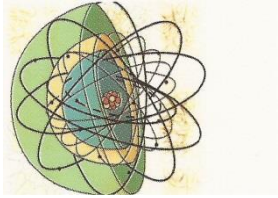


*LEO-BASED*

*PNT GNSS BACKUP*

- LEO GEO GNSS Key individuals features
- Accuracy and traceability path



# GNSS-based PNT features are mandatory in our daily life and in Critical infrastructure

## GNSS vulnerabilities ask for back-up PNT solutions

Multiple technologies are available (cf GNSS vulnerabilities mitigation @ [www.aubryconseil.fr/time-frequency](http://www.aubryconseil.fr/time-frequency))

After long time to think about, alternative technologies are under test and qualification:  
fiber-based (PTP, PTP-HA, RF-based, LEO,....

Fiber based mesh network (based on high accuracy synchronization of infrastructure (DC, Gvt, proprietary fiber channel, or even on telecom infra (DWDM, ON...)) might be adequate for ground application traceable timing

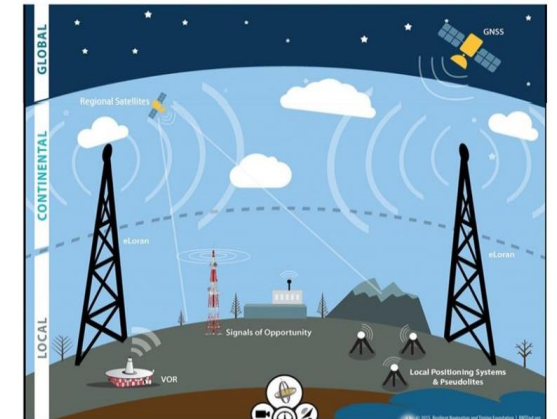
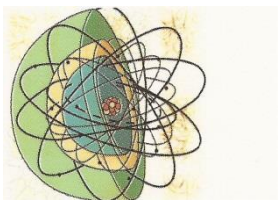


Image from RNT foundation

**So far, LEO is felt as the most relevant global PNT back up potential provider:  
May offer Position, Navigation Timing every where on earth and seas**

HYBRID time reference and hybrid PNT receivers solutions at the user level seem to be the most realistic picture



# LEO MEO GEO for PNT provision ?

- [www.satellite-evolution.com](http://www.satellite-evolution.com)

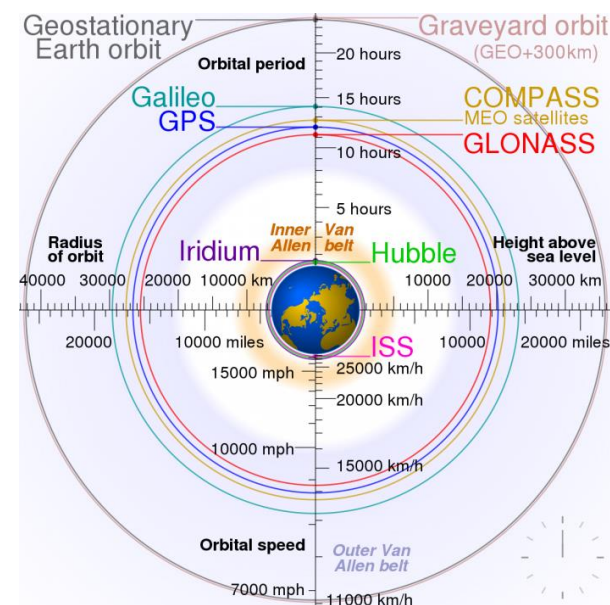
<a href="#">Rayon</a> équatorial	6 378,137 <a href="#">km</a>
Rayon polaire	6 356,752 <a href="#">km</a>

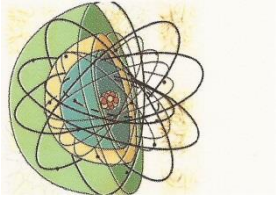
<a href="#">Périmètre</a> équatorial	40 075,017 <a href="#">km</a>
<a href="#">Périmètre</a> méridional	40 007,864 <a href="#">km</a>

GEO altitude : 35'000 km / rotation 24 H

MEO altitude : 5'000 / 12'000 km, rotation 2 – 8 H

LEO altitude : 800 / 1'600 km, rotation 40-100 minutes





## Frequency Bands

- C-Band (4-8 GHz)
- X-Band (8-12 GHz)
- Ku-Band (12-18 GHz)
- Ka-Band (26-40 GHz)

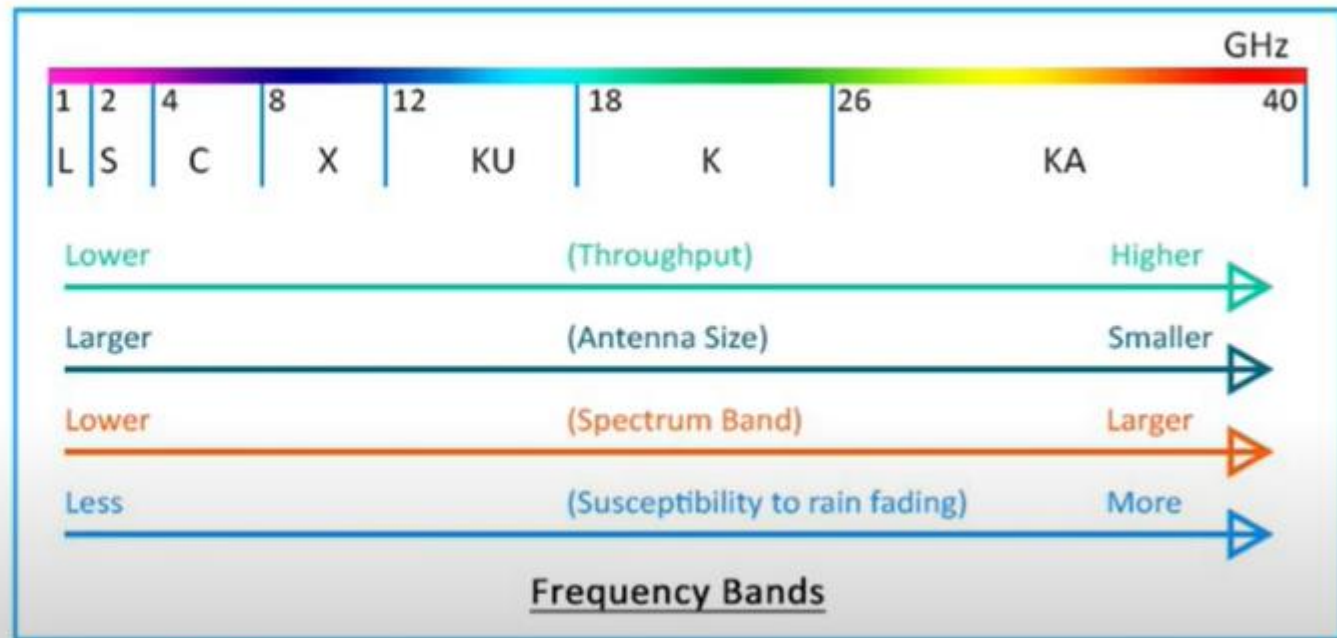
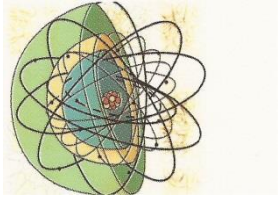
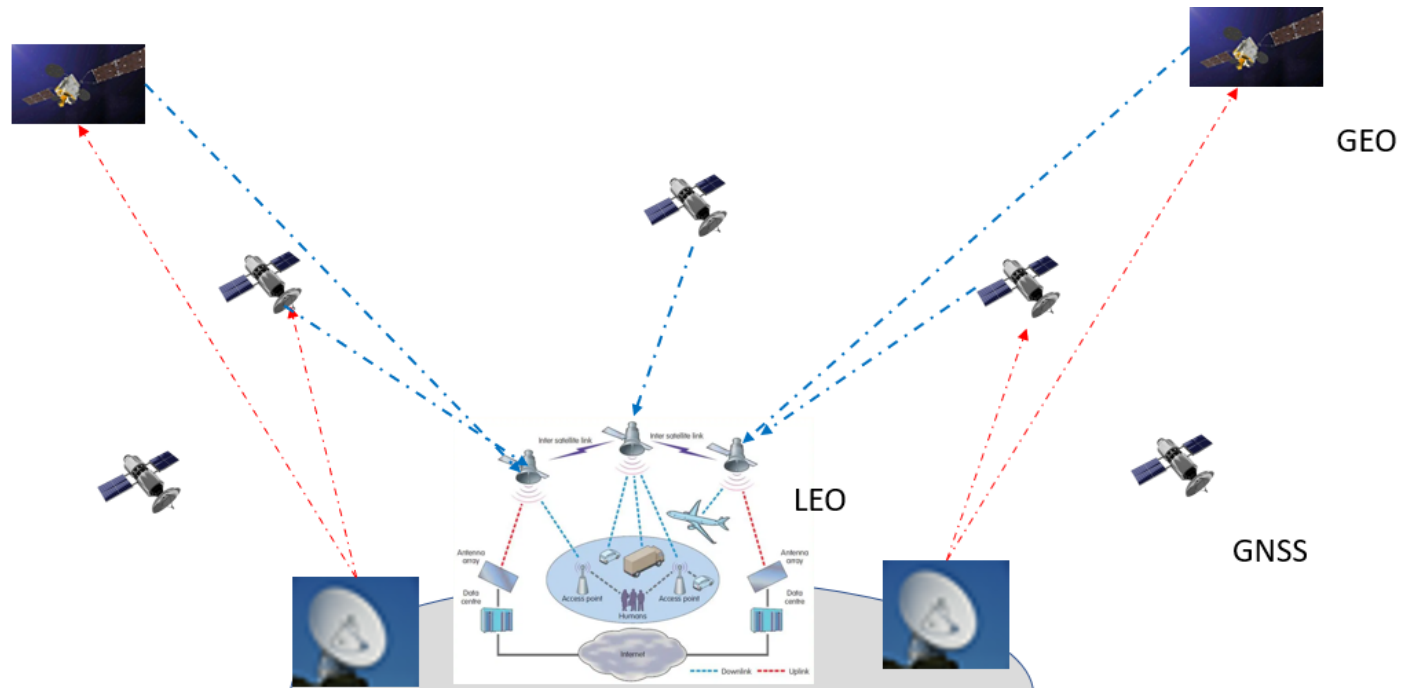


Photo Credit: Editorial Team, "Radar Letter Frequency Bands", Everything RF, 12 Aug. 19,  
<https://www.everythingrf.com/community/ku-band>

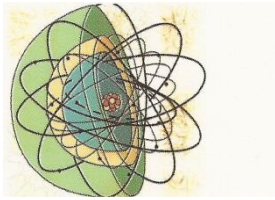


## *Accurate PNT scheme down to user*



Accuracy traceability chain down to the user involves LEO-GNSS-GEO (or direct link from earth)

GEO (or direct link from earth) is required to provide real time correction data of GNSS satellites to on board LEO satellite



# LEO constellations... where is Europe ?



Des dizaines de constellation en preparation (FCC frequency allocation,..., funding announcement,...)

PNT back up

Internet access everywhere

Communication, surveillance, ...

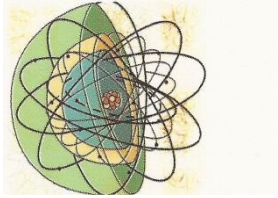
Digital traffic

IoT access

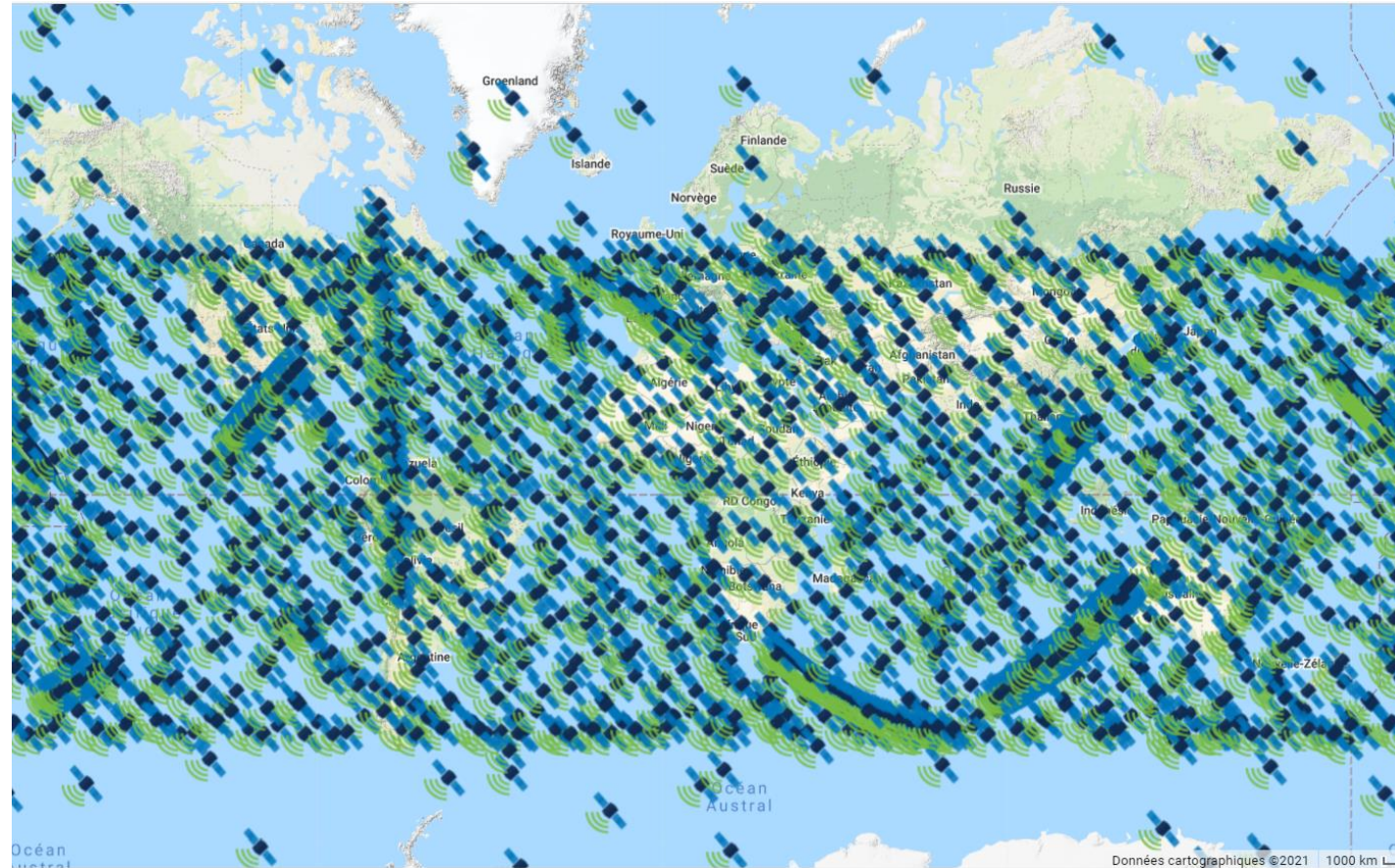
....

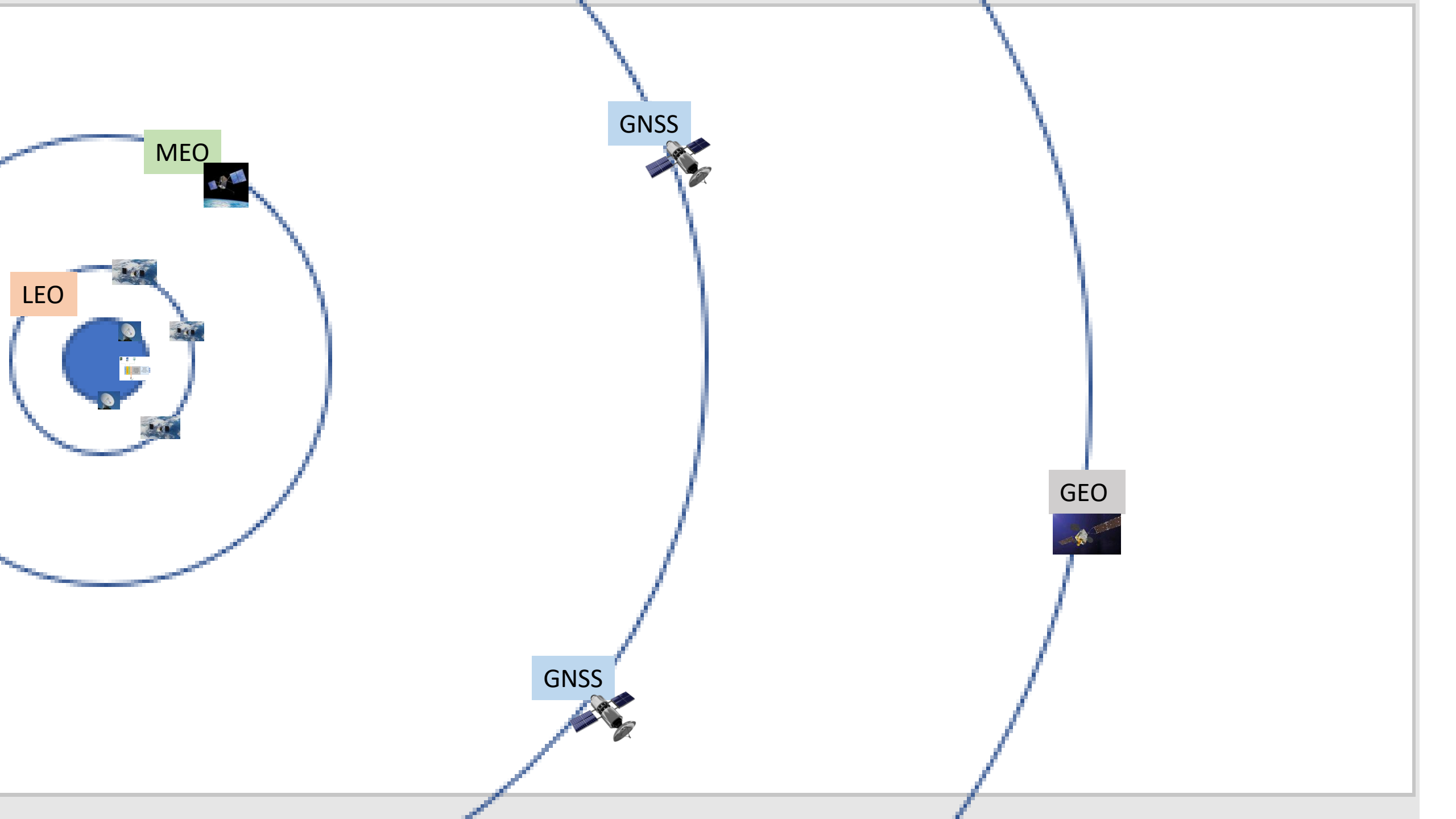
Thierry Breton ask for European Constellation to back-up PNT and multiples services in "poor access areas"

[www.lefigaro.fr/societes/le-projet-de-constellation-europeenne-doit-etre-boucle-en-2021-20210112](http://www.lefigaro.fr/societes/le-projet-de-constellation-europeenne-doit-etre-boucle-en-2021-20210112)



# ***LEO : un monde reel: Instantané des satellites LEO en action le 1/5/21...***





LEO

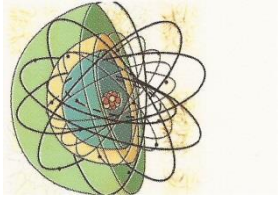
MEO

GNSS

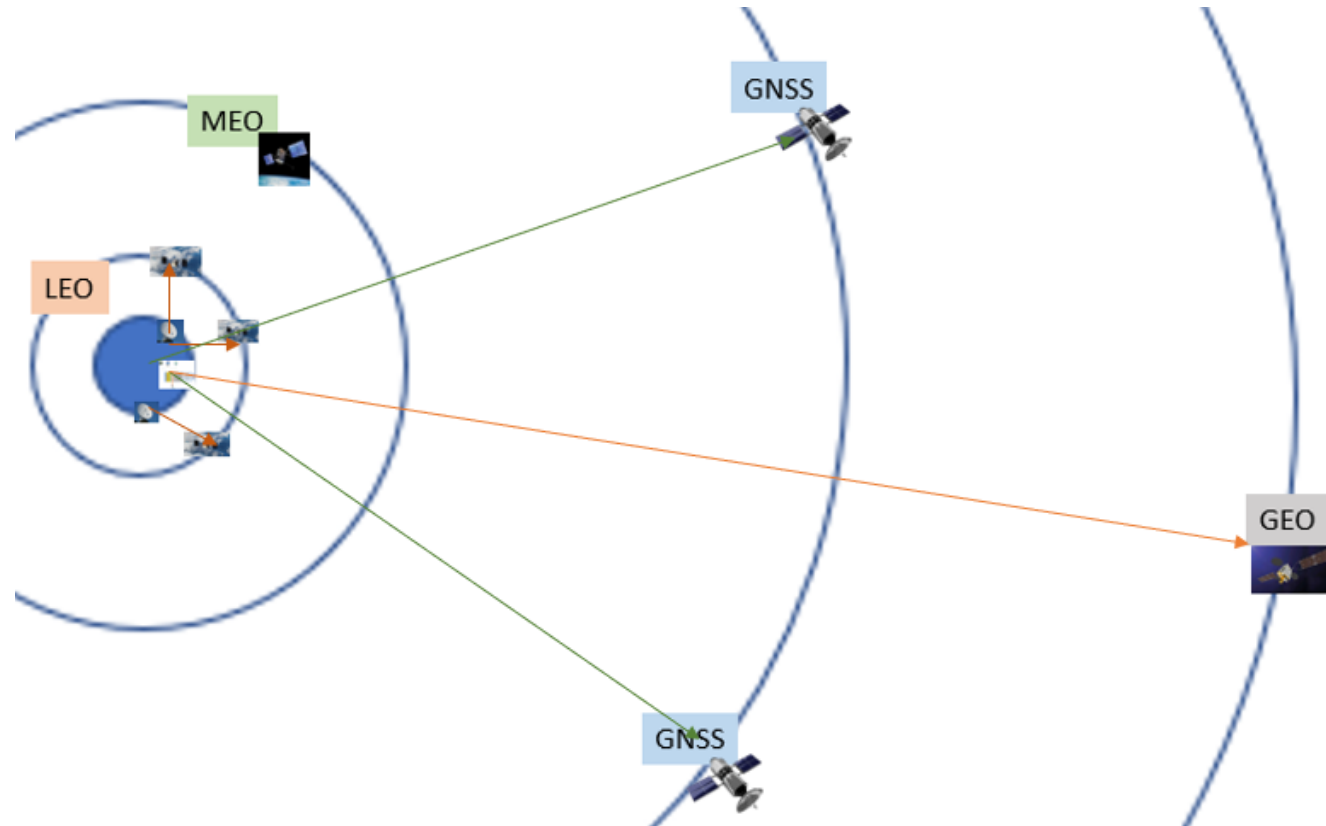
GNSS

GEO





# *Control path*

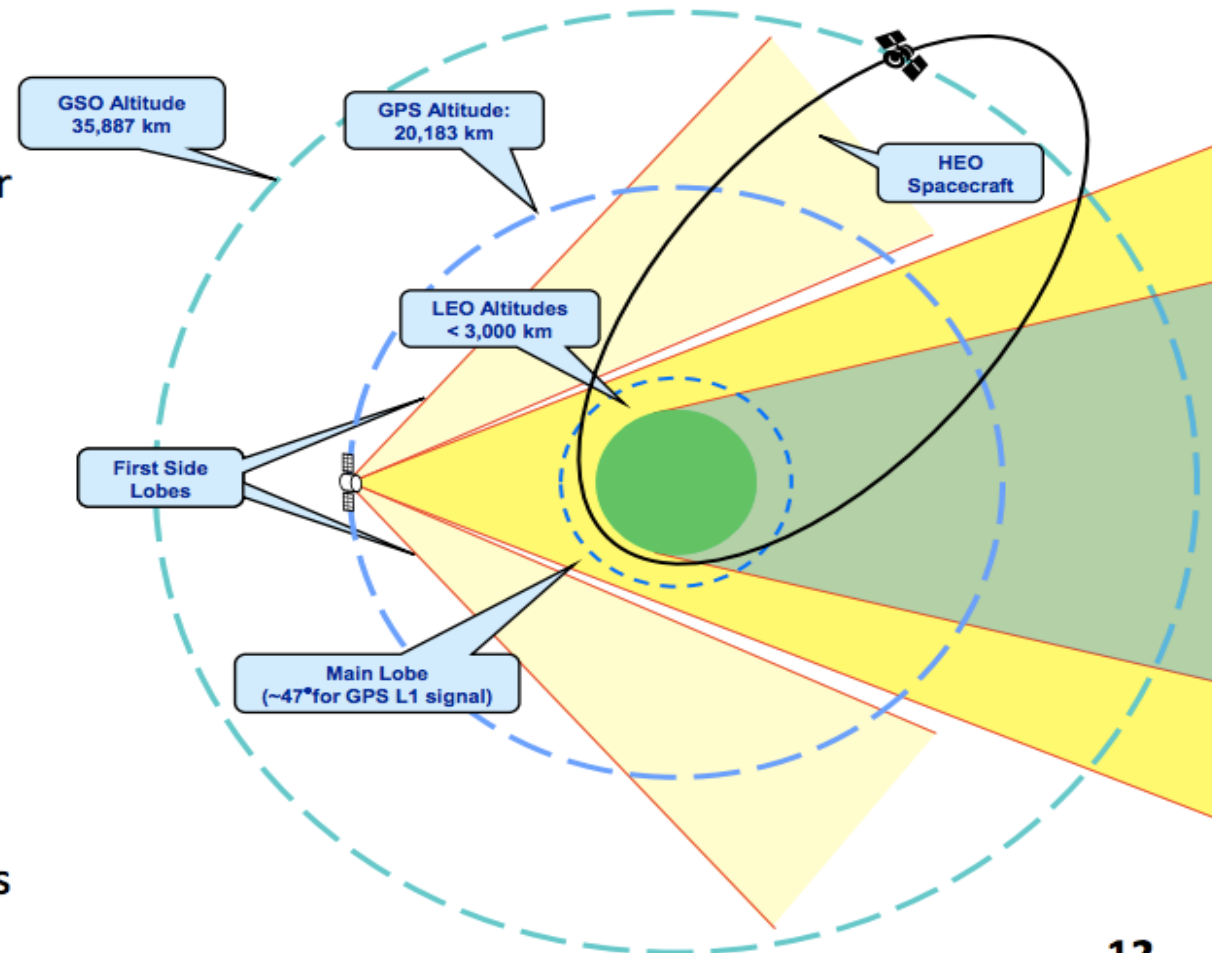


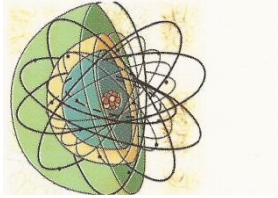


# Using GPS Beyond LEO: Reception Geometry for GPS Signals



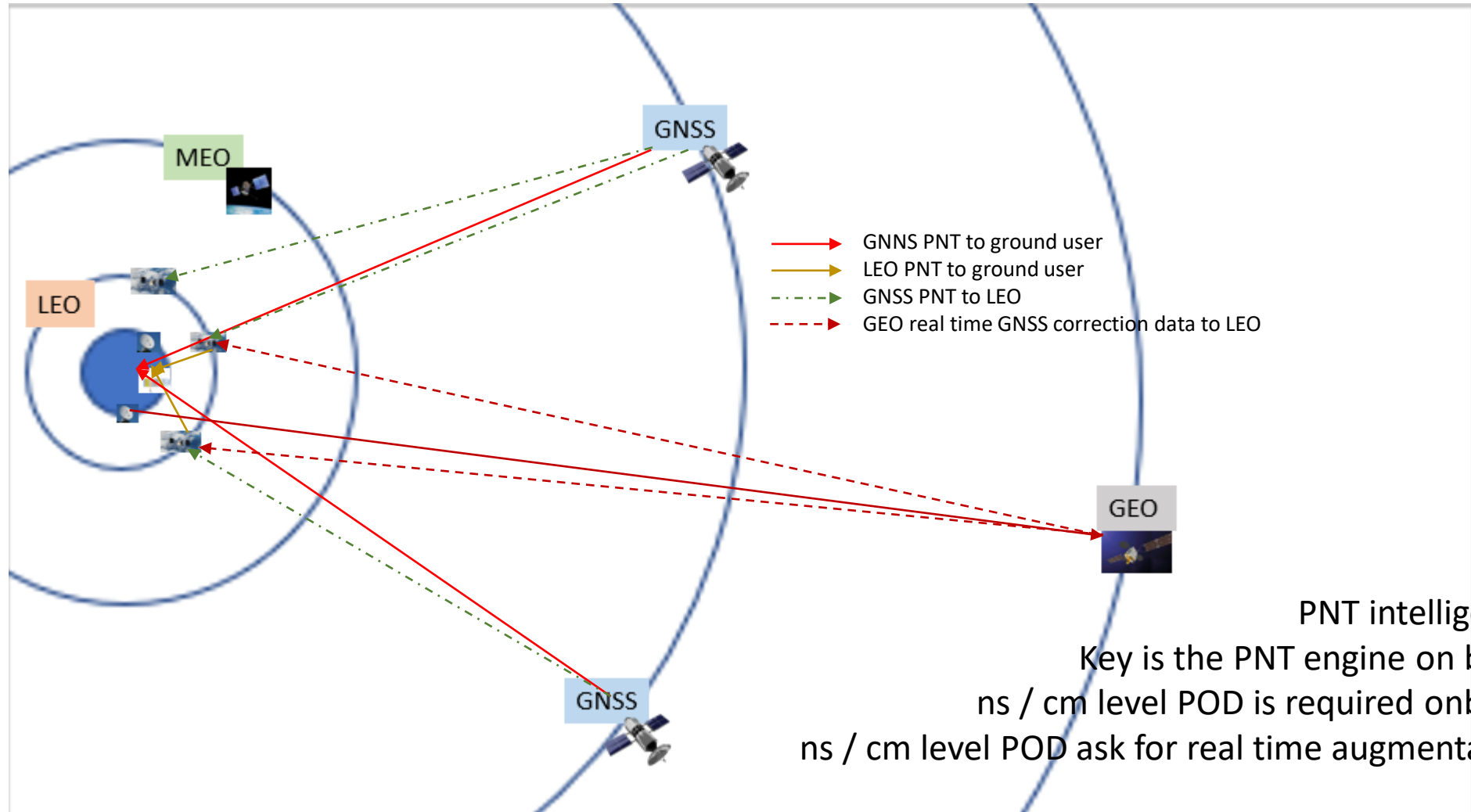
- When operating at higher orbits we are tracking the GPS signals broadcast “over the limb” of the Earth
- This is sometimes referred as ‘above the GPS constellation’ navigation
- Earth is blocking most of the GPS signals, so the availability is much smaller
- This is why the GPS transmitter ‘side lobes’ become vital to space users

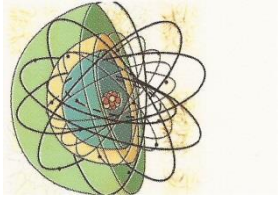




# LEO based back-up GNSS PNT features

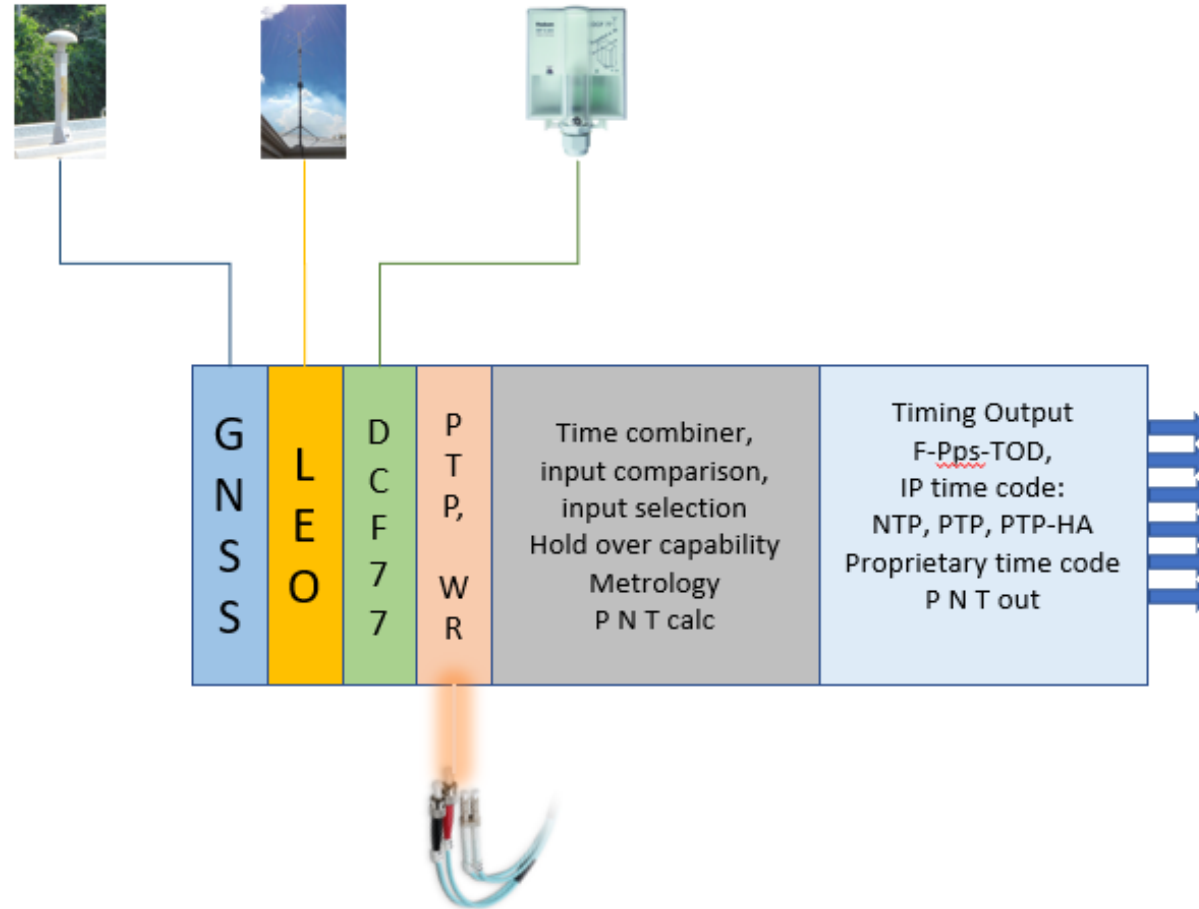
## Accuracy & traceability path

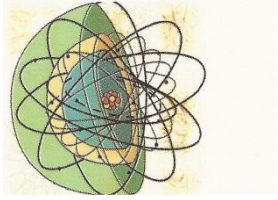




# Secure time receiver

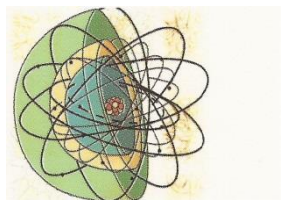
Multi GNSS constellation, multi frequencies (GPS, GALILEO, GLONASS, BEIDOU,...)  
optionnal multi time reference (GNSS, **LEO**, DCF77, fiber,...)





## *LEO-based high accuracy PNT mechanisms*

- The user must get a PNT signal from LEO satellites
- The received power (30 dB above GNSS power) and the density of satellites will be hard to jam/spoof on earth
- Ground PNT requirements (ns / cm level) need the onboard LEO PNT data at this level of accuracy (reception will degrade, not improve...), and receiver will have already tough time to manage doppler effect, number of handover, etc...
- LEO must derive its PNT data (orbit position and time from GNSS constellation, multi constellation, multifrequencies,...)
- LEO must get real time augmentation data (WAAS, EGNOS) to improve its position and time ( through GEO satellites or through the control link from ground or through the internet connection channel, or any other mean)
- Onboard high accuracy PNT features (POD Precise Orbit Determination) is mandatory



## *Need support?*

- Need some support to put in place a timing GNSS-back up strategies ?
- Need some market survey ?
- Need some technology survey?
- Need support to find partners in accurate PNT
- Need to find manufacturer/designer/vendor ?

Please contact : [aubryconseil-tf@orange.fr](mailto:aubryconseil-tf@orange.fr)