

PDS ANALYST'S NOTEBOOK FOR MSL. T. C. Stein¹ and R. E. Arvidson², ¹Washington University in St. Louis, 1 Brookings Drive, CB 1169, St. Louis, MO 63130, tstein@wustl.edu, ²arvidson@wunder.wustl.edu.

Introduction: The PDS Analyst's Notebook (<http://an.rsl.wustl.edu>) [1] provides access to science information from several of NASA's landed missions: Mars Exploration Rover (MER) [2], Mars Phoenix Lander [3], LCROSS, and Lunar Apollo surface mission data archives. With the PDS release of Mars Science Laboratory [4] data from the mission's first 90 sols in February 2013, an Analyst's Notebook for MSL has been made public.

The Analyst's Notebook enriches data archives by integrating sequence information, engineering and science data, observation planning and targeting, and documentation into web-accessible pages to facilitate "mission replay". In this paper, we focus on the Analyst's Notebook for MSL.

Populating the Notebook: The Analyst's Notebook for MSL contains data, documentation, and support files for a given mission. During active mission science operations, inputs are incorporated on a daily basis into a science team version of the Notebook. This approach assists with data validation and builds on strong collaboration between data producers and PDS archivists that begins soon after mission selection with creation of the project data management and archive plans.

The public version of the MSL Analyst's Notebook is comprised of peer-reviewed, released data and is updated coincident with PDS data releases as defined in mission archive plans. All data and documents have been ITAR cleared.

Data. The Notebook for MSL contains publicly released, peer-reviewed PDS archives from all science instruments. The data are provided by the instrument teams and are supported by documentation describing data format, content, and calibration.

Both Operations Products Generation Subsystem (OPGS) and Science data products are included in the MSL Notebook. The OPGS versions were generated to support mission planning and operations on a daily basis. They are geared toward researchers working on machine vision and engineering operations. Science versions of observations from some instruments are provided for those interested in radiometric and photometric analyses.

Documents. The MSL Notebook contains data set documentation and sol (i.e., Mars day) documents. The sol documents are the mission manager and documentarian reports that provide a view into science operations—insight into why and how particular observations were made. The reports have not been edited ex-

cept for grammar and spelling, and to remove spacecraft and instrument sensitive materials.

Data set documents contain detailed information regarding the mission, spacecraft, instruments, and data formats, including calibration information and errata when provided by the MSL project.

Science Plans. Observation planning and targeting information is extracted from each sol's science plan and presented in both timeline and list form. This information includes instrument settings such as filters used and sensors selected, as well as observation parameters such as distance to target. Effort has been made to link source commands with resulting data products, albeit with limits due to the absence of round trip data tracking.

Targets. Objects of interest that have been classified as targets by the science team are included in the MSL Notebook, including location information.

Navigating through the Notebook: A number of methods allow user access to the Notebook contents.

Mission Summaries. A searchable and sortable summary table provides an overview of surface operations by sol. Links enable quick access to details for a given sol.

Sol Summaries. The Sol Summaries are the primary interface to integrated data and documents contained within the MSL Notebook (Fig. 1). Data, documents, planned observations, targets and mosaics are grouped for easy scanning. Detailed information is displayed as items are selected by the user.

Data products are displayed in order of acquisition, and are grouped into logical sequences, such as a series of image data. Sequences and the individual products that comprise them may be viewed in detail and downloaded, either directly or as part of a cart order.

Detail data product views vary by instrument. PDS labels, data set documents, and activity details are available for all products. In some cases, derived data also are available. Image data are presented in both browse and full-resolution versions, the latter supported by a custom viewer that supports zoom and pan operations. This mechanism is especially useful for previewing mosaics—which can be 100s of MBs—without having to first download the data file.

Within the Sol Summaries, documents from the mission manager and documentarian may be viewed and downloaded. Science plans are available in timeline or list form, including the resulting products. Targets defined by the science team are plotted on locator images, with links to other data containing the target.

Maps. The MSL rover traverse is plotted on a HiRISE basemap using the raw and corrected drive telemetry provided by the MSL project. Users may zoom and pan the map. Clicking on a traverse location brings up links to corresponding data.

Searching. The MSL Notebook supports searches on data products, sol documents, and targets.

Data products may be searched by time (sol, spacecraft clock time, and UTC date), location (rover-specific site and position), instrument, command sequence, product type, image eye and filter, product type, and product ID. Sol documents may be searched by type, and time, filename. In addition, free text searches are supported. Targets may be searched by name, time, and location.

Results are displayed based on user settings, and searches can be bookmarked for later recall.

Resources. Data set documents and references to published mission papers are contained in the Resources, along with links to related web resources.

Online Help. Guidance is provided through a series of searchable help pages. Topics include release notes, landing site, coordinate frame, instruments, data processing, and data product file naming and structure.

Additional Features: Several features have been added to the MSL Notebook to improve usability relative to the MER and Phoenix Notebooks. These additions are based on feedback from the user community.

Data Ordering via Cart. Data and documents may be ordered using a cart paradigm common to commerce web sites. Selected items may be added to the user's cart in the Sol Summaries and Search portions of the Notebook. At checkout, the user specifies whether to receive primary or derived products, sort order, and delivery mechanism. Presently, zip/gzip files and a web page of links to requested items are supported outputs.

Bookmarks. Users may create a personalized list of favorite data products, targets, documents, and mosaics

for later recall using the bookmark function. In addition, custom searches may be saved as bookmarks. User bookmarks are for individual use only, and are not shared or made public.

Feedback. User comments and suggestions have sparked many aspects of the Analyst's Notebook. Such feedback can be submitted using a built-in form available on every Notebook page, alleviating the need to send email from a separate program.

User accounts. The public MSL Notebook allows users to optionally create and use personal accounts for an enhanced experience. At present, using an account gives the user synchronized bookmarks and cart settings across browsers and machines. An account is not required for the cart order function.

Future Development: A number of Notebook functions are based on previous user suggestions, and feedback continues to be sought. (User feedback should be submitted to an@wunder.wustl.edu or by using the online form.) Work continues to incorporate additional features, especially in the areas of related observations and visualization.

Acknowledgement: The Analyst's Notebook is developed through funding provided by the Planetary Data System Geosciences Node. Ongoing cooperation of the MSL and MER science and operations teams is greatly appreciated. The Analyst's Notebook is available at <http://an.rsl.wustl.edu>.

References: [1] Stein, T.C. et al. (2010), LPS XLI, Abstract #1414. [2] J.A. Crisp, M. Adler, J.R. Matijevic, S.W. Squyres, R.E. Arvidson, and D.M. Kass, JGR, 108(E12), 8061, doi:10.1029/2002JE002038, 2003. [3] Arvidson, R.E. (2008) Jet Propulsion Laboratory Document D-29392. [4] Grotzinger, J. et al. (2012) Space Science Reviews, 170, 5-56.

The screenshot displays the MSL Curiosity Analyst's Notebook interface. The top navigation bar includes links for Home, Mission Summaries, Sol Summaries, Search, Map, Resources, User, and Help. The main content area is divided into several sections:

- Summary:** A search bar with the text "Enter a sol or select from list." and a dropdown menu showing "Sol 34". Below it, there are buttons for "Back 3 sols" and "Next 3 sols", and a "Number of sols to show" dropdown set to 3.
- SOL 34 OVERVIEW:**
 - Time:** A table showing Sol 34, UTC TBD, and Lsub 5 TBD.
 - Location:** A map showing the rover's path on the Martian surface with markers for Sol 29 and Sol 30.
 - Context:** A table listing activities for Sol 34, such as "Arm Teach Point and CHIMRA Dynamics Checkout and Targeted Remote Sensing" (Sol 37) and "Arm Teach Point Checkout, ChemCam Recovery, and Remote Sensing" (Sol 36).
 - Data product summary:** A table showing the sequence of data products for Sol 34, including categories like "cam", "dan", and "mhl".

Fig. 1. Example MSL Analyst's Notebook Sol Summaries web page.