# Software Radio as Technology Brick for the Development of GNSS Multi-System Receiver: Results Obtained in Torino

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ICG 2010 - Torino

# Introducing ISMB

**ISMB is a non-profit applied research institution operating in the ICT field (Information and Communication Technologies).**

**Main objective is to innovate at both technology and process levels**

- 2000 The Institute is founded by **Compagnia di San Paolo** and **Politecnico di Torino**
- 2001 **Motorola, STMicroelectronics, Telecom Italia** as industrial partners
- 2003 Start of the operations and ISMB "Official Institution" of **Compagnia di San Paolo**
- 2005 ISMB consolidates as a cluster of 8 R&D Labs
- 2010 Cooperation agreement with Microsoft in order to set up the **Microsoft Innovation Center Torino**

Compagnia di San Paolo is one of the largest private-law foundations in Europe

# Introducing NavSAS

**NavSAS** is a joint research group of ***ISMB*** and ***Politecnico di Torino*** University, operating in the satellite navigation, localization technologies and embedded solutions sectors

- Research is focused specifically on advanced technologies for GPS / EGNOS / Galileo receivers and applications as well as on advanced SW and FW for embedded solutions.
- NavSAS cooperates with major industrial and institutional players operating in the field (e.g. EC and European Space Agency funded projects).
- 30 researchers, more that 160 publications, 5 patents and 15 R&D projects on going

# A Research Lab Devoted to GPS and Galileo

ISMB
Istituto Superiore Mario Boella

Private Research Center

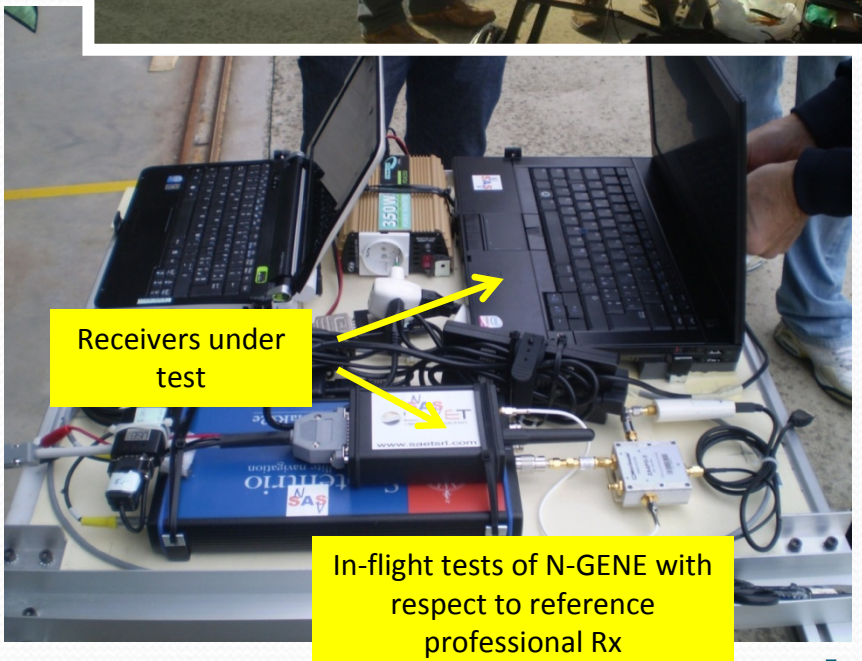
Top Technical University

NAVSAS

# NavSAS on Core Nav Technologies

NavSAS Keywords on Galileo, EGNOS and other GNSS:

- GNSS receiver core technologies and algorithms (professional, Safety-Of-Life)
- Fully SW and SW Radio implementations for GNSS receivers
- SIS analysis
- Advanced automatic guidance solutions
- Ultra tight GNSS+INS integration
- Interference detection and mitigation algorithms
- Jamming and Spoofing



# N-GENE: in the Future of GNSS Multi-Systems Receivers


**N-GENE** is a Real Time Galileo, EGNOS/EDAS and GPS Fully Software Receiver supporting the following modulations

| SIS | Acquisition | Tracking | Navigation & PVT |
|---|---|---|---|
| L1 – GPS C/A | ✓ | ✓ | ✓ |
| L2C - GPS | ✓ | ✓ | X |
| E1 – GIOVE A and B BOC(1,1) | ✓ | ✓ | X |
| E1 – Galileo BOC(1,1) | ✓ | ✓ | ✓ |
| E1 - EGNOS | ✓ | ✓ | ✓ |
| E1 – Galileo CBOC(6,1,1/11) | ✓ | ✓ | X |

**N-GENE** can be uses for:

R&D tasks, GNSS multi-system solutions, INS+GPS, A-GPS, spoofing mitigation, interference monitoring & mitigation, ....

# Software Radio Approach

- Simple fundamental design philosophy: place the ADC as close as possible to the antenna in the chain of front end components. Software processing of the resulting samples using a programmable microprocessor.

**Major Advantages**

1. Removal of analog components and their nonlinear, temperature-based, age-based characteristics . Software-based receiver
2. A single antenna/front end configuration can be used to receive and demodulate a variety of distinct signals. Flexible and multi-standard/system receiver
3. The software radio provides the ultimate simulation/testing environments 100% reconfigurable receiver

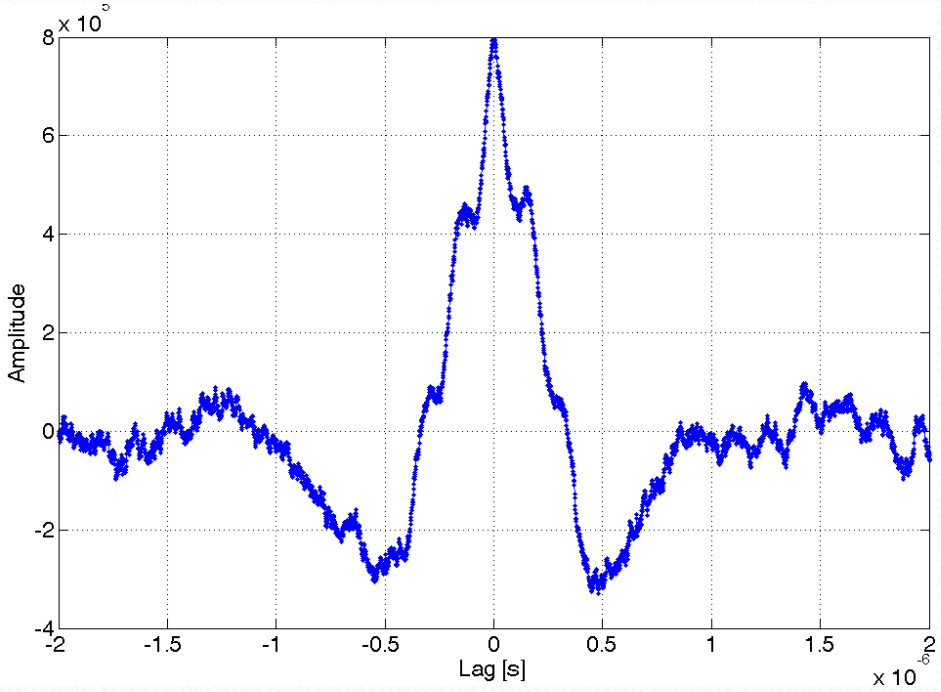
**By SR we mean: "Fully software", completely developed in software running on general purpose processor (like a PC), not on dedicated HW**

# N-GENE: a Tool for GNSS multi-Systems receiving platforms

The N-GENE (i.e. software radio) technology provides the necessary flexibility for simulation, testing environment and implementation

- Pillar activities of the research roadmap in the area of GNSS multi-systems receivers are
  - Analysis of new core algorithms for the next generation GNSS SIS (Modernized GPS, Galileo, Glonass, Compass)
  - Design of innovative receiver architectures
  - Interference monitoring strategies
  - Analysis of new signal modulation
  - Anti-spoofing techniques
  - Hybridization techniques

CBOC(6,1,1/11) correlation function reconstructed from real collected data broadcast by the GIOVE-B satellite



# N-GENE Main Features

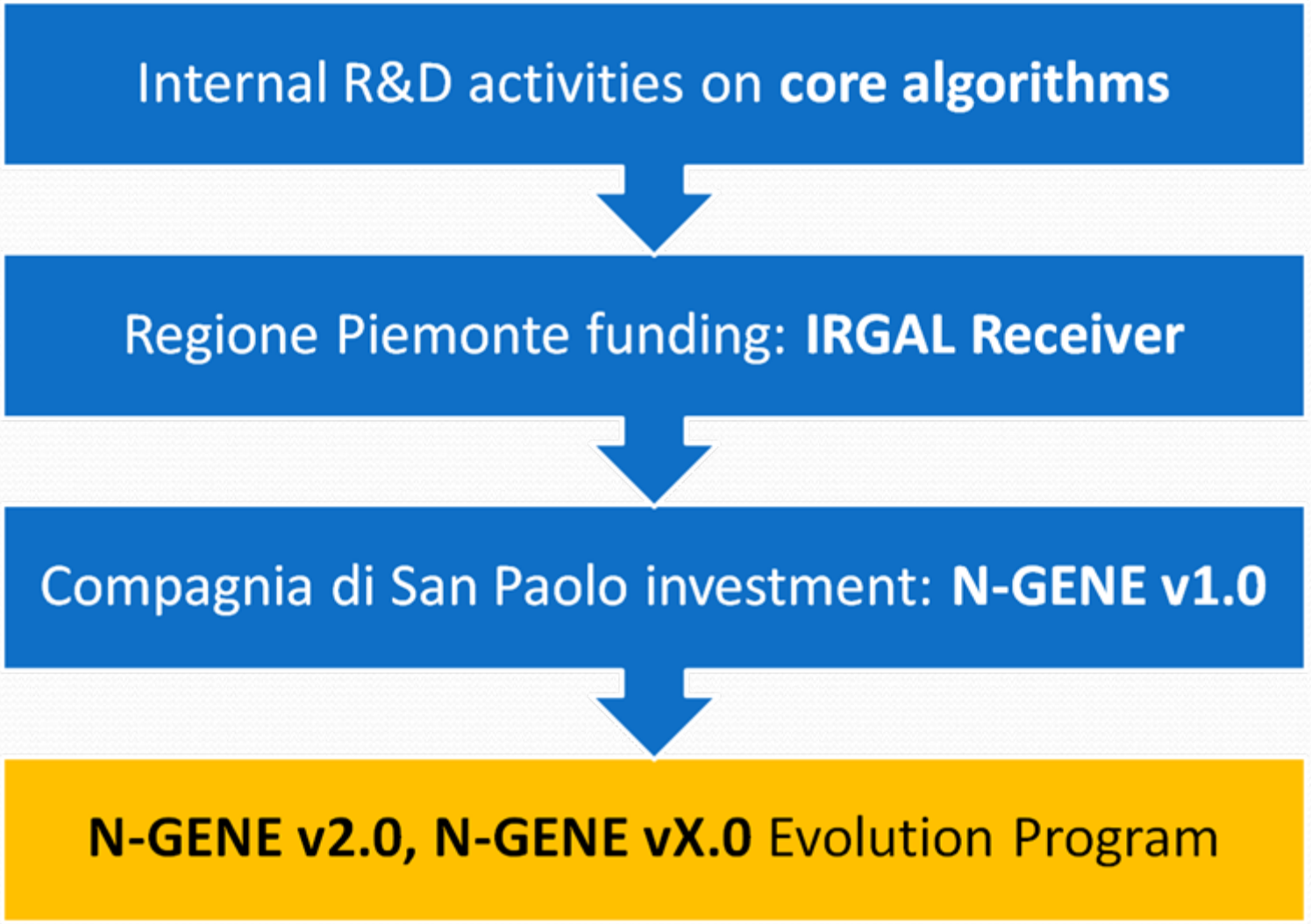
The software approach makes N-GENE flexible, but at the same time N-GENE provides performance equivalent to single frequency professional receivers

| N-GENE Software Receiver - Performance | |
|---|---|
| **Max. n. satellite tracked** | - Selectable by the user;<br>- Up to 16 channel in real time, with a sampling frequency of ≈17.5 MHz and 8 bits per sample. |
| **Signal tracked** | - GPS L1 C/A code; GPS L2C<br>- Galileo E1 BOC (1,1), MBOC;<br>- GIOVE-A and GIOVE-B signals;<br>- EGNOS and EDAS |
| **Positioning accuracy** | - r.m.s<6 m using code-based measurements; |
| **Pos. fix update rate** | - Selectable by the user;<br>- Up to 60 Hz |
| **Cold start** | - 45 s;<br>- The user set the target probability of false detection. |
| **Warm Start** | - Possibility to use assisted information to reduce the Time to First Fix coming from the Communication (GSM/UMTS) network |

| N-GENE Software Receiver – Enhanced Characteristics | |
|---|---|
| **Front end Interface** | - Any front end using a USB 2.0 interface;<br>- The receiver is able to process both I and Q samples at baseband and real samples at IF. |
| **Quantization** | - User selectable: up to 8 bit per sample. |
| **Sample Recording** | - Possibility to store raw samples to binary files |
| **Assisted GPS** | - The receiver is equipped with Assisted-GPS software routines that recover A-GPS data employing the OMA-SUPL protocol. |
| **Modular Approach** | - Receiver easily reconfigurable;<br>- Access to low level signal processing routines; |
| **Output files** | - NMEA standard;<br>- RINEX 3.0 standard;<br>- Proprietary Log files. |

**N-GENE is now the core of N-SPOOF, the NavSAS internal program for development of innovative anti-spoofing techniques on open signals**

# N-GENE: A Model for Scientific Developments



# NavSAS Ready-to-Use Tools


Galileo/GPS/EGNOS fully SW RX


Extended GPS+EGNOS EV kit


Matlab SIS gen


GNSS Multi-systems samples grabbing (data storage)


Distance learning kit


Professional tracking solution

# NavSAS Mid-Term Strategy on N-GENE

- Focus on safety and liability critical applications. Effort on spoofing and anti-spoofing solutions from both practical and theoretical standpoints. Same as for interference monitoring & mitigation algorithms implementation

- Increase the use for scientific applications e.g radio-occultation (TEC) and scatterometry (soil composition) toward integration of Galileo and GMES

- Evolve N-GENE Fully SW receiver toward GNSS multi-systems development platform (with industrial partners)

- Push at the industrial and the system integrator levels the multi-system (and multi-frequency) approach in mass-market applications

- Increase the effort on Higher Education using N-GENE (e.g. NAVIS South-East Asia Center on GNSS, Hanoi)

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