**THE LUNAR MAPPING AND MODELING PROJECT (LMMP).** B. A. Cohen, M. E. Nall, R. A. French, K. G. Muery, and A. R. Lavoie, Marshall Space Flight Center, Huntsville AL 35812 (Barbara.A.Cohen@nasa.gov).

**Introduction:** Two key focus areas for the Lunar Precursor Robotic Program (LPRP) at MSFC are to provide a three-dimensional map to support lunar mission site selection and operations and to provide information about the lunar environment. The Lunar Mapping and Modeling Project (LMMP) is an LPRP project tasked by the Exploration System Mission Directorate (ESMD) Advanced Capabilities Division to develop maps and tools to benefit the Constellation Program (CxP) lunar planning by providing common, consistent and useful access to and dissemination of this information to the lunar exploration and science communities.

**Project scope and purpose:** The LMMP will provide: 1) a single, common, consistent, uniform, intuitive and easy to use NASA portal that accesses lunar mapping and modeling products, tools and data; 2) transparent conduits to appropriately sanctioned portions of the widely dispersed and distributed universe of lunar data, products and tools; 3) registration to an appropriately updated control network for data products; and 4) a database and collaborative environment for the collection of lunar data that does not necessarily vary by position/location (e.g., a lunar wiki). The LMMP's primary customers are the CxP designers and planners; therefore, the project philosophy is to have the CxP customers identify the needs and requirements they have for lunar mapping and tools and to use this information to define content and prioritize objectives. A secondary purpose is to support the dissemination of and access to this data to support the science community, potential future LPRP missions, international partners, commercial entities, education and public outreach, etc. 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 may also utilize historical lunar data (e.g., Apollo, Lunar Orbiter, Clementine, Lunar Prospector, Earth-based observations) and international lunar mission data (e.g., SMART-1, Kaguya, Chandrayaan, Chang'e), as available and appropriate, to meet specific near-term product, product type and/or product resolution and accuracy needs.

**Project approach and status:** LMMP held its kick-off meeting with prospective CxP customers and developers on August 6th and 7th at the Lunar and Planetary Institute (LPI) to obtain initial level 1 and 2 requirements. A follow-up meeting was held with customers and developers October 29th and 30th at the LPI to confirm level 1 and 2 requirements and identify CxP "owner(s)" for each requirement. LMMP representatives also participated in the ESMD Integrated Simulation and Modeling (IS&M) workshop October 23rd through 25th in Houston. We have partnered with development organizations, internal and external to NASA, that bring relevant areas of expertise to the LMMP: the US Geological Survey (USGS) Flagstaff, the Jet Propusion Laboratory (JPL), Goddard Space Flight Center (GSFC), Ames Research Center (ARC), and the US Army Cold Regions Research and Engineering Laboratory (CRREL). We are currently working with developers and customers to flow level 2 project requirements (in draft, shown in Table 1) down to level 3 implementation requirements, ensuring the development teams have customer representation and input during development and at all relevant product reviews. Once developer assignments and level 3 requirements are understood and agreed to, detailed budget, schedule, technical approach, and work breakdown will be developed for implementation. This effort has a fixed budget, and product development will be descoped as necessary to meet funding caps. The final products and interface will be available as early as possible – possibly in staged releases as data, products, and models become available. The final products and interface will be completed no later than 2014.

**Data sources:** Many relevant data sets, products, and models currently exist or are planned to be created by the lunar science and exploration communities. We will identify these products and tools that can be leveraged or used directly in the LMMP so that efforts will not be unnecessarily duplicated. We have agreements in place with the CxP Lunar Surface Operations Simulator (LSOS) and the CxP Environments & Constraints System Integration Group (E&C SIG), who are developing lunar lighting, communications coverage, and thermal models, to utilize these products. We are also coordinating with the LRO science team to fully understand funded data product deliverables to NASA, ensure that LRO science team efforts and products are not unnecessarily duplicated by LMMP, and incorporate appropriate LRO data products into the LMMP. For needs not covered by these three groups the LMMP will identify relevant data sources, both existing and planned, determine availability dates for relevant future data products; determine which source best matches the customer requirements; and determine what agreements may need to be made for international data sources. The assessment of what data are included in the LMMP may not always be straightforward (e.g., differences in resolution or coverage, dif-

ferences in band centers of multispectral data, resources required to geo-register terabytes of high-resolution images, wait time for international data releases); therefore, developers will document dependencies among data sources and products and the project will assess them accordingly with concurrence from the users and external experts.

**Summary:** The LMMP will create a single, common, consistent, uniform, intuitive and easy to use NASA portal that accesses lunar mapping and modeling products, tools and data. The Project will use standard data formats and interfaces when available and practical so that data may be downloaded for use in any standard GIS application. Data products and tools will be interoperable so as to allow for easy visualization and data fusion. Tools and products will be designed to support and be extensible to surface operation needs (real-time mission and/or planning) to the extent practical. The LMMP will coordinate with the Outpost Science and Exploration Working Group (OSEWG) to ensure continued cross-relevance between ESMD/CxP and the Science Mission Directorate (SMD). The Lunar Mapping and Modeling Project provides a unique and needed contribution to both the Constellation Program and the science community.

**Table 1: LMMP Level 2 Requirements (Draft as of 1/8/08, subject to change; provided for topical awareness)**

- **Albedo Base Maps:** The LMMP shall provide geo-registered global and local albedo (visible image) base maps of the Moon.
- **Surface Roughness and Rock Size Maps:** The LMMP shall provide geo-registered global and local surface roughness and rock size frequency and distribution maps of the Moon.
- **Terrain Feature Maps:** The LMMP shall provide geo-registered terrain feature maps of the Moon (e.g., mountains, rilles, craters).
- **Communication Coverage Models:** The LMMP shall provide communications coverage models that provide the user with communication coverage information for surface-to-surface, surface-to-orbiting asset, and surface-to-Earth communications.
- **Human Emplaced Artifacts Maps and Tools:** The LMMP shall provide tools with the capability to superimpose, based upon user input, human associated activities such as architectural elements, surface modifications, surface debris, chemicals, organics, and logistical information such as route planning to support lunar surface mission planning and operations.
- **Surface Digital Elevation Models:** The LMMP shall provide geo-registered global and local surface digital elevation models (DEM) of the Moon.
- **Lighting Maps and Models:** The LMMP shall provide geo-registered lunar lighting maps and models that provide lunar lighting information for any location at or near the lunar surface for any lunar time reference.
- **Temperature Maps and Models:** The LMMP shall provide geo-registered lunar temperature maps and models that provide lunar temperature information for any location and for any lunar time reference.
- **Gravity Maps and Models:** The LMMP shall provide a geo-registered global lunar gravity model.
- **Geochemical, Mineralogical, and Resource Maps:** The LMMP shall provide geo-registered global resource maps of the Moon.
- **Standardized Formats:** The LMMP shall utilize standardized data and interface output formats.
- **Accessibility and Usability:** The LMMP shall develop usable and accessible interfaces, display tools, and models for defined user communities.
- **Open Source Code:** The LMMP product source code shall be made freely and publicly available.
- **Collaborative Database Environment:** The LMMP shall provide a database and collaborative environment for the propagation of lunar information that is not necessarily variable with position.
- **Availability:** The LMMP shall make available all its software and data products through a single web portal.
- **Support for Education and Public Outreach:** The LMMP shall provide ready access to tools and materials for Education and Public Outreach (EPO).
- **Extensibility:** The LMMP products shall be extensible to other systems and easily accessible by defined user communities, including the Constellation Communication System Infrastructure/Architecture.
- **Standard Geographic Information System:** The LMMP shall provide standard Geographic Information System (GIS) capability.
- **Relevant Source Data:** The LMMP shall consider potentially relevant data sets, including past, future and international missions, when determining which data to include for the specified products.
- **Geo-Registration:** The LMMP shall geo-register all relevant data sets used in the specified products.
- **Validation:** The LMMP shall validate all models against actual lunar data.