Mars Exploration Rover (MER) Project

Archive Generation, Validation and Transfer Plan

Revision C

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JPL

Jet Propulsion Laboratory
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CHANGE LOG

DATE	SECTIONS CHANGED	REASON FOR CHANGE	REVISION
9/12/00	All	First draft	Draft
1/2/01	All	Incorporated comments from DAWG; added discussion of validation, Planetary Atlas and Analyst's Notebook	Draft
1/8/01	Title page	Added signature line for Mission System Manager	Draft
12/20/01	1.4 Applicable Documents and Constraints	Fixed incomplete references	Draft
12/20/01	Title page	Added signature line for Science Manager	Draft
12/20/01	2.1, Tables 1, 4, 5	Removed Suncam references	Draft
12/20/01	2.2 Data Flow	Revised discussion of data release dates	Draft
12/20/01	2.3 Data Validation and Peer Review	Revised discussion of peer review in accordance with new PDS policy of beginning review early, during design phase	Draft
12/20/01	2.4 Integrated Archives 3.2 Planetary Data System Responsibilities	Changed "Planetary Atlas" to "PDS Online Services" to reflect new services to be offered by PDS	Draft
12/20/01	4 Detailed Archive Generation, Validation, and Release Schedules	Replaced section 4 with Table 6, MER Archive Generation, Validation, and Release Schedule	Draft
12/20/01	Table 2. Definitions of Processing Levels for Science Data Sets	Removed NASA Level 1C, since not used	Draft
1/15/02	Table 3, Components of MER Archives, and Table 4, MER Archive Component Suppliers	Revised and expanded to make the two tables consistent	Draft
1/28/02	2.3 Data Volume	Section added	Draft
1/28/02	Table 5, MER Standard Data Products	Removed Data Volume column	Draft
2/18/02	2.2 Data Flow	Described OSS and SSS access and use for storing EDRs and RDRs. New requirement for Project to deliver 3 copies of archives on hard digital media to the PDS (consistent with the new Mars Program Data Management Plan)	Draft
2/18/02	2.3 Data Volume	Increased the total data volume estimate	Draft
2/18/02	Fig.1	Added a Figure showing the Mission Timeline	Draft
3/22/02	Section 3.3 NSSDC	Added a sentence: NSSDC may also provide support for distribution of MER data to the general public, although this is beyond the domain of this MER Archive Generation, Validation, and Transfer Plan.	Draft

5/12/03	2.2 Data Flow	Added paragraph about delivery of special products	Rev. A
5/12/03	Tables 3, 4, and 5	Added specific rover engineering products	Rev. A
5/12/03	Table 5, MER Standard Data Products	Revised to match John Callas' list of standard products; added NASA processing levels	Rev. A
5/12/03	Section 3.2 Planetary Data System Responsibilities	Revised description of PDS Central Node participation based on comments from PDS Mars Data Engineer	Rev. A
6/25/03	Section 2.2 Data Flow	Revised description of science team access to data products	Rev. A
6/25/03	Figure 1, Mission Timeline	Replaced with revised timeline figure	Rev. A
8/25/03	Table 5, MER Standard Data Products	Revised to match John Callas' list (again)	Rev. A
9/3/03	Section 1.4, Applicable Documents Section 2.2, Data Flow	Added requirements for Data Product and Archive Volume SISs	Rev. A
9/17/03	Signature cover page	Replaced Jim Erickson, MER Mission System Manager, with Peter Theisinger, MER Project Manager as a signatory	Rev. A
9/29/03	Section 3.2, Planetary Data System Responsibilities	Clarified archiving of RDRs between Imaging and Geosciences Node	Rev. A
12/29/03	Section 3.2 Planetary Data System Responsibilities	Added the Atmospheres Node for the Inertial Measurement Unit data and the Geosciences Node for the radio science data. Clarified the responsibility for archiving EDRs to include Science Team. Put the responsibility for making hard copy (DVDs) of the archives on the Project.	Rev. B
12/29/03	Tables 3, 4, 5	Added the Atmosphere structure data and radio science data to the tables.	Rev. B
4/17/04	Tables 1 and 3	Added the Descent camera	Rev. B
4/17/04	Table 1	Corrected the camera parameters for Hazcam, Navcam, and Pancam	Rev. B
4/17/04	Section 2.2	Explained the different kinds of EDRs, who would generate the EDRs and RDRs, and where they would be stored. Deleted the reference to the MIPL Alternate Storage Server (MASS)	Rev.B
4/17/04	Acronyms Table	Removed acronyms from the list no longer used in the document	Rev. B
4/17/04	Section 2.1	Updated the mission description, changing to the past tense, and including dates.	Rev. B
4/17/04	Sections 2.4 and 3.1	Removed all mention of the Science Data Validation Team (SDVT). We will not use an SDVT.	Rev. B
4/17/04	Table 3	Deleted Science Theme Group Documentarian Notes	Rev. B
4/17/04	Table 4	Deleted RAT RDRs and Science Theme	Rev. B

		Group Documentarian Notes. Added Pancam and MI Science EDRs.	
4/17/04	Table 5	Added Operations Uplink Information (Tables of science features and targets, and tables of uplink plans and rover activities accomplished).	Rev. B
4/17/04	Table 6 and Section 2.2	Made it more clear that the Third Archive Release will be due 6 months after the last data are received.	Rev. B
4/21/04	Acronyms Table	Corrected the definition of the SPICE acronym	Rev. B
4/21/04	Table 4	Changed the primary responsibility for Engineering Camera RDRs to J. Maki. Changed the responsibility for Mini-TES EDRs to P. Christensen	Rev. B
5/11/04	Table 5	Removed E Kernels, added FK, LSK, SCLK	Rev. B
6/11/04	Table 5	Removed Mini-TES mineral map special products	Rev. B
6/17/04	Table 5	Updated the table of data products to be consistent with the list of PDS datasets	Rev. B
6/17/04	Table 4	Added OPGS RDRs	Rev. B
6/17/04	Table 3	Added OPGS archives	Rev. B
7/2/04	Table 4	Removed the old Table 4 (MER Archive Component Suppliers). This information is now a part of what used to be Table 5 and is now Table 4 (MER Data Products)	Rev. B
7/2/04	Cover page	Changed Project Manager to Jim Erickson, added Joy Crisp as a coauthor	Rev. B
7/2/04	Table 5 (now called Table 4)	Replaced the information in this table with a more detailed listing of every individual data product, its producer, curator, data set ID, controlling document, archive volume producer, and volume ID. Removed International Traffic and Arms (ITAR) sensitive products from the table since we have determined that we cannot archive them in the PDS. These products are: Rover engineering telemetry, Rover mobility reports, and Rover operations documents. Changed RS in the Data Product ID for Radio Science to RSS.	Rev. B
7/2/04	Table 3	Removed Engineering Data Archives, due to ITAR considerations.	Rev. B
7/14/04	Applicable Documents	Replaced Planetary Data System Data Preparation Workbook, which is being phased out, with the PDS Data Dictionary Document	Rev. B
7/14/04	TBD Items	Removed the TBD table.	Rev. B
7/14/04	Table 5	Replaced launch window dates with actual launch dates	Rev. B

7/14/04	Table 4	Updated the Data Product IDs to be consistent with the products being prepared for the PDS archives	Rev. B
1/6/06	Cover page	Updated name and title of PDS signatory	Rev. C
1/6/06	1.4 Applicable Documents; 2.2 Data Flow; 3.3 National Space Science Data Center Responsibilities	Revised text to mention PDS-NSSDC MOU	Rev. C
1/6/06	2.2 Data Flow; Table 3 Components of Mer Archives	Minor edits	Rev. C
1/6/06	Table 4 MER Data Products	Revised some document names, data set IDs, and volume IDs. Changed Archive Volume Producer from MIPL to GEO for 4 data sets. Deleted MB CALSPEC data set because it has been combined with the SUMSPEC data set.	Rev. C
7/20/06	Cover page	Changed signatories	Rev. C
7/20/06	Table 4 MER Data Products	Added a rover mobility product, added asterisks next to special products that are not archived on the same schedule as the other products. Added a footnote to the table: ** = Special products are not on the same schedule as the standard products. Our goal is to have preliminary Moessbauer mineralogical analysis tables and APXS chemical concentrations available on the PDS 3 months after the corresponding EDRs are delivered, and PDS-compliant versions available 6 months after the corresponding EDRs are delivered. The schedule for other special products is on a best-efforts basis. Changed data producer for EDL Atmosphere RDRs from David Kass to tbd.	Rev. C
7/22/06	Table 4	Made several corrections to data set IDs and archive volume IDs	Rev. C

CONTENTS

FIGURES

TABLES

ACRONYMS

APXS   Alpha Particle X-ray Spectrometer
DAWG   Data and Archives Working Group
EDR   Experiment Data Record
FOV   Field of View
GDS   Ground Data System
JPL   Jet Propulsion Laboratory
LAN   Local Area Network
MB   Mössbauer Spectrometer
MER   Mars Exploration Rover
MI   Microscopic Imager
Mini-TES   Miniature Thermal Emission Spectrometer
MIPL   Multi-mission Image Processing Laboratory
NAIF   Navigation and Ancillary Information Facility
NSSDC   National Space Science Data Center
OSS   Operations Storage Server
PDS   Planetary Data System
RAT   Rock Abrasion Tool
RDR   Reduced Data Record
RPIF   Regional Planetary Image Facility
SIS   Software Interface Specification
SOWG   Science Operations Working Group
SPICE   Spacecraft, Planet, Instrument, Pointing C-matrix, and Event kernels (historical acronym for navigation and ancillary data)
TBD   To Be Determined
VPN   Virtual Private Network

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to provide a plan for generation, validation, and transfer to the Planetary Data System (PDS) of archives from the 2003 Mars Exploration Rover (MER) Mission. The archives will contain raw and reduced data, documentation, and algorithms or software.

1.2 Scope

The plan covers archiving of raw and reduced data sets and related information to be acquired or derived during the MER mission.

Specific aspects addressed in this plan are:

- Generation of high-level mission, spacecraft and instrument documentation, instrument calibration reports, and documentation of algorithms and/or software used to produce reduced data records.

- Reduction of science packet data to reduced data records, including generation of data sets expressed in geophysical units, with associated documentation that records when and where the data were acquired and for what purpose.

- Generation of SPICE archives for use with software from the Jet Propulsion Laboratory's Navigation and Ancillary Information Facility (NAIF).

- Generation and validation of archive volumes containing MER science and engineering data, software, algorithms, documentation, and ancillary information.

- Delivery to the PDS of validated MER archives.

1.3 Contents

This plan begins with a summary of MER mission phases and an overview of the archiving flow. This section is followed by a description of the roles and responsibilities for organizations and personnel associated with generation, validation, and archiving of MER data. The document ends with specific archiving plans.

1.4 Applicable Documents and Constraints

This Archive Generation, Validation, and Transfer Plan is responsive to the following Mars Exploration Program and MER documents:

1. Mars Exploration Program Data Management Plan, R. E. Arvidson and S. Slavney, Rev. 3, March 20, 2002.

2. Mars Exploration Rover Project Plan, P. C. Theisinger, MER 420-1-100, JPL D-19374.

3. Mars Exploration Rover Mission Plan, J. Ludwinski, MER 420-1-300, JPL D-19659.

4. Mars Exploration Rover Project Athena Science Implementation Plan, S. Squyres, MER 420-1-201, JPL D-20458.

5. Mars Exploration Rover Project Science Management Plan, J. Crisp, MER 420-1-103, JPL D-19637.

6. Mars Exploration Rover Analyst's Notebook Functional Requirements Document, E. A. Guinness et al., Draft 1.0, April 26, 2001.

The plan is consistent with the principles delineated in the following National Academy of Sciences reports:

7. Data Management and Computation, Volume 1, Issues and Recommendations, 1982, National Academy Press, 167 p.

8. Issues and Recommendations Associated with Distributed Computation and Data Management Systems for the Space Sciences, 1986, National Academy Press, 111 p.

The plan is also consistent with the following Planetary Data System documents:

9. Planetary Science Data Dictionary Document, August 28, 2002, JPL D-7116, Rev. E.

10. Planetary Data System Data Standards Reference, June 15, 2001, Version 3.4, JPL D-7669, Part 2.

11. Memorandum of Understanding between National Space Science Data Center and the Planetary Data System, March 1, 1988. (to be revised)

The plan requires the generation of the following Project documents:

12. Data Product Software Interface Specification (SIS) for all Standard Products.

13. Archive Volume Software Interface Specification (SIS) for all Standard Products.

Finally, the plan is meant to be consistent with the contract negotiated between the MER Project and the Athena Principal Investigator (PI) in which reduced data records and documentation are explicitly defined as deliverable products.

2. MER ARCHIVE GENERATION, VALIDATION, AND TRANSFER TO THE PDS

2.1 The Mission

The Mars Exploration Rover Mission consisted of two launches of identical spacecraft June 10, 2003 and July 7, 2003, with placement of a lander and rover in two different localities on Mars on January 3 and 25 of 2004. Each rover conducted traverses and acquired scientific data using the Athena payload and rover engineering systems. Each rover operated for a 90-sol primary mission, with an extended mission of unknown duration (both rovers are still in operation at the time of writing of this document). Figure 1 shows the mission timeline, as it was understood pre-landing.

The two identical flight systems each consisted of a cruise stage, an entry, descent, and landing system, and a rover. The Athena Payload on each rover included a mast-mounted stereo color panoramic imager (Pancam) and a mid-IR spectrometer (Mini-TES), arm-mounted Mössbauer

and Alpha Particle X-ray Spectrometers (MB and APXS), a microscopic surface imager (MI), and a Rock Abrasion Tool (RAT). Navigation and hazard avoidance cameras were also included on the rover. Table 1 summarizes the MER rover payload and Descent Camera. In addition, physical properties experiments were conducted using the rover wheels to dig into soils and characterizing the exposed materials with the Athena instruments.

2.2 Data Flow

As part of the MER Ground Data System (GDS), the JPL Multi-Mission Image Processing Laboratory (MIPL) have generated Experiment Data Records (EDRs) from telemetry data from the Athena science instruments. Members of the Science Team also have generated EDRs for Pancam and Microscopic Imager using slightly different processing, as described in the Camera EDR/RDR SIS; these products are called "Science EDRs." Both MIPL and Science Team members have generated Reduced Data Records (RDRs) for some instruments. Table 2 defines processing levels associated with Reduced Data Records. MIPL-generated EDRs and RDRs will be stored on the MER Operations Storage Server (OSS). EDRs and RDRs generated by the Science Team members will also be stored on the OSS.

EDRs and RDRs will be generated according to designs specified in Data Product Software Interface Specification (SIS) documents. Every MER standard product is described in a Data Product SIS.

Access to the OSS is restricted by a network firewall to users on workstations within the Mission Support Area Flight LAN. Users outside the network firewall may use FEI (File Exchange Interface) subscriptions or Smart Cards (and VPN, if outside of the JPL Institutional network) to access files on the OSS. For analysis performed outside of the network firewall, science team members may download EDR and RDR products for processing using the Image Atlas front-end (web page). RDRs intended to support operations may be uploaded to the OSS, as necessary via FEI or SSH using Smart Cards.

The Analyst Notebook (AN) will be the repository for externally produced science data products to be archived with PDS. The AN will contain additional archive materials such as documentation, software, calibration data, engineering data, and SPICE kernels. Table 3 lists the high-level elements that comprise the MER archives and Table 4 provides a detailed list of all the data sets.

The MER Project is required to generate, validate, and deliver relevant mission raw and derived data and supporting documentation to the Planetary Data System within six months of data acquisition. In keeping with this requirement, the MER Project will deliver to the PDS two integrated archives for each rover mission, the first one no later than six months after Sol 30 data are received on Earth, and the second one no later than six months after Sol 90 data are received on Earth. For the extended rover missions, a third release will occur no later than six months after the last data from the extended mission are received on Earth. Table 5 shows the dates for archive data acquisition and release.

In addition to the standard products in Table 4, special products may be generated by some data suppliers as time and other resources permit. Some of these special products are listed in Table 4 with double-asterisks. Those special products that are completed and validated in time for a scheduled release to PDS may be delivered along with the standard products. PDS will continue

to accept special products after the end of the mission as long as they are documented and validated according to PDS standards.

Payload Element Leads are responsible for preparing data from their payload elements, along with supporting materials, for release to the PDS. A data release may take the form of electronic transfer or delivery on physical media to the appropriate PDS Node (section 3.2). PDS personnel will work closely with science team members to ensure a smooth transfer. When data products have been released to the PDS, they are regarded as publicly available. It is expected that the data will be made available to the public online through the PDS online distribution system, and in the form of an Analyst's Notebook (section 2.5).

All MER archive collections will be assembled according to designs specified in Archive Volume Software Interface Specification (SIS) documents.

Although online access will be the primary distribution method for MER archives, the PDS requires that archives be stored on appropriate physical media (e.g. CDs, DVDs) for long-term maintenance at the PDS and at the National Space Science Data Center (NSSDC). PDS is responsible for delivering a copy of MER archives to NSSDC according to the agreement between PDS and NSSDC (Applicable Document 11).

2.3 Data Volume

For planning purposes, the total downlinked data volume from both rovers is estimated at approximately 4 Gigabytes for the primary mission, based on sample mission scenarios. The total volume of EDR products after decompression is estimated to be the downlink volume times 16. The total volume of RDR products is not yet determined, but could be as much as 25 times the EDR volume, which would correspond to a total archive data volume (EDR and RDR) of 1.6 Terabytes. Extremely optimistic outcomes could result in twice as much downlinked data.

2.4 Data Validation and Peer Review

MER science archives will be validated before being released to the PDS. Validation is accomplished in two parts: validation for scientific integrity and validation for compliance with PDS standards. Science team members are expected to conduct validation for scientific integrity in the course of their analysis of EDRs and their production of RDRs. The details of the science validation process are the responsibility of the Payload Element Leads.

Validation for compliance with PDS standards is also the responsibility of each Payload Element Lead, with help from the PDS Node that will receive the data products. PDS will provide software tools, examples, and advice to help make this part of the validation as efficient as possible. This validation includes a peer review of the design and labeling of data products as laid out in the Data Product Software Interface Specification (SIS) documents, and validation of the PDS labels using sample data. The review will take place well before the start of operations, to allow sufficient time to correct problems. Reviewers will consist of a small group of scientists who represent typical users of the data; for example, Participating Scientists would be good candidates for reviewers. After the start of operations, when generation of standard products has begun, each individual product will be validated to see that it conforms to the design specified in the SIS. Validation of individual products will be automated as much as possible.

2.5 Integrated Archives

The concept of integrated archives is the key to making the best use of the data returned by the various science instruments on MER. Unlike previous orbital and landed missions in which instruments were operated mostly independently of one another, in a rover mission the instruments must operate in close coordination. Furthermore, a rover mission is non-deterministic; a decision to conduct a sequence of observations may be driven by recently acquired data rather than by a plan determined in advance. The Athena Team and the general science community will require access to science data archives that are integrated across instruments by time, by location, and by observation target, at a minimum. Two complementary systems, PDS online services (such as the Planetary Image Atlas) and the Analyst's Notebook, will provide the desired accessibility.

2.5.1 PDS Online Services

PDS will offer a Web-based system of access to MER science data products. It will allow selection based on various search criteria, browsing of data, and downloading in various formats. A version of the online system adapted specifically to the needs of the MER mission will be available for use by mission personnel. The system can also be used by the general science community to view and download data products that have been made public.

2.5.2 The Analyst's Notebook

The Analyst's Notebook is a Web-based tool for correlating data products from various Athena instruments based on time, location, observation target, and other criteria. The Notebook will provide detailed views into operational decisions, results, and access to raw and derived data and instrument calibration information. Using the Notebook, a scientist can virtually replay mission events to better select and understand data products of interest. The Analyst's Notebook will be designed and implemented by the Deputy Principal Investigator at Washington University, based in part on the Experimenter's Notebooks built to support analyses of data collected during the FIDO rover field trials. The Analyst's Notebook is a deliverable to the MER Project.

The PDS Atlas and the Analyst's Notebook are intended to be complementary tools. The Atlas will probably be used to satisfy most requests for locating and downloading data products by MER mission personnel and the general science community. The Analyst's Notebook will probably be used by a smaller set of scientists who need access to the most detailed information available about the data.

3. ROLES AND RESPONSIBILITIES

In this section the roles and responsibilities for personnel and organizations involved in MER archive generation, validation, transfer, and distribution are summarized.

3.1 Mars Exploration Rover Project Responsibilities

The MER Project has overall responsibility for generation and validation of archives for release to the PDS. The Project is also responsible for distribution of data and associated information to MER personnel.

The Project Scientist co-chairs the Project Science Group and provides oversight of the archiving process from a science perspective. The Project Scientist will review data analysis plans to assure timely and adequate analysis of spacecraft data and delivery of documented, complete data to the PDS. The MER Science Manager is responsible for the administrative management of data archive planning and implementation.

The Data and Archives Working Group (DAWG) will coordinate the planning of the generation, validation, and release of PDS-compliant archives to the PDS. The DAWG is a subgroup of the MER Project Science Group and reports to the PSG Co-Chairs (MER Project Scientist and MER Program Scientist). The DAWG Chair is the MER Interdisciplinary Scientist for Data and Archives (also the Athena Deputy Principal Investigator). DAWG membership includes the MER Project Scientist, the Athena Principal Investigator and Payload Element Leads, representatives from NAIF and MIPL, and project personnel selected to ensure that raw packets, engineering data sets, and documentation are included in archives. Representative PDS personnel will be liaison members of the DAWG. For the most part, the DAWG's work will take place before mission operations begin. During the active mission the DAWG will meet when necessary.

MIPL is responsible for generating validated, PDS-compatible archives containing Experiment Data Records (Level 0) from the Athena science instruments.

The Athena Principal Investigator is responsible for generating validated, PDS-compatible archives containing derived data products (Level 1 and above) from Athena data, along with documentation, algorithms or software for generating derived data products, calibration data and reports, and other supporting materials.

3.2 Planetary Data System Responsibilities

The PDS is the designated point of contact for MER on archive-related issues. The PDS is also the interface between MER and the National Space Science Data Center (NSSDC). The PDS will work with the DAWG to ensure that the MER archives are compatible with PDS standards and formats. Personnel from the PDS Geosciences, Imaging, Atmospheres, NAIF and Central Nodes will be liaison DAWG Members.

The PDS will provide funds for generation, distribution, and maintenance of MER archives for the NASA planetary science community once the archives have been released by MER.

Primary responsibility for archiving will be shared between the PDS Geosciences and Imaging Nodes, as follows. The Geosciences Node will provide overall coordination of PDS activities for MER. The Imaging Node will work with MIPL and the Science Team to archive EDRs from all Athena science instruments, both imaging and non-imaging instruments. The Imaging and Geosciences Node will work together to archive RDRs from all Athena science instruments as a set of integrated archives using the PDS online services (e.g., Atlas and Notebook). The Imaging Node will archive all camera RDRs, while the Geosciences Node will archive Mössbauer, APXS, and Mini-TES RDRs. The Geosciences Node will also archive rover engineering data from the MER Project. The Atmospheres Node will archive the atmospheric entry data, and the Geosciences Node will archive the radio science data.

The Project will be responsible for generating copies of MER archives on physical media for long-term storage. EDR and RDR archives will be captured on physical media, probably DVDs.

The Mars Data Engineer from the PDS Central Node will work with the PDS Discipline Nodes involved with MER throughout the archive planning, generation, and validation phases.

The PDS NAIF Node will archive MER telemetry packet data and SPICE files. SPICE files will also be included in the MER integrated archives at the Geosciences Node.

3.3 National Space Science Data Center Responsibilities

The National Space Science Data Center will maintain a "deep archive" of MER data for long-term preservation and for filling large delivery orders to the science community. The PDS will deliver a copy of MER archive volumes to NSSDC according to the agreement between PDS and NSSDC (Applicable Document 11). NSSDC may also provide support for distribution of MER data to the general public, although this is beyond the domain of this MER Archive Generation, Validation, and Transfer Plan.
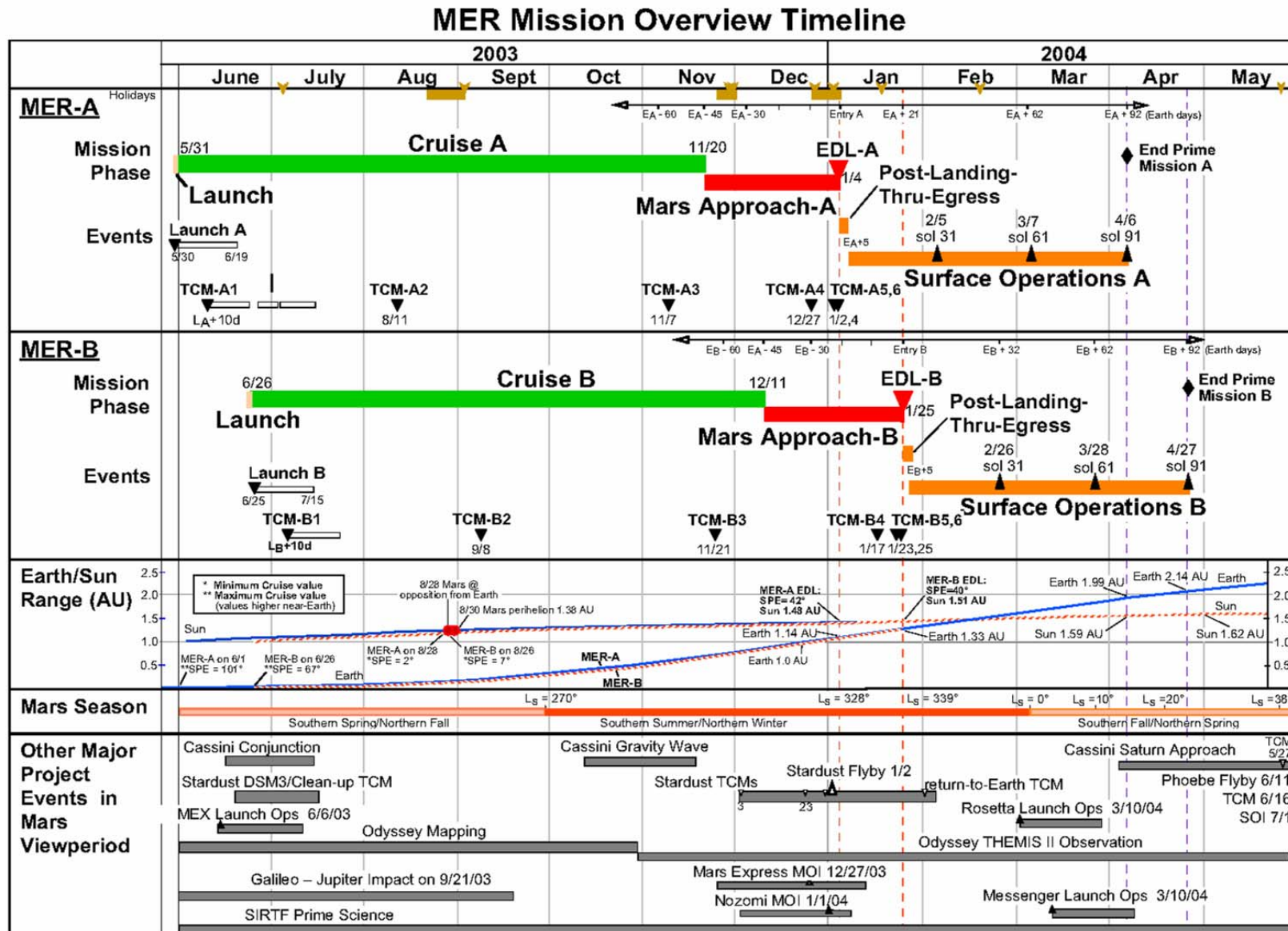
Figure 1. Mission Timeline for June 2003 – May 2004

Table 1. MER Athena Rover Payload and Engineering Cameras

Instrument	Key Parameters	Purpose
Athena Mast-Mounted Instruments		
Pancam	Eleven filters (0.4 to 1.0 µm) for stereoscopic multispectral imaging plus two color solar ND filter imaging; 0.28 mrad IFOV; 16° by 16° FOV; 1024x1024 pixel CCD detector	Detailed imaging of surface for geologic and topographic characterization; atmospheric optical depth and scattering properties
Mini-TES (Miniature Thermal Emission Spectrometer)	Emission spectra (5 to 29 µm, 10 cm^{-1} resolution) with 8 or 20 mrad FOV	Mineralogical mapping of key targets identified using imaging data; thermophysical properties of surfaces; determination of pressure, temperature, water vapor profiles
Athena Arm-Mounted *In-Situ* Package		
APXS (Alpha Particle X-Ray Spectrometer)	^{244}Cm alpha particle and X-ray sources, solid-state alpha and X-ray detectors, FOV 4 cm in diameter	Elemental abundances for rock and soil targets
MB (Mössbauer Spectrometer)	^{57}Fe spectrometer in backscatter mode; Co/Rh source and Si-PIN diode detectors; field of view approximately 1.5 cm^2.	Identification of iron-bearing minerals and iron oxidation states
MI (Microscopic Imager)	Monochrome imaging, 30 µm per pixel, 3x3 cm FOV, 6 mm depth of focus	Close-up imaging of texture and mineralogy of surfaces
RAT (Rock Abrasion Tool)	Capable of removing up to 5 mm of rock from a circular region 4.5 cm in diameter	Remove dust, loose debris, weathered material, and surface coatings from rock, exposing fresh rock for analysis by instruments
Engineering Cameras		
Hazcams (Hazard Avoidance Cameras), body-mounted	Monochrome stereo imaging, 2.1 mrad IFOV, 124°x124° FOV; 1024x1024 pixel CCD detector	Front and rear stereo cameras used for hazard avoidance during traverses and for planning purposes
Navcams (Navigation Cameras), mast-mounted	Monochrome stereo imaging, 0.82 mrad IFOV, 45°x45° FOV; 1024x1024 pixel CCD detector	Acquire images and panoramas for traverses and Instrument Arm deployment support

Instrument	Key Parameters	Purpose
Descent Camera, lander-mounted	Monochrome imaging, 0.82 mrad IFOV, 45°x45° FOV; 1024x1024 pixel CCD detector	Acquire 3 images during descent of the spacecraft towards the surface of Mars in order to determine, during descent, horizontal velocity with respect to the surface

Table 2. Definitions of Processing Levels for Science Data Sets

NASA	CODMAC	Description
Packet data	Raw – Level 1	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Level 0	Edited - Level 2	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed.
Level 1A	Calibrated - Level 3	Level 0 data that have been located in space and may have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied).
Level 1B	Resampled - Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength).
Level 2	Derived - Level 5	Geophysical parameters, generally derived from Level 1 data, and located in space and time commensurate with instrument location, pointing, and sampling.
Level 3	Derived - Level 5	Geophysical parameters mapped onto uniform space-time grids.

Table 3. Components of MER Archives

Component	Contents
SPICE Archives	SPICE Kernels
	NAIF Software
Science Data Archives	Science Experiment Data Records and Reduced Data Records
	High-level mission, spacecraft, instrument, data set, software, and personnel descriptions for the PDS Catalog
	Data Product Software Interface Specification (SIS) Documents
	Archive Volume Software Interface Specification Documents
	Processing Descriptions, Algorithms, and Software (to use in understanding reduced data product generation)
	Instrument Calibration Plans and Reports and associated data needed to understand level 1 product generation
	Analyst's Notebooks for primary and extended missions
	Notes that describe uplink and downlink results
OPGS Archives (Operations Product Generation System)	Operations Experiment Data Records and Reduced Data Records
Atmospheric Structure Data Archive	Raw data collected by the Inertial Measurement Units during entry and descent through the atmosphere
Radio Science Data Archive	Raw range and Doppler data

Table 4. MER Data Products

Data Sets	Data Set Producer	Archive Volume Producer	Curator	Controlling Document	Data Set IDs	Volume ID
Pancam OPGS EDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-PANCAM-2-EDR-OPS-V1.0 Experiment Data Records	MERnOP_0XXX
Pancam Science EDRs	Cornell	WU	IMG	Science EDR Archive Volume SIS	MERn-M-PANCAM-2-EDR-SCI-V1.0 Experiment Data Records	MERnPC_0XXX
Pancam OPGS RDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-PANCAM-3-ILUT-OPS-V1.0 Inverse-Lookup-Table rescaled images MERn-M-PANCAM-3-RADIOMETRIC-OPS-V1.0 Radiometrically corrected images MERn-M-PANCAM-4-LINEARIZED-OPS-V1.0 Geometrically corrected images MERn-M-PANCAM-5-DISPARITY-OPS-V1.0 Maps of parallax in images that have stereo pairs MERn-M-PANCAM-5-XYZ-OPS-V1.0 Maps of 3-D XYZ coordinates for pixels in images that have stereo pairs MERn-M-PANCAM-5-NORMAL-OPS-V1.0 Maps of surface normal vectors for pixels in images that have stereo pairs MERn-M-PANCAM-5-RANGE-OPS-V1.0 Maps of distances from the camera reference point to the XYZ position of each pixel, for images that have stereo pairs MERn-M-PANCAM-5-SLOPE-OPS-V1.0 Slope maps for a images that have stereo pairs	MERnOP_1XXX

Data Sets	Data Set Producer	Archive Volume Producer	Curator	Controlling Document	Data Set IDs	Volume ID
					MERn-M-PANCAM-5-ROUGHNESS-OPS-V1.0 Roughness maps for images that have stereo pairs MERn-M-PANCAM-5-ANAGLYPH-OPS-V1.0 Anaglyph stereo images	
Pancam Science RDRs	Cornell	WU	IMG	Science RDR Archive Volume SIS	MERn-M-PANCAM-3-RADCAL-RDR-V1.0 Radiometrically corrected images	MERnPC_1XXX
Pancam OPGS Mosaics	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-PANCAM-5-MOSAIC-OPS-V1.0 Image mosaics	MERnOP_2XXX
Pancam OPGS Meshes	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-PANCAM-5-WEDGE-OPS-V1.0 Terrain wedge meshes MERn-M-PANCAM-5-MESH-OPS-V1.0 Terrain polygon meshes	MERnOP_3XXX
Pancam Atmospheric Opacity	Mark Lemmon, Texas A&M	WU	ATM	Atmospheric Opacity Data Product SIS	MER1/MER2-M-PANCAM-5-ATMOS-OPACITY-V1.0	MERAO_1XXX
MI OPGS EDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-MI-2-EDR-OPS-V1.0 Experiment Data Records	MERnMI_0XXX
MI Science EDRs	USGS	WU	IMG	Science EDR Archive Volume SIS	MERn-M-MI-2-EDR-SCI-V1.0 Experiment Data Records	MERnSC_0XXX
MI OPGS RDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-MI-3-ILUT-OPS-V1.0 Inverse-Lookup-Table rescaled images MERn-M-MI-3-RADIOMETRIC-OPS-V1.0 Radiometrically corrected images	MERnOP_1XXX

Data Sets	Data Set Producer	Archive Volume Producer	Curator	Controlling Document	Data Set IDs	Volume ID
					MERn-M-MI-4-LINEARIZED-OPS-V1.0 Geometrically corrected images MERn-M-MI-5-ANAGLYPH-OPS-V1.0 Anaglyph stereo images	
MI Science RDRs	USGS	WU	IMG	Science RDR Archive Volume SIS	MERn-M-MI-2-RDR-SCI-V1.0 Radiometrically corrected images	MERnMI_1XXX
MI OPGS Mosaics (special product)	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-MI-5-MOSAIC-OPS-V1.0 Image mosaics	MERnOP_2XXX
Navcam OPGS EDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-NAVCAM-2-EDR-OPS-V1.0 Experiment Data Records	MERnOP_0XXX
Navcam OPGS RDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-NAVCAM-3-ILUT-OPS-V1.0 Inverse-Lookup-Table rescaled images MERn-M-NAVCAM-3-RADIOMETRIC-OPS-V1.0 Radiometrically corrected images MERn-M-NAVCAM-4-LINEARIZED-OPS-V1.0 Geometrically corrected images MERn-M-NAVCAM-5-DISPARITY-OPS-V1.0 Maps of parallax in images that have stereo pairs MERn-M-NAVCAM-5-XYZ-OPS-V1.0 Maps of 3-D XYZ coordinates for pixels in images that have stereo pairs MERn-M-NAVCAM-5-NORMAL-OPS-V1.0 Maps of surface normal vectors for pixels in images that have stereo pairs	MERnOP_1XXX

Data Sets	Data Set Producer	Archive Volume Producer	Curator	Controlling Document	Data Set IDs	Volume ID
					MERn-M-NAVCAM-5-RANGE-OPS-V1.0 Maps of distances from the camera reference point to the XYZ position of each pixel, for images that have stereo pairs MERn-M-NAVCAM-5-SLOPE-OPS-V1.0 Slope maps for a images that have stereo pairs MERn-M-NAVCAM-5-ROUGHNESS-OPS-V1.0 Roughness maps for images that have stereo pairs MERn-M-NAVCAM-5-ANAGLYPH-OPS-V1.0 Anaglyph stereo images	
Navcam OPGS Mosaics	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-NAVCAM-5-MOSAIC-OPS-V1.0 Image mosaics	MERnOP_2XXX
Navcam OPGS Meshes	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-NAVCAM-5-WEDGE-OPS-V1.0 Terrain wedge meshes MERn-M-NAVCAM-5-MESH-OPS-V1.0 Terrain polygon meshes	MERnOP_3XXX
Hazcam OPGS EDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-HAZCAM-2-EDR-OPS-V1.0 Experiment Data Records	MERnOP_0XXX
Hazcam OPGS RDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-HAZCAM-3-ILUT-OPS-V1.0 Inverse-Lookup-Table rescaled images MERn-M-HAZCAM-3-RADIOMETRIC-OPS-V1.0 Radiometrically corrected images MERn-M-HAZCAM-4-LINEARIZED-OPS-V1.0 Geometrically corrected images MERn-M-HAZCAM-5-DISPARITY-OPS-V1.0 Maps of parallax in images that have stereo pairs	MERnOP_1XXX

Data Sets	Data Set Producer	Archive Volume Producer	Curator	Controlling Document	Data Set IDs	Volume ID
					MERn-M-HAZCAM-5-XYZ-OPS-V1.0 Maps of 3-D XYZ coordinates for pixels in images that have stereo pairs MERn-M-HAZCAM-5-NORMAL-OPS-V1.0 Maps of surface normal vectors for pixels in images that have stereo pairs MERn-M-HAZCAM-5-RANGE-OPS-V1.0 Maps of distances from the camera reference point to the XYZ position of each pixel, for images that have stereo pairs MERn-M-HAZCAM-5-SLOPE-OPS-V1.0 Slope maps for a images that have stereo pairs MERn-M-HAZCAM-5-REACHABILITY-OPS-V1.0 Maps showing where the Instrument Deployment Device instruments could reach MERn-M-HAZCAM-5-ROUGHNESS-OPS-V1.0 Roughness maps for images that have stereo pairs MERn-M-HAZCAM-5-ANAGLYPH-OPS-V1.0 Anaglyph stereo images	
Hazcam OPGS Meshes	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-HAZCAM-5-WEDGE-OPS-V1.0 Terrain wedge meshes MERn-M-HAZCAM-5-MESH-OPS-V1.0 Terrain polygon meshes	MERnOP_3XXX
Rover Motion Counter	MIPL	WU	GEO	None (special product)	MERn-M-ENG-6-RMC-OPS-V1.0	MERnRM_0XXX
Descam OPGS EDRs	MIPL	MIPL	IMG	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-DESCAM-2-EDR-OPS-V1.0 Experiment Data Records	MERnOP_0XXX

Data Sets	Data Set Producer	Archive Volume Producer	Curator	Controlling Document	Data Set IDs	Volume ID
EDL Atmosphere EDRs	David Kass, JPL	ATM	ATM		MER1/MER2-M-IMU-4-EDL-V1.0 Experiment Data Records	MERIMU_1001
EDL Atmosphere RDRs	tbd	ATM	ATM		(TBD by ATM Node) **	MERnAT_1XXX
Mini-TES Science EDRs	ASU	WU	GEO	Science RDR Archive Volume SIS	MERn-M-MTES-2-EDR-V1.0 Experiment Data Records	MERnMT_0XXX
Mini-TES Science RDRs	ASU	WU	GEO	Science RDR Archive Volume SIS	MERn-M-MTES-3-RDR-V1.0 Radiometrically calibrated data products MERn-M-MTES-4-BTR-V1.0 Brightness temperature products MERn-M-MTES-4-EMR-V1.0 Emissivity products	MERnMT_1XXX MERnMT_2XXX MERnMT_3XXX
APXS OPGS EDRs	MIPL	WU	GEO	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-APXS-2-EDR-OPS-V1.0 Experiment data records	MERnOP_0XXX
APXS Science RDRs	Max Planck	WU	GEO	Science RDR Archive Volume SIS	MERn-M-APXS-2-XRAYSPEC-SCI-V1.0 Merged and summed spectra MER1/MER2-M-APXS-5-OXIDE-SCI-V1.0 Tables of chemical concentrations**	MERnAP_1XXX MERAP_2XXX
MB OPGS EDRs	MIPL	WU	GEO	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-MB-2-EDR-OPS-V1.0 Experiment Data Records	MERnOP_0XXX
MB Science RDRs	Univ. Mainz	WU	GEO	Science RDR Archive Volume SIS	MERn-M-MB-4-SUMSPEC-SCI-V1.0 Merged and summed spectra MER1/MER2-M-MB-5-MINERAL-SCI-V1.0 Mineralogical analysis tables**	MERnMB_1XXX MERMB_2XXX

Data Sets	Data Set Producer	Archive Volume Producer	Curator	Controlling Document	Data Set IDs	Volume ID
RAT OPGS EDRs	MIPL	WU	GEO	Ops EDR / Cam RDR Archive Volume SIS	MERn-M-RAT-2-EDR-OPS-V1.0 Experiment Data Records	MERnOP_0XXX
Radio Science EDRs	William Folkner, JPL	WU	GEO	Science EDR Archive Volume SIS	MERn-M-RSS-1-EDR-V1.0 Experiment Data Records**	MERnRS_0XXX
SPICE Kernels	NAIF	NAIF	NAIF		MERn-M-SPICE-6-V1.0 Observation geometry data and events: SPK, PcK, I, C, FK, LSK, SCLK kernels	MERnSP_0XXX
Mobility Reports	WU	WU	GEO	None (special product)	MERn-M-ENG-6-MOBILITY-v1.0 Rover mobility reports**	MERnMO_0XXX

ATM = PDS Atmospheres Node, New Mexico State University

GEO = PDS Geosciences Node, Washington University

IMG = PDS Imaging Node, JPL/USGS

MIPL = Multimission Image Processing Laboratory, JPL

NAIF = Navigation and Ancillary Information Facility, JPL

WU = Washington University

** = Special products are not on the same schedule as the standard products. Our goal is to have preliminary Moessbauer mineralogical analysis tables and APXS chemical concentrations available on the PDS 3 months after the corresponding EDRs are delivered, and PDS-compliant versions available 6 months after the corresponding EDRs are delivered. The schedule for other special products is on a best-efforts basis.

Table 5. MER Archive Generation, Validation, and Release Schedule

Event	MER-A Spirit	MER-B Opportunity
Launch Date	June 10, 2003	July 7, 2003
Sol 1: Start of operations	January 4, 2004	January 25, 2004
Sol 31	February 4, 2004	February 25, 2004
Sol 91: Start of extended mission	April 5, 2004	April 26, 2004
Release 1, data acquired on Sols 1-30	August 3, 2004	August 24, 2004
Sol 180	July 6, 2004	July 27, 2004
Release 2, data acquired on Sols 31-90	October 4, 2004	October 25, 2004
Release 3, data acquired on Sols 91-180	February 28, 2005	
Release 4, data acquired on Sols 181-270	April 22, 2005	
Release 5, data acquired on Sols 271-360	July 29, 2005	
Release 6, data acquired on Sols 361-450	October 28, 2005	
Release 7, data acquired on Sols 451-540	February 3, 2006	
Release 8, data acquired on Sols 541-630	April 27, 2006	
Release 9, data acquired on Sols 631-720	July 27, 2006	
Future releases every 90 sols; final release no later than 6 months after end of mission for each rover		