



**Processing of
Lunar Reconnaissance Orbiter Camera
Narrow Angle Camera Image Frames with ISIS 3**

featuring

How to Create NAC CDRs

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PDS Imaging Node

U.S. Geological Survey

Jet Propulsion Laboratory

What is ISIS?

- ***Integrated Software for Imagers and Spectrometers***
 - USGS software to process data from NASA planetary missions
 - Missions/instruments supported
 - Viking, Voyager, Mariner, Galileo, Clementine, MGS, Mars Odyssey, Cassini, Mars Pathfinder, MER, MRO HiRISE, MESSENGER/MDIS NAC & WAC, and **LRO NAC & WAC cameras**
 - Used to make cartographic products (mosaics and maps)
 - Input is PDS-formatted raw image files => Experiment Data Records (EDRs)
 - Includes visualization capability, radiometric and geometric processing, etc.
 - Both ISIS 2 and ISIS 3 versions currently available
 - **ISIS 3 is the correct version for LROC data**
 - See <http://isis.astrogeology.usgs.gov/UserDocs/index.html>
 - 35-year heritage
 - ISIS3 < ISIS2 < PICS < FIPS < pre-FIPS

Supported OS Platforms

- ISIS3 runs on many Unix variants including:
 - Ubuntu, RHEL, Debian, Fedora, SUSE, MacOSX
- ISIS3 does not run on MS Windows
- ISIS requirements (depending on your needs):
 - 64-bit x86 processors (more cores is better)
 - 2GB memory (more memory is better)
 - 10GB to 180GB disk storage for ISIS installation
 - 10GB to many TB disk storage for processing images
 - Quality graphics card (one that support two monitors can be useful)

How to Get ISIS 3

- Start at the ISIS Website
 - <http://isis.astrogeology.usgs.gov>
 - Installing ISIS
 - <http://isis.astrogeology.usgs.gov/documents/InstallGuide/index.html>
- User documentation
 - <http://isis.astrogeology.usgs.gov/UserDocs/index.html>
- List of ISIS applications (alphabetical)
 - <http://isis.astrogeology.usgs.gov/Application/alpha.html>
 - Run programs from command line or using GUI interface

Where to Get Help in ISIS 3

- Start at the ISIS Support Website
 - <https://isis.astrogeology.usgs.gov/IsisSupport/>
- Online workshops available
 - <http://isis.astrogeology.usgs.gov/IsisWorkshop/index.php/IsisWorkshop>
- **Note: ISIS3 is not a PDS product**
 - If you have questions or need installation help, please contact the ISIS Support staff first
 - If you get no timely response, contact Lisa Gaddis (lgaddis@usgs.gov) of the PDS Imaging Node

Cartographic Processing with ISIS

- **Level 0**
 - Ingest PDS Engineering Data Record (EDR) into ISIS
 - Add SPICE (basic geometry)
- **Level 1**
 - Radiometrically calibrate
 - Remove noise
 - *Creates Calibrated Data Records (CDRs)*
- **Level 2**
 - Improve camera pointing
 - Geometrically rectify to a map projection
 - *Creates Reduced Data Records (RDRs)*
- **Level 3**
 - Photometric normalization
- **Level 4**
 - Create mosaic
 - Evaluate mosaic

- ****BUT**** you can find LROC RDR data here:
 - http://wms.lroc.asu.edu/lroc/rdr_product_select
- These RDRs have already been processed to high level(s)!

Pre-Processing Steps: Get NAC Data

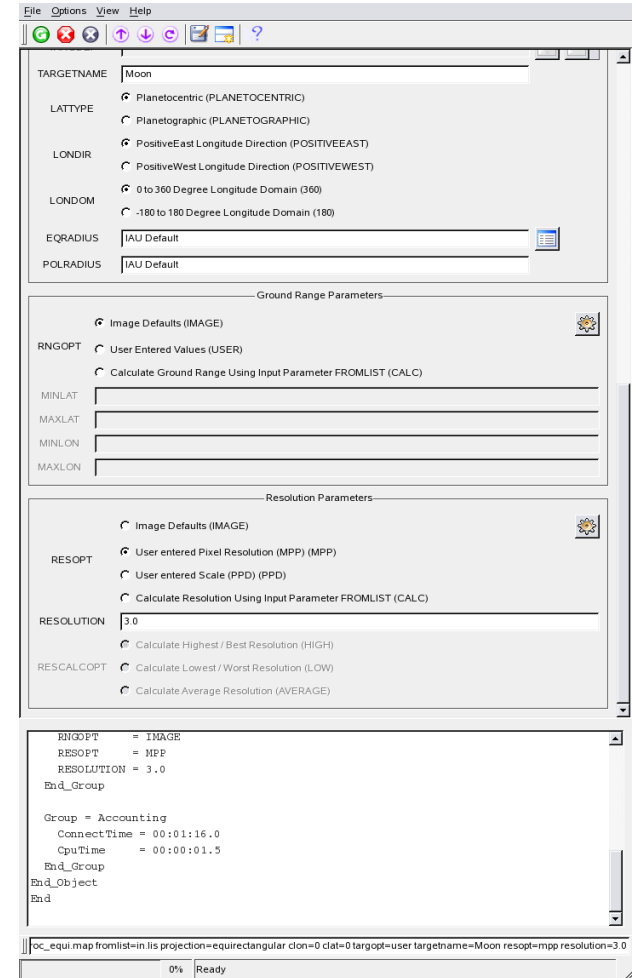
- Find LROC NAC data
 - LROC Science Operations Center interface to PDS Archives
 - <http://wms.lroc.asu.edu/lroc/>
 - <http://lroc.sese.asu.edu/data/>
 - Image Atlas, PDS Imaging Node
 - <http://pds-imaging.jpl.nasa.gov/search/search.html#QuickSearch>
 - ACT-REACT QuickMap for LROC data
 - <http://target.lroc.asu.edu/q3/>
 - Lunar Orbital Data Explorer, PDS Geosciences Node
 - <http://ode.rsl.wustl.edu/moon/>
- Download LROC EDR files to local disk
 - Use single or bulk-download options at the above sites to copy the EDR files
 - Recall that NAC images are initially stored as Left and Right frames
 - Example of a “Right” frame: M102064759RE.IMG
 - You may need both for complete coverage of a site

Pre-Processing Steps

- Get ready to start processing:
 - Make sure ISIS3 is installed and running on your system
 - See slide #4
 - As part of the ISIS3 release, you will receive a lunar surface topography model (or a Digital Elevation Model, DEM) so that images will be placed accurately onto the lunar surface during processing
 - The current default DEM is the [March 2011 version of the LROC LOLA DEM](#)
 - Create a map template file
 - Used by cam2map to map-project the images
 - See next slides
 - **Note:** “>command” here means run in Linux at prompt

Pre-Processing: Creating a Map Template File

- Use ISIS 3 “maptemplate” GUI to create a pvl file that describes the desired map projection, spatial resolution, etc. of your products
- The same .map file can be used for all frames
 - These parameters **must** be the same for all frames to make a mosaic
- Can choose (for example):
 - Projection (Mercator, PolarStereographic, etc)
 - Planetocentric or Planetographic
 - Center Longitude
 - Pixel Resolution
- Or you can manually edit an existing .map file



Pre-Processing: Maptemplate Output

■ Sample Iroc_equi.map

- Group = Mapping
- ProjectionName = Equirectangular
- CenterLongitude = 180.0
- CenterLatitude = 0.0
- TargetName = Moon
- EquatorialRadius = 1737400.0 <meters>
- PolarRadius = 1737400.0 <meters>
- LatitudeType = Planetocentric
- LongitudeDirection = PositiveEast
- LongitudeDomain = 360
- PixelResolution = 3.0 <meters/pixel> *<< change as needed; use lower resolution for quick-look mosaics or for smaller images*
- End_Group
- End

Level 0 Processing of LROC NAC data

- Ingest NAC EDR to ISIS 3 with “Ironac2isis”
 - Converts EDR to ISIS 3 cube file with attached label
 - `>Ironac2isis from=M102064759RE.IMG to=M102064759RE_lev0.cub`
- Update labels with camera pointing information using “spiceinit” and the system defaults
 - `>spiceinit from=M102064759RE_lev0.cub`
 - Uses the default lunar shape model or DEM

Level 1 Processing of LROC NAC data

- Calibrate image to convert to I/F values using “Ironaccal”
 - >Ironaccal from= M102064759RE_lev0.cub
to=M102064759RE_lev1.cub
- Remove artifacts using “Ironacecho”
 - A correction designed to remove an observed brightness “echo” across adjacent pixels in NAC frames
 - >Ironacecho from= M102064759RE_lev1.cub
to=M102064759RE_lev1.echo.cub
- **Result is a Calibrated Data Record (CDR)**

Level 2 Processing of LROC NAC data

- Map-project image using “cam2map”
 - This creates a Level 2 image, or a Reduced Data Record (RDR)
 - Sinusoidal Projection (default)
 - For more information and examples, see ISIS Map Projection Online workshop
 - http://isis.astrogeology.usgs.gov/IsisWorkshop/index.php/Working_with_Mars_Reconnaissance_Orbiter_HiRISE_Data
 - Interpolation options
 - Nearest Neighbor
 - Bilinear
 - Cubic Convolution (default)

```
>cam2map from=M101271375LE_lev1.echo.cub  
to=M101271375LE_lev2.cub
```

Level 3 Processing of LROC NAC data

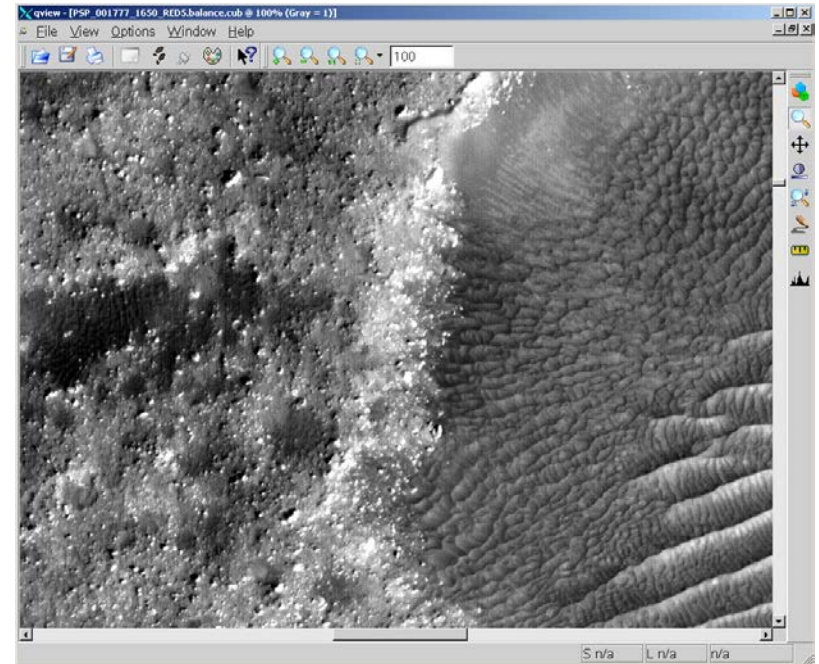
- Photometric correction
 - This step is not yet used routinely for correcting NAC data
 - Research is being conducted on this topic, for example:
 - Clegg et al., 2013
 - <http://www.lpi.usra.edu/meetings/lpsc2013/pdf/2171.pdf>
 - Boyd et al., 2012
 - <http://lunarscience.nasa.gov/lsc2012/lunar-reconnaissance-orbiter-camera-narrow-angle-camera-global-photometric-solution-empirical-functi>

Level 4 Processing of LROC NAC data

- Create a mosaic of NAC images using “automos”
 - `>ls -1 *lev2.cub > lev2.lis`
 - `>automos fromlist=lev2.lis mosaic=testmos.cub`or
 - `>automos fromlist=lev2.lis mosaic=testmos.cub
grange=user minlat=X maxlat=X minlon=X maxlon=X
matchbandbin=false`
- View and evaluate images or mosaic
 - `>qview testmos.cub`

Level 4 Processing of LROC data

- View cubes and/or mosaic
 - `>qview testmos.cub`
 - Zoom, Pan, Stretch
 - Track, Measure
 - Color composite
 - Link, Blink, Plot
 - Save, Print



Exporting ISIS3 files

- Within ISIS3
 - Directly from qview or
 - `>isis2std from=LROCfile.cub to=LROCfile.png`
- GDAL: Geospatial Data Abstraction Library
 - See <http://www.gdal.org/>
 - Open Source library, supports PDS v3, ISIS2, and ISIS3 file formats
 - Binaries available for Mac, Windows, Linux
 - Export raw and many other image file formats
 - Maintains projection information and some metadata to output
 - Utility applications have stretching (scaling options), map projection support, clipping, resampling and mosaic capabilities
 - To output lossless geoJpeg2000
 - `>gdal_translate -of JP2KAK -co quality=100 input.cub out.jp2`
 - This .jp2 product retains geospatial information and can be exported directly into an Arc GIS project

Finding Help

- For ISIS 3, start at the ISIS Support Website
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Finding Help

- For help using LROC NAC data
 - LROC Instrument Overview (Space Science Reviews, 2010):
<http://link.springer.com/article/10.1007%2Fs11214-010-9634-2>
 - LROC EDR/CDR PDS Product Description:
http://lroc.sese.asu.edu/data/LRO-L-LROC-2-EDR-V1.0/LROLRC_0001/DOCUMENT/LROCSIS.PDF
 - LROC RDR Product Description:
http://lroc.sese.asu.edu/data/LRO-L-LROC-5-RDR-V1.0/LROLRC_2001/DOCUMENT/RDRSIS.PDF
 - For questions regarding LROC PDS products, send email to the address [lroc dn@ser.asu.edu](mailto:lroc_dn@ser.asu.edu). For questions regarding the LROC PDS Data Node interface, send email to the address lroc_webmaster@asu.edu.