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INDRA ESPACIO, S.A.

Satellite Navigation Systems

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Introduction

- The field of satellite navigation, and its applications, has experienced a continuous growth since the commissioning of the American GPS system back in 1993, up to present European initiatives like EGNOS, and currently Galileo.

- Since its beginning INDRA has contributed significantly to those European programs, performing its activities in the field of satellite navigation thanks to the use of state of the art technology, and to its highly qualified team.

Introduction

- The Satellite Navigation Systems Department of Indra Espacio has as main activity the development of navigation and positioning systems and applications based on the existing satellite positioning systems (the American GPS and the Russian GLONASS), including its augmentations (EGNOS, WAAS, GBAS, …), as well as on Galileo, the European system currently under development.

Activities

- Main Activities:
    - Satellite navigation systems and equipments
    - Navigation and Positioning Applications
    - Consultancy

- A staff of more than 50 engineers.

- Special emphasis on R&D projects (Internal, PNE, EC)

- To this end, the Satellite Navigation Systems Department provides:
    - Navigation Systems Engineering
    - Systems Integration
    - Project Development
    - Reference & Monitoring Stations and networks
    - GBAS systems
    - Control and Processing Centres
    - Navigation Applications (differential systems, assisted navigation, sensor integration, Search and Rescue, fleet management, railway security applications, aviation, ...)
    - Consultancy and Technical Assistance for Navigation Systems

Areas

- **Vehicle fleet management / merchandise management**
- **Multimodal transport applications (terrestrial, maritime, railway)**
- **Air Navigation domain**
- **Differential Systems (DGPS/LAAS/RAAS)**
- **Navigation & Communication system integration**
- **Reference Stations / Monitoring Stations / Station Networks**
- **GBAS Stations / GBAS Monitoring Stations**
- **Control Centres**
- **Sensors integration (INS)**
- **Navigation Algorithms**
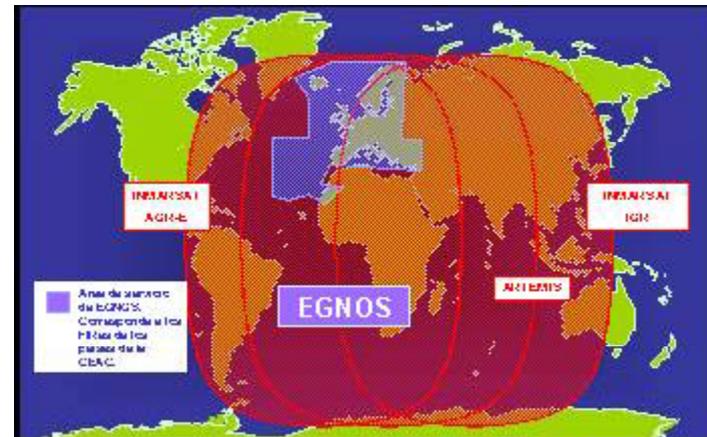
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Satellite Navigation Systems

- Participation in GNSS projects

- EGNOS Project

- Galileo Project

- SESAR

- GBAS

- Applications
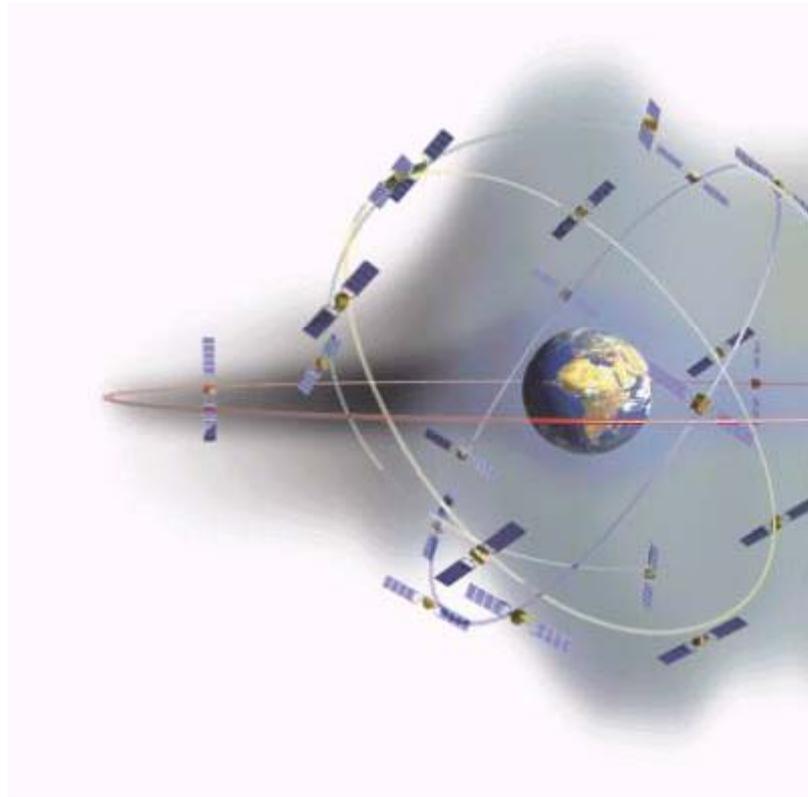
EGNOS (I)

- Systems Engineering: Participation in the system definition

- Specification, development, integration, tests and production of the RIMS (Ranging and Integrity Monitoring Stations). Now in maintenance phase.

- Specification, development, programming and test of the <u>Mission Monitoring element</u> from the Central Control Facility CCF.

- Specification, development, programming and test of the <u>Archiving element</u> from the Central Control Facility. Now in maintenance phase.

EGNOS (II)

- ESTB: Deployment of the EGNOS Test Bed Reference Stations in the Spanish airports (Málaga, Palma, Gran Canaria)
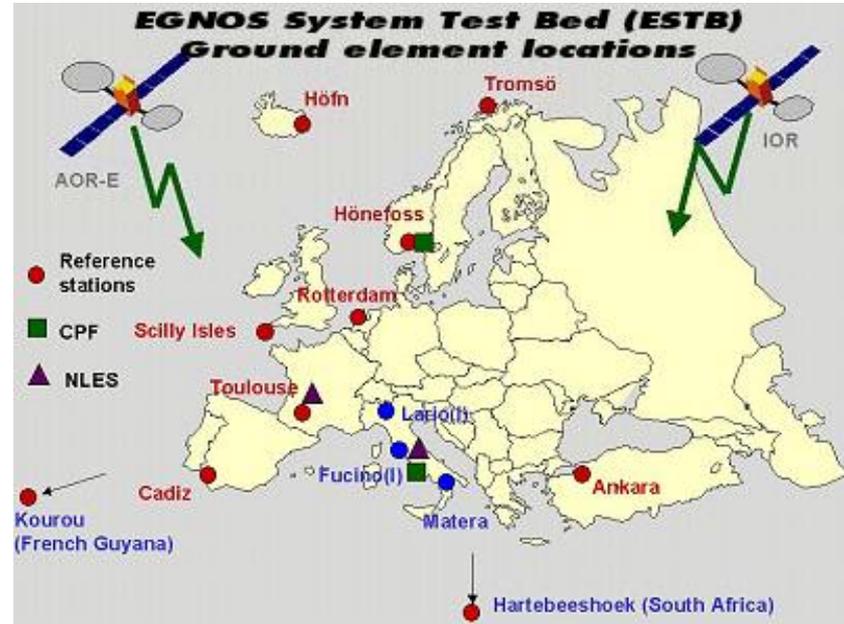

- EGNOS Operations Tooling: Application to support maintenance operations, providing on-line documentation and activity tracking

Other SBAS (I)

- EDISA (EGNOS Demonstration in South America): Indra has provided the communications network to link the deployed stations in Central America with the ESTB

EDISA architecture

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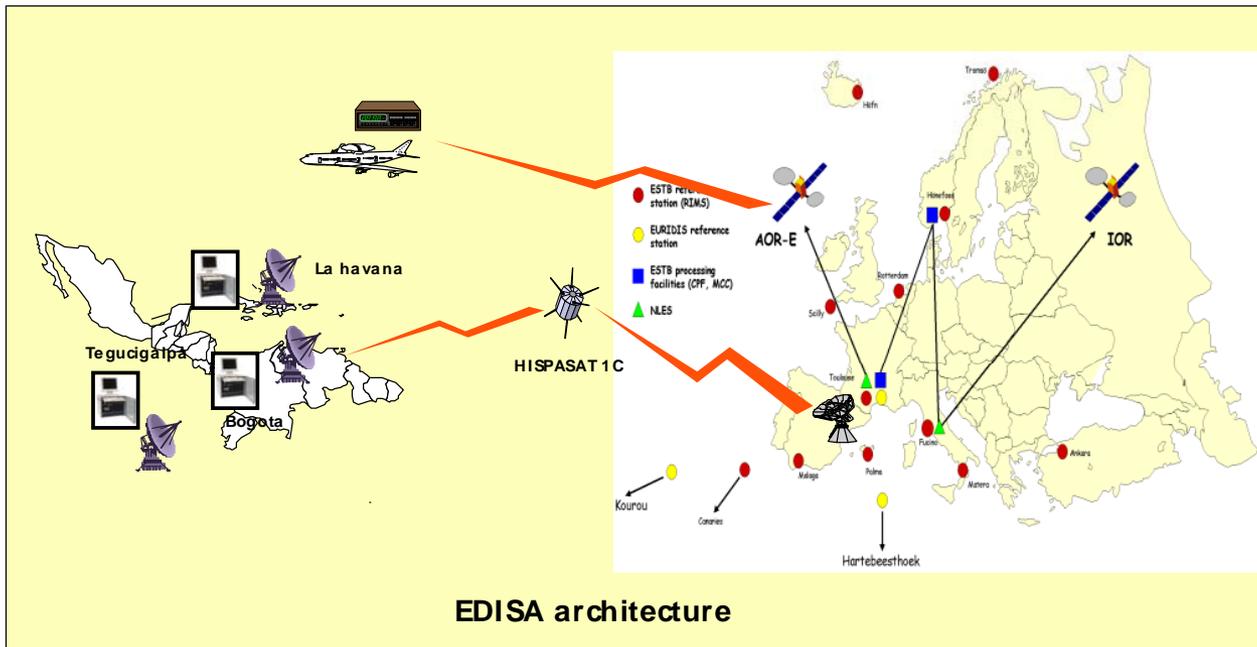
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Other SBAS (II)

- SACCSA (Solución de Aumentación para Caribe, Centro y Sur América): Indra participates in the feasibility studies being developed for ICAO to define and implement an SBAS for Central and South America
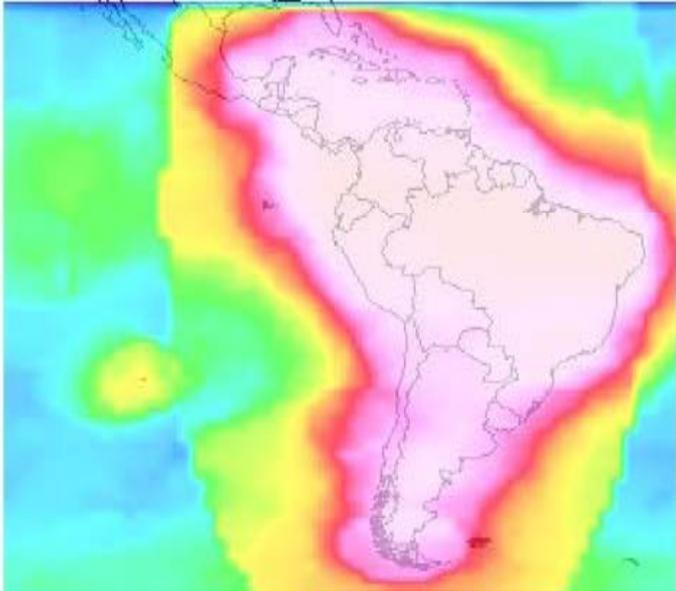
- In SACCSA II Indra has provided de definition of most ground segment elements, and the communications

- In SACCSA III, definitions are being refined, and the infrastructure to collect GPS data from stations in the area, and to disseminate results is being developed

Galileo (I)

- Participation in the initial phase of the system definition
  - **GALA**: Requirement system definition, requirement analysis, architectural study of the Galileo receivers, feasibility study of navigation applications, …

  - **INTEG**: Analysis of the integration of EGNOS in Galileo.

  - **GalileoSat**: Satellite infrastructure definition, system requirements definition and of the various subsystems, benefits analysis, ...

Galileo (II)

- Participation in Galileo

    - **INDRA** is a founder member of Galileo Sistemas y Servicios, the Spanish partner of European Satellite Navigation Industries (formerly Galileo Industries), the initial consortium designated as a Main Contractor of Galileo

    - This assures our participation at all levels in the program, from decision making levels up to the responsibility in key elements of the system

    - **INDRA** is also a founder member of Galileo Services, an international organization devoted to the promotion of Galileo downstream applications

Galileo (III)

- The activities performed during the definition and specification phases include the following:

    - First level responsibility in system engineering activities.
    - Responsibility of the service definition, architecture, benefits and terrestrial infrastructure of the service Search and Rescue of Galileo
    - Participation in the definition of the system architecture of the terrestrial control (of the satellites and of the mission)
    - Architecture definition and requirements of the reference stations.
    - Participation in operational and mission monitoring aspects.

Galileo IOV (phase CDE1) (I)

- Participation in the system integrated teams in Ottobrunn and Rome (external interfaces, search and rescue, system architecture)

- Participation in the mission segment integrated team in Toulouse (on interfaces , technical follow-up of ULS, MUCF and SPF)

- Participation in the control segment integrated team in Portsmouth

- Participation in the overall system integration and validation (SI & V) (responsibility at ground segment level)

- Responsible of the data server of the "Galileo System Test Bed" (GSTB v1)

- Responsible of the mission segment of the "Galileo System Test Bed" (GSTB v2), including the development of the sensors stations (GESS), and the data server (DSF). An evolution of it will constitute the "Time and Geodetic Validation Facility" (TGVF), in which Indra is responsible for the upgrade of the GSTB infrastructure

Galileo IOV (phase CDE1) (II)

- Responsible of the data server (E-DSF) of the mission segment End-to-End simulator

- Responsible of the Galileo Sensor Stations (GSS) core computer (including development of the SW, with criticality level DAL-C)

- Responsible of the of the Uplink Stations (ULS) (including development of the Mission Processor SW, with criticality level DAL-C)

- Responsible of the Telemetry, Tracking & Command (TTC) stations

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Galileo - European Commission/GJU

- European Commission (1999 – 2002):
    - Participation in the projects GALA (receiver/sensors integration, railway pilot project), INTEG (integration of EGNOS in Galileo), Galilei (local elements)
- 6th Framework Program of the European Commission
  (2003 – …):
    - Responsible for the GISAR project (implementation of the ground segment for the Galileo Search and Rescue service)
    - Participation in the projects:
        - GEM (responsible for the Search and Rescue activity)
        - GILT (pseudolites)
        - GAC (Galileo advanced concepts)
        - GRAIL (Galileo railway application)
        - M-TRADE (Galileo multimodal application)
        - PROGENY (network of experts in Galileo)
        - CELESTE (GJU – Galileo introduction in Latin America)

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Galileo - GSA

- Responsible of the Galileo Security Monitoring Centre (GSMC) definition study (2006 – 2007):

  - The GSMC is the centre in charge of the PRS management in Galileo, as well as of the setting of the security protocols needed for the safe and reliable broadcast of the PRS signal
  - The main tasks of the study are to define:
    - GSMC mission, functions, responsibilities and roles
    - GSMC internal organization
    - GSMC architecture
    - GSMC interfaces (with EU institutions, European countries, GSA, Galileo Concessionnaire, Galileo Control Centre, …)
  - Indra is leading a consortium that includes also ESYS Consulting (UK), CS (F), and FDC (F)

Consultancy

- **Technical Assistance to AENA in GNSS aspects**

- **Technical Assistance to EUROCONTROL Experimental Centre, in EGNOS certification aspects**

SESAR
Navigation activities inside CNS WP15

- **Indra is one of the major contributors to the SESAR Programme**

- **Reinforcing the recognized excellence of Indra in the aeronautical field, Indra Espacio will provide their expertise on the Satellite-based Navigation systems**
  - **Major contributor to the European SBAS system, EGNOS**
  - **Major contributor to the Galileo programme**

- **Indra Espacio has been integrated in the overall proposal of Indra for the SESAR Programme**

SESAR
Navigation activities inside CNS WP15

- Indra Espacio contributes to the WP-15-3 Non-avionic CNS System / Navigation

  - Support studies in GNSS applications on the Aeronautical field (WP.15.3.1/4)
  - Support studies in GNSS / SBAS evolutions (WP.15.3.5)
  - Support studies and first prototypes of a multiconstellation GBAS Cat II/III (WP.15.3.7)
    - Concept of Operations and requirements
    - Feasibility Analysis
    - System definition, performance assessment and prototyping

GNSS Monitoring
Portable GNSS Monitoring Station (PGMS)

- The objective of the PGMS is to monitor the performance of the GNSS systems available in an airport (GBAS, SBAS/EGNOS, GPS, RAIM).

- PGMS computes the navigation solution with the different augmentation systems.

- Positioning errors, protection levels, integrity and availability are obtained for each solution.

- The station monitors the quality of the received signals through the correlation function analysis and the interferences in the L-band and VHF bands of interest.
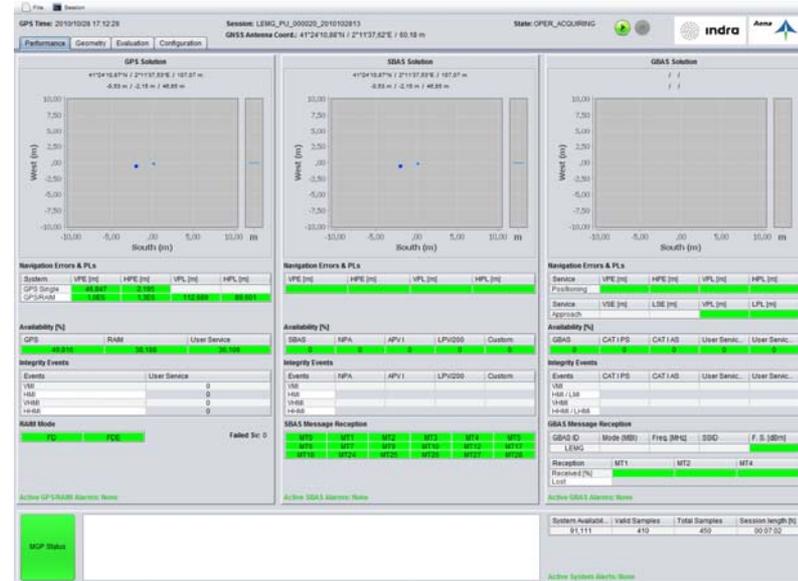
GNSS Monitoring
Portable GNSS Monitoring Station (PGMS)

- The Monitor is able to work autonomously (without operator assistance) for long periods of time (minimum 8 hours with batteries) acquiring and processing GNSS data.

- The station could be deployed by 2 people in less than 2 hours.

- It is equipped with an operator's interface that can be activated to follow the process in real time.

- Special emphasis is put on the data storage, retrieval and exportation and on the robustness of the continuous collection.

- All acquired data, intermediate results, processed data, alarms, alerts, status information, etc. are stored, assuring its integrity, and can be exported to the appropriate standard formats (ie PEGASUS).

- A visualisation interface is provided to retrieve and plot the archived data.

GNSS Monitoring
EGNOS Monitoring & Recording Network (GNSSU)

- Indra, through its German subsidiary AC-B, will implement a station network for DFS (Deutsche Flugsicherung GmbH), to measure GPS and EGNOS signals in order to guarantee accuracy and reliability of the data submitted to any aircraft in German territory.

- The network consist initially in 3 fixed sensor stations, located North, Centre and South of Germany, measuring the GPS and EGNOS signals and evaluating the performances of the GNSS navigation service.

- A hot-redundant control centre, located in DFS HQ (Langen) will monitor the network, and can access to the performance data through a web interface.

GBAS Activities

- Indra Espacio is working on the GBAS developments, based on different funding

  - Internal R&D programme

  - National R&D programmes

  - European SESAR programme

- Indra Espacio shall include his GBAS solution into the global offer of INDRA group, a leader in the ATM sector with subsidiaries in the five continents.

- INDRA's portfolio include, amongst others, Air Traffic and Airports Management Systems, Air Space Surveillance Systems, Aeronautical Communications, MLS systems, etc.

GBAS Activities
GBAS Cat-1 Prototype

- Indra is working on a prototype of the main concepts of the GBAS system. This consists on:

  - An Integrity Monitoring Test Bed, in which the differential solution is computed and the integrity monitoring algorithms are evaluated

  - An User Receiver prototype, in which the user GBAS solution is computed

  - A Satellite Constellation Simulator, in which some non-nominal behaviour of the signal are simulated

  - A set of receivers (3) installed at Indra premises, for the continous monitoring of the GPS signal.

- This is an ongoing activities, developed taken advantage of some internal or national R&D activities.

GBAS Activities
GBAS Applications

- Following the developments on the GBAS prototype, Indra Espacio is developing some navigation tools for UAVs:

    - ATOL (Automatic Take-off and Landing) system for a small rotor UAV (Pelicano, developed by Indra UAS division), consisting on a base station and an airborne receiver (integrated in the autopilot).

    - Study (with the Aeronautic Engineering school of UPC/Castelldefels) to analyse the feasibility to use UAV to support the validation of conventional nav-aids in the regional airports.

- Specific navigation needs for fire control applications:

    - Support the navigation during the night, for extinction of fires, based on GNSS (SBAS&GBAS) (CDTI R&D CENIT program PROMETEO)

More applications / references

- Portable reference stations for the GNOS system (Global Navigation Overlay System)

- Comparative study between Local DGPS Systems

- Integration of INS (Inertial Navigation Systems) and DGPS into urban traffic

- ASTRON: Study of the Synergy between satellite technologies: Observation / Telecommunications/ Navigation

- ISAGNSS: Development of the infrastructure allowing operational certification of EGNOS in aeronautical environments

- High Speed Positioning application (racing cars)

Product: Reference Station

Based on a product initially developed for the European satellite navigation system EGNOS, Indra provides a versatile and modular reference station, with the following characteristics:

- GPS (11+11 channels L1-L2), GLONASS (11 channels L1) and GNSS-1 (4 channels L1) signal acquisition
- Atomic clock (Rubidium or Caesium) frequency reference
- Robustness against interferences and multipath
- Remote or local monitoring and control.
- Optional meteorological station

Main applications:

- Reference station for GNSS systems
- Differential station
- Monitoring station

Product: Monitoring and Archiving Center

- Key part of the control center, the Monitoring and Archiving Center allows to know in real time the state and the performances of satellite navigation systems, as well as to archive all the information generated by the system. Its main characteristics are:

  - Real time visualisation on a map of the different performances of the system (precision, availability)

  - Prediction capability of the future state of the system.

  - User friendly Man-Machine Interface

  - Selective retrieval and archive of the information.
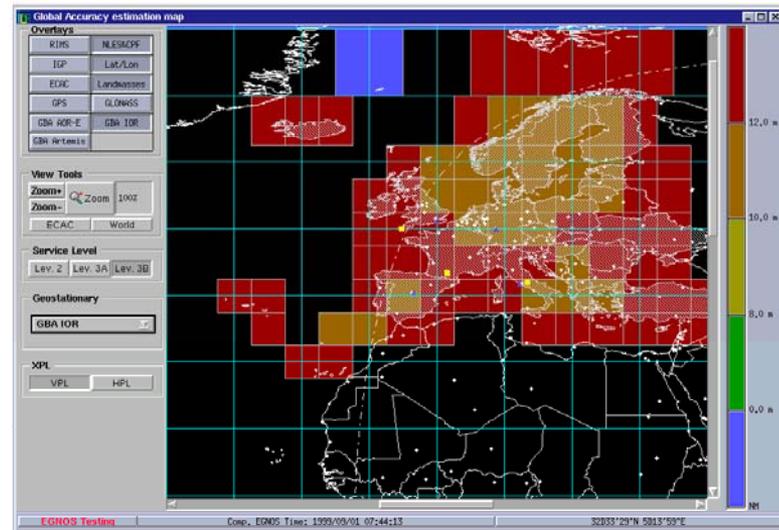
Product: Galileo/GIOVE Experimental Sensor Station (GESS)

- The GESS, manufactured by *Indra*, is a dual-constellation multi-frequency receiver station that is capable of tracking GPS L1, L2 and L5 and Galileo L1, E5a, E5b, E5 (AltBOC) and E6 signals

- The main capabilities of Sensor Station are:
  - Acquisition of the SiS from GIOVE satellites and GPS constellation
  - Provision of a high quality frequency reference
  - Generation of raw data 15min files
  - Compression and local archive up to 10 days
  - Support to the remote monitoring, configuration and control from the DSF
  - Remote SW upgrades from the DSF
  - Local console for first level of maintenance
  - Support more than 1 hour of power outages

GKIR: Kiruna (Sweden)

GUSN: USNO (USA)

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