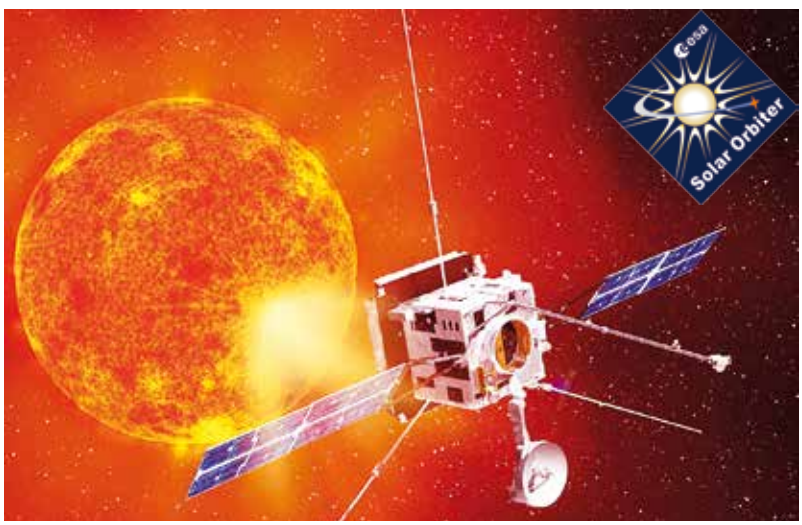
On Board Payload Data Processing

Transferring Earth observation data processing from the Earth to the Space Segment

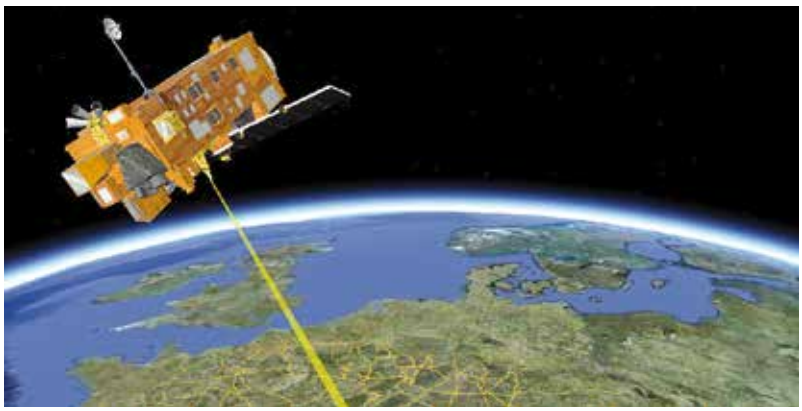
Today we are faced with an ever increasing stream of data provided by space missions focussing on Earth Observation, Astronomy and Planetary Exploration. Matching that stream with the needs of its users, scientists and their institutions, is therefore becoming a more and more complex task.
To face both the data management (available mass memory) and the data transmission (available bandwidth), many recent R&D activities study how to move the data processing from the Ground Segment to the Space Segment through the development of so-called On-board Payload Data Processing.
The main idea is that, often, the "useful" part in acquired (raw) data is only a piece of the whole, so it makes sense to process final information already on-board and transmit only them to the ground. Data reduction work flow is thus moved from the ground to the space segment. In addition, having such information already on-board can increase the efficiency with which the actual space mission is operating. For example, pieces of information processed with on-board payload data processing can be used to steer the automatic control of a satellite constellation, modifying the data acquisition schedule. The instrument pointing can be moved to the spot of interest, or an acquisition request can be transmitted to the next cooperating satellite. For example, this will increase the efficiency of monitoring specific events that are limited in time, such as oil spills or illegal traffic, as compared to the traditional ground segment workflow.
Planetek has solid experience in the design and development of on-board processing systems starting from the development of the SpacePDP (Space Payload Data Processing) project, co-funded by the Italian Space Agency (ASI). SpacePDP is an Open and modular Payload Data Processing system, composed of Hardware and Software modules and completed by a dedicated SDK, by which it is possible to perform both the mission's standard tasks (e.g. sensors control, mass storage devices management, uplink and downlink), as well as specific scientific tasks. Its advanced processing system can be fully adopted both as an on-board module for Satellites and for Planetary Exploration rovers.

The Solar Orbiter Mission

The Sun and its extended atmosphere, the heliosphere, is a very complex system. The inner planets of the Solar System, including the Earth, lie within the heliosphere and its influence can sometimes be clearly detected by researchers and scientists during phases of high solar activity.
The Solar Orbiter mission, part of the European Space Agency's Cosmic Vision program, is a new mission (launch planned in 2017) intended to explore the Sun and its heliosphere to improve our understanding of Space weather and its effects on



the Earth. It will observe the Sun and collect measures in an orbit ranging from 0.28 (closer than Mercury) to 1.4 AU (the Earth is at 1 AU). In addition, this mission will be provided with a natural laboratory to study processes in fundamental physics, astrophysics and plasma physics that cannot be studied elsewhere in such detail.
The scientific payload of Solar Orbiter is composed of ten experiments. Among the instruments, the Solar Wind Analyser suite (SWA) will provide comprehensive in-situ measurements with very high temporal resolution of solar wind's particle composition (ions, protons and electrons) and velocity distributions. The final goal is to establish the fundamental physical links between the highly dynamic magnetised atmosphere of the Sun and the solar wind in all its quiet and disturbed states.
SWA is, in turn, composed of four sensors devoted to the analysis of particles at different energy levels. Two of the instruments measure electrons (Electron Analyser Sensor, or EAS), one measures protons and alpha particles (Proton Analyser Sensor, or PAS) and one measures heavy ions, which are a minor constituent of solar wind



(Heavy Ion Sensor, or HIS). The instruments will independently measure 3D velocity distribution functions, evaluate density, speed, temperature and the thermal flux of the plasma composing solar wind.
Italy will participate in the SWA experiment providing the Data Processing Unit (DPU) through a project involving Roberto Bruno from the Institute for Space Astrophysics and Planetology (IAPS) as the chief scientist and SWA Co-Principal Investigator. The DPU project will:

- Provide single interfaces to the spacecraft for power, telemetry, tele-commands and power management;
- Provide commands management, data handling and data compression for the four instruments;
- Provide the Electrical Ground Support Equipment (EGSE) for the instrument suite;
- Contribute to the on-board data compression SW definition.
- Contribute to the implementation of the Mechanical Ground Support Equipment (MGSE);
- Contribute to sensor definition;

In charge of the project is a group of companies composed of TSD, Planetek Italia, Sitael and SSI. Planetek activities focus on the EGSE SW layer and on the on-board software for scientific data processing.

Project resources:
www.planetek.it/eng/solar_orbiter_dpu