NASA AMMOS Multi-Mission Geographic Information System (MMGIS) version 2.0: Updates and Mission Operations.

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Introduction: The Multi-Mission Geographic Information System (MMGIS) is a free and open source geospatial (FOSS4G) web application developed by the NASA Advanced Multi-Mission Operations System (AMMOS) to provide part of a spatial data infrastructure to support planetary mission operations [1]. This software has been deployed on four Mars surface missions, and one Earth-based geophysical monitoring network. We've performed a code refactor with modern coding standards and support for cloud based deployments. Additional improvements in the drawing system and support for cloud deployment were added for the Mars2020 Perseverance rover mission where it is being used to support tactical and strategic operations. Additional enhancements are in development to support real-time operations on the Moon.

Code Refactor: Our initial MMGIS release, version 1.1.1, was Javascript based for deployment in a single server configuration with an Apache webserver with a drawing system built around reading/editing/writing directly to GeoJSON [2] vector files. Dynamic modules and dependencies used Require.js for managing different aspects of the application. We've now refactored the code using ECMAScript (ES6) and webpack allowing easier integration with React components and other modern frameworks, and production builds. The application is deployed fully within Node.js, though users may choose to put NGINX or other web servers in front of MMGIS to act as a proxy. Additional modifications were made to allow single sign on (SSO), Docker installation, and general support for the Amazon cloud infrastructure (AWS), and accessing data in S3, EBS, and EFS. Currently, our 3D Globe viewer is being further reworked into a standalone application (Lithosphere) that will be integrated back into MMGIS with enhanced support for GLTF models and 3D Tile support via [3].

New and Improved Tools: The Mars2020 Mission requested significant enhancements to our drawing system to support pre-landing mapping efforts and strategic planning tools.

Geologic Mapping: To support the Mars2020 science team's desire to conduct photogeologic mapping in Jezero Crater around the landing site and primary mission support area at 1:5000 scale [4] on a HiRISE orthophoto mosaic [5], we expanded the multiuser editing support to include polygon clipping, splitting, editing, symbolization, and sharing among users inside CAMP [6] (Figure 1), an implementation of MMGIS for the rover mission. The same system was implemented within the European Space Agency (ESA) COSMOS mission support infrastructure to allow similar quad scale photogeologic mapping in the Oxia Planum landing site for the ExoMars Rosalyn Franklin rover [7]

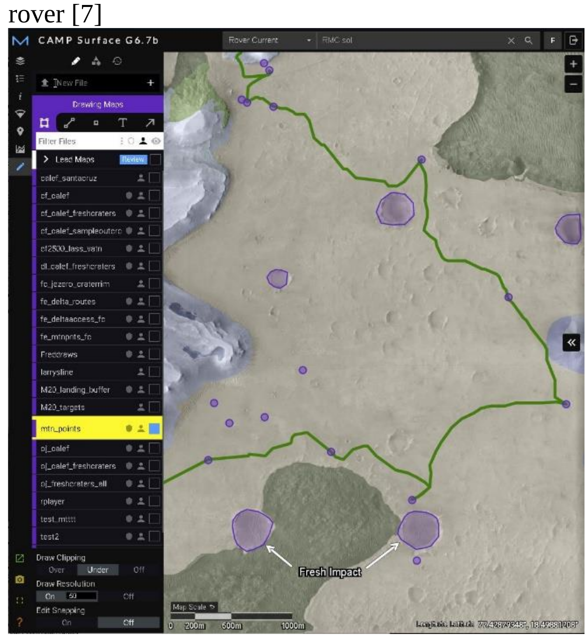

Figure 1: Enhanced drawing tool within MMGIS, CAMP version, for Mars2020 rover mission.

Measure Tool Enhancements: Our initial Measure Tool performed simple straight-line distances, angles, and generated an elevation profile. To support broad-scale mapping for missions at high latitudes, we've implemented the Haversine formula and can now show the true great-circle line at high latitudes over large distances.

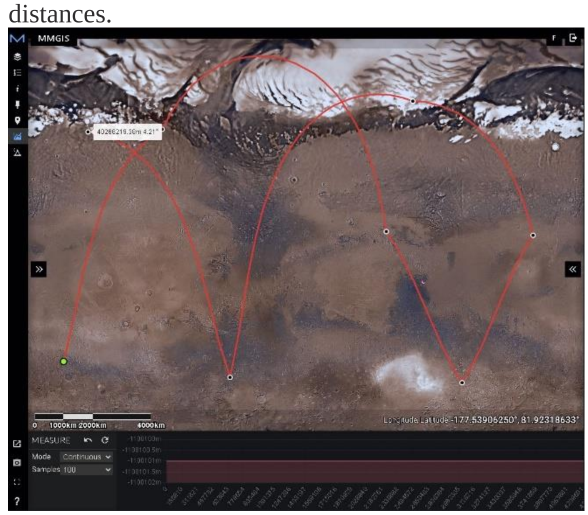

Figure 2: Great-Circle measurements across Mars .

Viewshed Generation: A new tool for viewshed creation (i.e. "what can I see from this location?") was developed for MMGIS to support Mars2020 strategic mission planning (see Soliman and Calef, this conference)(Figure 3). The science team also adopted this tool to understand what features are visible within mosaics taken by the rover's Mastcam-Z and SuperCAM Remote Microscopic Imager (RMI). This new tool repurposes MMGIS elevation datasets (DEM tiles) and implements algorithms from [8] in a similar way as [9], but in client-side in Javascript.

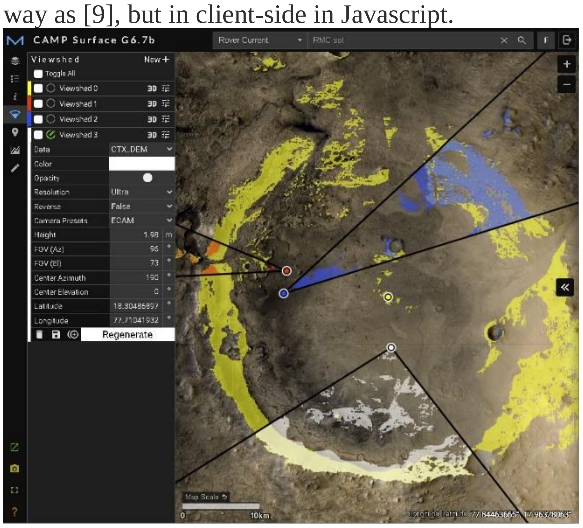

Figure 3: Several viewshed within Jezero Crater with different parameters.

Time-series Datasets: The NASA MEaSUREs project, a joint collaboration between the NASA Jet Propulsion Laboratory (NASA-JPL) and the Scripps Instution of Oceanography (SIO), implemented MMGIS as MGViz [10] to support viewing Earth Science Data Records (ESDRs) of geodetic plate motion. Millimeter scale motion can be viewed interactively from one or many GPS stations in graphs showing northing, easting, and vertical offsets from unique sources, types, and trends. Site information can be viewed to learn of sensor status and raw data records downloaded (Figure 4). Another custom tool was made for showing vector arrows of plate motion, both horizontal and vertical.

WMS Support: Beyond the TMS and WMTS tile formats, we've added support for WMS layers, with various options, including support for Lunaserv [11].

Projection Support: We're currently in the process of making MMGIS improvements to support the Lunar VIPER mission [12]. The current MMGIS v2.3 can be set up to read IAU2000 projections in Lunaserv or other servers (e.g. MapServer), including lunar north and south polar projections, including those with custom parameters (e.g. different projection center). We also provide a script, gdal2customtiles.py for building out TMS datasets separate from a dedicated map server.

Conclusion: Our code refactor and new tools for MMGIS v2.3 build on our initial work which now supports four Mars missions and one Earth project. The enhanced drawing tools and viewshed generation increase the ability for science and engineering team members to have relevant situational awareness for tactical and strategic decision making. The increased projection support expands the software's applicability for polar and other non-equatorial centred missions.

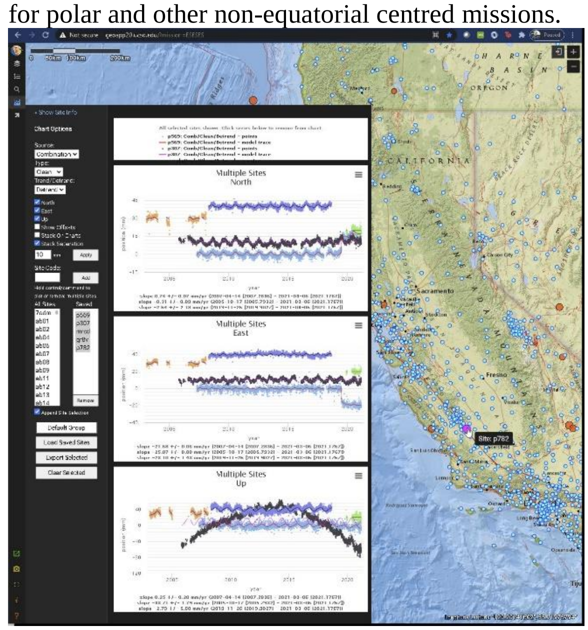

Figure 4: Several GPS timeseries from the MGViz application, built on MMGIS.

Future Improvements: New improvements will include more support for real-time missions like Lunar VIPER and human missions with requirements such as dynamic and time aware layers and user interface improvements.

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Software:Download and support for MMGIS v2.3: https://github.com/NASA-AMMOS/ MMGIS/.

References: [1] Calef et al., 2019, AGU, abs#IN11B-06 [2] Internet Engineering Task Force RFC 7946, https://tools.ietf.org/html/rfc7946. [3] https://github.com/NASA-AMMOS/3DTilesRendererJS. [4] Stack et al., 2020, https://doi.org/10.1007/s11214-020-00739-x [5] Fergason et al., 2020, LPSC 51, abs#2020. [6] Williams et al., 2020, LPSC 51, abs# 2254. [7] E. Sefton-Nash et al., 2020, LPSC 51, abs#2417 [8] Wang et al., 2000, PS&RS, p81 [9] gdal_viewshed, https://gdal.org/programs/gdal_viewshed.html [10] MGViz application, http://mgviz.ucsd.edu/.[11] Estes et al., 2017, LPSC48, abs#1614 [12] Lunar VIPER, https://www.nasa.gov/viper