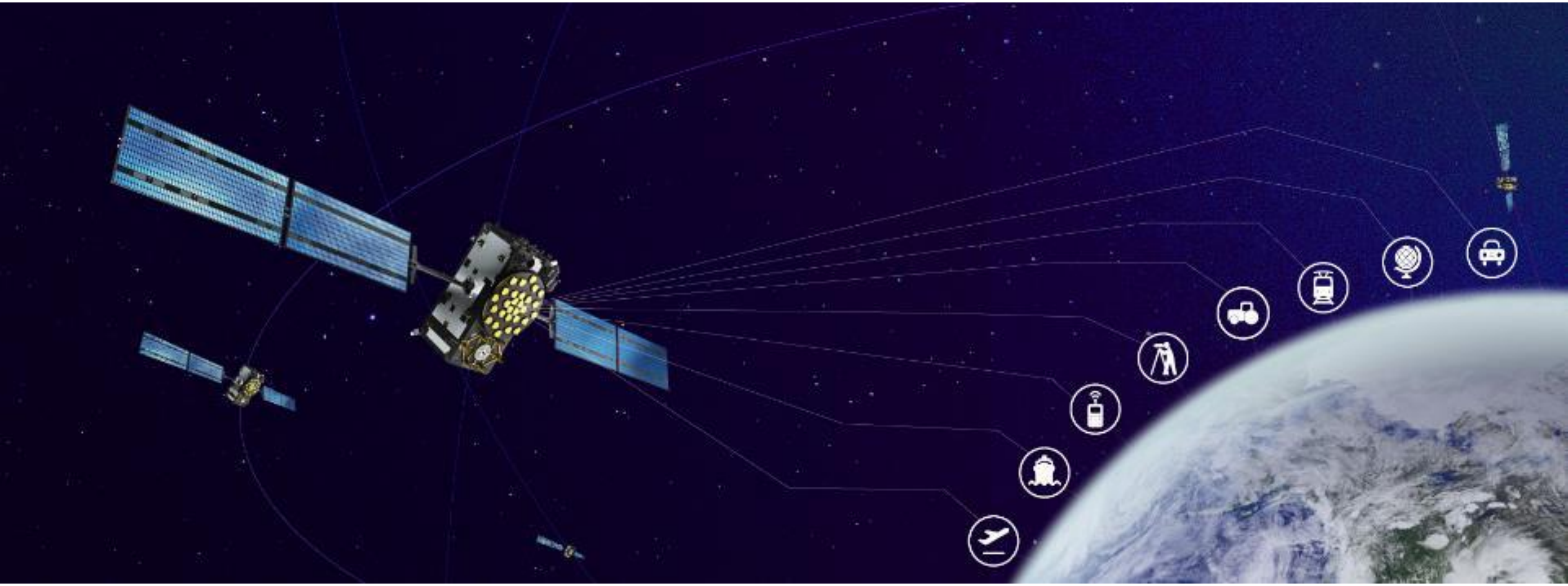


European Global Navigation Satellite Systems Agency

Galileo as a multi-purpose source of space-generated big data

Space Forum 2019

Omar Valdés – Market Development Officer

22 May 2019, Luxembourg

GALILEO EGNOS

NAVIGATION SOLUTIONS POWERED BY EUROPE

Agenda

GSA and EGNSS in a nutshell

Why using Galileo?

Big data

Securing the data

Agenda

GSA and EGNSS in a nutshell

Why using Galileo?

Big data

Securing the data

The European GNSS Agency (GSA) is responsible for market development and operations of Galileo and EGNOS

- Staff: around **160**
- Nationalities: **22**
- Headquarters: **Prague, Czech Republic**
- Other Locations:
  - France
  - The Netherlands
  - Spain
  - United Kingdom

The GSA's mission is to support European Union objectives and achieve the highest return on European GNSS investment, in terms of benefits to users and economic growth and competitiveness

Galileo is the European GNSS offering a wide range of services

Open Service (OS)

Galileo open and free of charge service set up for positioning and timing services

High Accuracy Service (HAS)

A service complementing the OS by providing an additional navigation signal and added-value services in a different frequency band. The HAS signal can be encrypted in order to control the access to the Galileo HAS services

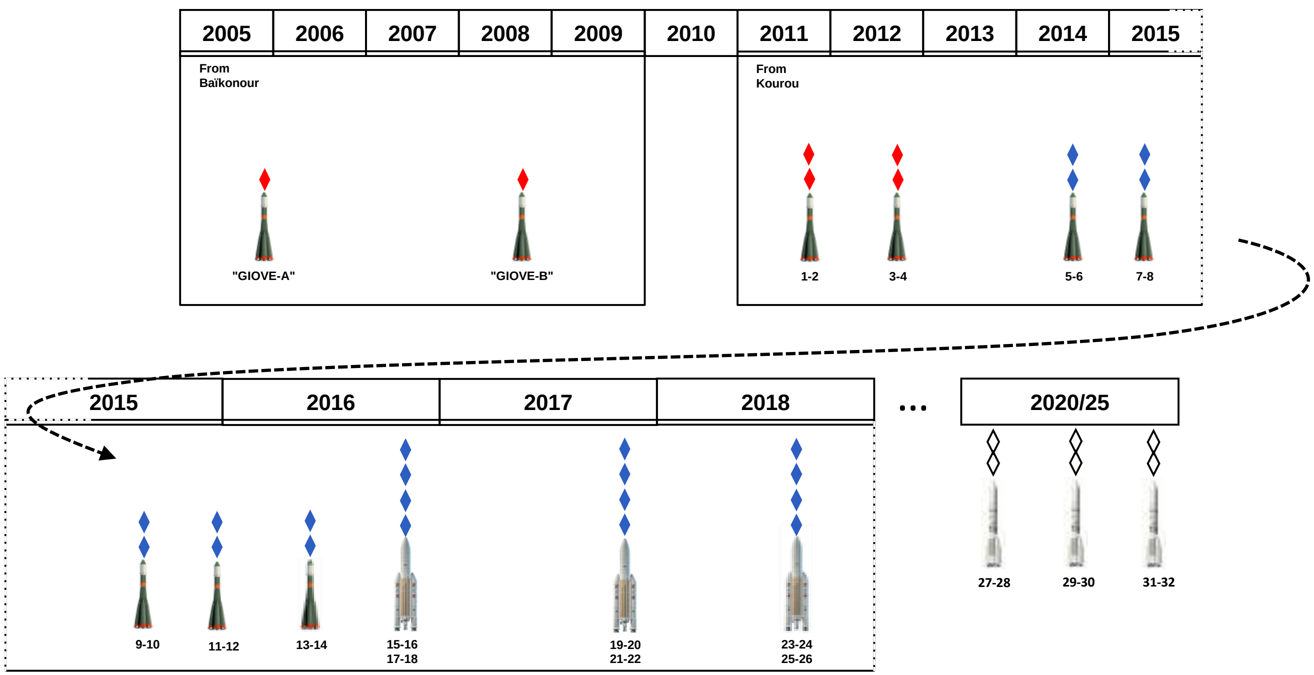
Search and Rescue Service (SAR)

Europe's contribution to COSPAS-SARSAT, an international satellite-based search and rescue distress alert detection system

Public Regulated Service (PRS)

Service restricted to government-authorised users, for sensitive applications that require a high level of service continuity

Galileo is already operational with 26 satellite already in orbit

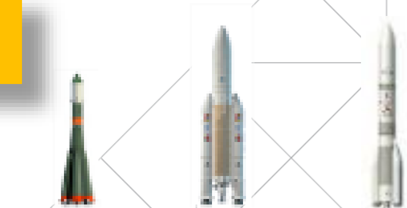


2016

Galileo Initial Services

2019

26 satellites already launched out of which 22 operational



Agenda

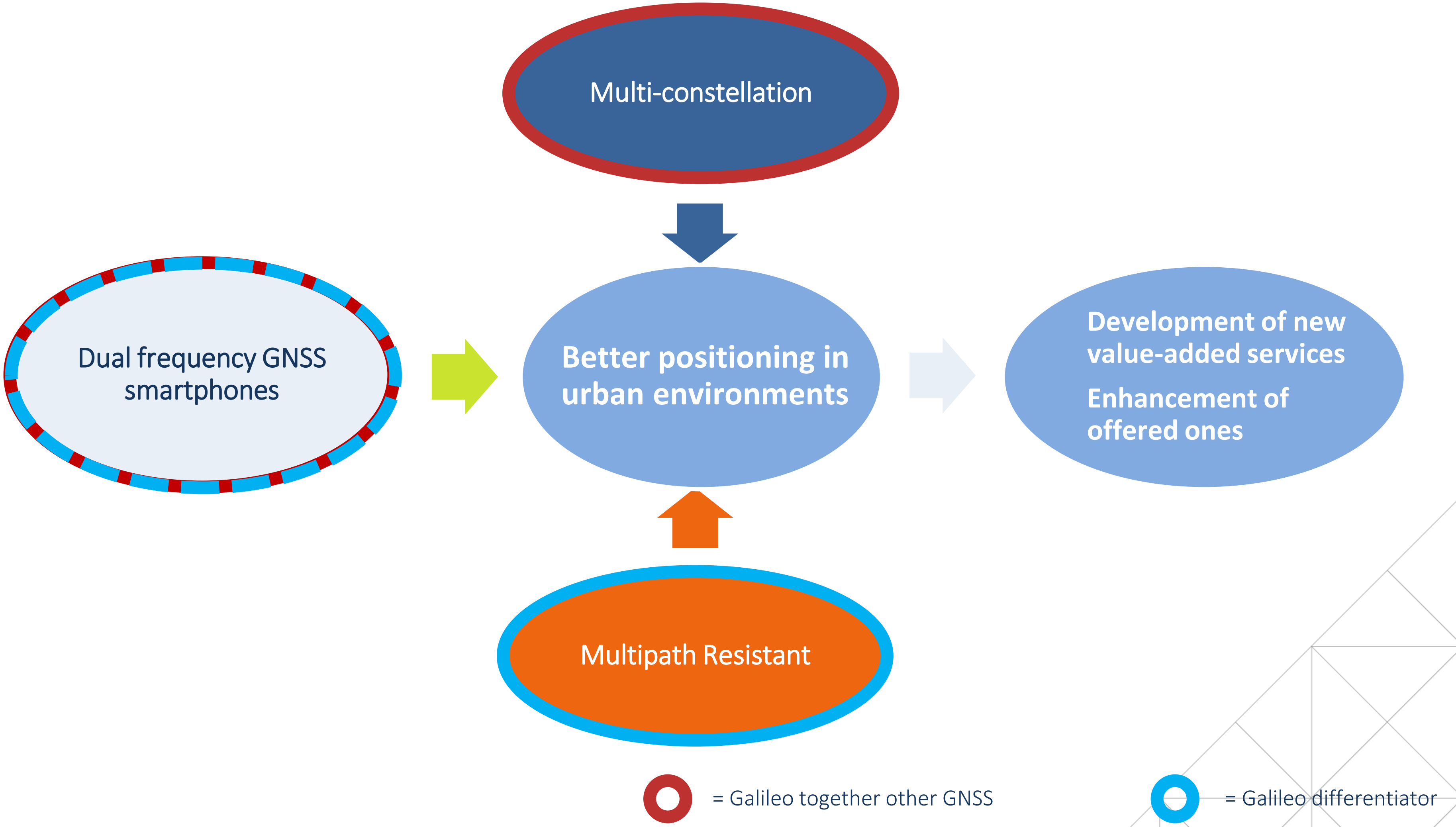
GSA and EGNSS in a nutshell

Why using Galileo?

Big Data

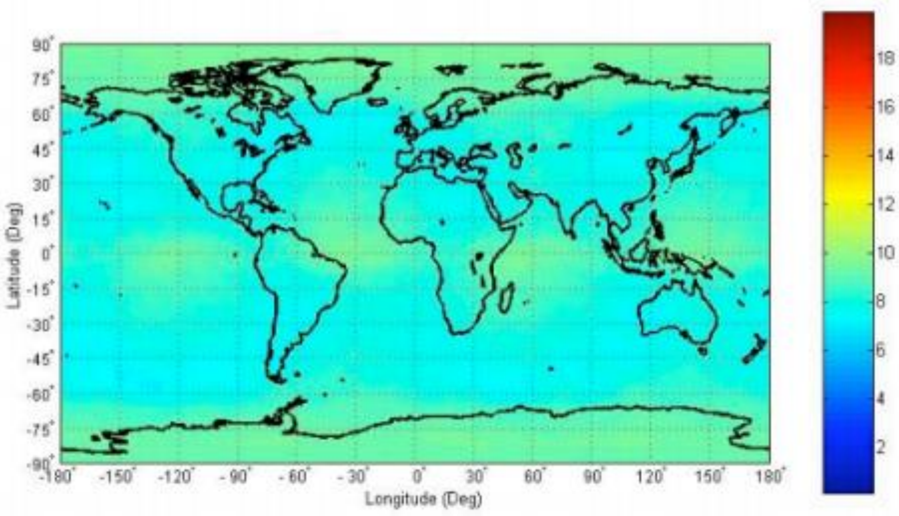
Securing the data

The current Galileo added value in mass market

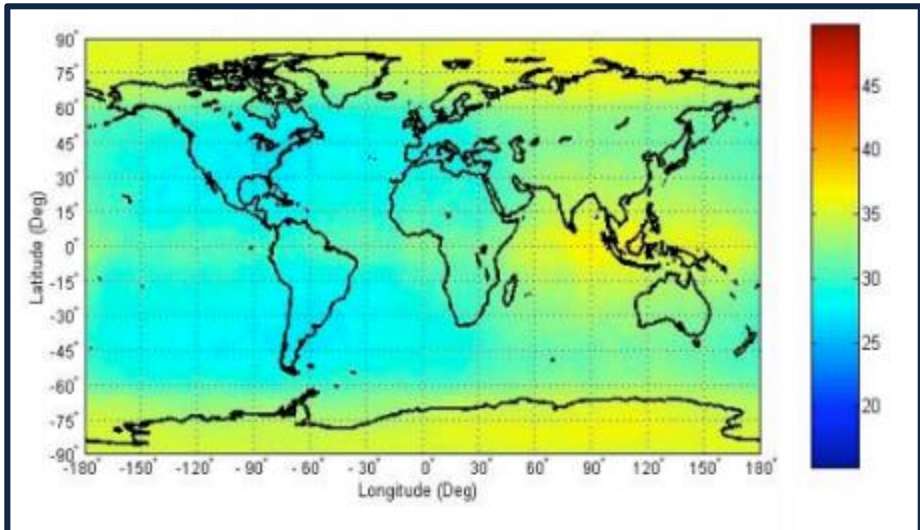


Galileo in multi-GNSS provides improved accuracy, availability and a faster time-to-first-fix

Multi-constellation



GPS only: Average number of satellites in view



GPS, Glonass, Galileo, Beidou, IRNSS and QZSS: Average number of satellites in view*

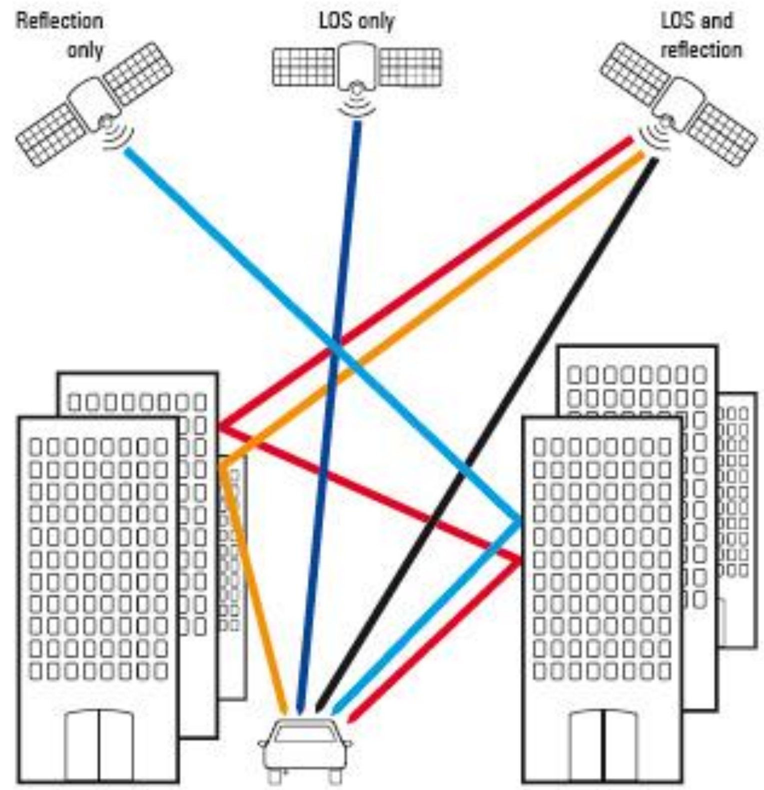
*Source: "Experimental Results for the Multipath Performance of Galileo Signals Transmitted by GIOVE-A Satellite", Andrew Simsky, DavidMertens, Jean-Marie Sleewaegen, Martin Hollreiser, and Massimo Crisci, Septentrio, ESA, 2008

** Above a 15 degree elevation angle over a 24 hours perios

Galileo improves GNSS location in challenging urban environments

The strength of Galileo signal, together with an advanced code modulations, makes Galileo **better mitigating multipath effects** (especially in E5, but also E1)**

Multipath Resistant



**Source: "Estimating the Time-To-First-Fix for GNSS Signals Theory and Simulation Results" *'Marco Anghileri, Matteo Paonni, Stefan Wallner, José-Ángel Ávila-Rodríguez, Bernd Eissfeller, Institute of Geodesy and Navigation, University FAF Munich, Germany'*

Dual frequency receivers and raw measurements will enable innovative apps

Dual frequency GNSS smartphones

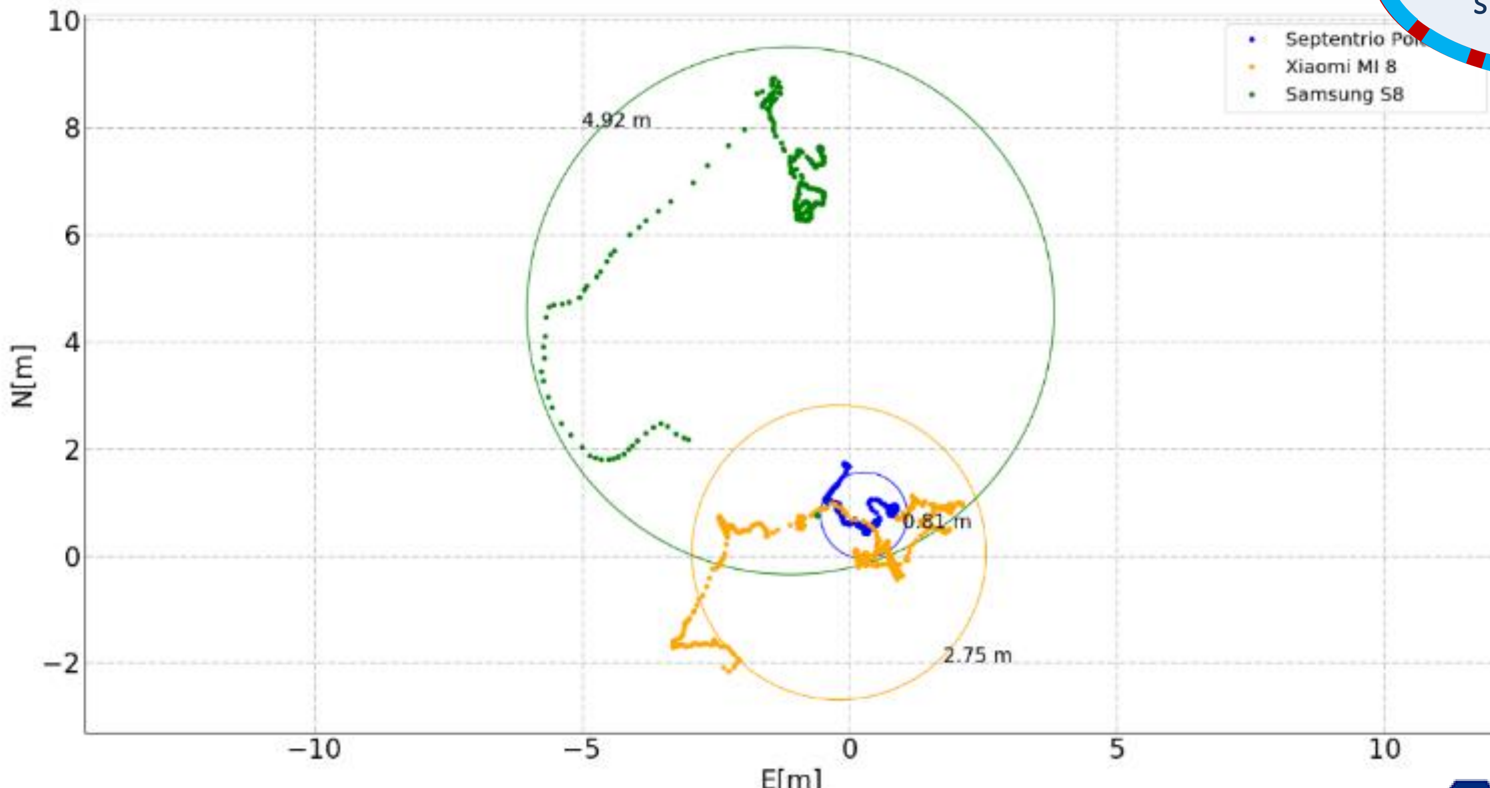
- Availability of raw GNSS measurements
- Entry into the market of **dual frequency GNSS receivers smartphones**:
  - XiaomiM8, presented in June 2018, is the first phone using a dual frequency chipset (BCM47755 by Broadcom)
  - By using L1 and L5 frequency bands, It is able to provide an accuracy up to 30 cm
  - Galileo is the GNSS currently providing the biggest number of L5 satellites

HUAWEI Mate 20

HUAWEI

Test results on GNSS dual frequency smartphones

Dual frequency GNSS smartphones



Source: [NSL]

Dual frequency and Galileo

Dual frequency GNSS smartphones

Why Dual Frequency now?

L5/E5 satellite launches have sped up in 2015 and 2016

Now, there are enough L5/E5 satellites that it is worth using a dual frequency receiver

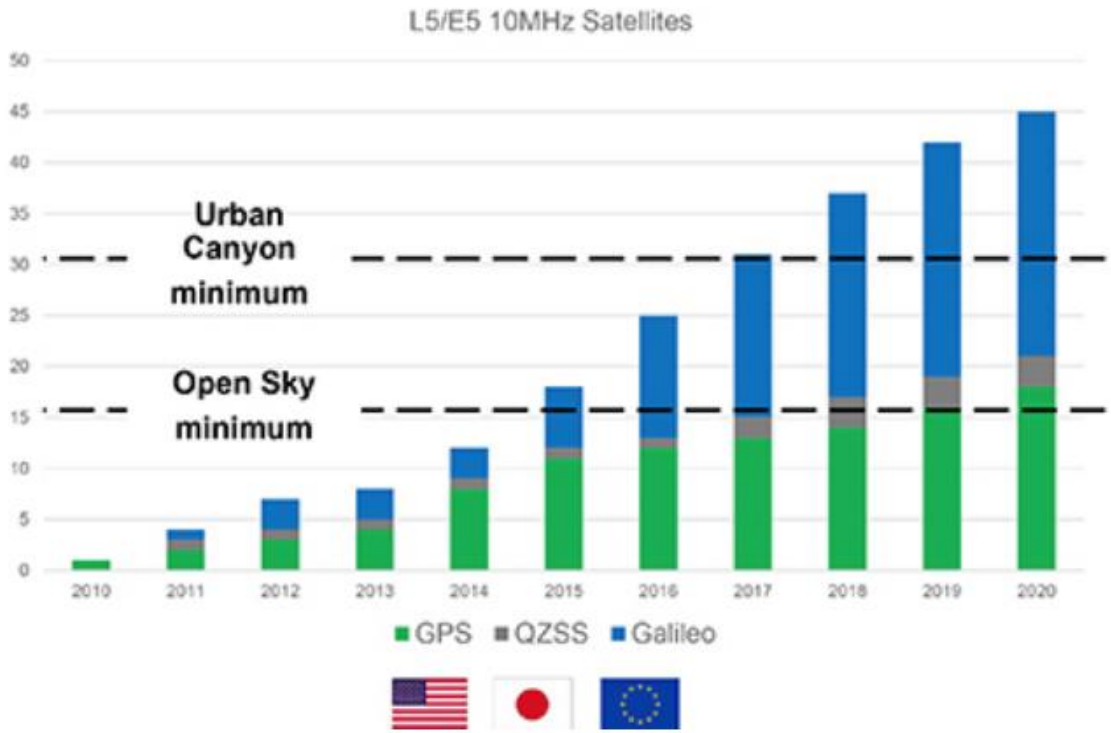
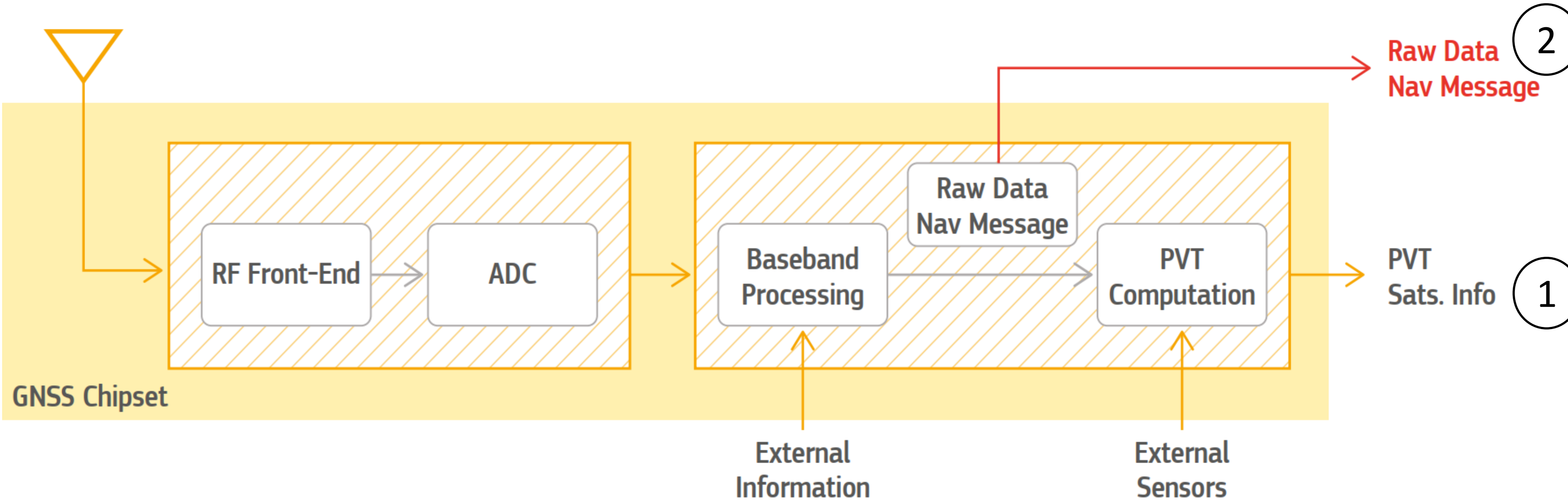


Image: Broadcom

Agenda

- GSA and EGNSS in a nutshell
- Why using Galileo?
- **Big data**
- Securing the data

Two approaches for positioning processing



Generic block diagram of a GNSS receiver (source: https://www.gsa.europa.eu/system/files/reports/gnss_raw_measurement_web_0.pdf)

1. "Classic": PVT processed in the receiver and provided to the application as processing data
2. External processing of "Raw data" for PVT estimation

The classic approach

PVT provided to the application already processed receiver in a suitable format (e.g. RINEX, NMEA)

```
$GPGGA,132318.00,5005.8586,N,01426.0729,E,1,15,01.0,207.0,M,45.5,M,,*5C
$GPRMC,132318.00,A,5005.8586,N,01426.0729,E,00.00,092.8,250815,,,A*52
$GPGSV,5,1,17,07,12,314,42,08,23,296,34,13,07,025,22,15,14,056,32*7D
$GPGSV,5,2,17,16,55,215,49,18,56,104,29,19,20,293,39,20,14,042,24*7F
$GPGSV,5,3,17,21,44,068,27,22,43,167,36,26,32,187,43,27,63,297,45*72
$GPGSV,5,4,17,33,26,216,44,37,32,170,,39,32,166,37,40,21,131,*76
$GPGSV,5,5,17,49,32,192,*49
$GLGSV,3,1,10,65,50,096,02,66,23,159,34,72,26,032,,78,08,220,16*66
$GLGSV,3,2,10,79,30,262,41,80,22,328,35,81,65,329,43,82,07,286,37*6C
$GLGSV,3,3,10,87,11,094,,88,56,069,*6A
$GAGSV,1,1,02,162,34,281,44,169,11,169,00*63
$GNGSA,A,3,27,18,22,07,26,16,08,19,,,,,01.6,01.0,01.2*11
$GNGSA,A,3,162,,,,,,,,,,,01.6,01.0,01.2*2C
$GNGSA,A,3,66,78,79,80,81,82,,,,,,,01.6,01.0,01.2*13
$PORZD,A,016.1*3A
```

- Continuous tracking with 1 Hz frequency
- 1 sec data block
- $GPGSV: GPS satellite tracked
- $GLGSV: GLONASS satellite tracked
- $GAGSV: Galileo satellite tracked

```
$GPGGA,132319.00,5005.8586,N,01426.0729,E,1,15,01.0,207.0,M,45.5,M,,*5D
```

- New second block begins

The classic approach

- For the previous example one hour of continuous tracking resulted in roughly 3MB of data
- For example:
  - Luxembourg City had by 01/01/2017 174 buses[1]
  - Assuming that continuous tracking as presented before of the bus fleet is desired
  - The amount of data generated every day would be:

    174 x 3MB/hour x 12 hours/day ~ 6,3 **TB/day**
  - Assuming **only positioning** data is necessary!
  - If other data is necessary, the amount would be even greater

1 https://www.vdl.lu/sites/default/files/media/document/Le%20r%C3%A9seau%20en%20chiffres.pdf

External processing of raw data

Full bias ns

Cn0 DbHz

Pseudorange m/s

# Raw	ElapsedRealtimeNanosSystemClock	TimeNanos	LeapSecond	TimeUncertaintyNanos	FullBiasNanos	BiasNanos	BiasUncertaintyNanos	DriftNanosPerSecond	DriftUncertaintyNanosPerSecond	HardwareClockDiscontinuityCount	SVID	TimeOffsetNanos	State	ReceivedSVTimeNanos
#														
Raw	135606	75418000000			-1.19669E+18	0	13.23280023			0	2	0	47	3.95E+14
Raw	135607	75418000000			-1.19669E+18	0	13.23280023			0	5	0	47	3.95E+14
Raw	135607	75418000000			-1.19669E+18	0	13.23280023			0	6	0	47	3.95E+14
Raw	135607	75418000000			-1.19669E+18	0	13.23280023			0	7	0	47	3.95E+14
Raw	135607	75418000000			-1.19669E+18	0	13.23280023			0	9	0	47	3.95E+14
Raw	135607	75418000000			-1.19669E+18	0	13.23280023			0	16	0	47	3.95E+14

# Raw	ReceivedSVTimeUncertaintyNanos	Cn0DbHz	PseudorangeRateMetersPerSecond	PseudorangeRateUncertaintyMetersPerSecond	AccumulatedDeltaRangeState	AccumulatedDeltaRangeMeters	AccumulatedDeltaRangeUncertaintyMeters	CarrierFrequencyHz	CarrierCycles	CarrierPhase	CarrierPhaseUncertainty	MultipathIndicator	SNRInDb	ConstellationType
#														
Raw	61	23.71351242	-7.5321121	0.305104553	6	-867.37607	3.40E+38					0		1
Raw	94	16.26821327	-633.52109	4.200237801	6	-42004.792	3.40E+38					0		1
Raw	37	27.96049881	457.666486	0.187633808	3	30857.606	0.00342582					0		1
Raw	26	30.86655998	-289.41956	0.135272371	6	-20367.979	3.40E+38					0		1
Raw	11	38.48816299	230.254993	0.057577176	3	15748.575	0.001081328					0		1
Raw	37	27.94695663	41.0942701	0.19056277	3	1226.9034	0.003431165					0		1

- Raw measurements are extracted from the receiver
- They are transferred somewhere else via a data channel
- The PVT is estimated “somewhere else” using a computing platform

External processing of raw data

- The previous slide shows an abstract of the raw data recorded for a 160 minutes observation session
- The whole data file measures roughly 31MB
- Applying this scenario to the Luxembourg’s buses example:

174 x 11,6MB/hour x 12 hours/day ~ 24 **TB/day**

- Under the same assumptions (only positioning data, no other data of the vehicles recorded)
- This solution then requires:
  - More data capacity than the “classic” one
  - More computing processing on the remote site
- But
  - It reliefs the tracking device from a heavy computing charge
  - Reduces battery consumption
  - Enables tracking on applications that have limited availability of power

A real example

- Vietnam passed legislation requiring all vehicles used for transport must be equipped with tracking devices
- According to the **Director of the Transport Department in the Ministry of Transport of Vietnam** the regulation requires tracking devices to send the following data to the concerned authority:
  - Route itinerary.
  - Speed: measured by GNSS chipset, and counter meter.
  - Continuous driving time
  - Working time of drivers in a day
- This resulted in:
  - **2 billion** data packs submitted every day
  - **1,4 TB of data** per day!

A few GNSS applications needing big data

- Location-Based Services, e.g.:
  - Smartphones producing geo-tagged pictures
  - Augmented reality games
- IoT
- Road, e.g.:
  - Fleet tracking (like shown in the Luxembourg's buses example)
  - Connected vehicles in general
- Time stamping of financial transactions
- Scientific applications

Agenda

- GSA and EGNSS in a nutshell
- The Galileo differentiators
- Galileo impact in emerging mass market applications
- **Securing the data**

Risks to GNSS data

- Two main risks are well known to the use of GNSS data:
  – Jamming

    Blocking the reception of GNSS signals by tone signals emitted in the GSNSS frequency rates: studies going on to limit its impact but so far it can be easily detected and reported

  – Spoofing

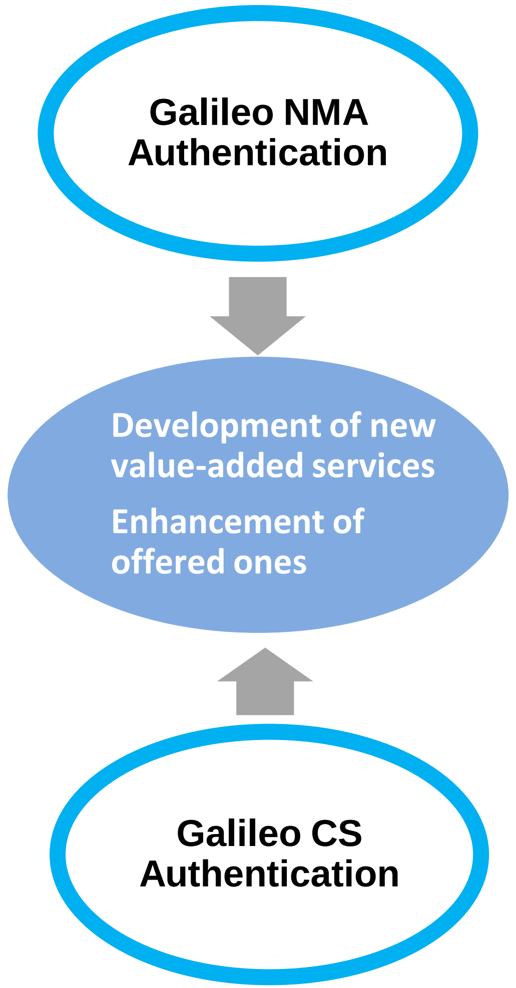
    Altering the PVT solution by emitting signals that replicate those emitted by the GNSS satellites so that an inaccurate solution is reported (e.g. the receiver believes it is in Luxembourg while it is in Prague)

Overcoming spoofing

Need for authentication emerges from users to enhance Galileo value proposition with regards to:

- Enabling **commercially sensitive applications**
- Enhancing **big data** collection

Main applications: Law enforcement, fraud management, billing, payment by location…



= Galileo differentiator

Concluding

- GNSS in general is a source of valuable space-generated data that can benefit from the technologies associated to big data and computing
- Galileo in particular can be valuable to making such solutions more secure by improving the quality and reliability of the collected data
- Stay tuned to the GSA website for R&D funding opportunities in these synergies

Check our funding opportunities!

- GSA fosters adoption of Galileo and EGNOS with funding opportunities:
  - Horizon 2020 calls for development of GNSS applications
  - Fundamental Elements R&D actions for the development of receiver technologies
- We also have actions to expand the market of European companies overseas. E.g.:
  - BELS+ project http://www.belsproject.eu/
  - GNSS.Asia https://gnss.asia/

THANK YOU FOR YOUR ATTENTION!

Linking space to user needs

How to get in touch:

- GSA Newsletter
- GNSS YouTube Channel
- GSA Twitter - @EU_GNSS
- EGNOS Twitter - @EGNOSPortal
- European GNSS Agency LinkedIn Page
- GNSS Market, Research & Development
- GNSS Facebook page
- GNSS Slideshare Page (presentations)

www.GSA.europa.eu