Servicio de Posicionamiento GNSS en Tiempo Real de España

SPTR GNSS ESPAÑA

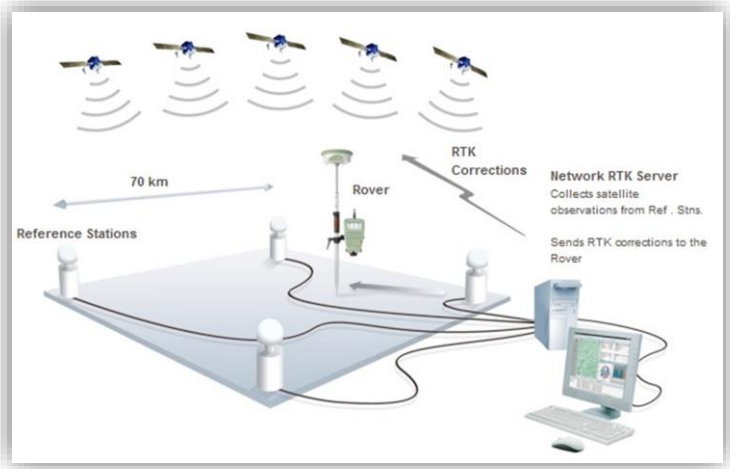
Experiencias de los Servicios de Posicionamiento GNSS en Tiempo Real, vigentes en la región SIRGAS y contribuciones a nivel global

José Manuel Serna [IGN, RIG]

9 de abril de 2024

WHAT IS SPTR?
How can it help us?

SPTR GNSS ESPAÑA



cm accuracy in real time!

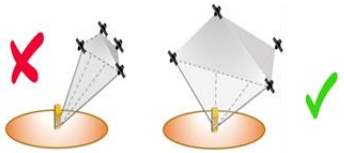
> 12500 users.
> 750 simultaneous users daily.
Many different activity areas.

GNSS multiconstellation: why so important?

A **multi-constellation receiver**: **GPS, GLONASS, GALILEO and BEIDOU**.

The use of other constellations in addition to GPS, results in there being a larger number of satellites in the field of view, which has the following **benefits**:

- **Reduced signal acquisition time.**
- **Improved position and time accuracy**.
- Reduction of problems caused by obstructions such as buildings and foliage.
- **Improved spatial distribution of visible satellites,** resulting in improved dilution of precision.
- Redundancy is built into the solution. If a signal is blocked due to the working environment, there is a very high likelihood that the receiver can simply pick up a signal from another constellation, ensuring solution continuity.
- While extremely rare, if a GNSS system fails, there are other systems available.

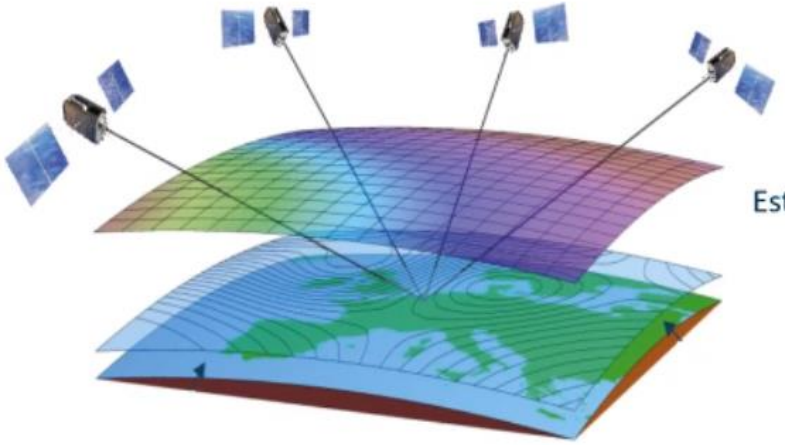


To determine a position in **GPS-only** mode, a receiver must track a minimum of four satellites. In **multi-constellation** mode, the receiver must track five satellites, at least one of which must be from a satellite in the other constellation, so the receiver can determine the time offset between constellations.

5-10m → 1-2cm → mm

Accuracy →

GNSS error sources



Corrected by Augmentation

Satellite error sources
- orbits (0.2 .. 5 m)
- atomic clocks (0.2 .. 10 m)
- Hardware code biases (0 .. 1 m)
- Hardware phase biases (0 .. 2 Pi)
- Satellite antenna PCV + GDV

Estimated by Rover (PPP / PPP-AR)
Or
Corrected by Augmentation
(Network-RTK & PPP-RTK)

Signal delays by
- Ionosphere (0,5 .. 100 m)
- Troposphere (0 .. 2 m)
- Water vapour (0 .. 0,5 m)

Receiver error sources

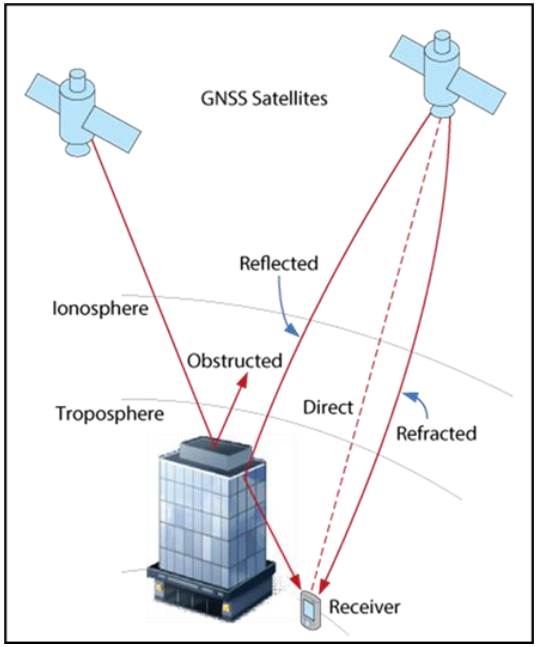
Corrected by Calibration
- Receiver Antenna (mm to m)
- Multipath Nearfield

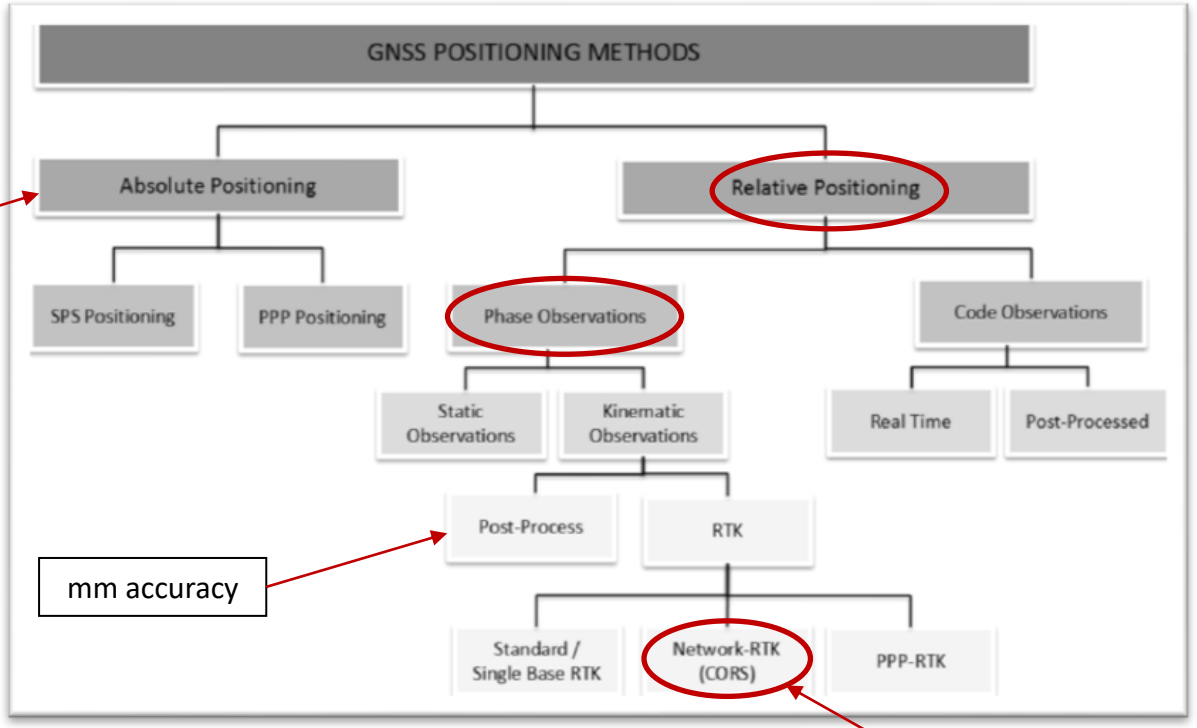
Current Research
- Multipath Farfield

GNSS observation modes: accuracy thresholds

- Absolute or Relative.
- Code or phase.
- Static, kinematic
- Post-processing or **Real Time**.

SINGLE RX: 5-10m





mm accuracy

REAL TIME!

MULTIPLE RX: 1-2cm

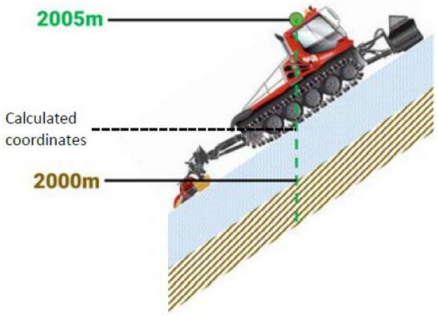
GNSS APPLICATIONS

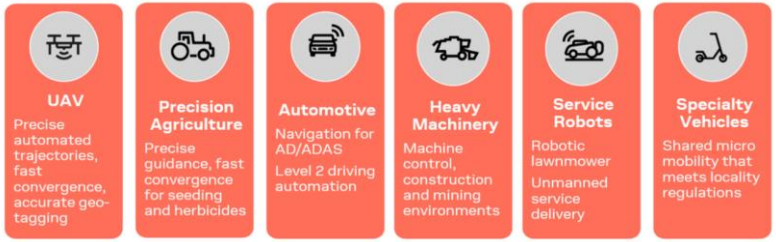
- *Cartography.*
- *Topography.*
- *Geodesy.*
- *Cadastre and property.*
- *GIS (Geographic Information System).*
- *Construction.*
- *Agriculture.*

Different levels of accuracy required

Future…TODAY!

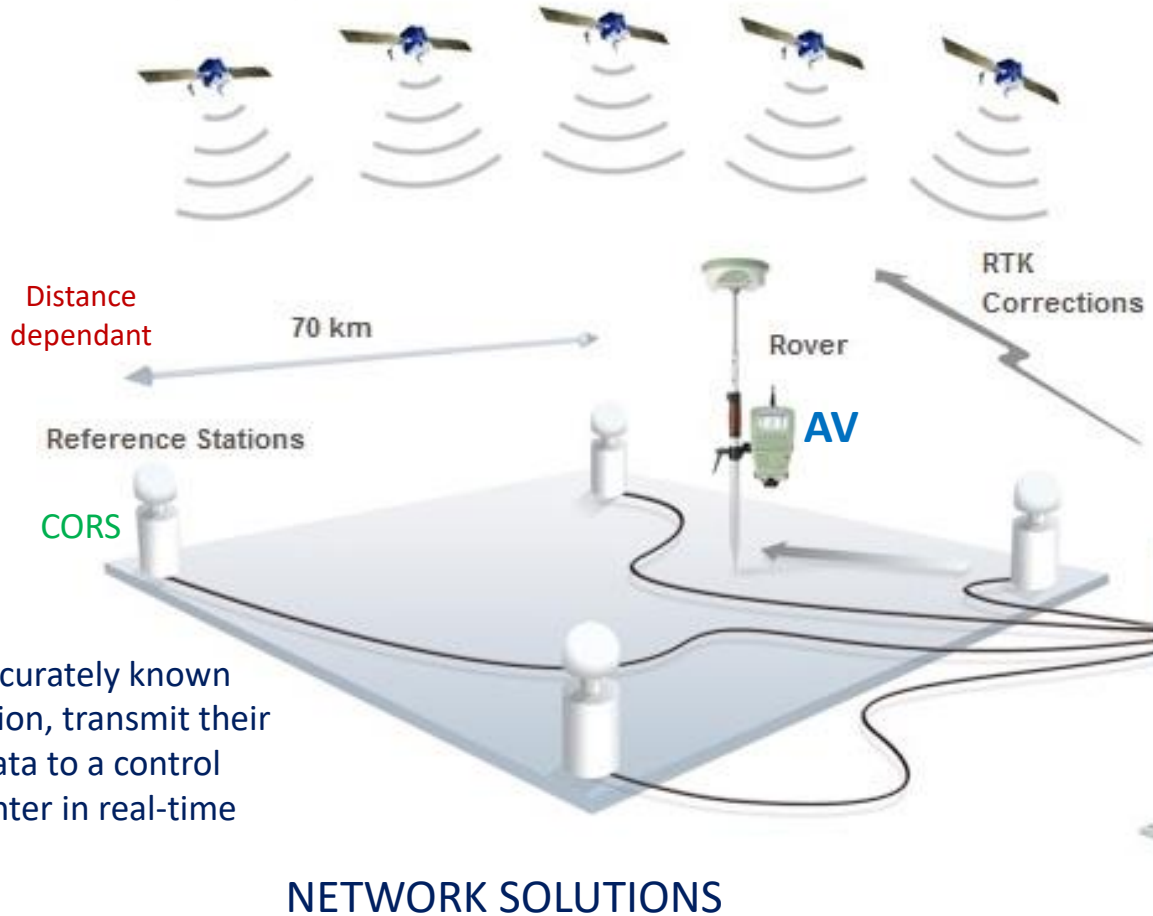
- 5G
- **Autonomous navigation**
- …





Network RTK (NRTK)

Receives and processes the data of the stations in real-time, ambiguity fixing phase for all satellites of each permanent station and calculating ionospheric and tropospheric delays, clock biases, etc.



Data latency < 2-3s

Accurately known position, transmit their data to a control center in real-time

NETWORK SOLUTIONS
SINGLE STATION SOLUTIONS

NTRIP protocol
(RTCM through TCP/IP)
Server + client + caster

Network real time error modelling (ambiguities resolution).

The error modelling depends on the distance station-rover (baseline). Up to 80-100km.

Advantages:

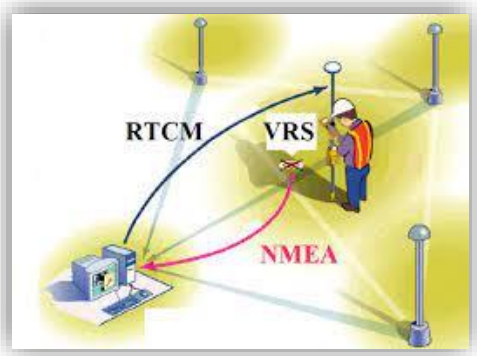
- **Only rover receiver neccessary (no base station)**. Network of reference stations.
- **Homogenous** accuracy in the network area (1-2cm), worse in height.
- 80-100km baseline (depending on the software).
- **Corrections availability and reliability improved**.
- **Not neccessary to know the closest reference station.**

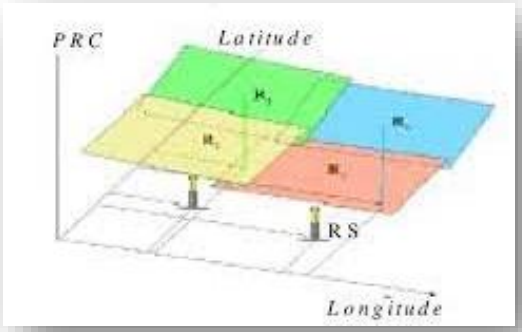
Drawbacks:

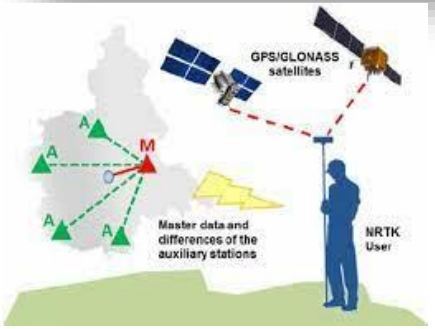
- Communications availability.

Main solutions:

- **VRS** (virtual reference station).
- **FKP** (Flächen Korrectur Parameter).
- **MAC** (master auxiliary concept).
- **CERCANA** and **SINGLE POINTS**.







- Read carefully **receiver** error messages to help understanding the problem.
- Incorrect **receiver setup parameters** (IP, port, mountpoint, user and password).
- **Reference station too far away**.
  - Difficulty to solve ambiguities.
  - Mainly when connected to single station corrections. Better using network solutions.
  - Higher time necessary to solve ambiguity.
- **Internet connection**.
  - Bandwidth: net overloading.
  - Poor internet coverage.
  - Interferences.
  - Cell jump.
- **Corrections latency** too high.
  - Time between GNSS signal generation and correction arrival to the rover (<3-4s).
- Monofrequency/low quality antenna in **low cost receivers** (smartphones, drones…).
- **Dark areas and moving rover** (cycle-slips, ambiguity fixing lost).
- **SPTR down, reference station down**.

CORE: IGN - ERGNSS network

122 stations

29 inside worldwide networks.

Multiconstellation

Others:

- CCAA
- Puertos del estado
- EUREF
- IGS

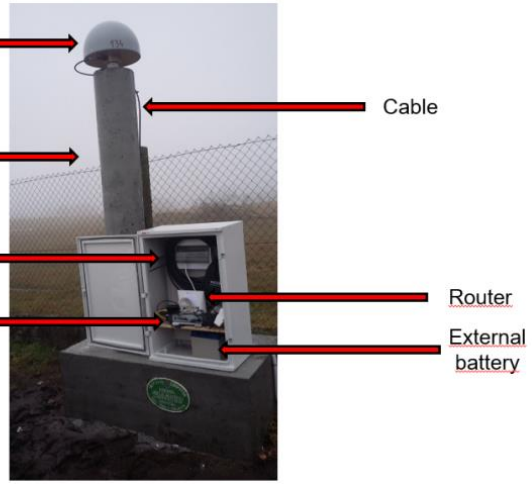
The performance of a NRTK infrastructure can be improved realizing a correct design of the network, in term of CORSs inter-distances and geometrical distribution. Considering the quality of the GNSS products used in a NRTK as precise ephemerids and the quality of algorithms devoted to estimate the phase ambiguity, inter-distances can be extended up to 100 kms.

Permanent stations network

- Antenna + receiver + communications system + power supply system.
- Good location (visibility, Multipath, RFI…).
- Stability, integrity.
- Antenna calibration.
- Antenna height nivelation.

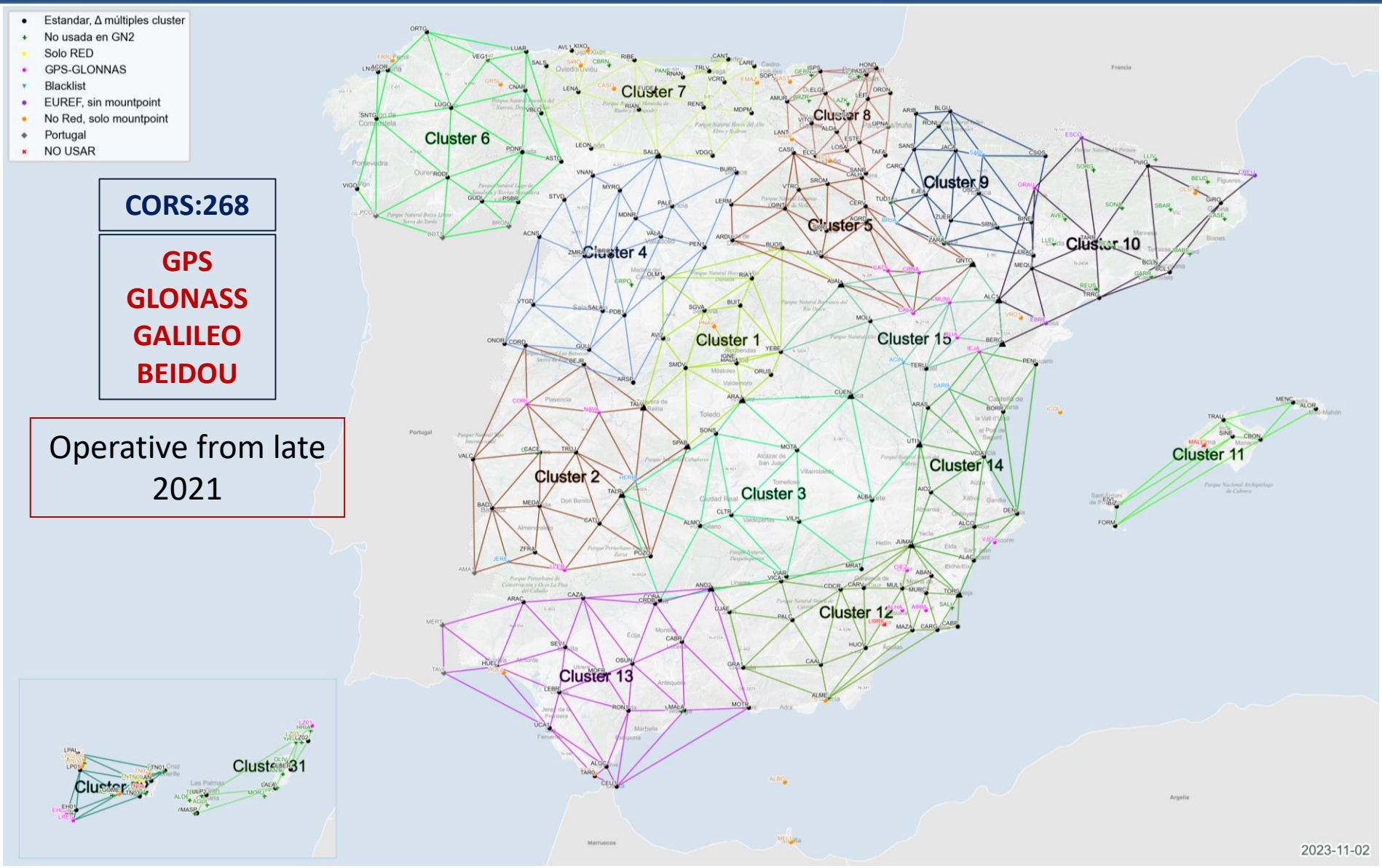
- FTP: RINEX (hour, day).
- TCP/IP: real time.

Position known with very high accuracy



- Scientific reasearch: geodynamics.
- Reference frame stablishment.
- Atmospheric modelling.
- Network RTK.

Subnetworks architecture



CORS:268

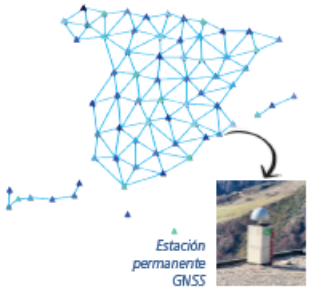
GPS
GLONASS
GALILEO
BEIDOU

Operative from late 2021

¿Cómo se asegura el servicio en toda España?

Con más de 250 estaciones de referencia

Comunidades Autónomas, Puertos del Estado e Instituto Geográfico Nacional (IGN) han puesto en común sus estaciones GNSS para proporcionar un servicio de posicionamiento de precisión para toda España que es suministrado por el IGN.



- **ERGNSS:** Red Geodésica Nacional de Estaciones de referencia GNSS del Instituto Geográfico Nacional
- **ARAGEA:** Red de Geodesia Activa de Aragón
- **ERVA:** Red de Estaciones de Referencia de Valencia
- **ITACYL:** Red de estaciones GNSS de Castilla y León
- **RAP:** Red Andaluza de Posicionamiento
- **REGAM:** Red de Geodesia Activa de la Región de Murcia
- **REP:** Red Extremeña de Posicionamiento
- **RGAC:** Red GNSS Activa de Cantabria
- **RGAN:** Red de Geodesia Activa de Navarra
- **RGAPA:** Red GNSS Activa del Principado de Asturias
- **RGE:** Red GPS/GNSS de Euskadi
- **RGM:** Red de estaciones GNSS de la Comunidad de Madrid
- **RIOJA:** Red de estaciones permanentes GNSS - La Rioja
- **XGAIB:** Xarxa de Geodesia Activa de les Illes Balears

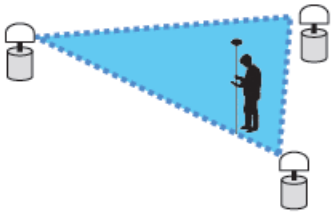
¿Qué ofrece el SPTR?

Si dispone de un dispositivo GPS/GNSS que admita correcciones a la posición y una conexión a Internet, puede utilizar cualquiera de los dos tipos de soluciones que ofrece el servicio:

Solución con el conjunto de red

Las correcciones enviadas son generadas a partir de modelos que se alimentan de los datos registrados por todas las estaciones permanentes de la red. El servicio ofrece varias técnicas para la generación de las correcciones, como son MAC, VRS, FKP o CERCANA.

Esta es la solución más recomendable dado que su precisión es homogénea en todo el territorio y no exige conocer la estación permanente más próxima a la ubicación del dispositivo GNSS.



Solución con estación única (punto simple)

Las correcciones son calculadas utilizando una única estación permanente de referencia. En este caso, el usuario ha de indicarla explícitamente.

Su precisión es menor a medida que el dispositivo GNSS se aleje respecto a la estación permanente de referencia. Por ello es recomendable utilizar la más próxima.

¿Cómo conectarse?

1 El acceso al servicio requiere registro previo para obtener un usuario y contraseña. Puede registrarse a través de la siguiente URL en su navegador:

http://ergnss.ign.es/gnuserportal/

O en su dispositivo móvil a través del siguiente código QR:

2 Dependiendo del tipo de solución que elija, deberá configurar su dispositivo GNSS con los parámetros requeridos:

Solución con el conjunto de Red

URL: ergnss-tr.ign.es

IP: 192.148.213.42

Puerto: 2101

Punto de montaje: Ejemplos válidos pueden ser cualquiera de los siguientes:

- **GPS+GLONASS+GALILEO+BEIDOU (RTCM3.2,MSM):** MAC3M, VRS3M, FKP3M, CERCANA3M
- **GPS+GLONASS (RTCM3.1):** MAC3, VRS3, FKP3, CERCANA3

Solución con estación única o punto simple

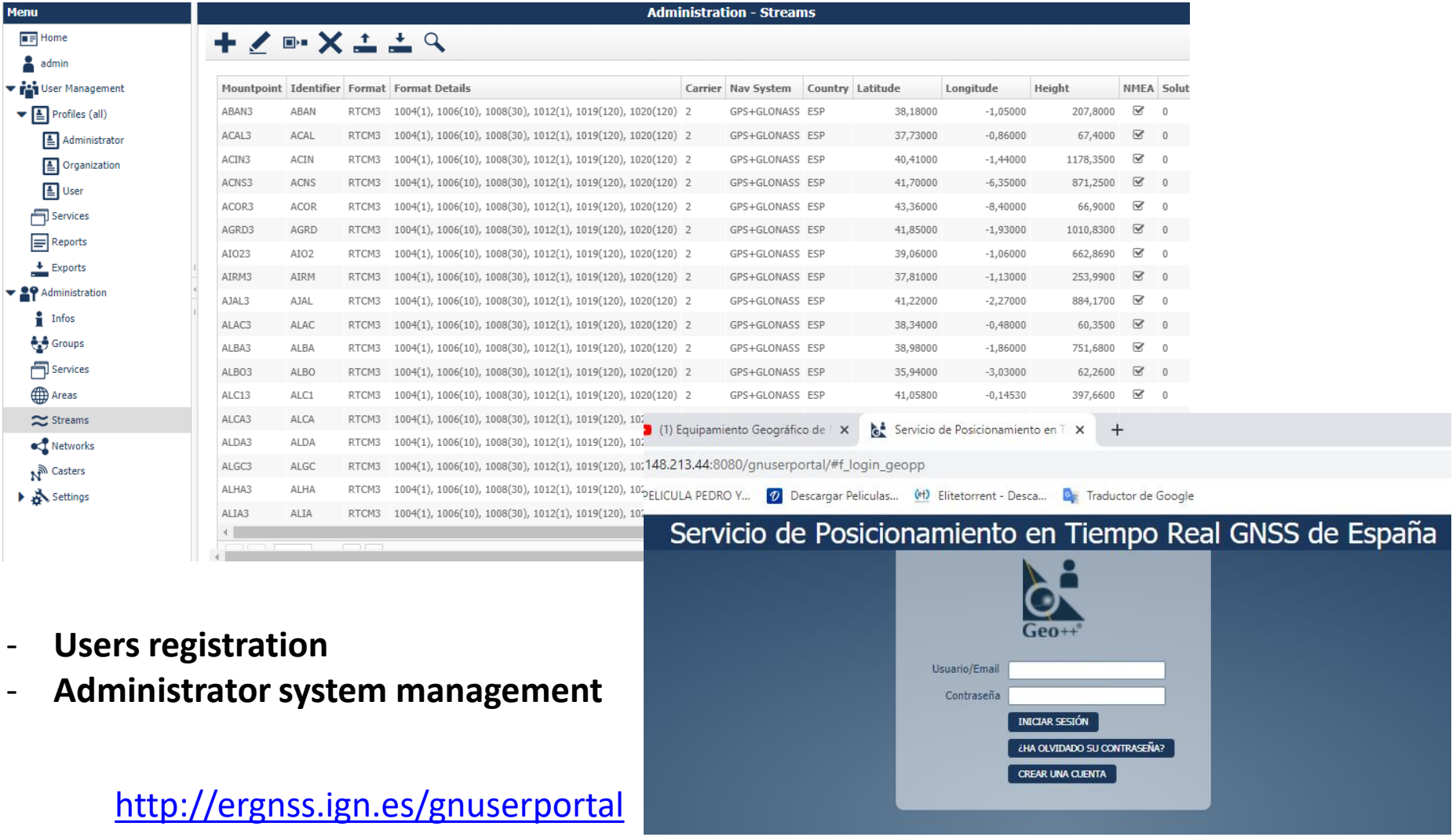
URL: ergnss-tr.ign.es

IP: 192.148.213.42

Puerto: 2102

Puntos de montaje (RTCM3.2,MSM): Nombre de la estación de 4 caracteres, seguido de 3M (ejemplos: IGNE3M, ALBA3M,...)

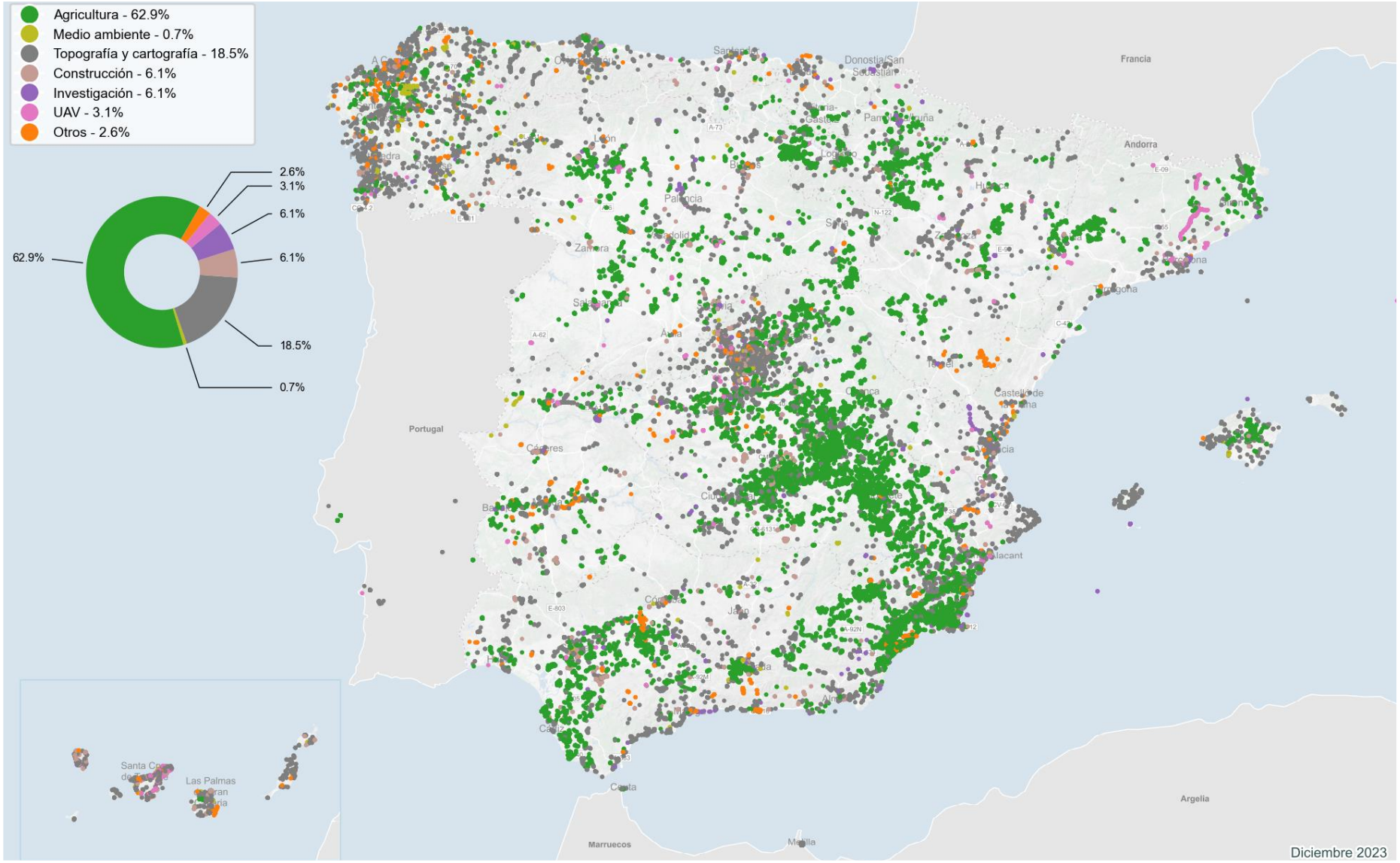
Userportal



- **Users registration**
- **Administrator system management**

http://ergnss.ign.es/gnuserportal

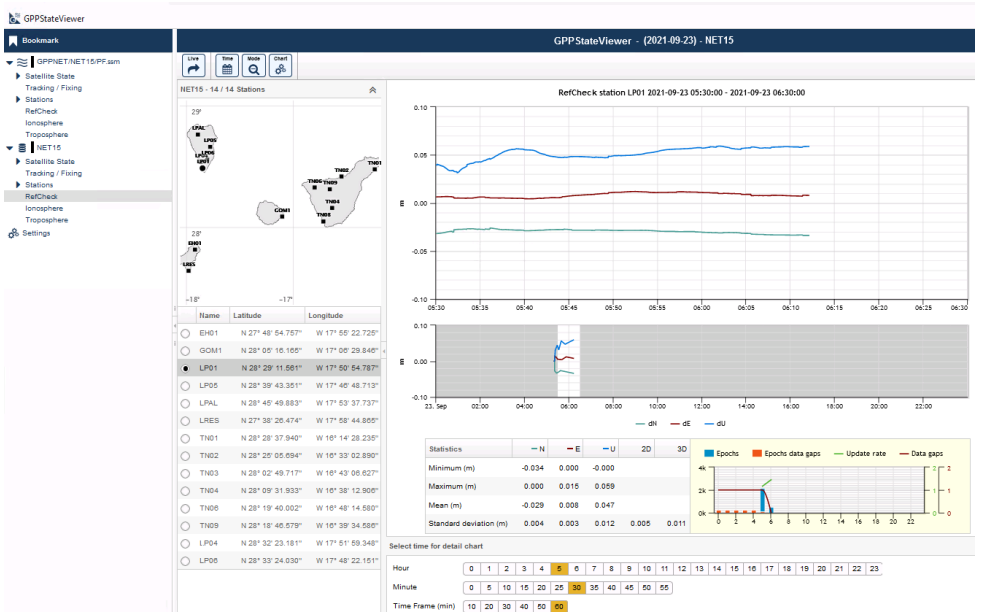
SPTR users activity areas (December 2023)



Monitoring and maintenance

GNSMART2 tools
GNERROR, GNALERT, DFMON, GNIP, RXODELAY, CASTERS status

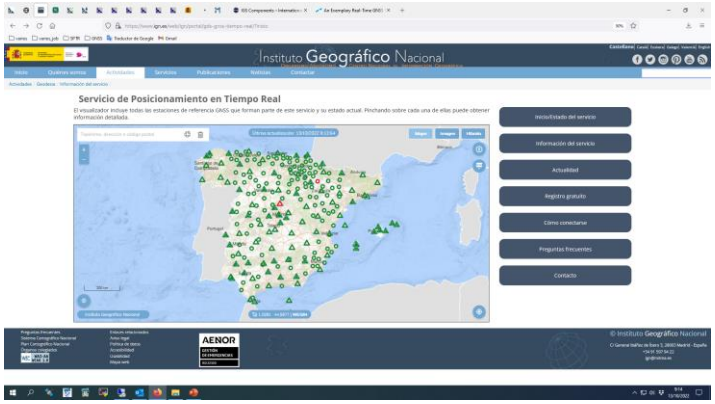
GNSMON
USERPORTAL
GPPStateviewer



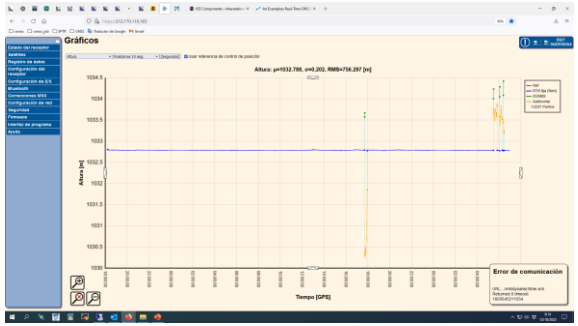
ERGNSS BASE STATIONS DATA MONITORING
NETWORKS MONITORING

Laboratory Rx
Field monitoring

VISOR_IGN



RTKNAVI - BNC



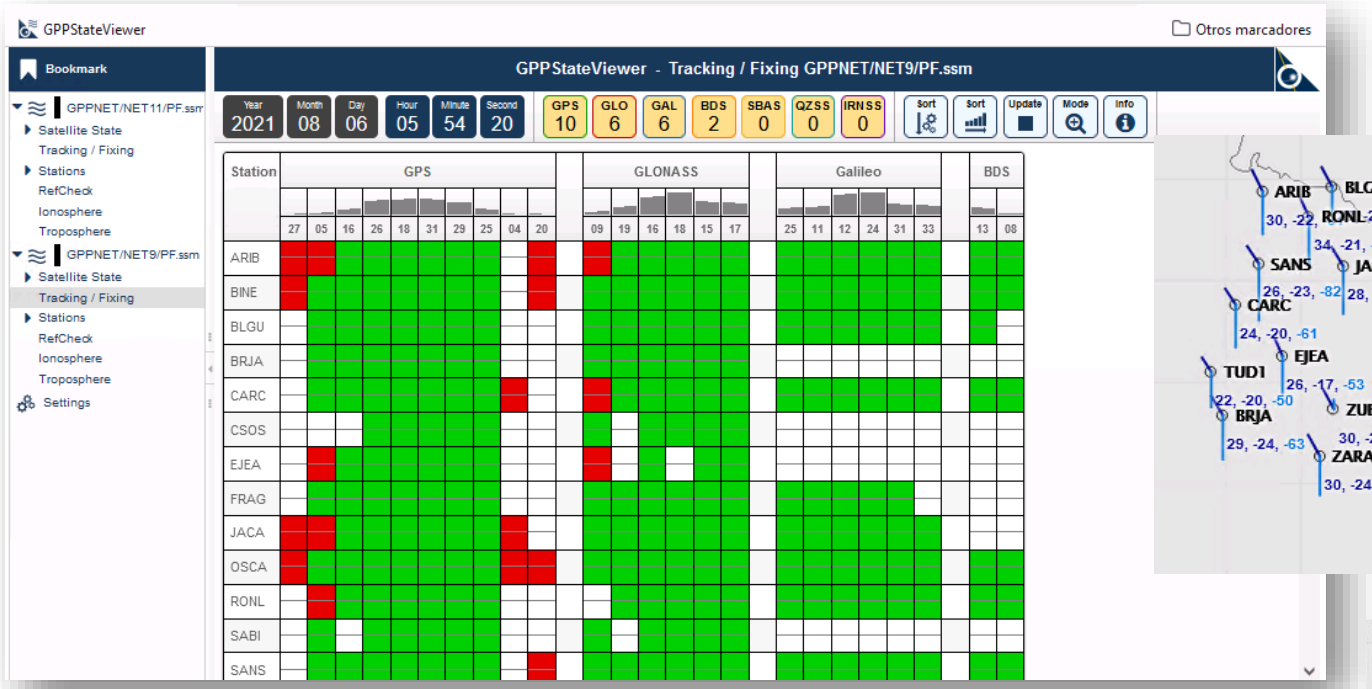
GPPReceiver

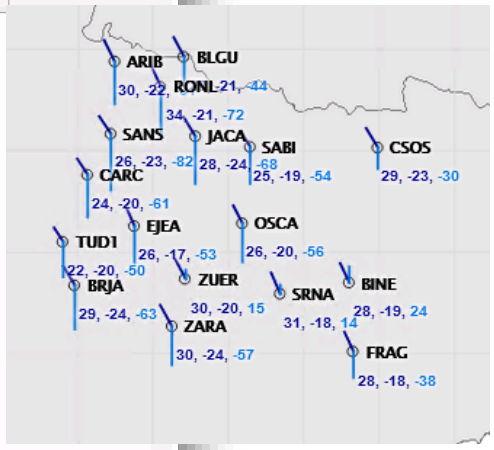
To show the current status of the GNSMART system some Java web services are available. These web services must run within a Java servlet container. The GNSMART installer provides Apache Tomcat for this task. The GNSMART web services are provided as web archive files (*.war).

More information: skyplot satellites information, pseudorange correction, observation details (pseudorange, phase, doppler, signal strength, loss of lock), receiver information.

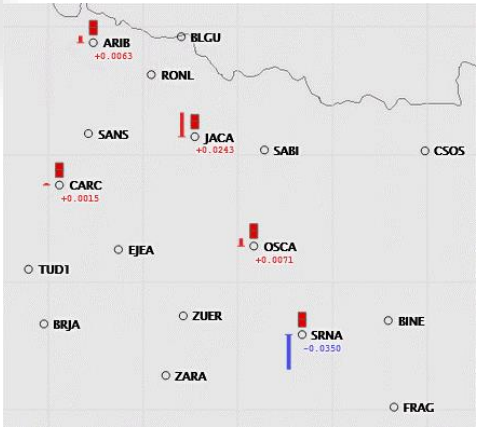
GPPStateViewer

SPTR monitor_server





RefCheck



Tracking/fixing window

Ionosphere
Troposphere
info

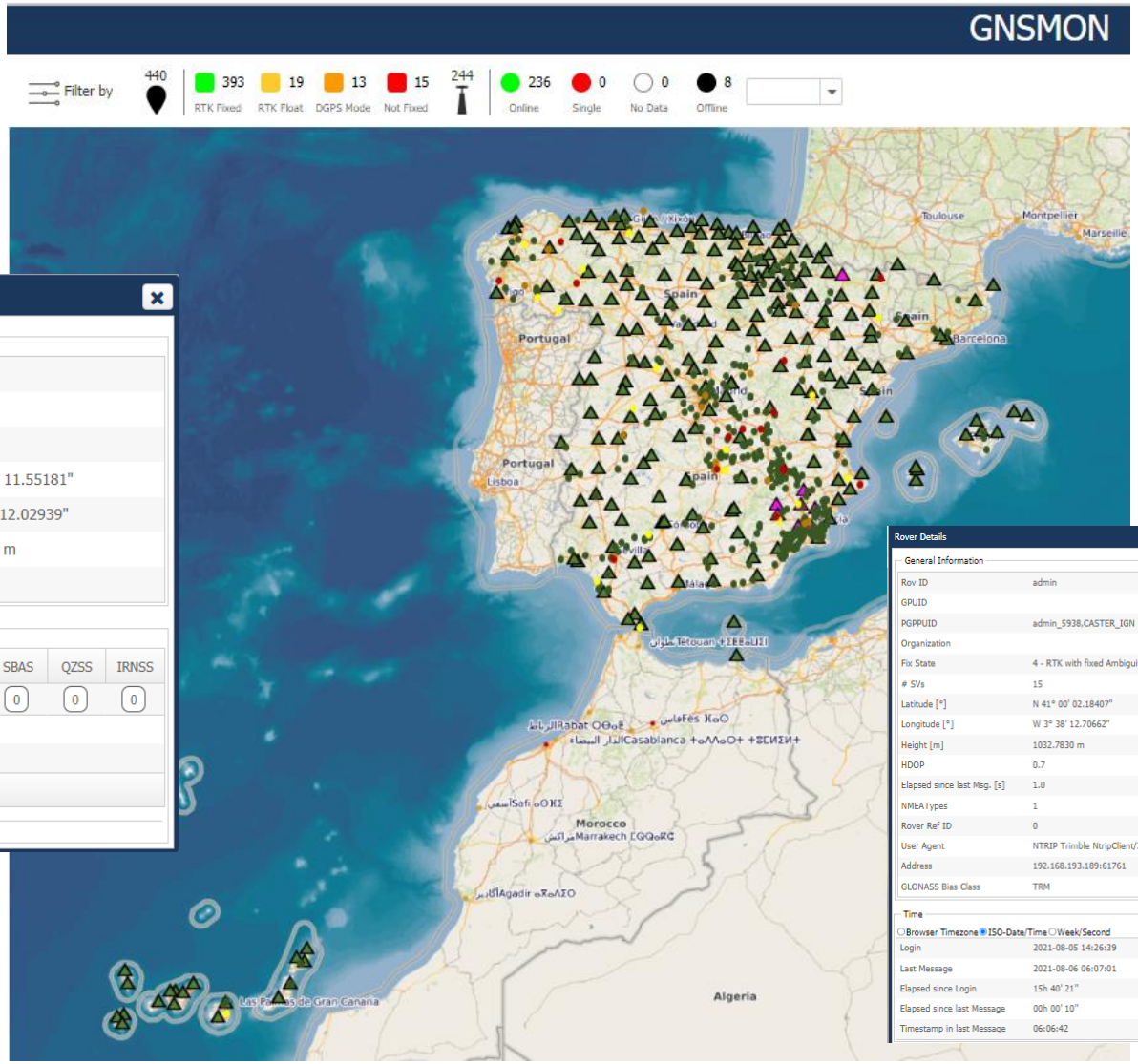
Monitor system clusters:

-Stations ambiguity resolution for each satellite/each constellation.

-Refcheck, ionosphere, troposphere for each station.

SPTR: Network monitoring

- Rovers status/info
- CORS status/info



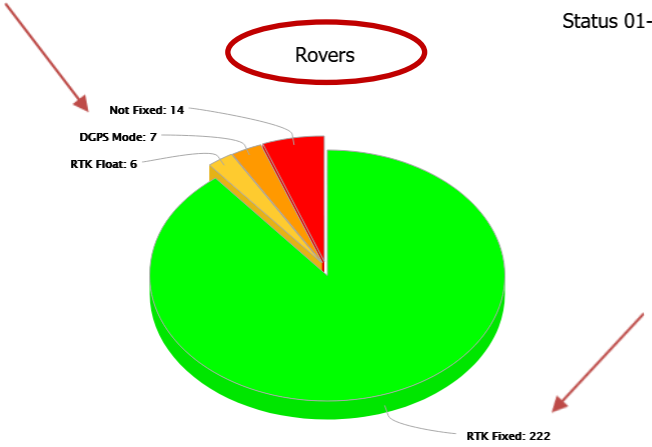
http://192.148.213.42:8009/gnsmon_servlet

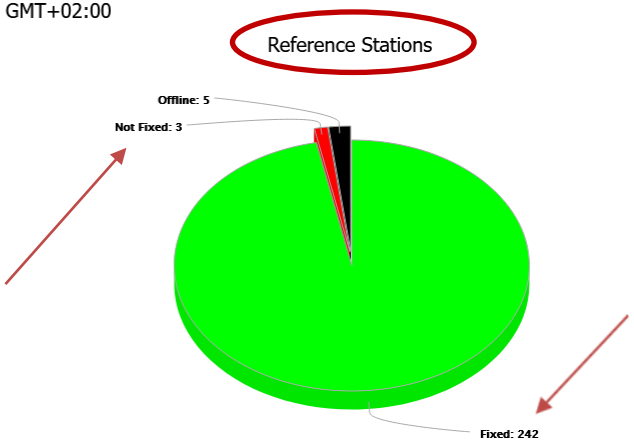
SPTR: Network monitoring

GNSMON

- Status
- Map
- Reference Stations
- Rovers
- Reference Station History
- Rover History
- Settings
- Logout

Status 01-ago-2022 8:31:57 GMT+02:00



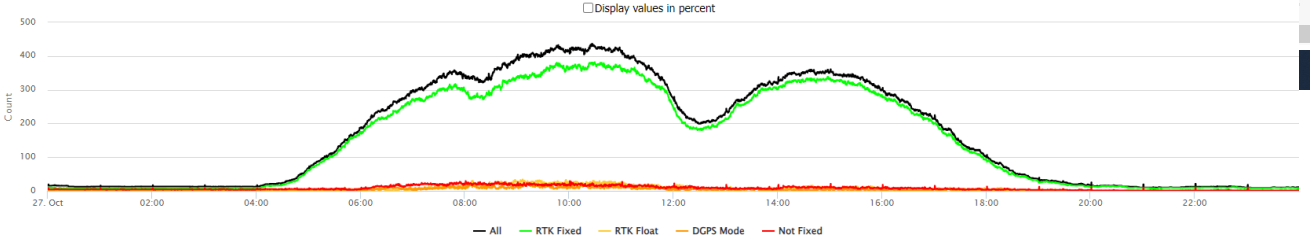


Rov ID	Status	# SVs	Ref ID	PGPPUID	Elapsed since Login [s]	Ela
7s180	4 - RTK with fixed Ambiguities	25	AIRM	7s180_523,CASTER_IGN	5484	1.0
8732	4 - RTK with fixed Ambiguities	12	TORR	8732_6730,CASTER_IGN	4146	1.0
abdenavarro	4 - RTK with fixed Ambiguities	12	PALC	abdenavarro_636,CASTER_IGN	6351	1.0
acana669	4 - RTK with fixed Ambiguities	17	VCIA	acana669_582,CASTER_IGN	643	1.0
acre	4 - RTK with fixed Ambiguities	7	BUOS	acre_73346,CASTER_IGN	523	0.6
acre	4 - RTK with fixed Ambiguities	12	MAL1	acre_73347,CASTER_IGN	394	0.0
acre	4 - RTK with fixed Ambiguities	10	YEB1	acre_73344,CASTER_IGN	2904	0.0
AFITOVI	4 - RTK with fixed Ambiguities	11	MOTA	AFITOVI_908,CASTER_IGN	3596	1.0
agricolartk						
AGRIMENSOR						

Ref ID	Status	Net ID	RTCM ID	# SVs	Elapsed since last Message	Map
ABAN	Fixed			17	0d 00h 00' 09"	
ACAL	Offline			17	46d 10h 30' 29"	
ACIN	Fixed			10	0d 00h 00' 09"	
ACNS	Fixed			24	0d 00h 00' 05"	
ACOR	Fixed			25	0d 00h 00' 11"	
AGRD	Fixed			25	0d 00h 00' 04"	
AIO2	Fixed			20	0d 00h 00' 08"	
AIRM	Fixed			17	0d 00h 00' 09"	

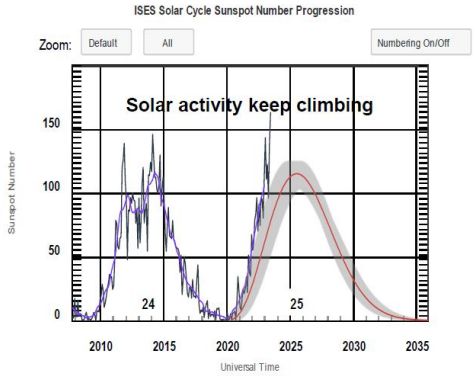
Rover History 27-oct-2023 GPS time

Display values in percent

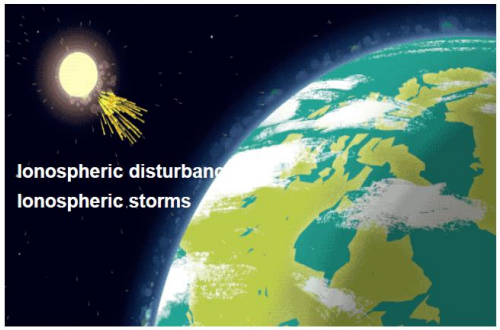


IONOSPHERE – SOLAR ACTIVITY

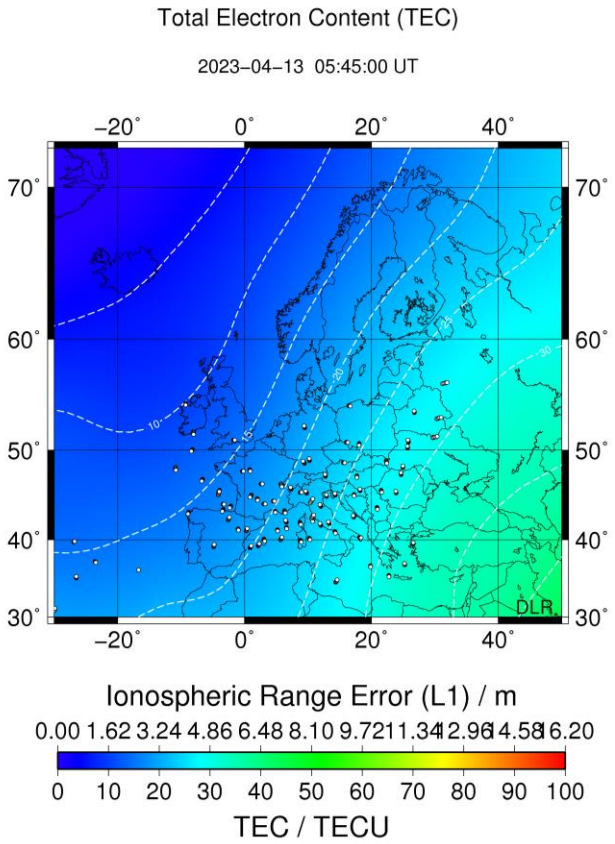
- The 25th solar cycle is approaching its peak year, which is expected to be 2024-2028
- The occurrence and amplitude of ionospheric anomalies will be significantly increased

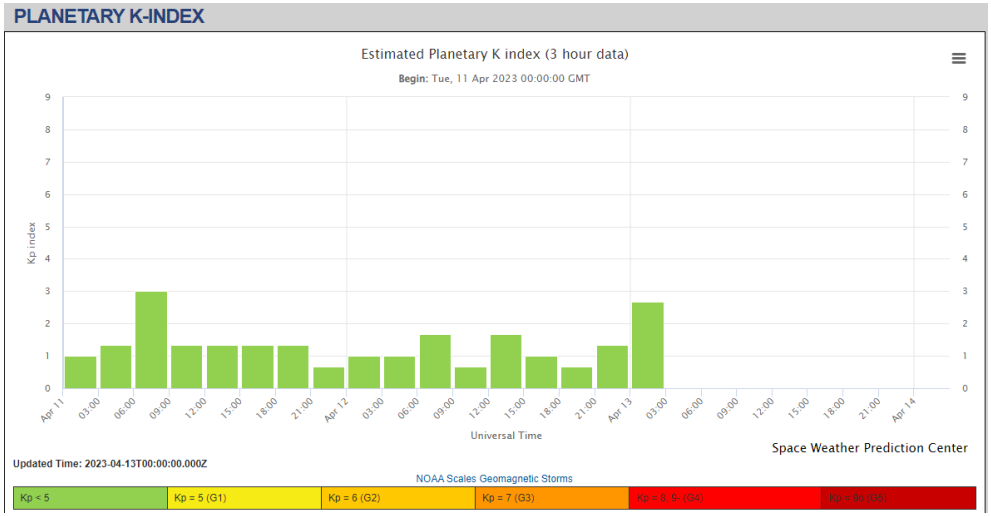


The time series of Sunspot number (*from NOAA*)



Solar activities is the main driver of ionospheric variations

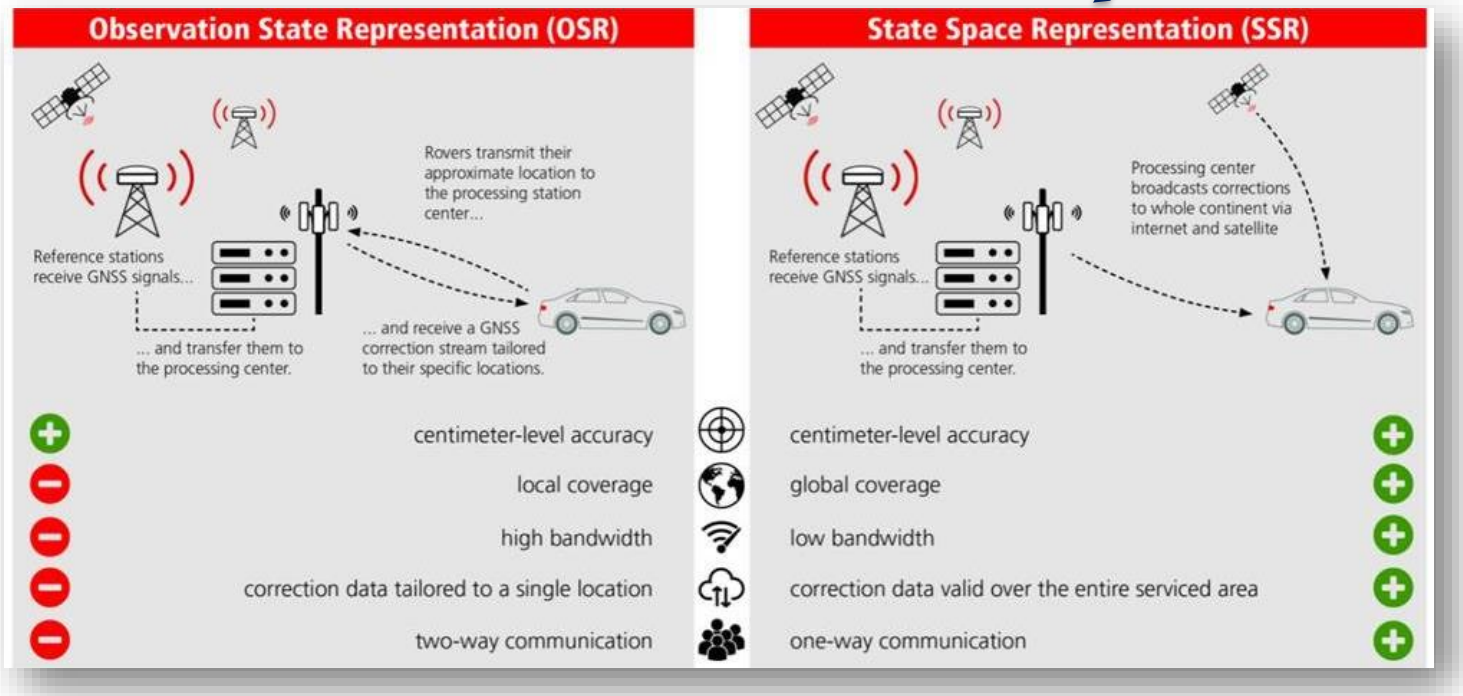




IGN-SPTR FUTURE?

- Service in the state of the art (infrastructure, SW).
- Support spanish R&D teams to develop AVs technologies.
- SSR?
  - Global mass-market applications.
  - OSR: scaling up difficulties.
  - SSR: allows to broadcast GNSS corrections.
  - Broadcasting: NTRIP, Satellite, DAB+…

Our system already allows SSR



Geo++: **GNSMART**
https://www.geopp.de/gnsmart/

Trimble: **PIVOT**
https://www.trimble.com/Real-Time-Networks/Trimble-Pivot-Platform.aspx

Leica: **SPIDER**
https://leica-geosystems.com/es-es/products/gnss-reference-networks/software/leica-gnss-spider

Topcon: **TopNet+**
https://www.topconpositioning.com/office-software-and-services/reference-network-software/topnet

Norway: **CPOS**
https://www.kartverket.no/en/on-land/posisjon/guide-to-cpos

Kartverket

Germany: **SAPOS**
https://www.sapos-bw.de/

SAPOS®

Sweden: **SWEPOS**
https://swepos.lantmateriet.se/

SWEPOS

Finland: GNSS-Finland service
https://gnss-finland.nls.fi/#/map

Hungary: **GNSSnet.hu**
https://www.gnssnet.hu/index.php?r=site%2Frealtime

GNSS

Republic of Estonia
Land Board

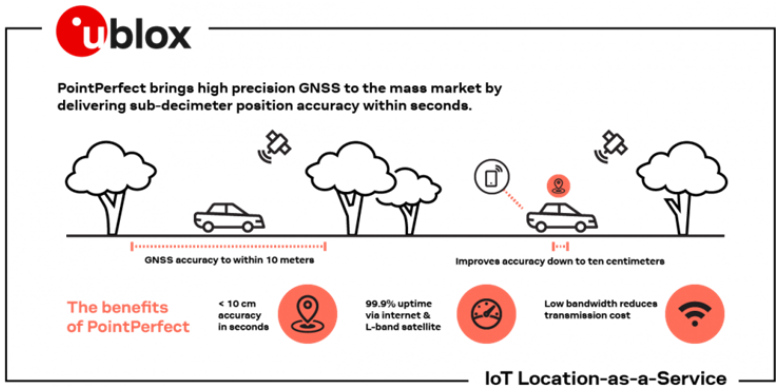
Estonia: **ESTPOS**
https://geoportaal.maaamet.ee/eng/Spatial-Data/Geodetic-Data/Geodetic-Networks/ESTPOS-p671.html

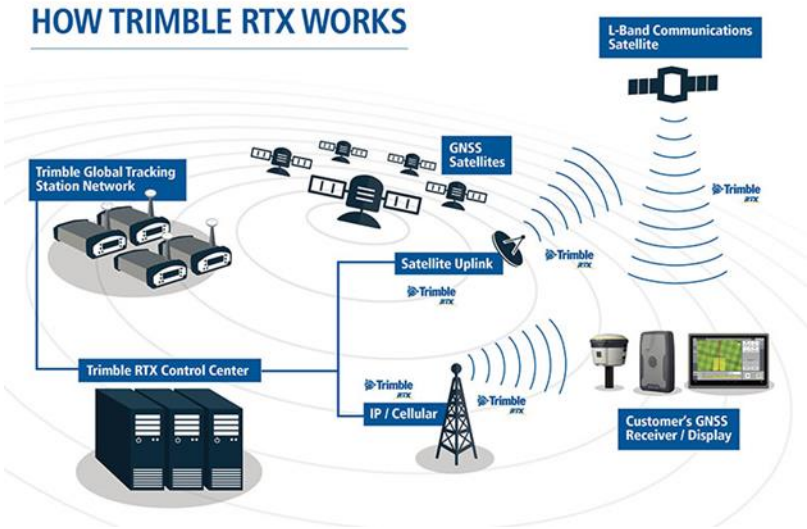
Hexagon: **HxGN SmartNet**
https://hxgnsmartnet.com/es-ES/home/services/Network-RTK

Trimble: **VRS Now**
https://www.allterra-iberica.es/wp-content/uploads/2019/01/ficha-tecnica-vrs-now-allterra-iberica.pdf

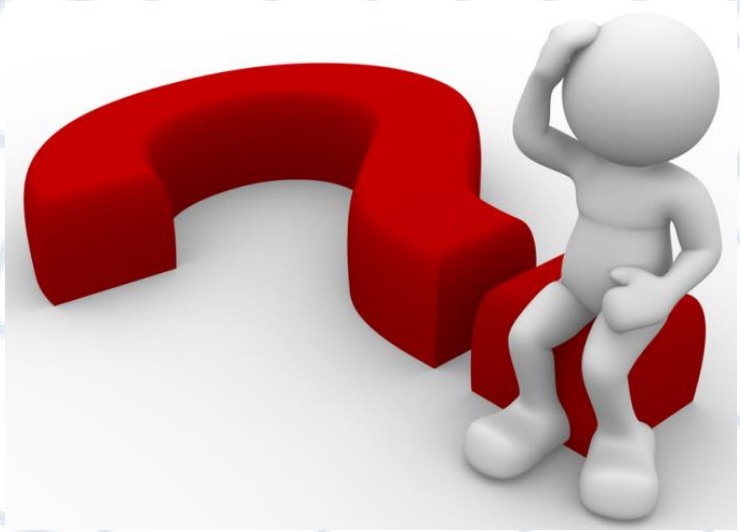
Topcon: **TopNet Live**
https://www.topconpositioning.com/office-software-and-services/gnss-correction-services/topnet-live-corrections

U-blox: **PointPerfect**
https://www.u-blox.com/en/product/pointperfect





Thank you
¿Questions?



SPTR GNSS ESPAÑA

SPTR web page:
https://www.ign.es/web/ign/portal/gds-gnss-tiempo-real

User Portal:
http://ergnss.ign.es/gnuserportal

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SIRGAS

Instituto Panamericano de Geografía e Historia - OEA - Sección Nacional del Ecuador