

STEM ENGAGEMENT WITH NASA'S SOLAR SYSTEM TREKS PORTALS FOR LUNAR AND PLANETARY MAPPING AND MODELING. E. S. Law¹ and B. H. Day², ¹Jet Propulsion Laboratory, California Institute of Technology. M/S 168-200. 4800 Oak Grove Dr. Pasadena, CA, USA 91109. (Emily.S.Law@jpl.nasa.gov, +01-818-354-6208), ²NASA Solar System Exploration Research Virtual Institute. NASA Ames Research Center. M/S 17-1. Moffett Field, CA, USA. 94035. (Brian.H.Day@nasa.gov, +01-650-604-2605).

Introduction: This presentation will provide an overview of the uses and capabilities of NASA's Solar System Treks family of online mapping and modeling portals. While also designed to support mission planning and scientific research, this presentation will focus on the Science, Technology, Engineering, and Math (STEM) engagement and public outreach capabilities of these web based suites of data visualization and analysis tools.

Online Web Portals for Inspiration and STEM Engagement: NASA's Solar System Treks program of lunar and planetary mapping and modeling produces a suite of interactive visualization and analysis tools. The program is 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 originally initiated for mission planning and science, this technology has demonstrated great benefits for STEM engagement and public outreach. As a component of NASA's Science Mission Directorate's STEM Activation Infrastructure, they are available as resources for NASA outreach and STEM engagement programs, and to the greater outreach and STEM communities. As new missions are being planned to a variety of planetary bodies, these tools are facilitating the public's understanding of the missions and engaging the public in the process of identifying and selecting where these missions will land.

The portals provide easy-to-use tools for browsing, data layering and feature search, including detailed information on the source of each assembled data product. Interactive maps, include the ability to overlay a growing range of data sets including topography, mineralogy, abundance of elements, and geology.

There are currently three web portals in the program available to the public: Moon Trek (<https://moontrek.jpl.nasa.gov>), Vesta Trek (<https://vestatrek.jpl.nasa.gov>), and Mars Trek (<https://marstrek.jpl.nasa.gov>). More portals for additional planetary bodies are in the works. The team has developed and demonstrated prototypes for Mars' larg-

er moon, Phobos; and the dwarf planet, Ceres. Work has begun on a portal for Saturn's moon, Titan.

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 new Trek interface provides enhanced 3D visualization and navigation. Standard keyboard gaming controls allow the user to maneuver a firstperson visualization of "flying" across the surface of the Moon. User-specified bounding boxes can be used to generate STL and/or OBJ files to create physical models of surface features with 3D printers. Such 3D prints are valuable tools in museums, public exhibitions, and classrooms – notably including opportunities for the visually impaired. This interface will become the standard across all of the Trek portals. The data visualization capabilities of the portals provide easy access to data from NASA and other agencies, allowing the public to personally explore these destination worlds, and become directly engaged in current missions as well as plans for future exploration.

A new virtual reality extension being developed by the team allows users to draw a path using the web client and then fly the path in virtual reality using a range of VR goggles. A new

Using the portals, students and members of the public can conduct their own explorations of planetary surfaces, measuring diameters of craters, creating elevation profiles of peaks and valleys, and plotting traverse paths. A collaboration with DLR resulted in the integration of new Mars Express HRSC data into Mars Trek for a very popular interactive guided tour of fictional astronaut Mark Watney's epic journey across the terrain of Mars from the story, *The Martian*.

Along with 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. A prototype touch table implementation is attracting interest from science centers and museums. Through its APIs, the Solar System Trek project is serving data to a growing community of digital planetariums. NASA challenges and hackathons are

also providing members of the international software development community opportunities to participate in tool development and leverage data from the portals. In the 2016 NASA SpaceApps Challenge, 14 projects were created using the Trek data.

Informal and formal educators are integrating the Trek portals into their programs. Now in its third year, “Explore Mars!” has K-12 students in classrooms and afterschool programs using Mars Trek to come up with their own proposals in a student version of NASA’s Mars Human Landing Site Selection Workshop. Through a partnership between JPL and Cal State University L.A., computer science students are developing new tools and capabilities for the Solar System Treks as senior projects. High school astronomy students in Palo Alto are taking on beta testing the new Phobos Trek portal as a class project.

Summary and Conclusions: Imagery from the international fleet of spacecraft exploring the solar system provides a unique and particularly effective means to engage, inspire, and educate students and the public. NASA’s online, web-based Solar System Treks planetary mapping and modeling portals provide exciting, interactive tools of great value to informal educators, as well as to scientists working to share the excitement of the latest developments in planetary science and exploration. The user community is invited to provide suggestions and requests as the development team continues to expand the capabilities of the portals, the range of data and tools that they provide, and partner in new ideas for their application in STEM engagement and outreach. As we look forward to a new generation of surface and orbital lunar robotic activities, as well as preparation for human return to the Moon, and the first human missions to Mars, tools such as the Trek portals will become increasingly essential to engage and involve students and the public.

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