Mars Express
Archive Generation, Validation and Transfer Plan

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http://solarsystem.estec.esa.nl/MEXSOC/archiving

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	1.4	2001 June 20	added distribution information; applied comments from MaRS team; added column with delivery schemes to table G
Issue	1.0	2001 June 21	archive plan issued

Contents

List of Acronyms

ASCII	American Standard Code for Information Interchange
ASPERA	Mars Express Energetic Neutral Atoms Analyser Experiment
CDROM	Compact Disk Read Only Memory
DVD	Digital Versatile Disk
ESA	European Space Agency
ESOC	European Space Operations Center
HRSC	Mars Express High-Resolution Stereo Camera Experiment
MaRS	Mars Express Radio Science Experiment
MARSIS	Mars Express Subsurface Sounding Radar/Altimeter Experiment
MESDA	Mars Express Science Data Archive
NAIF	Navigational Ancillary Information Facility
NASA	National Aeronautics and Space Administration
NSSDC	National Space Science Data Center
OMEGA	Mars Express IR mapping spectrometer Experiment
PDS	Planetary Data System
PFS	Mars Express Atmospheric Fourier Spectrometer Experiment
SFDU	Standart Formatted Data Unit
SIS	Software Interface Specification
SPICAM	Mars Express UV Atmospheric Spectrometer
WDC	World Data Center

1 Introduction

1.1 Purpose

The purpose of this document is to provide a plan for generation, validation, and transfer of raw data, reduced data, documentation and software/algorithms from the European Mars Express mission to the Mars Express Science Data Archive (MESDA) of ESA.

1.2 Scope

The plan covers archiving of raw and reduced data sets and all information necessary for an interested scientist to read, understand and analyze the data long time after the mission has finished. Data from all mission phases including prelaunch - if appropriate - will be included.
Addenda to this plan will be published at a later date, if products generated by the Interdisciplinary Scientists are deemed appropriate. The next step in the archiving process, following this plan, is the detailed specification of the instrument data, the SIS (Software Interface Specification), due before delivery of the first data, expected soon after the launch of the spacecraft.
The Beagle-2 lander of Mars Express will be considered as one PI instrument concerning the data archiving.
Mars Express flight dynamics and other spacecraft ancillary information will be considered as one PI experiment concerning the data archiving.
Specific aspects addressed in this plan are:

- Generation of high-level mission, spacecraft and instrument documentation, instrument calibration reports, algorithms and documentation of software used to produce level 1 to 3 data records.
- Reduction of science packet data (e.g. SFDU packets) to reduced data records, including generation of data sets expressed in geophysical units, with associated documentation that determines when and where the data were acquired and for what purpose.
- Description of ancillary data formats from ESOC
- Generation and validation of archive volumes containing Mars Express data, software, algorithms, documentation and ancillary information.
- Delivery to MESDA (Mars Express Science Data Archive) .
- Delivery to the NSSDC for long term data preservation.

All schedules in this document are conform to the Mars Express Science Management Plan [Ref. 8] and other ESA rules, [Ref. 9], and EU directives, [Ref. 12]. All PDS concerned items are conform to the appropriate PDS documentation and guidelines, see [Ref. 3] and [Ref. 2].

1.3 Content

After the overview of the Mars Express mission and the mission phases, the science operations and the ground data segment will be described, followed by the definition of the archive structure and the archiving process. Then follows the responsibilities for institutes, organizations and personnel for archiving. The document finishes with the plans for data delivery.

Several tables and appendixes give information about data types, formats, data volumes, data rights and responsibilities, etc.
Not covered in this plan are the activities for data quicklook, outreach, educational purposes and other data handling issues.

2 Overview of the Mars Express Mission

The Mars Express spacecraft will be launched in June 2003 by a Soyuz class launch vehicle. The total spacecraft weight is about 1100 kg, including 106 kg of the scientific payload and 60 kg of the Beagle lander. The spacecraft is 3-axis stabilized and will be placed into an elliptical (250x11582km) Martian orbit of 86.35 deg inclination and 7.6 h period after a cruise phase of nearly 7 months. The nominal mission life time is one Martian year (687 days) with a possible extension of another Martian year. The Beagle-2 lander will be released just a few days before the spacecraft goes into its orbit.
The spacecrafts 1.8m high gain antenna will communicate with ESA's ground stations in Perth, Australia, Kourou, French Guiana and Sardinia, Italy, as well as the Deep Space Network, if feasible. During communication the spacecraft points to Earth thus imaging and radar experiments can not observe Mars.
The science planning is based on the concept of mission phases [Ref. 10] and scientific scenarios (TBC). There are four major mission phases identified, Near-Earth Commissioning, Cruise Phase, Nominal Orbital Phase and Extended Orbital Phase. The Nominal Orbital Phase consists of four components divided by the predicted data volumes. The Extended Orbital Phase consists of 4 components, further described in table **??**.
The Mars Express Mission has objectives that pertain to geoscience and atmospheric sciences. The primary geoscience objectives are to search for subsurface water and obtain a global high resolution map of the topography and of the mineralogic composition.
The primary atmospheric objectives are the precise determination of the atmospheric circulation and composition as well as the study of the interaction of the atmosphere with outer space. Mars Express objectives require mapping of most of the parameters in spatial and temporal dimensions. The intent is to generate a suite of products that depict atmospheric, surface and subsurface characteristics as a function of latitude, longitude, altitude and time. Table A lists the instrument on board of the Mars Express orbiter.
Beagle-2 Lander objectives are to search for subsurface life, image the landing site surroundings as well as the robotic activities, measure environmental conditions and to analyse solid probes. Table B lists the scientific instruments on Beagle-2.

3 Science Operations

The primary responsibility for developing the payload operations strategy for the Mars Express Scientific Mission will be with the Mars Express Science Working Team chaired by the Project Scientist.

The ground segment of the Mars Express mission will consist:

- Mission Operations Center
- Beagle-2 Lander Operations Center

– Project Scientist Team (PST)
– Operations Team at RAL

The science operations tasks of the orbiter will be split between the Project Scientist Team and the Operations Team at RAL. The Beagle-2 Lander Operations Center will be responsible for the Beagle-2 instrument operations.

3.1 Project Scientist Team

The Project Scientist and his team are situated at ESA/ESTEC. For critical mission phases as the commissioning phase the PST will be co-located to the MOC. The ESA archive team will coordinate the scientific data archive and report to the Project Scientist. The responsibilities of the PST are: to be written

3.2 Operations Center at RAL

to be written

3.3 Beagle-2 Lander Science Operations

to be written

4 Overview of Archiving Functions

4.1 Introduction

The ESA Mars Express Data Archive is a set of *archive collections*. An *archive collection* itself is a group of related *data sets*, supplemental data, software and documentation that are logically linked to facilitate their use and administration. All this information is stored on one or several raw data media which are called *archive volumes*. For online publication, the term *archive collection* is used and not further broken down. Table M shows the proposed Mars Express *archive collections*.
All raw data, calibrated data, derived data, multiple-instrument merged data, calibration software and documentation will be archived. The structure of a typical archive volume is given in table K.

4.2 Data Flow and Archive Generation

The Mars Express Mission Operations Center at ESOC, Darmstadt, will provide the instrument SFDU data packets as well as all spacecraft ancillary data on the Data Distribution System (DDS) for at least 3 weeks ([Ref. 1]) after the data have been captured from the spacecraft. All the lander instrument data are transferred as a whole to the Lander Operations Center in XX, UK. The orbiter instrument teams request or download their data from the DDS, the lander instrument teams from the Lander Operations Center. ESOC will keep the data on the DDS for at least 3 weeks (tbc) and will create a physical copy (CD,DVD,tbc) of the data and

ship these in regular intervals to the principal investigators and PST. Concerning the scientific data archive, an instrument team works on consecutive data of 6 months length (Archive Data Collection Phase). The Archive Data Collection Phase is followed by an Archive Preparation Phase of 3 months duration. The Archive Preparation Phase ends with the delivery of the PDS labeled data sets from the Archive Data Collection Phase to the ESA archive team. See 6 for a detailed schedule.
The individual delivery times will be discussed with the instrument teams such that for the PST the data reception from the different teams is spread out over time. The delivery will be electronically.
The interface of the data exchange and the usage and definition of appropriate software and database tools to support a required archive functionality is defined in [Ref. 11].
The ESA archive team combines the instruments sets to *archive collections* during the Archive Merge Phase. See Figure 1 for a conceptual diagram of the data flow.

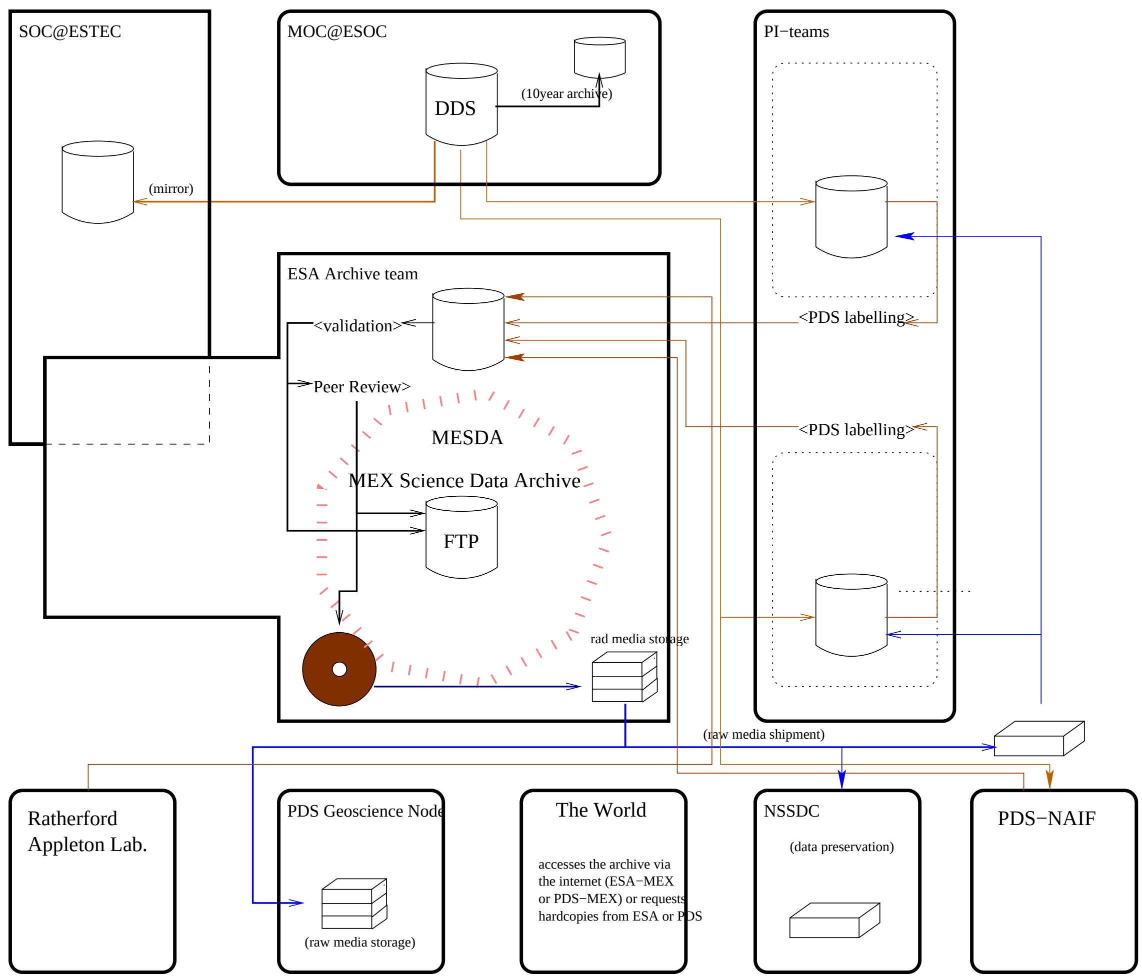

Figure 1: Mars Express Data Flow Overview

4.3 Validation and Delivery

Within 3 months of the reception from the teams, the ESA archive team generates the archive, validates the data and calls in a *Peer Review*. We name this period the Archive Merge Phase. 6 months after the Archive Data Collection Phase, the ESA archive team will publish the PDS

labeled data online (WWW,ftp). This is the online MESDA and *the* official Mars Express data archive.
Archive Collections of uncalibrated data (data level 1b) will be written on a physical medium (tbc) after the *Peer Review* and distributed. These *Archive Collections* are considered to be stable (will not improve or change over time) and are the final data product for level 1b.

Archive collections of calibrated data will be published on a public network. These data sets are expected to improve over time due to better knowledge of the instrument and calibration. Revision control, - a PDS functionality exists - is applied to these data sets and will be made visible to the online user. All *archive collections* containing improved calibrated (level 2) or highler-level (level 3) data will be reissued as soon as available from the instrument teams to the ESA archive team. All *archive collections* calibrated data from the nominal mission phase will be written on physical media 6 months after the nominal mission phase ends.
Appropriate rules apply for an extended mission.
Details of the *archive collections* and proposed *archive volumes* are given in table M.
Each PI team will receive one copy of the *archive volumes*. *Archive volumes* are raw media, and will be distributed via postal mail. No costs will be involved for instrument teams and the interested PDS nodes. Other interested parties can order additional *archive volumes* from ESA paying the postal costs.

4.4 Data Distribution

As the MESDA is *the* official Mars Express data archive, some teams want to distribute in addition their own data sets from their home institutes or experimenters with U.S. contributions want to distribute in addition their data sets via a PDS discipline node. These distributions have to be identical copies of the MESDA data sets. For planned distributions, please see L.

4.5 PDS consultancy

The disciplinary nodes and the main node of the Planetary Data System, especially the Geoscience Node at the Washington University at St. Louis, U.S.A., will support the ESA archive team and the instrument teams by giving consultancy on request basis. Further going support can be requested and will be discussed when applicable. All activities between the PDS nodes and the instrument teams will be transparent for the ESA archive team. All activities between the ESA archive team and PDS nodes will be transparent for all the instrument teams.

4.6 Standards

Concerning data structures and format, the PDS standards will apply. The teams delivering software products for the archive collections are not required to follow the ESA standards PSS-05 or ECSS. The software should however be delivered in such a way, that understandability and reproduction of the computational steps is garanteed.

5 Roles and Responsibilities

5.1 Responsibilities of each Instrument Team

Each instrument team is responsible for

1. Formatting all data files to PDS standards, for describing completely the calibration and basic reduction procedures, for providing any software (as documented source code) and data files that might be appropriate for recalibration or reprocessing, and for providing all calibrated data files.
2. Providing electronic copies of all documents needed to describe the instrument and its operation. Each instrument team is responsible for ensuring that there are no copyright restrictions on reproducing the documents in the scientific archive.
3. Ensuring that the electronic documents are in a format that is acceptable to PDS. Normally this means that critical documents must be provided in a plain ASCII format in addition to any format that includes formatting information. This, in turn, means that documents not provided with an ASCII version will be considered optional extras.
4. Providing higher level products to the archive. These are detailed in "Supplement A: Higher Level Data Products' of this archive plan. Each instrument team is responsible for collaborating with the IDS's (Interdisciplinary Scientist) to ensure that higher-level products based on data from the appropriate instrument are properly archived.
5. Providing suitable parameter tables that contain important instrumental parameters that are not included as keywords in the labels.
6. Providing index tables to enable searching for desired data files in a straightforward manner. The index tables may be combined with the parameter tables if appropriate.
7. Solving problems which have been identified on their data sets.
8. Distribution of the data from its instrument to all members of the instrument team.

5.2 Responsibilities of ESOC

ESOC is responsible for

1. Providing to each of the instrument teams up-to-date information on the attitude and orbital position of the spacecraft at the time of all observations by any instrument.
2. Providing to the MESDA-team complete details of the orbit and attitude of the spacecraft throughout the mission. This may involve some software tools, at the very least interpolating tables with the appropriate precision, as well as the appropriate data tables, all prepared according to PDS standards.
3. Providing retroactive updates to the orbital and attitude data products whenever the precision is significantly improved.
4. Providing to the MESDA-team the complete SFDU-labeled telemetry stream.
5. Long term storage of the level 1a data

5.3 Responsibilities of Interdisciplinary Scientists

Interdisciplinary scientists who develop higher-level data products are responsible for providing those products to the MESDAteam with all required ancillary information formatted and documented according to PDS standards. These higher-level data products may include products based solely on data from one instrument or from a combined data source from different instruments.

5.4 Responsibilities of the ESA archive team

The MESDA-team is responsible for

1. Ensuring the usability of the archive by other scientists; this includes advising on understandability of documentation, suitability of formats, etc
2. Ensuring preservation of a long-term copy of the SFDU-labeled telemetry stream, although this product will not be a part of the scientific archive. This will be obtained directly from ESOC and need not be provided by any instrument team.
3. Advising the instrument teams regarding appropriate formats for the data from their instrument.
4. Coordinating any media containing data from several instruments, other than any coordination voluntarily undertaken by some instrument teams.
5. Validating the delivered data from the PI teams to be conform to the PDS format standard.
6. Conducting all peer reviews of the instrument data, with support from the appropriate instrument team as needed.
7. Depositing the final archive with "deep archiving" organizations including NASA's NSSDC and appropriate World Data Centers.
8. Distributing the raw data media to the PI teams and the interested PDS discipline nodes.
9. Distributing the raw data media to interested parties in the worldwide scientific community.
10. Supporting the ESOC-auxiliary data to SPICE kernels tranformation software and make the computed SPICE kernels available to the instrument teams on a public network.
11. Creating and maintaining the online data archive well beyond the end of the official Mars Express mission.
12. transferring all tasks, information and responsibility after the end of the Mars Express mission to the Planetary Archive Group (TBD) of the Space Science Department of ESA.

5.5 Responsibilities of Other Organizations

Organizations such as NASA's NSSDC (National Space Science Data Center) and the WDC (World Data Center) are responsible for ensuring long-term preservation of the archive. Organizations TBD are responsible for providing suitable versions of the archive for educational and outreach users.

PDS is offering advice, examples, and software tools to instrument teams to help them design and validate data products and archive volumes.

The NASA's PDS discipline node Navigational Ancillary Information Facility (NAIF) will design a transformation software tool to generate automatically Mars Express orbit and attitude SPICE kernels. The NAIF team will with the help of the individual instrument teams, the Flight Dynamnics Team and PST design and support necessary instrument, spacecraft and timing kernels. The kernels will be distributed by NAIF and the ESA archive team.

6 Delivery Schedule

The ESA-PDS archive will by all means respect the data rights defined in [Ref. 8] and [Ref. 9]. Satellite and instrument data will be available shortly after the observations have been done at the ESOC Data Distribution System, see [Ref. 1]. It is in the responsibility of the PI to download this data asap and check for data completeness. The data on the DDS will be available for at least 2 weeks. ESOC will store and preserve these data for at least 10 years.

After the Beagle-2 lander delivery to Mars, the lander instrumentation will observe for 6 months (nominal lifetime). Three months after the end of the nominal lifetime, the lander instrument teams will deliver their data sets to the Beagle-2 Science Operations Center (tbc) who will integrate all the different data sets to form the Beagle-2 scientific data archive. Together with the ESA archive team, a peer review will be called. After a successful peer review (or after the liens are solved) the Beagle-2 archive is delivered the ESA archive team (tbc). The Beagle-2 archive will be distributed from both teams and whenever a better - e.g. with new calibration information - data set is delivered to the Beagle-2 archive team, the data set will also be delivered to the ESA archive team.

During the nominal mission of the orbiter, a 6 months period will be taken as the underlying scientific archive baseline.

– 6 months of data collection - and of course validation, calibration, analysis, etc; (scientific archive data collection phase)
– followed by additional 3 months which ends in the archive preparation and (proprietary, validation and archive preparation phase)
– the delivery to the ESA archive team;
– within the following 3 months the ESA archive team ensures the correctness of the archive, merges the instrument contributions to prepare for online distribution and calls in and arranges a *Peer Review* of the data sets for the first and last delivery of data (archive merge and generation phase); if it should be required or demanded by the PI's, additional *Peer Reviews* can be called in after other data deliveries to the archive team;
– scientific data will be available online 6 months after the data collection phase;
– after a successful *Peer Review* or after problems (*liens*) are solved, the archive will be transferred to a physical device (e.g. CDROM or DVD) and distributed to the PI teams and interested scientific community as soon as possible (tbc). Calibrated scientific data

which are likely to be improved during the mission lifetime, will be stored on physical media when the calibration is stable or latest 6 months after the end of the nominal mission lifetime. Individual agreements with instrument teams will be made and appended to this archive plan.

For a visualization of the delivery scheme, see Figure 2.

Scientific and engineering data collected during the near-Earth commissioning phase and the cruise phase, will be archived too. A delivery to the community (and online distribution) will be dependent on the usefulness of the archive and be decided by the Project Scientist.

When encountering problems during the archiving process by any of the involved parties during the preparation of the instrument part or the merged part, the ESA archive team will publish the archive as it is on a public network when the 6+6 month period is finished, after consultation with the Project Scientist. If an experimenter is convinced that the data set should not be published, he should bring his concern to the Project Scientist, who decides on this issue. Still existing uncertainties about calibrated or raw data will be indicated to users of the online distribution. Preparations of physical media are based on the certainty of a good data set.

ESA will publish all available data sets on a public network for long-term access for the scientific community. The data sets on the archive will be improved and updated - as well as the technical equipment - for at least 10 years after the mission ends.

9 months after the end of the Mars Express mission, the ESA archive team expects the last routine delivery from the instrument teams. In addition, all data which have been recalibrated or reprocessed since the launch are expected to be delivered. If necessary, a redistribution on physical media will be done. Experimenters are welcome to deliver further data sets and information to the ESA archive team team in the then following 10 years, so to ensure the accessibility of the latest calibration and processing efforts.
Spacecraft Auxiliary data, especially orbital data, will be improved and redistributed as long as needed, at least one redistribution at 12 months after the end of the mission is foreseen.

The data sets on the physical media will be shipped to the experimenter teams and to scientific institutes immediately after production. A set of 100 copies will be shipped to the PDS Geoscience Node (tbc), where American scientists may request and order them. One set of data will go to the NSSDC for long-term data preservation. A set of 200 copies will be stored at the ESA publication service, where scientists world-wide can order these data sets on request.

Delivery schedules for individual instruments to the ESA archive team will be negotiated timely in order to balance workload for the ESA archive team. In the case that an instrument team indicates an earlier delivery or a continuous delivery (e.g. weekly, daily), the ESA archive team will engineer a solution to fulfil the instrument team requirements on an individual basis.

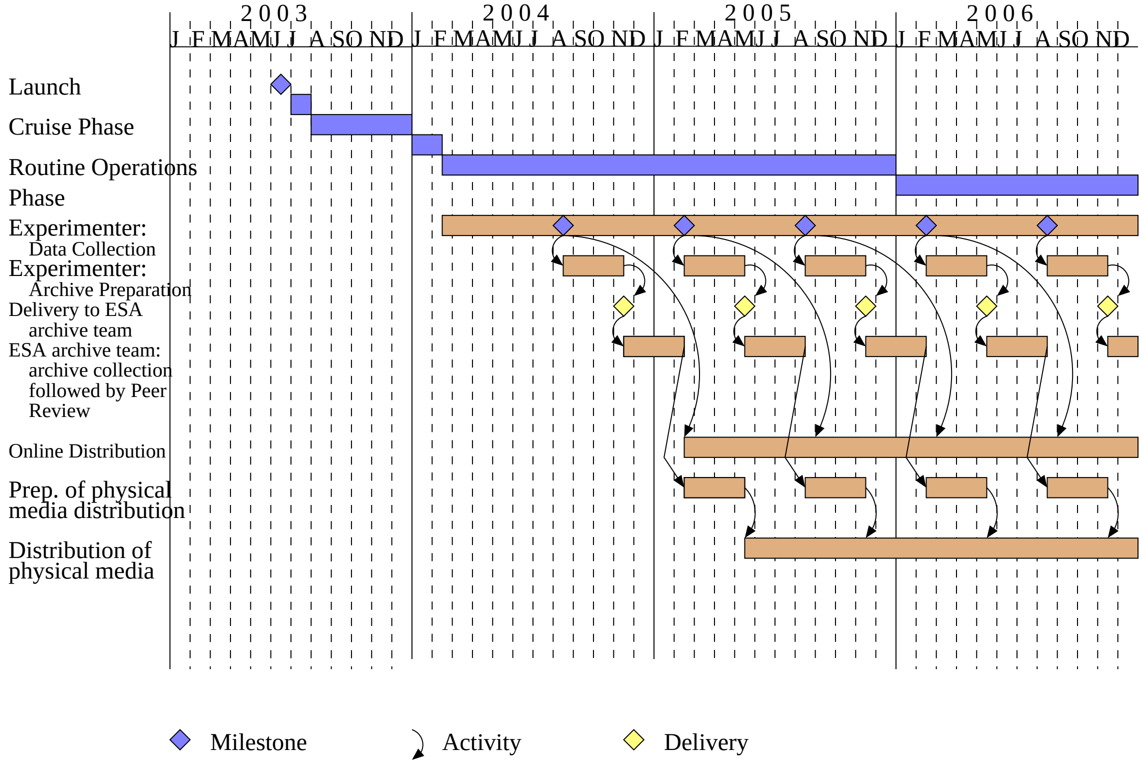

Figure 2: Mars Express Scientific Data Archive Schedule

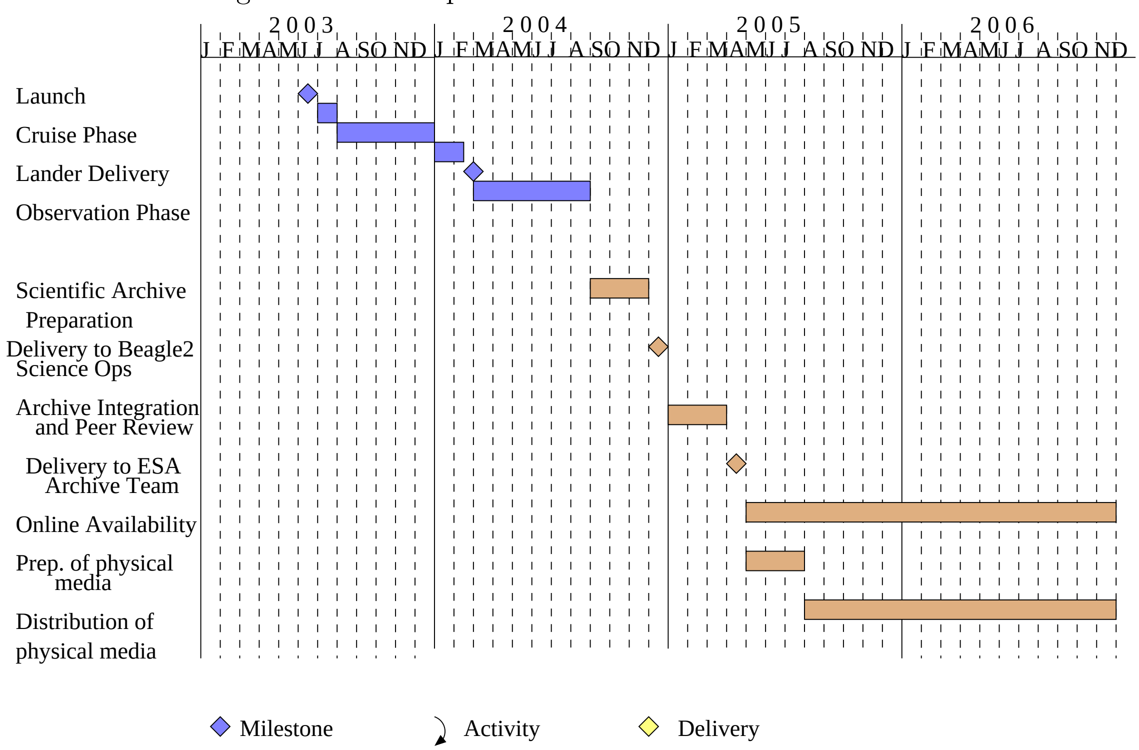

Figure 3: Beagle-2 Scientific Data Archive Schedule (tbc)

A Mars Express Orbiter Instruments

Mars Express Orbiter Instruments

HRSC (High Resolution Stereo Imager)	G. Neukum, DLR, Berlin	Stereo color images at resolution of 10-30m. 10 different CCD's are used. Two pairs of 5 CCD's are taking images from different angles and allow 3D representations. Selected sides can be imaged by a high-resolution channel with a resolution of 2m
OMEGA (IR mapping spectrometer)	J.P. Bibring,	Emitted radiance from $0.5 - 1.0\mu m$ (visible) and from $1.0 - 5.2\mu m$ (IR) from surface. Dependant on the orbit, the resolution will range from 300m to 4km
PFS (Atmospheric Fourier Spectrometer)	V. Formisano	Similar to OMEGA, but measures over a wider wavelength range ($1.2 - 45\mu m$) with lower resolution and is thus better suited to measure molecules in the atmosphere.
MARSIS Subsurface Sounding Radar/ Altimeter)	G. Picardi	A ground penetrating radar operating at 1.3-5.5 MHz from a 40 m long antenna. During Marsian daytime, the radar sounds ionosphere.
ASPERA (Energetic Neutral Atoms Analyser)	R. Lundin	Energetic neutral atom detector and neutral particle detector. The neutral particle detector will provide information on individual hydrogren and oxygen atoms whereas the neutral atom detector provides information of the energetic regions and no information on the atoms itself.
SPICAM (UV Atmospheric Spectrometer)	J.L. Bertraux	Composition of the atmosphere is derived from two sensors, one for UV light (118-320 nm), and the other for IR light (1-1.7 micron). Ozone (250nm absorbtion) can be measured with a column cross section of 10 km2.
MaRS (Radio Science Experiment)	M. Pätzold	Two radio downlinks on Mars Express, one in the X-band (8.4 GHz) the other in the S-band (2.3 GHz), will be used for probing the neutral atmosphere and ionosphere, mapping the planets gravity field, measuring the Martian surface roughness and probing the solar corona during two solar conjunctions

B Beagle-2 Lander Instruments

descent phase		Environmental Sensors (ESS)	M. Sims (Leicester U.) J. Zarnecki (Open U.)	Accelerometers, uni-axial (Z) g measurements during entry and descent; tri-axial measurement of g for reconstruction of entry trajectory and analysis of upper atmosphere density and pressure
surface ops.	lander based	Gas Analysis Package	I. Wright (Open U.)	measurements of carbonates; characterization of organics, isotopic composition, trace of noble gases, ages of rock
		Environmental Sensors (ESS)	M. Sims (Leicester U.) J. Zarnecki (Open U.)	wind sensor, oxide sensor, pressure sensor, temperature sensor, dust sensor, UV sensor, radiation sensor
	robotic arm based	X-ray spectrometer (XRS)	G. Fraser (Open U.)	elemental chemical analysis of rocks and soils precise measurements of K for isotopic dating (K-Ar) of samples
		Mössbauer spectrometer	G. Klingel-höffer TU-Darmstadt	Identification of Fe bearing phases; oxidation state of Fe bearing minerals; relict environmental conditions vi Fe carbonates, sulphates, nitrates, etc; soil oxidation and magnetic phases; detection of nanophase and amorphous hydrothermal Fe minerals
		Stereo Camera System	A. Kriffiths MSSL, CSEM	Terrain reconstruction; multi-spectral panorama robotic arm navigation; optical properties of the atmosphere, wide-angle camera
		Microscope	N. Thomas MPAE, Lindau	dust coatings; rock and soil texture; coarse mineralogy; micro structures
		PLUTO-Mole	L. Richter DLR-Cologne UNII Transmaster St. Petersburg	soil sample acquisition; temperature measurement geotechnical properties of subsurface; sample delivery to GAP
		PLUTO-Corer	xx DLR-Cologne Honkong Poly. University	sample extraction from rocks; sample delivery to GAP
		PLUTO-Grinder	xx DLR-Cologne	removal of weathering rind from the rocks; preparation of a flat surface for spectrometers

C Mars Express Mission Phases and Total Data Volume

6 months archive phases	data volume [GBytes]	nr of 8.2 GBytes DVD
1/04 - 6/04	32	3
7/04 - 12/04	18	2
1/05 - 6/05	44	5
7/05 - 12/05	146	17
1/06 - 6/06	51	6
7/06 - 12/06	17	2
1/07 - 6/07	27	3
7/07 - 11/07	28	3

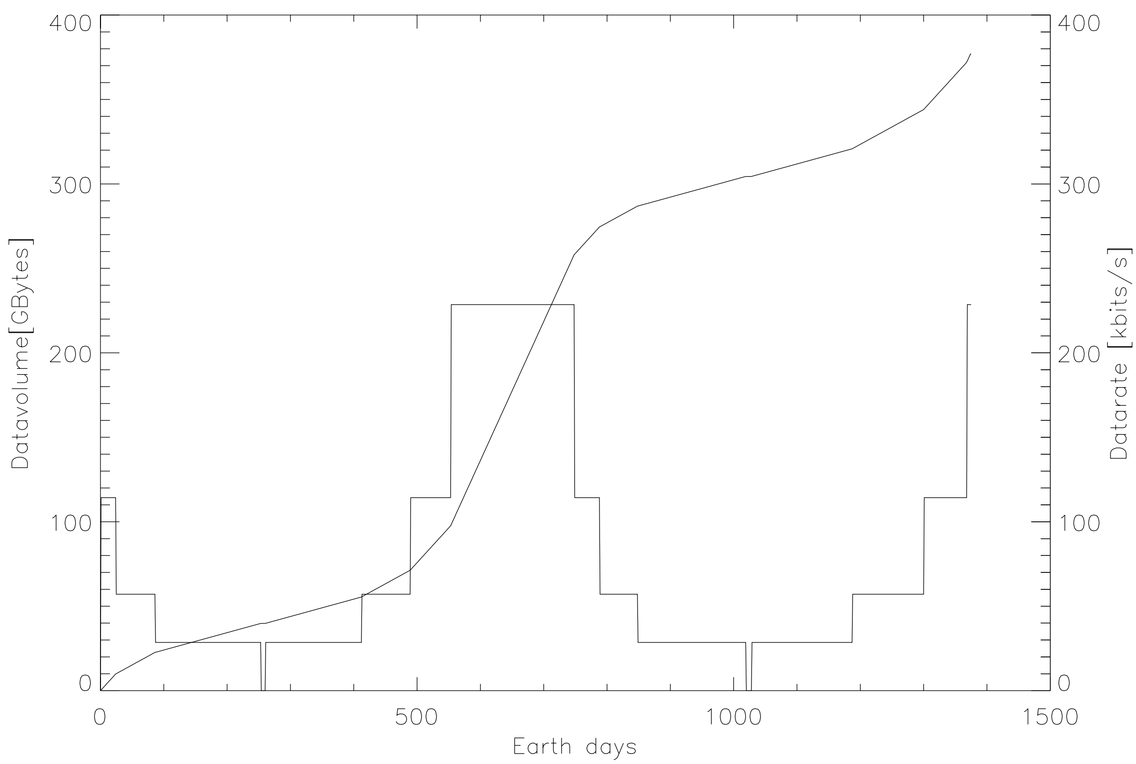

Figure 4: Data Volume over Mission and Data Rate

Upper table and image is based on the *datarate file provided by ESOC. The file is dated June 2000.*
The values represent the brutto data rate:

- *spacecraft housekeeping not considered*
- *data volume from lander not considered*
- *based on 8 hours communication time per day*
- *radio science data volume not considered*
- *instrument compression not considered*
- *represents level 1b data in best case*

D Standard Data Products, Orbiter Experiments

High Resolution Stereo Camera HRSC	HRSC-SR-SDP super resolution image standard data product HRSC-LS-SDP line sensor image standard data product HRSC-DEM digital elevation models HRSC-GMI global map image HRSC-CM color mosaics
OMEGA	
Planetary Fourier Spectrometer PFS	PFS-IFG raw interferogram data PFS-SPC raw spectra data PFS-OBS other observational data PFS-GDAD global derived atmospheric data PFS-GDSPM global derived surface property maps
Subsurface Sounding Radar MARSIS	MARSIS_SS1 subsurface sounding, mode 1 MARSIS_SS2 subsurface sounding, mode 2 MARSIS_SS3 subsurface sounding, mode 3 MARSIS_SS4 subsurface sounding, mode 4 MARSIS_SS5 subsurface sounding, mode 5 MARSIS_AI active ionosphere sounding MARSIS_PI passive ionosphere sounding MARSIS_REC passive mode, receive only MARSIS_CAL hardware calibration MARSIS_ATLAS subsurface sounding maps
ASPERA	ASPERA-NPI-Science neutral particle imager science data ASPERA-NPI-Eng neutral particle imager housekeeping data ASPERA-NPD-Science neutral particle detector science data ASPERA-NPD-Eng neutral particle detector housekeeping data ASPERA-IMA-Science ion mass analyzer science data ASPERA-IMA-Eng ion mass analyzer housekeeping data ASPERA-ELS-Science electron spectrometer science data ASPERA-ELS-Eng electron spectrometer housekeeping data ASPERA-SU-Science scanning unit data ASPERA-SU-Eng scanning unit housekeeping ASPERA-DPU-Eng data processing unit housekeeping ASPERA-OA-GRF orbit and attitude data in galactic frame ASPERA-OA-SRF orbit and attitude data in s/c reference frame
SPICAM	SPICAM-Raw experiments data record SPICAM-Cor same as raw, with calibration and corrections applied SPICAM-Atm atmospheric transmission (altitude and wavelength) SPICAM-Limb limb brightness absolute units (altitude and wavelength) SPICAM-Disk disk brightness absolute units (latitude, longitude and wavelength)
Mars Express Orbiter Radio Science Experiment MaRS	MaRS-ATDF raw doppler data and doppler MaRS-ODR raw voltage samples MaRS-IFMS raw ranging MaRS-IFMS raw doppler MaRS-FCL doppler closed MaRS-RNG ranging MaRS-AOL power spectra MaRS-FOL doppler open MaRS-POL polarisation

Table entries represent the knowledge at the issueing date of this document (version 1.0) and are likely to be improved and changed during the process of the archive preparation.

E Standard Data Products, Beagle Lander Instruments

Gas Analysis Package GAP	GAP-MS-RAW GAP-HK-RAW GAP-ISO-RAW GAP-ISO-COR GAP-SC	Raw mass spectral data Raw HK data (furnace temps, gas pressures, MS operating parame Raw isotope ratio data (unknown and onboard reference samples) Corrected isotope ratio data (unknown and onboard reference samp Stepped combustion data (i.e. temperature, time, gas yield, isotope
Stereo Camera System SCS	SCS-SINGLE SCS-STEREO SCS-PAN-FLAT SCS-PAN-STEREO SCS-PAN-COLOUR SCS-PAN-GEOL SCS-SOLAR-SINGLE SCS-SOLAR-MULTI SCS-DEM-WORK SCS-DEM-SITE MIC-MAP MIC-COLOUR MIC-FLOUR	Single 1024 x 1024 x 16bit frame = 2Mb Stereo pair (ignoring overlap) = 4 Mb Flat panorama with 1 filter (requires 36 images) = 72 Mb Stereo panorama with 1 pair of filters (requires 2 x 23 images) = 9 Colour panorama (RGB filters) = 216Mb (flat) or 276 Mb (stereo) Geology panorama (RGB filters) = 216Mb (flat) or 276 Mb (stereo Single solar filter image (30 x 30 pixel sub frame) = 1.8kb Six solar filters (single time) observation = 10.8kb Digital Elevation Model of the in-situ working zone Digital Elevation Model of the landing site 3D surface elevation map Colour image Fluorescence image
X-Ray Spectrometer XRS	XRS-MCA XRS-DIAG XRS-COMP	Multi-Channel Analyzer mode (i.e. temperature corrected histogra Diagnostic Mode (raw data, each event stamped with temperature) Table of elemental compositions (major/trace elements versus weig
Mssbauer Spectrometer MBS		
Environmental Sensor Suite ESS		
Rock Corer Grinder RCG	RCG-PP	Power profiles (coring, grinding, translation table)
PLUTO	PLUTO-PP PLUTO-HK	Power profiles (winch, hammer and lock motors) Temperature monitor, winch pot etc

Table entries represent the knowledge at the issueing date of this document (version 1.0) and are likely to be improved and changed during the process of the archive preparation.

F Standard Data Products, Spacecraft Housekeeping

to be written

G Types and Sizes of Standard Data Products, Orbiter Experiments

Used PDS data types: TOV for Time Ordered Vector, CUBE for Cube, GP for Gridded Product, TOS for Time Ordered Scalar, TABLE for Table, MDA for multi-dimensional array

Description and Acronym	Data Type	Data Level	Delivery Scheme	data set size
PFS-IFG raw interferogram data	TOV	1b	A	
PFS-SPC raw spectra	TOV	1b	A	
PFS-GDAD global derived atmospheric data	GP GP	3 3	C C	
PFS-GDSPM global derived surface property maps	GP GP	3 3	C C	
PFS-OBS other observational data	TOV	1b	A	
HRSC-SR-SDP super resolution image standard data product	GP	1B	A (tbc)	
HRSC-LS-SDP line sensor image standard data product	GP	1A	NO	
HRSC-DEM digital image standard data product	GP	3	C (tbc)	
HRSC-DEM digital elevation models	GP	3	C (tbc)	
HRSC-GMI global map image	GP	3	C (tbc)	
HRSC-CM color mosaics	GP	3	C (tbc)	
MARSIS-SS1 subsurface sounding mode 1	TOV	1B	A	
MARSIS-SS2 subsurface sounding mode 2	TOV	1B	A	
MARSIS-SS3 subsurface sounding mode 3	TOV	1B	A	
MARSIS-SS4 subsurface sounding mode 4	TOV	1B	A	
MARSIS-SS5 subsurface sounding mode 5	TOV	1B	A	
MARSIS-PI passive ionosphere sounding	TOV	1B	A	
MARSIS-AI active ionosphere sounding	TOV	1B	A	
MARSIS-CAL hardware calibration	TOV	1B	A	
MARSIS-RAW raw data	TOV	1B	A	
MARSIS-REC receive only	TOV	1B	A	
MARSIS-ATLAS maps	CUBE	3	C	

Description and Acronym	Data Type	Data Level	Delivery Scheme	data set size
ASPERA-NPI-Science	TABLE (tbc)	1B	A	
ASPERA-NPI-Eng	TOS (tbc)	1B	A	
ASPERA-NPD-Science	MDA (tbc)	1B	A	
ASPERA-NPD-Eng	TOS (tbc)	1B	A	
ASPERA-IMA-Science	MDA (tbc)	1B	A	
ASPERA-IMA-Eng	TOS (tbc)	1B	A	
ASPERA-ELS-Science	MDA (tbc)	1B	A	
ASPERA-ELS-Eng	TOS (tbc)	1B	A	
ASPERA-SU-Science	TABLE (tbc)	1B	A	
ASPERA-SU-Eng	TOS (tbc)	1B	A	
ASPERA-DPU-Eng	TOS (tbc)	1B	A	
ASPERA-OA-GRF	TOS (tbc)	1B	A	
ASPERA-OA-SRF	TOS (tbc)	1B	A	
SPICAM-raw raw data	SPECTRA	1B	A	
SPICAM-cor corrected data	SPECTRA	2	A	
SPICAM-atm atmospheric data	SPECTRA	3	A	
SPICAM-limb limb brightness	MDA (TBC)	3	A	
SPICAM-disk disk brightness	MDA (TBC)	3	A	

Schemes for Delivery:

- A: delivery every 6 months as given in Delivery Chapter
- B: delivery of calibration files and software every 6 months and delivering of calibrated data sets latest 6 months after end of nominal mission;
- C: delivery of level 3 data when available

H Types and Sizes of Standard Data Products, Beagle-2 Lander Experiments

Used PDS data types: TOV for Time Ordered Vector, CUBE for Cube, GP for Gridded Product, TOS for Time Ordered Scalar, TABLE for Table

Description and Acronym	Data Type	Data Level	data set size
GAP-MS-RAW raw mass spectral data	TALBE (tbc)	1b (tbc)	
GAP-HK-RAW housekeeping data	TOS (tbc)	1b	
GAP-ISO-RAW raw isotope ratio	TABLE (tbc)	1b (tbc)	
GAP-ISO-COR corrected isotope ratio	TABLE (tbc)	1b (tbc)	
GAP-SC stepped combustion data	TOS (tbc)	1b (tbc)	
SCS-SINGLE single image	GP	1b (tbc)	
SCS-STEREO stereo image	GP	1b (tbc)	
SCS-PAN-FLAT flat panorama image	GP	2 (tbc)	
SCS-PAN-STEREO stereo panorama image	GP	2 (tbc)	
SCS-PAN-COLOUR color panorama image	GP	2 (tbc)	
SCS-PAN-GEOL geology panorama image	GP	2 (tbc)	
SCS-SOLAR-SINGLE 1x solar filter image	GP	1b (tbc)	
SCS-SOLAR-MULTI 6x solar filter image	GP	1b (tbc)	
SCS-DEM-WORK digital elevation model	GP	2 (tbc)	
SCS-DEM-SITE DEM of landing site	GP	2 (tbc)	
MIC-MAP 3D microscope surface elevation map	GP	1b (tbc)	
MIC-COLOUR microscope color image	GP	1b (tbc)	
MIC-FLOUR microscope fluorescene image	GP	1b (tbc)	
XRS-MCA multi-Channel Analyzer mode	TABLE (tbc)	1b (tbc)	
XRS-DIAG diagnostic Mode	TOS (tbc)	1b (tbc)	
RCG-PP power profiles	TOS	1b (tbc)	
PLUTO-PP power profiles	TOS	1b (tbc)	
PLUTO-HK temperature monitor, etc	TOS	1b (tbc)	

I Descriptive Summary of Standard Data Products, Orbiter Experiments

Below are brief descriptions of each of the Mars Express Standard Data Products. Each Standard Data Product is identified by an Mars Express Scientific Data Archive Identifier and is followed by a product acronym.

PFS-IFG	Raw interferogram data from the PFS instrument
PFS-SPC	Raw spectra data from the PFS instrument
PFS-GDAD	Calibrated and atmosphere corrected and derived radiance observations from Mars atmosph
PFS-GDSPM	Calibrated, derived radiance observations resulting in surface property maps
PFS-OBS	Other raw, calibrated and atmosphere corrected observations from PFS, e.g. received power vs. time profile sets.
MaRS-ATDF	Raw doppler and ranging data
MaRS-ODR	Raw voltage samples
MaRS-IFMS	Meteo data
MaRS-IFMS	Ranging data
MaRS-IFMS	Doppler data
MaRS-FCL	Doppler closed
MaRS-RNG	Ranging
MaRS-AOL	Power spectra
MaRS-FOL	Doppler open
MaRS-POL	polarization
HRSC-SR-SDP	Decompressed and radiometrically - but not geometrically - corrected data. The Super-Resolution channel holds high resolution data all image lines related to the same sampling time
HRSC-LS-SDP	Decompressed and radiometrically - but not geometrically - corrected data. Line samples are related to sampling time. This applies to all scan rates, subsamplings and macro pixel formats.
HRSC-DEM	Decompressed, radiometrically and geometrically corrected digital elevation maps
HRSC-GMI	Decompressed, radiometrically and geometrically corrected global image maps.
HRSC-CM	Derived color mosaic maps.
MARSIS_SS1	Subsurface sounding using frequency x1 and x2; 2 antennas; passive ionosphere sounding
MARSIS_SS2	Subsurface sounding using frequency x1 and x2; 1 antennas(dipole); multi-look (on-board); passive ionosphere sounding
MARSIS_SS3	Subsurface sounding using frequency x1 and x2; 1 antennas(dipole); multi-look (possible on ground); passive ionosphere sounding
MARSIS_SS4	Subsurface sounding using frequency x1; 2 antennas; passive ionosphere sounding multi-look (possible on ground)
MARSIS_SS5	Subsurface sounding using frequency x1; 2 antennas; passive ionosphere sounding 4 pre-summed short pulses
MARSIS_PI	Passive ionospheric sounding
MARSIS_AI	Active ionospheric sounding
MARSIS_CAL	Hardware calibration
MARSIS_RAW	Unprocessed individual pulse echoes which has been transmitted to the ground before on-board processing. The main use is to test on-ground the processing algorithms which have been implemented on-board.
MARSIS_REC	Passive mode, receive only
MARSIS_ATLAS	Map-based data product, each pixel consisting of several layers of of information, gained from time delay or time delays from the surface to subsurface reflections, the received power 'strength' of any reflection as well a parameter reporting the level of confidence that a first, second and nth reflection was observed.

ASPERA-NPI-Science	Neutral Particle Imager
ASPERA-NPI-Eng	Neutral Particle Imager
ASPERA-NPD-Science	Neutral Particle Detector
ASPERA-NPD-Eng	Neutral Particle Detector
ASPERA-IMA-Science	Ion Mass Analyzer
ASPERA-IMA-Eng	Ion Mass Analyzer
ASPERA-ELS-Science	Electron Spectrometer
ASPERA-ELS-Eng	Electron Spectrometer
ASPERA-SU-Science	Scanning Unit
ASPERA-SU-Eng	Scanning Unit
ASPERA-DPU-Eng	Digital Processing Unit
ASPERA-OA-GRF	Orbit/Attitude
ASPERA-OA-SRF	Orbit/Attitude
SPICAM-raw	unprocessed spectra from spicam light
SPICAM-cor	calibrated (cosmics, dark current) and corrected (wavelength assignment) spectra
SPICAM-atm	atmospheric transmission function of altitude and wavelength for occultations (star, Sun); ratio of current spectra by spectrum out of atmosphere in absolute units
SPICAM-limb	limb brightness in absolute units, as a function of line of sight altitude and wavelengt
SPICAM-disk	disk brightness in absolute units, as a function of line of sight altitude and wavelengt ratio of current spectra by solar spectrum

J Descriptive Summary of Standard Data Products, Lander Experiments

Below are brief descriptions of each of the Mars Express Standard Data Products. Each Standard Data Product is identified by an Mars Express Scientific Data Archive Identifier and is followed by a product acronym.

K PDS Archive Volume Structure

Each *volume* (a single unit of media,e.g. one DVD) of a data set will contain the top-level file 'AAREADME.TXT' describing the data set as a whole and the volume specifically.
The top-level structure of a typical Mars Express data archive *volume* is given below:

- **Catalog** Directory
  used for loading PDS catalog
  - Instrument Host Catalog File
    Brief description of spacecraft and instrument's mounting relationship to spacecraft.
  - Instrument Catalog File
    Brief description of instrument (likely to be the same in all deliveries, unless updates are needed)
    There will be one file for each instrument providing data to this delivery
  - Dataset Catalog File
    Description of the dataset currently being submitted, one file for each data product (tbc).
  - Mission Catalog File
    Description of mission and a summary of significant events during the mission.

  These files will be submitted in the standard PDS-established format. The *Instrument Host Catalog File* and *Mission Catalog File* will be the same on all *archive volumes*. They will be updated periodically during the mission and a final version will be produced after the end of the mission. The responsibility for maintaining the these files lies with the MEX Science Operations Manager (tbc). Citations of published papers that provide more detailed information will be given in any of the files in the *Catalog Directory*.
- **Calib** Directory contains calibration files relevant for the data in this data set
- **Document** Directory
  - Instrument Description
    one file for each instrument, in ASCII format
  - Calibration Description
    at least one file for each instrument, in ASCII format

  Documentation in other formats (TeX, Word, WP, Framemaker,etc) are not required but encouraged.
- **Extras** Directory
  Papers describing scientific results (in any format)
  Spreadsheets useful for interpreting or using the data Any other documents that are helpful in using the data
- **Index** Directory
  Index Files (PDS-labeled ASCII tables) summarizing all data by mode, by phase of mission, by key instrument parameters, all organized to optimize finding the data of interest for a particular scientific question.
- **Software** Directory
  - calibration algorithms (source code)
  - algorithms for generating derived products (source code)
  - algorithms concerning satellite information (source code, from ESOC)
  - model calculation algorithms
- **Geometry** Directory
  - Position and attitude files received from ESOC
  - Derived ASCII tables of position and attitude

– Raw Data Directory
– **Calibrated** Data Directory
– Derived Higher-level Products Directory
– **MERGE** Products Directory
  This directory includes any products derived in collaboration of several teams using data from more than one instrument. Whenever formats are known, they should be specified in the instrument specific chapters or in the SIS at a later stage. Products from the Interdisciplinary Scientists will normally be in this directory unless data are solely based on one instrument.

L Archive Distribution

Experiment	distributed from
ASPERA	MESDA + tbd
HRSC	MESDA + tbd
MaRS	MESDA + tbd
SPICAM	MESDA
OMEGA	MESDA + IAS CDP
PFS	MESDA + IFSI Rome
MARSIS	MESDA + PDS Geoscience Node
Beagle-2	MESDA + Lander Operations Center

M Archive Collection Definition

1. Ancillary Data Archive Set (to be published after end of the mission)

N Software Interface Specification Outline for Instrument-related Data

N.0.1 Introduction

1. Purpose
2. Scope
3. Contents
4. Applicable Documents and Constraints

N.0.2 Overview of Processing and Product Generation

N.0.3 Archive Collection Components

1. High level catalog templates
2. Documentation, including instrument calibration reports, contributions to I and E Kernels
3. Algorithms and software
4. Science data packets
5. Reduced data records
6. Indices - Summary tables of data products

N.0.4 Archive Volume Organization

Provides details as to how components are grouped into physical volumes.

N.0.5 References Cited

Key references, including data product Software Interface Specification documents.

O Definition of Processing Levels for Science Data Sets

Level 0 The raw telemetry data as received at the ground receiving station or ground test GSE, organized by contacts or ground test.

Level 0a The telemetry data as produced by the C&DH system on the spacecraft and passed to the telemetry subsystem. Level 0a contains transfer frame packets organized by contacts or ground tests

Level 1 Level 0a data that have been cleaned and merged , time ordered, and in packet format. Cleaned and merged means that duplicate data have been deleted, missing packets are padded out, and the data are organized by days. The actual format of these data is the same as level 0. This is the level which should be passed to the instrument GSE's for their processing.

Level 1a The level 1 data that have been separated by instrument.

Level 1b Level 1a data that have been sorted by instrument data types and instrument modes. Data are in scientifically usefull form, e.g. as images or indiviudal spectra. These data are still uncalibrated.

Level 1c Level 1a data that have been sorted by instrument data types and instrument modes. Data are in scientifically usefull form, e.g. as images or indiviudal spectra. The data are in calibrated form and have been calibrated in board of the spacecraft. The calibration was irreversible and the level 1b data can not be reproduced on ground.

Level 2 Level 1b with calibration and corrections applied to yield data in scientific units.

Level 3 Higher level data products developed for specific scientific investigations.

P Interdisciplinary Scientists

tbd

Q Data Rights and Release Policy including Public Information

Relevant section from the Mars Express Science Management Plan, Chapter 5, “Scientific Data Archive”:

– “The Mars Express data rights will follow the established ESA rules (ESA/C(89)93). Therefore all scientific data obtained during the full mission duration will remain proprietary of the Orbiter and the Lander Module Investigator teams for a period of up to 6 months after they have been received from ESA. After this period, the scientific data products (in a reduced and calibrated form) from the mission will become accessible by the scientific community via Internet. However, the scientific data that ESA considers useful for its Communications and Public Relations effort will be made immediately available on the World Wide Web.
  The Science Operations Center will prepare the final Mars Express Scientific Data Archive (MESDA) within one year of the receipt of the complete data sets from the individual Mars Express Orbiter and Lander Module science investigations. Based on current technology (and IMEWG recommendation on standards for scientific data of future missions to Mars), the archive would be distributed as a set of CD-ROM’s based on the NASA Planetary Data System (PDS) standard.
  ESA will have - with the knowledge of the Orbiter and Lander Module Investigators and Team Members unlimited access to all mission data being obtained, processed and analysed before archiving.”

Relevant section from ESA/c(89)95, rev. 1, page 14ff, paragraph 3:

– 3. Rights in Data resulting from Payload
  a) Experimenter’s Right of Prior Access
  The Agency (acting on behalf of the Member States or on behalf of the participating States, as appropriate) shall be the owner of all data directly resulting from the in-flight operation of a payload flown on board a space vehicle provided free of charge to an Experimenter as part of an Agency program (this excludes any data which are required for the control of the payload itself).
  The Agency shall, however, grant the Experimenter an exclusive right of prior access to said data. The duration of the right of prior access shall be agreed between the Agency and the Experimenter(s) concerned and shall be approved by the relevant delegate body. The duration shall, however, not be shorter than half a year and shall not normally be longer than one year. The duration shall depend on, inter alia:
  - the extent and nature of the involvement of the Experimenter in the development of the payload,
  - the type and complexity of the data to be received from the payload,
  and shall take due account of the provisions in paragraph (i) below....

R Glossary of Selected Terms

Archive collection Data Products, supplemental data, software, and documentation that are logically linked to facilitate their use and administration.

Archive Volume, Archive Volume Set A volume is a single unit of media on which one or more data sets are stored; e.g. one DVD. When the data span multiple volumes, the group of volumes is called volume set. The media supported by PDS are CD-ROMS's, DVD's and magnetic tape. Within each volume is a directory structure listing the sub-directories and files contained on that volume. Magnetic tapes have a virtual directory structure provided in a directory and file map included on the volume.

Data product A labeled grouping of data resulting from a scientific observation. A product label, identifies, describes, and defines the structure of the data. Examples of data products are planetary images, spectrum tables, and time series tables.

Data Set Collection A Data Set Collection consists of data sets that are related by observation type, discipline, target, or time and therefore are to be treated as a unit, to be archived and distributed together for a specific scientific objective and analysis. In respect to the Mars Express project, we can speak about a Mars Express Data Set Collection (sometimes also called archive collection) as the overall archive including all ground-based and mission data.

Data Set A logical grouping of data products, secondary data, software and documentation, that completely document and support the use of those data products. A data set can be part of a data set collection. In respect to the Mars Express mission, a data set could be the archive of data from a given number of consecutive orbits. Physically, the data set could be on one DVD. The DVD would be called volume. It could also be on several DVDs. All these DVDs would be called volume set.

Data Product Labeled groupings of data resulting from scientific observations, e.g. we would call all data from SPICAM during mission phase cruise/commissioning a data product. All instrument teams will deliver data products to the ESA archive team for each mission phase.

Volume Set see data set

Volume see data set

Experiment Data Record Level 1.0 data product produced from instrument packet data with PDS labels

High-level catalog High-level descriptive information about mission, spacecraft, instrument, data sets, and related items. Catalog inputs derived from templates expressed in Object Description Language (ODL) which are suitable for loading into a catalog.

Reduced data records Raw science data that have been processed to some level and output as set of data products.

Science packets Level 0 (raw) data for a given instrument in unchannelized telemetry packeted form.

Special Data Products derived from Level 1.0 products by use of data analysis, data transformation in space, spectra and/or time. Examples include dust models, 3-dimensional topography models and map products.

Standard data product Reduced data record generated in standard or predefined way using well-understood procedures. Processed in ”pipeline” fashion.

References

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