ESA's Planetary Science Archive and Associated Scientific Activity. N. Manaud[1], D. Heather[1], M. Barthelemy[1], S. Martinez[1], J.L. Vazquez[1], M. Szumlas[1], [1]European Space Agency, ESAC, Villafranca del Castillo, 28080 Madrid, Spain. (nmanaud@sciops.esa.int)

Introduction: The European Space Agency's Planetary Science Archive (PSA) makes all scientific and engineering data returned by ESA's planetary missions accessible to the world-wide scientific community.

The prime objectives of the PSA are: (1) to support the experimenter teams in the preparation for the spacecraft and ground-based long-term archives, (2) to enable and ensure the long-term preservation of these archives, (3) to distribute scientific useful data to the world wide scientific community, and (4) to provide supplementary data services aiming to maximize the usage of planetary mission data and ease the scientific data analysis.

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

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).

Long-term Preservation / data quality: The PSA provides expert consultancy to all of the data producers throughout the archiving process. As soon as an instrument is selected, PSA begins working with the instrument team to define a set of data products and data set structures that will be suitable for ingestion into the long-term archive.

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.

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. In future, a further more qualitative validation step is envisaged at the PSA to ensure correctness, completeness and cross correlation of all information, label and data content, within a data set.

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.

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 intruments, 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 server-

side implementation of Planetary Data Access Protocol (PDAP) being developed by the IPDA in order to enable interoperability of planetary data archive systems.

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 e-mailed 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 hands-on workshops, with expert members of the instrument teams providing direct support on the best ways in which to calibrate and use their data for science. Typically, these workshops are organized for two instruments at once and some effort is put in to show how data can be combined to maximize the science output.

These workshops have been very successful, and have engendered a very positive response from the students attending, who are provided with the opportunity to meet members of instrument teams and build working relationships, as well as getting direct experience with data handling, processing and analysis.

In cooperation with the mission instrument teams, the PSA has already supported data workshops in Europe and in the USA for the following instruments on Mars Express: HRSC, OMEGA, MARSIS and Mars Radio Science. Presentations and software used during the workshops are made accessible to all via the PSA website.

Future workshops are planned on data from both Mars Express and Venus Express and, depending on interest, these could be combined to address scientific themes (e.g. planetary upper atmospheres) rather than specific Mars or Venus 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 higher-level profiles for the community.

PSA staff are actively involved in the production of global mineral maps of Mars using the OMEGA data, and geo-referencing 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