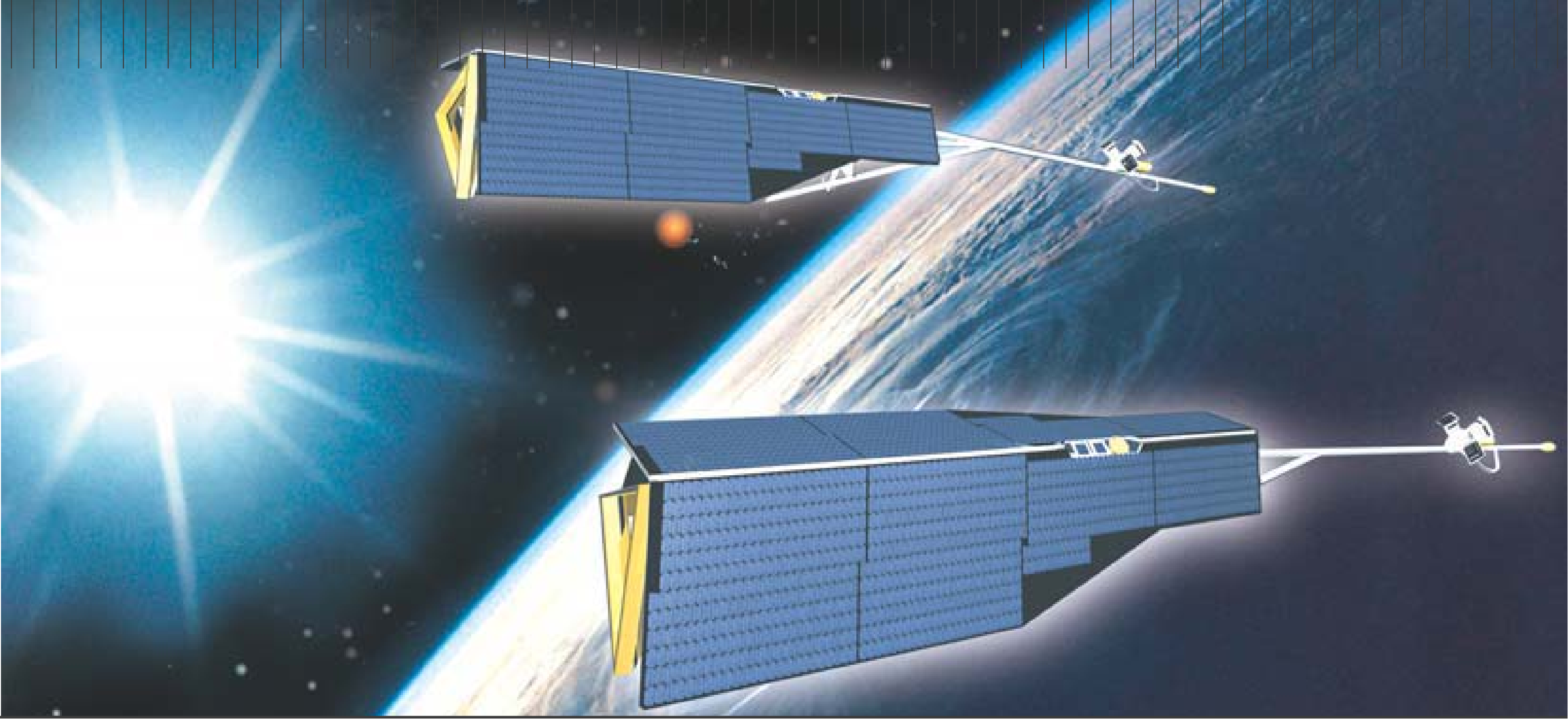

EADS Astrium

Artist's impression of two of the three satellites in the ESA's Swarm mission constellation. In 2010 these will map the Earth's magnetic field using very-high-resolution scalar magnetometers developed by CEA/LETI jointly with the CNES and IPGP.

IV. MAGNETISM, THE EARTH AND SPACE

Weak though it may be, the Earth's magnetic field is vital for our planet's inhabitants, because it protects them from cosmic radiation. Yet this field is far from immutable. Over time it has already undergone a number of upheavals. The origins of the Earth's magnetic field are now better understood than ever before.
In particular, researchers have succeeded in generating a magnetic field in a turbulent conducting fluid, like the Earth's liquid iron core. This field behaves like the Earth's, through the experimental reconstitution of the dynamo effect. Interpreting these experiments requires a sound knowledge of turbulence and chaos theories.
In other work – not described here – the CEA has calculated the magnetic field created by the turbulence in conducting seawater moving within the Earth's magnetic field (the Lorentz effect) created by the propulsion of a submarine. Despite the low conductivity of seawater and of the ambient magnetic field, this effect can be measured using specially-geared high-resolution instrument systems.
The Earth's magnetic field is also being measured more and more accurately by magnetometers that the CEA has been gradually refining over the last decades. Mapping the field using state-of-the-art scalar magnetometers, as described in this section, forges a link between the Earth and space.
To measure a weak field, a device such as the helium-4 magnetometer developed at the CEA is used.
Its operation is based on the fact that certain energy levels of helium-4 are separated by an energy gap proportional to the ambient magnetic field. If these levels can be optically 'pumped' with a laser, alternately emptying and refilling them with their electrons, a signal is obtained with a frequency proportional to the magnetic field. The accurate measurement of this frequency gives the absolute value of the field.
Magnetometry is also making spectacular progress in terms of both efficiency and economy, with developments in microtechnology such as the micro-fluxgate. Work is also in progress on other miniaturisation technology based on the principle of optical pumping.
Paradoxically, access to space by means of increasingly sophisticated satellite launchers requires much ground-based experimentation. Magnetic levitation can mimic weightlessness and so replace some experiments that would be much more costly to conduct in space.
It is still necessary to travel beyond the Earth's atmosphere to study the cosmos through its full range of radiation. To cool the detectors on board new satellites and avoid interfering radiation, magnetism again comes to the rescue, via the technique of adiabatic demagnetisation refrigeration, which makes it possible to reach extremely low temperatures.
Lastly, one further link between magnetism and space is described: the clever coupling of magnetic sensors and miniature accelerometers to sense body motion in three dimensions. This technique will find many applications of interest to the general public.