FITS AND PDS4: PLANETARY SURFACE DATA INTEROPERABILITY MADE EASIER. C. Marmo[1], T.M. Hare[2], S. Erard[3], B. Cecconi[3], M. Minin[4], A. P. Rossi[4], F. Costard[1] and F. Schmidt[1], [1]GEOPS, Univ. Paris-Sud, CNRS, Univ. Paris-Saclay, Rue du Belvédère, Bât. 509, 91405 Orsay, France, chiara.marmo@u-psud.fr, [2]U. S. Geological Survey, Astrogeology Science Center, Flagstaff, AZ, [3]LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité, Meudon, France, [4]Jacobs University, Bremen, Germany.

Introduction: Planetary science is a vast field of investigation that brings together several research communities (geologists, astronomers, physicists, geochemists, etc.), and produces an impressively growing amount of heterogeneous data. Interoperability and openness of data formats and processing techniques are becoming a necessity, to avoid the risk of being unable to efficiently extract scientific information from the data, and to guarantee the reproducibility of the scientific results.

This abstract will describe how Flexible Image Transport System (FITS) [1, 2] can be used in planetary surface investigations, and how its metadata can easily be inserted in the PDS 4 [3, 4] metadata distribution model.

FITS for Planetary Surfaces: FITS is an open digital standard, defined by the astronomical scientific community for data acquisition and archiving in astronomical observatories back in the late 70's, and is used for spatial telescope data too. FITS is one of the standard formats in the Virtual Observatory (VO) and it is compatible with PDS (version 3 and 4) archiving specifications. It is supported by a large number of open libraries and software tools, including the growing Astropy [5, 6] initiative, that provides an efficient and well documented framework for astronomical data reduction pipeline in Python.

The option to use FITS within the planetary domain is an opportunity to allow sharing of data across different domains and homogenize methods from acquisition, to visualization, while optimizing data processing.

FITS is already able to propose standard formatting for some data products quite common by now in planetary surface investigations. In particular, Multi-Extension FITS (MEF) schema proposes an easy way to store inhomogeneous digital information (reflectance, calibration data, vector table data, etc.) in the same file each with relative metadata, as well as multi-detector imagery (e.g. from HiRISE [7]) or hyperspectral cubes (e.g. from CRISM [8] or OMEGA [9]). FITS has been already chosen to distribute, e.g., Hayabusa [10] and some of the Dawn [11] data.

To be efficiently used in planetary surface investigations, FITS metadata must be extended in order to take into account the size of the reference body. In the framework of the VESPA [12, 13] component of the Europlanet 2020 project an extension to FITS metadata (GeoFITS) has been proposed [14].

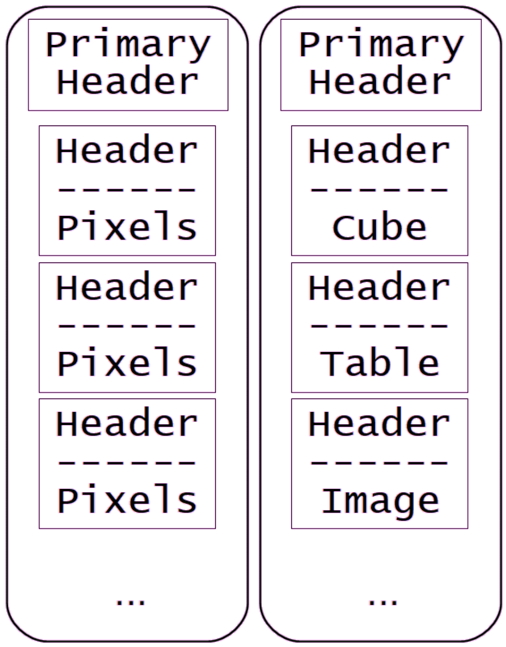

Fig. 1: Scheme of Multiple Digital Objects as MEF

Developments are in progress [15] in order to provide interoperability between the FITS format and geospatial applications commonly used by planetary surface research community by using the open source Geospatial Data Abstraction Library (GDAL) [16].

PDS4 evolution: PDS standard version 4 completely assumes its role of data modeling for archiving and distribution, detaching archiving metadata from data. This means that in PDS 4 archiving structure, labels and data products are always detached. PDS4 labels are written in eXtensible Markup Language (XML). XML was chosen because it is a widely used international standard for which a large amount of software already exists. In particular XML is used as exchange format in a wide number of on-line applications: PDS4 will simplify retrieving archive metadata by remote clients.

Like PDS3, PDS4 has a set of tags to support geospatial applications. Developments to provide interoperability to geospatial applications have already started [17, 18].

FITS to PDS4 dictionary: As previously outlined, PDS4 is meant to be an archiving standard, while FITS is proposed here to simplify and automatize processing logistics. PDS4 Classes and Attributes do not correspond literally to FITS keywords. The relation between them is highlighted in Table 1 as a way of example, to show how standard FITS keyword can be used to export a data product model in PDS4.

Table 1: Standard FITS keywords in the PDS4 archiving scheme

FITS	PDS4	Notes
BITPIX	Data_type	8 → UnsignedByte or UnsignedBitString 16 → SignedMSB2 32 → SignedMSB4 -32 → IEEE754MSBSingle -64 → IEEE754MSBDouble
BSCALE	Scaling_Factor	*Real*
BZERO	Value_Offset	*Real*
BUNIT	unit	*Short_String*
DATAMAX	valid_maximum	
DATAMIN	valid_minimum	
NAXIS	axes	axis_index_order = Last Index Fastest
DATE	creation_date_time	
DATE-OBS	start_date_time	
INSTRUME	Instrument	
TELESCOP	Instrument_Host	
OBJECT	Target	
ORIGIN	Institution_Name	
AUTHOR	author_list	
REFERENC	citation_information	

New FITS keywords proposed in the GeoFITS extension will be used to fill the PDS4 Cartography discipline namespace. See Table 2 and 3 for simple translations to the Coordinate_Representation and the Geodetic_Model classes.

Table 2: Filling Coordinate_Representation class with FITS metadata

PDS4	FITS
pixel_resolution_x	CD1_1 (in meters)
pixel_resolution_y	CD2_2 (in meters)
pixel_scale_x	1/CD1_1 (in degrees)
pixel_scale_y	1/CD2_2 (in degrees)

Table 3: Filling the Geodetic_Model class with FITS metadata

PDS4	FITS
latitude_type	WCSNAME
spheroid_name	WGCCRECS
semi_major_radius	A_RADIUS
semi_minor_radius	B_RADIUS
polar_radius	C_RADIUS
Longitude direction	CD1_1

References: [1] https://fits.gsfc.nasa.gov/. [2] Wells D. C. et al. (1981) Astronomy and Astrophysics Supplement, Vol. 44, P. 363. [3] https://pds.nasa.gov/pds4/about/. [4] https://pds.jpl.nasa.gov/pds4/doc/sr/current/StdRef_1.9.0.pdf. [5] http://www.astropy.org/. [6] Robitaille T. M. (2013) Astronomy & Astrophysics, Volume 558, id.A33. [7] McEwen A. S. et al. (2007) Journal of Geophysical Research, Volume 112, Issue E5. [8] Murchie S. et al. (2007) Journal of Geophysical Research, Volume 112, Issue E5. [9] Bibring, J.-P. et al. (2005), Science, doi:10.1126/science.1109509. [10] https://darts.isas.jaxa.jp/planet/project/hayabusa/data.html. [11] https://sbn.psi.edu/pds/archive/dawn.html. [12] http://europlanet-vespa.eu/. [13] Erard S. et al. (2017) Planet. Space Sci., doi:10.1016/j.pss.2017.05.013. [14] https://epn-vespa.github.io/geofits/. [15] Marmo et al. (2016) *LPS XLVII*, Abstract #1870. [16] http://www.gdal.org/gdal_vrttut.html. [17] Hare T. M. et al. (2017) PSS, doi:10.1016/j.pss.2017.04.004. [18] http://www.gdal.org/frmt_pds4.html

Acknowledgments: This work benefits from support of VESPA/Europlanet. The Europlanet 2020 Research Infrastructure is funded by the European Union under the Horizon 2020 research and innovation programme, grant agreement N° 654208.