MARS GLOBAL SURVEYOR

Mars Orbiter Laser Altimeter

MOLA EXPERIMENT GRIDDED DATA RECORD
SOFTWARE INTERFACE SPECIFICATION
(MOLA EGDR SIS)

MGS-M-MOLA-5-IEGDR-L3-V1.0
MGS-M-MOLA-5-IEGDR-L3-V2.0
MGS-M-MOLA-5-MEGDR-L3-V1.0

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Wallops Flight Facility
Wallops Island, VA 23337

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MARS ORBITER LASER ALTIMETER EXPERIMENT GRIDDED DATA RECORD SOFTWARE INTERFACE SPECIFICATION (MOLA EGDR SIS)

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1.0 Introduction

The MOLA Science Team is required to create, validate, and archive the MOLA standard data products. To define each standard data product, the MOLA Science Team is required to provide a Software Interface Specification (SIS). The SIS shall describe the data product contents and define the record and data format. The Planetary Data System's (PDS) Geosciences Node has agreed to archive the MOLA standard data products. The MOLA archive volume shall be described in a separate SIS. The MOLA standard science data products are the Aggregated Experiment Data Record – all MOLA raw data aggregated by orbit; Precision Experiment Data Record – MOLA science data processed into profiles with precision orbit locations added; and the Experiment Gridded Data Record – MOLA gridded data in various densities. This SIS shall define the Experiment Gridded Data Record Data Product. The term EGDR Data Product refers to the generic data product as all densities have the same format.

1.1 Purpose

This document generically describes the format and contents of the EGDR Data Product.

1.2 Scope

The description in this SIS can be applied to all densities of the EGDR Data Product. Where necessary, comments appropriate to the specific densities of EGDR Data Products are included. Also, the EGDR Data Product software, hardware, and human interfaces shall be mentioned in order to describe the interface; the actual software, hardware, or human node on the other side of the interface shall be described in detail in its own interface or other reference document.

1.3 Applicable Documents

1.	MOLA-672-PL-89.354	*Operations Facility Configuration and Control Plan*, Version 1.0, NASA Goddard Space Flight Center Wallops Flight Facility, January 5, 1990
2.	SFOC-0088-00-06-02	*Space Flight Operations Center User's Guide for Work Station End Users*, Volume 2: Working with File Data, Version 17.0, Draft, Jet Propulsion Laboratory, January 1992
3.	MO-642-3-PDB-UG-01	*Mars Observer Project Database (MO PDB) User Overview*, Strawman, Jet Propulsion Laboratory, February 7, 1990
4.	MOSO0099-04-00	*Planetary Science Data Dictionary Document*, PDS Version 3.0, Jet Propulsion Laboratory, November 20,1992, JPL D-7116, Rev C

5.	MOLA-9w72-SP-92.230	*Mars Orbiter Laser Altimeter Precision Experiment Data Record Product Software Interface Specification Document*, Version 2.718, NASA Goddard Space Flight Center Wallops Flight Facility, October 14, 1999
6.		*Mars Observer Cartography White Paper*, Draft, Version 1.0, R. E. Arvidson, E. A. Guinness, T. A. Duxbury, December 15, 1992
7.	MOLA-972-SP-92.213	*MOLA Standard Product Archive Volume Software Interface Specification*, Version 4.3, S. Slavney, R. E. Arvidson, Washington University, November 18, 1999

1.4 Functional Description

1.4.1 Data Content Summary

The EGDR data product contains the mapped collection of MOLA science data. The gridded products are created by binning data from the PEDR Data Products into maps covering the entire planet. A gridded product is stored either as a set of images or as an ASCII table with one row per data bin. The table has columns for mean observed planetary radius, areoid radius, median observed topography, and number of observations in the bin. Multiple revisions to the EGDR product may be released in increasingly higher resolutions. The EGDR Data Product is described further in section 4.0.

1.4.2 Source and Transfer Method

The EGDR Data Product is created from the PEDR Data Products. The data are binned into cells using a series of active image grid map files. After creation, the EGDR Data Product shall be transferred to the MOLA Science Operations Planning Computer (SOPC) for transfer to the PDS Geosciences Node. The EGDR Data Product shall remain available to the MOLA Science Team on the MOLA operations file system.

1.4.3 Recipients and Utilization

The PDS Geosciences Node will receive the EGDR data product and make it available to the science community.

The EGDR data product shall remain on the MOLA operations file system and be available to the MOLA science team for further analysis.

1.4.4 Pertinent Relationships with Other Interfaces

The EGDR data product is created from the Precision Experiment Data Record (PEDR) data product. Any changes to the PEDR data product can affect the EGDR data product format or content. Changes in the PEDR aggregation frequency or scheduled availability can cause changes to the EGDR Data Product's availability or density. See applicable document #5 for a detailed description of the PEDR Data Product.

Any changes to the EGDR data product, either format or content, shall also affect the software that creates the data product.

1.5 Assumptions and Constraints

The EGDR data product contains only data elements collected from MOLA science mode data.

2.0 Environment

2.1 Hardware Characteristics and Limitations

Not applicable.

2.2 Interface Medium and Characteristics

The EGDR data product shall be produced on computer(s) within the MOLA operating environment. The EGDR data product shall be transferred to the MOLA SOPC via FTP in preparation for distribution to the PDS Geosciences Node for archival. The SOPC architecture is described in applicable document #1.

2.3 Failure Protection, Detection, and Recovery Features

2.3.1 Backup Requirements

The EGDR data product will be backed up on magnetic media on the MOLA operations file system via the MOLA operations' back-up plan. The EGDR Data Product will be archived to CD-ROM by the PDS Geosciences Node. The MGS Project Data Base will be available as an additional backup location.

2.3.2 Security / Integrity Measures

Refer to applicable document #1 for a description of the MOLA operations system security and integrity plan.

2.4 End-Of-File (or Medium) Convention

When stored in table format, the EGDR Data Product is an ASCII file with fixed-length records. Each record ends with a carriage return followed by a line feed. When stored as an image, the EGDR Data Product is a binary file with fixed-length records. The end of an EGDR Data Product is detected by the end-of-file marker.

3.0 Access

3.1 Access Tools

The MOLA Science Team shall have access to the EGDR data product on the MOLA operations file system via FTP. The science community will have access to the EGDR Data Product through the Archive Volume produced by the PDS Geosciences Node and should obtain the MOLA Archive Volume SIS for information on data access. The MOLA Science Team will not provide the PDS any special tools to access the EGDR Data Product.

3.2 Input / Output Protocol

N/A

3.3 Timing and Sequencing Characteristics

There will be at least two deliveries of MOLA Experiment Gridded Data Products – the Initial Experiment Gridded Data Record (IEGDR) released during the course of the mission, and the Mission Experiment Gridded Data Record (MEGDR) released at the end of the mission. The EGDR product is delivered either as a table or as a set of images.

The IEGDR data product requires a period of nominally 70 days to generate and covers the first 90 mapping days (all data acquired through May 31, 1999). Revisions to the IEGDR product may be released throughout the mission, with increasingly higher densities as more complete coverage of the planet is obtained. The MEGDR data product requires a period of nominally 761 days to generate and covers the entire mapping mission which shall be approximately 687 days. Each completed EGDR data product will be examined by the MOLA Science Team for product quality control and validation. Upon team approval, the EGDR data product is delivered to the PDS Geosciences Node for archive.

3.4 PDB Information

The EGDR Data Product will be stored in the Science category as a science data product in the Mars Global Surveyor PDB. See applicable document #3 for an end user overview of the PDB. The PDB catalog attributes (as part of the K-header) are listed and described below in section 4.3.1.2.

The data set IDs for the MOLA EGDR Data Products are:

MGS-M-MOLA-5-IEGDR-L3-V1.0 – Initial Experiment Gridded Data Record, table format

MGS-M-MOLA-5-IEGDR-L3-V2.0 – Initial Experiment Gridded Data Record, image format

MGS-M-MOLA-5-MEGDR-L3-V1.0 – Mission Experiment Gridded Data Record.

These are the data set IDs that were provided to the PDB and the Planetary Data System. These IDs describe the EGDR data product level and version number. The version number is incremented should the EGDR Data Product format change.

The required catalog keywords for the EGDR Data Products are:

PDS_VERSION_ID
RECORD_TYPE
FILE_RECORDS
LABEL_RECORDS
RECORD_BYTES
DATA_SET_ID
FILE_NAME
PRODUCT_ID
SOFTWARE_NAME
UPLOAD_ID
SOURCE_PRODUCT_ID
PRODUCT_RELEASE_DATE
START_TIME
STOP_TIME
NATIVE_START_TIME
NATIVE_STOP_TIME
PRODUCT_CREATION_TIME
START_ORBIT_NUMBER
STOP_ORBIT_NUMBER
MISSION_PHASE_NAME
MINIMUM_LATITUDE
MAXIMUM_LATITUDE
MINIMUM_LONGITUDE
MAXIMUM_LONGITUDE
POSITIVE_LONGITUDE_DIRECTION
SPACECRAFT_NAME
INSTRUMENT_ID
INSTRUMENT_NAME
TARGET_NAME
PRODUCER_ID
PRODUCER_FULL_NAME
PRODUCER_INSTITUTION_NAME
DESCRIPTION

4.0 Detailed Interface Specifications

4.1 Labeling and Identification

The data set IDs for the EGDR Data Products and required catalog keywords are listed in Section 3.4.

The file naming convention for EGDR tabular files is xEGnnn[n][v].TAB, where x is replaced with I for the IEGDR or M for the MEGDR, nnn or nnnn is the bin resolution, e.g. 100 for 1.0 degree bins or 025 for 0.25 degree bins, and v is an optional letter representing the product version, the first version being A. The file naming convention for EGDR image files is xEGnnn[n]z.IMG, where x is replaced with I or M, nnn or nnnn is the bin resolution, and z is a letter indicating the type of data: a for areoid, c for counts, r for radius, and t for topography.

4.2 Structure and Organization Overview

When stored in table format, the EGDR Data Product is written as an ASCII file with one row per latitude-longitude bin. The table has columns for center latitude, center longitude, mean observed planetary radius, areoid radius, median observed topography, and number of observations in the bin. The file has fixed-length records terminated by carriage return and line feed characters. The EGDR has a detached PDS label in a separate file of the same name, extension .LBL.

At higher resolutions the size of the EGDR product makes storage as an ASCII file impractical; therefore the EGDR may be stored as an image instead. When stored in image format, the EGDR is written as a binary array of 16-bit integers, with one image line per

file record. The file is described by a detached PDS label in a separate file of the same name, extension .LBL.

See Appendix B for examples of PDS labels for EGDR products.

4.3 Volume, Size, and Frequency Estimates

There shall be one IEGDR Data Product produced from data collected up through the first 90 days of the MGS mapping mission. The first IEGDR Data Product will have a bin size of one degree, thus containing 360 x 180 = 64800 bins of data. One line in the table represents one bin. With about 60 characters (bytes) per line, the approximate size of the IEGDR Data Product is therefore 64800 x 60 / 1024000 = 3.8 megabytes. It is expected that this data product will be reprocessed up to 3 times for a total of about 11.4 megabytes over the life of the mission, or more if higher resolutions are used.

The MEGDR Data Product shall be produced from data collected during the entire Mars Global Surveyor mapping mission for a total of one data product. The MEGDR Data Product shall cover a period of 687 days. It shall have a bin size of at least one-quarter degree, thus containing 360 x 4 x 180 x 4 = 1036800 bins of data, making a product size of approximately 60.8 megabytes, or more if a higher resolution is used.

APPENDICES

APPENDIX A Acronyms

EGDR	Experiment Gridded Data Record
FTP	File Transfer Protocol
MEGDR	Mission Experiment Gridded Data Record
MOLA	Mars Orbiter Laser Altimeter
PEDR	Precision Experiment Data Record
PDB	Project Data Base
PDS	Planetary Data System
SIS	Software Interface Specification
SOPC	Science Operations Planning Computer

APPENDIX B.1 Example Tabular EGDR Label

```
PDS_VERSION_ID            = PDS3
RECORD_TYPE               = FIXED_LENGTH
FILE_RECORDS              = 64800
RECORD_BYTES              = 58
^TABLE                    = "IEG100_A.TAB"

DATA_SET_ID               = "MGS-M-MOLA-5-IEGDR-L3-V1.0"
PRODUCT_ID                = "MOLA-IEG100_A.TAB"
SPACECRAFT_NAME           = MARS_GLOBAL_SURVEYOR
INSTRUMENT_ID             = MOLA
INSTRUMENT_NAME           = MARS_ORBITER_LASER_ALTIMETER
TARGET_NAME               = MARS
START_TIME                = 1997-09-15T19:10:00.000
STOP_TIME                 = 1999-05-31T23:59:59.999
START_ORBIT_NUMBER        = 3
STOP_ORBIT_NUMBER         = 11027
PRODUCT_CREATION_TIME     = 1999-10-18T20:05:00.000
PRODUCER_ID               = MGS_MOLA_TEAM
PRODUCER_FULL_NAME        = "DAVID E. SMITH"
PRODUCER_INSTITUTION_NAME = "GODDARD SPACE FLIGHT CENTER"
DESCRIPTION               = "This data set is a topographic
   map of Mars at a resolution of 1 by 1 degree, based on
   altimetry data acquired by the Mars Global Surveyor MOLA
   instrument and accumulated over the course of the mission so far.
   The MOLA Precision Experiment Data Records (PEDRs) are the source
   for this data set. The map is in the form of an ASCII table with
   one row for each 1 by 1 degree latitude-longitude bin, from 90 to
   -90 degrees latitude and from 0 to 360 degrees longitude. The binned
   data include all MOLA nadir observations from the Orbit Insertion
   phase, plus Mapping Phase nadir observations from the beginning of
   mapping through the end of May 1999, plus off-nadir observations
   of the north pole above 86 degrees latitude acquired during
   spring 1998. Orbits 355 and 358 of the Orbit Insertion Phase
   and orbits 10709 through 10716, inclusive, of the Mapping Phase are
   excluded because solutions for these orbits are deemed to be
   poor. (Note: subtract 10000 from MOLA mapping phase orbit number
   to determine the equivalent MGS Project orbit number.) Also excluded
   are shots more than 1 degree off-nadir (except as noted above),
   channel 4 returns, and any returns not classified as ground returns,
   e.g. clouds or noise, according to the SHOT_CLASSIFICATION_CODE.
   A total of 52,495,550 observations are represented."

OBJECT                    = TABLE
 INTERCHANGE_FORMAT       = ASCII
 ROWS                     = 64800
 ROW_BYTES                = 58
 COLUMNS                  = 6

 OBJECT                   = COLUMN
  NAME                    = AREOCENTRIC_LONGITUDE
  DATA_TYPE               = REAL
  START_BYTE              = 1
  BYTES                   = 8
  FORMAT                  = "F8.1"
  UNIT                    = DEGREE
```

```
 MINIMUM                = 0.5
 MAXIMUM                = 359.5
 DESCRIPTION            = "Areocentric east longitude of the center
   of the 1 by 1 degree area of observation. The rows in the table
   are in order by increasing longitude (0.5 to 359.5) and
   decreasing latitude (89.5 to -89.5), with longitude varying
   first."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = AREOCENTRIC_LATITUDE
 DATA_TYPE              = REAL
 START_BYTE             = 9
 BYTES                  = 8
 FORMAT                 = "F8.1"
 UNIT                   = DEGREE
 MINIMUM                = -89.5
 MAXIMUM                = 89.5
 DESCRIPTION            = "Areocentric latitude of the center of
   the 1 by 1 degree area of observation. The rows in the table
   are in order by increasing longitude (0.5 to 359.5) and
   decreasing latitude (89.5 to -89.5), with longitude varying
   first."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = MEAN_PLANETARY_RADIUS
 DATA_TYPE              = REAL
 START_BYTE             = 17
 BYTES                  = 12
 FORMAT                 = "F12.2"
 UNIT                   = METER
 MINIMUM                = 3373396.58
 MAXIMUM                = 3416455.71
 DESCRIPTION            = "Mean observed planetary radius within
   the 1 by 1 degree area. Where no observations lie within the area,
   an interpolated value is supplied. The mean of the observations
   is provided as an areodetically useful average, while the median is
   used for topography."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = AREOID_RADIUS
 DATA_TYPE              = REAL
 START_BYTE             = 29
 BYTES                  = 12
 FORMAT                 = "F12.2"
 UNIT                   = METER
 MINIMUM                = 3378182.02
 MAXIMUM                = 3397474.00
 DESCRIPTION            = "Areoid radius at the center of the 1 by 1
   degree area of observation. The areoid radius lies on an
   equipotential surface whose mean radius at the equator is 3396000
   meters. The surface is defined by the Goddard Mars Potential
   Model MGM0964C20, evaluated to degree and order 50."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
 NAME                   = MEDIAN_TOPOGRAPHY
 DATA_TYPE              = REAL
```

```
  START_BYTE              = 41
  BYTES                   = 10
  FORMAT                  = "F10.2"
  UNIT                    = METER
  MINIMUM                 = -7501.22
  MAXIMUM                 = 20882.70
  DESCRIPTION             = "Median observed topography within the 1
    by 1 degree area.  Where no observations lie within the area, an
    interpolated value is supplied. The minimum and maximum topography
    observations within the current data set are -8162.04 and 21223.5.
    Topography is the planetary radius minus the areoid radius at a
    longitude and latitude. The areoid radius at the center of the area
    is not, in general, the same as the mean of the areoid radii at the
    individual observations. Moreover, the median observed topography
    follows sharp transitions in height more rapidly than the mean.
    Thus, the median topography added to the areoid radius is not
    exactly equal to the mean planetary radius."
 END_OBJECT               = COLUMN

 OBJECT                   = COLUMN
  NAME                    = OBSERVATIONS
  DATA_TYPE               = INTEGER
  START_BYTE              = 51
  BYTES                   = 6
  FORMAT                  = "I6"
  MINIMUM                 = 0
  MAXIMUM                 = 2152
  DESCRIPTION             = "Number of observations in the 1 by 1 degree
    area."
 END_OBJECT               = COLUMN

END_OBJECT                = TABLE

END
```

APPENDIX B.2 Example Image EGDR Label

```
PDS_VERSION_ID            = PDS3
RECORD_TYPE               = FIXED_LENGTH
FILE_RECORDS              = 720
RECORD_BYTES              = 2880
^IMAGE                    = "IEG025R.IMG"

DATA_SET_ID               = "MGS-M-MOLA-5-IEGDR-L3-V2.0"
PRODUCT_ID                = "MOLA-IEG025_RADIUS.IMG"
SPACECRAFT_NAME           = "MARS GLOBAL SURVEYOR"
INSTRUMENT_ID             = MOLA
INSTRUMENT_NAME           = MARS_ORBITER_LASER_ALTIMETER
TARGET_NAME               = MARS
START_TIME                = 1997-09-15T19:10:00.000
STOP_TIME                 = 2000-06-01T16:51:07.180
START_ORBIT_NUMBER        = 3
STOP_ORBIT_NUMBER         = 15516
PRODUCT_CREATION_TIME     = 2000-07-14T12:00:00
PRODUCER_ID               = MGS_MOLA_TEAM
PRODUCER_FULL_NAME        = "DAVID E. SMITH"
PRODUCER_INSTITUTION_NAME = "GODDARD SPACE FLIGHT CENTER"
DESCRIPTION               = "This data product is a shape
   map of Mars at a resolution of 0.25 by 0.25 degrees, based on
   altimetry data acquired by the Mars Global Surveyor MOLA
   instrument and accumulated over the course of the mission so far.
   The MOLA Precision Experiment Data Records (PEDRs) are the source
   for this data set. The map is in the form of a binary table with
   one row for each 0.25-degree latitude, from 0 to 360 degrees East
   longitude and 90 to -90 degrees latitude. The binned
   data include all MOLA nadir observations from the Mapping Phase,
   from the end of aerobraking through June 2000. Additionally, off-nadir
   observations of the north pole are included from 87 N latitude and
   northward, taken during the spring of 1998, and of both poles taken
   during Mapping from 87 N and S to the poles. Parts of orbits
   are excluded where solutions for
   these orbits are deemed to be poor. (Note: subtract 10000 from a MOLA
   mapping phase orbit number to determine the equivalent MGS Project
   orbit number.) Also excluded are shots more than 1 degree off-nadir
   (except as noted above), channel 4 returns, and any returns not
   classified as ground returns, e.g. clouds or noise, according to the
   SHOT_CLASSIFICATION_CODE. A total of approximately 333 million
   observations are represented."

OBJECT                    = IMAGE
 NAME                     = MEAN_RADIUS
 DESCRIPTION              = "Mean observed planetary radius within the
   0.25 by 0.25 degree area, after subtracting 3,396,000 meters (the mean
   radius at the equator).  Where no observations lie within the area,
   an interpolated value is supplied."
 LINES                    = 720
 LINE_SAMPLES             = 1440
 SAMPLE_TYPE              = MSB_INTEGER
 SAMPLE_BITS              = 16
 UNIT                     = METER
 SCALING_FACTOR           = 1
 OFFSET                   = 3396000
 MINIMUM                  = -22957
 MAXIMUM                  = 21245
```

```
END_OBJECT                = IMAGE

OBJECT                    = IMAGE_MAP_PROJECTION
 ^DATA_SET_MAP_PROJECTION = "DSMAP.CAT"
 MAP_PROJECTION_TYPE      = "SIMPLE CYLINDRICAL"
 A_AXIS_RADIUS            = 3396.0 <KM>
 B_AXIS_RADIUS            = 3396.0 <KM>
 C_AXIS_RADIUS            = 3396.0 <KM>
 FIRST_STANDARD_PARALLEL  = "N/A"
 SECOND_STANDARD_PARALLEL = "N/A"
 POSITIVE_LONGITUDE_DIRECTION = "EAST"
 CENTER_LATITUDE          = 0.0 <DEGREE>
 CENTER_LONGITUDE         = 180.0 <DEGREE>
 REFERENCE_LATITUDE       = "N/A"
 REFERENCE_LONGITUDE      = "N/A"
 LINE_FIRST_PIXEL         = 1
 LINE_LAST_PIXEL          = 720
 SAMPLE_FIRST_PIXEL       = 1
 SAMPLE_LAST_PIXEL        = 1440
 MAP_PROJECTION_ROTATION  = 0.0
 MAP_RESOLUTION           = 4.0 <PIXEL/DEGREE>
 MAP_SCALE                = 14.818 <KM/PIXEL>
 MAXIMUM_LATITUDE         = 90.0 <DEGREE>
 MINIMUM_LATITUDE         = -90.0 <DEGREE>
 WESTERNMOST_LONGITUDE    = 0.0 <DEGREE>
 EASTERNMOST_LONGITUDE    = 360.0 <DEGREE>
 LINE_PROJECTION_OFFSET   = 360.5
 SAMPLE_PROJECTION_OFFSET = 720.5
 COORDINATE_SYSTEM_TYPE   = "BODY-FIXED ROTATING"
 COORDINATE_SYSTEM_NAME   = "PLANETOCENTRIC"
END_OBJECT                = IMAGE_MAP_PROJECTION

END
```