HRSC Map & reference issues

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Map & reference frame issues
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- HRSC Level4 data are map-projected:
  - Sinusoidal projection (Latitudes from 85° S to 85° N)
  - Polar-Stereographic projection (polar areas)

- The map reference body is a sphere with $r = 3396.0$ km

- The vertical reference for DEM is either:
  - A sphere with $r = 3396.0$ km (DT4)
  - An aeroid (DA4) directly comparable with MOLA MEGDR grids

http://pds-geosciences.wustl.edu/missions/mgs/megd.html
Sphere & ellipsoid

~ Mars MOLA sphere

A_AXIS = 3396.0 km
B_AXIS = 3396.0 km
C_AXIS = 3396.0 km

Mars IAU2000 ellipsoid

A_AXIS = 3396.19 km
B_AXIS = 3396.19 km
C_AXIS = 3376.2 km

Level3 data STILL with A=B=C = 3396.19 km

(May ’08)
The HRSC data with a latitude center between -85 and +85 degrees are presented in a sinusoidal equal-area map projection. In this projection, parallels of latitude are straight lines, with constant distances between equal latitude intervals. Lines of constant longitude on either side of the projection meridian are curved since longitude intervals decrease with the cosine of latitude to account for their convergence toward the poles.

The transformation from latitude and longitude to line and sample is given by the following equations:

\[
\text{line} = \text{INT} (\text{LINE\_PROJECTION\_OFFSET} - \text{lat} \times \text{MAP\_RESOLUTION})
\]

\[
\text{sample} = \text{INT} (\text{SAMPLE\_PROJECTION\_OFFSET} + (\text{lon} - \text{CENTER\_LONGITUDE}) \times \text{MAP\_RESOLUTION} \times \cos(\text{lat}))
\]

Note that integral values of line and sample correspond to the center of a pixel. Lat and lon are the latitude and longitude of a given spot on the surface. Line and sample are assumed to be 1-based, rather than 0-based.

LINE\_PROJECTION\_OFFSET is the line number minus one on which the map projection origin occurs. The map projection origin is the intersection of the equator and the projection longitude. The value of LINE\_PROJECTION\_OFFSET is positive for images starting north of the equator and is negative for images starting south of the equator.

SAMPLE\_PROJECTION\_OFFSET is the nearest sample number to the left of the projection longitude. The value of SAMPLE\_PROJECTION\_OFFSET is positive for images starting to the west of the projection longitude and is negative for images starting to the east of the projection longitude.

CENTER\_LONGITUDE is the value of the projection longitude, which is the longitude that passes through the center of the projection.

MAP\_RESOLUTION is measured in pixels/degree.

ftp://psa.esac.esa.int/pub/mirror/MARS-EXPRESS/HRSC/MEX-M-HRSC-5-REFDR-MAPPROJECTED-V2.0/CATALOG/DSMAP.CAT
**Proj. Offset**

### PDS Data Dictionary Lookup Detail

**Column Name** = `line_projection_offset`  
**BL Name** = `lineprojoff`  
**Terse Name** =  
**Gen Data Type** = REAL  
**Unit Id** = pixel  
**Std Value Type** = RANGE  
**Minimum Column Value** = N/A  
**Maximum Column Value** = UNK  
**Minimum Length** = N/A  
**Maximum Length** = N/A

**Description**

The `line_projection_offset` element provides the line offset value of the map projection origin position from the line and sample 1,1 (line and sample 1,1 is considered the upper left corner of the digital array). Note: that the positive direction is to the right and down.

### PDS Data Dictionary Lookup Detail

**Column Name** = `sample_projection_offset`  
**BL Name** = `sampprojoff`  
**Terse Name** =  
**Gen Data Type** = REAL  
**Unit Id** = pixel  
**Std Value Type** = RANGE  
**Minimum Column Value** = N/A  
**Maximum Column Value** = UNK  
**Minimum Length** = N/A  
**Maximum Length** = N/A

**Description**

The `sample_projection_offset` element provides the sample offset value of the map projection origin position from line and sample 1,1 (line and sample 1,1 is considered the upper left corner of the digital array). Note: that the positive direction is to the right and down.

**source:**

http://pds.nasa.gov/tools/data_dictionary_lookup.cfm

### LINE_PROJECTION_OFFSET

LINE_PROJECTION_OFFSET is the line number minus one on which the map projection origin occurs. The map projection origin is the intersection of the equator and the projection longitude. The value of LINE_PROJECTION_OFFSET is positive for images starting north of the equator and is negative for images starting south of the equator.

**source:**

ftp://psa.esac.esa.int/pub/mirror/MARS-EXPRESS/HRSC/MEX-M-HRSC-5-REFDR-MAPPROJECTED-V2.0/CATALOG/DSMAP.CAT

### SAMPLE_PROJECTION_OFFSET

SAMPLE_PROJECTION_OFFSET is the nearest sample number to the left of the projection longitude. The value of SAMPLE_PROJECTION_OFFSET is positive for images starting to the west of the projection longitude and is negative for images starting to the east of the projection longitude.
DEM: aeroid vs. spheroid

“MOLA” sphere
\[ r = 3396.0 \text{ km} \]

IAU ellipsoid
\[ A = B = 3396.19 \text{ km} \]
\[ C = 3376.2 \text{ km} \]

Aeroid Surface, GMM3, NASA

Latitude:
\[ \alpha = \text{planetocentric} \]
\[ \beta = \text{planetographic} \]
DTM: aeroid vs. spheroid

Height above GMM3 Aeroid

Height above sphere (r = 3396.0 km)

Height above IAU ellipsoid (r = 3396.0 km)

Latitude:
\( \alpha = \) planetocentric
\( \beta = \) planetographic

(Courtesy K. Gwinner, DLR)
DTM: DT4 vs. DA4

e.g. H0010_0009_DA4.IMG

Height above GMM3 Aeroid

Height above sphere (r = 3396.0 km)

DA4

DT4

e.g. H0010_0009_DT4.IMG
HRSC Level4 DEM (dt4 & da4 products)
DEM: Summary

- HRSC DT4 DEMs:
  - HEIGHT reference = sphere

- HRSC DA4 DEMs:
  - HEIGHT reference = aeroid (~MEGDR)

- ALL HRSC Level4 data use as MAP reference a sphere with $r = 3396.0$ km
DT4 vs. DA4: Labels

SEE HRSC EXPERIMENT TO ARCHIVE INTERFACE CONTROL DOCUMENT (EAICD) IN THE HRSC DATASET IN THE PSA:

http://www.rssd.esa.int/PSA/
Level 4 DEM: example

DT4 DEM viewed in “xvd”
HRSC DEM vs. MOLA
HRSC DEM vs. MOLA

For a comprehensive presentation on the comparison between HRSC Level4 Digital Elevation Models and MOLA (Mars Orbiter Laser Altimeter), please see K. Gwinner’s presentation at the 2007 EMSEC Conference (Friday, W.02)

http://sci.esa.int/mars07/

http://www.rssd.esa.int/SYS/include/pubs_display.php?project=MarsEXPRESS&id=2799137
Local high differences in height between MOLA and HRSC DA4 DEM might be due to the lower resolution of MOLA and its interpolation (due to unevenly spaced MOLA profiles, especially at low latitudes).