OREGIN Workshop
“GALILEO, the Road to Success”

Demonstration Tools
ELCANO and EGNOS Tools

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GMV has been involved in the development of several GNSS tools, these tools are not only covering design aspects but also demonstration aspects, some of these tools are:

- EETES, EGNOS End To End Simulator
- ESTB, EGNOS System Test Bed
- ASQF, Applications Specific Qualification Facility
- ECUREV, ESTB expansion and user tools
- ELCANO, system design and performances evaluation tool

From those tools ECUREV and ELCANO are the most suitable tools for demonstration purposes.
Constellation Design and Performance Evaluation Tool

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AGENDA (I)

- Main characteristics of ELCANO
- ELCANO Modules, brief description
- Latest developments
- Urban environments demonstration
- Conclusions
ELCANO is a tool for the optimisation of satellite constellations. Currently, it is also capable of assessing performances and analysing their stability over time.

ELCANO has been developed in C and C++ languages.

It can be compiled in a Workstation, under UNIX operative system or it can be easily exported into a PC under LINUX operative system or under Windows. No special libraries are required.

The Graphic User Interface has been developed in Visual C++ and runs under Windows 95 & 98 & NT operating systems.

High flexibility: ELCANO is easy to maintain and to readapt to new requirements.

High reliability: ELCANO algorithms have been optimised to reduce the computational time and to be robust. They have been extensively used inside Galileo projects.
ELCANO Modules, brief description (I)

- Long Failures
  - MTTR (in months)
  - Percentage of Change of Vertical Accuracy Availability
  - Reliability: 0.75, 0.80, 0.85, 0.90

- Input Constellation File Module & Constellation Optimisation
- Input Terrestrial Points File Module
- Satellite Failures Statistics Module
ELCANO Modules, brief description (II)

Performance Assessment

ELCANO is a very powerful tool for Performance Assessment. It is possible to compute:

- DOPs values
- Visibility, number of satellites in view
- Average availability without limitations due to number of satellite failures
- Daily (or any fixed period) availability
- Continuity
- Accuracy for any fixed availability figure, or for any combination of satellite failures
- Maximum outage time, including percentage of days for which the outage time is shorter than any predefined value
- Percentage of days without service
- Etc.
ELCANO Modules, brief description (III)
Performance Assessment

- Vertical positioning accuracy for a 90% daily availability
- Number of days without service
- Maximum outage time in minutes
- Percentage of days for which the outage time is below 30 minutes
ELCANO Modules, brief description (IV)
Performance Assessment

Vertical positioning accuracy for a 99.7% availability, Galileo constellation

Vertical positioning accuracy for a 99.7% availability, Galileo+3 GEO constellation

Continuity risk

Vertical positioning accuracy for a 99.7% availability, Galileo+GPS constellation
Orbit perturbations lead to performances degradation
Corrective manoeuvres are to be avoided
  Decrease performance availability
  Increase cost
Orbit stability must be analysed
  A powerful orbit propagator has been developed
Performances are computed at predefined time intervals
The evolution of the orbital parameters is analysed and the initial constellation is re-optimised to minimise the need of maintenance manoeuvres
The high efficiency of the implemented algorithms allow the analysis of ten of years in seconds.
ELCANO Modules, brief description (VI)
Constellation Stability

Nominal Constellation

Optimised Constellation
ELCANO Modules, brief description (VII)
Graphics Generation Utility

- Ground tracks
- Performances
- Coverage points plots
A fully comprehensive On-line help

A new module to analyse navigation and communication performances inside urban environments. It allows the user to design a street with buildings of different heights on each side.

Update the library functions to analyse the impact on the navigation performances when other systems are used with Galileo (e.g. LORAN-C, Local Area Differential Systems, EGNOS-like or WAAS-like systems).

A completely new RAIM algorithm is currently under development.
ELCANO: A Constellation Design Tool

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Latest Developments (III)
Urban environments

Masking patterns at different user locations along a street

Number of satellites in view inside urban canyons
Conclusions

- ELCANO is a state-of-art tool that designs navigation and communication constellations, and evaluates performances.
- ELCANO is ready to be delivered and it is very useful to support demonstrations.
- Widely reviewed to improve the speed of its algorithms (the main problem for this kind of tools).
- Modular architecture: new functional modules could be added without considerable effort.
AGENDA

- Introduction to ECUREV
- Major Components of ECUREV-UMU (User Monitoring Unit)
- ESTB Receiver: a major element for reuse in Pilot Projects
- Real Time and Off-line performance analysis
ECUREV is a project performed under E.C. contract whose objective is to develop tools allowing to provide an expansion of the EGNOS service out of Europe (ECAC area).

It involves two major developments:

- Upgrade of the EGNOS System Test Bed (ESTB) allowing the provision of a Service out of Europe (target areas South America, North Africa, Middle East).
- Development of user tools allowing to build-up today EGNOS prototype applications and analyse the resulting performance: User Monitoring Unit (UMU).

**What is EGNOS Expansion?:**
A potential feature of EGNOS allowing that a reduced additional investment (infrastructure and development) produces a large increment in the number of EGNOS potential users.

**How to analyse and promote EGNOS Expansion?:**
Thanks to the upgrade of the EGNOS System Test Bed (ESTB) developed within ECUREV project.
GPS/GEO Receiver:

Either Acquarius from DSNP...
... or Novatel Millenium
Configured to provide only raw data and messages

Real Time function:
Data processing (key function):
- MOPS standard compliant
- Implementing specific features for Expansion

Real Time performance analysis

Off-Line processing function:
Long term performance analysis based on stored data
Aquarius/Millenium Receiver + Data processing function (ESTB Receiver) provides a highly valuable tool for experimentation with ESTB signal for all modes of transport:

All EGNOS Receiver functions are available:

- Computation of Navigation Solution
- Computation of Protection levels
- Generation of alarms
- RAIM

MOPS/SARPS standard compliant

Fully Tested with ESTB Signal

Only receiver able to exploit ESTB expansion capabilities

Receiver is already used for the following applications:

Systematic ESTB performance analysis

NLR experimental aircraft (already flying)

Being currently installed in Aena GNSS experimental aircraft
Real Time Performance Analysis:
Computation of accuracy and integrity
Other computed data:
- GPS/GEO SIS quality indicators
- HDOP, VDOP, PDOP
- GPS/GEO satellite visibility

Off-line long-term performance analysis based on stored data:
Computation of accuracy, integrity, continuity and availability (using also external data sources such as NANU and IGS data).
Residual UERE computation
ECUREV: Conclusions

- ESTB SIS is available, and it is able to provide a navigation service out of Europe.
- A EGNOS-ESTB Receiver fully compatible with ESTB SIS and valid for all modes of transport is available.
- The tool has been tested with ESTB SIS and is already operational for different applications.
- This tool is a key element for future Pilot Projects.