GNSS Satellite Simulators

The essential tool for all receiver developers & manufacturers

Specifications & Availability for Galileo

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March 2006
Agenda

- The GNSS Constellation Simulator
- Capabilities & interfaces
- Design changes for Galileo
- Specification
- Availability
- Why Spirent?
GNSS Testing - the main challenges

- For Galileo - No *navigable* Signals in space yet!
For GPS and GLONASS - Signals in space – but no control of them (orbits, clocks, atmosphere all changing)
The GNSS Constellation Simulator

With a simulator you have your own constellation “in a box” under your definition & control.
Main Input and Output Interfaces

- Synchronisation & timing in/out
- Trigger in/out
- External Reference Clock in/out
- Jammer in

Remote trajectory (File or Real-Time)
- NMEA data from your receiver
- Antenna patterns (file via GUI)
- Iono / tropo delays
- Remote commands to control the simulation or for HWIL applications
- Almanac (Yuma, Rinex, SEM)

Logged simulation data (all parameters)
- NMEA data
- Differential corrections (RTCM104, LAAS) on RS232

GALILEO/GPS/SBAS monitor output (-70dBm +/-20dB)

GALILEO/GPS/SBAS RF output
Software scenario definition

Define receiver motion:
- Trajectory
- Location

Define Constellation:
- Almanac
- Signal Outputs
- Data Messages

Define satellite position, clock
And navigation data errors
01101001000110

Define atmospheric errors

Define multipath & obscuration

Define Antenna Patterns

Compare RX interpretation with Truth
GNSS simulator - key design

- FPGA containing the signal & code designs
- Signal generator cards each producing 4 modulated IF channels
- Modulators, Up-converters, synthesisers filtering and RF combination
- Integrated into a multi-channel, software controlled system
Spirent is supplying RF Constellation Simulators under the C/D/E phase for GAiN this year to support testing for:

- **GSS = Galileo Sensor Station**
  - The Monitoring Stations and their link to central Galileo Control Centre (GCC), part of the Ground Control Segment (GCS)

- **GRC = Galileo Reception Chain**
  - Part of Monitoring Stations – Fixed Receivers

- **TUS = Test User Segment**
  - General Use, all applications – the roving part
Re-designing for Galileo

- Galileo simulator based on existing, proven and refined Spirent GSS7XXX series architecture
  - Simulator concept and fundamental design principles proven over >20 years
  - high-fidelity VME based architecture used for existing GPS and GLONASS constellation simulators
  - CASM modulation on E6 and L1 same characteristics as Modernised GPS, already implemented on GSS7XXX
  - Actual signal capability demonstrated back in May 2004

- But – some important design changes were required for Galileo….
Re-designing for Galileo

- **FPGA and DAC**
  - Bigger, faster devices with higher clock rate and modulation format to cope with BOC signals

- **I.F. Module**
  - Wider bandwidth
  - Higher power

- **R.F. filters**
  - New inter-digital filters with ultra-flat response
Re-designing for Galileo

- New dual synthesiser (IF + RF & 2RF) to cope with new frequencies
Re-designing for Galileo

- Added software capabilities
Galileo Simulator - main specifications

- All frequencies and services available
  - L1 A/B/C  E5A/B  E6 A/B/C
  - OS, CS, SoL, PRS

- Satellite Channels
  - 4, 8, 12 or 16 per frequency

- Dynamic performance
  - Relative velocity 120000 m/s
  - Relative acceleration 3600 m/s/s
  - Relative jerk 5000 m/s/s/s
Galileo Signal Plots from Spirent GSS7800 Galileo Simulation System

BOC (1,1) Sine (L1 OS)

BOC (15,2.5) Cosine (L1 PRS)

BOC(10,5) (E6 PRS)

AltBOC (15,10) 8-PSK (E5ab OS)
Galileo Simulator - main specifications

Industry leading fidelity and stability

- Nominal power levels
  - $-152\text{dBw} \pm 20\text{dB}$ at $0.1\text{dB}$ resolution

- Phase noise performance
  - SSB CW phase noise @ L-band $\sim 0.01\text{ Rads/rms}$

- Master clock stability
  - $\pm 5 \times 10^{-10}$ per day

- Carrier phase difference between any 2 channels
  - $\pm 0.000265\text{ m (RSS)}$
Galileo Simulator - main specifications

- Synergy with existing GNSS platforms
  - Will allow integrated and coherent simulation of
    - Galileo L1 A/B/C E5A/B E6 A/B/C +
    - GPS L1 C/A, P(Y), M-noise
    - GPS L2 C/A, P(Y), L2C, M-noise
    - GPS L5 I&Q
    - GPS L1/L2/L5 WAAS-EGNOS-MSAS and LAAS
    - GLONASS L1
    - Coherent jamming/interference
    - CRPA antenna testing
    - GPS+INERTIAL systems
<table>
<thead>
<tr>
<th>Year</th>
<th>Equipment</th>
</tr>
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<tbody>
<tr>
<td>2004/5</td>
<td>L1 Galileo Demonstrator, L1/E5ab Galileo Demonstrator</td>
</tr>
<tr>
<td>2006</td>
<td>L1 E5ab E6 for GSS &amp; TUS, L1 E6 for PRS</td>
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<tr>
<td>2007+</td>
<td>L1 E5ab OS GSS7800Commercial Galileo Simulator*, L1 E5ab OS</td>
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*availability depends on ICD public availability
Galileo functionality will be added to the existing range of test tools to provide a solution for each application.

<table>
<thead>
<tr>
<th>Production test</th>
<th>Maintenance</th>
<th>Qualification</th>
<th>Integration</th>
<th>R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single channel</td>
<td>Portable</td>
<td>Commercial</td>
<td>Fully flexible</td>
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- GSS6100
- GSS4200
- STR4500
- GSS6560
- GSS77/7800
Galileo Simulator Availability

- Galileo SIS-ICD is currently a controlled document
  - Available only to those involved in official ESA contracts

- Commercial Galileo simulator availability after SIS-ICD release
  - Timing uncertain; some indications this could be May/June 06

- For customers interested in Galileo simulation
  - Please contact Spirent for further information
  - We will register your interest and keep you informed as the Galileo programme progresses
  - Product Specification available under NDA
Why Spirent?

- The GNSS Simulator is still an essential tool for receiver developers and manufacturers, long after the SIS Segment is established – this has been proven with GPS and GLONASS

- Spirent has over 20 years experience in the Constellation Simulator business

- Spirent’s products are well proven in all applications, we will simply build on that sure foundation for Galileo.

- Spirent already has an evolved range of GPS/GLONASS test tools, Galileo is simply the next step in that evolution

We are ready and waiting to provide the solution to your testing needs, please contact us....
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