MARS GLOBAL SURVEYOR

Mars Orbiter Camera
Reduced Data Record (RDR)
Software Interface Specification (SIS)

DRAFT
Ver. 3.0

Prepared by:

Planetary Data System (PDS) - Cartography and Imaging Sciences Node

With Acknowledgement to:

Malin Space Science Systems

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DOCUMENT CHANGE LOG

Date	Description	Sections affected
8/3/16	Initial Draft	All

TBD ITEMS

Section	Description

CONTENTS

ACRONYMS

EDR	Experiment Data Record
MGS	Mars Global Surveyor
MOC	Mars Orbiter Camera
NA	Narrow Angle (Camera)
PDS	Planetary Data System
RDR	Reduced Data Record
SIS	Software Interface Specification
TBD	To Be Determined
WA	Wide Angle (Camera)

1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this Data Product SIS is to provide users of the Mars Orbiter Camera (MOC) Reduced Data Record (RDR) with a detailed description of the product and a description of how it was generated, including data sources and destinations. The MOC RDR consists of maps generated from MOC Narrow Angle (NA) and Wide Angle (WA) Camera images. This SIS is intended to provide enough information to enable users to read and understand the data product. The users for whom this SIS is intended are the scientists who will analyze the data, including those previously associated with the MGS Project and those in the general planetary science community.

1.2 Contents

This Data Product SIS describes how the MOC RDR data product is processed, formatted, labeled, and uniquely identified. The document discusses standards used in generating the product and software that may be used to access the product. The data product structure and organization is described in sufficient detail to enable a user to read the product. Finally, an example of a product label is provided.

1.3 Applicable Documents and Constraints

This Data Product SIS is responsive to the following MGS Project documents:

1. Mars Global Surveyor Science Data Management Plan (JPL 542-310).
2. Mars Global Surveyor Project Archive Generation, Validation and Transfer Plan (JPL 542-312).

This SIS is also consistent with the following Planetary Data System documents:

3. Planetary Data System Archive Preparation Guide, April 1, 2010, Version 1.4, JPL D-31224.
4. Planetary Data System Data Standards Reference, February 27, 2009, Version 3.8, JPL D-7669, Part 2.

The reader is referred to the following documents for additional information:

5. Mars Orbiter Camera Software Interface Specification – Narrow Angle and Wide Angle Standard Data Products, September 1999.
6. Malin, M.C., G.E. Danielson, A.P. Ingersoll, H. Masursky, J. Veverka, M.A. Ravine, and T.A. Soulanille, (1992) "Mars Observer Camera," *J. Geophys Res., 97, (E5), 7699-7718*.
7. Malin, M.C, G.E. Danielson, M.A. Revine and T.A. Soulanille, (1991) "Design and Development of the Mars Observer Camera", *International Journal of Imaging Systems and Technology, vol. 3, 76-91*.

8. Caplinger, M., (Jan. 1995) "Mars Observer Camera Ground Data System Overview," http://www.msss.com/mars/observer/camera/papers/gds_papers/GDS_overview/GDSoverview.html

2. DATA PRODUCT CHARACTERISTICS AND ENVIRONMENT

2.1 Instrument Overview

Mars Observer Camera (MOC) is a three-component imaging system (one narrow-angle and two wide-angle cameras) designed to take high spatial resolution pictures of the surface and to obtain lower spatial resolution, synoptic coverage of the surface and atmosphere [MALINETAL1992, MALINETAL1998]. The cameras are based on the 'push broom' technique, acquiring one line of data at a time as the spacecraft orbits the planet. Using the narrow-angle camera during the Mapping Phase of the mission, areas ranging from 2.8 x 2.8 km to 2.8 x 25.2 km (depending on available internal digital buffer memory) can be imaged at about 1.4 m/pixel. Additionally, lower-resolution pictures (to a lowest resolution of about 11 m/pixel) can be acquired by pixel averaging; these images can be much longer, ranging up to 2.8 x 500 km at 11 m/pixel.

The following table summarizes MOC characteristics.

Camera	Min wavelength (nm)	Max wavelength (nm)	Focal length (cm)	Aperture	F number	Resolution (380 Km, m/pixel)
Narrow angle	500	900	350.0	0.35 m	10	1.5
Wide angle red	600	630	1.1	1.7 mm	6.4	230
Wide angle blue	420	450	1.14	1.8 mm	6.3	230

A detailed instrument overview and operating capabilities of the MOC can be found in the MOC Instrument paper [5,6].

2.2 Data Product Overview

This archive is a comprehensive collection of maps generated from Mars Orbiter Camera (MOC) Narrow Angle (NA) Camera images and MOC Wide Angle (WA) Camera images taken of Mars from the Mars Global Surveyor (MGS) Satellite between 1998 and 2006. Each MOC image taken was mapped separately using a suitable map projection and scale for the data resolution and location on the planet.

An attempt was made to map project each image. The only MOC images omitted from this archive were those that were blank after processing, or high resolution MOC NA images that were entirely or partially off-planet..

2.3 Data Processing

Image maps were generated according to the following pipeline:

- Ingest from MOC Standard Data Product (MSDP) format with recovery of lost data
- Noise removal (MOC NA sum 1 images only)
- Destriping after conversion to absolute DN
- Histogram preserving scale back to 8 bit
- Map projection
- Conversion from MSSS image format to PDS format

A detailed description of each processing step is provided in Section 2.3.2.

2.3.1 Data Processing Level

This documentation uses the "Committee on Data Management and Computation" (CODMAC) data level numbering system. The MOC instrument RDRs referred to in this document are considered "Level 4" or "Resampled Data" (equivalent to NASA Level 1-B).

Refer to Table 1 for a breakdown of the CODMAC and NASA data processing levels.

2.3.2 Data Product Generation

2.3.2.1 INGEST FROM MSDP FORMAT

Ingest processing included a number of manual and automatic repair steps, not previously attempted on such a grand scale. Repair includes recovering compressed data previously lost due to lost/corrupt bits, and determining the lengths of lost data gaps.

The following repairs were automated with a reasonable success rate:

- recovery of predictively (lossless) compressed image lines data backwards from the next good sync, which should have occured every 128 lines.
- recovery of DCT compressed image blocks backwards from the end of the MSDP record.
- forward recovery of DCT compressed blocks in the interior of MSDP records, and placement using best across block correlation.
- correct placement of DCT uncompressed data after loss of one or more MSDP records.
- placement of data gaps for predictively uncompressed unsummed NA image data by correlating the noise signature.

The following repairs were automated with a marginal success rate:

- correct placement of predictively uncompressed data after loss of one or more MSDP records

Manual repairs were limited to removing "foreign" records from MSDP files, and occasionally rearranging data gaps in a few predictively uncompressed images.

Repair information was included in DATA_QUALITY_ID in the final PDS image files.

2.3.2.2 NOISE REMOVAL FOR UNSUMMED NA IMAGES

Unsummed MOC NA image data includes a very distinct noise pattern with a fixed known period, generated by the power supply. Simple auto-correlation techniques were used to identify the per-line noise offset. Then the pixels affected by the noise were replaced by values computed from their nearest neighbors using a custom convolution filter.

2.3.2.3 CONVERSION TO ABSOLUTE DN AND DESTRIPING

Raw camera COUNT was converted to absolute DN according to following:

DN = ((COUNT - Z + OFFSET)/GAIN - G - DC*EX)/EX

Here, GAIN, OFFSET, and EX (exposure modified for summing) were derived from the downlinked data. The remainder of the variable values were fixed.

For NA, Z = 25.5767, G = 0.381963 and DC = 0. For WA, Z = 27.6765,

G = 0.123262, and DC = 0.

Initial values for these variables were included in the processing notes in the PDS file labels.

Gains and offsets for global WA images were pre-programmed to change at fixed lines (times) during acquisition. These values were used in the above formulas as needed, but do not appear in the PDS file processing notes.

Absolute DN were destriped using the best available flat tables for MOC NA and WA. Then they were converted to unsigned 16-bit values as follows: output = factor * DN + 10000, where A = 2000 for NA, A = 4866.511024 for WA red, and A = 41891.835342 for WA blue.

2.3.2.4 HISTOGRAM PRESERVING SCALE BACK TO 8-BIT

Histogram preserving means that most of the structure and relative value of the histogram are retained by the scaling. The following algorithm was used to scale the destriped data back to 8-bit:

- starting with absolute DN converted to 16-bit, compute the image histogram H[i] for unit integer bins i; let M = max H[i]

- avoid losing significant single bins let iM1 be the least i such that H[i] >= .20*M/2; left iM2 be the greatest i such that H[i] >= .20*M/2

- guarantee we preserve the middle 98% of the histogram let iN1 be the least i such that over i < iN1, sum H[i] < .01; let iN2 be the greatest i such that over i > iN2, sum H[i] < .01

- let i1 = min(iM1, iN1) and i2 = max(iM2, iN2)

- look for the first consecutive run of three H[i] = 0 below i1; replace i1 by the end of this run

- look for the first consecutive run of three H[i] = 0 above i2; replace i2 by the start of this run

- backoff (subtract) 10 bins from i1; backoff (add) 10 bins to i2

- scale the 16-bit range [i1,i2] down to [1,255]; 0 is reserved for missing data

2.3.2.5 MAPPING

The maps contained in this archive use just a few map projections, but with a wide variety of scales. If the number of input pixels per unit area was N, map scale was chosen so the number of map pixels per unit area was roughly 2N. The following formulas were used to compute map scale (pixels/degree). Given upfront knowledge of the pixel aspect (>= 1) and crosstrack summing:

- for NA, scale = 59270 / sqrt(summing*summing*aspect)

- for WA, scale = 360 / sqrt(summing*summing*aspect)

- special WA cases, if summing = 13, scale = 32; if summing = 27, scale = 16

If pixel aspect was not known upfront, but summed pixel width and height could be computed:

- for NA and WA, scale = 59270 / sqrt(height*width/2)

Projections were chosen to reduce the distortion in each map, according to the following rules:

- for NA, if the center latitude was above 55n or below 55s, polar stereographic was used; otherwise sinusoidal was used. In both cases, the prime meridian was the center longitude, rounded to the nearest degree.

- for WA, if the northernmost latitude was above 60n and the middle latitude was above 35n, or if the southernmost latitude was below 60s and the middle latitude was below 35s, polar stereographic was used. In these cases, the prime meridian was the center longitude rounded to the nearest degree.

- otherwise for WA, if the image was bracketed between 65n and 65s, sinusoidal was used; otherwise transverse Mercator was used. In these cases, the prime meridian was the approximate center longitude near the equator, rounded to the nearest degree.

The planet kernel used for these maps was PCK00008.TPC. The maps are all J2000 planetocentric, longitude direction east, with equal major and minor axis lengths of 3396.19 km.

According to

ftp://naif.jpl.nasa.gov/pub/naif/pds/data/mgs-m-spice-6-v1.0/mgsp_1000/catalog/spiceds.cat

the time bias in MGS C-kernels was -1.15 seconds prior to1999-02-26T11:45, was switched between -1.15 and -2.3 seconds for data between 1999-02-26 and 1999-03-31, and was -2.3 seconds after that. The MOLA team, however, concluded that the larger value -2.3 was too large and that the smaller value -1.15 was more likely correct.

The maps in this archive were generated in a way such that the effective time bias in the C-kernels was -1.15 seconds.

The Euler angles (roll, pitch, yaw radians) used to generate these maps were

- NA 0.001340 -0.000080 0.00
- WA red 0.016846 -0.0061 -0.013727
- WA blue 0.017632 -0.006191 0.005269

The WA angles were re-used from a previous mapping project at MSSS. The NA angles were determined by comparing against Mars Reconnaissance Oribter (MRO) Context Camera (CTX) maps. The NA field of view (FOV) was also refined by comparison with CTX maps. The NA FOV was reduced to 7.36e-3 radians.

At some point during the mapping process, it was determined that there was a downtrack offset between most predictively compressed images, and images that were either uncompressed, or compressed using DCT. This offset appeared to correspond to a time delay of one real-time clock step (0.125 seconds). So 1/8 second was added to the start time of each predictively compressed image. This is noted in the processing notes section of the PDS file labels.

2.3.2.6 CONVERSION TO PDS

Conversion from MSSS image format to PDS format was straightforward with the following notes.

The basis for ORBIT_NUMBER changes after the AB1, SP1 and SP2 cycles. MGS orbit numbers were renumbered starting with the FHA cycle, and these orbits are node-to-node. There are four image cycles prior to FHA: AB1, SP1, SP2, and CAL. Orbit numbers for CAL are relative to the renumbered orbits, and are therefore negative. Orbit numbers for AB1, SP1 and

SP2 are independent of the renumbering. The orbits used for these cycles are periapsis-to-periapsis.

Because of the complicated nature of the processing, including repair during ingest, a rather unconventional DATA_QUALITY_ID is used in this archive. The following is the corresponding DATA_QUALITY_DESC, repeated in each PDS image file:

DATA_QUALITY_ID is a 10-digit number no less than 1 billion. If the digits are 1abcdefghi, then

a = 0 if there was complete C-kernel coverage for this image;
a = 1 if the image was mapped using partial C-kernel coverage;
a = 2 if the image with mapped without using any C-kernel.
Nadir (adjusted for expected pitch angle) is used for pointing
when there is no C-kernel coverage.

b = 1 if the scale factor for converting from absolute DN was
greater than one, indicating an unexpectedly short image value
range; otherwise b = 0.

c = 0 if no errors were observed during the extraction from MSDP
phase for this image; if problems were observed, and automatic
repair was attempted c = 1; otherwise c = 2 and no further
quality analysis was performed.

The remainder of the digits are non-zero only if automatic repair was attempted.

d = the number of stretches of missing MSDP fragments, e.g., if
fragments 0-7 were expected, but only fragments 0/1/4/6/7 were
present, then d = 2.

e = the number of data gaps after repair, including both leading
and trailing gaps, if any; if there are more than 9 data gaps,
e = 9.

f = percent of missing data after repair, divided by 10 and
rounded to the nearest integer between 0 and 9.

g = length of the largest gap, measured in percent, divided by 10
and rounded to the nearest integer between 0 and 9.

h = length of the longest contiguous stretch of non-missing
image data, divided by 10 and rounded to the nearest integer
between 0 and 9.

i = 0 if there is reasonable confidence that the repair was successful, and that the correct number of missing data were placed before or after each data gap; i = 1 if there is little or no such confidence.

The NOTES section contains both image-specific observation notes and processing notes. For any given image, the observation notes typically is a one line reason why the image was taken, or why the image is interesting. The processing notes give the actual values used in the conversion of 8-bit image data to absolute DN. The processing notes also include any time offsets used during mapping.

2.4 Standards Used in Generating Data Products

2.4.3 PDS Standards

The MOC RDR data product complies with Planetary Data System PDS3 standards for file formats and labels, as specified in the PDS Standards Reference [4].

2.4.4 Cartographic Standards

Three map projections are used in the MOC RDR products: Polar Stereographic, Sinusoidal, and Transverse Mercator. Projections were chosen to reduce the distortion in each map, according to the following rules:

Polar stereographic – For NA, if the center latitude was above 55n or below 55s, the prime meridian was the center longitude rounded to the nearest degree. For WA, if the northernmost latitude was above 60n and the middle latitude was above 35n, or if the southernmost latitude was below 60s and the middle latitude was below 35s, the prime meridian was the center longitude rounded to the nearest degree.

Sinusoidal – For NA, if the center latitude was between 55n and 55s, the prime meridian was the center longitude, rounded to the nearest degree. For WA, if the image was bracketed between 65n and 65s, the prime meridian was the approximate center longitude near the equator, rounded to the nearest degree.

Transverse Mercator - For WA, if the image was above 65n and below 65s, the prime meridian was the approximate center longitude near the equator, rounded to the nearest degree.

The planet kernel used for these maps was PCK00008.TPC. The maps are all J2000 planetocentric, longitude direction east, with equal major and minor axis lengths of 3396.19 km.

The range in longitudes is [-360, 360], rather than [-180, 360]. This allows EASTERNMOST_LONGITUDE > WESTERNMOST_LONGITUDE for all images, even for those images containing poles. If the longitude range is only [-180, 360], and if there is an image containing a pole with prime meridian 240 (or -120) degrees, then there is no choice but to have EASTERNMOST_LONGITUDE = WESTERNMOST_LONGITUDE = 60. Many software packages cannot handle this condition correctly.

2.5 Data Validation

Each RDR product is automatically validated on the last step of the processing pipeline. These products were not part of the Mars Global Surveyor project delliverables and were received by PDS after the end of mission. Formal validation will be conducted through a PDS Peer Review, with the goal being to include this data set as a 'certified' PDS archive.

3. DETAILED DATA PRODUCT SPECIFICATIONS

3.1 Data Product Naming and Organization

The names of these RDRs are CCCNNNNN_FF.img, where CCC is the three digit cycle or phase name, NNNNN is the five digit image number and FF is the instrument or instrument/global-filter designation, and .img is the PDS image file extension. Label files follow the same naming convention, except that the .img extension is replaced by an .lbl extension.

The cycles (or phases) represented in this archive are

ab1 - initial aero-braking phase
sp1 - first science phasing phase
sp2 - second science phasing phase
cal - calibration, transition to mapping
fha - fixed high gain antenna testing
m01-m23 - primary mapping phase
e01-e23 - start of extended operations
r01-r23 - relay phase, support of MER
s01-s23 - continuation of extended operations

The instrument or filter types represented in this archive are

gb - wide angle global map swath & blue filter
gr - wide angle global map swath & red filter
na - narrow angle
wb - wide angle & blue filter
wr - wide angle & red filter

The PDS image files and corresponding label files are stored in the following directory structure:

```
<archive-root-directory>/CCCNNN/CCCNNNNN_FF.img
                                /CCCNNNNN_FF.lbl
```

The archive contains MOC Narrow Angle (NA) Camera images, commanded MOC Wide Angle (WA) Camera images, many of which were context images for the NA images and non-targeted daily global map swath MOC WA images, which were typically full planet scans.

3.2 Labels and Headers

Each RDR contains an image (.img) and label (.lbl) file. Section 5 provides an example of the PDS label.

4. APPLICABLE SOFTWARE

4.1 Applicable PDS Software Tools

PDS-labeled images and tables can be viewed with the program NASAView, developed by the PDS and available for a variety of computer platforms from the PDS web site https://pds.nasa.gov/tools/nasa-view.shtml. There is no charge for NASAView.

5. EXAMPLE OF A MOC RDR LABEL

```
PDS_VERSION_ID                 = PDS3

/*          FILE FORMAT AND LENGTH */
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 3051
FILE_RECORDS                   = 5924
LABEL_RECORDS                  = 2
INTERCHANGE_FORMAT             = BINARY

/*          POINTERS TO START RECORDS OF OBJECTS IN FILE */

^IMAGE                         = 3

/*          IMAGE DESCRIPTION */

DATA_SET_ID                    = "MGS-M-MOC-NA/WA-4-RDR-L1B-V1.0"
PRODUCT_ID                     = "S1801799_NA"
PRODUCER_INSTITUTION_NAME      = "MALIN SPACE SCIENCE SYSTEMS"
PRODUCT_TYPE                   = "MAP"
MISSION_NAME                   = "MARS GLOBAL SURVEYOR"
SPACECRAFT_NAME                = "MARS GLOBAL SURVEYOR"
INSTRUMENT_NAME                = "MARS ORBITER CAMERA"
INSTRUMENT_ID                  = "MOC-NA"
TARGET_NAME                    = "MARS"
START_TIME                     = 2006-05-22T21:47:50.490
STOP_TIME                      = 2006-05-22T21:47:55.118
SPACECRAFT_CLOCK_START_COUNT   = "0832801729.053"
SPACECRAFT_CLOCK_STOP_COUNT    = "N/A"
```

```
ORBIT_NUMBER                       = 32195
PRODUCT_CREATION_TIME              = 2008-02-27T00:00:00
DATA_QUALITY_DESC                  = "DATA_QUALITY_ID is a 10-digit
number no less than 1 billion.  If the digits are 1abcdefghi, then
  a = 0 if there was complete C-kernel coverage for this image;
      a = 1 if the image was mapped using partial C-kernel coverage;
      a = 2 if the image with mapped without using any C-kernel.
      Nadir (adjusted for expected pitch angle) is used for pointing
      when there is no C-kernel coverage.
  b = 1 if the scale factor for converting from absolute DN was
      greater than one, indicating an unexpectedly short image value
      range; otherwise b = 0.
  c = 0 if no errors were observed during the extraction from MSDP
      phase for this image; if problems were observed, and automatic
      repair was attempted c = 1; otherwise c = 2 and no further
      quality analysis was performed.
The remainder of the digits are non-zero only if automatic repair
was attempted.
  d = the number of stretches of missing MSDP fragments, e.g., if
      fragments 0-7 were expected, but only fragments 0/1/4/6/7 were
      present, then d = 2.
  e = the number of data gaps after repair, including both leading
      and trailing gaps, if any; if there are more than 9 data gaps,
      e = 9.
  f = percent of missing data after repair, divided by 10 and
      rounded to the nearest integer between 0 and 9.
  g = length of the largest gap, measured in percent, divided by 10
      and rounded to the nearest integer between 0 and 9.
  h = length of the longest contiguous stretch of non-missing
      image data, divided by 10 and rounded to the nearest integer
      between 0 and 9.
  i = 0 if there is reasonable confidence that the repair was
      successful, and that the correct number of missing data were
      placed before or after each data gap; i = 1 if there is little
      or no such confidence. "
MGS:DATA_QUALITY_ID                = "1000000000"
NOTE                               = "Observation notes:
NORTH POLAR SLOPE
Processing notes:
Raw camera COUNT was converted to absolute DN by
    DN = ((COUNT - Z + OFFSET)/GAIN - G - DC*EX)/EX
    where Z = 25.576700
     OFFSET = 160
       GAIN = 23.386000
          G = 0.381963
         DC = 0.000000
         EX = 1.446200
Absolute DN was destriped, and was scaled to an unsigned 16-bit
value by
    VAL16 = 2000*DN + 10000
The 16-bit value was scaled to an unsigned 8-bit value in the
range [1,255] by
    VAL8 = 0.048538*(VAL16 + -23359.000000) + 1.000000
The scaling factors for this last step were calculated to attain
good contrast while preserving the significant portion of the
image histogram. "

/*          DESCRIPTION OF OBJECTS CONTAINED IN FILE */

OBJECT                              = IMAGE
BANDS                             = 1
BAND_STORAGE_TYPE                 = BAND_SEQUENTIAL
BAND_NAME                         = "N/A"
LINES                             = 5922
```

```
LINE_SAMPLES                   = 3051
SAMPLE_TYPE                    = UNSIGNED_INTEGER
SAMPLE_BITS                    = 8
SAMPLE_BIT_MASK                = 2#11111111#
MINIMUM                        = 0
MAXIMUM                        = 255
CHECKSUM                       = 671882369
END_OBJECT                       = IMAGE

OBJECT                           = IMAGE_MAP_PROJECTION
^DATA_SET_MAP_PROJECTION       = "DSMAP.CAT"
COORDINATE_SYSTEM_TYPE         = "BODY-FIXED ROTATING"
COORDINATE_SYSTEM_NAME         = "PLANETOCENTRIC"
POSITIVE_LONGITUDE_DIRECTION = "EAST"
A_AXIS_RADIUS                  = 3396.1900000 <KM>
B_AXIS_RADIUS                  = 3396.1900000 <KM>
C_AXIS_RADIUS                  = 3396.1900000 <KM>
MAP_PROJECTION_TYPE            = "POLAR STEREOGRAPHIC"
MAP_RESOLUTION                 = 24195.9968392 <PIXEL/DEGREE>
MAP_SCALE                      = 0.002449772907 <KM/PIXEL>
CENTER_LATITUDE                = 90.0000000 <DEGREE>
CENTER_LONGITUDE               = 342.0000000 <DEGREE>
REFERENCE_LATITUDE             = "N/A"
REFERENCE_LONGITUDE            = "N/A"
FIRST_STANDARD_PARALLEL        = "N/A"
SECOND_STANDARD_PARALLEL       = "N/A"
LINE_FIRST_PIXEL               = 1
SAMPLE_FIRST_PIXEL             = 1
LINE_LAST_PIXEL                = 5922
SAMPLE_LAST_PIXEL              = 3051
LINE_PROJECTION_OFFSET         = -252007.5000000
SAMPLE_PROJECTION_OFFSET       = -459.5000000
MAXIMUM_LATITUDE               = 79.6132658 <DEGREE>
MINIMUM_LATITUDE               = 79.3696469 <DEGREE>
EASTERNMOST_LONGITUDE          = 342.7978594 <DEGREE>
WESTERNMOST_LONGITUDE          = 342.1020724 <DEGREE>
MAP_PROJECTION_ROTATION        = 0.0000000
END_OBJECT                       = IMAGE_MAP_PROJECTION END
```

Table 1. 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 1-A	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 1-B	Resampled - Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength).
Level 1-C	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.