

The Mariner Mars Far Encounter 1969 Image Bundle Overview

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1.0 Introduction

The Mariner Mars 1969 Mission (NASA SP, 1969 and MM69 Handbook, 1969) sent two spacecraft, Mariner 6 and Mariner 7, to Mars arriving 30 July and 04 August 1969, respectively. Each spacecraft carried a wide angle and narrow angle camera, mounted to two degree-of-freedom scan platforms to point the cameras at Mars during encounter. Each spacecraft implemented Far Encounter and Near Encounter sequences. Mariner 6 took 49 Far Encounter images and 32 Near Encounter images while Mariner 7 took 92 Far Encounter images and 30 Near Encounter images (Collins, 1970, Leighton, et. al., 1969 and Leighton, et. al., 1971).

These images and associated NAIF SPICE kernels were created under the NASA Planetary Data Restoration, Archive and Tools Program within the Planetary Science Division of the Science Missions Directorate. The first year activity, ended in 2017, focused on the Far Encounter images while the second year activity, ending in 2018, will focus on the Near Encounter images. This Mariner Mars Far Encounter Bundle Archive is shown in Figure 1.

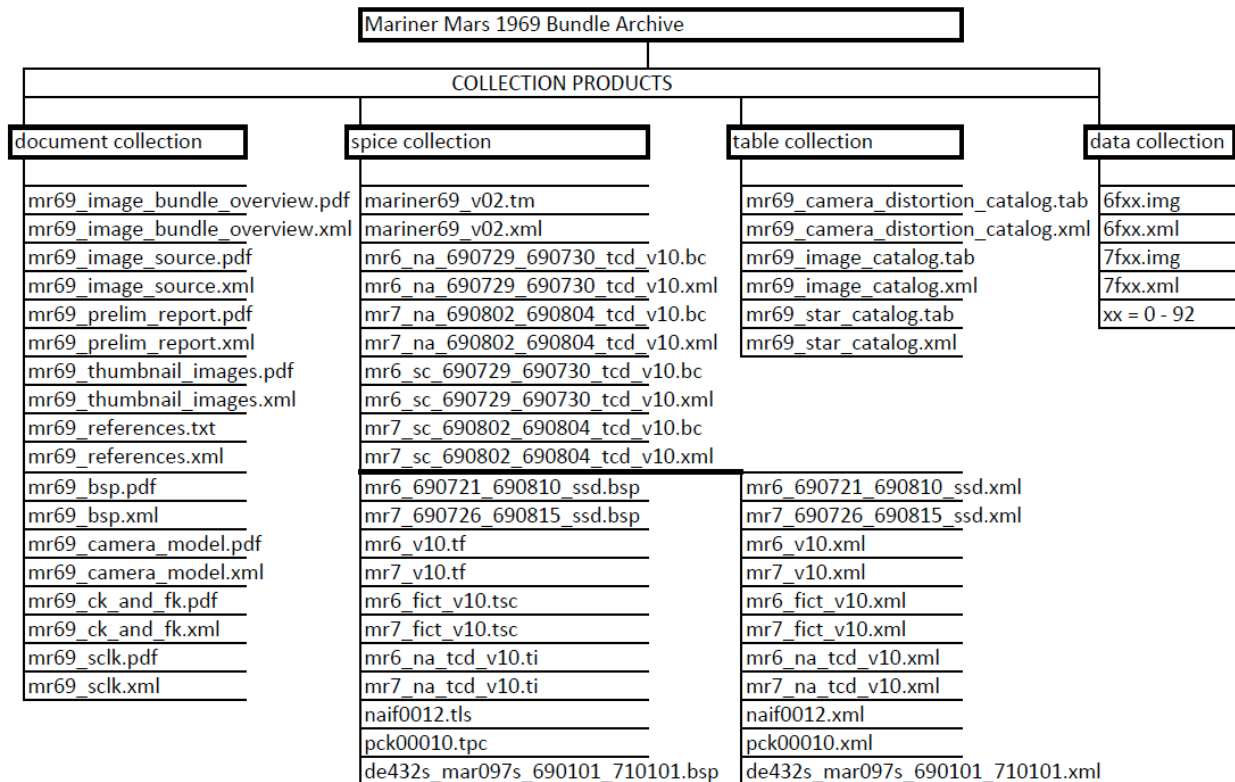


Figure 1. The Mariner Mars Far Encounter 1969 Bundle Archive

2.0 Far Encounter Bundle Archive

The Mariner Mars 1969 Bundle archive has the following four data collections:

1. Document Collection;
2. SPICE Kernel Collection;
3. Table Collection; and
4. Image Collection.

The contents of these PDS4 and NAIF compliant Far Encounter collections are described in the following subsections. All archival files listed in the following sections also have detached PDS4 .xml label files.

2.1 Far Encounter Document Collection

Supporting documentation in the bundle archive includes:

- This document describing the content of the archive collection (*mr69_image_bundle_overview.pdf*);
- The source of each Experiment Data Record image archived plus a listing of over 500 other versions (*mr69_image_source.pdf*) that were produced by the Mariner Mars 1969 mission that were not included within the scope of the PDART;
- A Mariner-Mars 1969, A Preliminary Report, 1969 (*mr69_prelim_report.pdf*);
- The thumbnail images of all Mariner 6 and 7 Far and Near Encounter images (*mr69_thumbnail_images.pdf*)
- The derivations of the SPICE kernels (*mr69_camera_model.pdf*, *mr69_ck_and_fk.pdf*, *mr69_sclk.pdf* and *mr69_bsp.pdf*);

and supporting publications that are listed in *mr69_references.txt*:

- The first-look science derived from the images (Leighton, et.al., 1969, Leighton, et al., 1971);
- Camera and digital image descriptions (Danielson and Montgomery, 1970 and Rindfleisch, et. al., 1971);
- Phobos (Smith, 1969)
- Mission and spacecraft descriptions (The Mariner Mars 1969 Handbook, 1969); and
- Conference abstracts describing this PDART task

2.2 Far Encounter SPICE Kernel Collection

The NAIF SPICE system (Acton, 1996 and Acton, et. al., 2017) did not exist in 1969 and therefore SPICE kernels were not produced for the Mariner Mars 1969 Mission or its spacecraft systems and subsystems, cameras and images, making any higher-level data processing difficult to perform. A unique aspect of this PDART task was to create the necessary NAIF SPICE kernels so that the full capability of the NAIF Toolkit could be applied to these images, making them tremendously more useable by the planetary science

community. A complete set of SPICE kernels were created that are listed in the SPICE meta-kernel “*mariner69_v02.tm*”. These make using the Mariner 69 kernels collection much easier. The following SPICE kernels can be loaded (“furnished”) into a users program to take advantage of the NAIF Toolkit software system:

Trajectory S Kernels (mr69_bsp.pdf, Duxbury and Jacobson, 2017):

mr6_690721_690810_ssd_v10.bsp,
mr7_690726_690815_ssd_v10.bsp

covering the entire far and near encounter time periods

Instrument I Kernel (mr69_camera_model.pdf, Duxbury, 2017):

mr6_na_tcd_v10.ti, mr7_na_tcd_v10.ti

Spacecraft Attitude/Camera Pointing C Kernels (mr69_ck_and_fk.pdf, Duxbury and Semenov, 2017):

mr6_sc_690729_690730_tcd_v10.bc,
mr7_sc_690802_690804_tcd_v10.bc ,
mr6_na_690729_690730_tcd_v10.bc,
mr7_na_690802_690804_tcd_v10.bc

where

mr6 is for Mariner 6

mr7 is for Mariner 7

na is for the Narrow Angle TV camera pointing in EME J2000

sc is for the spacecraft-fixed **ABC** axes orientation in EME J2000

and the time span given in YRMNDY_YRMNDY

Frames Kernels (also mr69_ck_and_fk.pdf, Duxbury and Semenov, 2017):

mr6_v10.tf, mr7_v10.tf

Spacecraft Clock Kernels (mr69_sclk.pdf, Duxbury and Semenov, 2017b):

mr6_fict_v10.tsc, mr7_fict_v10.tsc

SPICE Generic Kernels (Acton, et. al., 2017):

naif0012.tls,
mariner69_v02.tm,
pck00010.tpc, and
de432s_mar097s_690101_710101.bsp

Descriptions of the derivations and contents of these SPICE kernels are listed in the references.

2.3 Far Encounter Table Collection

Three type of catalogs were produced: 1) a star catalog (*mr69_star_catalog.tab*) with detached label (*mr69_star_catalog.xml*) that contains information about stars in the vicinity

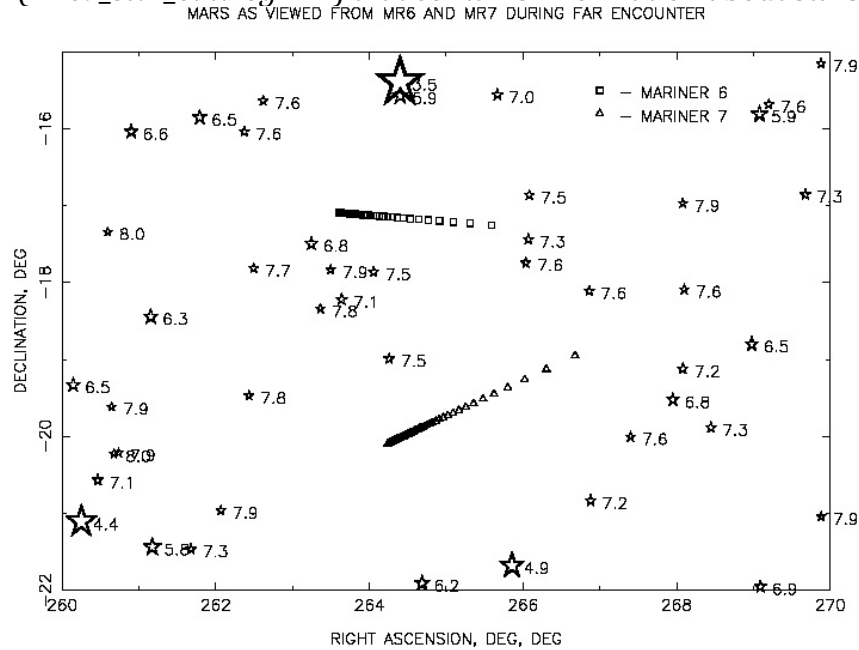


Figure 2. Star background during Mars Far Encounter mission phases

of Mars (Figure 2) as seen from the spacecraft during Mariner 6 and 7 far encounters; 2) parameter values for the camera vidicon geometric models, *mr69_camera_distortion_catalog.tab*, with a detached label, *mr69_camera_distortion_catalog.xml*; and 3) a searchable catalog *mr69_image_catalog.tab*, with detached label, *mr69_image_catalog.xml*, to allow a user to determine which images and image locations contain areas of interest.

The star catalog (Figure 2) contains all stars brighter than 8th visual magnitude that were within 5 degrees of the direction to Mars during Far Encounters. The catalog was derived from the Tyco II catalog in EME J2000 at an epoch of 01 August 1969.

The Mariner Mars 1969 cameras used vidicon tubes, which had significant geometric distortions that changed from image to image. Therefore the table *mr69_camera_distortion.tab* with label *mr69_camera_distortion.xml* contains the vidicon geometric parameter values for Mariner 6 and 7, Narrow Angle camera, Far Encounter images needed for geometric computations. Average vidicon geometric parameter values are included in the SPICE Instrument kernels *mr6_na_tcd_v10.ti* and *mr7_na_tcd_v10.ti*. The camera optical parameters were constant across all images and are also included in the SPICE Instrument kernels *mr6_na_tcd_v10.ti* and *mr7_na_tcd_v10.ti*. For those performing precision geometric computations, the vidicon geometric parameter values included in *mr69_camera_distortion.tab* should be used in place of the average values included in *mr6_na_tcd_v10.ti* and *mr7_na_tcd_v10.ti*.

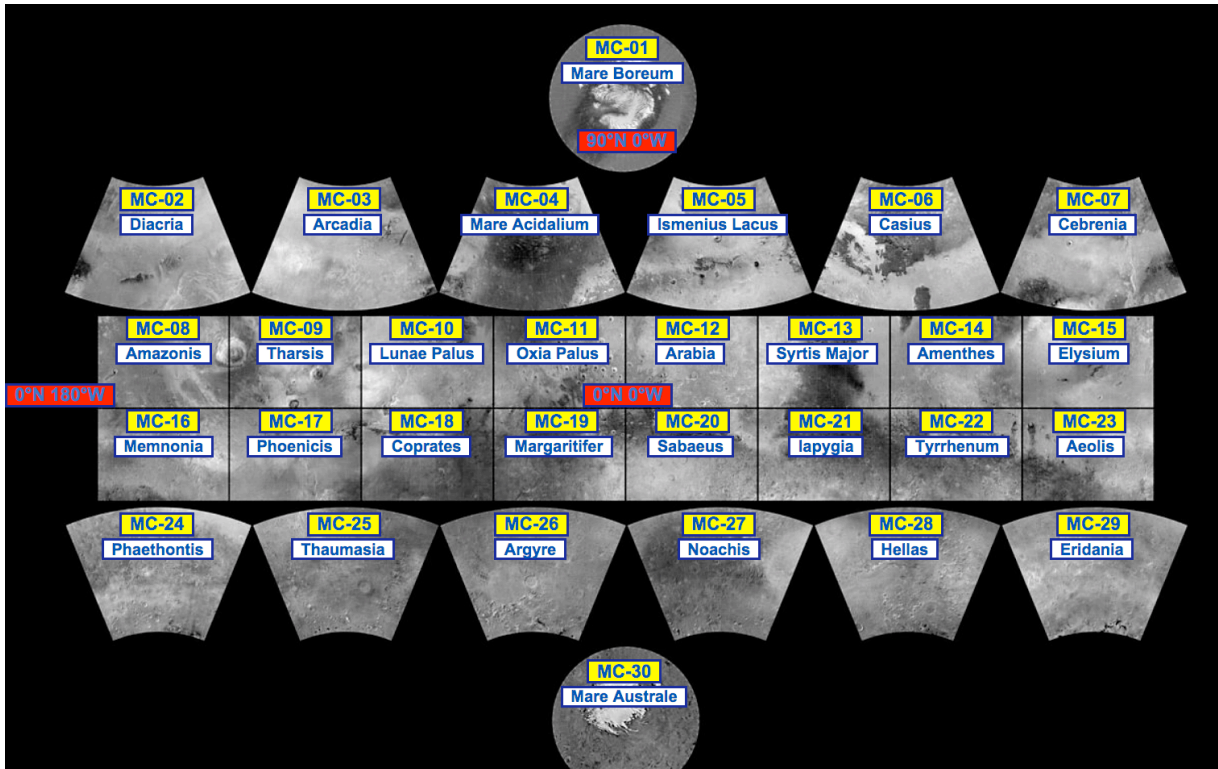


Figure 3. Mars Quadrangles taken from https://en.wikipedia.org/wiki/List_of_quadrangles_on_Mars

With the creation of SPICE kernels associated with the images, a searchable catalog was produced (mr69_image_catalog.tab with a detached xml label) for the images allowing users to locate areas of interest across all images from both spacecraft and all four cameras. Since Mars only partially fills the camera fields-of-view during Far Encounter making the image corners not on the Mars surface, Mars was divided into the 30 Mars Quadrangles (Figure 3) and each quadrangle divided into 4 sub-quadrangles to provide 120 searchable Mars location metadata. The viewing and lighting conditions for each of the 120 Mars sub-quadrangles and all NASA landers to date, through MSL, were computed and stored in the searchable table. The searchable quantities include

- Mission, Spacecraft and Image ID (PICNO)
- Filter position and shutter direction;
- Image time (UTC);
- Time from Mars closest approach (DAYS:T:HOURS:MINUTES:SECONDS)
- The Mars sub-quadrangle name and number (1-30: a, b, c and d) and 8 landers (VL-1, VL-2, MPF, MPL, Beagle 2, MER-A, MER-B, and MSL);
- Image PICNO and image location (sample and line) of sub-quadrangles and landers/rovers;
- The viewing / lighting angles of emission, incidence, phase and solar distance of the sub-quadrangles and landers/rovers;

- The scaling parameters of slant range and km/pixel at the quadrangle centers and lander/rover locations;
- The Mars season, L_s ;
- The sub-spacecraft and sub-solar points on Mars of latitude, longitude and range;

All angles are Areocentric and have units of degrees and distances are expressed in km. Since there are 4 sub-quads for each of the 30 Mars-quads, up to 4 lines in the catalog may exist for a Mars quad relative to its a, b, c and d sub-quads.

2.4 Far Encounter Image Collection

An image cube was produced for each of the Far Encounter images having five planes and each plane having 946 samples per line, 704 lines and 8 bits/pixel where:

1. Plane 1 contains the original level-2 Experiment Data Record (EDR) image;
2. Plane 2 contains Plane 1 but with all known / found artifacts of reseaux, missing lines, blemishes and noise spikes removed;
3. Plane 3 contains a high-pass filtered version of Plane 2 to enhance Mars surface features and point sources such as Phobos, Deimos and stars. A latitude grid at every 20 deg, a longitude grid at every 45 deg, the prime meridian or 180 deg longitude meridian, the south pole (S) and the predicted locations of Phobos, Deimos and stars were drawn as overlays within the 8 bit/pixel image. The limb / terminator overlays have DN = 253, the sub-spacecraft (+) and sub-solar (*) points have DN = 254 and the Phobos / Deimos / star overlays have DN=255;
4. Plane 4 contains a simulated Mars image derived by illuminating the global Mars Orbiter Laser Altimeter (MOLA) global digital terrain model (DTM) to better show what surface features were imaged; and
5. Plane 5 contains the simulated image in plane 4 with Mars quadrangle boundaries and lander locations included as overlays within the 8 bit/pixel image. The overlay image information have DN = 0 or 255.

The image cube file naming convention used was

XYZZ.IMG where

X = 6 for Mariner 6 and = 7 for Mariner 7;

Y = F for Far Encounter and = N for Near Encounter;

ZZ = 0 – 92 to indicate the image number within the mission phase.

Each image cube has a detached label record XYZZ.xml.

An example of a 5-band restored image is shown in Figure 4 for Mariner 7 Far Encounter image # 63 and its detached label record is listed in Table 1.

References

Acton, C.H. (1996), Ancillary data services of NASA's Navigation and Ancillary Information Facility, *Planetary Space Sci.*, 44, 1, 65-70.

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Leighton, R. B. and B. C. Murray (1971), *One year's processing and interpretation - An overview*, *J. Geophys. Res.*, 76, 2, 293 - 296, doi{10.1029}/JB076i002p00293.

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Bradford A. Smith, *Phobos: Preliminary Results from Mariner 7(1969)*, DOI: 10.1126/science.168.3933.828, *Science* 168 (3933), 828-830.

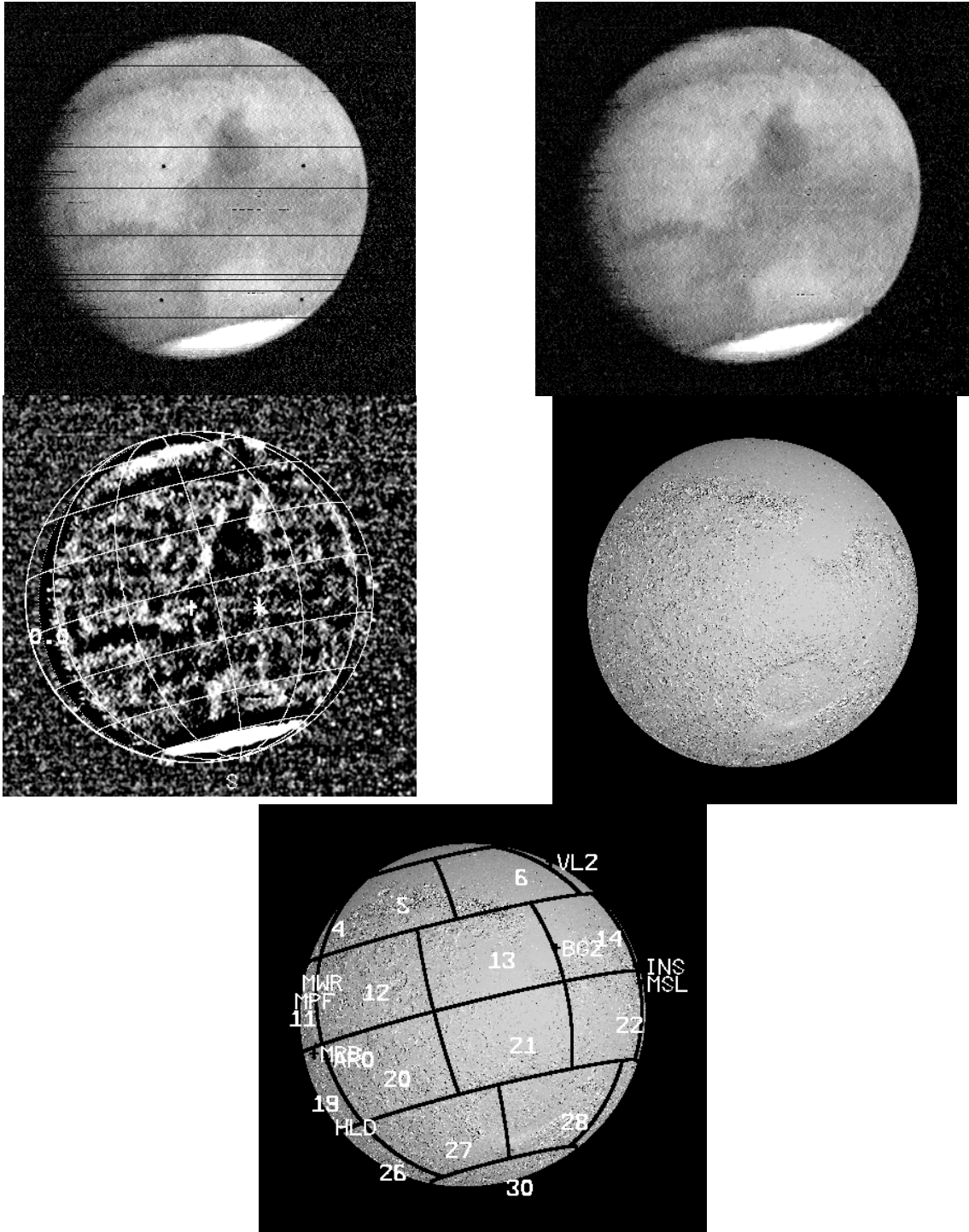


Figure 5. Five-band restored image for 7F63: upper left – raw EDR; upper right – cleaned EDR; middle left – high pass filtered with limb/terminator/latitude/longitude/Phobos/Deimos/star overlays; middle right – simulated image using illuminated MOLA DTM; lower – MOLA DIM with Mars quad and lander locations

Table 1. Example detached image cube label record

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    2. Plane 2 contains Plane 1 but with all known / found artifacts
    of reseaux, missing lines, blemishes and noise spikes removed;
    3. Plane 3 contains a high-pass filtered version of Plane 2 to
    enhance Mars surface features and point sources such as Phobos,
    Deimos and stars. A latitude grid at every 20 deg, a longitude
    grid at every 45 deg, the prime meridian or 180 deg longitude
    meridian, the south pole (S) and the predicted locations of Phobos,
    Deimos and stars were drawn as overlays within the 8 bit/pixel
    image. The limb / terminator overlays have DN = 253, the
    sub-spacecraft (+) and sub-solar (*) points have DN = 254 and the
    Phobos / Deimos / star overlays have DN=255;
    4. Plane 4 contains a simulated Mars image derived by illuminating
    the global Mars Orbiter Laser Altimeter (MOLA) global digital terrain
    model (DTM) to better show what surface features were imaged; and
    5. Plane 5 contains the simulated image in plane 4 with Mars
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