MARS EXPLORATION ROVER IN-SITU GLOBAL OBSERVATION LOCALIZATION DATASET (MERIGOLD). H. Abarca[1] and F. Calef III[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109, hallie.e.gengl@jpl.nasa.gov.

Introduction: MERIGOLD is a newly funded NASA ROSES 2020 PDART (Planetary Data Archive, Restoration, and Tools) task with the goal of mapping all Mars Exploration Rover (MER) instrument science data products into a common basemap. The expected start for the task is summer 2021. The MERIGOLD dataset will be released through the Planetary Data System (PDS) Imaging Node for the planetary science community. During the 14 years of the MER program, the Spirit and Opportunity rovers covered a combined drive distance of 52.89 km and generated over 200,000 unique science data products by the onboard instruments: Miniature Thermal Emission Spectrometer (Mini-TES), Navigation Cameras (NAVCAM), Panoramic Cameras (PANCAM), Front and Rear Hazcams (HAZCAM), and those deployed on the Robotic Arm (IDD) that include the Mössbauer Spectrometer (MB), Alpha X-Ray Spectrometer (APXS), Microscopic Imager (MI), and the Rock Abrasion Tool (RAT).

Dataset: The MERIGOLD dataset will contain a series of tables separated by rover and instrument, each containing 37 fields for each PDS archived data product with global localization, instrument and rover state at the time of acquisition, localization and validation methods, and all necessary information to transform the observation localizations when the rover localizations [1] are updated in the future.

The Mars rover datasets released to the PDS contain metadata on the rover spatial position but are often not in the same coordinate frame, nor are they located relative to a unified basemap. Each instrument observation needs translation from its internal coordinate system to the rover coordinate system [2], then to a global coordinate system (Figure 1).

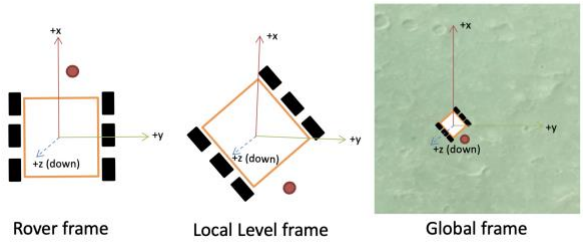

Figure 1. Coordinate frames used by the MER rovers and the Global frame.

While enough information is available in the current raw formatting to translate these coordinates, there are significant challenges for researchers outside those with rover surface operations experience due to internal naming and process conventions, which are not apparent otherwise. For example, XYZ coordinate fields stored in the PDS are frequently in a right-handed coordinate system as opposed to the standard cartographic left-hand rule frames; instruments on masts need a different localization solution compared to those physically attached to the spacecraft body, which is different still from those deployed on a multi-joint arm. This project will address these initial localization, interoperability, and contextual challenges. Specifically, this PDS compliant public release will allow future researchers to identify where any observation took place on a unified Mars projection and coordinate system, what other instruments are coincident with that observation, whether observations overlap from multiple rover positions (Figure 2), help to provide spatial context between distant rover positions, and allow critical ground-to-orbit observations from past, current, and future orbital assets.

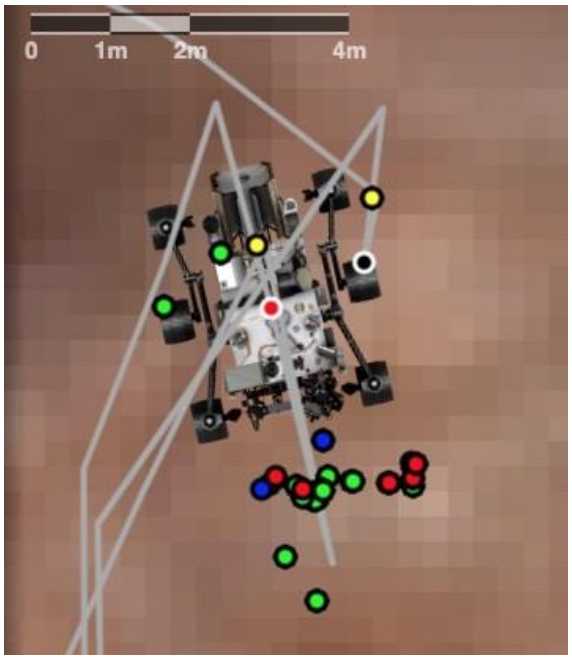

Figure 2. Example MSL science observations localized at Site 41, Drive 1108. Black circles are rover positions with science observations localized by instrument. Blue = Mastcam, green = ChemCam, red = APXS, and yellow = DAN.

Instrument Localization Methods: All MER instrument teams archived data products within the Planetary Data System (PDS) archive along with PDS3/4 labels that describe the complete state of the rover and instruments at the time of the observation. Using rover position and pointing parameters in the data product labels, we will localize the mast, robotic arm, and rover body-mounted instruments with three unique methods (Figure 3). The conversions from rover-centric frames to global frames are made possible by coordinate-transforming to the rover localizations and basemaps, both of which are provided by the MER Analyst Notebook [3].

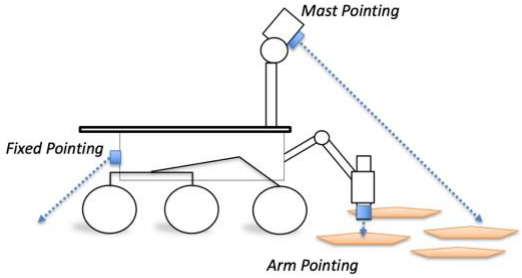

Figure 3. Rover ray intersected localizations for Fixed, Mast, and Arm pointed targets.

Fixed Frame. Fixed Frame instruments are localized by applying a series of transforms to their known fixed location on the rover and applying a chain of coordinate transforms.

Mast Pointed. Mast Pointed instruments contain the rover mast azimuth and elevation pointing information, allowing for spherical to cartesian coordinate transforms that can be ray intersected with a surface to provide a central coordinate of the observation.

Robotic Arm Pointed. The IDD instruments are localized by using the instrument position, pointing, and focus to determine the location of the observations in the rover workspace.

PDS Delivered Data Format: Our primary dataset will be in two PDS compliant forms: comma-separated value (CSV) and geospatial comma-separated value (GeoCSV). CSV is a standard comma-delimited ASCII format readable by any simple text or spreadsheet viewer. GeoCSV provides a similar format, with the added benefit of including mapping coordinates in Well-Known-Text (WKT) format, which is an open-source spatial format known in the mapping community. We will also provide two additional commonly used mapping product formats to the PDS IMG Annex, which provides a location to archive NASA-funded geospatial data products derived from PDS image data: GeoJSON (an ASCII web-enabled format) and Shapefile (used by all major commercial and open-source mapping programs). Overview maps will be delivered as GeoTIFF to the Annex meant as a visual quicklook of the data products (Figure 4, as an example applied to MSL). Standard PDS4 labels will accompany GeoCSV and CSV datasets.

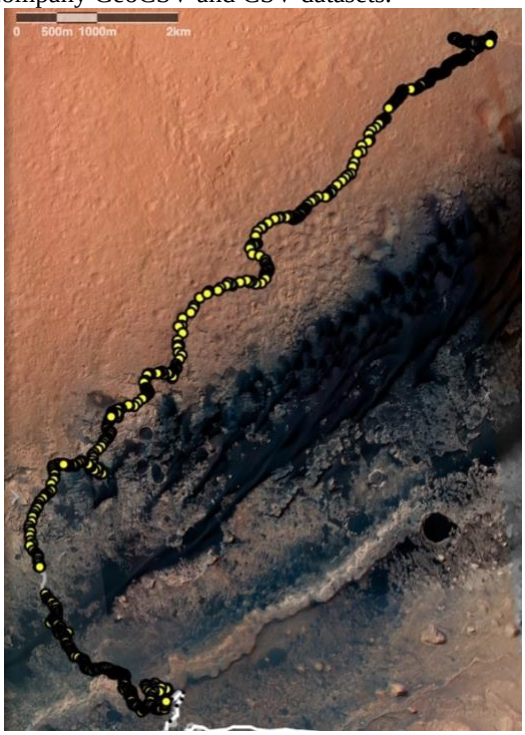

Figure 1. Example of 2,940 unique Mars Science Laboratory's DAN (Dynamic Albedo of Neutrons) Instrument science observations at 822 rover locations throughout 2,333 sols localized to the MSL mission HiRISE basemap.

Acknowledgments: The MERIGOLD dataset archive support will be provided by the PDS Cartography and Imaging Sciences Node [4]. Additionally, we would like to acknowledge the support of the MSL Project and MGSS AMMOS supporting the precursor MSL instrument localization that this task was based upon.

PDS Peer Review: PDS Peer Review will take place in Winter 2022. Please contact us if interested in participating as a peer reviewer.

References: [1] Parker, T. et al. (2003) LPI Contributions, 1719-2534 [2]Maki J. (2003) Mars Exploration Rover Coordinate Systems Relevant to Imaging & Rover Motion Counter. [3] MER Analyst Notebook http://an.rsl.wustl.edu/mer/ [4] Eliason, Eric M., Susan K. LaVoie and Laurence A. Soderblom, The Cartography and Imaging Sciences Node for the Planetary Data System, Planet. Space Sci., Vol. 44, No. 1, pp. 23-32, 1996.