



The ESA's Planetary Science Archive

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1 Introduction

The European Space Agency's Planetary Science Archive (PSA) is responsible for the long-term preservation of all the scientific and engineering data returned by ESA's planetary missions, as well as for the provision of services to increase the accessibility and usability of the archived PSA data.

The PSA currently holds data from Mars Express, Venus Express, SMART-1, Huygens, Rosetta and Giotto, as well as several groundbased cometary observations. It will be used for archiving on ExoMars, BepiColombo and the European contributions to Chandrayaan-1.

2 Standards

All PSA data are compliant with NASA's Planetary Data System (PDS) Standards for formatting and labeling files, including requirements for documentation and the structuring of data sets.

It was decided at an early stage that PSA data would comply with PDS Standards to maximise the cross-compatibility of ESA and NASA data.

The Standards are based around a *Data Dictionary* containing a set of keywords that can be used to provide all of the information required to access and analyse the data. PSA maintain their own PSA Data Dictionary, built up from the PDS version and appending many of their own local data dictionaries to specify information pertinent only to individual ESA missions. In addition, the PSA dictionary is used to define which keywords are required for each mission, instrument or sensor for which we have data archived.

PSA staff work in close collaboration with the PDS as the Standards continue to develop, in order to ensure compatibility and to maintain the scientific integrity of the data. The lessons learned from our work with the PDS are channelled into the definition of broader, more global standards and recommendations on archiving processes. This is done as part of the

PSA's contribution to the IPDA (International Planetary Data Alliance).

3 Long-term usability

The long-term preservation of data and knowledge from all of ESA's planetary missions is a core focus. All data provided within the Planetary Science Archive are therefore passed through a set of rigorous procedures designed to ensure the usability of the data not only at the time of ingestion, but also in the long-term, after the mission has closed and direct support from personnel involved with the mission can no longer be guaranteed. Each phase of the archiving process is controlled by a corresponding *peer review*, during which external experts are asked to validate the data and documentation for their suitability for long-term archiving.

Compliance with the conventions and requirements on each mission/instrument, and with the PDS Standards is verified using a *validation* tool developed by the PSA and distributed to all data providers, allowing them to syntactically validate their data at all phases in development of their pipelines, and before each delivery to the PSA.

A new *highly automated system* is being developed to streamline the current archiving process from end-to-end, providing support for data producers in the design, preparation and delivery phases, tracking data internally after delivery and through the standard validation, ingestion and release procedures, and delivering additional support tools for end users wishing to visualize, analyse and manipulate data from the PSA.

4 Data query and retrieval

The PSA offers three types of interfaces to query and retrieve data from the PSA archive:

- A *java-based user interface* provides search, preview, download, notification and delivery basket functionality. You can search at the data

set or data product level using a wide variety of query parameters (illumination condition, planetary features, instrument modes, etc). Visual querying of geographically referenced data, currently available only for Mars Express HRSC and OMEGA instruments, is also possible.

- In addition to this interface, the PSA provides access to all publicly available data via an anonymous *FTP server*. Unlike the other interfaces, it has no search capability but you can quickly browse the content of the archive using the FTP client application of your choice.
- Lastly, expert users can develop software applications that need to query and retrieve data from the PSA archive by bypassing the java-based user interface. This is made possible by the ESA's Planetary Archive InterOperability system (PAIO). The PAIO is a serverside implementation of *Planetary Data Access Protocol* (PDAP) being developed by the IPDA in order to enable interoperability of planetary data archive systems.

5 Scientific Support

The PSA supports the scientific community and the production of scientific data in many ways.

Help desk: Any enquiries related to the access or the usage the data can be emailed directly to the PSA help desk.

Data Workshops: Once the scientific instrument data are available in the PSA, workshops are organized to demonstrate the best practices for their use. These are aimed at the scientific community at large, and take the form of lectures and hands-on exercises, with expert members of the instrument teams providing direct support on the best ways in which to calibrate and use their data for science. The PSA also support SPICE workshops. These workshops are organised on request and typically take place once per year, with the support of the NAIF team from JPL. During these workshops expert advice is provided on the use of SPICE and ancillary data with archived instrument data.

Data analysis: ESA and the PSA support both internal and external efforts to enhance the scientific content of the archive.

Recently, data from the SMART-1 mission to the Moon were released in the PSA. As this was primarily a technology testing mission, instrument teams were left with no resources to provide archive data themselves. Instead, the data were produced after intense

efforts internally at the PSA to develop pipelines and data sets in close collaboration with remaining team members. For Mars Express, ESA have funded contracts to produce calibrated data from the MARSIS subsurface radar experiment. The resulting Total Electron Count (TEC) data sets are now available online, and the pipeline is stable for further data deliveries. Also on MARSIS, calibrated profiles have been delivered by the Ionospheric Sounder and the PSA are working with the science team to produce valid archive products and data sets from these in order to deliver them to the community. Work is ongoing to analyse the MaRS (Mars Radio Science) data internally and develop higherlevel profiles for the community. PSA staff are actively involved in the production of global mineral maps of Mars using the OMEGA data, and georeferencing of the data in close collaboration with the instrument team.

The Mars Express team is also investigating the best way in which to provide 'science-themed' data sets with a combination of instrument data. In particular, efforts are underway with the Project Scientist and the community to look at the requirements for data sets focusing on the Martian upper atmosphere. Archive consultancy is also provided to the teams producing their own calibrated data, and higher level products are being delivered by HRSC, ASPERA, MARSIS, and are in preparation for PFS on Mars Express. On Venus Express, calibrated data are provided for VMC, MAG, VIRTIS and SPICAV-SOIR, and for SMART-1 there are calibrated data from the AMIE camera. Many Rosetta instruments have also provided calibrated data for the Mars, Earth and asteroid flybys.

Additional Information

Further information about ESA's Planetary Science Archive and the data workshops can be found here: <http://www.rssd.esa.int/psa>