2001 Mars Odyssey Orbiter

ARCHIVE GENERATION, VALIDATION, AND TRANSFER PLAN

REVISION 1

April 16, 2003

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8/25/00	Corrected dates of instrument operation based on timeline in Mission Plan	5.3, Table 6
10/17/00	Remove Tom Thorpe from signature page and added Scott Hubbard	Signature page
	Added statement that SPICE kernels are generated by Project and archived by NAIF	3.0
	Removed Figure 2, Flow of archive volume generation, validation and transfer (TBD)	Figure 2
11/3/00	Removed Figure 1, Mission Timeline (TBD)	Figure 1
	Revised to include new paradigm for electronic data distribution	2, 3, 4, 5
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5/21/01 Revision 0, first official release	Changed name of Mars Program Director from Scott Hubbard to Orlando Figueroa	Signature page
	Removed some references	1.4
	Combined tables 3-1 and 3-2; removed data volume column from Standard Products table (now 3-3)	Tables 3-1, 3-2, 3-3
	Updated estimate of data returns	2.1
	Miscellaneous minor edits	All
9/12/01	Changed description of GRS derived data sets	Table 2.1
4/16/03	Added revised delivery schedule as addendum	6

TBD ITEMS

Section	Description

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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 2001 Mars Odyssey Orbiter Mission archives containing raw and reduced data, documentation, and algorithms or software. Release of data to the public is delineated in a separate Public Information Plan.

1.2 Scope

The plan covers archiving of raw and reduced data sets and related information to be acquired or derived during the Mars Odyssey Orbiter Mission.

Specific aspects addressed in this plan are:

1. Generation of high-level mission, spacecraft and instrument documentation, instrument calibration reports, and documentation of software or algorithms used to produce reduced data records (RDRs).
2. Reduction of science packet data to experiment data records (EDRs) and RDRs, 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.
3. Generation of SPICE archives for use with software from the Jet Propulsion Laboratory's Navigation and Ancillary Information Facility (NAIF).
4. Generation and validation of PDS compliant archives containing Odyssey EDRs and RDRs, software, algorithms, documentation, and ancillary information.
5. Delivery to the community of validated Odyssey archives through the PDS.
6. Generation of deep archive volumes for permanent storage at the National Space Science Data Center (NSSDC).

1.3 Contents

This plan begins with a summary of Mars Odyssey mission phases, expected data volumes, and an overview of the ground data system. This section is followed by a description of the roles and responsibilities for organizations and personnel associated with generation, validation, and distribution of Odyssey archives that are compliant with PDS standards. The document ends with specific plans for each archive function: generation, validation, transfer, and distribution.

1.4 Applicable Documents and Constraints

The Archive Plan flows from and is responsive to the documents listed below.

1. Mars Exploration Program Data Management Plan, R. Arvidson and S. Slavney, Rev. 1.11, 2000.
2. Mars Odyssey Orbiter Mission Plan, Rev. B, Project Document 722-201, JPL D-16303, August 2000.

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

3. Data Management and Computation, Volume 1, Issues and Recommendations, 1982, National Academy Press, 167 p.
4. Issues and Recommendations Associated with Distributed Computation and Data Management Systems for the Space Sciences, 1986, National Academy Press, 111p.

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

5. Planetary Data System Data Preparation Workbook, February 1, 1995, Version 3.1, JPL D-7669, Part 1.
6. Planetary Data System Data Standards Reference, June 1, 1999, Version 3.3, JPL D-7669, Part 2.

Finally, the plan is meant to be consistent with the contracts negotiated between the Mars Odyssey Project and each Principal Investigator (PI) in which EDRs and RDRs and associated documentation are explicitly defined as deliverable products.

2. OVERVIEW OF MARS ODYSSEY ORBITER MISSION

2.1 Payload and Mission

The Odyssey Orbiter will carry three science instruments, the Thermal Emission Imaging System (THEMIS), the Gamma Ray Spectrometer (GRS), and the Martian Radiation Environment Experiment (MARIE). THEMIS will map the mineralogy and morphology of the martian surface using multispectral imaging in the visible and thermal infrared. GRS will map the elemental composition of the surface. GRS includes the Gamma Ray Sensor Head (GSH), a Neutron Spectrometer (NS), and a High Energy Neutron Detector (HEND) to map the abundance of hydrogen in the shallow subsurface. Depth of the seasonal carbon dioxide polar caps will also be inferred from data collected by the neutron spectrometer subsystem on GRS. HEND data will be used to define a time series of gamma ray bursts and charged particle events. MARIE will characterize the near-space radiation environment. MARIE is an instrument provided by the Human Exploration and Development of Space Program, whereas THEMIS and GRS are provided through the Office of Space Science. Table 2-1 summarizes the Odyssey Orbiter payload.

The Mars Odyssey Orbiter was launched April 7, 2001, and will arrive at Mars in October 2001. The Orbiter will use aerobraking to be placed into a 400 km circular orbit about 65 days after arrival. The nominal science mission for the Mars Odyssey Orbiter extends for 917 Earth days after the spacecraft has achieved a near-circular orbit in December 2001. MARIE will acquire data continuously throughout the science mission. On the other hand, THEMIS and GRS have conflicting observation requirements. Signal to noise is highest for THEMIS observations occurring before 5:00 pm local true solar time. The initial mapping orbit is designed to achieve a LTST of 4:13 pm, consistent with requirements for thermal imaging. However, the GRS requires a beta angle of less than -57.5 degrees, which is violated during the initial mapping orbit. To meet both

requirements the spacecraft orbital node precession rate is controlled so that appropriate observing periods are reached during the mapping mission for both payloads. GRS will begin acquiring data approximately 140 days into the science mission and will continue until the end of the science mission in June 2004. THEMIS will have two prime periods of data acquisition, the first from December 2001 through October 2002, and the second from September 2003 to the end of the mission; however, THEMIS will make observations throughout mapping to produce night IR maps and take additional visible images.

During the mission the primary, relay, and extended mapping mission downlink returns for THEMIS alone are estimated to be 242 gigabytes. Estimates for processed data from the primary and extended missions could be as much as 5 terabytes for the THEMIS instrument alone. GRS is estimated to produce 14.9 gigabytes telemetry data, processed into 29.8 gigabytes of EDRs and RDRs. MARIE should downlink 2.8 gigabytes, processed into 5.6 gigabytes. The total volume of science telemetry is therefore approximately 260 gigabytes, and the total volume of raw and derived data from the mission is over 5 terabytes.

2.2 Ground Data System

Principal Investigators will be responsible for retrieving science packets (science telemetry), SPICE files, and other relevant information from the appropriate project data bases and transferring the files to their respective home institutions, using electronic transfer. Principal Investigators will generate EDRs and RDRs at their home institutions and will make these products available to Co-Investigators and other personnel, using the data use policies outlined in the Mars Exploration Program Data Management Plan [1]. Once EDR and RDR data products have been validated and released to PDS as archives, the data and associated information will be made available to the research, education, and public communities.

Table 2-1. Mars Odyssey Orbiter Payload

THEMIS (Thermal Emission Imaging System	THEMIS data sets will consist of 9 band thermal infrared (6.3 to 15.5 micrometers) images with 100 m/pixel and 5 band visible-reflected infrared (0.425-0.950 micrometers) images with 20 m/pixel. The data sets will be used to determine the mineralogy and thermophysical properties of Mars, to map the surface morphology, and to search for hydrothermal systems using pre-dawn observations.	P. Christensen, Arizona State University
GRS (Gamma-Ray Spectrometer, includes Gamma Ray Sensor Head, Neutron Spectrometer, and High-Energy Neutron Detector)	GRS derived data sets will consist of a suite of global maps depicting elemental ratios and abundances with a precision as good as 10% and a spatial resolution as good as 500 km. The prime data products from the NS and HEND will be global maps depicting hydrogen (with depth of water inferred) and polar CO_2 ice abundances. An additional HEND data product will consist of time series of gamma ray and particle fluxes from non-martian sources.	W. Boynton, University of Arizona
MARIE (Martian Radiation Environment Experiment)	MARIE data sets will consist of H and He energy spectra associated with solar energetic events and galactic cosmic rays from approximately 15 MeV/n to 500 MeV/n.	G. Badhwar, Johnson Space Center

3. OVERVIEW OF ARCHIVING FUNCTIONS

Standard products form the core of the archives to be produced by Odyssey and released to the PDS for distribution to the science community and others. Standard products are well-defined, systematically generated data products, i.e., EDRs and RDRs. These products and associated supporting information (e.g. documentation, index tables) will be validated and delivered to the PDS at regular intervals. Table 3-1 lists the components of the Odyssey archives, their suppliers, and the organizations responsible for archiving and distributing them. Table 3-2 shows the standard processing levels defined for science data. Standard products for each instrument are listed in Table 3-3.

In the following section we discuss the processes and schedules for generation and validation of standard products and archives, delivery to the PDS, and distribution to the science and other communities.

3.1 Generation of Archives

Instrument science packets, spacecraft engineering packets, other engineering information and data, and SPICE kernels will be generated by Mars Odyssey Data Administration and archived by NAIF. Principal Investigators will access the relevant project data base, retrieve instrument science packets and other information and generate EDRs and RDRs (see Table 3-3). These data products will form the Mars Odyssey science data archives, along with supporting materials such as documentation, index tables, calibration files, and algorithms and/or software. The archives will be assembled under Principal Investigator auspices with guidance and assistance as needed from the Mars Odyssey Interdisciplinary Scientist for Data and Archives and the Mars Odyssey Data Products Working Group (DPWG). The DPWG will also help generate plans for these archives and provide oversight during the archiving phase of the mission. The DPWG is a subgroup of the Odyssey Project Science Group.

3.2 Validation and Delivery of Archives to the Planetary Data System

The Planetary Data System requires that science archives be validated both for scientific integrity and for compliance with PDS standards. Validation will be done at several points along the path from receipt of raw packets to delivery of standard products, by a combination of mission and PDS personnel. Broad oversight of the validation work will be accomplished by the Science Data Validation Team (SDVT), a multi-mission team that ensures that all Mars Exploration Program projects are maintaining archiving schedules. The DPWG will work on a detailed level to ensure that validation steps are accomplished.

Validation of standard products and associated information will be done by the instrument teams as an integral part of their data analysis work. Standard products will then be assembled with supporting materials such as labels, index tables, documentation and software to form archives.

An important step is the validation of standard product archives before delivery to the PDS. The first archive delivery from an instrument will undergo a formal PDS peer review with participation by mission personnel, PDS personnel, and invited reviewers

from the science community, under DPWG auspices. The archives will be examined for integrity of scientific content, compliance with the applicable Data Product Software Interface Specification (SIS) and Archive SIS, and compliance with PDS standards. Often a peer review will result in requests for changes or additions to the supporting material in the archive ("liens"). The liens will be resolved before the archive can be accepted by PDS. Subsequent deliveries of archives throughout the mission are not required to undergo another peer review, as long as they do not vary substantially from the first delivery. They are, however, required to pass a validation check for PDS compliance. If minor errors are found, they may simply be documented in an errata file that accompanies the archive. Major errors will be corrected before the archive is accepted by PDS. When an archive has passed peer review and the PDS validation check, it will then be considered to be released, or "delivered", to the PDS.

3.3 Distribution of Data Products

The Mars Odyssey Project is responsible for making data products available to its own personnel. The PDS is responsible for making data products available to the rest of the science community and to the public.

Archives from previous missions have often been distributed to the science community on a set of physical media (e.g. CD-ROMs). The large volume of data expected from Mars Odyssey makes this form of distribution expensive and impractical. Instead, distribution will be accomplished chiefly by Internet access in ways that take advantage of the capabilities and expertise associated with Principal Investigator home institution systems.

Specifically, the MARIE archives will be transferred to the PDS PPI Node at UCLA for online access once the archives have been validated and released. GRS RDRs will likewise be transferred to the PDS Geosciences Node at Washington University for online access. In addition, the University of Arizona GRS facility will retain EDRs and RDRs and become a PDS Data Node, processing data on demand for special purposes as required by the research community. Because of the expertise and extensive facilities located at the Arizona State University THEMIS facility, Arizona State will also become a PDS Data Node and be responsible for maintenance and online distribution of THEMIS archives. It is the intent to fill as many orders as possible using online systems. The PDS is also prepared to distribute hard copy volumes (primarily DVDs) upon request.

PDS Data Nodes are formed to archive and distribute particular data sets for a limited period of time. Some time after the end of the mission, when demand for the THEMIS and GRS data sets has become reduced, the Data Nodes may be dissolved, at which point the responsibility for archiving and distributing the data will pass to permanent PDS Nodes.

3.4 Permanent Storage and Backups

The PDS is responsible for maintaining copies of its science archives on permanent physical media, and for delivering copies of science archives to the National Space Science Data Center (NSSDC). As archives are released, the PDS Discipline Nodes or their Data Nodes will generate at least three copies on appropriate physical media for long-term storage by PDS and NSSDC.

During the six-month validation period before delivery, and the interval following delivery during which the PDS is writing the archives to physical media, the data products will exist as online archives only. To reduce the risk of data loss, the Mars Odyssey Project is responsible for conducting periodic backups or otherwise maintaining redundant copies of online archives until they are permanently stored with PDS.

Table 3-1. Mars Odyssey Orbiter Archive Components

Archive Component	Supplier	Archive and Distribution
Science Data Archives		
Experiment Data Records (EDRs), including labels and ancillary information	Science Operations and Support Team	THEMIS and GRS Data Nodes, PDS PPI Node
Reduced Data Records (RDRs), including labels and ancillary information	Science Operations and Support Team	
Processing Descriptions, Algorithms, and Software (to use in understanding RDR product generation)	Science Operations and Support Team	
Instrument Calibration Reports and associated data needed to understand RDR product generation	Science Operations and Support Team	
Data Product and Archive Volume Software Interface Specification (SIS) Documents	Science Operations and Support Team	
High-level mission, spacecraft, instrument, and data set descriptions for the PDS Catalog	Science Operations and Support Team	
SPICE Archives		
SP Kernels	Navigation Team	NAIF
I Kernels	Science Operations and Support Team	
C Kernels	Spacecraft Team	
E Kernels	Data Administration	
E Kernel contributions - instrument specific	Science Operations and Support Team	
Predicted Events File input to E Kernel	Mission Planning, Sequencing, & Execution	
Sequence of Events File input to E Kernel	Mission Planning, Sequencing, & Execution	
NAIF Software	NAIF	
SPICE Software Interface Specification Documents	NAIF	
Engineering Data Archives		
Science Packet Data	Data Administration	NAIF
Engineering Packet Data	Data Administration	
Monitor Data	Data Administration	
Spacecraft Status Report	Spacecraft Team	
Mission Controllers' Real-Time Operations Log	Spacecraft Team	
Other engineering products as appropriate	Data Administration	
Data Product and Archive Volume Software Interface Specification Documents	Data Administration	

Table 3-2. 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 1C	Derived - Level 5	Level 1A or 1B data that have been resampled and mapped onto uniform space-time grids. The data are calibrated (i.e., radiometrically corrected) and may have additional corrections applied (e.g., terrain correction).
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 3-3. Mars Odyssey Orbiter Standard Data Products

	Product	Description
MARIE	MARIE-EDR	Raw time series of counts and radiation levels for various detectors
	MARIE-RDR	Time series of radiation levels reduced to geophysical units
THEMIS	THM-VISEDR	Image cube of visible bands
	THM-IREDR	Image cube of infrared bands
	THM-VISRDR	Visible-band image cubes in radiance units
	THM-IRRDR	Infrared-band image cubes in radiance units
GRS	GRS-EDR	Raw spectra
	GRS-RDR	Maps of element ratios and/or concentrations
	GRB-EDR	Gamma ray burst and charged particle events as time series of counts
	GRB-RDR	Gamma ray burst and charged particle events as time series of fluxes
	NS-EDR	Raw spectra
	NS-RDR	Maps of hydrogen concentrations and carbon dioxide ice thickness
	HEND-EDR	Raw spectra
	HEND-RDR	Maps of hydrogen concentrations
SPICE	SPK	SPK kernels
	PcK	PcK kernels for times of interest
	IK	I kernels for instruments
	CK	C kernels for spacecraft rotations
	EK	E kernels delineating sequences and Experimenter's Notebooks depicting events

4. ROLES AND RESPONSIBILITIES

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

4.1 Mars Odyssey Project

The Project Scientist and the Project Science Group, through the Data Products Working Group (DPWG), provide an oversight function for implementation of the Archive Generation, Validation, and Transfer Plan. The Mars Exploration Program Interdisciplinary Scientist for Data and Archives will advise the Project with regard to archiving. He will work with Mars Odyssey and the PDS to help ensure that detailed plans are in place for generation of Planetary Data System-compatible products and associated documentation, and that archive volumes are generated, validated, and transferred to the Planetary Data System.

The Mars Odyssey project will archive engineering and science packets from spacecraft instruments, DSN monitor data, and SPICE files. Principal Investigators will archive EDRs and RDRs, documentation, the algorithms or software used to generate RDRs from the EDRs, and other supporting materials. Each data provider is responsible for publishing Data Product Software Interface Specification (SIS) documents that describe in detail the format and content of the data products, along with an Archive SIS. SISs may be included in the archives as part of the documentation.

The Mars Exploration Program Science Data Validation Team (SDVT) will be responsible for providing an oversight function that keeps archive generation, validation, and delivery on schedule.

The Mars Odyssey Project will provide funds to distribute Odyssey archives internally to Odyssey scientists and mission personnel.

4.2 Planetary Data System

The PDS is the designated point of contact for Mars Odyssey on archive-related issues. The PDS is also the interface between Odyssey and the NSSDC.

The PDS, through the Interdisciplinary Scientist for Data and Archives and the DPWG, will work with the SDVT and other Odyssey elements to ensure that the Odyssey archives are compatible with PDS standards and formats.

The PDS will provide funds for generation, distribution, and maintenance of Odyssey archive volumes for the NASA-supported science community. It may be necessary to augment the basic PDS funding line with MO&DA funds for the new GRS and THEMIS Data Nodes.

PDS Data Nodes for GRS and THEMIS are responsible for maintaining the capability (software and/or algorithms) to generate their derived data products from EDRs. When the time comes for a Data Node to be dissolved (some time after the end of the mission, when demand for the data is no longer as great), the Data Node is

responsible for passing on the processing capability to the permanent PDS Node that takes over the maintenance of the data.

4.3 National Space Science Data Center

The National Space Science Data Center will maintain a "deep archive" of Mars Odyssey data for long-term preservation and for filling large delivery orders to the science community. The PDS will deliver copies of Mars Odyssey archive volumes on physical media to NSSDC.

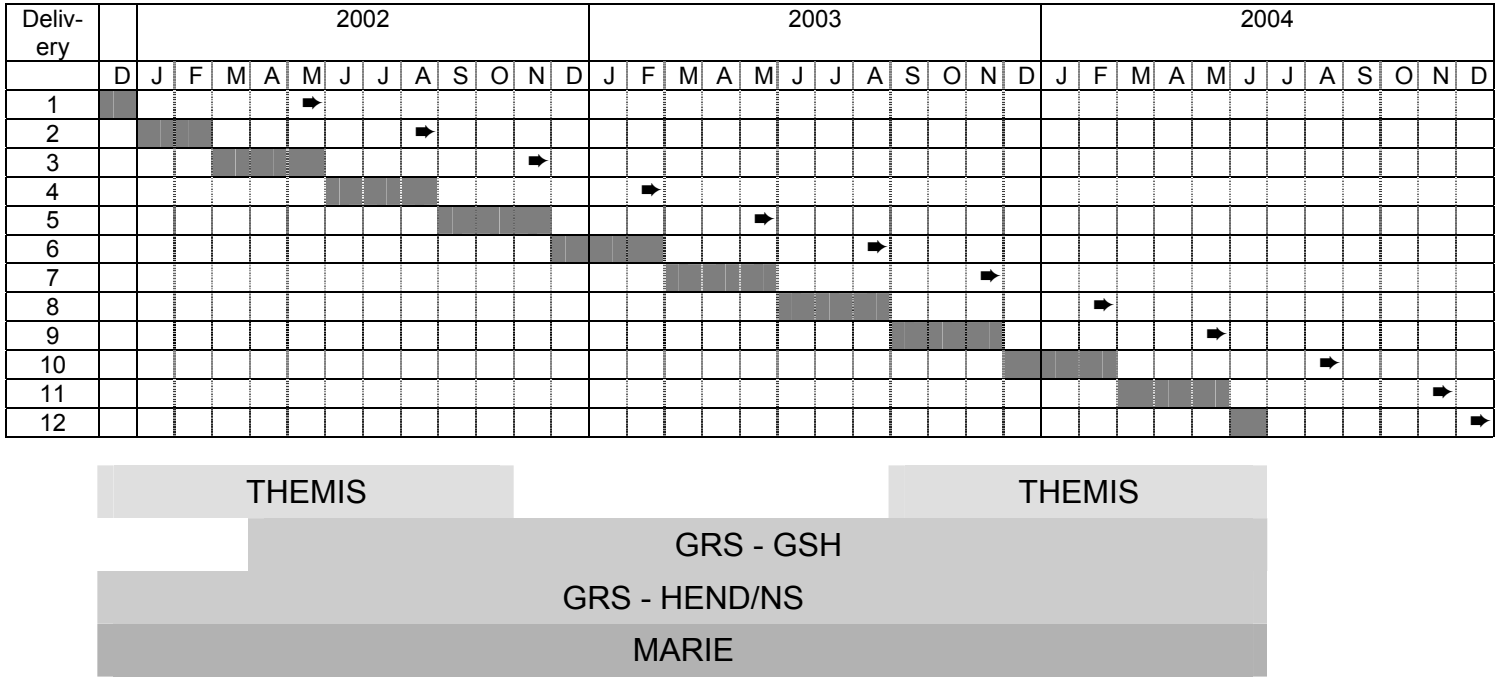
5. ARCHIVE GENERATION, VALIDATION, AND RELEASE SCHEDULES

The Mars Odyssey Project will release science data archives within six months of receipt of the last raw data included in the archives, in compliance with the Mars Exploration Program data release policy. During the six month interval the data will be processed to standard products, validated through analyses, assembled into archives (on line), and checked for compliance with PDS standards.

The nominal science mission for the Mars Odyssey Orbiter extends for 917 Earth days after the spacecraft has achieved a near-circular orbit in December 2001. The Orbiter instruments have different scheduled times for data acquisition. MARIE will acquire data continuously throughout the science mission. GRS will begin acquiring HEND and NS data at the beginning of mapping, and GSH data at about 140 days into the science mission, to continue until the end of the mission on August 1, 2004. THEMIS will have two periods of prime data acquisition, the first from December 2001 through October 2002, and the second from about September 2003 to the end of the mission. In addition, THEMIS will use all unallocated data volume throughout mapping to create night IR maps and additional visible images.

In accordance with the Mars Exploration Program data release policy, a six-month period after data acquisition is allotted for product generation and validation. Therefore, the first Mars Odyssey data release will occur six months after the science mission begins, and will consist of data acquired during the first month. Thereafter, data releases will occur every three months. The second delivery will consist of data collected in months 2 and 3 of the science mission. Each of the remaining deliveries will include three months' worth of data acquired six to nine months previously. See Table 5-1 for a detailed delivery schedule.

Table 5-1. Mars Odyssey Orbiter Archive Delivery Schedule



6. ADDENDUM: REVISED ARCHIVE DELIVERY SCHEDULE April 16, 2003

The Odyssey primary mapping mission began on February 19, 2002, later than originally expected. The 917-day mapping mission will end on August 24, 2004. An extended mission is likely.

As the start of mapping was delayed, the first release of Odyssey data to the PDS occurred later than planned, on October 1, 2002. It included data acquired through March 31, 2002, which was more than the one month's worth of data originally planned for the first release. Subsequent releases occurred on January 1, 2003 and April 1, 2003. Table 6-1 shows the revised delivery schedule through the remainder of the primary mission.

Table 6-1. Revised Odyssey Archive Delivery Schedule

Release	Release Date	Data Coverage
1	October 1, 2002	February 19 – March 31, 2002 plus pre-mapping data
2	January 1, 2003	April 1 – June 30, 2002
3	April 1, 2003	July 1 – September 30, 2002
4	July 1, 2003	October 1 – December 31, 2002
5	October 1, 2003	January 1 – March 31, 2003
6	January 1, 2004	April 1 – June 30, 2003
7	April 1, 2004	July 1 – September 30, 2003
8	July 1, 2004	October 1 – December 31, 2003
9	October 1, 2004	January 1 – March 31, 2004
10	January 1, 2005	April 1 – June 30, 2004
11	April 1, 2005	July 1 – August 24, 2004