Editorial - Éditorial

This report, drawn up by CNES with input from the French scientific community after the 39th COSPAR meeting, summarises two years (2010-2011) of scientific space research in France. It includes both an overview of current research programmes in universe science, Earth and environmental science, materials science and life science in space, and also a small selection of noteworthy scientific results obtained over this period.

Among the missions assigned to it by the French government, CNES, the French space agency, organises national research in the space sciences. It has no research laboratories of its own but works jointly with the French scientific community, especially through public research laboratories and organisations, which it provides with technical and financial support. A major feature of 2011 were celebrations marking the Agency's fiftieth anniversary in December; the various events included a scientific symposium celebrating 50 years of scientific space research in France and the successful partnership between CNES and the French scientific community.

There are two sides to the French space programme: (i) participation in programmes run by the European Space Agency, with CNES managing the French contribution to ESA, and (ii) programmes carried out outside this framework, almost all of which are undertaken through bilateral or multilateral partnerships. Participation in ESA and non-ESA programmes is planned with complementarity in mind.

All of the aforementioned scientific disciplines have an increasing appetite for satellite data, whether they be investigating the Universe or the Earth and its environment. Discoveries made by space missions over the last ten years or so have overturned many conventional notions of the universe and led to a golden age for astrophysics, especially in cosmology, the structure of the Universe and the formation and evolution of its constituent parts, such as galaxies, stars and planets. Moreover, forty years of exploring the Solar System with interplanetary probes has radically transformed our vision of this system by revealing great diversity in the objects it contains, in the stages of their evolution, in their levels of activity and degrees of complexity of unimagined variety. Prospective planning by the European scientific community for the period 2015-2025 in the framework of ESA's Cosmic Vision programme has identified four major themes for research:

- What are the conditions under which planets form and life can emerge?
- What mechanisms operate within the Solar System?
- What are the fundamental physical laws of the Universe?
- How was the Universe first formed, and what is it made of?

The Cosmic Vision programme is at the heart of the French space programme in the field of Universe sciences. With backing from CNES, French laboratories supply more than a quarter of the scientific instruments carried on the programme's missions, whereas the French GDP, by which France's contribution to Cosmic Vision is calculated, is only 15.5% of the contributions. CNES is directly involved in preparing the ground segment for the GAIA astrometry mission, in which it plays a major role.

In the framework of this multilateral programme, dates have also been set for the start of the development phase of the Taranis microsatellite (for studying light phenomena above storms) in June 2010 and of the Microscope microsatellite (for testing the Equivalence Principle as between gravitational and inertial mass) in December 2011. The French planetary science community has long been preparing a mission for robotic exploration of Mars within a decade and the possibility of a return trip carrying samples. In this context we should mention the successful launch of the American Mars Science Laboratory probe in November 2011. It carried with it the Curiosity rover, fitted with two major scientific instruments with considerable French input, ChemCam and SAM, for analysing the soil and atmosphere of Mars, respectively. With the decision in 2011 to continue exploiting the International Space Station (ISS) until 2020, an agreement was signed between CNES and NASA to extend the joint use in the American laboratory of the DECLIC instrument (a facility for investigating growth and the behaviour of critical fluids), whilst Cardiomed, the cardiovascular monitoring instrument, was installed in the Russian module at the start of 2010.

Development is continuing on PHARAO, the cold-atom atomic clock, a French component of the ACES assembly, to be installed in the European COLUMBUS module in 2015. The CNES space centre in Toulouse also carried out flight control, docking and deorbiting operations for the ATV-2, Johannes Kepler, after it was launched by Ariane 5 from the Kourou Space Centre in French Guiana.

Robotic and human exploration of the Solar System, which will be an important theme for the coming decades, must be planned as an international enterprise, through equitable cooperation between partners, without any one country taking an exclusive interest or more than a fair share, with each participant being allowed to contribute according to its capabilities, its strengths and its preferences. The European Space Agency currently bears the greatest burden in terms of Europe's contribution to exploration, but if exploration is to be opened up to international cooperation, then a shared political vision is necessary. Following on from preparatory meetings in Prague (2009) and Brussels (2010), the first meeting of an international forum on space exploration, organised jointly by the European Union and ESA, was held in Lucca (Italy) in November 2011.

CNES helped to prepare all these events, as well as participating in the work of the International Space Exploration Coordination Group (ISECG), a working group representing 14 space agencies and created to draw up global strategy concerning exploration.

In the sciences of Earth and the environment, a large proportion of scientific activities are bound up with major social issues that require the global, consistent and long-term vision made possible by satellite observation. Space can make an essential contribution to key challenges such as environmental surveillance and protection, adaptation to climate change and the management of natural resources. Such observations are of benefit to much more than just fundamental science, because it is vital for our survival on Earth that we improve our knowledge of how the planet works. We are now acquiring a vision of it as a holistic system, where all the components interact in a complex manner, with the effects of human activity playing an increasingly important role in these mechanisms.

In this context, the scientific community has defined two principal themes for research:

- *To understand, experiment and model the processes governing the physical, chemical and biological functions taking place in the surface envelopes of planet Earth: biosphere, lithosphere, ocean and atmosphere, a natural interconnected system where matter, energy and living creatures interact.*
- *To understand, observe, model and mitigate the way these systems respond at every level (global, regional and local) to past and present human pressure on these envelopes and on the workings of the great bio-geo-chemical cycles, by identifying their characteristic durations, and the manner in which ecosystems and societies adapt to these changes.*

In the field of sciences of the Earth and the environment, international cooperation has a primordial position. Noteworthy recent events include:

- *with Germany: a cooperation agreement between CNES and the DLR on development of the Merlin microsatellite (for measuring atmospheric CH_4) whose Phase A will be completed in mid-2012;*
- *with the USA: an agreement on Phase A studies for the SWOT mission (continental and oceanographic hydrography) and finalisation of task-sharing between CNES and the JPL;*
- *with China: DORIS equipment carried on China's HY-2A oceanography satellite launched in August 2011 and, at the end of 2010, start of the development phase of the CFOSAT oceanography project that will carry the French SWIM instrument, slated for launch in about 2014;*
- *with India: the launch by the ISRO on 12 October 2011 of the Megha-Tropiques satellite with three French instruments on board (Marfeq, Saphir and Scarab), while development of the SARAL mission, which will carry the French AltiKa instrument together with DORIS and Argos 3, is continuing for a launch planned for 2012.*

We may also mention CNES participation in ESA's Earth Explorer scientific missions and the exploitation by scientists of data from operational missions such as Eumetsat's weather satellites or the future GMES Sentinel satellites. A notable difference compared to sciences of the Universe is that the instruments are not usually supplied by laboratories.

The space segment needs to be completed with processing and archiving systems to allow users easy access to the data obtained, for use in both research and service applications, and to allow past data to be reprocessed. A unit devoted to "Land masses" (continental surfaces) will be set up alongside the existing ICARE (clouds and aerosols) and ETHER (atmospheric chemistry) units, associating CNES and the user community.

CNES also organises campaigns involving the launch of balloons for science missions, mainly for environmental and climate studies. Three campaigns took place in 2010, at Mahé in the Seychelles (February), at Kiruna in Sweden (April) and the Concordiasi campaign in Antarctica (September - October) and another three in 2011: a double campaign in Kiruna (February and again in April) and a validation campaign for tethered balloons (May - June) in Nançay, near Orléans. At the same time, development continues on the new NOSYCA monitoring and backup system to be qualified in 2013. Discussions are under way with Canada for a cooperative partnership to allow the launch of CNES balloons at medium latitudes in Canada for 2013-2014.

Various pre-project studies are under way, including Microcarb for measuring atmospheric CO_2, the atmospheric probe IASI NG, for the next generation of Eumetsat's European polar weather satellites, to be launched in the decade to come, and support for science laboratories to prepare for future missions of ESA's Cosmic Vision programme.

These pre-project activities make full use of a programme combining technology research and demonstrator projects. For example, it will be necessary to perfect formation flying to create future space telescopes with long focal length in the range of hard X-rays and Gamma rays, or space-based interferometers in the visible and infrared ranges to detect exoplanets and probe their atmospheres.
The Swedish PRISMA demonstrator, launched in June 2010 at the same time as the French Picard microsatellite (on solar physics) carried the French Fjord experiment for controlling a formation of 2 satellites by radio link, which functioned perfectly.

To conclude, I would like to add a few words about the seminars on the outlook for science that CNES organises about once every five years. They provide a forum for the French scientific community to debate its priorities. The recommendations resulting from these seminars serve as a roadmap for the authorities to draw up a programme for science. The previous one was held in Biarritz in March 2009. During CNES's 50th anniversary celebrations, we announced that the next one would be held at La Rochelle in the spring of 2014. We have two years during which to prepare this important event.

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