APPENDIX B

PLANETARY MISSIONS AND DATA SETS

This appendix provides an overview of the various planetary missions, with descriptions of the imaging instruments and data products produced by each mission.

1. VOYAGER

The Voyager mission has returned over 60,000 television images of Jupiter, Saturn, their satellites, and their rings. More data are expected during the next decade as the Voyager 2 spacecraft flies past Uranus and Neptune before leaving the solar system.

The Voyager spacecraft were equipped with two mechanically shuttered cameras, each fitted with vidicon sensors and color filter wheels. Specifications for the Voyager cameras are given in Table B-1.

Most of the photographic products generated from the digital data were produced by the Mission and Test Imaging System (MTIS). A comprehensive description of the computer programs used to process the Voyager data is given in the MCCC/MTIS Voyager Program Description Document, JPL 618-792 (Ref. A-1). A final version of the Experiment Data Record (EDR) containing a minimum number of missing or defective pixels was generated for each Voyager image. The Voyager EDRs are recorded on 9-track tapes at a density of 1600 bpi. Each image comprises one file on the EDR tape, with as many as 24 files on a tape. One end-of-file marker (EOF) separates images. There are two EOFs after the last image on a tape. Each image file consists of a single header record of 1280 eight-bit bytes, followed by 800 line records consisting of 1040 bytes each. Each line record includes an MTIS header block, a source data summary, status/engineering data followed by 800 bytes of pixel data.

The major Voyager data catalogs include the Voyager picture catalog set and the Voyager SEDR catalogs. The Voyager picture catalogs contain a subset of SEDR parameters for each image as well as identification of digital image data sets and film products. There is a single major picture data file for Voyager 1 and 2 images of each planet system, and a number of sub-catalogs containing other parameters. There are three SEDR master catalogs, one for each spacecraft for Jupiter and a single tape for Saturn. These catalogs are available as stack tapes of the original delivered SEDRs or in files where all parameters have been converted to EBCDIC or ASCII character strings. Catalog file and tape identifiers are listed in Table B-2.

Copies of these catalogs in digital format can be obtained from the MIPL librarian, 818-354-4244, FTS 792-4244. Copies of printed catalogs on microfilm are available from the National Space Science Data Center (NSSDC).

Table B-1. Characteristics of Planetary Camera Systems

Mission	Focal Length (mm)	Field of View (degrees)	Field of View (Pixels (P) X Lines (L))	Bits per Pixel
Voyager				
Wide angle	200	3.0 X 3.0	800P X 800L	8
Narrow angle	1500	0.4 X 0.4	800P X 800L	8
Viking Orbiter				
Both cameras	475	1.69 X 1.54	1204P X 1056L	7
Viking Lander				
Both cameras	53.7	0.04 X 20	512P X Var.	6
Mariner 10				
Narrow angle(2)	1500	0.48 X 0.37	832P X 700L	8
Wide angle optics	62	14 X 11	832P X 700L	
Mariner 9				
Narrow angle	500	1.41 X 1.06	832P X 700L	9
Wide angle	52	13.5 X 10.5	832P X 700L	9
Mariners 6 and 7				
Narrow angle	508	1.4 X 1.1	945P X 704L	8
Wide angle	52	14 X 11	945P X 704L	8
Mariner 4				
	305	1.1 X 1.1	200P X 200L	6

2. VIKING ORBITER

In the 3-year period from June 1976 to October 1979, two Viking Orbiter spacecraft returned more than 50,000 images of the Martian surface and satellites to Earth. Although the Voyager missions have returned a greater number of images, the larger image format of the Viking cameras makes this the largest planetary data set in existence. Descriptive material on this data set is dispersed through many scientific papers, formal reports, and informal memoranda. There is no single organized catalog of data such as those that exist for Mariner 9 or for the Viking Landers.

Table B-2. Planetary Image Catalog Files

Mission and Target Body	Picture Catalogs	SEDR Catalogs
Voyager 1 Jupiter	J1PIC1	J1SDR1
Voyager 2 Jupiter	J2PIC1	J2SDR2
Voyager 1 Saturn	SPIC1	S1SDR1
Voyager 2 Saturn	SPIC1	S2SDR2
Viking Orbiter	VOPIC1	VOSED1, 2 and 3
Viking Lander	VLPIC1	VLSDR1 and 2
Mariner 10	MVMPC1	
Mariner 9	M9PIC1	SDRM71
Mariners 6&7	PICM69	
Special Catalogs		
Viking Lander Team Data Record		VLTDR
Viking Orbiter Mosaic Catalog		VOMOS1
Voyager Tape Catalog		VGRCAT
Viking Tape Catalog		VIKCAT

The Viking Orbiter imaging experiment used two identical telescopic cameras, each equipped with large format vidicon sensors and provided with a movable color filter wheel located near the focal plane. The camera characteristics are described in Table B-1. Images were initially recorded on 7-track magnetic tape recorders on the spacecraft. The data were played back to Earth one track at a time by operating the tape recorder alternately in the forward and reverse directions. Each raw data frame retrieved from the tracking station thus contains every seventh pixel arranged in either increasing or decreasing order. Image data reconstructed from these raw data frames by the MTIS form the Experiment Data Record (EDR).

The majority of Viking images were acquired as strips of contiguous and slightly overlapping images, which are most useful when assembled into mosaics. In many cases multiple strips can be assembled to form still larger mosaics, which provide a synoptic view of a regional surface and can support detailed geologic mapping.

Viking Orbiter EDRs are recorded on 9-track tape at densities of either 800 or 1600 bpi (800 was used only during the first few weeks of the mission). A maximum of 14 images are contained on one tape recorded at 1600 bpi. Images are separated by single EOFs with two EOFs following the last image on a tape. Each image file consists of an EDR header record of 1200 bytes, an SEDR record of 2000 bytes and 1056 line records, each 1600 bytes long. Records are not blocked. Pixel values are stored as 8-bit integers with a range from 0 to 255. The values represented on the EDR tape are actually two times the value received in the telemetry stream. Because of the nature of the recording and

playback system, strings of missing bits appear as vertical bars at 7-pixel intervals. Missing pixels are set to zero on the EDR tapes.

Viking Orbiter catalogs include the picture catalog, a collection of SEDR and image data product information, a set of four SEDR stack tapes, and a mosaic catalog documenting the large set of digital and hand mosaics produced by JPL during and after the mission. Table B-2 identifies tapes containing the Viking catalogs.

3. VIKING LANDER

The Viking Lander imaging data set was acquired by the two Viking Lander spacecraft on the surface of Mars. Viking Lander 1 began operation on July 10, 1976 and continued to return data until early 1983, when communications were lost. Viking Lander 2 began operation on September 3, 1976 and concluded transmission in February 1980. The camera systems utilized by the Landers are summarized in Table B-1.

A comprehensive description of this data set is provided in a three-document picture catalog. The first document, "Viking Lander Imaging Investigation: Picture Catalog of Primary Mission Experiment Data Record" (Ref. B-1) describes data from the primary mission covering the period from landing through the solar conjunction period in December 1976 when data transmission ended. The second document, "Viking Lander Imaging Investigation During Extended and Continuation Missions," in two volumes (Ref. B-2), describes the Lander 1 and 2 missions through February 1979. The final document, "Conclusion of Viking Lander Imaging Investigation" (Ref. B-3), describes the last several years of imaging activities.

The introductory material in each of the three documents includes a description of the Viking Lander cameras, their calibration, and the coordination of the Viking Lander cameras and their image data. The Viking Landers were designed to directly transmit data to Earth at low data rates as well as to relay data via the Orbiters at much higher data rates. Those documents describe the implications of these data modes for the types of data recovered from the Landers as well as the extraction of image data from the telemetry to produce the EDR data set.

The Viking Lander EDRs are recorded at 1600 bpi on 9-track tapes. A variable number of images are contained on each tape with each image separated by a single EOF and two EOFs following the last image on the tape. Image files are written in standard VICAR format with a variable number of label records followed by 512 line records. The logical record length of each label or line record is equal to the number of vertical lines in the image (variable from image to image), or 360 bytes, whichever is larger. All label information is represented in EBCDIC (Extended Binary Coded Decimal Interchange Code) format. Each pixel is stored as an 8-bit binary value ranging from 0 to 255, which represents the actual 6-bit data value from the instrument times 4.

There is also another Viking Lander digital data set called the Team Data Record (TDR). This record consists of sets of specially enhanced images

and includes mosaic data sets, color images, and other special products. Image data is stored on 9-track tapes in VICAR format recorded at 1600 bpi.

4. MARINER 10

The Mariner 10 mission was the first multiplanet mission carried out by a single spacecraft. In one flyby of Venus followed by three flybys of Mercury, Mariner 10 returned more than 12,000 images to Earth. Images of the airless body Mercury were of interest to planetary geologists, while the images of cloud-shrouded Venus were of meteorological significance.

The Mariner 10 spacecraft was equipped with two vidicon framing cameras, whose characteristics are detailed in Table B-1. The narrow-angle camera was used to image Venus and Mercury from long range and to obtain the highest resolution pictures near closest approach to the two planets. EDR and radiometrically decalibrated data exist for Mercury.

The "Atlas of Mercury" (Ref. B-4) covers the Mercury portion of the Mariner 10 mission. The Atlas includes an outline of the mission, a description of the cameras, photomosaics, maps and a set of references to the scientific photomosaic, and maps and a set of references to the scientific results. The Mercury observations of the Mariner 10 data set remain unique in that there have been no subsequent spacecraft observations of Mercury. The Venus images have recently been supplemented by the imaging type observations obtained by the Pioneer Venus Orbiter cloud photopolarimeter.

5. MARINER 9

Mariner 9 was launched on May 30, 1971. Between the time of Mars orbit insertion on November 14, 1971 and October 22, 1972, the spacecraft conducted an intensive orbital reconnaissance of the planet. The first complete geological map of Mars and the discovery of a host of hitherto unsuspected landmarks were among the spectacular results. A comprehensive description of the Mariner 9 mission and its imaging data set is provided in "Mariner Mars 1971 TV Picture Catalog," Vols. 1 and 2 (Refs. B-5 and B-6).

Mariner 9 was equipped with wide-angle and narrow-angle telescope cameras, small format selenium-sulphide vidicon sensors, and mechanical shutters. The wide-angle camera had a color filter wheel which functioned for only part of the mission. Characteristics of the cameras are given in Table B-1.

A set of Mariner 9 RDR (Reduced Data Record) images was also produced. The planetary image conversion task attempted to copy the RDR data set to high-density tape, but so many read errors were encountered that processing had to be abandoned. Substantial concern had been expressed by imaging scientists about the validity of the RDR data set, so its loss is not as tragic as it might have been.

6. MARINERS 6 AND 7

Mariner 6 and 7 spacecraft acquired 200 images of Mars at a variety of resolutions in the summer of 1969. These data are described in the "Scientific Findings from Mariner 6 and 7 Pictures, Final Report" (Ref. B-7) and "Mariner Mars 1969: A Preliminary Report" (Ref. B-8). The image tapes located by the conversion task have been computer-enhanced and actually represent a Reduced Data Record rather than an EDR. The wide-angle camera had a rotary shutter with four colored filters in the sequence red, green, blue, green, etc. The narrow-angle camera used a minus-blue haze filter. Mariner 6 and 7 images consist of 704 lines of 945 pixels. Three versions of each image were transmitted, composite analog video, digital video (every 7th pixel - 8 bits, 2 MSB truncated); and ETE (every 28th pixel). Table E-6 identifies all known Mariner 6 and 7 image tapes. All tapes are 7-track, but no other format documentation has yet been located.

7. MARINER 4

The Mariner 4 (Mars) mission acquired 22 images of Mars in 1965. By present standards the images are of very poor quality. A detailed description of the images is provided in "Mariner Mars 1964 Project: Television Experiment" (Ref. B-9) and "The Mars 1964-1965 Apparition" (Ref. B-10). Mariner 4 images contain 200 lines, each consisting of 200 six-bit pixels. The Mariner 4 digital tapes located at JPL include Master Data Records (K-xxx), MDR reacquisition tapes (MDL-xxx), TV picture tapes (KC-xxxx), and final flight pictures (RBLM-xx). Format documentation has only been found for the final flight pictures. They are stored on two identical sets of tapes: RBLM19 through RBLM22 and RBLM 23 through RBLM 26. Tape formats are described as being binary, high-density, with a physical record size of 256 bytes per block. There are 19 images contained on each tape with a single end-of-file mark after the last picture. RBLM 19 contains the true intensities of the flight pictures in regular format. Each picture consists of 16 x 172 blocks. To obtain one block from the tape, use the following FORTRAN statements:

```
DIMENSION P(16,172)
READ (L)P
```

where L is an integer constant specifying a logical unit where the tape is mounted. P(1,1) of the first block of each picture corresponds to the picture element at line 7 and column 29, and P(16,172) of the first block corresponds to the picture element at line 22, column 200. RBLM 21 contains the true intensities of the sharpened images in regular format and has the same recording characteristic as RBLM 19. Tape RBLM 20 contains the true intensities of flight pictures in rectified format. Each picture consists of twelve 16 x 193 blocks. To read an image the following FORTRAN statements can be used:

```
DIMENSION P(16,193)
READ (L) P
```

P(1,1) of the first block of each picture corresponds to the picture element at line 0 and column 11, and P(16,193) of the first block corresponds to the picture element at line 15 and column 203. RBLM 22 contains the true

intensities of the sharpened flight pictures in rectified format with the same structure as RBLM 20.

Other undocumented Mariner 4 Tape ids are listed below.

K-13,19,25,28,44,49-50,68,70,74,87,92,114-117,123-126,128,133
K-142-142,149,162-164,167-169,173

MDL-1,MDL3-5,MDL4-5,MDL-5,6-5,MDL-7,9-5

XA-001-040,042-063
X-039,053,128,137,179,199,201,202,206,208

8. OTHER PLANETARY MISSIONS

The Pioneer 10 and 11 missions carried photopolarimeters which produced image data of the Jupiter and Saturn (Pioneer 11 only) systems. The Pioneer Venus Orbiter radar has also produced an image data set which should be incorporated into the image archive.