



## CNES's activities on space electronics and photonics

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Worldwide, the interest for photonics technology applied to satellite communication, either SatCom or DTE, free space optics or on-board photonics, has significantly increased in the last 10 years. For instance, Data relay infrastructures such as EDRS in Europe and now LCRD in the USA, are emerging, and Optical Inter Satellite Links are being deployed in new Satellite constellations.

Based on a French industrial network previously involved in Earth Observation applications, SILEX or LOLA demonstrations or in non space related applications, CNES, the French Space Agency, has initiated or supported a number of activities preparing further space communications applications of photonics, through its national programme or its contribution to the ESA ARTES programme.

In the field of Satellite Communication, CNES mainly supports the French industry technological overall roadmap and carried out some internal activities related to both on-board photonics and free space optics applications.

This support applied from the System/Payload level down to the component development and qualification.

Concerning On-board photonics to enhance payload functions so far implemented with fully electronic technology, the main R&D activities have been carried out with Thales Alenia Space in the framework of ESA ARTES studies and more recently of the national CUSCO project. All together they helped to identify target SatCom payloads, to assess and demonstrate innovative photonic sub-systems bringing significant advantage with respect to conventional solutions, namely high-throughput digital interconnects (already flying today), LO distribution or multi-LO RF frequency conversion as well for HTS/VHTS. These findings, from the specifications of the required photonic devices to the end-to-end payload performance were consolidated through extensive component evaluation, laboratory experiments and/or breadboarding as well as complex system simulations. Reliability at payload level was also considered since it had a critical impact on the overall architecture. In parallel, CNES supports various low TRL R&T activities at component level to go on improving the photonic sub-systems that could be implemented on the mid-term.

Concerning Free Space Optics applications, an ambitious technological and demonstration industrial roadmap is supported by CNES in the framework of the DYSCO project and the France Relance Project CO-OP. The DYSCO project prepares and supports the TELEO Demonstrator (Airbus Defence and Space and partners) that should implement GEO-to-Ground optical communication links for demonstration purpose in 2023. This demonstrator takes benefit from early initiated development of on-board devices in the framework of the FOLC2 ARTES Scylight activity (Airbus Defence and Space, Bertin Technologies, iXblue, COMAT, Sercalo).

The CO-OP France Relance project aims at developing a new generation of on-board and on-ground devices to implement Satellite-to-ground links up to several hundreds of Gbps, based on a throughput per wavelength in the 50-100 Gbps range. 17 French industrial partners are cooperating under the coordination of Airbus Defence and Space and a system design shared with Thales Alenia Space to develop space and/or ground telescope, mechanisms, focal plane technologies including Adaptive Optics, electronics, optical amplifiers, MUX/DEMUX devices, Rx/Tx front-end, ... to be proposed as commercial products and systems in the next 3 years. Synergy between on-board photonics and Free Space Optics are also existing, the experience acquired on the first will faster the development of the second.

In parallel, various low TRL R&T activities are continuously preparing Generation 2 technologies and concepts to improve SatCom systems on the mid- and long-term.

Concerning LEO Direct to earth optical transmissions, CNES is also supporting the French industry. Following the first optical links performed within international campaigns with NICT, NASA and DLR and an experimental OGS at the French Riviera observatory, CNES supports the LASIN: « LASer through INstrument » demonstration, which is an optical terminal developed by ADS on-board one of the Co3D satellite, that uses a subpupil of the main imagery optical telescope and benefit from the platform agility for pointing. This demonstrator also embarks some photonics development of the ARTES Scylight FOLC2 activity for laser, modulation and optical amplification.