OREGIN Workshop
"GALILEO, the Road to Success"

Demonstration Tools
ELCANO and EGNOS Tools

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Introduction

- 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

Miguel M. Romay Merino & Esperanza Herraiz Monseco (GMV)

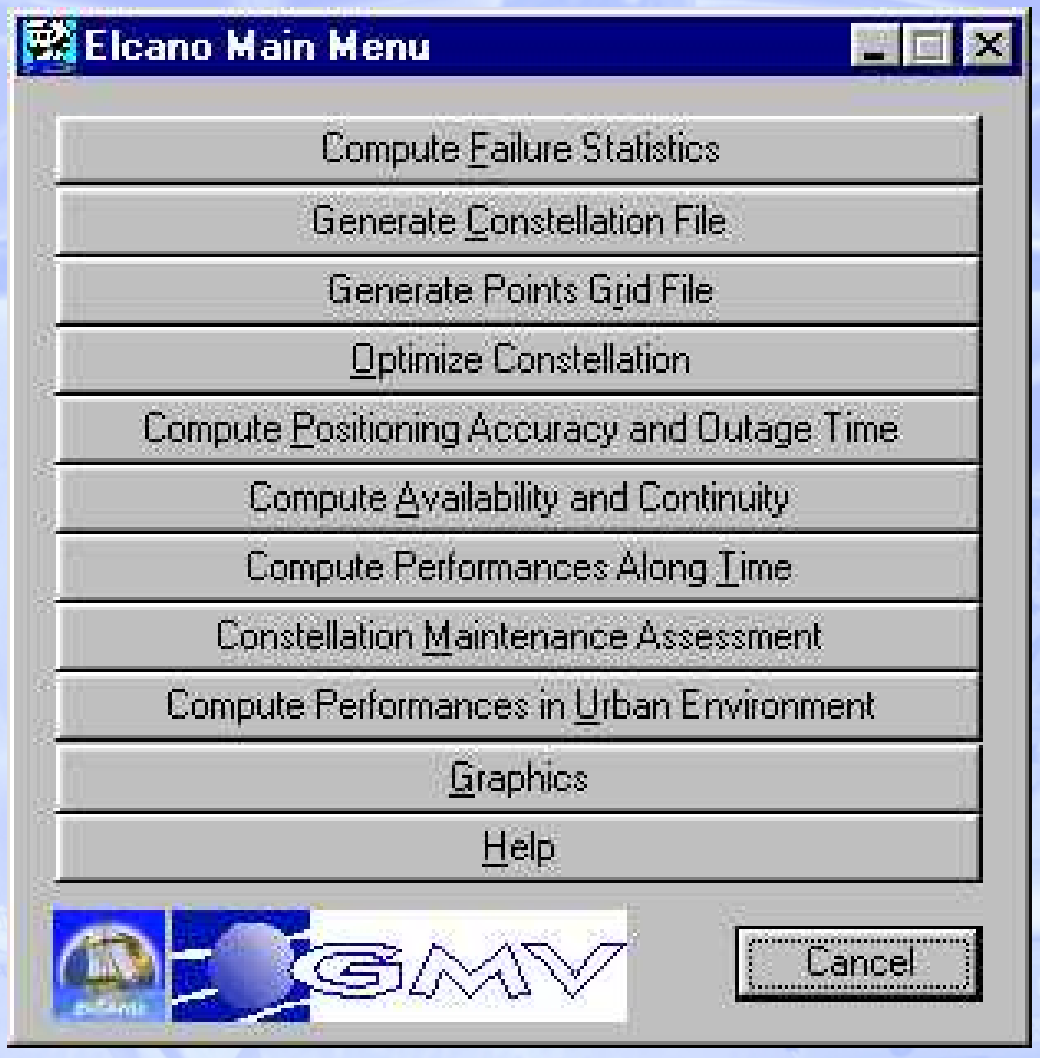
AGENDA (I)

- Main characteristics of ELCANO
- ELCANO Modules, brief description
- Latest developments
- Urban environments demonstration
- Conclusions

Main characteristics of ELCANO

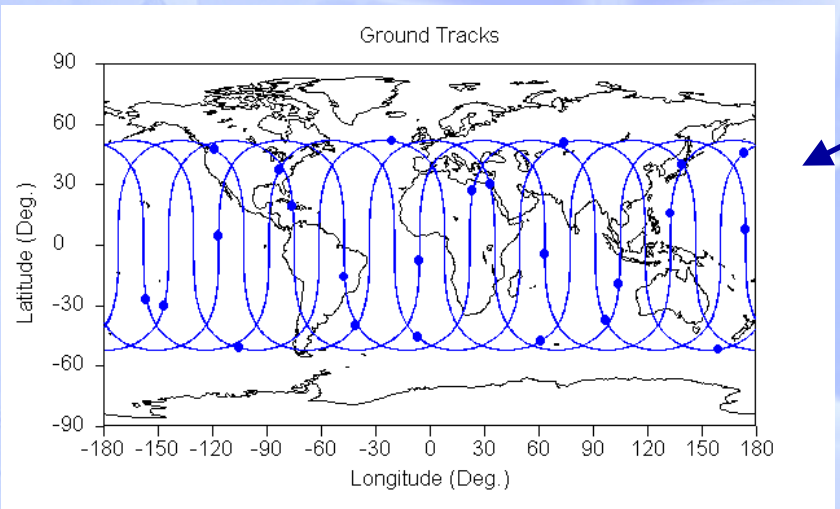
- **ELCANO is a tool for the optimisation of satellite constellations. Currently, it is also capable of assessing performances and analysing their stability over time.**
- **ELCANO has been developed in C and C++ languages**
- **It can be compiled in a Workstation, under UNIX operative system or it can 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

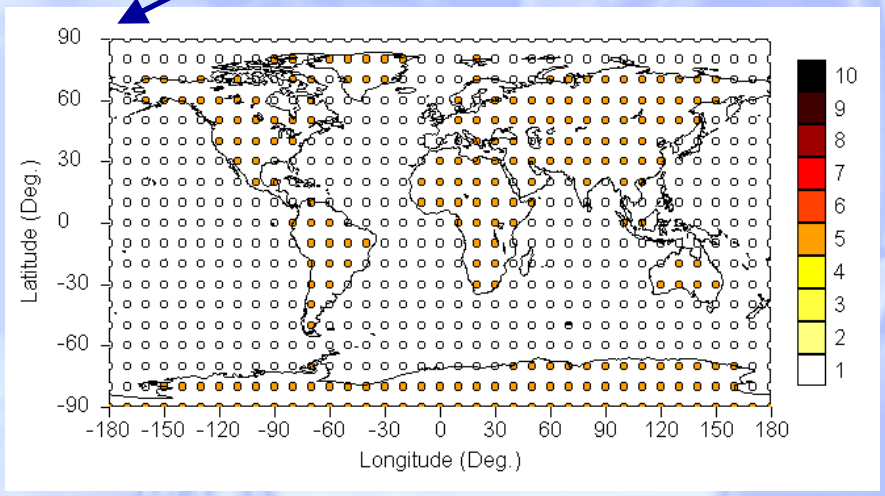


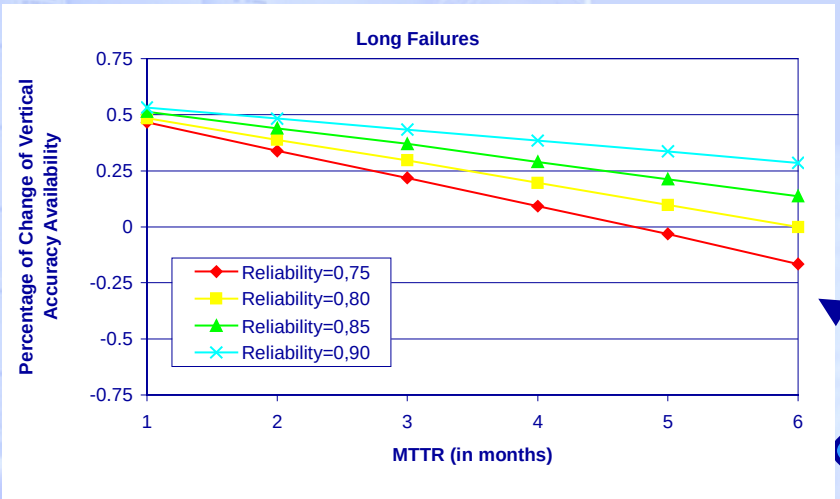
ELCANO Modules, brief description (I)

Input Constellation File Module & Constellation Optimisation



Input Terrestrial Points File Module



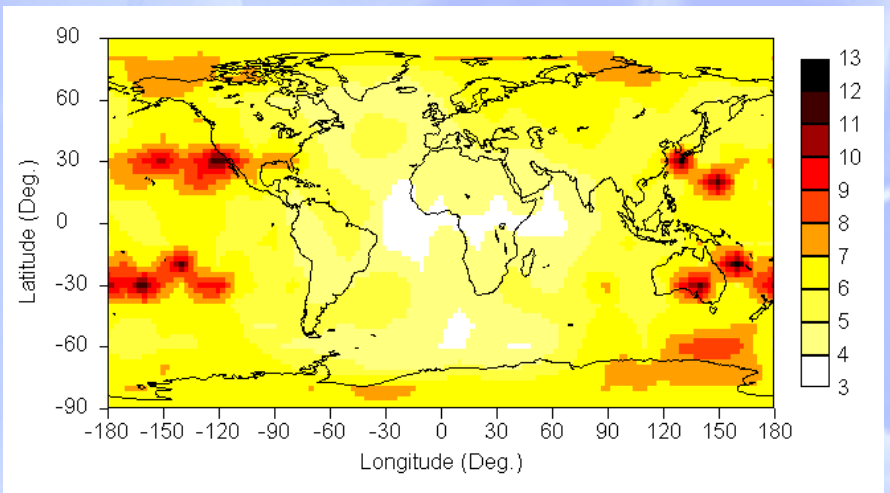


Satellite Failures Statistics Module

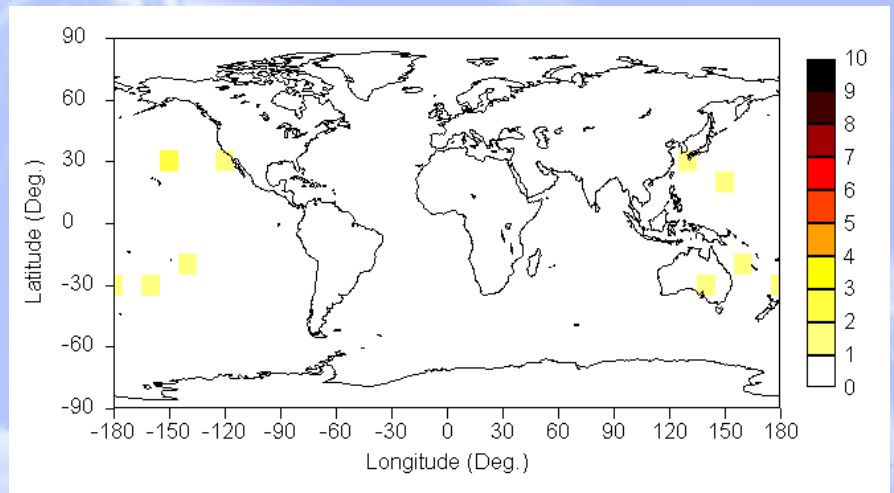
ELCANO Modules, brief description (II)
Performance Assessment

- **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.**

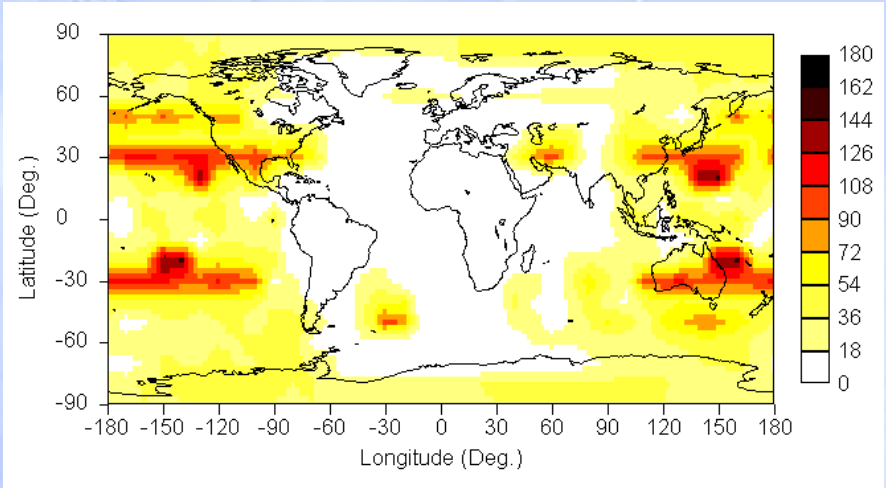
ELCANO Modules, brief description (III)
Performance Assessment



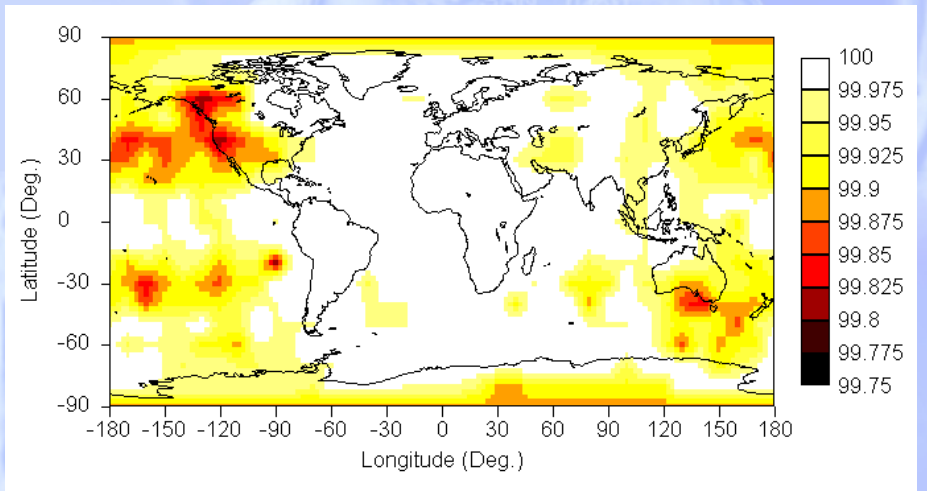
Vertical positioning accuracy for a 90% daily availability



Number of days without service

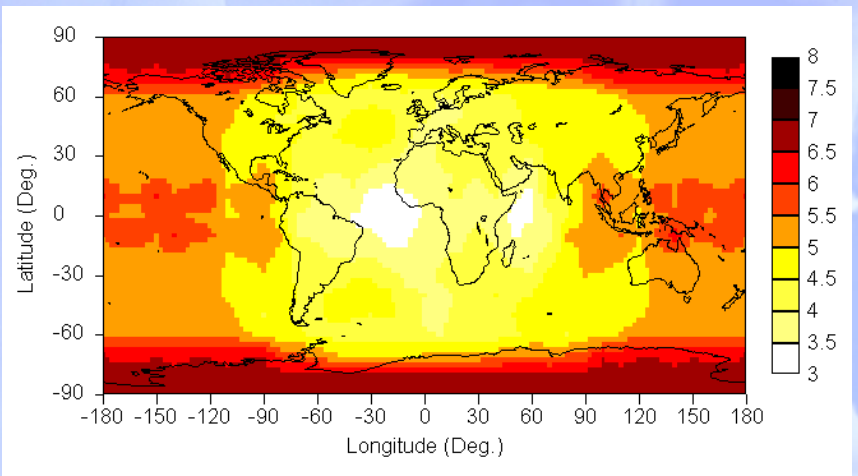


Maximum outage time in minutes

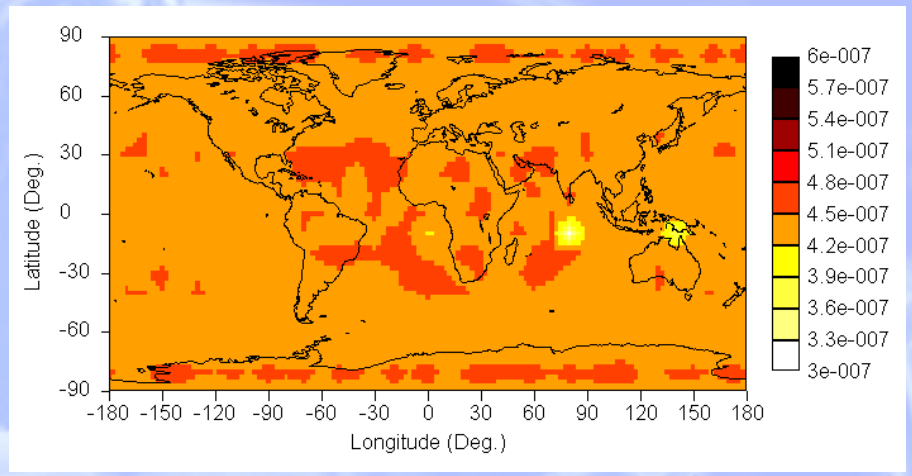


Percentage of days for which the outage time is below 30 minutes

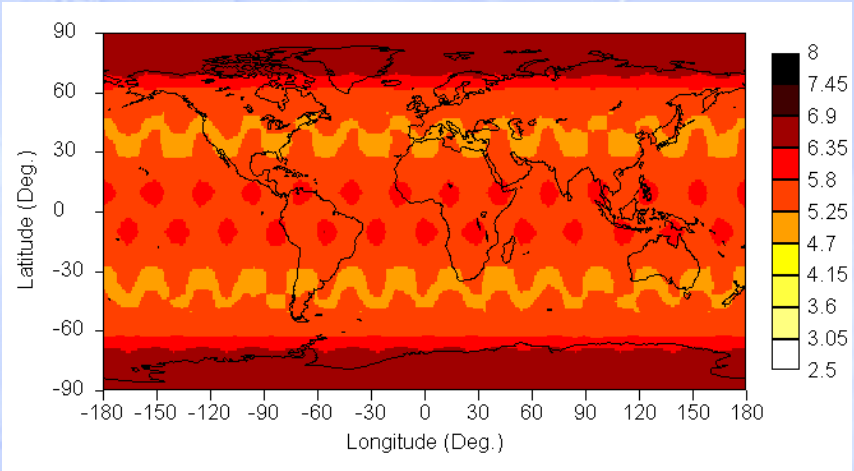
ELCANO Modules, brief description (IV)
Performance Assessment



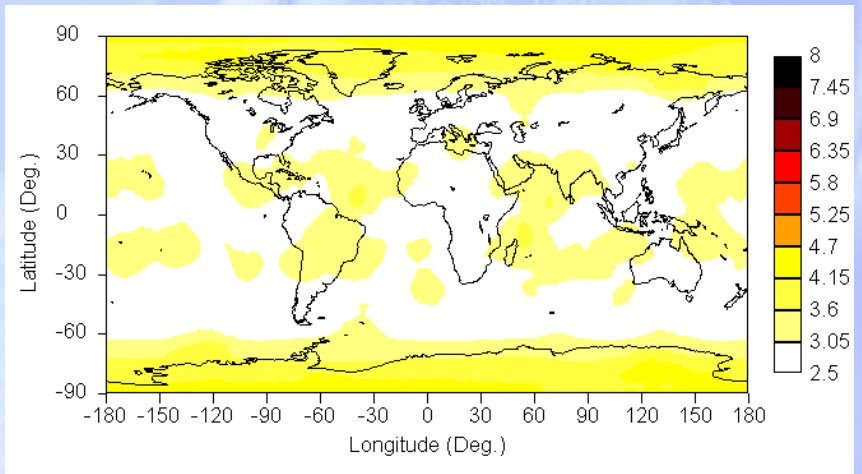
Vertical positioning accuracy for a 99,7% availability, Galileo+3 GEO constellation



Continuity risk



Vertical positioning accuracy for a 99,7% availability, Galileo constellation

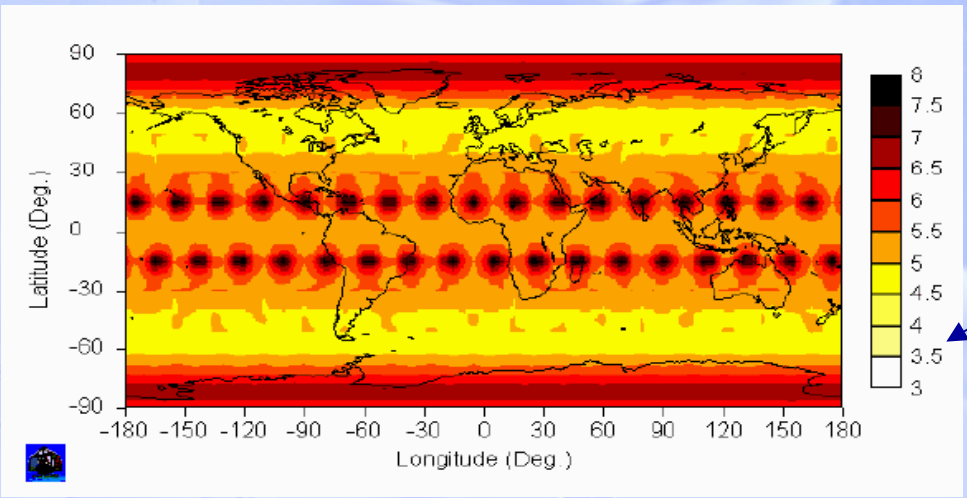


Vertical positioning accuracy for a 99,7% availability, Galileo+GPS constellation

ELCANO Modules, brief description (V)
Constellation Stability

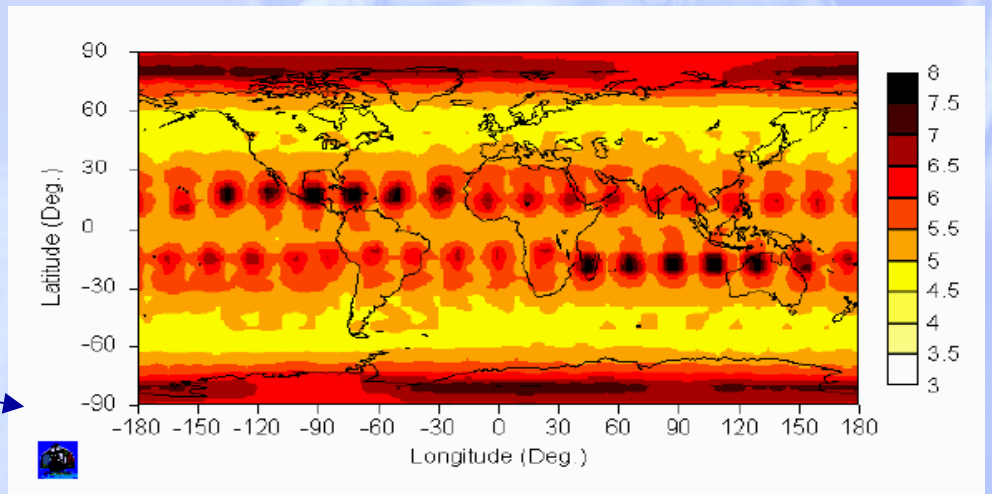
- Orbit perturbations lead to performances degradation
- Corrective manoeuvres are to be avoided
  - Decrease performance availability
  - Increase cost
- Orbit stability must be analysed
  - A powerful orbit propagator has been developed
- Performances are computed at predefined time intervals
- The 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

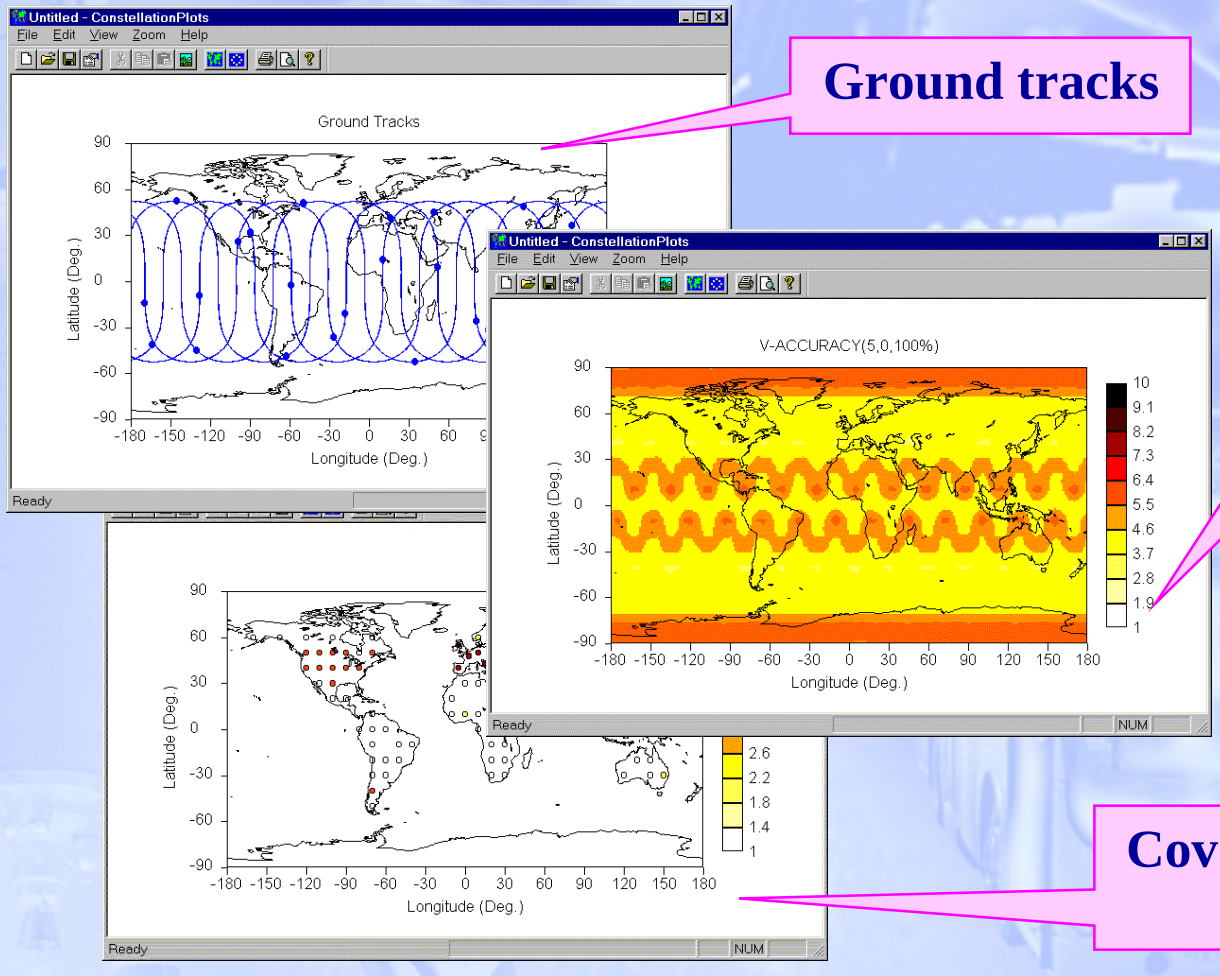


Nominal Constellation

Optimised Constellation



ELCANO Modules, brief description (VII)
Graphics Generation Utility



Ground tracks

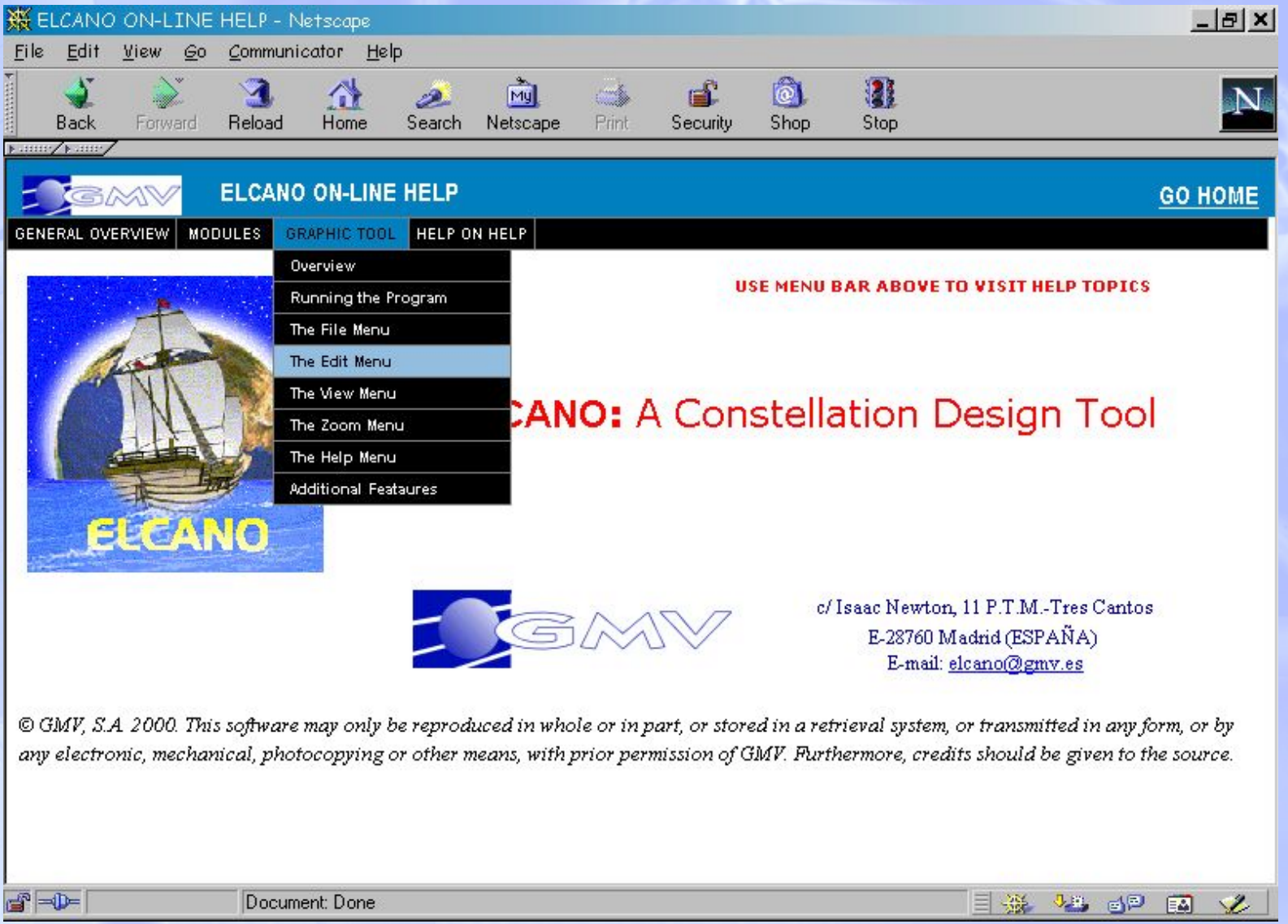
Performances

Coverage points plots

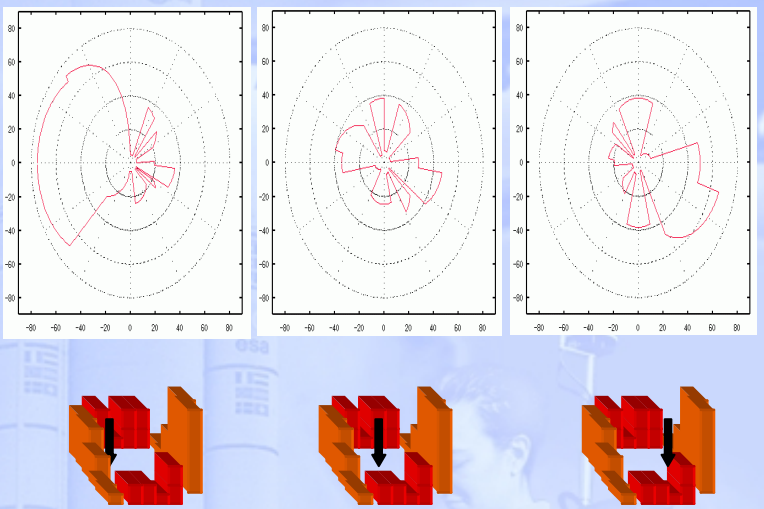
Latest Developments (I)

- 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

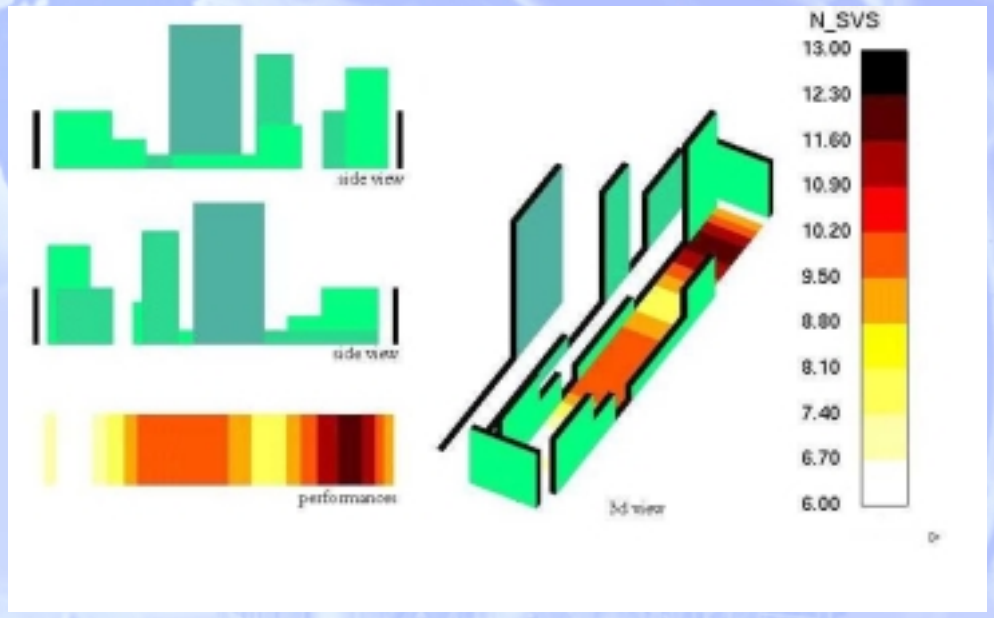
Latest Developments (II)
On-line help



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

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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:UMU. Introduction

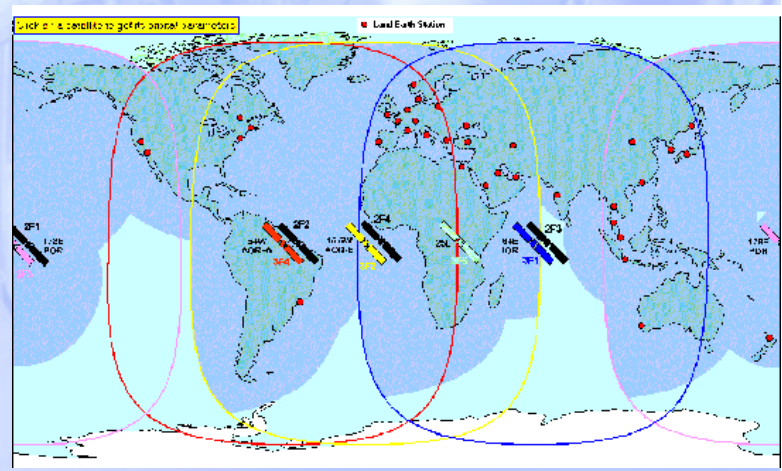
- ECUREV is a project performed under E.C. contract whose objective is to develop tools allowing to provide an expansion of the EGNOS service out of Europe (ECAC area).
- It involves two major developments:
  - Upgrade of the EGNOS System Test Bed (ESTB) allowing the provision of a Service out of Europe (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?:

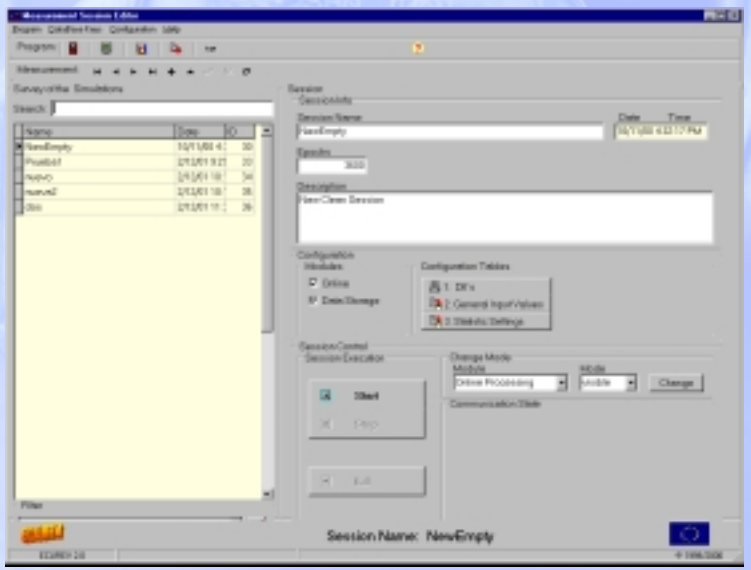
Thanks to the upgrade of the EGNOS System Test Bed (ESTB) developed within ECUREV project.



ECUREV: UMU. Components

- **GPS/GEO Receiver:**
  - **EitherAcquarius 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**

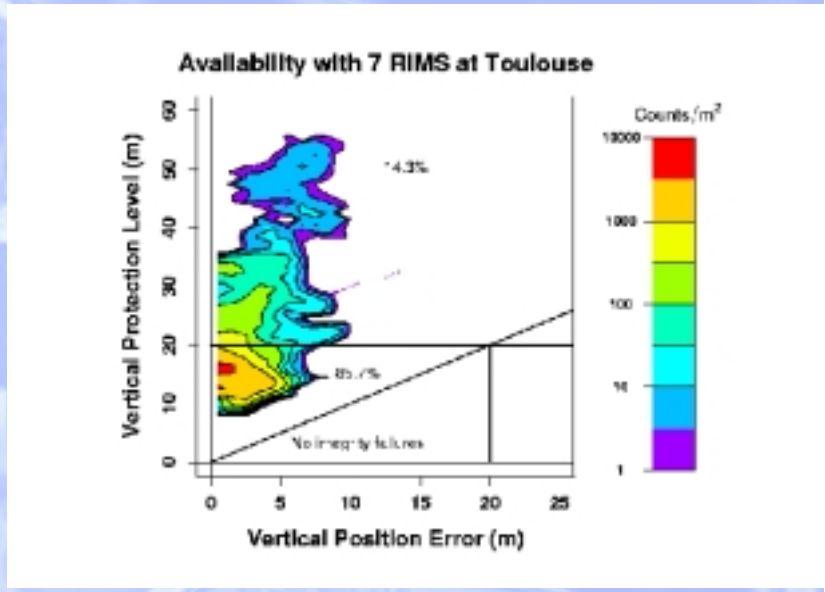
EGNOS-ESTB Receiver

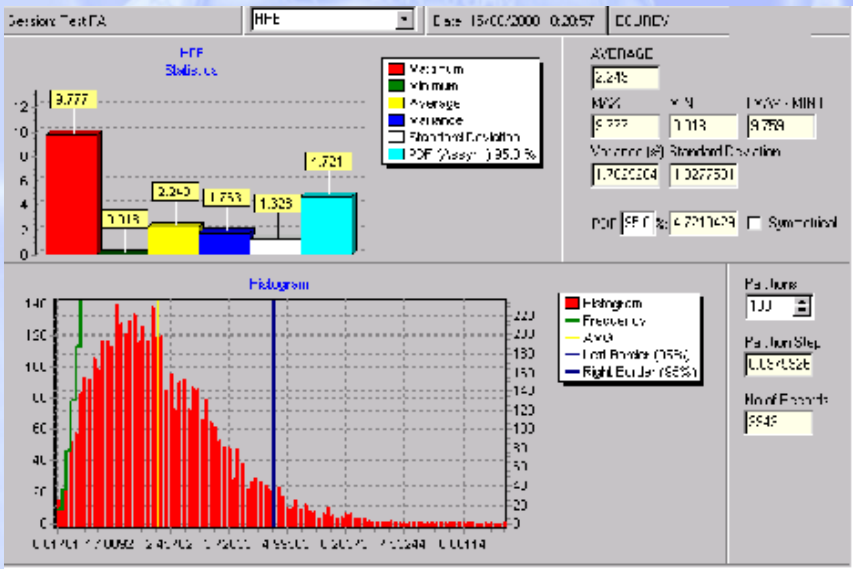


ECUREV: UMU. EGNOS-ESTB Receiver

- 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.