Report on the 1st Colloquium Scientific and Fundamental Aspects of the Galileo Programme

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ICG Expert Meeting

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- International colloquium on fundamental aspects and scientific applications of Galileo and GNSS has been held in Toulouse on **1-4 October 2007**. ANAE (Académie Nationale de l'Air et de l'Espace), Bureau des Longitudes, Académie de Marine and ESA (European Space Agency), are the main instigators of this colloquium meant to contribute to the 50th anniversary celebrations of the launch of Sputnik.
- Scientific Program Committee Chairman: **Jean Francois Minster**
- Venue: **Toulouse**, Cite de l'Espace
- Ca. 140 participants
- 95 papers

The colloquium addressed three major issues:

- The fundamental aspects of navigation by satellites and Galileo: geodetic and temporal reference frames, relativistic frame, on board and ground clocks, orbits, radiative environment in orbit, intersatellite links, fundamental aspects of propagation, tropospheric and ionospheric corrections, calibration and validation, relations with international organisations (BIPM, IGS).
- Scientific applications in meteorology, geodesy, geophysics, space physics, oceanography, land surface and ecosystem studies, using either normal or reflected signals, differential measurements, phase measurements, occultations using receivers placed on the ground, in airplanes or in scientific satellites.
- Scientific developments in physics and dealing with future systems, particularly in testing fundamental laws, in astronomy, in quantum communication, and in developing clocks or experiments based on GNSS.

3 invited talks

- **Impact of Global Navigation Satellite Systems on Geodesy and Geophysics** - Gerhard Beutler, University of Bern, Switzerland
- **Cold Atom Space Clocks and Fundamental Tests** - Christophe Salomon, LKB, Paris,
- **Soil Moisture Monitorization Using GNSS Reflected Signals** - Giulio Ruffini et al., Starlab, Spain

Earth Sciences

- E01 - Geodesy and Geodynamics
- E02 - Geodynamics
- E03 - Global Tectonics
- E04 - Reference Frames
- E05 - Ionosphere and Space Weather
- E06 - Troposphere
- E07 - Atmospheric tomography
- E08 - Earthquakes
- E09 - Gravity field
- E10 - Remote sensing of Earth / Ocean
- E11 - GNSS reflectometry

E04 – Reference Frames

- The Global Geodetic Observing System and Galileo; *Rothacher, M. et al.*
- The International Terrestrial Reference System, Galileo and other Global Navigation Satellite Systems; *Boucher, C et al.*
- GGSP - Realisation and Maintenance of the Galileo Terrestrial Reference Frame; *Gendt, G. et al.*
- The International Terrestrial Reference Frame: ITRF2005 and Future Developments; *Altamimi, Z.*
- The Transformation between the Terrestrial and Celestial Reference Systems: Needs and Potential of GPS and Galileo; *Capitaine, N. et al.*

Metrology

- M01 - Atomic Clocks (Optical and Maser)
- M02 - Galileo timing system
- M03 - Time scales and offsets
- M04 - Inter-satellite links
- M05 - Precise Orbit determination
- M06 - Signal propagation aspects

Physics

- P01 - Space-Time symmetries
- P02 - Fundamental constants
- P03 - Relativistic reference frames
- P04 - Equivalence Principle
- P05 - General Relativity
- P06 - Astrometry, VLBI, Pulsar Timing
- P07 - Atomic physics for clocks
- P08 - Astronomy and GNSS
- P09 - Quantum non-locality and decoherence

P05 - General Relativity

- The Chrono-geometrical Structure of General Relativity and Clock Synchronization; *Lusanna, L.*
- A Relativistic Framework for Positioning Systems; *Pascual-Sánchez, J.-F.*
- What Galileo can Learn from the Scientific Investigations and Some of the Controversies on GPS and Relativity; *Spallicci, A.*
- Possible Detection of the Gravity Field Disturbance with Help of Gradiometer on the Galileo Orbit and Higher; *Zielinski, J.B., Galazka, R.R., Peron, R.*

P09 - Quantum Physics

- Engineering the Spectrum of Photons for Quantum Metrology Applications; *Valencia, A. et al.*
- The Utilization of the Galileo Timing Signals for Quantum Communications; *Capraro, I et. al.*
- Quantum Enhancement of Time Transfer between Remote Clocks *Lamine, B. et al.*
- Polarization Transformations on Qubits in a Earth-to-Space Quantum Communication System Involving Galileo Satellites; *Bonato, C. et al.*
- Quantum Information and Quantum Physics in Space; *Ursin, R. et al.*

Conclusions

- Establish an independent and committed scientific team in support of Galileo **GNSS Science Advisory Committee**
- Elaborate a **Scientific Opportunity Document for Galileo**
- Facilitate access to data to scientists, including non processed data.
- Organize a second colloquium on the scientific and fundamental aspects of Galileo **Padova, 14-16 Oct. 2009**
- Offer to the scientific community regular opportunities to embark secondary payloads onboard Galileo through open call for opportunities.
- Encourage research based on Galileo signal through grants and support to workshops.
- Organise the cooperation between the system and signal providers, i.e. industries, operators, ESA and the scientific communities using the system.

GNSS Science Advisory Committee scope:

- Support the preparation of announcements of opportunity (AO) for science studies within the European GNSS Evolution Program.
- Support ESA in evaluating the proposals in reply to the AO.
- Recommend improvements to Galileo and EGNOS for scientific applications
- Advise on secondary payloads for Galileo satellites
- Report activities and progress to ESA's High Level Science Policy Advisory Committee

Science Opportunity Document scope:

- Technical information as well as a summary of possible scientific activities
- 3 main parts have been designated
    1. Earth sciences
    2. Metrology
    3. Fundamental physics

Proceedings CD-ROM can be requested at:

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1st Colloquium
Scientific and Fundamental Aspects of the Galileo Programme

Cité de l'Espace in Toulouse France, 1-4 October 2007

http://www.congrex.nl/07a06/

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