D7.1-public

- Executive Summary
- List of acronyms
- Introduction
  - Scope of the document
  - Beneficiaries using data
  - Beneficiaries producing data
  - Adherence to FAIR principles
  - Data types, formats and standards
  - Data
    - Raw data
    - Base mapping data
    - Integrated mapping products
  - Metadata
    - Raw data
    - Base mapping data
    - Integrated mapping products
  - Documentation
  - Software
- Data exploitation, accessibility and intellectual property
  - Data and metadata
  - Documentation
  - Software
  - Data/Software citation
- Data storage and management during project
- Data curation, archiving, preservation and security
  - Data curation
  - Data preservation
  - Data security
  - Data sharing
    - EPN-TAP VESPA-based sharing on premise
      - Exemplar metadata for mapping products to be released via VESPA:
    - ESA PSA data deliveries
      - Exemplary metadata for mapping products to be released via PSA:
- Annex-A: Planmap datasets
  - Base data
      - CTX (Malin et al., 2007)
      - HRSC
      - Hirise (McEwen et al., 2007)
      - OMEGA
      - SHARAD
      - CRISM
      - MARSIS
    - Moon
      - LROC NAC (Chin et al., 2007; Robinson et al., 2010)
      - M3 (Pieters et al., 2009)
      - SELENE (Kaguya) Terrain Camera
    - Mercury
  - Mapping products - Standard
    - Feature representation in GIS environment
  - Mapping products - non-Standard
  - 3D geomodels
    - Complementary data and metadata
  - Virtual reality products
- Annex-B: File formats used and envisaged
  - Base formats depending on data type
  - Other formats
- Annex-C: Data curation and preservation plans per partner
  - UNIPD
  - OU
  - WWU
  - INAF
  - CNRS
  - JacobsUni
- References

Executive Summary

List of acronyms

Acronym	Description

ASCIII	American Standard Code For Information Interchange
ASI	Agenzia Spaziale Italiana
CC-BY	Creative Commons Attribution (license)
CRISM	Compact Reconnaissance Imaging Spectrometer for Mars
CRS	Coordinate Reference System
CTX	Context Camera
DOI	Digital Object Identifier
EPN-TAP	EuroPlaNet Table Access Protocol (TAP)
ESA	European Space Agency
FELICS	Fast Efficient & Lossless Image Compression System
FTP	File Transfer Protocol
HRSC	High Resolution Stereo Camera
ISIS	Integrated Software for Imagers and Spectrometers
GDAL	Geospatial Data Abstraction Library
GNU	GNU's Not Unix (recursive acronym)
GPL	GNU General Public License
H2020	Horizon 2020 (Framework Programme)
HiRISE	High Resolution Imaging Science Experiment
OMEGA	Observatoire pur la Minéralogie, l'Eau, les Glaces et l'Activité
LROC	Lunar Reconnaissance Orbiter Camera
M3	Moon Mineralogy Mapper
MESSENGER	MErcury, Surface, Space ENvironment, GEochemistry and Ranging
MDIS	Mercury Dual Imaging System
MLA	Mercury Laser Altimeter
MOC	Mars Orbiter Camera
NAC	Narrow Angle Camera
OGC	Open Geospatial Consortium
PDS	Planetary Data System (archive, organisation, standard)
PSA	Planetary Science Archive (ESA planetary archive)
RDR	Reduced Data Record
SME	Small, Medium Enterprise
SNR	Signal to Noise Ratio
SPICE	Spacecraft ... Planet ... Instrument ... C-matrix (orientation) ... Events
SWIR	Short-Wave InfraRed (spectral range)
TAP	Table Access Protocol (VO)
USGS	United States Geological Survey
VESPA	Virtual European Solar and Planetary Access
VICAR	Video Image Communication And Retrieval
VNIR	Visible and Near Infrared (spectral range)
VO	Virtual Observatory
WAC	Wide Angle Camera

comments from matt (colour linked in the document):

1) please define what is meant by "granule" and "granularity" - Earth remore sensing data sometimes uses granules, but this sin't something I have seen in any of the planetary data I have worked with. I suggest not using this term except where it is formally defined as technical data-type. Also "granularity" is a very looosely defined concept - better to be more precise

2). Some acronyms are not in the table - and all should really be defined "spelled-out" on first usage.

3) For raster datasets, should we try to stick to a single format for internal sharing - e.g. GeoTiff? and then archive as PDS/PSA format plus ~~GIS~~ready public format (GeoTiff again probably)?

4) I think some of hte instrument details are too detailed - e.g. CTX. I can't see that this level of detail is needed, and it will just make it harder to get similar levels of detail for the other instruments and makle more work. The important thing should be the detail about how that data are used in a mapping project and how they can/should be processed, analysed and intepreted. I haven't deleted stuff, but I have highlighted the areas i think are too detailed. Some bits need text writing.

Introduction

PLANMAP will both use and produce data. Different data categories can be distinguished in the framework of PLANMAP:

Base mapping data:

- **A)** Individual higher-level data products derived from raw experiment data (which are archived on PDS or PSA), e.g. map-projected individual images or custom calibrated cubes (e.g. CTX, OMEGA, CRISM)
- **B)** Custom processed or mosaicked data from multiple data products (i.e. derived hyperspectral summary product, multi-image mosaic) available in public archives or repositories (e.g. PSA, PDS, USGS)
- **C)** Individual higher-level data products already produced by experiment teams and available from PDS/PSA archives (e.g. HRSC)
- **D**) Custom processed or mosaicked data with from multiple data products (i.e. derived hyperspectral summary product, multi-image mosaic) produced by the consortium

Integrated mapping products:

- Intermediate temporary mapping products (for scientific discussion and sharing internal to the consortium)
  - Raster imagery/data
  - Vector mapping data
- finished geological maps (See D2.1 (Mapping Standards), Rothery et al, 2018)
  - Standard USGS-like geological maps
  - Integrated geo-spectral and geo-stratigraphic maps
  - Geo-structural maps
  - Geo-modelling maps
  - Landing site and traverse maps
  - In-situ integrated maps
  - Digital outcrop models
  - Subsurface models
  - 3D models for Virtual Reality environments (from one or more of the above categories)

The fate of datasets and data products belonging to these categories is different. Individual data products (A B, C) are preserved for the long-term in respective archives. Their eventual reduction and reprocessing is reproducible, with well-known open source tools, and supported for the long term by robust institutions and agencies (e.g. USGS/NASA). Intermediate mapping products are instrumental to producing final, released and/or published PLANMAP digital mapping products (see section on Data Storage and Management during the project) and their long term-storage is not planned, but documentation, in the form of wiki or individual documents is going to be preserved during the course of the project, and significant summaries and excerpts will be included as deliverable text and annexes, and can also be used as ancillary material attached to scientific publications.

Scope of the document

The present document outlines the type of data, their characteristics and their use, archiving and preservation plans throughout the PLANMAP project. Intellectual property rights are also clarified, as well as specific per-partner data use and responsibilities. The document outlines the basic data management directions that are going to be updated throughout the project and issued at discrete steps.

Beneficiaries using data

All beneficiaries will use data, in either individual or - most of the cases - combined form. Data access to archived (NASA/ESA) mission data is free for anyone. Some data will have temporary team-only access (during an embargo of up to several months), such as mapping data used by PLANMAP researchers (see section on Data Storage and Management during the project)

Beneficiaries producing data

All beneficiaries will produce either derived data (higher-level data products) or new data derived by both human-assisted and computer/algorithm-assisted mapping.

In particular, beneficiaries are set to produce these data categories (see Annex A, B):

- UNIPD:
  - mosaics and higher level products derived from planetary archives
  - vector mapping products (geologic/geomorphologic maps)
  - 3D models
  - (subject to increase/expansion)
- OU
  - mosaics and higher level products derived from planetary archives
  - vector mapping products (geologic/geomorphologic maps)
  - (subject to increase/expansion)
- WWU
  - mosaics and higher level products derived from planetary archives
  - vector mapping products (geologic/geomorphologic maps)
  - (subject to increase/expansion)
- INAF
  - mosaics and higher level products derived from planetary archives
  - (subject to increase/expansion)
- CNRS
  - 3D and virtual reality models
  - digital outcrop maps
  - vector mapping products (geologic/geomorphologic maps and models)
  - (subject to increase/expansion)
- JacobsUni
  - mosaics and higher level products derived from planetary archives
  - vector mapping products (geologic/geomorphologic maps)
  - (subject to increase/expansion)

Adherence to FAIR principles

Data produced by PLANMAP will impact future robotic and space exploration, mainly through mature, finished, published mapping products. Underlying data and special mapping products will be of scientific use also before and beyond that.

Findable:

- Longer-term discoverability will be guaranteed via VESPA sharing and inclusion in planetary data archives that are accessible and commonly used by the community.
- Shorter-term discoverability will be supported by the PLANMAP web-map and data access

Accessible:

- Geological mapping products will have multiple level of accessibility, with variable scale and complexity, from individual units to finished products and thematic maps

Interoperable:

- OGC standards for CRS and formats will be adopted
- Data discovery interoperability will be granted via the use of state-of-the-art VESPA EPN-TAP (Virtual European Solar and Planetary Access EuroPlanet Table Access Protocol) for data search and query.

Re-usable:

- Raw data will be used and processed/reduced, with embedded re-usability upstream with respect to PLANMAP
- Custom base-map data (e.g. mosaics) and partial mapping products and processed/derived datasets underlying geological mapping products (standard, non-standard, integrated, etc.) will be usable by others, also in the future, regardless of the final geological mapping products.
- Integrated and/or final mapping products will be re-usable directly or indirectly, with access to combined information content or individual layers (See D2.1 (Mapping Standards)) with relevant topologies (units, contacts, etc.).

Data types, formats and standards

Planmap uses existing datasets and data products and creates new products deriving from combination or derivation of existing, processed data products, as well as from completely new mapping (e.g. units), see D2.1 (Rothery et al., 2018).

Data

Raw data

Planetary archives, PDS3, PDS4 imagery and cubes

Base mapping data

OGC-compliant data already available from external entities (e.g. USGS) or base mapping data produced by PLANMAP partners, some in PDS standards /formats.

Integrated mapping products

Integrated mapping products with individual layers are being produced in OGC-compliant formats, both raster and vector, as well as with suitable 3D formats (See Annex A). All individual layers/components of maps are in geospatial format and with CRS suitable for the specific mapping project: in-situ, local (mostly non-standard, see D2.1 (Mapping Standards)), regional or global (both standard and non-standard).

Metadata

The aim of including metadata is to allow reproducibility by providing information about the processing steps used

Raw data

Metadata from processed raw data are the same as those from archived data. SPICE kernel version and software used (e.g. USGS ISIS) should be recorded.

Isis Cube labels (i.e. recording cumulative processing steps and used ancillary data, metadata, CRS and alike). The information is going to be recorded in processing labels and as temporary output in ASCII format.

Base mapping data

Projection, cubes and images used, type of control network used, and relevant additional information available from original derived data producers (e.g. USGS, ESA, academic institutions or local PLANMAP base mapping data producers or groups) will be recorded.

Integrated mapping products

Metadata for integrated mapping products will be both map-related and sub-map (i.e. geological unit)-related.

Map-related metadata include, as a minimum:

- Used datasets and products
- Mapping individuals
- CRS
- Summary of used tools and documented workflow

Unit-related data/metadata include, as a minimum, recorded and updated during the mapping processes, see also D2.1 (Mapping Standards)

- Individual products and layers used to determine unit extent and contacts
- Eventual interpolation/extrapolation of data underlying mapped unit outline
- Qualitative assessment on uncertainties involved in the unit determination

Authors of the maps, programs, processing and basic info to allow for reproducibility of the underlying workflow will be included, and added to the documentation. Also, geocoding of units (i.e. associating toponyms to locations and to mapped surface units) will be produced in order to allow ease of search of at least individual maps, optimally individual units and their occurrence within maps (see e.g. http://geometrics.jacobs-university.de/, Rossi et al, 2018).

Documentation

Documentation of PLANMAP will be available on the project wiki space (https://wiki.planmap.eu/display/planmap), which will be kept functional after project-end based on best-effort and availability of resources. The internal wiki space is used for both internal project coordination and technical, scientific documentation. The latter, in evolved form, will be also shared via the project public wiki space (https://wiki.planmap.eu/display/public).

The types of documentation in the PLANMAP wiki include:

- Summary of relevant activities per WP
- Procedures and workflows
- Mapping use case description
- Best practices and recommendations
- Tutorials on data handling and mapping
- Other documents

Software

The software used to access and analyze PLANMAP data will be based on Open Standards, in particular OGC standards. Both Open Source and proprietary software (such as QGIS, ArcGis, and alike) will therefore be suitable for accessing PLANMAP data. A particular case is constituted by the software that is employed for 3d geological modeling, for which open source alternatives rarely exists. For the choice of the software package two criteria will be considered: a) the feasibility for the task that will be undertaken b) the academic licensing scheme that is adopted. Under the same feasibility conditions, software packages granting low-cost/affordable licensing schemes for academic porpuses will be favored.

The consortium will use a wide range of publicly available Open Source and commercial tools to work and perform mapping tasks. Additionally algorithmic and programmatic methods that add value to interactive human-computer mapping will also use, as far as possible, Open Source tools, packages and libraries.

Software, tools and scripts or snippets developed throughout the project will be shared both internally and externally via the PLANMAP GitHub organization and relevant repositories (https://github.com/planmap-eu). Some repositories might be private, with access restricted to beneficiaries, during the early phases of the project. Ultimately, all will be made public and will be made available indefinitely after the end of PLANAMP.

Data exploitation, accessibility and intellectual property

Intellectual property rights on individual science outputs will be held by the scientific collaborators and publishing venue/journal (e.g. individual papers).

Data and metadata

Produced base mapping data are provided as CC-BY (attribution).

Published maps (of any kind) are going to be provided, free to use, with CC-BY (attribution).

Acknowledgment of the PLANMAP EC H2020 Space project is requested from those using PLANMAP-derived data. A relevant acknowledgement message will be included in the documentation provided to ESA, as well as within the global metadata of VESPA-shared datasets.

Documentation

Documentation licensing will follow Creative Commons CC-BY-4.0 (https://creativecommons.org/licenses/by/4.0/). Documentation will be also available, complementing or copying information on the public wiki space, on GitHub and possibly other public repositories.

At the end of the project the entire body of documentation will be consolidated and available both on the PLANMAP public (https://wiki.planmap.eu/display/public) wiki and Github (https://github.com/planmap-eu).

Software

Software developed by PLANMAP partners is going to be open source, with the possible exception of specific software involving SMEs (e.g subcontracted within virtual-reality tasks) GPLv3 is recommended, or any other license covered by the Open Source initiative (https://opensource.org/licenses/category).

Specific licensing for WP involving SMEs and potential exploitation beyond the project of pre-existing or specific technological aspects WP5 will be established and documented.

Software, tools and scripts produced by PLANMAP will be available as soon as they are considered usable, on the public GitHub organisation (https://github.com/planmap-eu). Private repositories will be used during the course of the project, but will cease to exist at its end and all will be made public.

Data/Software citation

Archived data used that comes from mission archives will follow the custom of quoting experiment description papers and eventual relevant follow-up papers (e.g. Malin et al., 2007; McEwen et al., 2007; Neukum et al., 2004; Jaumann et al., 2007).

Datasets from NASA/ESA archives (PDS, PSA) follow the citation requirements of those archive. E.g., if NASA public domain, then to follow the custom of quoting experiment-description papers (e..g Malin et al., 2007) in scientific publications. ESA data follow similar citation styles (suggested citations are included in the PSA entry pages).

Datasets produced by the PLANMAP consortium will be possibly quoted via:

- Relevant peer-reviewed publications or published maps indicated in the dataset metadata (similar to PSA/VESPA)
- Dataset-specific DOI, i.e via OpenAIRE/Zenodo/GitHub for relevant datasets
- Eventual additional DOI-generating data services that might become available during the project lifetime

Data storage and management during project

During day-to-day operations and technical/scientific activities of the consortium, data will be stored on each partner's premises as well as, when relevant, on shared network resources (such as cloud, FTP and web mapping data access services). In principle, data will be made publicly available as soon as possible during the project, respecting publication embargoes.

Data curation, archiving, preservation and security

Data curation

Base data and maps (See Annex A) undergo archiving review by the archive maintainers (PDS, PSA). If any issue is encountered (e.g. missing or problematic labels, metadata and/or eventual problems with data themselves) the PLANMAP consortium will share those information with respective archive data publishers (PDS, PSA).

Mapping is an iterative, interactive process that will go through a few levels of interactive, informal and formal scientific review within the PLANMAP partners and consortium. Before a final map is produced (and its related scientific publication is submitted), preliminary versions will be shared on the PLANMAP web page, wiki and web-mapping data access page (https://maps.planmap.eu/ - going to be operational later).

In case underlying base mapping data require or are subject to improvements that will affect the mapping, newer versions will be used and posted and metadata updated.

Data preservation

Input data (based data and maps) are preserved by the respective archives and not under PLANMAP responsibility.

Custom higher-level data imagery, cubes, virtual environments and 3D models produced by PLANMAP partners during the course of the project will be preserved on PLANMAP storage services. After the project data will be shared (See Data Sharing subsection), optimally with some redundancy and in different geographic location, for longer-term availability.

Data security

The PLANMAP data processed, produced and analysed are not sensitive. No specific security measures are planned. Data recovery, in case of storage failures will be optimised by the use of central backup and local copies across PLANMAP partner institutions.

Data sharing

Data sharing will be performed via 4 possible channels:

- Individual partners. E.g., on own web site or repositories using industry standards for geodata (e.g. web-GIS)
- PLANMAP consortium, via web-gis and data-access web page, linked form the planmap web page
- ESA PSA, upon delivery of data and mapping products
- VESPA, via distributed VO-compliant systems for integrated mapping products and, in the future, potentially sub-map, mapping unilt-level access (e.g. individual mapping units).

EPN-TAP VESPA-based sharing on premise

VESPA-shared data contain data-product-level metadata pointing to actual data sources. The release of data (see DoA) is planned at steps, ultimately by the end of the project.

Exemplar metadata for mapping products to be released via VESPA:

A set of mandatory, documented metadata for VESPA services exists (https://voparis-confluence.obspm.fr/display/VES/Implementing+a+VESPA+service), plus optional ones. Those are mostly related to data-products (in PDS sense) with some dataset-wide. Individual unit granularity is not yet covered by VESPA technical capabilities.

New developments of VESPA (currently not implemented nor developed, but envisage for future VESPA developments within the lifetime of PLANMAP) should allow for metadata-based discovery and search that could extend the geographic data search and experiment metadata search with feature/unit data/metadata search.

ESA PSA data deliveries

Individual used data products already existing in planetary archives (PDS, PSA) will not be released to PSA (already in PDS in either raw or processed form).

Exemplary metadata for mapping products to be released via PSA:

Release to PSA of non-PDS data geological mapping data, with relevant documentation of a minimum of:

- target body
- geographic extent (bounding box) of mapping product
- CRS

Detailed data and metadata exchange formats will be updated in future iterations of the present document.

Annex-A: Planmap datasets

PLANMAP will use existing datasets both as previously and externally processed, mosaicked and merged data ("Base Maps") and selected subsets of datasets, including multiple data products used individually and/or in combination. Individual datasets used or envisaged are listed in the Annex. The list and information contained is subject to updates and improvement throughout the course of the project and the mapping activities.

Base data

Planetary Body	Product	Resolution	Additional info /datasets	URL
Mars	Mars HRSC MOLA Blended DEM Global	200 m/pixel		https://astrogeology.usgs.gov/search/map/Mars/Topography/HRSC_MOLA_Blend/Mars_HRSC_MOLA_BlendDEM_Global_200mp_v2
Mars	MOLA	463 m/pixel	MEGDR/PEDR	https://astrogeology.usgs.gov/search/map/Mars/GlobalSurveyor/MOLA/Mars_MGS_MOLA_DEM_mosaic_global_463m
Mars	THEMIS daytime mosaic	100 m/pixel	IR day	https://astrogeology.usgs.gov/search/map/Mars/Odyssey/THEMIS-IR-Mosaic-ASU/Mars_MO_THEMIS-IR-Day_mosaic_global_100m_v12
Mars	THEMIS nighttime mosaic	100 m/pixe	IR night	https://astrogeology.usgs.gov/search/map/Mars/Odyssey/THEMIS-IR-Mosaic-ASU/Mars_MO_THEMIS-IR-Night_mosaic_60N60S_100m_v14
Mars	Viking MDIM2.1 Grayscale Global Mosaic	232 m/pixel		https://astrogeology.usgs.gov/search/map/Mars/Viking/MDIM21/Mars_Viking_MDIM21_Mosaic_global_232m
Moon	LRO LROC-WAC Global Morphology Mosaic	100m/pixel		https://astrogeology.usgs.gov/search/map/Moon/LRO/LROC_WAC/Lunar_LRO_LROC-WAC_Mosaic_global_100m_June2013
Moon	LROC WAC DTM GLD100	118 m/pixel		https://astrogeology.usgs.gov/search/map/Moon/LRO/LROC_WAC/Lunar_LROC_WAC_GLD100_79s79n_118m_v1_1
Moon	LRO NAC Frames and Higher Level Data Products		Mosaics/DTMs	http://wms.lroc.asu.edu/lroc/rdr_product_select
Moon	LRO LOLA Elevation Model (LDEM GDR)	118m		https://astrogeology.usgs.gov/search/details/Moon/LRO/LOLA/Lunar_LRO_LOLA_Global_LDEM_118m_Mar2014/cub
Moon	Clementine UVVIS Warped Color Ratio Mosaic	200 m/pixel		https://astrogeology.usgs.gov/search/map/Moon/Clementine/UVVIS/Lunar_Clementine_UVVIS_Warp_ClrRatio_Global_200m
Moon	Clementine UVVIS FeO Color Binned	1 km/pixel		https://astrogeology.usgs.gov/search/map/Moon/Clementine/UVVIS/Lunar_Clementine_UVVIS_FeO_ClrBinned_70S70N_1km
Moon	LRO LOLA and Kaguya Terrain Camera DEM Merge	59 m/pixel	From 60N to 60S	https://astrogeology.usgs.gov/search/map/Moon/LRO/LOLA/Lunar_LRO_LrocKaguya_DEMmerge_60N60S_512ppd
Mercury	BDR (map-projected Basemap RDR)	166 m/pixel	monochrome morphology mosaic	https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_MESSENGER_MDIS_Basemap_BDR_Mosaic_Global_166m ftp://pdsimage.wr.usgs.gov/Missions/MESSENGER/MSGRMDS_4001
Mercury	HIE (map-projected High-Incidence angle basemap illuminated from East RDR)	166 m/pixel	monochrome morphology mosaic with Sun from East	ftp://pdsimage.wr.usgs.gov/Missions/MESSENGER/MSGRMDS_7001
Mercury	HIW (map-projected High-Incidence angle basemap illuminated from West RDR)	166 m/pixel	monochrome morphology mosaic with Sun from West	ftp://pdsimage.wr.usgs.gov/Missions/MESSENGER/MSGRMDS_7101
Mercury	LOI (map-projected LOw-Incidence basemap RDR)	166 m/pixel	monochrome low-incidence angle mosaic	https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_MESSENGER_MDIS_Basemap_LOI_Mosaic_Global_166m ftp://pdsimage.wr.usgs.gov/Missions/MESSENGER/MSGRMDS_7201
Mercury	USGS M10+MESSENGER	500 m/pixel	Mariner 10 + MESSENGER flybys combined mosaic	https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_M1_M2_M3_M10_mosaic_global_2010

CTX (Malin et al., 2007)

Dataset reference and name and acronym	Context Camera (CTX)
Organisation	Malin Space Science Systems, Inc.

Instrument description	CTX is a linescan camera with a 5000-element linear CCD (Kodak KLI-5001G) with 7x7 micron pixels. The CTX telescope is a 350 mm f/3.25 catadioptric with two front and two rear correcting elements. Its field of view is about 5.7 degrees, covering a 30-km swath from 300 km altitude at a resolution of 6 meters/pixel. Its mechanical structure is a composite configuration in which the metering structure is graphite/cyanate-ester (GR/CE), the primary mirror is Zerodur, and the elements are mounted in Invar and titanium cells.
Dataset Description	The Mars Reconnaissance Orbiter (MRO) Context Camera (CTX) is designed to obtain grayscale (black & white) images of Mars at 6 meters per pixel scale over a swath 30 kilometers wide. CTX provides context images for the MRO HiRISE and CRISM.
Standards	PDS3
Spatial extent	Swath width: 30 km Swath length: variable between 50 km and 300 km nearly 80% of Mars covered at 2018
Spectral Range	none
Temporal extent	2006-still active
Archive contact (e. g. PDS)	http://pds-geosciences.wustl.edu/contact/default.htm
Data format (raw)	.IMG
Data format (processed)	JP2, PNG, GeoTIFF, OGR web services
Archiving URL (archive)	https://pdsimg.jpl.nasa.gov/data/mro/mars_reconnaissance_orbiter/ctx/
Preservation	performed by NASA PDS
Acknowledgements	

Table X: Dataset description for the MRO CTX dataset

HRSC

Dataset reference and name	**High Resolution Stereo Camera**
Organisation	DLR Institute of Planetary Research, Freie Universität Berlin
Instrument Description	
Dataset Description	MEX-M-HRSC-3-RDR-V3.0 The High Resolution Stereo Camera (HRSC) Digital Terrain Map Reduced Data Record (DTMRDR) data products are 8-bit orthoimages for the Nadir channel and the 4 color channels and 16-bit DTMs (1 m numeric height resolution). The orthoimages are based on the DTMs, and are thus available exclusively for areas covered by the DTMs. The DTM and the adjusted orientation data are finally applied for orthoimage production. The only additional pre-processing step for orthoimages consists of a histogram-based linear contrast stretch which does not affect the linear metrics of the radiometric image calibration.
Dataset Description	MEX-M-HRSC-5-REFDR-DTM-V1.0 DTM generation is based on multi-image matching using pyramid-based least-squares correlation after pre-processing by adaptive (variable bandwidth) Gaussian low pass filtering of the stereo images to reduce the effects of image compression. 3D Point determination by least-squares forward intersection is followed by DTM grid interpolation (distance weighted averaging within a local interpolation radius). The overall process involves automatic procedures in combination with standardized quality checks. DTM generation uses adjusted orbit and pointing data. Based on the high-resolution DTM result, the quality of co-registration with the Mars Orbiter Laser Altimeter (MOLA) DTM is evaluated, and final improvements to the exterior orientation data are derived.

Dataset Description	MEX-M-HRSC-5-REFDR-MAPPROJECTED-V3.0 The High Resolution Stereo Camera (HRSC) Version 3 Map-Projected Reduced Data Record (REFDR3) data products are standard IMAGE objects derived from the RDRV3 data products. Version 3 products were produced after an improved radiometric calibration. REFDR3 products are also produced in JPEG 2000 format in addition to the typical IMG format. Footprints are also calculated for each image along with map projection.
Standards	PDS3
Spatial Resolution	DTM: 100 m RDR V3.0: 12.5 m/pixel
Spatial Extent	Swath width: 52 km Swath length: 300 km (minimum)
Spectral Range	Panchromatic: 675±90 nm Nadir, 2 stereo, 2 photometric Near-IR: 970±45 nm Red: 750±20 nm Green: 530±45 nm Blue: 440±45 nm
Temporal Extent	2003-present
Upstream contact (e.g. PDS)	ESA PSA - https://www.cosmos.esa.int/web/psa/contact-us
Data Format (raw)	.IMG (VICAR)
Data Format (processed)	JP2, PNG, GeoTIFF, OGR web services
Access URL (archive)	ftp://psa.esac.esa.int/pub/mirror/MARS-EXPRESS/HRSC/
Preservation	Performed by ESA PSA
Acknowledgements	ESA planetary Science Archive, HRSC Principal Investigator(s): G. Neukum (Freie Universitaet, Berlin, Germany),

Table X: Dataset description for the MEX HRSC dataset

Hirise (McEwen et al., 2007)

Dataset reference and name	**High Resolution Imaging Science Experiment**		
Organisation	University of Arizona		
Instrument Description	The High Resolution Imaging Science Experiment (HiRISE) camera offers unprecedented image quality, giving us a view of the Red Planet in a way never before seen. It's the most powerful camera ever to leave Earth's orbit imaging Mars at a resolution of ~0.25 m/pixel. Color information can be derived from RED (covering the whole swath) Blue-Green and NIR channels. HiRISE is designed to take stereo couples that can be used to reconstruct with photogrammetry the topography of Mars at 1m of horizontal resolution and tens of centimeters of vertical accuracy. HiRISE offers three data sets, the Experiment Data Record (EDR) data set, the Reduce Data Record (RDR), and the Digital Terrain Model (DTM) data set (in addition, ODE presents the Anaglyphs as a fourth data type - see below). EDRs are raw images from the spacecraft. RDRs are combined and processed images based on several EDRs. DTMs are sets of digital elevation models along with the ortho images used to create them.		

Dataset Description	MRO-M-HIRISE-3-RDR-V1.0 HiRISE reduced data records without embedded map projection The High Resolution Imaging Science Experiment (HiRISE) Reduced Data Record (RDR) products are combined and processed radiometrically-corrected, geometrically-mapped images based on several EDRs at nominal resolution of 30 cm/pixel from 300 km altitude. Due to a mid-2008 change in RDR format to include embedded map projection information within the JPEG 2000 files, the majority of RDR products are Version 1.1.		
Dataset Description	MRO-M-HIRISE-3-RDR-V1.1 HiRISE Reduced Data Records with embedded map projection		
	MRO-M-HIRISE-2-EDR-V1.0 The High Resolution Imaging Science Experiment (HiRISE) Experiment Data Record (EDR) products are the permanent record of the HiRISE raw image data collection. An EDR contains unprocessed image data (except as noted below), ancillary engineering data, and information about the instrument commanding used to acquire the image. An EDR image has the inherent properties of raw and unprocessed data. Data gaps may exist in an EDR primarily due to telemetry communication problems between Mars and Earth. The image pixel values are raw counts not yet radiometrically corrected. No geometric processing has been applied to the data to correct for optical distortion or view geometry. The format is nearly identical to the original from of the data stream as produced by the instrument. Some processing was applied to the data for (1) FELICS decompressing an image (if the data were optionally compressed on the spacecraft), (2) identifying and filling gaps with "no-data" values, (3) mirroring the pixel order of an image line for data read out in reverse order, and (4) adding a PDS label to the beginning of the file.		
Dataset Description	DTM HiRISE images are usually 0.25 - 0.5 m/pixel, so the post spacing is 1-2 m with vertical precision in the tens of centimeters. • The DTM in standard PDS image object (.IMG) format with an embedded label • Orthoimages at the same resolution as the DTM, in JPEG2000 format with detached label • Orthoimages at the resolution of the original image, in JPEG2000 format with detached label		
Standards	PDS3		
Spatial Resolution	0.25 m/pixel		
Spatial Extent	local, targeted Swath width(Blue-Green-NIR): 1.2 km Swath width(RED): 6 km Swath length: 12 km		
Spectral Range	Blue-Green (BG): 400 to 600 nm Red: 550 to 850 nm Near infra-red (NIR): 800 to 1000 nm		
Temporal Extent	2006-present		
Upstream contact (e. g. PDS)	NASA PDS- https://pds.nasa.gov		
Data Format (raw)	.IMG		
Data Format (processed)	.JP2		
Access URL (archive)	https://hirise-pds.lpl.arizona.edu/PDS/		
Preservation	Performed by NASA PDS		
Acknowledgements	NASA/JPL/University of Arizona, A. McEwen (UoA)		

Table X: Dataset description for the MRO HiRISE daset

CaSSIS (Thomas et al., 2017)

Dataset reference and name and acronym	CaSSIS - Colour and Stereo Surface Imaging System
Organisation	University of Bern
Instrument description	CaSSIS will characterise sites that have been identified as potential sources of trace gases and investigate dynamic surface processes – for example, sublimation, erosional processes and volcanism – which may contribute to the atmospheric gas inventory. The instrument will also be used to certify potential landing sites by characterising local slopes, rocks and other possible hazards by acquiring stereoscopic images. The rotation mechanism will be able to turn the entire telescope system by 180° while its support structure remains fixed. This rotation system will also enable the camera to acquire stereo images with only one telescope and focal plane assembly. A stereo image pair will be acquired by first rotating the telescope to point 10° ahead of the spacecraft track to acquire the first image, then rotating it 180° to point 10° behind for the second stereo image. Optimal correlation of the stereo signals will be ensured as there will be identical illumination conditions every time a stereo image pair is acquired. The imager will cover an eight-kilometre-wide swathe of the planet's surface in four different wavelength ranges.
Dataset Description	4 color (PAN, IR, RED, BLUE) with stereo acquisition along track. Stereo angle from 400 km altitude 22.39° DTM: n/a, available in late 2018
Standards	PDS4 to be implemented
Spatial Resolution	4.62 m/pixel
Spatial extent	Swath width: 7-9 km Swath length: variable 40-50 km
Spectral Range	Pan: 675 nm / 250 nm Blue-Green: 485 nm / 165 nm Red: 840 nm / 100 nm IR: 985 nm / 220 nm
Temporal extent	Nominal mission: 2018-still active
Archive contact (e.g. PDS)	n/a
Data format (raw)	.dat, .xml
Data format (processed)	.cub, JP2, PNG, GeoTIFF, OGR web services
Archiving URL (archive)	n/a
Preservation	University of Bern, to be continued by PSA/PDS
Acknowlegements	Prof. Nicolas Thomas, University of Bern, Dr. Gabriele Cremonese, INAF OaPD

OMEGA

Dataset reference and name	**Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA)**
Organisation	Institut d'Astrophysique Spatiale, Orsay, France
Instrument Description	OMEGA is a mapping spectrometer, with co-aligned channels working in the 0.38-1.05 m visible and near-IR range (VNIR channel) and in the 0.93-5.1 m short wavelength IR range (SWIR channel) in 352 contiguous spectral elements (spectels). The signal-to-noise ratio (SNR) is >100 over the whole spectral range for observations obtained in nadir mode and considering low solar zenith angles. Due to the MEx spacecraft elliptic orbit, the scan widths in each orbit are changed (16, 32, 64, 128 pixels) accordingly to the variation of the observing distance. The spatial resolution of OMEGA is in the range 0.3-4-5 km/pixel . The SWIR detector (covering the 1-2.5 µm diagnostic wavelength range) is not functioning any more since 2010.
Dataset Description	The data products constitute three-dimensional 'image-cubes', with two spatial and one spectral dimensions. OMEGA provides global coverage at medium-resolution (2-5 km) for altitudes from 1500 km to 4000 km, and high-resolution (< 350 m) spectral images of selected areas, amounting to a few percent of the surface, when observed from near-periapsis (< 300 km altitude).

Standards	PDS3
Spatial Extent and Resolution	Images can vary between 16, 32, 64, 128 pixels of swath depending on the distance. On the ground images are circa from 5-7 km X 3000 km (with 360m/px) up to 300-600 km X 3000 km (with 5km/px).
Spectral Range and Resolution	0.35-5.1um divided into three range: VNIR with a spectral sampling ranging from 7 nm between 0.38 and 1.05 um; SWIR-C with 14 nm between 0.93 and 2.73 um; and SWIR-L with 20 nm between 2.55–5.1 um.
Temporal Extent	Nominal Mission (19 Feb 2003 - 19 Jan 2006; cruise through orbit 2595) Extended Mission 1 (22 Jan 2006 - 23 Oct 2007; orbits 2607-4890) Extended Mission 2 (4 Nov 2007 - 3 Jan 2010; orbits 4931-7697) Extended Mission 3 (4 Jan 2010 - 19 Oct 2012; orbits 7701-11193) Extended Mission 4 (20 Oct 2012 - 11 Jan 2015) Extended Mission 5 (14 Jan 2015 - 9 Jan 2017) Extended Mission 6 (10 Jan 2017 - 3 Jun 2017)
Upstream contact (e. g. PDS)	ESA PSA - https://www.cosmos.esa.int/web/psa/contact-us
High level products	The OMEGA Mars Global Maps data products are primarily available in PDS format in the DATA directory of this data set. Raster maps are formatted using the PDS IMAGE object, and vector maps are formatted using the PDS SPREADSHEET object. NIR Albedo Map Ferric Oxide Map Dust Map Hydrated Mineral Map Olivine Maps (3 maps) Pyroxene Map
Data Format (raw)	The OMEGA files extensions are .QUB for the data (level 1B in the "cube" PDS format) and .NAV for the geometry. Files are named from the corresponding OMEGA observation: ORBNNNN_S where NNNN is the orbit number (format I4.4) and S is the rank of the OMEGA observation on that orbit (starting with 0).
Data Format (processed)	for data: .sav, .txt for images: .png, .tiff/.geotiff
Access URL (archive)	ftp://psa.esac.esa.int/pub/mirror/MARS-EXPRESS/OMEGA/
Preservation	Performed by ESA PSA
Acknowledgements	ESA planetary Science Archive, OMEGA PI Dr. Jean-Pierre Bibring, Institut d'Astrophysique Spatiale, Orsay, France

SHARAD

Dataset reference and name	**Shallow Subsurface Radar**
Organisation	ASI, NASA
Instrument Description	The first hundred meters of the subsurface are investigated with a vertical resolution of about 20 metres, horizontal at about one hundred metres in trajectory, while perpendicularly the resolution is in the order of a kilometre depending on subsurface characteristics and local surfaces. The radar instrument points to the nadir with functioning and impulses on two modalities of radar and altimeter. In order to isolate, the reflectors of the subsurface use the synthetic aperture technique. The instrument consists of an antenna and an electronic system working at a wavelength range centred at MHz +/- 5 MHz This configuration enables the analysis of dielectric properties in the subsurface, thereby maintaining low clutter at the surface. The frequencies selected can penetrate the ionosphere. The total cycle of transmission and reception of each impulse is a few milliseconds

Dataset Description	**Raw Data Products - EDR (SHARAD Operations, Italy)** **mro-m-sharad-3-edr-v1** The Shallow Radar (SHARAD) Experiment Data Record (EDR) for SHARAD is a data product produced by the Italian SHARAD team that consists of the instrument telemetry correlated with the auxiliary information needed to locate observations in space and time and to process data further. Apart from editing of data to remove duplicates and transmission errors, no processing is applied to the scientific data of the instrument. Each Data Product contains data from one or more data blocks collected continuously using the same operation mode, instrument status and on-board processing scheme; that is, using a single Operation Sequence Table (OST) line. The content of each SHARAD data product is highly variable in terms of number of data blocks, and depends on how operations for the instrument were planned during a given data collection period. The natural organization for data blocks within a Data Product is a table, in which each line contains data from a single data block, and each column contains the value of a single parameter or time sample across different data blocks. Each Data Product consists of three files: 1) A binary file containing the scientific telemetry of the instrument. This is a sequence of echoes, each of which is preceded by a header containing information on the collection and on-board processing of the data. This file is called the Science Telemetry file. 2) A binary table containing geometric quantities generated on-ground from spacecraft navigation data, parameters extracted from instrument and spacecraft housekeeping telemetry, and flags describing the completeness and usability of the associated scientific telemetry. This file is called the Auxiliary Data file and contains one record for every data block in the Science Telemetry file. 3) A detached ASCII label file describing the content of the data product. The label is written according to standards defined by the Planetary Data System (PDS), and lists parameters describing both the observation in which data were acquired and the structure of the files in which data are stored.
Dataset Description	**Derived Data Products - RDR (SHARAD Operations, Italy)** **mro-m-sharad-4-rdr-v1** The Shallow Radar (SHARAD) Reduced Data Record (RDR) for SHARAD is a data product produced by the Italian SHARAD team that consists of received echoes that have been Doppler filtered, range compressed, and converted to complex voltages, correlated with the auxiliary information needed to locate observations in space and time and to process data further. Data users must be aware that processed echoes may contain artifacts due to off-nadir surface reflections, the so-called clutter, reaching the radar after nadir surface echoes, and thus appearing as subsurface reflections. Each Data Product is the result of the processing of all echoes acquired continuously in time using the same operation mode, instrument status and on-board processing scheme. There is one RDR data product for every Experiment Data Record (EDR) data product acquired in subsurface sounding mode, which in fact constitutes the input for the RDR product generation. Each processed radar observation in an RDR data product is the result of range and azimuth processing of a variable number of raw echoes. The natural organization for processed echoes within a Data Product is a table, in which each line contains data from a single processed echo, and each column contains the value of a single parameter or time sample across different processed echoes. Each Data Product consists of two files: 1) A binary file containing the scientific data of the instrument: a sequence of processed echoes, each of which is preceded by a header containing information on the instrument setting and on-board processing of the data, and followed by parameters characterizing the ground processing of the echoes, by geometric quantities generated on-ground from spacecraft navigation data, and by parameters extracted from instrument housekeeping telemetry. 2) A detached ASCII PDS label file describing the content of the data product.

Dataset Description	**Derived Data Products (Radargrams) (SHARAD Science Team, U.S.)** mro-m-sharad-5-radargram-v1 The Shallow Radar (SHARAD) Reduced Data Record of Radar backscatter power **(USRDR)** is a data product produced by the U.S. SHARAD team. The image product, the radargram, is a backscatter power presented with along-track distance in the horizontal dimension and round-trip time delay along the vertical axis. The U.S. radargram processing uses a uniform amplitude model for the frequency components of the SHARAD linear frequency-modulated chirp signal. This leads to asymmetric offset of the characteristic transform sidelobes, with greater sidelobe amplitude on the downrange (greater delay) side of any echo. This approach preserves a two-fold oversampling (i.e., 3600 complex samples from 3600 real samples) of the signal after range compression, which allows for flexibility in later interpolation. Ionospheric distortion is compensated using a model for the frequency dependence of the phase errors. The resulting correction term is approximately linear with total electron content (TEC), and thus with the change in delay time for signals from the surface and subsurface. The image-restoring and range corrections are applied where the solar zenith angle (SZA) is less than 100°. A Hann window function is applied to the frequency-domain data prior to the inverse Fourier transform to reduce sidelobe levels in the range-compressed echo. Two basic parameters define the processing of SHARAD data. The first is the coherence time or aperture length, TC (in seconds). The frequency resolution (in Hz) of the resulting Doppler spectrum is 1/TC, independent of the time spacing between the pulses that make up the synthetic aperture. The degree of pre-summing, which reduces the pulse repetition frequency (PRF) from the initial value of 700.28 pulses per second, affects only the Doppler frequency bandwidth (in Hz) of the Doppler spectrum, which is given by 1/PRF. The second parameter specifies the Doppler frequency bandwidth (in Hz), B, of echoes about the center of the Doppler spectrum to be included in the radar backscatter mapping. If this frequency width is less than 1/TC, the output map will have only one sample for each output pixel location. This is a one-look radar image. If the frequency width is larger than 1/TC, more than one Doppler resolution cell will be averaged, yielding a multi-look image. Each 32-bit floating-point format radargram file is accompanied by a TIFF image that logarithmically scales the backscattered power over an 8-bit range corresponding to -3 dB to +32 dB with respect to the noise background (i.e., each DN step is about 0.137 dB). The noise-scaling factor was determined from the average behavior over the period between orbits 7500 and 32999. Tracks collected before about orbit 7200 have a slightly higher (about 1.4 dB) background noise, so their TIFF radargram products will appear slightly brighter due to the use of the lower scaling factor. A reduced-quality JPEG version of each TIFF is provided for browsing the archive. The Shallow Radar (SHARAD) Geographic, geometric, and ionospheric properties **(USGEOM)** data file accompanies each U.S. Reduced Data Record of Radar backscatter power (USRDR). The ASCII-format table file contains location information for each radargram column, the spacecraft and surface radius values required to change the reference planetary shape, and the phase correction value related to the correction of ionospheric distortion and delay. The coordinate system of planetocentric, with longitude positive toward the east. Radius values tabulated in the GEOM files are interpolated using a polynomial fit between the along-track elapsed time and data from Mars Orbiter Laser Altimeter (MOLA). The topographic information for the polynomial fit is drawn from the MOLA 128-ppd (pixels per degree) areoid gridded database for non-polar tracks, and from the 512-ppd gridded dataset for tracks that cross the polar terrain.
Standards	PDS3
Spatial Resolution	Vertical resolution 20 m
Spatial Extent	linear, along track.
Spectral Range	none
Temporal Extent	2006-present
Upstream contact (e.g. PDS)	NASA PDS- https://pds.nasa.gov
Data Format (raw)	.dat, .lbl
Data Format (processed)	.img, .lbl, .tab
Access URL (archive)	**http://pds-geosciences.wustl.edu/mro/**

Preservation	Performed by NASA, PDS
Acknowledgements	ASI, NASA, Principal Investigator Dr. Roberto Seu of the INFOCOM Department of the Università “La Sapienza” of Rome.

CRISM

Dataset reference and name	**Compact Reconnaissance Imaging Spectrometer for Mars (CRISM)**		
Organisation	NASA - The Johns Hopkins University/Applied Physics Lab		
Instrument Description	CRISM is a hyperspectral imager covering wavelengths from 0.36 to 3.92 microns. The SNR is .... The MRO will operate from a sun-synchronous, near- circular (255x320 km altitude), near-polar orbit with a mean local solar time of 3 PM. ... https://pds.nasa.gov/ds-view/pds/viewInstrumentProfile.jsp?INSTRUMENT_ID=CRISM&INSTRUMENT_HOST_ID=MRO		
Dataset Description	The data products consist in image cubes. In targeted mode (Gimbaled, Hyperspectral Modes), CRISM acquires hyperspectral images from circa 0.4 to 4.0 mm in 544 channels (VNIR 107+ IR 438) at a spatial resolution up to 18 meters per pixel; whereas in global mode (pushbroom modes) images have different spectral sampling in the VNIR (from 19 to 107 channel) and IR (from 0 to 438 channel) with spatial resolution between 100-200 m . This datasets are defined as: 1) Gimbaled: Full Resolution (FRT); Half resolution short (HRS); Half resolution long (HRL); Full resolution short (FRS); Along-track oversampled (ATO); Along-track undersampled (ATU) 2) Pushbroom: Multispectral Window (MSW); Multispectral VNIR (MSV); Multispectral Survey (MSP); Hyperspectral Mapping (HSP); Hypersepctral VNIR (HSV); Tracking Optical Depth (TOD); Flat Field Calibration (FFC)		
Standards	PDS3		
Spatial Extent and Resolution	**Full Resolution (FRT):** Spatial pixels unbinned for target – 18 m/pixel @ 300 km, **Half resolution short (HRS):** Spatial pixels 2x binned for target – 36 m/pixel @ 300 km, same swath length as above **Half resolution long (HRL):** Spatial pixels 2x binned for target – 36 m/pixel @ 300 km, twice swath length as above **Full resolution short (FRS):** Spatial pixels unbinned for target – 18 m/pixel @ 300 km; half swath length as above **Along-track oversampled (ATO):** Spatial pixels unbinned for target – 18 m/pixel cross-track, up to ~3 m/pixel downtrack, requires special processing for increased resolution; half swath length as above **Along-track undersampled (ATU):** Spatial pixels unbinned for target – 18 m/pixel cross-track, 36 m/pixel downtrack; half swath length as above		
Spectral Range and Resolution	0.36 to 3.92 microns at 6.55 nanometers/channel		
Temporal Extent	2007-present EDR / CDR Volume Coverage MROCR_0001 Sept. 27, 2006 - Dec. 31, 2007 MROCR_0002 Jan. 1, 2008 - Aug. 8, 2008 MROCR_0003 Aug. 9, 2008 - Aug. 8, 2010 MROCR_0004 Aug. 9, 2010 - Aug. 8, 2011 MROCR_0005 Aug. 11, 2011 - Aug. 3, 2012 MROCR_0006 Sept. 14, 2012 - Aug. 8, 2013 MROCR_0007 Aug. 9, 2013 - Aug. 8, 2014 MROCR_0008 Aug. 9, 2014 - Nov. 8, 2015 MROCR_0009 Nov. 9, 2015 - Nov. 8, 2016 MROCR_0010 Nov. 9, 2016 - Nov. 8, 2017 MROCR_0011 Nov. 9, 2017 - Feb. 8, 2018		
Upstream contact (e. g. PDS)	NASA PDS- https://pds.nasa.gov http://crism.jhuapl.edu		
High level products	....		

Data Format (raw) and derived	Crism file extensions are: Experiment Data Record (EDR) Raw data from the telemetry stream rearranged but unmodified except for lossless decompression. Calibration Data Record (CDR) Derived values needed to convert a scene-viewing EDR into units of radiance. Whereas derived CRISM files are: Derived Data Record (DDR) A companion file for each EDR or TRDR pointed at Mars's surface that contains physical parameters such as latitude, longitude, and incidence, emission, and phase angle. Used for map projection, photometric correction, and to locate correction information in an ADR. Limb Data Record (LDR) A companion file for each EDR or TRDR pointed at Mars's limb that contains physical parameters such as latitude, longitude, and incidence, emission, and phase angle. Used to locate measurement tangent relative to the surface and model the radiance. Targeted Reduced Data Record (TRDR) Image data from an EDR converted to units of radiance or I/F using CDRs. A TRDR also contains a set of derived spectral parameters (summary products) that provide an overview of the data set. Ancillary Data Record (ADR) Reference information used to correct scene measurements for photometric, thermal emission, or atmospheric effects. Multispectral Reduced Data Record (MRDR) One of many tiles that make up a global mosaic, an MRDR contains map-projected data in units of radiance (extracted from TRDRs), plus I/F, summary products, and the DDR data used to generate them. Targeted Empirical Record (TER) A spatially reconciled, full spectral range I/F targeted observation central scan image cube in the IR (L-detector) sensor space that has been corrected for geometric, photometric, atmospheric, and instrumental effects. Map-Projected Targeted Reduced Data Record (MTRDR) Similar in concept to an MRDR, MTRDRs are map-projected versions of TER data products.		
Data Format (processed)	for data: .sav, .txt for images: .png, .tiff/.geotiff		
Access URL (archive)	http://pds-geosciences.wustl.edu/mro/		
Preservation	Performed by NASA, PDS		
Acknowledgements	CRISM Principal Investigator: Scott Murchie, The Johns Hopkins University/Applied Physics Lab		

MARSIS

Dataset reference and name and acronym	Mars Advanced Radar for Subsurface and Ionosphere Sounding
Organisation	Università La Sapienza, Roma
Instrument description	The primary objective is to map the distribution of water and ice in the upper portions of the Martian crust. The instrument analyzes reflections of radio waves in the upper 2-3 km of Martian crust to reveal the subsurface structure. MARSIS also studies the ionosphere by characterizing the interaction of the solar wind with the ionosphere and upper atmosphere of Mars.
Dataset Description	Nominal Mission MEX-M-MARSIS-2-EDR-V2.0 Nominal Mission MEX-M-MARSIS-2-EDR-EXT1-V2.0 For more information about the dataset http://pds-geosciences.wustl.edu/mex/mex-m-marsis-2-edr-v2/mexme_1001/catalog/dataset.cat
Standards	PDS3
Spatial extent	2-3 km in depth
Spectral Range	none
Temporal extent	2003-present

Labeling	
Archive contact (e. g. PDS)	http://pds-geosciences.wustl.edu/mex/
Data format (raw)	.dat, .lbl
Data format (processed)	
Archiving URL (archive)	http://pds-geosciences.wustl.edu/mex/
Preservation	NASA-PDS
Acknowledgements	MARSIS Principal Investigator: Roberto Orosei, MARSIS Principal Investigator from Istituto di Astrofisica e Planetologia Spaziali, Bologna, Italy. Formerly Prof. Giovanni Picardi, Universita di Roma 'La Sapienza', Rome, Italy angelo.rossi

Moon

See here for labels and format etc.: http://ode.rsl.wustl.edu/moon/pagehelp/quickstartguide/index.html?lroc_mdrwvs.htm

LROC NAC (Chin et al., 2007; Robinson et al., 2010)

Dataset reference and name and acronym	LROC NAC
Organisation	NASA PDS
Instrument description	The Lunar Reconnaissance Orbiter Camera (LROC) has been designed to address two of the measurement requirements: • Landing site certification • Polar illumination LROC acquires images to assess meter and smaller scale features to facilitate safety analysis for potential lunar landing sites near polar resources and elsewhere on the Moon. Synoptic 100 m/pixel imaging of the poles during every orbit for a year will unambiguously identify regions of permanent shadow and permanent or near-permanent illumination.
Dataset Description	The Lunar Reconnaissance Orbiter Camera (LROC) Experiment Data Record Narrow Angle Camera (EDRNAC) data product is a NAC panchromatic image corresponding to a single observation (either full resolution or summed), with Digital Number (DN) counts in 8-bit format, companded from 12-bit in the instrument. The image data consists of one series of contiguous lines up to 52,224 lines with 5,000 samples in full resolution mode, or 104,448 lines with 5,000 samples in 2x cross-track summation mode. The image file is composed first of the even pixels from each line (with a 20 byte CTX heritage header every 1 MB) and padded to a 1 MB boundary, followed by the odd pixels in the same style. The EDR file generation process extracts the odd and even pixels, interleaving them to reconstruct original scan lines. If compression was enabled at image acquisition, the data stream is first de-compressed before the interleaving is performed. Information from the meta-file, housekeeping, and the SOC database are combined to generate the PDS label with the binary data to compose the EDR file. Specifications for the right and left NACs are in the table below. The NAC-L is off-pointed ~2.85° from the NAC-R so that the footprints of the two images overlap ~130 pixels.
Standards	PDS3
Spatial extent	0.5 m/pixel scale panchromatic images over a 5 km swath and a wide-angle camera component (WAC) to provide images at a scale of 75 m/pixel in five visible bandpasses and 400 m/pixel (source LROC RDR SIS)
Spectral Range	
Temporal extent	
Archive contact (e. g. PDS)	http://pds-geosciences.wustl.edu/contact/default.htm

Data format (raw)	.IMG
Data format (processed)	JP2, PNG, GeoTIFF, OGR web services
Archiving URL (archive)	http://pds-geosciences.wustl.edu/lro/
Preservation	performed by NASA PDS
Acknowledgements	tba

M3 (Pieters et al., 2009)

Dataset reference and name and acronym	**Moon Mineralogy Mapper**
Organisation	NASA/ISRO
Instrument description	M3 is a broad spectral range imaging spectrometer, measuring from 430 to 3000 nm with 10 nm spectral sampling (### channels), with one detector, through a 24 degree field of view with 0.7 milliradian spatial sampling. It was designed to measure compositionally diagnostic spectral absorption features from a wide variety of known and possible lunar materials. The instrument's SNR was greater than 400 for the specified equatorial reference radiance and greater than 100 for the polar reference radiance. Chandrayaan1 had a nominal 100 km inertially fixed polar orbit, but from the 19th of May 2009, for mission safety, the orbit of Chandrayaan1 was raised from 100 km to 200 km.
Dataset Description	Dataset was defined with two instrument measurement modes, defined as "Target Mode" and "Global Mode". Target Mode is characterized by a full resolution with 260 spectral detector elements for every alongtrack sample with a nominal spatial sampling of 70 m. Global Mode was defined to collect rapid full lunar coverage at reduced spatial (140 m/pixel) and spectral sampling (86 spectral channels). 825 nominally illuminated Global Mode and 79 Target Mode images were acquired. 336 contiguous Global Mode images strips provide nearly full coverage of the lunar surface. The acquired M3 measurements provide 95%complete Global Mode coverage of the Moon.
Standards	PDS3
Spatial extent and Resolution	40 km swath and 70 m spatial sampling from the nominal 100 km orbit
Spectral Range and Resolution	430 to 3000 nm with 10 nm of spectral sampling
Temporal extent	OP1A Nov 18 2018 -- Jan 24 2019 119 100 km extended commissioning OP1B Jan 25 -- Feb 14 247 100 km operational, high solar zenith angles OP2A Apr 15 -- Apr 27 197 100 km operational, high solar zenith angles OP2B May 13 -- May 16 20 100 km S/C emergency, orbit raised OP2C May 20 -- Aug 16 375 200 km operational, variable conditions
Archive contact (e. g. PDS)	http://pds-geosciences.wustl.edu/contact/default.htm
Data format (raw)	.IMG
Data format (processed)	for data: .sav, .txt for images: JP2, PNG, GeoTIFF, OGR web services
Archiving URL (archive)	
Preservation	performed by NASA PDS
Acknowledgements	tba

SELENE (Kaguya) Terrain Camera

Dataset reference and name and acronym	
Organisation	

Instrument description	
Dataset Description	
Standards	PDS3
Spatial extent	
Spectral Range	
Temporal extent	
Archive contact (e.g. PDS)	
Data format (raw)	
Data format (processed)	
Archiving URL (archive)	
Preservation	performed by JAXA
Acknowledgements	tba

Mercury

MDIS-NAC/WAC (Hawkins, S.E. III et al., 2007, Space Sci. Rev.)

Dataset reference and name and acronym	MDIS - MESSENGER Mercury Dual Imaging System
Organisation	NASA/Johns Hopkins University Applied Physics Laboratory
Instrument description	MDIS consists of a monochrome narrow-angle camera (NAC) and a multispectral wide-angle camera (WAC). The NAC has a single medium-band filter centered at 747.7 nm to match to the corresponding WAC filter for monochrome imaging. The WAC has a 12-position filter wheel (FW) provides color imaging over the spectral range of the CCD detector. Eleven spectral filters spanning the range 395-1,040 nm are defined to cover wavelengths diagnostic of different potential surface materials. The WAC's 10.5° x 10.5° FOV is sufficient that overlap occurs between nadir-pointed image strips taken on adjacent orbits, even at northern mid-latitudes where low altitudes occur. The NAC's 1.5° FOV is sufficiently narrow that 375 m/pixel sampling is attained at 15,000 km altitude. MESSENGER was placed in a highly eccentric orbit with a periapsis altitude of 200 km, a periapsis latitude of ~60° and an apoapsis altitude of 15,200 km. The orbit has a 12-hour period, is inclined 80° to the planet's equatorial plane, and is not Sun synchronous.
Dataset Description	MDIS dataset consists of single wavelength images at variable scales and with variable filters combination. They provided global coverage on B/W, three colors, five colors or eight colors of Mercury surfaces. Targeted region can be characterized by very high spatial resolution from few tens of meters for NAC filter up to few hundred of meters for 8 color image.
Standards	PDS3
Spatial Extent and Resolution	NAC: ~5 m/px at 200-km altitude, 380 m/px at 15,200-km altitude WAC: ~ 36 m/px at 200-km altitude, 2720 m/px at 15,200-km altitude

<table>
<tr><td>Spectral Range and resolution</td><td>NAC: single medium-band filter (721–770 nm) centered at 747.7 nm, WAC: 395–1040 nm in 12 filters

<table>
<tr><th>Filter number</th><th>Filter letter</th><th>System wavelength
measured at -26°C (nm)</th><th>System bandwidth
measured at -26°C (nm)</th></tr>
<tr><td>6</td><td>F</td><td>430</td><td>18.0</td></tr>
<tr><td>3</td><td>C</td><td>480.4</td><td>8.9</td></tr>
<tr><td>4</td><td>D</td><td>559.2</td><td>4.6</td></tr>
<tr><td>5</td><td>E</td><td>628.8</td><td>4.4</td></tr>
<tr><td>1</td><td>A</td><td>698.8</td><td>4.4</td></tr>
<tr><td>2</td><td>B</td><td>700</td><td>600</td></tr>
<tr><td>7</td><td>G</td><td>749.0</td><td>4.5</td></tr>
<tr><td>12</td><td>L</td><td>828.6</td><td>4.1</td></tr>
<tr><td>10</td><td>J</td><td>898.1</td><td>4.3</td></tr>
<tr><td>8</td><td>H</td><td>948.0</td><td>4.9</td></tr>
<tr><td>9</td><td>I</td><td>996.8</td><td>12.0</td></tr>
<tr><td>11</td><td>K</td><td>1010</td><td>20.0</td></tr>
<tr><td>NAC</td><td>M</td><td>747.7</td><td>52.3</td></tr>
</table></td></tr>
<tr><td>Temporal extent</td><td>Mercury flyby 1 14 January 2008
Mercury flyby 2 6 October 2008
Mercury flyby 3 29 September 2009
Orbital phase March 2011 - April 2015</td></tr>
<tr><td>Archive contact (e.g. PDS)</td><td>PDS</td></tr>
</table>

High Level Products	**Mercury Messenger Global Mosaic 2010** This mosaic represents the best geodetic map of Mercury's surface as of 2010. https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_M1_M2_M3_M10_mosaic_global_2010 **Mercury MESSENGER MDIS Basemap Enhanced Color Global Mosaic 665m (64ppd)** This view uses a global mosaic with 430, 750, and 1000 nm bands and places the second principal component, the first principal component, and the 430/1000 ratio in the red, green, and blue channels respectively. https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_MESSENGER_MDIS_Basemap_EnhancedColor_Mosaic_Global_665m **Mercury MESSENGER MDIS Global Basemap BDR 166m (256ppd)** The Map Projected Basemap RDR (BDR) data set consists of a global monochrome map of reflectance at a resolution of 256 pixels per degree (~166 m/px). https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_MESSENGER_MDIS_Basemap_BDR_Mosaic_Global_166m **Mercury MESSENGER MDIS Basemap MD3 Color Global Mosaic 665m (64ppd)** The mosaic shows Mercury's colors as viewed by placing images from MESSENGER's 1000 nm, 750 nm, and 430 nm narrow-band filters in the red, green, and blue channel respectively. https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_MESSENGER_MDIS_Basemap_MD3Color_Mosaic_Global_665m **Mercury MESSENGER MDIS Basemap LOI Global Mosaic 166m (256ppd)** The Map Projected Low-Incidence Angle Basemap RDR (LOI) data set consists of a global monochrome map of reflectance at a resolution of 256 pixels per degree (~166 m/px). https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_MESSENGER_MDIS_Basemap_LOI_Mosaic_Global_166m **Mercury MESSENGER MDIS Color Global Mosaic 665m v3** The color mosaic is comprised of photometrically corrected I/F (radiance factor) for 3 narrow-band color filters of the Mercury Dual Imaging System (MDIS) Wide Angle Camera (WAC), placing the 1000-nm, 750-nm, and 430-nm filters in the red, green, and blue channels, respectively. https://astrogeology.usgs.gov/search/map/Mercury/Messenger/Global/Mercury_MESSENGER_MDIS_ClrMosaic_global_665m_v3 **Mercury MESSENGER Global DEM 665m (64ppd) v2 Oct. 2016** The map is a colorized shaded-relief of the original digital elevation model (DEM) https://astrogeology.usgs.gov/search/map/Mercury/Topography/MESSENGER/Mercury_Messenger_USGS_DEM_Global_665m **Mercury MESSENGER Global Colorized Shade 2km** Global DEM of Mercury from a least-squares bundle adjustment (jigsaw in ISIS3 [Becker 2016]) of common features, measured as tie point coordinates in overlapping NAC and WAC-G filter images. https://astrogeology.usgs.gov/search/map/Mercury/Topography/MESSENGER/Mercury_Messenger_USGS_ClrShade_Global_2km **MESSENGER Global Mosaic** 8-color (MDR) 64 ppd (all backplanes) 5-color (MP5) 128 ppd (all backplanes) 3-color (MP3) 128 ppd (all backplanes) Moderate incidence angle (BDR) 256 ppd (image plane only), 43 ppd (all backplanes) Low incidence angle (LOI) 256 ppd (image plane only), 43 ppd (all backplanes) East illumination (HIE) 256 ppd (image plane only), 43 ppd (all backplanes) West illumination (HIW) 256 ppd (image plane only), 43 ppd (all backplanes) http://messenger.jhuapl.edu/Explore/Images.html#global-mosaics
Data format (raw)	MDIS file extensions are: Experiment Data Record (EDR) Calibrated Data Record (CDR) Derived Data Record (DDR) Map Projected Multispectral RDR (MDR) and the raw format is: .IMG
Data format (processed)	For images: .jpg, .PNG, For data: .GeoTiff, .cub, .dat

Archiving URL (archive)	https://pds-imaging.jpl.nasa.gov/volumes/mess.html http://ode.rsl.wustl.edu/mercury/index.aspx https://pds-imaging.jpl.nasa.gov/search/index.html?ATLAS_MISSION_NAME:messenger
Preservation	Performed by NASA PDS
Acknowledgements	tba

Mapping products - Standard

Standard mapping products refer to existing USGS documentation (See D2.1 + USGS guidelines, and references therein), see also van Gasselt and Nass (2011).

Feature representation in GIS environment

To promote consistent representaiton across GIS software packages, the styling of GIS vector data will be provided in an open format. SLD standard, which stand for Styled Layer Descriptor, is an XML scheme which specifications are published by the Open Geospatial Consortium, and thus it constitutes the best practice in terms of open standards.

http://www.onegeology.org/wmsCookbook/7_4_5.html provides useful information about the creation of SLD files for geological maps. SLD files can then be easily used in most server side applications for serving maps over the internet.

Mapping products - non-Standard

3D geomodels

Three dimensional geological models provides a numerical representation of geological elements within a volume of interest.This is normally accomplished by following a BRep (Boundary Representation) strategy. Subvolumes of the model are defined by boundary surfaces, while surfaces are in turn bounded by lines and lines by end points. Geological planar elements that are modeled (i.e. faults, fractures and units contacts) are used to define the boundaries of subvolumes within the region in which the modeling is made. Volumetric elements, as e.g. the hanging wall block of a fault or a sedimentary body comprises in between two surfaces can thus be completely defined by specifying the specific role of one or more surfaces.

The numerical representation of three dimensional surfaces can be straightforward achieved by storing a lists of vertices, faces and edges (see e.g. https://en.wikipedia.org/wiki/Polygon_mesh#Representations). When it comes to geological models the relationship occurring between different surfaces must indeed be specified in an explicit way by grouping one or more surfaces in geologically meaningful object (e.g. an horizon, a fault, an unconformity). This kind of representation requires dedicated software and formats. Although recent efforts (see Pellerin, 2017, which also constitute a good introduction to the numerical representation of geological models) to create an unified library for the definition of 3d geological elements, there is still no widely-accepted representation standard, which must be evaluated case by case, depending on the specific needs. The Following table illustrates the expected outputs of 3D geological modeling software and its usage depending on the context. Each row (namely native/exchange/pure3d) represents a decreasing level of compexity and completeness of a 3D geological model as it is reduced to different numerical representations.

Product completeness level	Definition	Main expected usage	Pro	Cons
native	gocad/3dmove/leapfrog (or any other 3D geomodeling software packages) in native formats (projects)	INTERNAL	Perfect during model development and short term preservation.	Bad for archiving, programmatic access and injection in other WPs, because it is strongly tied to the specific software
exchange	Formats maintaining specific geological information about the surfaces and volumetric meshes. E.g. RINGMesh-supported formats or any other geological-aware data exchange format that might be suitable for a specific software-to-software exchange task	INTERNAL /CROSS SOFTWARE SHARING /POSSIBLY LONG-TERM PRESERVATION	The format can be accessed by the software packages of interest and maintain most of the geological information.	The formats might still not be the perfect solution for long-term preservation. Commercial packages can drop the retro-compatibility with some formats.
pure3d	Pure mesh representation (e.g. triangular meshes) without any predefined way of storing the geological meaning of the surfaces/volumes.	LONG TERM ARCHIVING /PUBLIC and WPs SHARING /OUTREACH **DELIVERABLES**	Perfect for long term preservation. Mainly ascii based formats and well-establishes IO libraries for accessing the files	These formats leave out information that is instead present in native and exchange level representations. Some of the information might be provided through metadata.

These different data representations are connected with a sort of data reduction pipeline going from high-to-low completeness. All the levels will be stored once generated although no level is mandatory. E.g. "native" level data can be transformed to "pure3d" level data for composing a deliverable without obtaining "exchange" level data. In the other hand "pure3d" level data might be directly generated for simple task where complex geomodeling software packages are not needed (via ad-hoc modeling strategies).

Complementary data and metadata

Geological constraints. Geological modeling software packages make use of constraints to build the geological model. These might be provided by either referreing to the specific product (either PLANMAP's or external) that was used as source of constraints or by providing them as a separated dataset within the metadata of the 3D model. In most of the cases the first strategy will sufficie although it is highly desirable to release also 3D constraints as numerical dataset by disclosing to the public "native" level data format or by providing specific supplementary materials. This strategy is meant to increase reproducibility and peer-validation of results.

Metadata, that are especially important for deliverables, must concisely document the geological meaning of each (or groups of) 3D meshes that are provided, their creators and the dataset that were used for their production. In addition to these information three dimensional models will be provided with all the data that might be needed to correclty identify and localize the modeled region (ROI of interest on map, projection system that has been used etc...).

Virtual reality products

There is currently no real standard in Virtual Reality (VR) in our field of research. VR is a domain which is very quickly evolving, after a major technological breakthrough which occurred in April 2016 when mature virtual reality headsets have been released to the public. The HTC Vive followed by the Oculus rift headsets (and the PSVR on Playstation) have been accessible at reasonable prices at the end of 2016. Low cost solutions have also appeared in parallel, based on cellphones (with the google Cardboard for example). Whereas providing less comfort and possibilities of interaction with the virtual world, these low cost solutions increased significantly the final number of potential users, but also of possible formats. At the time of writing, several new technological devices are about to be released, some further improving the experience and introducing for example mid-range wireless solutions.

As a consequence, standards for the developers are also very quickly evolving in this new field of research. In the framework of PLANMAP, we will produce 3D models (either from surface or satellite images) on landing sites that will be handled in formats such as .obj (with the corresponding .jpg textures and .mtl files). All the integration and interaction tools will be developed with softwares such as Unity, which allow to export executable files directly compatible with several VR systems. For simple models, new public exchange plateforms are currently growing very fast, and could serve to provide a quick worldwide and long-term free access in virtual reality to some of the most relevant 3D models. Sketchfab (https://sketchfab.com/) is one of these relevant emerging plateforms. The “destination” workshop in SteamVR could also be mentioned. The final choice of a repository for VR products will be made on a timely manner depending on which solution is gaining strength in the community in the coming monthes.

Existing solutions using WebGIS are for the moment not directly compatible with VR, but the main actors in the field (such as ArcGIS from ESRI) are currently doing active research to implement this VR facility in future releases. It should therefore be interesting to follow these developments in parallel during the course of the Planmap project.

Annex-B: File formats used and envisaged

File formats used for day-to-day activties and sharing, archiving might not be the same. PLANMAP envisages formats for both use and sharing, and archiving will be produced and these are indicated below. When relevant, appropriate PDS (PDS4) labels will be added to describe the data products, depending on actual arrangements with ESA on data delivery. Data shared via VESPA will not bear any PDS label and will contain metadata as needed for operating VESPA services and accessing and using data with commonly used geospatial software (e.g. GDAL/OGR-compatible).

Base formats depending on data type

Dataset type	Format	Common extensions	Products	Notes
Raster	GeoTiff with appropriate type and signedness (compressed or not)	.gtiff, .tif, .tiff	Imagery, possibly multi-band imagery and Digital Terrain Models	
	jpeg2000 (lossy or lossless)	.jp2 .jk2	Imagery for basemaps/mosaic for which higher compression rates is desirable	
	Portable network graphics	.png	Imagery for web publication and GIS, imagery intended only for visualization (i.e. grayscale/colour mosaics)	
	ASCII Gridded formats supported by gdal (arc/Info, GRASS, etc)	any [e.g. .txt, . grid, etc]	alternative to geotiff for Digital Terrain Models	geotiff is still preferable (e. g. no round-off errors)
	World (georeferencing) files	.twf, .pwf, .jwf (or similar)	Gereferencing information for raster dataset which is coupled with each raster file	
Vectors	ESRI Shapefile + DBF	.shp/.dbf (plus auxiliary files)	All mapping products in vector format	
	Geographical markups: JSON (GeoJSON)/XML (GML)	.json, .xml	Georeferenced products shareable on the web, WFS-served dataset	
	Relational DB (PostgreSql + PostGIS / SpatiaLite)	----	Dataset meant to be served by Web Feature Services [WFSs]	Internal use only

	Styled Layer Descriptors	.xml	XML files describing the styles to be used when displaying vector layers	
3D	Stanford Triangle Format, Wavefront OBJ, Stereolithography and comparable	.ply, .obj, .stl	Three dimensional meshes. Geological meaning must be provided by metadata.	Neutral file formats must be preferred. Might be equipped with texture files (i.e. for terrain with orthophoto)
	VTK File Formats	.vtu, .vtp, .vtk	Commodity format for data exchange. Useful for products that require the preservation of scalar fields associated to triangles or vertices of the meshes and scientific analysis via VTK.	
	Geological Aware Formats	application-specific	3D geological models from 3D geomodeling software packages	Neutral file formats must be preferred
Hierarchical archives	Planteary Data System (v3,v4)	.pds, .img	Archived dataset with variable content	

Other formats

Specific file formats might be used for either accessing mission-specific dataset or for use with specific software. These includes:

Flexible Image Transport System (FITS) ,Hierarchical Data Format (v4, v5), PDS label files (PDSv3 only), etc...

Annex-C: Data curation and preservation plans per partner

UNIPD

Data produced will be stored and backed up locally when possible as well as shared with JacobsUni for archiving and web-gis integration. Documentation on data production and pipelines used will be shared via git-hub and wiki. Metadata will be interactively improved during review and shared with JacobsUni for eventual updates. Preservation on premise after the end of the project will be attempted based on financial, human and computing resources. UNiPD has an institutional repository that is going to be used within PLANMAP activities to share data and mapping products: https://researchdata.cab.unipd.it/.

OU

Data produced will be stored and backed up daily as part of the OU automatic backup system, as well as shared with JacobsUni for archiving and web-gis integration. Documentation on data production and pipelines used will be shared via git-hub and wiki. Metadata will be interactively improved during review and shared with JacobsUni for eventual updates. Preservation on premise after the end of the project will be attempted based on financial, human and computing resources. Open University has an Open Access data sharing facility (Open research Data Online) that data can be uploaded to and accessed by the public: https://ou.figshare.com/.

An example of Planetary GIS data shared in this way can be found here: https://figshare.com/articles/Mercury_Catenae_Global_Survey_-_Shapefile/5466535

WWU

Data produced are stored and backed up locally on institute servers, which are backed up on a weekly basis on a university system. Each ArcGIS project and accompanying data sets, figures, and publications are archived on personal external drives, institute/university servers, and institute external drives. Preservation on premises after the end of the project will be attempted based on financial, human and computing resources. Management and documentation of the data is simplified for each project via use of a standard file organizational structure, including folders for documentation relating to each individual project (e.g., projection files, image processing scripts), different kinds of data, and different kinds of data products (e.g., CSFD measurement files/plots, figures, maps). General documentation is available locally and will be added to the wiki. Maps, data, and results will be released as per PLANMAP guidelines, and will accompany peer-reviewed publications either within the main manuscript or as supplemental online material.

INAF

TBA PLEASE

CNRS

Data produced are stored and backed up locally on a server maintained by the university. Data are backed up each 2-weeks using this system. Each mapping project and accompanying data sets, figures, and publications are also archived on personal external drives, institute/university servers, and institute external drives. Preservation on premises after the end of the project will be attempted based on financial, human and computing resources. General documentation is available locally and will be added to the wiki. Produced results will be released as per PLANMAP guidelines, and will accompany peer-reviewed publications either within the main manuscript or as supplemental online material.

JacobsUni

Data produced by JacobsUni will be stored during the project on premise as well as shared to all other partners via cloud and web mapping services, as well as backed up as much as possible given available computing resources. Documentation of data will be performed during the project using wiki and github. Metadata and documentation will be improved and - when detected - eventual mistakes corrected during the course of the project and reflected on saved data. Preservation on premise after the end of the project will be attempted based on financial, human and computing resources. Release of data via VESPA (distributed system), with possible duplication, for robustness, is planned. Release to ESA of data. Preservation of any other data or code /algorithm not performed via either VESPA or PSA, will be covered via release (see data citation section) on GitHub/Zenodo.

References

Anderson J. A., Sides S. C., Soltesz D. L., Sucharski T. L., and Becker K. J., 2004, Modernization of the Integrated Software for Imagers and Spectrometers, *Lunar Planet. Sci. Conf.* 35, 2039.

Barker M. K., Mazarico E., Neumann G. A., Zuber M. T., Haruyama J., and Smith D. E., 2016, A new lunar digital elevation model from the Lunar Orbiter Laser Altimeter and SELENE Terrain Camera, *Icarus* 273, 346-355.

Becker, K.J.; Robinson, M.S.; Becker, T.L.; Weller, L.A.; Turner, S.; Nguyen, L.; Selby, C; Denevi, B.W.; Murchie, S.L.; McNutt, R.L.; Soloman, S.C., Near Global Mosaic of Mercury, Eos, Vol. 90, Number 52, 29 December 2009, Fall Mtg. Suppl., Abstract P21A-1189.

Chin G., Brylow S., Foote M., Garvin J., Kasper J., Keller J., Litvak M., Mitrofanov I., Paige D., Raney K., Robinson M., Sanin A., Smith D., Spence H., Spudis P., Stern S. A., and Zuber M., 2007, Lunar Reconnaissance Orbiter overview: The instrument suite and mission: *Space Science Reviews* 129, 4, 391-419.

Jaumann, R., Neukum, G., Behnke, T., Duxbury, T. C., Eichentopf, K., Flohrer, J., ... & Hoffmann, H. (2007). The high-resolution stereo camera (HRSC) experiment on Mars Express: Instrument aspects and experiment conduct from interplanetary cruise through the nominal mission. *Planetary and Space Science*, *55*(7-8), 928-952.

Hawkins, S.E. III, Boldt, J.D., Darlington, E.H., Espiritu, R., Gold, R.E., Gotwols, B., Grey, M.E, Hash, C.D. , Hayes, J.R., Jaskulek, S.E., Kardian, C.J., Keller, M.R.,
Malaret, E.R., Murchie, S.L., Murphy, E.K., Peacock, K., Prockter, L.M., Reiter, R.A., Robinson, M.S., Schaefer, E.D., Shelton, R.G., Sterner, R. E., Taylor, H.W.,
Watters, T.R., Williams, D., 2007, The Mercury Dual Imaging System on the MESSENGER Spacecraft. *Space Sci. Rev.*131: 247–338. DOI: https://www.doi.org/10.1007/s11214-007-9266-3.

Haruyama, J., T. Matsunaga, M. Ohtake, T. Morota, C. Honda, Y. Yokota, M. Torii, Y. Ogawa, and the LISM Working Group, 2008, Global lunar-surface mapping experiment using the Lunar Imager/Spectrometer on SELENE, *Earth Planets Space* 60, 243-255.

Henriksen M. R., Manheim M. R., Burns K. N., Seymour P., Speyerer E. J., Deran A., Boyd A. K., Howington-Kraus E., Rosiek M. R., Archinal B. A., and Robinson M. S., 2017, Extracting accurate and precise topography from LROC narrow angle camera stereo observations, *Icarus* 283, 122-137.

Lucey, P.G., Blewett, D.T., Taylor, G.J., Hawke, B.R., 2000. Imaging of lunar surface maturity. J. Geophys. Res. 105.

Malin, M. C., J. F. Bell III, B. A. Cantor, M. A. Caplinger, W. M. Calvin, R. T. Clancy, K. S. Edgett, L. Edwards, R. M. Haberle, P. B. James, S. W. Lee, M. A. Ravine, P. C. Thomas, M. J. Wolff (2007), Context Camera Investigation on board the Mars Reconnaissance Orbiter, Journal of Geophysical Research, 112, E05S04, doi: 10.1029/2006JE002808.

McEwen, A. S., Eliason, E. M., Bergstrom, J. W., Bridges, N. T., Hansen, C. J., Delamere, W. A., ... & Kirk, R. L. (2007). Mars reconnaissance orbiter's high resolution imaging science experiment (HiRISE). *Journal of Geophysical Research: Planets*, *112*(E5).

Murchie S. , R. Arvidson, P. Bedini1 K. Beisser, J.-P. Bibring, J. Bishop, J. Boldt, P. Cavender, T. Choo, R. T. Clancy, E. H. Darlington, D. Des Marais, R. Espiritu, D. Fort1 R. Green, E. Guinness, J. Hayes, C. Hash, K. Heffernan, J. Hemmler, G. Heyler, D. Humm, J. Hutcheson, N. Izenberg, R. Lee, J. Lees, D. Lohr, E. Malaret, T. Martin, J. A. McGovern, P. McGuire, R. Morris, J. Mustard, S. Pelkey,9 E. Rhodes,1 M. Robinson,10 T. Roush, E. Schaefer,1 G. Seagrave, F. Seelos, P. Silverglate,1 S. Slavney, M. Smith, W.-J. Shyong, K. Strohbehn, H. Taylor, P. Thompson, B. Tossman, M. Wirzburger, and M. Wolff, Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on Mars Reconnaissance Orbiter (MRO), Journal of Geophysical Research, 112, E05S03, doi:10.1029/2006JE002682

Neukum, G., & Jaumann, R. (2004). HRSC: The high resolution stereo camera of Mars Express. In *Mars Express: The Scientific Payload* ESA Special Publication 1240, pp. 17-35).

Pellerin, J., Botella, A., Bonneau, F., Mazuyer, A., Chauvin, B., Lévy, B., Caumon, G., 2017. RINGMesh: A programming library for developing mesh-based geomodeling applications. Computers & Geosciences 104, 93–100. https://doi.org/10.1016/j.cageo.2017.03.005

Pieters, C. M., et al. (2009) The Moon Mineralogy Mapper (M^3) on Chandrayaan-1. Current Scienc, S. 500-505.

Robinson M. S., Brylow S. M., Tschimmel M., Humm D., Lawrence S. J., Thomas P. C., Denevi B. W., Bowman-Cisneros E., Zerr J., Ravine M. A., Caplinger M. A., Ghaemi F. T., Schaffner J. A., Malin M. C., Mahanti P., Bartels A., Anderson J., Tran T. N., Eliason E. M., McEwen A. S., Turtle E., Jolliff B. L., and Hiesinger H., 2010, Lunar Reconnaissance Orbiter Camera (LROC) Instrument Overview, *Space Science Reviews* 150, 81-124.

Rossi, A. P., Shin, J., Marco Figuera, R., Minin, M., Manaud, N. (2018) Mapping bibiometrics for Planetary Science, to be presented ad EPSC 2018, Vol. 12, EPSC2018-677-1, 2018

Rothery, D., et al, (2018) D2.1 - Mapping Standards Document- Planmap Deliverable - available online on D2.1-public

Sato, H., M.S. Robinson, B. Hapke, B.W. Denevi and A.K. Boyd (2104) Resolved Hapke parameter maps of the Moon, Journal of Geophysical Research: Planets, 119, 1775-1805, doi:10.1002/2013JE004580.

Scholten, F., J. Oberst, K.-D. Matz, T. Roatsch, M. Wählisch, E. J. Speyerer, and M. S. Robinson (2012), GLD100: The near-global lunar 100 m raster DTM from LROC WAC stereo image data, J. Geophys. Res., 117, E00H17.

Speyerer, E.J., Robinson, M.S., Denevi, B.W., and the LROC Science Team, 2011, Lunar Reconnaissance Orbiter Camera global morphological map of the Moon, Lunar Planetary Science Conference, Abstract #2387.

Thomas, N., Cremonese, G., Ziethe, R., Gerber, M., Brändli, M., Bruno, G., Erismann, M., Gambicorti, L., Gerber, T., Ghose, K., Gruber, M., Gubler, P., Mischler, H., Jost, J., Piazza, D., Pommerol, A., Rieder, M., Roloff, V., Servonet, A., Trottmann, W., Uthaicharoenpong, T., Zimmermann, C., Vernani, D., Johnson, M., Pelò, E., Weigel, T., Viertl, J., De Roux, N., Lochmatter, P., Sutter, G., Casciello, A., Hausner, T., Ficai Veltroni, I., Da Deppo, V., Orleanski, P., Nowosielski, W., Zawistowski, T., Szalai, S., Sodor, B., Tulyakov, S., Troznai, G., Banaskiewicz, M., Bridges, J.C., Byrne, S., Debei, S., El-Maarry, M. R., Hauber, E., Hansen, C.J., Ivanov, A., Keszthelyi, L., Kirk, R., Kuzmin, R., Mangold, N., Marinangeli, L., Markiewicz, W.J., Massironi, M., McEwen, A.S., Okubo, C., Tornabene, L.L., Wajer, P., Wray, J.J., 2017. The Colour and Stereo Surface Imaging System (CaSSIS) for the ExoMars Trace Gas Orbiter. Space Sci. Rev. https://doi.org/10.1007/s11214-017-0421-1

Tran T., Rosiek M. R., Beyer R. A., Mattson S., Howington-Kraus E., Robinson M. S., Archinal B. A., Edmundson K., Harbour D., Anderson E., and the LROC Science Team, 2010, Generating digital terrain models using LROC NAC images, in *ASPRS/CaGIS 2010 Fall Special Conference*, Orlando, Florida, http://www.isprs.org/proceedings/XXXVIII/part4/files/Tran.pdf.

van Gasselt, S., & Nass, A. (2011) Planetary mapping—The datamodel's perspective and GIS framework. Planetary and Space Science, 59(11-12), 1231-1242.

Wagner, R. V. Speyerer, E. J. Robinson, M. S., LROC Team, 2015, New Mosaicked Data Products from the LROC Team, 46th Lunar and Planetary Science Conference, Abstract #1473.