THE LUNAR MAPPING AND MODELING PROJECT. S. K. Noble$^{1,2}$, R. A. French$^1$, M. E. Nall$^1$, and K. G. Muery$^1$, $^1$NASA Marshall Space Flight Center, Huntsville AL 35805, sarah.k.noble@nasa.gov, $^2$University of Alabama Huntsville, Huntsville AL 35805.

Introduction: The Lunar Mapping and Modeling Project (LMMP) has been created to manage the development of a suite of lunar mapping and modeling products that support the Constellation Program (CxP) and other lunar exploration activities, including the planning, design, development, test and operations associated with lunar sortie missions, crewed and robotic operations on the surface, and the establishment of a lunar outpost. The information provided through LMMP will assist CxP in: planning tasks in the areas of landing site evaluation and selection, design and placement of landers and other stationary assets, design of rovers and other mobile assets, developing terrain-relative navigation (TRN) capabilities, and assessment and planning of science traverses.

Project Scope and Purpose: LMMP will provide access to this data through a single intuitive and easy to use NASA portal that transparently accesses appropriately sanctioned portions of the widely dispersed and distributed collections of lunar data, products and tools. Two visualization systems are being developed, a web-based system called Lunar Mapper, and a desktop client, ILIADS, which will be downloadable from the LMMP portal.

We are working closely with the LRO team to prevent duplication of efforts and to ensure the highest quality data products. While Constellation is our primary customer, LMMP is striving to be as useful as possible to the lunar science community, the lunar commercial community, the lunar education and public outreach (E/PO) community, and anyone else interested in accessing or utilizing lunar data.

Data Sources: The LMMP will focus predominantly on data products resulting from the Lunar Reconnaissance Orbiter (LRO) and Lunar CRater Observation and Sensing Satellite (LCROSS) missions, but will also utilize historical lunar data (e.g., Apollo, Lunar Orbiter, Clementine, Lunar Prospector) and international lunar mission data (e.g., Kaguya, Chandrayaan-1, SMART-1), as available and appropriate, to meet specific near-term product, product type and/or product resolution and accuracy needs.

Data products: LMMP will produce products on a global, regional, and local scale. Local products will be focused on the Constellation program’s 50 sites of interest [1]. LMMP will incorporate three different types of products. “Pass-through” products are those which LMMP will ingest and display “as is” from PDS or other sources. Examples of pass though products include the LOLA topography and Clementine and Prospector derived products. In some cases we will modify the data given to us. Examples of modifications include mosaicking the LROC WAC basemap and georeferencing local images. There are also some products that LMMP is producing. Examples of LMMP products include regional and local DEMs from Apollo and LROC NAC imagery, maps of slope and surface roughness, and maps of crater and boulder distributions.

LMMP team members and roles: The project draws on expertise from several NASA and non-NASA organizations (MSFC, ARC, GSFC, JPL, ASU, CRREL – US Army Cold Regions Research and Engineering Laboratory, and the USGS).

The team is well integrated but the major responsibilities are divided as follows:

- **MSFC** – Management and overall coordination
- **Ames** – Regional Apollo visible base imagery mosaics and DEMs, EPO web-based neo-geography interfaces
- **USGS** – Local/site visible base imagery mosaics, regional/polar visible base imagery mosaics, local/site DEMs
- **JPL** – Visualization system infrastructure, web portal and interoperable GIS infrastructure, local/site DEMs (stereo photoclinometry), local/site albedo maps, resource maps, hazard assessment maps
- **AZ State U** – Local/site DEMs
- **CRREL** – Web-based visualization system digital overlay tools (Lunar Mapper)
- **GSFC** – Desktop visualization client – Integrated Lunar Information Architecture for Decision Support (ILIADS)

Schedule: The LMMP project passed formulation review in April of 2009 and a level 3 requirements review in June. Following a series of individual product process validation audits and a preliminary system design audit, a beta version of the portal and visualization systems is expected to be released in late 2009. A version 1 release is planned for early 2011. Our schedule for the release of data products is, however, highly dependent on the timing of acquisition of data from LRO.

The Lunar Mapping and Modeling Project

Sarah Noble, Raymond French, Mark Nall, and Kimberly Muery

NASA Marshall Space Flight Center
Project Background and Overview

- **LMMP** was initiated in 2007 to help in making the anticipated results of the LRO spacecraft **useful** and **accessible** to Constellation.

- The LMMP is managing and developing a suite of lunar mapping and modeling tools and products that support the Constellation Program (CxP) and other lunar exploration activities.

- In addition to the LRO Principal Investigators, relevant activities and expertise that had already been funded by NASA was identified at ARC, CRREL (Army Cold Regions Research & Engineering Laboratory), GSFC, JPL, & USGS.

- LMMP is a cost capped, design-to-cost project (Project budget was established prior to obtaining Constellation needs).
Customers

• **Main customer is the Constellation program**
  The information provided through LMMP will assist them in:
  – planning tasks in the areas of landing site evaluation and selection
  – design and placement of landers and other stationary assets
  – design of rovers and other mobile assets
  – developing terrain-relative navigation (TRN) capabilities
  – assessment and planning of science traverses

• **Other customers**
  – Science community
  – Commercial community (e.g. GLXP teams)
  – Education/Public Outreach community
Management Structure Post LPRP

FY 2010-11

MSFC Team:
Project Manager: Mark Nall
Project Integration Lead: Ray French
Project Development Lead: Kim Muery
Project Scientist: Dr. Sarah Noble
Chief Engineer: Judy Ballance
S&MA TA: Rosalynne Strickland
Scheduling and Risk: Dominique Cavanaugh

Director
Advanced Capabilities Division
ESMD

Director
Directorate Integration Office
ESMD

ETDP Program Executive
Advanced Capabilities Division

Director
Marshall Space Flight Center

Engineering and Safety and Mission Assurance Technical Authority
MSFC

Lunar Geodesy and Cartography Working Group
(LMMP/CxP/LRO/International)

Manager
Lunar Mapping and Modeling Project
MSFC

LSOS
(CxP/DIO/JPL)

LRO PIs

ARC Lead
GSFC Lead
JPL Lead
CRREL Lead
USGS Lead
ASU
LMMP Team

- Regional Apollo visible base imagery mosaics
- Regional DEMs
- EPO web-based neo-geography interfaces

- Local/site visible base imagery mosaics
- Regional/polar visible base imagery mosaics
- Local/site DEMs

- Visualization system infrastructure, web portal and interoperable GIS infrastructure
- Local/site DEMs (stereo photoclinometry)
- Local/site albedo maps
- Hazard assessment maps (including slope maps)

- Local/site DEMs

- Web-based visualization system digital overlay tools

- Desktop visualization client – Integrated Lunar Information Architecture for Decision Support
Data Sources

- LRO
- M3
- Kaguya (gravity model)
- Apollo (metric & panoramic cameras)
- Clementine
- Prospector
Data Products

• “Passthrough”
  – e.g. LOLA DEM, Clementine, Prospector, gravity model, lighting model

• Modify
  – e.g. mosaicking basemap, georeferencing local images

• Create...
Created Products - DEMs

Regional DEMs using scanned Apollo metric camera data

Covers ~18% of the Moon (low latitudes)

Small section of DEM from orbit 33. DEM resolution ~40m/pixel

Map showing coverage of metric camera data
DEMNs

Local DEMs from LOLA NAC covering the 50 CxP regions of interest

Preliminary USGS Aristarchus Plateau (DEM 1) from JSC/ASU Apollo Pan Cam Scans

Aristarchus 1 ROI showing in red the NAC images acquired through the 1st month of mapping orbit
Created Products - Hazard Maps

- Craters
- Boulders
- Slopes
- Surface Roughness
Data Products Process

1. Produce preliminary data products
   - In some cases using Apollo or other historic data

2. Hold process validation audits
   - These have occurred

3. Acquire final data sets from LRO teams.
   - Adjust methods, if necessary.

4. Produce final products

5. Ingest into LMMP system

6. Hold final product validation audits
   - To insure that products are of high quality, display correctly, and meet CxP’s needs

7. Release to Public (or where appropriate, CxP internal use)
Lunar Mapper (pre-beta)

Lunar Mapper in Global Mode
Lunar Mapper (pre-beta)

Lunar Mapper in Search Mode
Integrated Lunar Information Architecture for Decision Support (ILIADS) (pre-beta)

Clementine Albedo (oblique view)

Lunar Surface Traverse Tool (oblique view)
Integrated Lunar Information Architecture for Decision Support (ILIADS) (pre-beta)

Clementine with high-res Lunar Orbiter

South Pole hazard analysis (surface roughness)
LMMP Milestones

- Apr 2009 – Formulation review
- Jun 2009 – LRO launched!
- Jun 2009 – Requirements review
- Aug-Sep 2009 – Individual product process validation audits
- Sep 2009 – Preliminary System design audit
- Dec 2009 – Beta release of Mapper, ILIADS, Portal, infrastructure and content
- Late 2010/Early 2011 – Version 1 release