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

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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

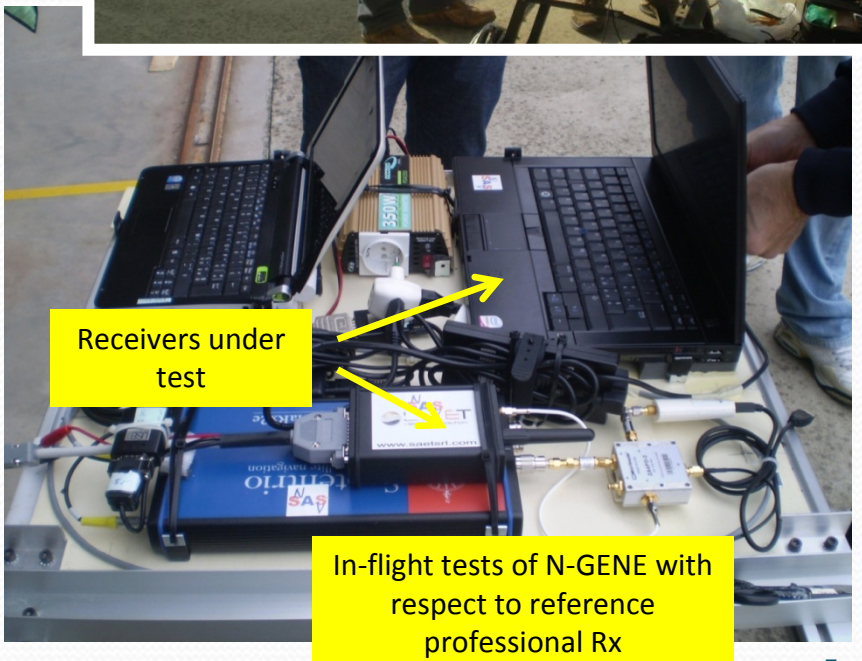
Top Technical University

NAVSAS

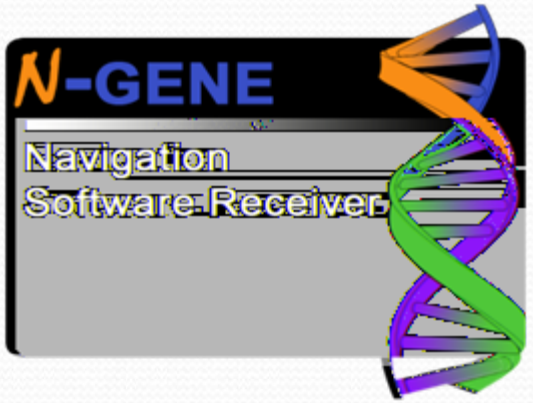
NavSAS on Core Nav Technologies

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

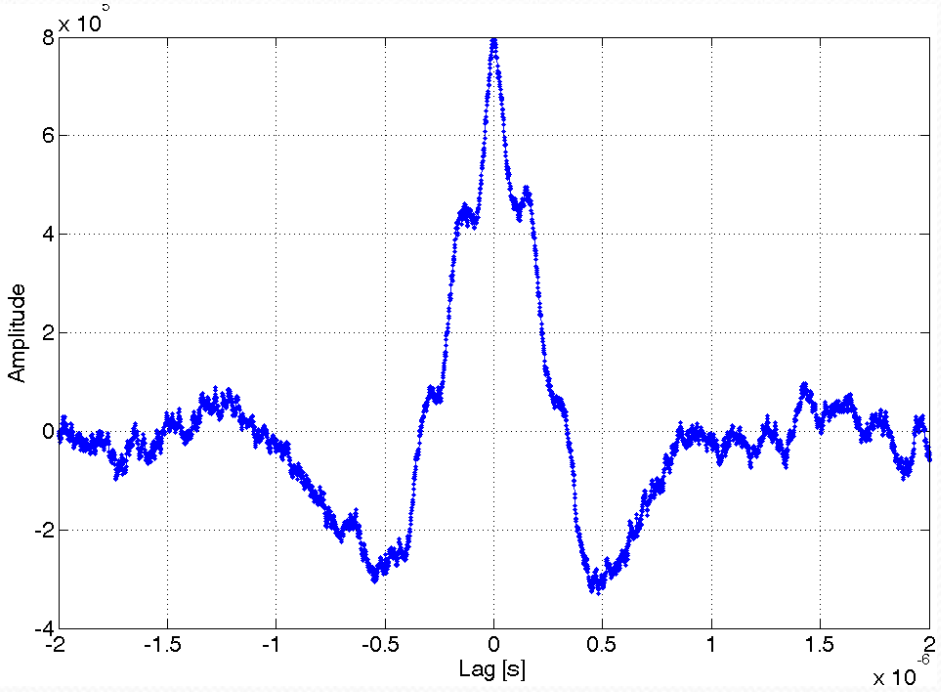
By SR we mean: "Fully software", completely developed in software running on general purpose processor (like a PC), not on dedicated HW

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

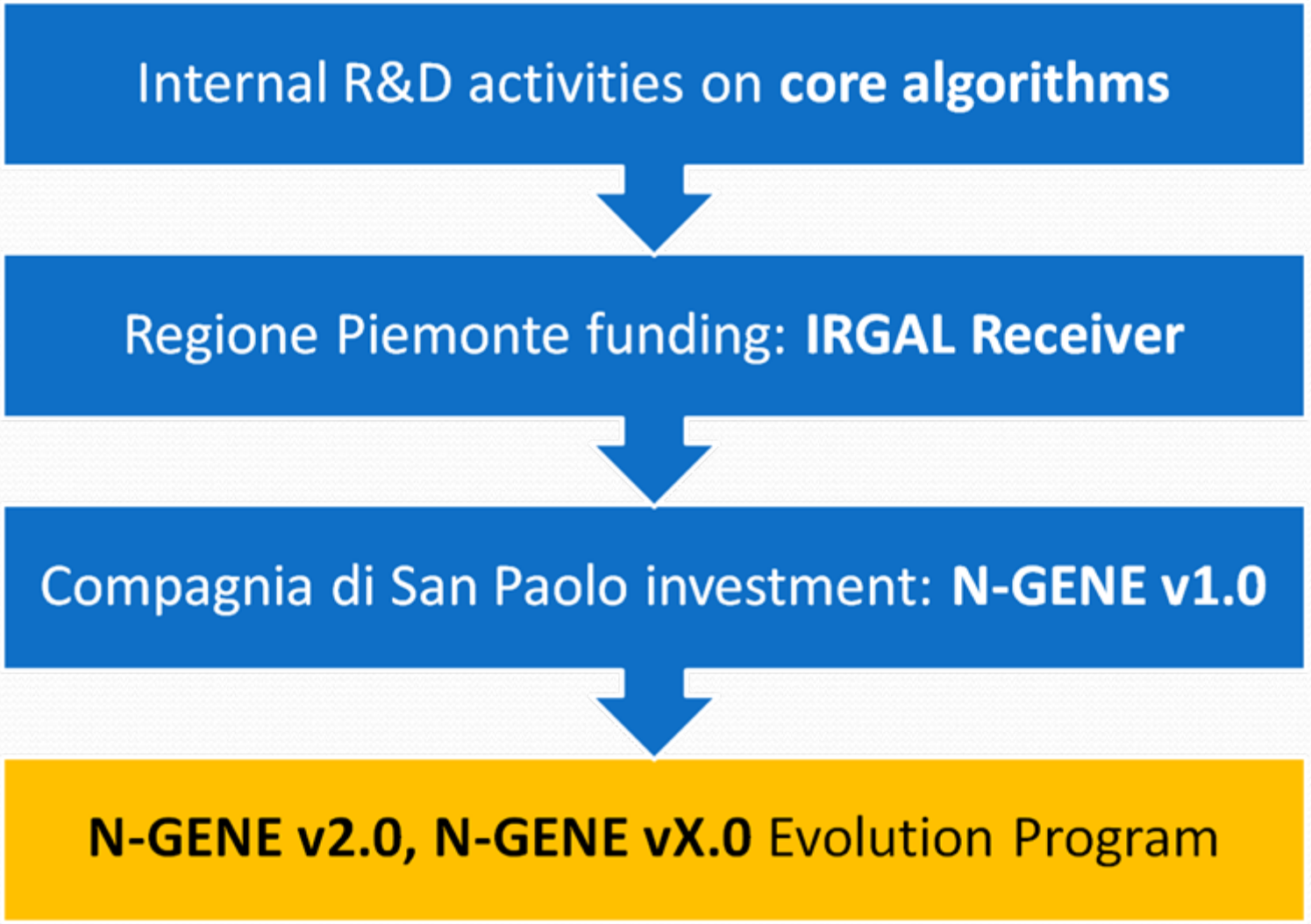
The software approach makes N-GENE flexible, but at the same time N-GENE provides performance equivalent to single frequency professional receivers

N-GENE Software Receiver - Performance	
Max. n. satellite tracked	- Selectable by the user; - 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 - Galileo E1 BOC (1,1), MBOC; - GIOVE-A and GIOVE-B signals; - EGNOS and EDAS
Positioning accuracy	- r.m.s<6 m using code-based measurements;
Pos. fix update rate	- Selectable by the user; - Up to 60 Hz
Cold start	- 45 s; - 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; - 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; - Access to low level signal processing routines;
Output files	- NMEA standard; - RINEX 3.0 standard; - 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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