MARS HUMAN EXPLORATION ZONES (MARSGIS) SPATIAL DATA INFRASTRUCTURE. T. M. Hare[1], R. M. Davis[2], R. B. Collom[2], B. H. Day[3], J. R. Hill[4], and E. S. Law[5] [1]U. S. Geological Survey, Astrogeology Science Center, Flagstaff, AZ, thare@usgs.gov, [2]NASA HQ, [3]NASA AMES, [4]Arizona State University, [5]JPL.

Introduction: The MarsGIS initiative is a NASA and community-based initiative currently being developed to support both landing site analysis and eventual human operations on Mars. The MarsGIS working group (WG) will be chartered through the Mars Exploration Program to integrate and manage MarsGIS efforts for NASA in support of the Mars Human Landing Site Study (HLS2). To help understand the MarsGIS initiative, it is useful to map their goals into a Spatial Data Infrastructure (SDI). An SDI is a robust framework for (1) data and data products, (2) metadata and data access mechanisms, (3) standards, (4) policies, and (5) a user community that helps to define and standardize the data and data access necessary to meet the specified goals [1]. Below, as defined by the MarsGIS Working Group (WG), are their initial requirements as mapped into these five overriding SDI goals.

Foundation Data Products: Laura [2] defines, for a Planetary Spatial Data Infrastructure (PSDI), that foundational geospatial data products include: (1) geodetic control networks, (2) topography, and (3) rigorously controlled and orthorectified images tied to a standardized reference frame. Both existing Mars foundational data sets (listed next) and framework data products (e.g. geology, composition, feature catalogs, etc. [2]) will be utilized within the MarsGIS PSDI. The MarsGIS WG also plans to survey the community for additional data sets and accuracy requirements.

Below, we enumerate the existing Mars foundational data sets in order of increasing resolution. Note that all these data sets are tied to Mars Orbiter Laser Altimeter (MOLA) spot observations, which have an absolute horizontal uncertainty of 100 m and 3 m vertical uncertainty. All subsequent data sets will, in the best case, share these absolute accuracies and in the worst case, cumulatively contribute additional uncertainty.

- MOLA topography, near-global coverage, 463 m/pixel, created by NASA Goddard and released from the PDS [3, 4].
- Mars Digital Image Mosaic (MDIM 2.1), global coverage, 231 m/pixel, created by the USGS and released from the PDS Annex [5, 6].
- THEMIS Controlled Day/Night Infrared Mosaics, near-global coverage, 100 m/pixel, created by USGS and released from the PDS Annex [6, 7].
- High Resolution Stereo Camera (HRSC) topography and derived orthorectified images, regional coverage, ~12 m/pixel, created by the HRSC Team and release by the PSA/PDS [8, 9].
- Controlled CTX and HiRISE topography and derived orthorectified images, very sparse coverage, ~6 m/pixel (CTX) and ~25 cm/pixel (HiRISE), created by the University of Arizona and USGS, released from the PDS Annex (CTX) and the PDS (HiRISE) [10].

If additional data sets are defined, the MarsGIS WG will recommend, when possible, that the data will be geospatially controlled to MOLA, the current IAU-recommended control network and reference frame for Mars [11].

Data Access and Metadata: A priority goal for the MarsGIS WG is to design and maintain a strategic investment plan for Mars data and infrastructural services that transcends individual missions. This includes goals for deploying a MarsGIS data catalog/registry for the discovery and access of existing data products and the development of standards and best practices on how to characterize, capture, and present uncertainty and distortion in metadata. These infrastructural services and data catalogs will help to separate the data storage and access from the tools that will consume it (Figure 1).

In addition to supporting infrastructural services, the MarsGIS WG will support well-documented guidelines and best practices for community-available processing workflows (on-line services and tools). Lastly, the MarsGIS WG will also research and determine processes to geospatially link features (e.g. Gale crater, Valles Marineris, mountains, etc.) to relevant published research to improve ease of access and searchability.

Standards: The MarsGIS WG has stated several goals related to supporting standards. This includes the metadata and data access standards mentioned above as well as the following:

- The promotion of common data formats for interoperability between different applications and facilities.
- The establishment of cartographic standards (e.g. symbologies) for engineering elements required for Exploration Zones using existing cartographic standard when possible (e.g. from the Federal Geographic Data Consortium [FGDC]),
- Defining standards and best practices for distributing, visualizing, and archiving temporal datasets (e.g. 3D + time).

Policies: The MarsGIS WG established responsibilities and policies within the working group's charter as summarized next.

- The MarsGIS WG will be chartered through the Mars Exploration Program to integrate and manage MarsGIS efforts for NASA.
- The MarsGIS WG will maintain and coordinate, with appropriate NASA management, a set of MarsGIS goals and recommend, where appropriate, potentially funded tasks.
- The MarsGIS WG shall operate by consensus management. Decisions and recommendations will be communicated to the Mars Exploration Program.

User Community: The MarsGIS WG has prioritized fostering a community of practice to support MarsGIS coordination, technical task execution, and sharing of knowledge and capabilities. This includes providing guidance to self-moderated citizen science initiatives and public outreach efforts to aid them in processing data and publishing their GIS-ready data sets in standardized formats.

Conclusions: The MarsGIS WG, in concert with a small representative group of the planetary community (e.g. mission planners and engineers, scientists, data providers, outreach specialists, etc.), have developed initial goals to support landing site analysis and eventual human operations on Mars. As described above, it is useful to map these goals into a SDI to highlight which areas might need to be further addressed. As defined in an SDI, one of the next steps for the MarsGIS WG will be to perform a knowledge inventory to help identify strategic gaps in foundational data products, the current state of data interoperability in off-the-shelf geospatial tools, and available access mechanisms, as well as to engage the user community.

References: [1] Rajabifard, 2003, Developing Spatial Data Infrastructures: From Concept to Reality, ISBN 0-415-30265-X, Taylor & Francis, U.K. 313pp. [2] Laura, et al., 2017, Towards a Planetary Spatial Data Infrastructure, IJGI doi:10.3390/ijgi6060181. [3] Smith, D.E., et al., 2010, Space Sci. Rev. 2010, 150, 209–241 [4] Planetary Data System, URL: https://pds.nasa.gov. [5] Archinal, B.A., et al., 2002, LPSC XXXIII, abs. #1632. [6] Hare, T.M., et al., 2015, 2nd Planetary Data Workshop, abs. #7060. [7] Fergason, R. L., et. al., 2013, LPSC XLIV, abs. #1642 [8] Jaumann, R., et al., 2007, Planet. Space Sci., 55 (7–8), pp. 928-952. [9] Planetary Science Archive, URL: https://archives.esac.esa.int/psa/. [10] Fergason, R.L., et al., 2016, Space Sci. Rev., 1572-9672, doi:10.1007/s11214-016-0292-x. [11] Archinal, B. A., et al., 2011, Celestial Mechanics and Dynamical Astronomy, 109(2):101–135.

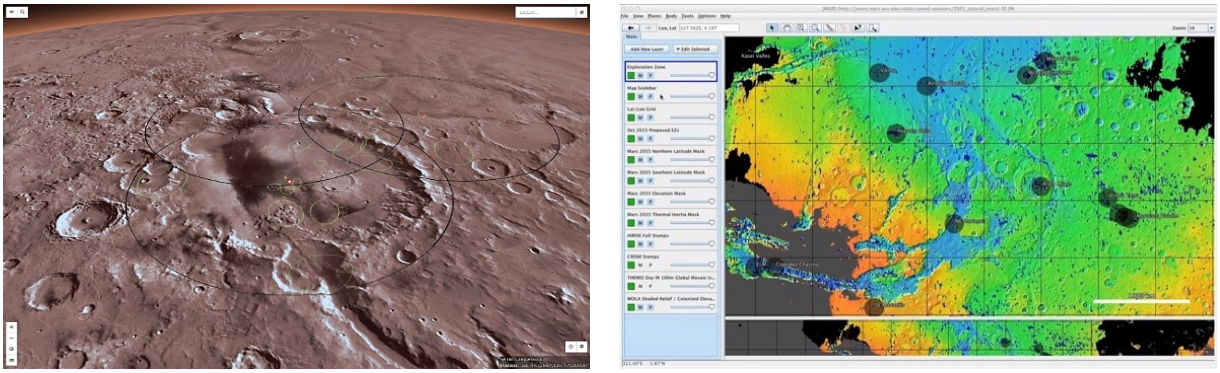

Figure 1. Showing JPL's MarsTrek (left) and ASU's JMARS (right) as initial consumers and GIS interfaces for the MarsGIS planetary spatial data infrastructure (PSDI) services. Both applications showing foundational data sets, the MDIM 2.1 mosaic (left) and MOLA topography (right), and a few proposed human landing sites (shown as black circles). URLs: MarsTrek - https://marstrek.jpl.nasa.gov, JMARS - https://jmars.asu.edu/.