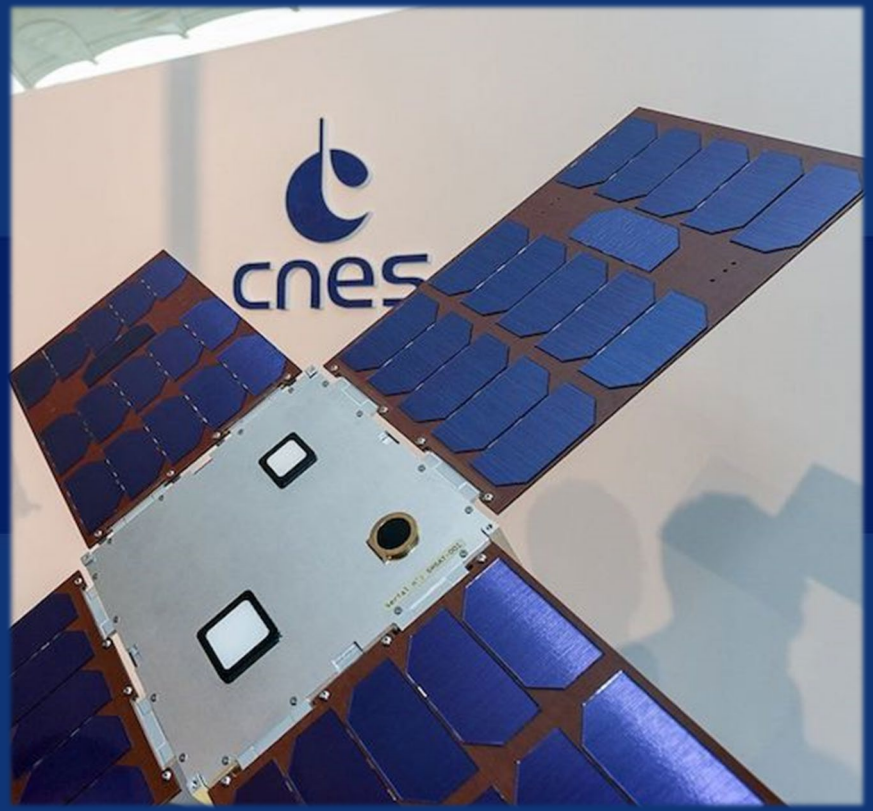
SSC19-I-02

CNES miniaturization policy: an answer to Nanosatellites challenges



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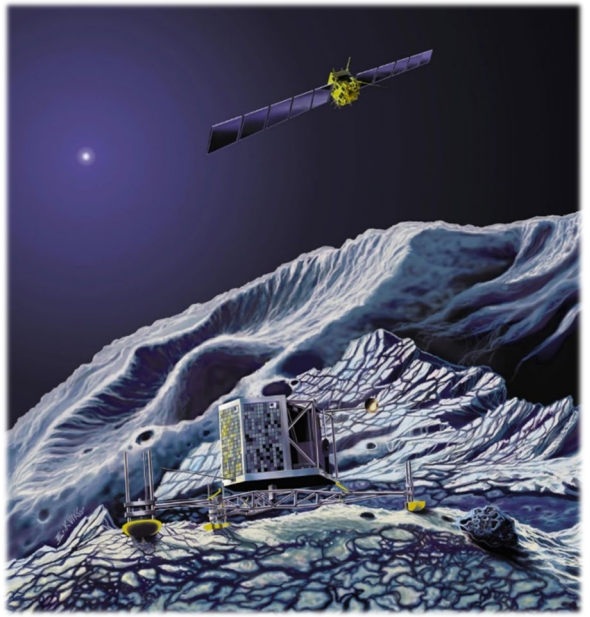
- Miniaturization policy
- Field of application: nanosatellites
- CNES structural evolution for nanosatellite activities
- Perspectives

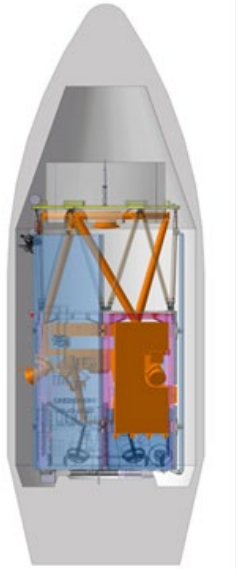
Miniaturization policy

- **CNES strategy for its missions**
  - Improve performance
  - Reduce mass, cost, volume of equipments and instruments

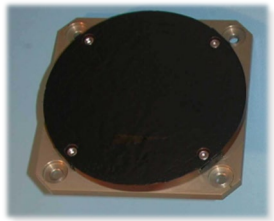


2002 : SPOT5 2m50
3000 kg / 2500 W

2011 : PLEIADES 70 cm
1000 kg / 1500 W



OTOS 30 cm
1500 kg / 2000 W



2004 : ROSETTA/PHILAE mission
ISL: 1 kg

payload miniaturization for Earth Observation missions

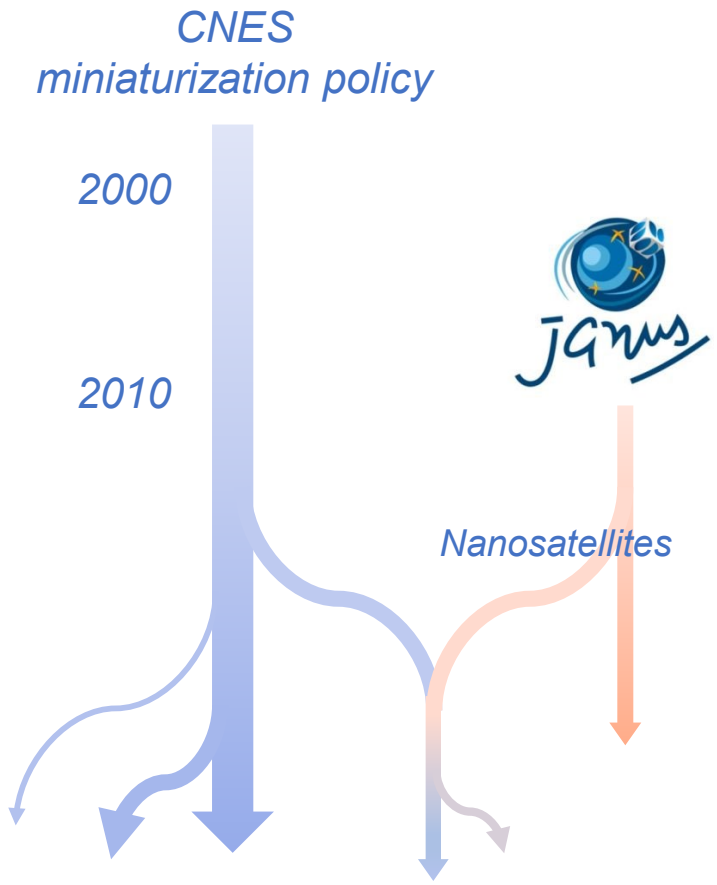
Miniaturization policy

- In the late 90's, CNES developed a new product approach to facilitate access to space for scientific missions
- Generic multi-mission platform with flexibility for subsystems and payloads: development of MYRIADE satellite family
- 25 to 50 kg of instruments
- Almost standardized structure in order to reduce the recurring cost of production
- First launched in 2004 (DEMETER), next and last in 2020 (TARANIS), about 20 satellites

Miniaturization and generic platform approach were initiated without specifically anticipating the nanosatellite market expansion but they were two essential steps towards it

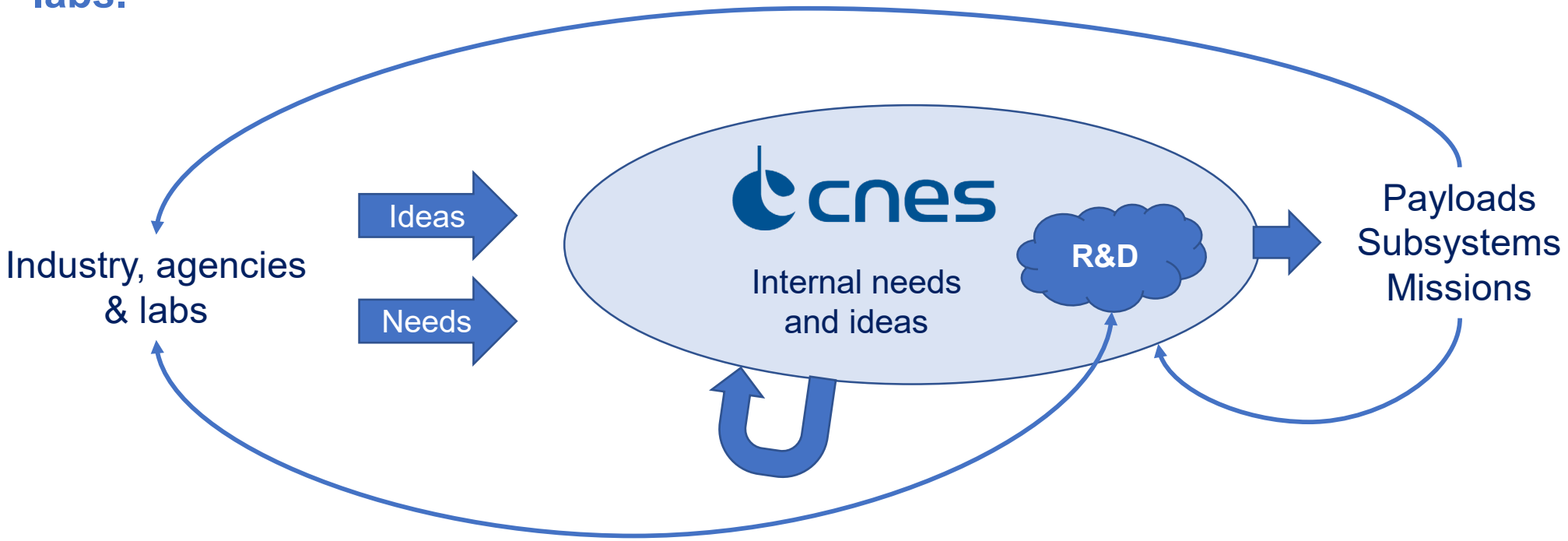
CNES first steps into nanosatellites

- **Work with universities (2006) and JANUS program (2012)**
  - A. Gaboriaud, "*JANUS a CNES Program for Developing Cubesats by Students*", SSC 2017
- **Support to specific satellite components like antennae or TT&C transceivers has led CNES to start internal technical activities with R&D budgets**
- **Industrial partnerships with small companies mostly, to develop new range of products adapted to nanosatellite format at reduced cost (TT&C, HDRT, antennae, OBC, …)**
- **Support to multiple partners such as quality analysis of new components and emission of recommendations in various fields (e.g. electromagnetic compatibility, space radiations)**



Spreading of nanosatellite activities

- **Subsystems, payloads and missions developments for nanosatellites were addressed in parallel by different CNES departments in collaboration with industrials, agencies and labs.**

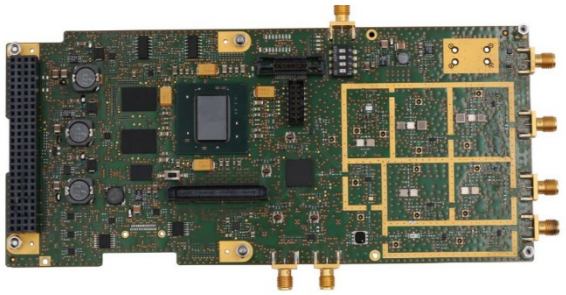


Nano-subsystems and nano-payloads

- **Since 2010, Software Defined Radio technologies allowed the growing of new perspectives for miniaturized payloads or integrated subsystem functions**
- **Development in several steps to reach the best final product with test-oriented approach**
  - Unitary modelling of elementary functions with COTS evaluation boards
  - Moving to nanosatellite format based on an SDR architecture
- **Flexible development method for project management (agile method)**

SDR flexibility allows versatile design. Same SDR platform can be used for different applications

Nanosubsystem and nanopayloads - Examples



- **RF payload development for spectrum monitoring**
  - Serpentine (2017): elementary functions evaluation (TRL 4)
  - Spectrolite (2018): flight model fitted to nanosatellite format (TRL 7)
  - Independently, a mission concept was studied internally and finally selected. In 2019, beginning of an in-flight demonstration mission using Spectrolite developments.
- **OBC with integrated avionics**
  - Ninano for Eyesat project Eye-Sat (2017)
    - Fabien Apper “Eyesat: *A 3U Student CubeSat from CNES Packed with Technology*”, SSC 2019

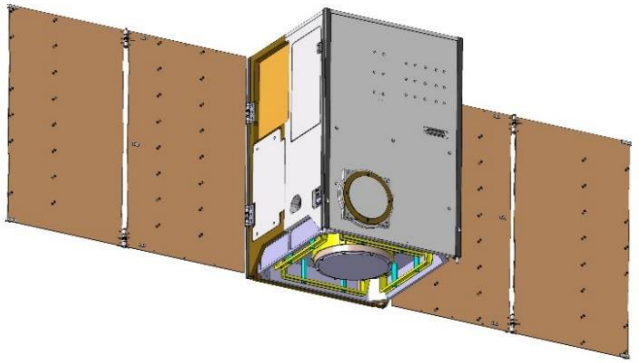
eyesat
Interplanetary dust and galaxy

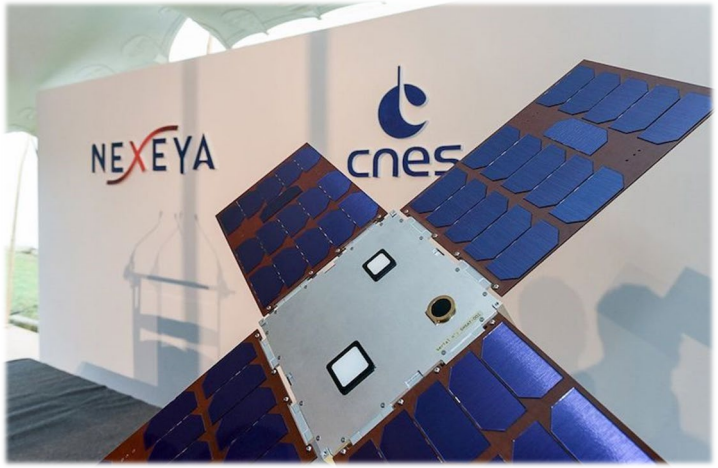
CNES nanosatellite activities evolution

- Years of academic initiatives support, equipment developments and conceptual studies
- In 2016, start of R&D projects to support the emergence of nanosatellite applicative programs both at payload and satellite levels
  - ANGELS
  - NƐSS

ANGELS (start 2017, launch 2019)

- Argos Neo on a Generic Economical and Light Satellite
- First CNES satellite outside the scope of JANUS program
- 12 U built by NEXEYA (now HEMERIA)
- ARGOS Neo instrument developed by Thales Alenia Space and Syrlinks
- Multiple challenges for implicated teams
  - nanosatellite platform
  - payload
  - project management





NESS (start 2019, launch 2021)

- **Nanosatellite 3U de Surveillance du Spectre or Spectrum Survey 3U Nanosatellite**
- **One step further in the direction of CNES Nanosatellite projects management**
- **Small core team (4 people)**
- **Platform development benefits from ANGELS legacy**
  - Optimized Product Assurance: the closest to the project needs in terms of costs, schedule and available human resources.
- **Payload developed with an AGILE method**
  - Benefited from Serpentine and Spectrolite development
  - Typical reviews (PDR, CDR, TRR) meetings replaced by key point meetings
  - Possibly dealing with different levels of maturity
  - Sprint meetings with experts to address specific problems

The perspectives

- **Current nanosatellite developments have made possible ambitious demonstration missions**
- **Efforts to accelerate the maturation of next-generation technologies by relying on target demonstration missions**
  - Single and multi-satellite missions

The perspectives

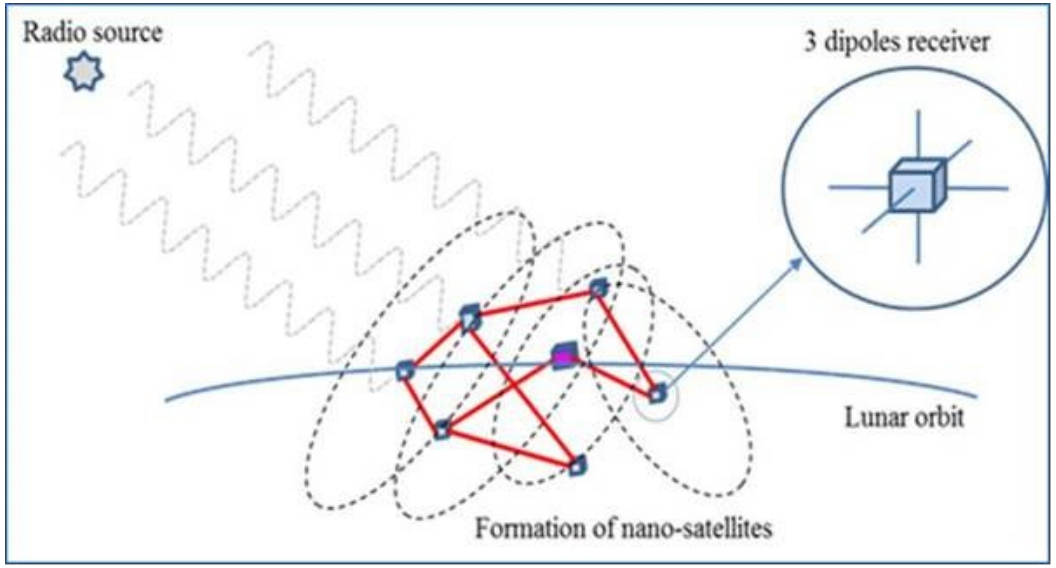
- **Single-satellite mission**
  - Mobile telephony ground network monitoring (from 2G to 5G)
  - Powerful on-board processing needed => new SDR components
  - Multifrequency antenna with enough gain => new efficient unfoldable solution

- **Challenging mission demonstration foreseen to validate technology maturity**
  - Several other mission applications

The perspectives

- **Multiple-satellite mission: interferometry**
- **Nanosatellite maturity allows developing ambitious scientific mission**
- **Nanosatellites swarm to produce a very large distributed instrument**

  - Low frequency observatory to cope with large signal absorption in the atmosphere encountered by ground-based radio interferometers in the low frequency bands



The perspectives

- The distribution principle on several satellites raises new issues such as mission programming, autonomy or inter-satellite links
- Each node is a sensor and all sensors must be used together to obtain a measurement
- Engineering and instrument development must be jointly studied
- Representative of the challenges to be covered by Nanosatellites in the medium/long term

Conclusion

- CNES strategy about miniaturized platforms and payloads.
- Constant efforts since 20 years
- Always smaller payloads or platforms while enhancing the performances.
- Fit the nanosatellite market that emerged 10 years ago
- Ambitious multi-nanosatellites missions with integrated SDR payloads