DESIGN AND PROCESSING OF THE LUNAR NORTH POLE MOSAIC. R. V. Wagner, M. S. Robinson, and the LROC Team. School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-3603 (rvwagner@asu.edu).

Introduction: The Lunar Reconnaissance Orbiter Narrow Angle Camera (NAC) consists of two line-scan cameras aimed side-by-side with a combined 5.7° FOV. The NAC acquired images with a pixel scale of 0.5 m from a 50 km near-circular orbit from 2009 through 2011, and pixel scales ranging from 0.5-2 m from a 30×180 km orbit since December 2011 [1].

In the northern hemisphere, where the orbit is highest, the relatively large size of NAC footprints allows for complete coverage at consistent, moderate incidence angles and high resolution to a startling distance from the pole. We have used this coverage to produce the Lunar North Pole Mosaic (LNPM), a 2 m/px mosaic from 60°N to the pole (Figure 1), currently released on the internet at lroc.sese.asu.edu/gigapan/. The current version contains 681 gigapixels of image data from 10,581 images [2,3]. We are now expanding this mosaic out to 40°N, which will contain just over 2 terapixels of image data.

Processing: The processing method for the LNPM was driven by the format required by Gigapan.com, the site we used to host the current LNPM product. The site requires millions of 256x256 pixel jpeg tiles at all zoom levels. Thus all subdivisions of the mosaic were selected in powers of 2 in image coordinates, rather than using map coordinates. Most of the processing was done using the USGS ISIS software [4].

To minimize file size used by non-image (null) data, individual NAC images, which are usually long strips with a ~10:1 length:width ratio, were map-projected in square segments. To reduce processing time and allow for parellelization, the image segments were mosaicked into 32,768 × 32,768 pixel tiles, rather than attempting to create the entire mosaic in one step (future versions will use 16,384 pixel tiles, to improve speed and memory usage in post-processing). Images included in each tile were selected using a database containing the bounds (in map X/Y space, rather than latitude/longitude) of each NAC segment.

The final processing step used a combination of ISIS and ImageMagick to scale the tiles to all resolutions from full size to a single 256x256 pixel tile containing the full LNPM, add resolution-dependent feature name and lat/lon grid annotations, and split each tile into correctly-named 256x256 pixel subtiles.

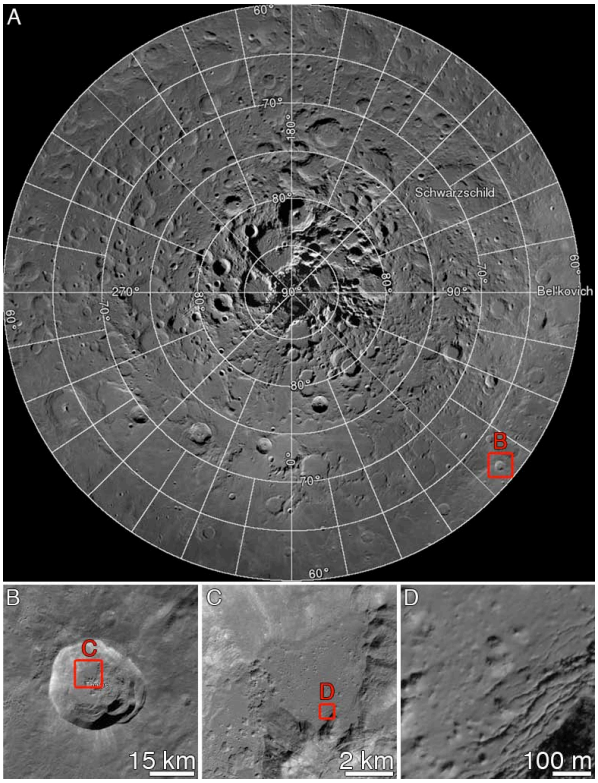

Figure 1: Panel A shows a zoomed-out view of the annotated version of the current Lunar North Pole Mosaic. Panels B-D show increasing zoom levels of a portion of Thales crater. Panel D is a single full-resolution tile from the final product.

Image Selection: Images for the LNPM were selected in three different ways, depending on the latitude range.

Collars (60-82°N): The LNPM is largely made up of "collars" of NAC images: for one-month periods, the NACs would image a specific latitude band on every orbit or every other orbit. Due to the high orbital altitude in the far northern hemisphere, NAC footprints on adjacent orbits overlap, so this imaging sequence produces seamless mosaics with consistent lighting at a given latitude. The released LNPM contains 17 complete and partial collars, and we have since acquired five additional collars to improve lighting uniformity in future updates.

Polar Region (82-90°N): The central section of the LNPM does not consist of collars. Instead, it is an expanded version of the 85.5-90°N north pole NAC mosaic [2,5]. The images are primarily from northern summer, with a sub-solar latitude north of the equator.

Image mosaicking order was based on [6]: first sort the images into 0.5° sub-solar latitude bins, then sort within each bin by the difference between the sub-solar longitude and the longitude of the southern end of the image. Pole-crossing images were trimmed to remove the part of the image on the opposite side of the pole from the sub-solar point. This list was then manually adjusted to clean up areas with inconsistent lighting, using a 100 m/px preview mosaic created using pixel-by-pixel, lowest-incidence-angle ordering (a very slow algorithm, which leaves some edge-of-image artifacts) as a "best possible" reference image.

Southern Expansion (40-60°N): Below 60°N, it is no longer possible to create true collars, as the ground tracks of adjacent orbits are farther apart than a single NAC pair can cover. For the future 40-60°N expansion of the LNPM, we are selecting images from the large existing image data set and targeting new observations to fill gaps in the high-Sun coverage. We are restricting image selection to those with a beta angle (angle between the orbital plane and the Sun-Moon vector) less than 45°, resulting in over 47,000 images in this region. The southern expansion campaign is estimated to finish sometime in 2015.

The ordering criteria have not yet been finalized for this expansion. While a simple "minimum incidence angle" approach may work, it will likely lead to many locations where adjacent images are lit from opposite directions. We are currently looking into algorithms to find clusters of images with similar lighting direction, so that while the mosaic as a whole may not have uniform lighting, there will be near-uniform regional lighting.

A note on sampling scale: This extended mosaic is sufficiently large that distortions from the polar stereographic projection will produce a significant difference in pixel scale between the center and edges of the map. While the scale at the center is 2 m/px, at the edge it is only ~1.6 m/px. Fortunately, the native resolution of NAC images improves as you get further south, and is usually slightly better than 1.6 m/px at 40°N, so even at the edges of the map, the mosaic will not be oversampling the original data. Further expansions will not fare as well, however- following the current mapping scheme images below about 35°N will be oversampled, so any equatorial expansion would require a different map projection. Image selection excludes any image with pixel scales worse than 2 m/px.

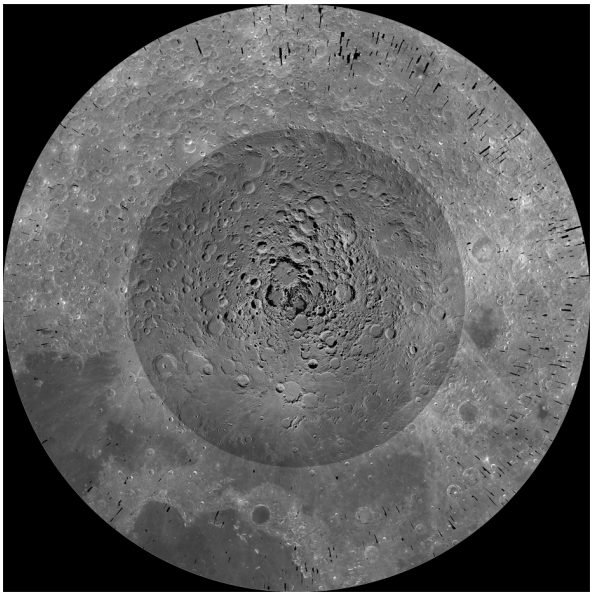

Figure 2: Images available for the expanded LNPM as of March 2015. The dark region in the center is the current LNPM. Close inspection of the upper-right edge shows gores where we do not yet have complete coverage with appropriate lighting.

South Pole: Due to the low orbital altitude near the south pole, a similar product for the southern hemisphere is not possible at this time. Preliminary testing shows that it should be possible to create a mosaic with reasonably consistent lighting out to 80-70°S, and due to the lower orbital altitude, this mosaic would have a higher resolution of 1 m/px. In the future the spacecraft altitude in the southern hemisphere may be raised to allow improved NAC coverage.

References: [1] Robinson et al. (2010) *Space Sci. Rev*. DOI: 10.1007/s11214-010-9634-2. [2] Wagner et al. (2015), LPS XXXXVI, Abstract #1473. [3] http://lroc.sese.asu.edu/posts/738 [4] Anderson et al. (2004), LPS XXXV, Abstract #2039. [5] Henriksen et al. (2013), LPS XXXXIIII, Abstract #1676. [6] Waller et al. (2012), LPS XXXXIII, Abstract #2531.