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Jean-Luc Issler is head of the Instrumentation, Telemetry & Telecommand and Propagation department of CNES, the French space agency. A graduate of the Ecole Supérieure d'Electronique de l'Ouest engineering school (ESEO, Angers, France), he has been involved in the development of several spaceborne RF systems in Europe, for transmissions and/or navigation. He has also contributed to CNES research into optical telemetry and related standardization efforts. In 2004 he was awarded the Astronautics Prize of AAAF, the French aeronautical and space association, and in 2008 the EADS science and engineering prize of the French science academy for his work on Galileo signals and spaceborne GNSS systems. Jean-Luc also wrote an unpublished sci-fi novel in 1990, about the exploration of a Trojan asteroid by a probe with a solar sail.

I have now been working in various management roles in space radiocommunications with CNES for nearly 20 years. To start with, I hesitated before focusing on optical transmissions or radionavigation, since I was very keen to obtain an internship at OCA working on lunar laser-ranging detectors and student projects on GPS. When I arrived at CNES's Toulouse Space Centre in September 1990, I finally settled on radionavigation engineering to study RF navigation for unmanned and manned spacecraft like the European Hermes space shuttle (similar JAXA's HOPE spaceplane). These activities involved a lot of RF digital and analogue signal processing and work in the laboratory. In 1992, I took charge of the development of a spaceborne GPS receiver prototype for NASA's and MIT's HETE spacecraft, after a chat over dinner with an MIT colleague. Nearly 200 units of the operational version of this equipment were produced for LEO or high-altitude satellites, so it was a great dinner. In the meantime, I was also involved in the air-interface design for several space radionavigation GNSS systems, like LEO or MEO constellations, and a worldwide network of pseudolites with both space and ground applications for the EGNOS SBAS experiment called CE-GPS, with successful transmissions in 1992 through an Inmarsat-2 L-band repeater and a complete system demonstration in 1993. I was in charge of the CNES Radionavigation department between 1996 and 2003, where I was closely involved in designing the signal for Galileo and EGNOS GNSS European systems. With CNES and other European colleagues, I invented most of the Galileo signals, like the CBOC, interoperable with its US and Chinese counterparts.

Telescope,  used for laser ranging, timing, and communications

Designing the Galileo signal was a quite epic adventure, with a lot of discussions between European colleagues, giving us the impression of building a kind of ‘King of Europe’, surpassing initial technical and political divergences. This time was also fascinating with similar discussions between the Galileo signal team and their counterparts in Japan, India, USA, Russia and China; this was very rewarding and allowed us to broaden our views. It also led to the proposal from European and Canadian colleagues for a Universal-SBAS standard related to GNSS orbital overlays, fully compatible with the JAXA QZSS regional Michibiki constellation, among other GNSS systems like EGNOS. The Galileo team was also inspired by JAXA’s pioneering experimental use by ETS-8 of a navigation PRN code in the MSS/RDSS S-band, which was filed for Galileo among others for possible future uses in several GNSS systems like IRNSS. I was involved in the effort at ITU to provide a worldwide RDSS allocation for that band in addition to MSS. I also produced more than 10 patents on GNSS and TT&C signal processing and signal design, and worked on a Metrological Formation Flying ranging and attitude determination system reusing GPS waveforms, tested on board the Swedish PRISMA satellites, derived from a proposal I had crafted for Hermes in 1991. The reuse of GNSS mass-market modulation reduced the costs of that equipment. Mass-market-inspired designs and standards are generally encouraged at CNES for cost and performance reasons. I became head of the Signal Processing and Transmission Techniques department between 2004 and mid-2009, still in charge of GNSS receivers, navigation payload and signal design, as well as signal propagation issues for multimedia and mobile space telecommunications, and GNSS ionospheric issues. This department was also in charge of TT&C and telemetry air-interface designs, as well as specifications and procurement of next-generation related equipment. This team was tasked with providing air-interfaces for space telecommunications during the early years, helping to nurture CNES’s idea of standardizing DVB-S2 for space telemetry at CCSDS. The goal was to benefit from the air-interface provided with HOMs to ensure both high performance and compatibility with the telecommunications mass market to save costs. CNES will use HOMs for telemetry in X band for Earth observation, like some Japanese LEO spacecraft that are already paving the way in this field. This is why CNES considers it important to preserve the full data-rate capacity of worldwide X-band assets for telemetry, which have experienced only very few and very short interferences seen from CNES ground stations, even polar ones. There is sometimes a need for coordination, but no need to change a lot flux numbers in the regulation related to EESS X-

GNSS signal monitoring dish above
the CNES Radio-Navigation Laboratory

band. CNES will therefore use DVB-S2 telemetry in X-band for small spacecraft, and also a telemetry rate of at least 2 Gbits/s at 8 GHz with a bigger LEO Earth observation satellite to be launched around 2022 (1 Gbit/s per circular polarization). CNES also intends to use DVB-S2 for high-data-rate LEO DTE optical telemetry, following current trends for an international high-data-rate optical telemetry format reusing the mass-market wavelength (1.55 micrometres) chosen for optical fibre transmissions. I took over as head of the Instrumentation, Telemetry & Telecommand and Propagation department mid-2009. Several developments of S-band and X-band transmission equipment for micro- and nanosatellites have been handled by this team, which also had end-to end responsibility for the Rosetta-Philae lander's S-band proximity link (specification, procurement, tests and early operations). The team is also providing technical support to DLR and JAXA for the Hayabusa 2-Mascot lander's proximity link. We are also closely involved in standardizing RF propagation models at ITU. A unique opportunity has arisen thanks to the Communication Laboratory at NICT, which agreed for CNES to participate in a LEO DTE optical telemetry and propagation experiment. This activity is being pursued in a very collaborative and friendly spirit, and involves the NICT small optical terminal (SOTA) on board a Japanese LEO satellite, transmitting a telemetry signal at 1.55 micrometres, the mass-market wavelength preferred by NICT and CNES, as well as many other agencies like JAXA, for performance, interoperability and eye-safety reasons. This collaboration has been a huge success and optical transmissions were performed between SOTA and the NICT OGS, and then the French OGS located at OCA near Nice, where I did my internship more or less 30 years before. I was impressed by the skills and know-how of NICT and OCA, confirmed by the results of this experiment. I am very grateful to NICT for enabling such collaborations on optical telemetry, which are very promising in terms of data exchanges and technical advances, and also to JAXA for other fruitful collaborations. I am also happy to see, despite sometimes different use cases, good convergence between Japanese and French views concerning space telemetry.

OCA-CNES experimental Optical Ground Station on OCA site, near Nice, France

**Glossary :**

CE-GPS : Complement Européen à GPS ( GPS European overlay experiment )
CBOC : Composite Binary Offset Carrier
CCSDS : Consultative Comitee for Space Data Systems
CNES : Centre National d'Etudes Spatiales
DTE : Direct To Earth
DVB-S2 : Digital Video Broadcasting-Satellite 2nd generation
EESS : Earth Exploration Satellite Systems
EGNOS : European Geostationary Navigation Overlay Service
GNSS : Global Navigation Satellite Systems
JAXA : Japan Aerospace eXploration Agency
HETE : High Energy Transcient Explorer
HOM : High Order Modulation
MSS : Mobile Satellite System
PRN : Pseudo Random Noise
RDSS : Radio Determination Satellite System
OCA : Observatoire de la Code d'Azur ( French Riviera observatory )

OGS : Optical Ground Station
QZSS : Quazi Zenithal Satellite System
SOTA : Small Optical TerminAl
TT&C : Telemetry and TeleCommand
U-SBAS : Universal-Space Based Augmentation System

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