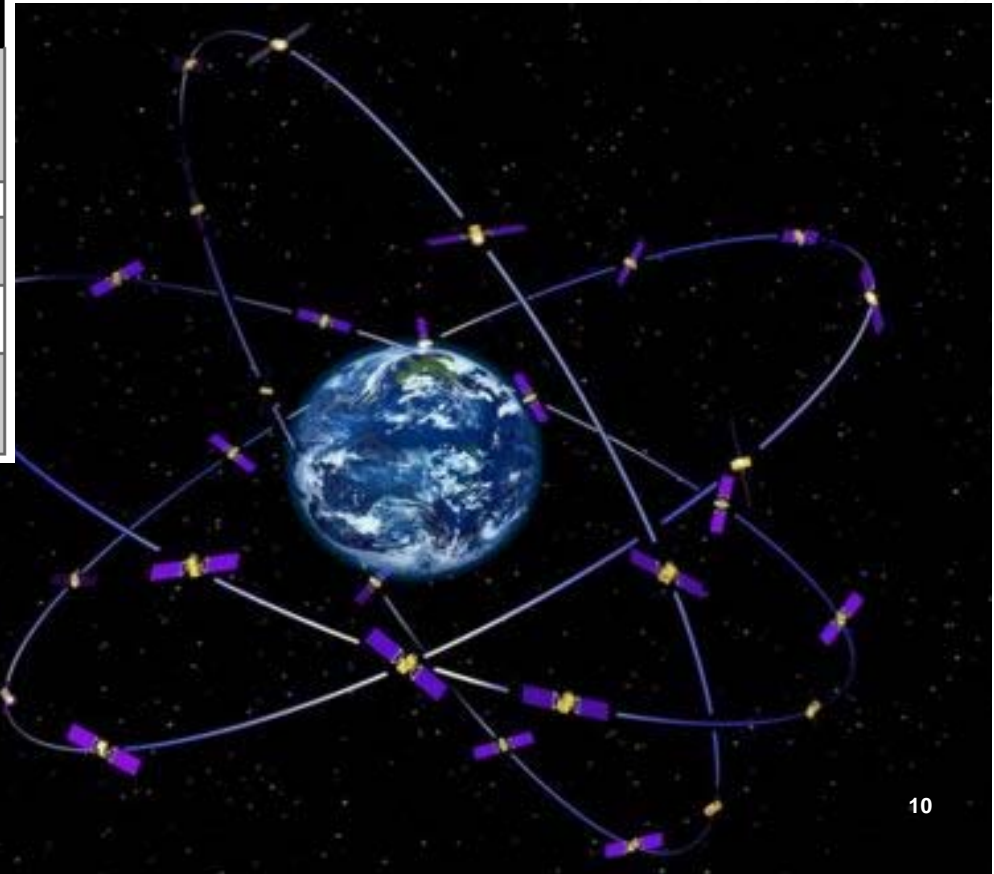- Road
- Surveying

Right pie: 17%, 7%, 20%, 4%, 30%, 4%, 3%, 3%, 3%, 3%, 3%

STAKEHOLDER CONSULTATION

- Views from consulted stakeholders on the provision by Galileo of a free High Accuracy Service

23%

Positive

Negative

77%

9
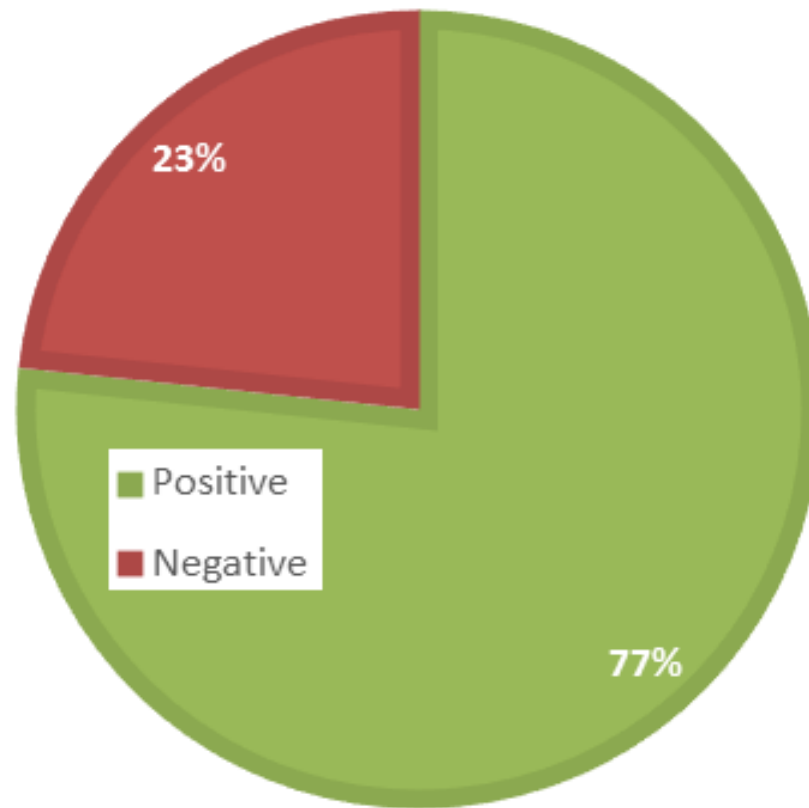
|	Galileo	QZSS	SBAS	Commercial
Coverage	Global	Regional	Regional	Global (except high latitudes)
Satellites orbits	MEO	IGSO	GEO	GEO
Bandwidth per sat.	448 bps	2000 bps	250 bps	from ~2500 bps
Nb sat typically visible (open-sky)	4-6	1-3	1-2	1-2
Band/Frequency	E6, 1278.75 MHz	L6, 1278.75 MHz	E5b, 1207.14 MHz	L-band (~1-2 GHz)

| Signal and Data features	
Frequency	1278.75 MHz
Signal	E6B
Min. Power	-158 dBW
Modulation	BPSK(5)
Chip Rate	5.115 Mcps
Code Length	1 ms
Symbol Rate	1000 sps
Data Rate	492 bps
HA Data Rate	448 bps
Data Coding	FEC, as per Galileo OS SIS ICD and interleaving 123 x 8
Spreading Code Encryption	No
Data Format	TBD but based on open standard.
Data (TBC)	Orbit and clock corrections, code and phase biases, SQM, flags, ionospheric information.
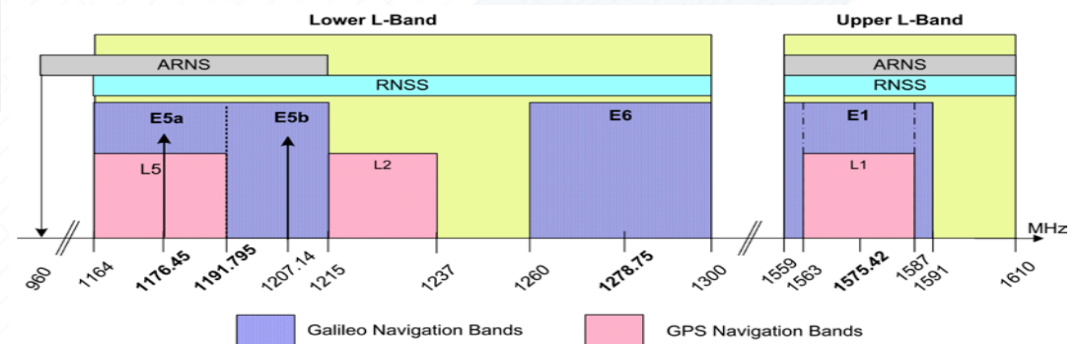
DOWNLINK CAPABILITY
(Estimation, Galileo FOC – 2020)

Connected Satellites Visibility Plot

Average Bandwidth Plot
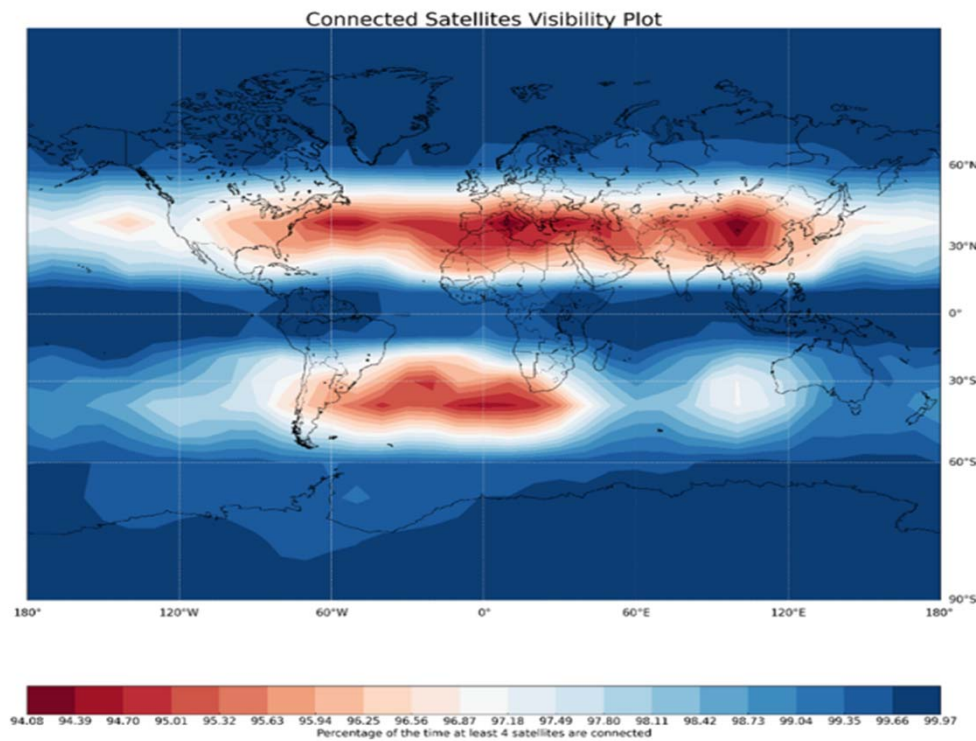
AVG. AVAILABILITY 4 SV [94-99.9%]
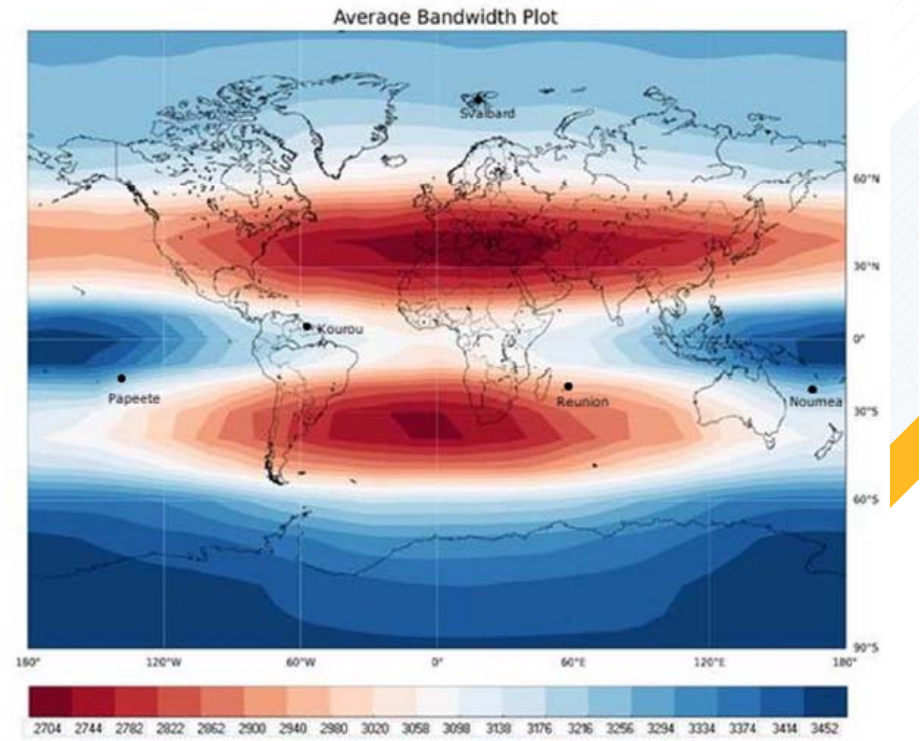
AVG. BW: [2704, 3472]

HAS DEFINITION

- High accuracy (PPP) corrections provided in the Galileo E6-B signal component:
  - Satellite orbits
  - Satellite clock corrections
  - Code biases for multi-frequency
  - Signal/correction quality information
  - Phase biases (to be confirmed)
  - Ionosphere in EU (to be confirmed)
- Corrections will for Galileo (E1, E5a, E5b, E6, E5 TBC) and GPS (L1, L2, others TBC), and in the future potentially for other GNSS.
- Global coverage when fully operational. Partial coverage before. EU always included.

- HAS data will be transmitted openly, for free, and through an open standard format. **RTCM CSSR used as starting point.** Format currently under definition.
- "user error of less than two decimetres". This depends on user receiver, algorithm and environment.
- Support HAS via terrestrial networks is under consideration.

| Sub Type	Sub Type Name	No. of Bit
1	Compact SSR Mask	37 + 60 x Nsys
2	Compat SSR GNSS Orbit Correction	25 + (51 or 49) x Nsat
3	Compact SSR GNSS Clock Correction	25 + 15xNsat
4	Compact SSR GNSS Satellite Code Bias	25 + 11 x Ncode x Nsat
5	Compact SSR GNSS Satellite Phase Bias	25 + 17 x Nphase x Nsat
6	Compact SSR GNSS Satellite Code and Phase Bias	28 + 28 x Nsig x Nsat
7	Compact SSR GNSS URA	25 + 6 x Nsat
8	Compact SSR TEC Correction	25 + 34 x Ngrid

HAS PROSPECTIVE PERFORMANCE
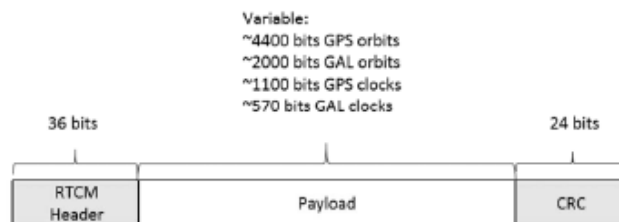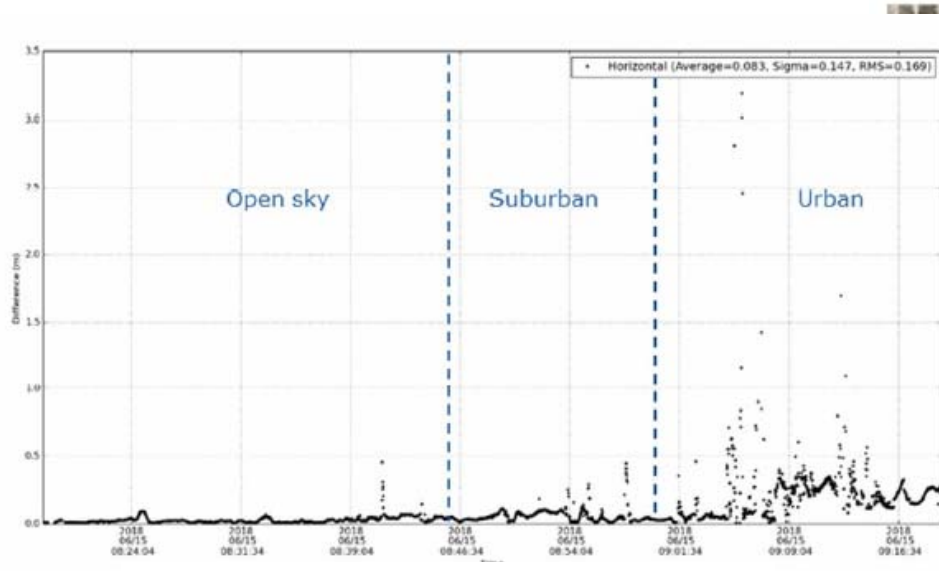
- Same message "transmitted" by all Galileo sats.
- Possible improvements:
  - More satellites
  - More frequencies
  - SIS format & coding optimization
  - Antenna and receiver: better carrier tracking, less code/carrier noise, better multipath mitigation

HAS PROSPECTIVE PERFORMANCE

- PPP Convergence time still *the* problem.
- Assisted users can do RTK-PPP
- Standalone users can use 3-4 frequencies and/or iono models for quasi-instantaneous (few s) convergence.
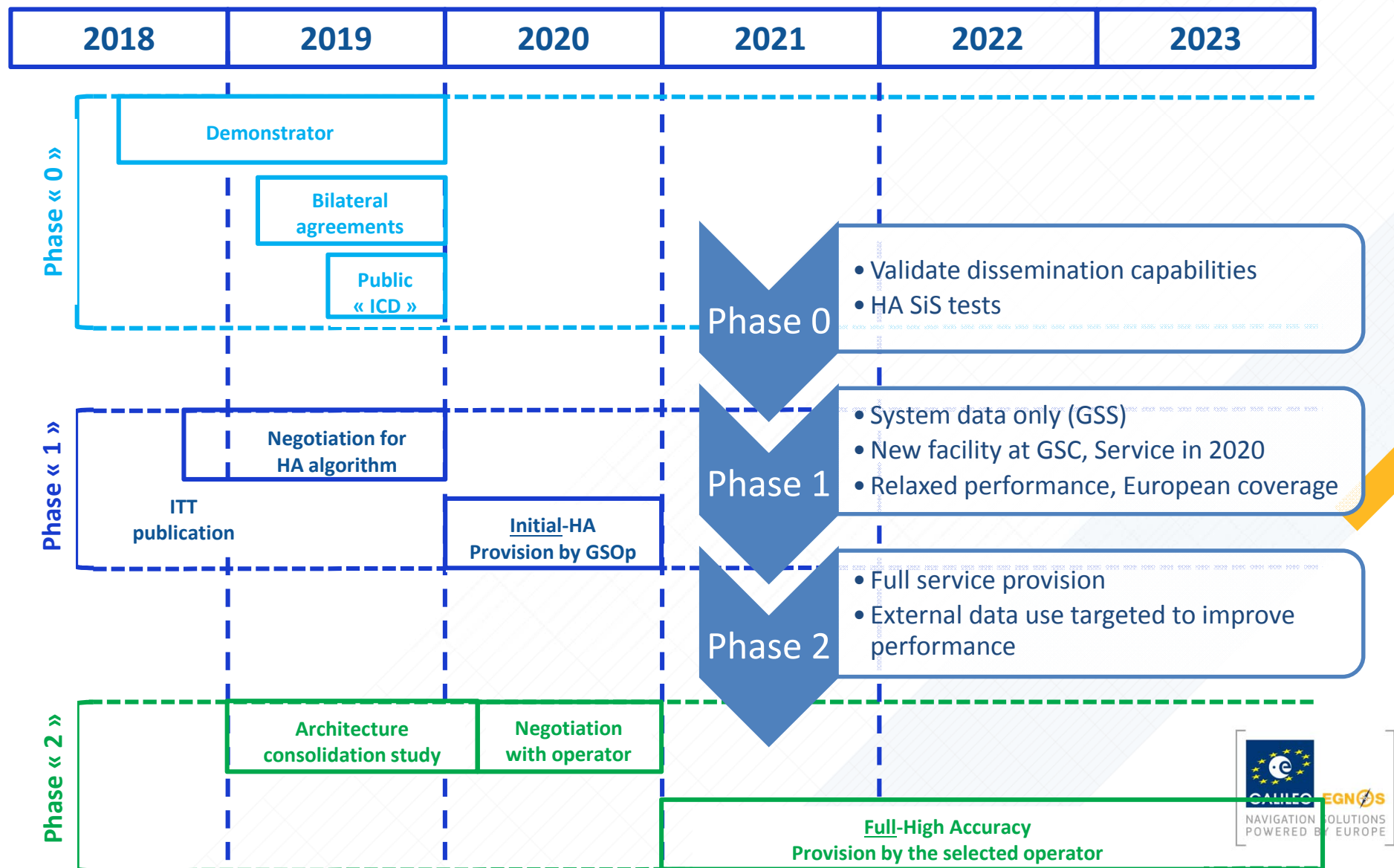

CONVERGENCE ANALYSIS
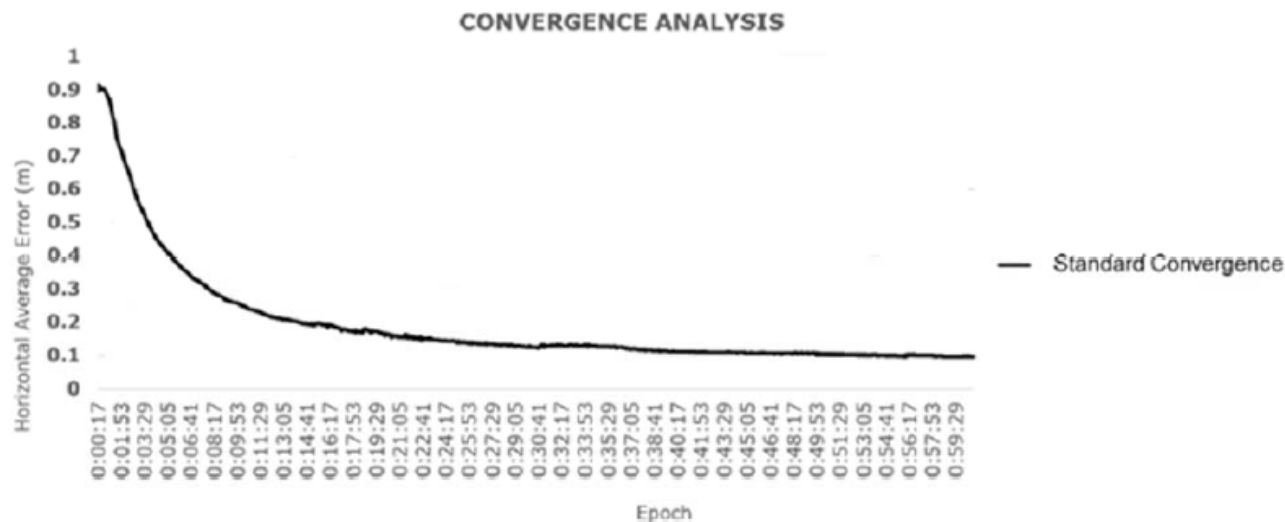
HAS PROSPECTIVE PERFORMANCE

- Galileo E6B SIS coding schemes can be key for time to 1st precise fix (several Kbits to receive).
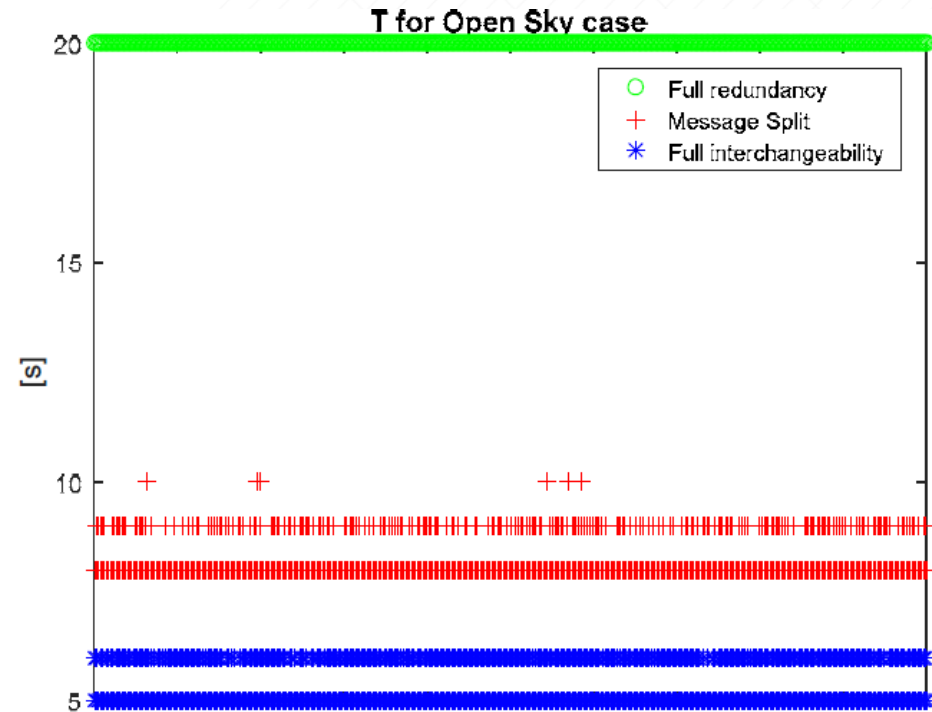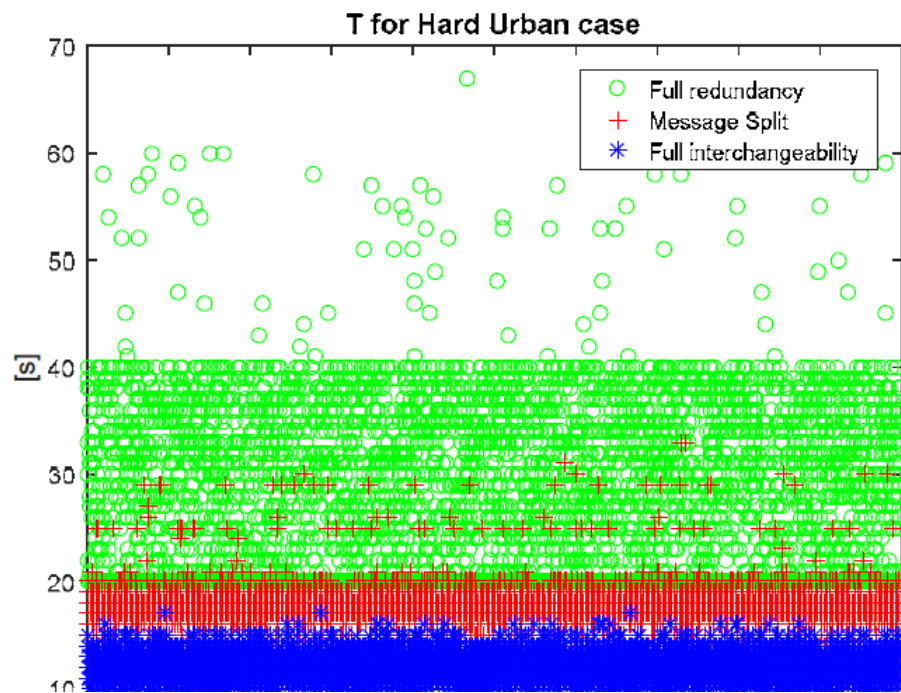
Reception of a 20-page (8320-bit) message in E6B with different coding/packing schemes

HIGH ACCURACY ROADMAP – UNDER CONSOLIDATION

2018	2019	2020	2021	2022	2023

Phase « 0 »

Demonstrator

Bilateral agreements

Public « ICD »

Phase 0
- Validate dissemination capabilities
- HA SiS tests

Phase « 1 »

Negotiation for HA algorithm

ITT publication

Initial-HA Provision by GSOp

Phase 1
- System data only (GSS)
- New facility at GSC, Service in 2020
- Relaxed performance, European coverage

Phase 2
- Full service provision
- External data use targeted to improve performance

Phase « 2 »

Architecture consolidation study

Negotiation with operator

Full-High Accuracy
Provision by the selected operator

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17 October, 2018

CONCLUSIONS

- The Galileo Programme will include a free and open High Accuracy Service (HAS) based on the transmission of PPP corrections globally through the E6-B Galileo signal component.
- HAS will coexist with commercial services and public and free HA initiatives. EC expects it will accelerate its adoption and lead to innovation and new applications: first truly global, standalone HA service.
- Based on open standards (RTCM CSSR as starting point)
- 2018 : Initial testing phase.
- 2020 : Operational phase
- Target accuracy: <20 cm.

Galileo High Accuracy, combined with Galileo Authentication Services, allow Galileo to pioneer the most accurate and resilient civil signals and services, worldwide, and for everyone.

THANK YOU

Ignacio Fernández Hernández

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