



HackUPC 2024 – Galileo Mastermind Challenge

03/05/2024



→ THE EUROPEAN SPACE AGENCY

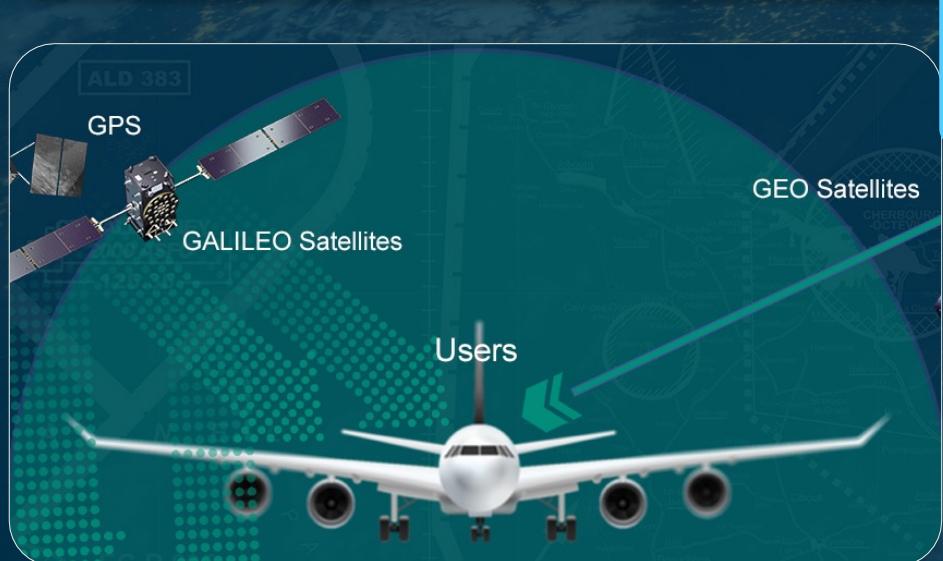
Building Satellite Navigation in Europe



- Initial Services operational since 2016.
- Most accurate and best performing system worldwide.
- 4 billions users worldwide.
- Services for rail, maritime, agriculture, financial timing and rescue operations.
- All smartphones sold in the European market are now guaranteed Galileo-enabled.
- Second Generation in full swing.



H2020/Horizon Europe
Supporting R&D for future
technologies and generations
of Galileo & EGNOS



- Augmenting GPS signals, soon also Galileo signals (v3).
- Ensuring safety-of-life for aviation, maritime, rail, road.
- Regional coverage over EU, worldwide compatibility.
- In use by 670+ airports/helipads and 60+ airlines across Europe.
- Cooperation with ASECNA for implement SBAS system with EGNOS technology in Africa.



Satellite Navigation “made in Europe”



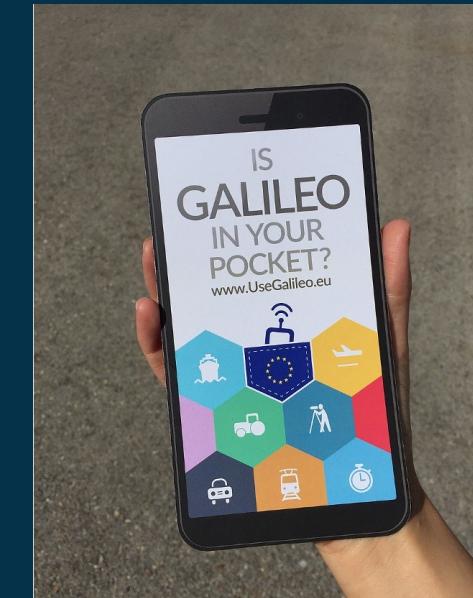
Putting Europe at the forefront of this strategically and economically important sector

Galileo provides a highly accurate, guaranteed global positioning service under civilian control



~ 4 Billion

Estimated number of Galileo enabled smartphones sold until today



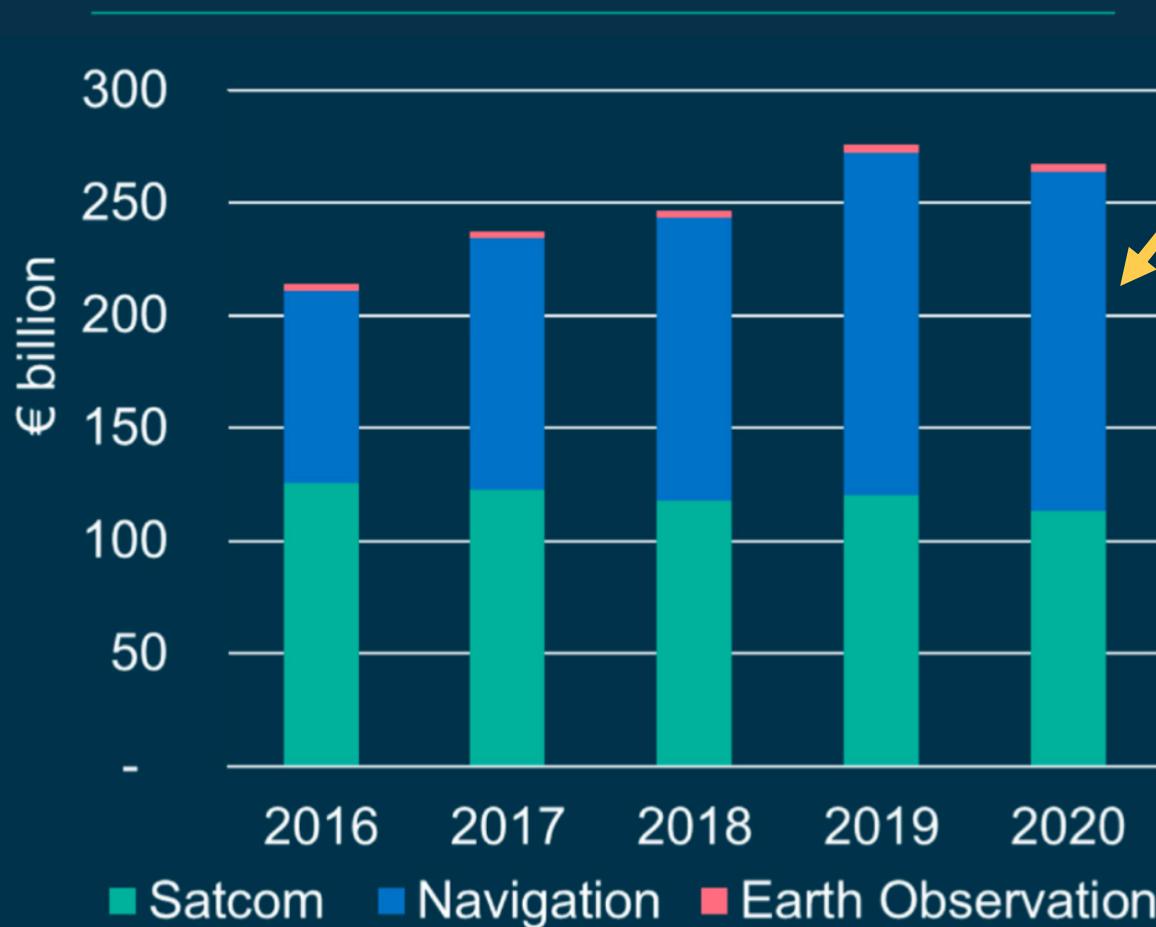
Your smartphone is not alone, discover the other devices that are Galileo-enabled.



Navigation: largest space downstream market



Global downstream revenues
2016-2020, by segment



Navigation #1 market segment

- **€40B/year downstream market in Europe**
- **€1B/year investment in space and ground infrastructure**

Sources | Euroconsult, 2021; Eurospace, 2021; GSA (EUSPA), 2019

Galileo Programme and Stakeholders



Galileo is a Programme of the European Union

The European Commission has overall responsibility for the programme, managing and overseeing the implementation of all activities on behalf of the EU.

Stakeholders (“Partners”) and roles

European Commission (EC): Galileo Programme Manager



European Space Agency (ESA): Galileo System Design Authority (SDA)

- Galileo System Architect
- System Prime for Galileo System Development and Qualification



EU Agency for the Space Programme (EUSPA): Galileo Operator

- Galileo System Exploitation, Galileo Services, System Security Accreditation
- System Prime for System in Operation

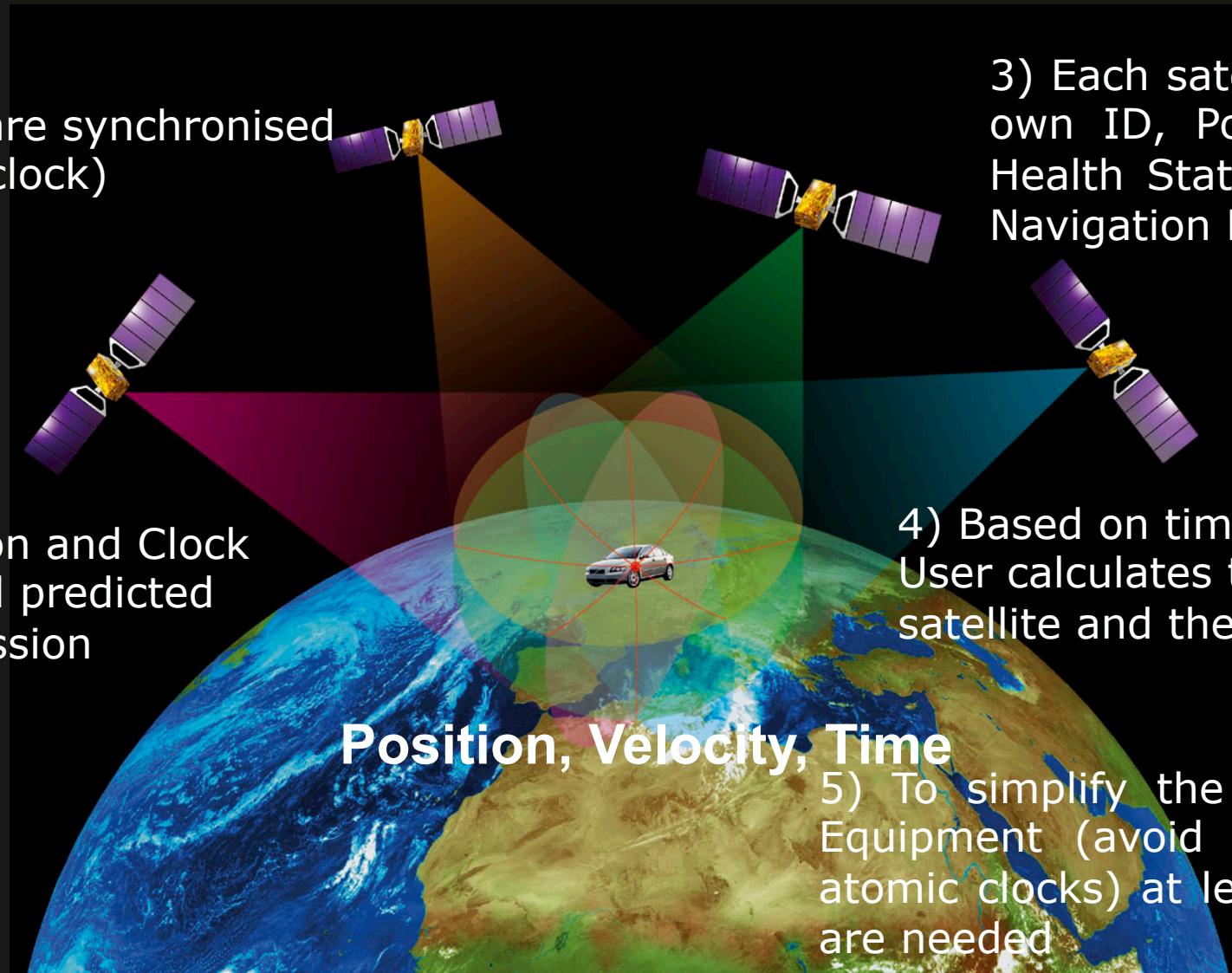


Galileo: How does a Navigation System work?



1) All satellites are synchronised to GST (atomic clock)

2) Satellite Position and Clock are estimated and predicted by the Ground Mission Segment



3) Each satellite transmits its own ID, Position, Time and Health Status as part of the Navigation Message

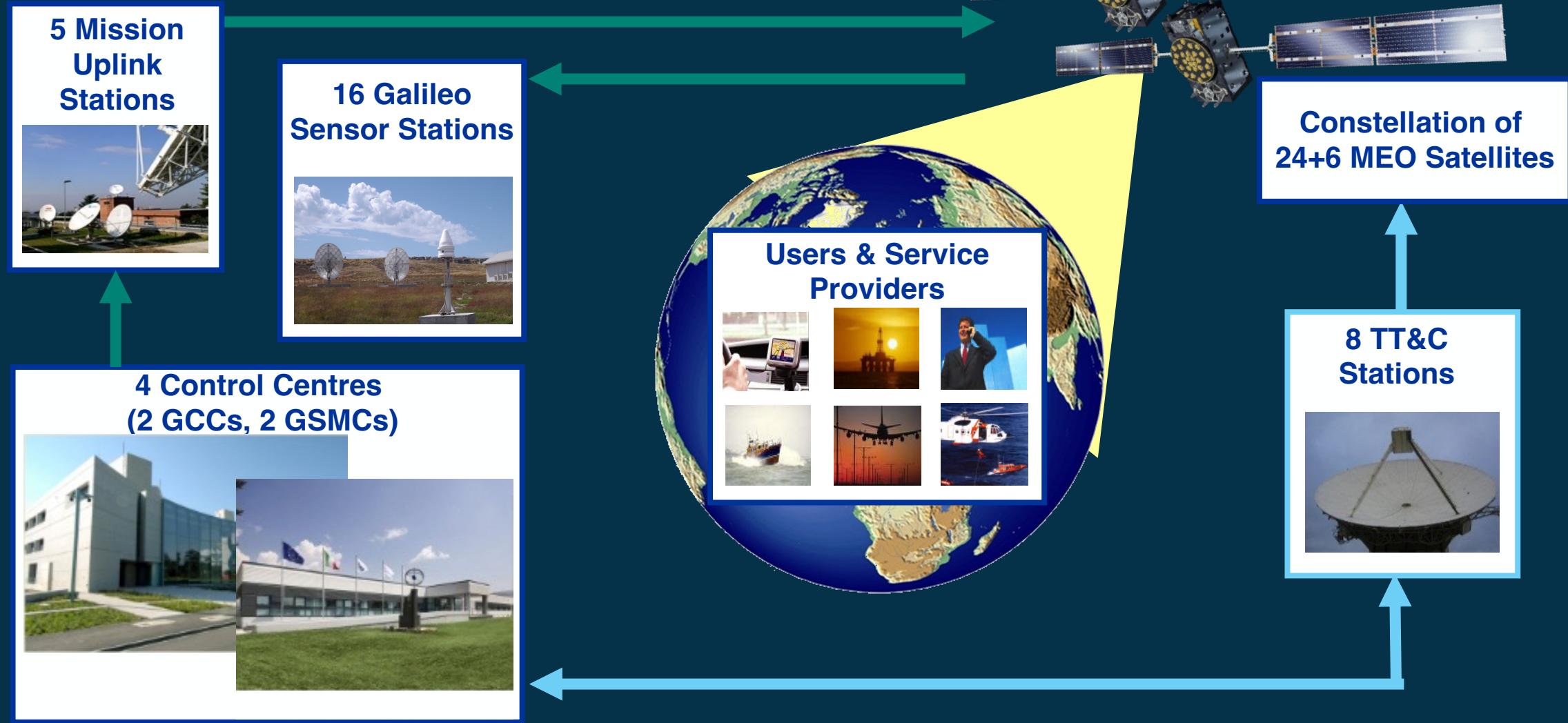
4) Based on time measurements the User calculates the distance to each satellite and then its own position

5) To simplify the design of the User Equipment (avoid heavy and complex atomic clocks) at least 4 measurements are needed

Galileo Roadmap & Development Approach



Galileo System



Open Service (OS)

Free of charge; positioning and timing for mass market



High Accuracy Service (HAS)

Allows sub-decimetre level positioning accuracy



I/NAV Improvement

Allows faster Time to First Fix

Search and Rescue

Near real-time; Precise; Return link available



Consists of GNSS antennas and receiver equipment used to process signals received from the GNSS satellites to determine position, velocity and time



Mass-market chipset and devices



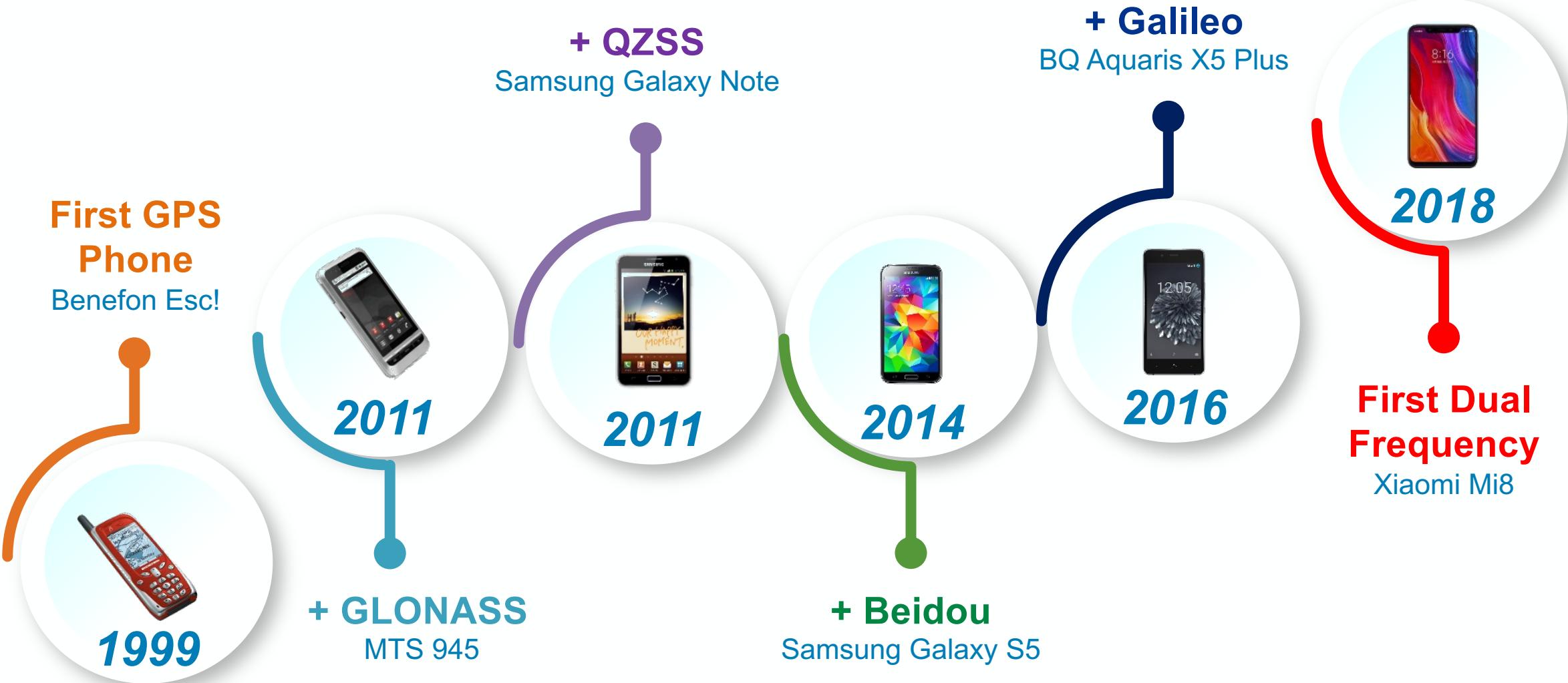
Location technology developers



End User HW providers



GNSS chips in smartphones



Sources: gsmarena, samsung, xiaomi, google, bq, wikipedia

Example Apps for inspiration



→ GalileoPVT

Galileo signals on your smartphone

RECEIVED SIGNS
SVID: 5
AZIM: 79°
ELEV: 25°
TYPE: FOC
MANUF.: OHB/SSTL
LAUNCH-17 NOV 2016
LNCHR: ARIANE 5
ORBIT: COI
C/N0: 34 dBm
FREQ: 1575.42 MHz
SYNC: TOW KNOWN
BEST: TOW KNOWN
MS/IV: 18294
TOW: S 146239372
NANOS: 312380953
RANGE: 26264 km

Lat: 52.2268° N
Long: 4.4526° E
Alt: 26.0 m
Speed: 25.7 m/s
S. Acc: 0.2 m/s
H/V Acc: 6.0/4.5 m
Sats: 28/31/31
Bearing: 178.6°
B. Acc: 10.0°
PDOP: 1.5
H/V DOP: 0.8/1.3

→ Visualise Galileo signals on your phone/tablet
→ Calculate your position and compare with GPS
→ Show real-time satellite positions with augmented reality view
→ Log raw data in CSV and NMEA formats for post-processing
→ For Galileo-enabled devices running Android 7.0 or later

GET IT ON Google Play

CAMALIOT

Improving Weather Predictions
with Navigation Satellites and
Artificial Intelligence

NEXT

Status

Lat: 1.3786742° Long: 103.8583180° Alt: 26.0 m Alt (MSL): 21.4 m Speed: 25.7 m/s S. Acc: 0.2 m/s H/V Acc: 6.0/4.5 m # Sats: 28/31/31 Bearing: 178.6° B. Acc: 10.0° PDOP: 1.5 H/V DOP: 0.8/1.3

ID	GNSS	CF	C/N ₀	Flags	Elev	Azim
1		L1	26.4	AE	20°	189°
3		L5	25.0	AE	30°	226°
3		L1	38.6	AEU	30°	226°
4		L5	24.1	AE	64°	322°
4		L1	32.5	AEU	64°	322°
8		L1	36.6	AEU	85°	241°
9		L1	34.0	AEU	26°	322°
9		L5	22.1	AE	26°	322°
16		L1	33.1	AEU	16°	21°
21		L1	32.1	AEU	32°	167°
22		L1	34.6	AEU	28°	199°
27		L1	35.4	AEU	51°	32°
27		L5	25.8	AEU	51°	32°
31		L1	39.3	AEU	14°	95°
5		L1	40.2	AEU	15°	169°
7		L1	37.3	AEU	32°	300°
3		E1	37.4	AEU	48°	305°
5		E1	34.9	AEU	67°	186°
5		E5a	23.9	AEU	67°	186°
11		E1	31.3	AEU	31°	84°
36		E1	32.7	AEU	42°	149°
36		E5a	24.1	AEU	42°	149°
194		L5	22.7	AE	30°	40°
194		L1	40.2	AEU	30°	40°
195		L1	35.6	AEU	45°	68°
195		L5	23.9	AEU	45°	68°
6		B1C	34.3	AEU	77°	94°
7		B1C	28.5	AEU	39°	2°
8		B1C	25.2	AE	27°	150°
9		B1C	25.5	AEU	68°	356°
10		B1C	34.2	AEU	46°	331°

Satellite table

GNSS Status

Fix 30/35

id	C/N ₀ (dB-Hz)	fix	azi	elev
22	45,3	✓	105°	33°
3	42,8	✓	92°	52°
22	42,8	✓	65°	62°
5	41,5	✓	45°	50°
19	41,3	✓	259°	25°
9	40,4	✓	238°	53°
11	38,8	✓	180°	36°
5	38,6	✓	246°	21°
12	38,4	✓	238°	37°
7	38,1	✓	184°	8°
21	36,8	✓	278°	53°
1	36,1	✓	159°	20°
17	35,9	✓	236°	17°
9	35,4	✓	259°	73°
36	35,2	✓	259°	61°
34	34,4	✓	274°	37°
18	34,3	✓	278°	19°
10	GPS			
7	GLONASS			
7	Galileo			
11	BeiDou			

Table

ESA FutureNAV – NAVISP – Moonlight



Commercial Activities



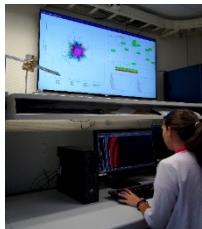
*Design, development and testing of pre-commercial and commercial ground (user/infrastructure) equipment.
Support to the implementation and testing of satellite navigation, telecom, and Earth observation systems falling within the division's TOR.*



ESA's NAVISP Programmes



InCubed (esa.int) EOP user/ground segment



Galileo
Performances



ODTS Perfo &
S&IV



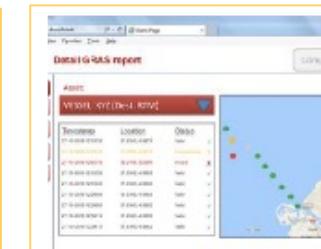
Space Borne
Receivers



Ground
Segment



Professional
Receiver



Anti-spoofing
Software



Real-Time
Simulators

A large, semi-transparent circular graphic of Earth is centered in the background. It is surrounded by numerous small, white satellite models in various orbits, creating a sense of a busy space environment. The Earth's horizon is visible at the bottom of the circle.

Your challenge,
should you choose to accept it!

Galileo Mastermind Challenge



Galileo is Europe's own global navigation satellite system with over 4 billion users

Imagine navigating with Galileo:

- Do you want to know how many Galileo satellites are used on your phone?
- How is Galileo contributing to your position accuracy?
- Are the signals being altered?



Be the mastermind of Galileo, get creative & develop a solution to exploit crowdsourcing mobile GNSS data!

The winning solution will contribute to the ESA GalileoPVT app



Galileo Mastermind Challenge



1. Register to <https://hackgnss.cloud/AcceptTheChallenge.html>
 1. You'll get a DB and the credentials to use it;
 2. The same credentials will work on a Grafana instances on <https://hackgnss.cloud> (feel free to use Grafana Cloud)
 3. You'll have access to a prepopulated DB with mobile measurements from test campaigns
2. Check the resources on <https://hackgnss.cloud>
3. Create your backend and API in the language you prefer. You can connect it to the DB with the obtained credentials.
4. Create a mobile App to collect the Galileo Raw GNSS Measurements and implement your API
5. Create cool visualisations using Grafana or any other technology
6. Feel free to extend your backend with data postprocessing for new features (ex. benchmarking phone performance, ionospheric disturbance, alteration detection based on unexpectedly low C/N0 values, etc...)
7. Feel free to mix and shake it with ML an AI technologies

InfluxDB Tips

- ❑ Use Measurements for Raw GNSSMeasurements, GNSS Navigation Message, NMEA, GNSS Measurement Status, Fix....
- ❑ Use the Tags to store indexed info, such as mobile phone information (HW/SW versions...)
- ❑ Use the Fields to store the collected measures

Mobile App Tips

- ❑ You can find a boilerplate Android app project in <https://hackgnss.cloud/Boilerplate.zip> with GNSS Raw measurements UI logging implemented. It can be useful to kickstart the challenge.
- ❑ Mind the user privacy, don't collect personal or info which can identify the user
- ❑ A set of compatible devices are available to test your app. Just ask us when you need it.
- ❑ Mind the data usage, consider to collect and push the data to the server only over WiFi

Android API for GNSS Raw Measurements



The screenshot shows the 'Raw GNSS Measurements' page under the 'Develop' section of the Android Developers website. The page includes a note about the GnsLogger app and a note about the GNSS Analysis app. It also links to the GPS Measurement Tools repo on GitHub.

The diagram illustrates the workflow: the GnsLogger app on a smartphone captures raw GNSS measurements, which are then analyzed by the GNSS Analysis software on a desktop computer. The GNSS Analysis software displays various plots and data visualizations.

GNSS Logger

GNSS Analysis

Available since Android 7: <https://g.co/gnsstools>



→ THE EUROPEAN SPACE AGENCY

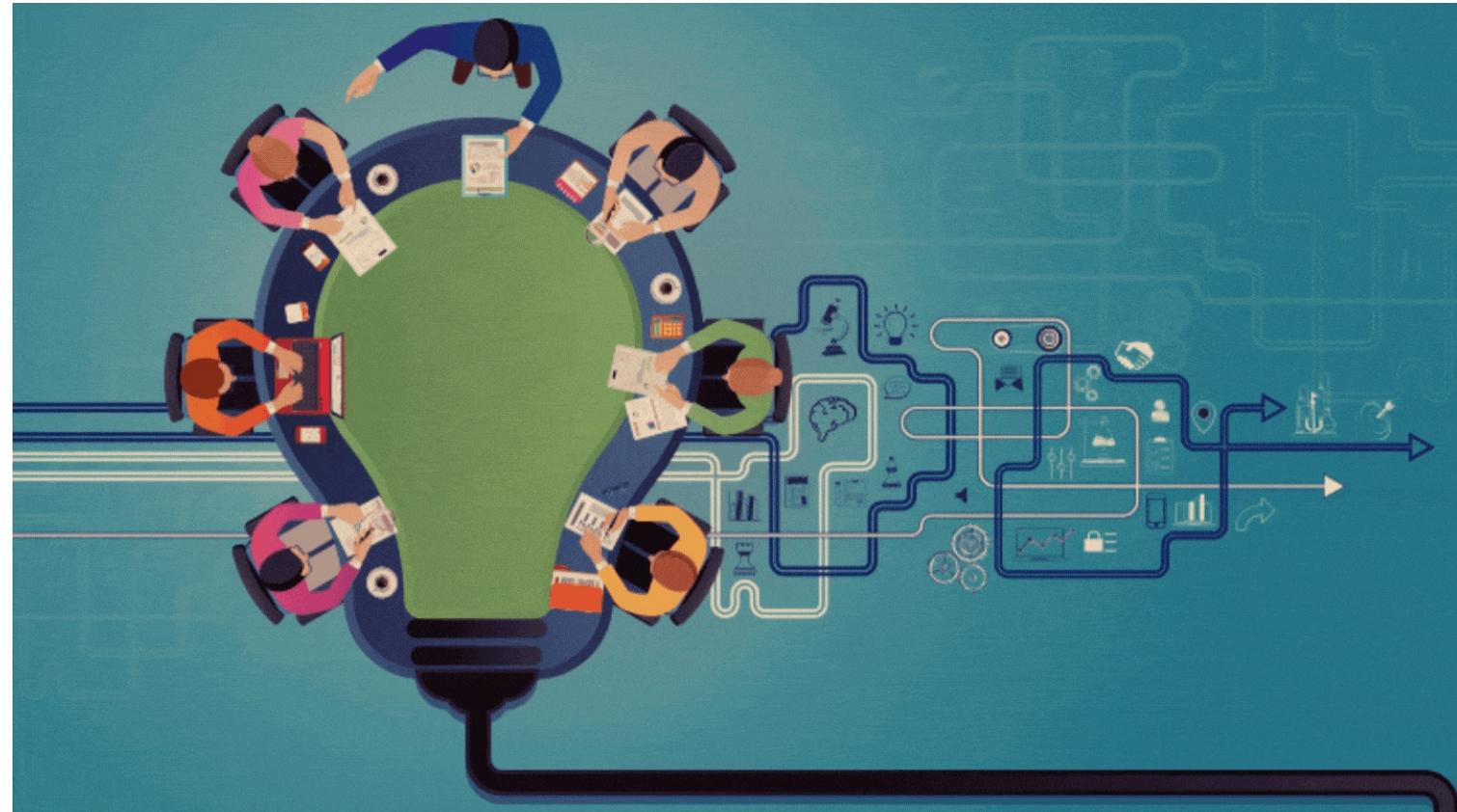
Android 7.0 revolution: GNSS API & Task force on GNSS raw measurements API



Galileo Mastermind Challenge - Evaluation Criteria

Evaluation by a jury based on achieved progress according to:

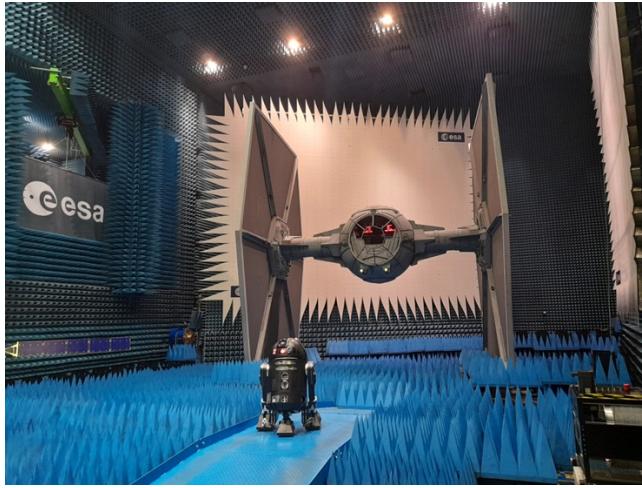
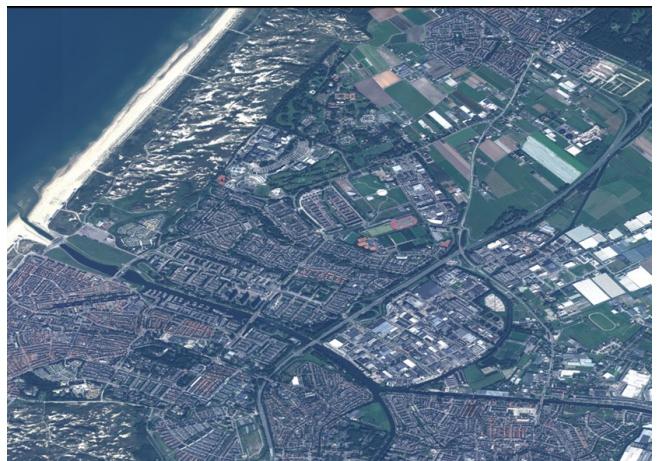
- Innovation
 - Creativity
 - Use of modern technology
 - Design complexity
 - Usability
 - Prototype progress
 - Meeting challenge objectives
 - Team diversity
 - Presentation



Galileo Mastermind Challenge - Winning Prizes

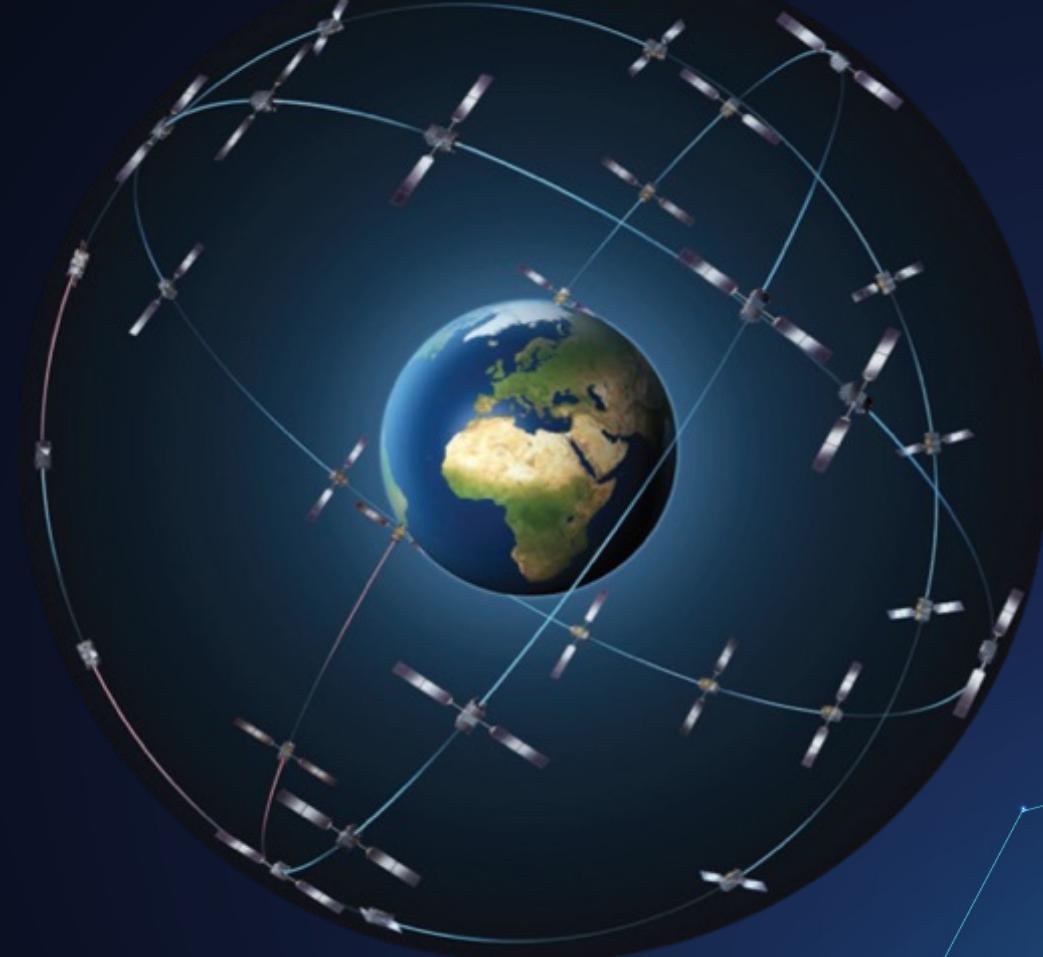


A shirt per winning hacker



Invitation to ESA Open Days in Noordwijk, Netherlands in October 2024
(with financial participation from ESA and opportunity to present your work to public)

Happy hacking!



<https://hackgnss.cloud>



<https://www.esa.int/Applications/Navigation>