**EDUCATION AND ENGAGEMENT APPLICATIONS OF NASA LUNAR AND PLANETARY MAPPING AND MODELING.** Brian H, Day[1] and Emily S. Law[2], [1] NASA Solar System Exploration Research Virtual Institute. (NASA Ames Research Center. M/S 17-1. Moffett Field, CA, USA. 94035. Brian.H.Day@nasa.gov), [2] Jet Propulsion Laboratory, California Institute of Technology. (M/S 168-200. 4800 Oak Grove Dr. Pasadena, CA, USA 91109. Emily.S.Law@jpl.nasa.gov).

**Introduction:** The Lunar and Planetary Mapping and Modeling Program produces a suite of interactive visualization and analysis tools. Managed by NASA's Solar System Exploration Research Virtual Institute and developed at NASA's Jet Propulsion Laboratory, these tools enable mission planners, planetary scientists, and engineers to access mapped data products from a wide range of instruments aboard a variety of past and current missions, for a growing number of planetary bodies.

While orinigally initiated for mission planning and science, this technology has demonstrated great benefits for education and engagement. NASA's Science Mission Directorate has designated this project as a componenet of its NASA Science Education Infrastructure. As such, it is available as a resource for NASA Science Education and Communication programs, and is available to the greater education and engagement community.

There are currently three web portals in the program available to the public: the Lunar Mapping and Modeling Portal or LMMP (http://lmmp.nasa.gov), Vesta Trek (http://vestatrek.jpl.nasa.gov), and Mars Trek (http://marstrek.jpl.nasa.gov). More portals for additional planetary bodies are in the works.

As web-based toolsets, the portals do not require users to purchase or install any software beyond current standard web browsers. All of the portals provide analysis tools that facilitate the measurement and study of planetary terrain. They allow data products to be layered and adjusted to optimize data visualization. Visualizations can easily be stored and shared. The portals each provide for 3D visualization as well as provide users with the ability to draw bounding boxes around any desired terrain for generation of STL files that can be directed to 3D printers. Such 3D prints are valuable tools in museums, public exhibitions, and classrooms – notably including classrooms for the visually impaired. The data visualization capabilities of the portals provide easy access to data from NASA and other agencies, allowing students and the public to personally explore these destination worlds, and become directly engaged in current missions as well as plans for future exploration.

In addition to the web portals, the program supports additional clients, web services, and APIs that facilitate dissemination of planetary data to a range of external applications and venues.

**LMMP:** The Lunar Mapping and Modeling Portal (LMMP) enables users to browse, search, download, and create visualizations utilizing data from a wide range of instruments on a wide range of lunar missions. Data products can be layered and their transparencies adjusted in order to optimally visualize specific aspects of lunar terrain. LMMP provides for visualizations to be made as 2D maps or 3D renders. With a heritage extending back to the Constellation program, LMMP has over 700 layers of data already integrated, with new layers continuing to be added in preparation for upcoming missions. LMMP's collection of data products is augmented by analysis tools that allow users to measure distances, plot elevation profiles, and more. Visualizations built with multiple data layers and transparency adjustment between layers can be saved and shared as simple URLs.

As potential landing sites are being studied for upcoming lunar missions such as Resource Prospector and Lunar Mission One, students can use LMMP to explore these candidate regions, gaining insights into the missions, their objectives, and the specific characteristics of the terrain being considered.

Looking ahead to a future release, the development team is currently working with the Astromaterials Office at NASA's Johnson Space Center to integrate their database of the returned Apollo lunar samples into LMMP. This will be particularly valuable for students, educators, and informal education institutions taking advantage of the opportunities to borrow these samples for educational uses. For a given sample, LMMP will display images and information about the sample, and allow the user to put the sample into context by providing visualizations of the location on the lunar surface from which it was retrieved.

**Vesta Trek:** On March 31, 2015, the LMMP team released Vesta Trek, a web-based application applying LMMP technology to visualizations of the asteroid Vesta. Data gathered from multiple instruments aboard Dawn have been compiled into Vesta Trek's user-friendly set of tools, enabling users to study the asteroid's features. The application features interactive maps, including the ability to overlay a range of data sets including topography, mineralogy, abundance of elements and geology, as well as analysis tools for

measuring the diameters, heights and depths of surface features and more. An improved user interface provides greatly enhanced 3D visualization and navigation. Standard keyboard gaming controls allow users to maneuver a first-person visualization of "flying" across the surface of the asteroid.

With the Dawn mission having moved on from Vesta to Ceres, data products from the mission are now being ingested for a forthcoming Ceres Trek portal.

**Mars Trek:** With an initial release in June, 2015, Mars Trek replicates the functionality of Vesta Trek for the surface of Mars. Surface features on Mars can be visualized and studied through the eyes of instruments aboard missions including Mars Rconnaissance Orbiter, Mars Express, Mars Odyssey, Mars Global Surveyor, and Viking. In addition to free-format exploration, Mars Trek includes guided tours of areas of particular interest including many of Mars' more spectacular landforms, as well as sites of past and current exploration including the Curiosity, Opportunity, and Spirit rovers. A new guided tour even allows users to follow the epic journey of fictional astronaut Mark Watney from the story of The Martian, traversing from Acidalia Planitia to Schiaparelli Crater with explanatory commentary from NASA.

Mars Trek is being integrated in to NASA's site selection and analysis program for identifying potential locations for planned human missions to Mars. As the tool is being adapted for human Mars mission planning, it will also be used to engage the public in the process of identifying and selecting where the first humans will land. Already, an afterschool program in California is utilizing Mars Trek to model NASA's Mars Exploration Zone process, having students propose, debate, and select potential human landing sites.

**Additional Clients and Interfaces:** In addition to the web portals, the Lunar and Planetary Mapping and Modeling Program supports a variety of additional clients, web services, and APIs. A prototype client for virtual reality goggles has been successfully demonstrated in venues such as AGU's Exploration Station education event and on Capitol Hill. A multiuser touch table originally designed for mission planning is now being adapted for use as an attended museum exhibit. Webservices and APIs are currently being used to serve data to the Hayden Planetarium of the American Museum of Natural History and the Morrison Planetarium of the California Academy of Sciences for integration in their planetarium program development. The California Academy of Sciences is conducting workshops for other planetariums, showing them how they too can access and integrate these data. Through these ways and more, NASA's Lunar and Planetary Mapping and Modeling Program is facilitating the dissemination of exciting planetary data, and making advanced tools available to students and the public.

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