APPLICATIONS OF GIS AND DATABASE MANAGEMENT IN THE 2016 CANMARS ANALOGUE MISSION.
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Introduction: The 2016 CanMars Analogue Mission was a Mars Sample Return (MSR) Analogue Mission carried out in partnership between the Canadian Space Agency and the Centre for Planetary Science and Exploration (CPSX) at the University of Western Ontario, as part of the NSERC CREATE project "Technologies and Techniques for Earth and Space Exploration" (create.uwo.ca) [1].

As with the previous mission in 2015 [2], the 2016 CanMars Analogue Mission Science Team used multiple orbital datasets processed to resemble those that would be available from Mars orbiter instruments. The team also received abundant imagery, rock analysis, and spatial data from the rover on each day ("sol") of mission operations. Because this is the second year in at the same field site, most regional scale satellite imagery and geographic information systems (GIS) tools were already in place. This allowed the GIS & Mapping team to explore new, innovative methods of representing spatial data, manage databases to assist the rest of the science team. By working with a Planning Team member, the GIS & Mapping team could quickly obtain rover coordinates and manage spatial information.

Datasets: Remote sensing datasets of the analogue site area were used prior to and during the mission. These datasets were pre-processed to closely simulate similar imagery available from Mars orbital instruments. Data included a HiRISE equivalent full colour QuickBird satellite image (60 cm/pixel), a CTX equivalent DTM (5-20 m/pixel), and greyscale image (6 m/pixel), CRISM and THEMIS equivalent spectral data from Landsat-8 visible to thermal infrared images (15-90 m/pixel), ASTER Thermal Infrared (90 m/scale), as well as THEMIS equivalent full colour image (100 m/pixel), DTM (110 m/pixel), and ASTER-derived apparent thermal inertia (ATI) image (90 m/pixel)

2D Geospatial Mapping: Most 2D mapping used the HiRISE-equivalent QuickBird satellite image. Interpretations for elevation (contours, comparing relative elevations) used a 5 metre vertical resolution CTX-equivalent DTM. Unlike the previous year of CanMars, coordinates of the rover were made available to the planning team in the Apogy software: a program that provides 3D models of the field site, and defines engineering constraints for rover actions [3]. The GIS group worked in conjunction with the data management member of the Planning team to determine rover positions at each waypoint during the daily traverse (Table 1). Having direct elevation measurements from the rover enabled ground-truthing for the 5m DTM measurements.

The GIS team recorded locations of any science experiments performed at outcrops between waypoints. These coordinates were recorded in Microsoft Excel databases, which were then imported to point shapefiles in ArcGIS. This allowed the Science Team to have a visual representation of the rover position, previously visited sites, and features of interest (FOIs) (Fig 1).

In addition to producing 2D GIS products, the GIS & Mapping team created two 3D digital terrain models based on the 5m DEM provided (see Morse et al. [4]).

Dataset Limitations: Mapping heavily depended on the QuickBird image, and the 5 m DTM. Although the vertical resolution was sufficient for comparing relative heights of peaks, smaller obstacles (<5 m) were overlooked at the DTM resolution. Caution was advised when using the DTM for stratigraphic interpretations, as most of the beds and FOIs were too thin to resolve accurately. Accurate elevation measurements came from the rover's position, rover LiDAR, or the Apogy software [3]. The QuickBird 60 cm/pixel resolution was sufficient for mapping and correlating m-scale bedforms across different peaks, especially when exploring 3D visualization [4]. However, many FOIs are either not resolvable, or difficult to see in the QuickBird image (typically those <2 m). On multiple occasions the Science Team could not find a target FOI in the QuickBird image, and needed precise coordinates from Apogy.

Regional datasets with lower spatial resolution were useful for preliminary surveys of the study site, but were not consulted during daily operations. Prior to the 2015 mission, the Landsat-8 and ASTER spectral data were used to interpret possible presence of gypsum, silica-rich material, carbonates, and phyllosilicate minerals in the region [5]. These interpretations provide regional context as to the types of minerals we might have expected to see in our science measurements, but the resolution of the images are too coarse to constrain the mineralogy at any given waypoint. Similarly, new this year we had an ASTER-derived ATI image. ATI is useful for differentiating amongst areas dominated by boulders, and soils, which highlighted inverted channels at a regional scale. However, at 90 m/pixel, our study area only contains 40 full pixels, which is insufficient for differentiating surficial materials between waypoints.

Fast-Motion Field Test: The 2016 traverse map (Fig. 1) reveals trends in planned rover movements. From sols 0-21, the rover followed a mostly linear path. In contrast, multiple waypoints were revisited during the fast-motion field test, when three sols were planned per uplink cycle. This is visible in the “circling” on the traverse path (Fig. 1). The rover moved while data were being processed, and could return to previous sites each uplink cycle. The most frequently visited waypoint, Haling, was visited each fast-motion field test uplink cycle, with five visits on Sols 22, 27, 30, 33, and 37.

Database Management: Coordinates were stored in a selection of Excel workbooks. The main database used for mapping has columns for sol, waypoint ID, and science experiments performed at each site. Specialized databases compiled types of data. The panorama and zoom/RMI image databases were most frequently used, particularly by the MastCam team who needed to keep track of at which waypoints these images were acquired. These spreadsheets contained rover coordinates, sols and waypoint IDs for each image taken by the rover. Links to the associated images were provided in adjacent columns. These specialized image databases were used to export coordinates as a point shapefile into ArcGIS. Within ArcGIS, the hyperlink feature can be enabled and set so the user can click on a rover point to open the associated image in an internet browser. Keeping an up-to-date geodatabase became vital during the fast motion field test when three sols of data were downlinked at the end of each day. Having the data organized by type (e.g. all waypoints for traverse, all zoom images together) substantially saves time when any science team member needs to recount at which rock or waypoint an image was taken or an experiment performed.

References: [1] Osinski G.R. et al. (2017) LPS XLVIII, this conference [2] Osinski G.R. et al. (2016) LPS XLVII [3] Sapers H.M. et al. (2016) LPS XLVII, [4] Morse Z.R. et al. (2017) LPS XLVIII, this conference [5] Pontefract A. et al. (2016) LPS XLVII

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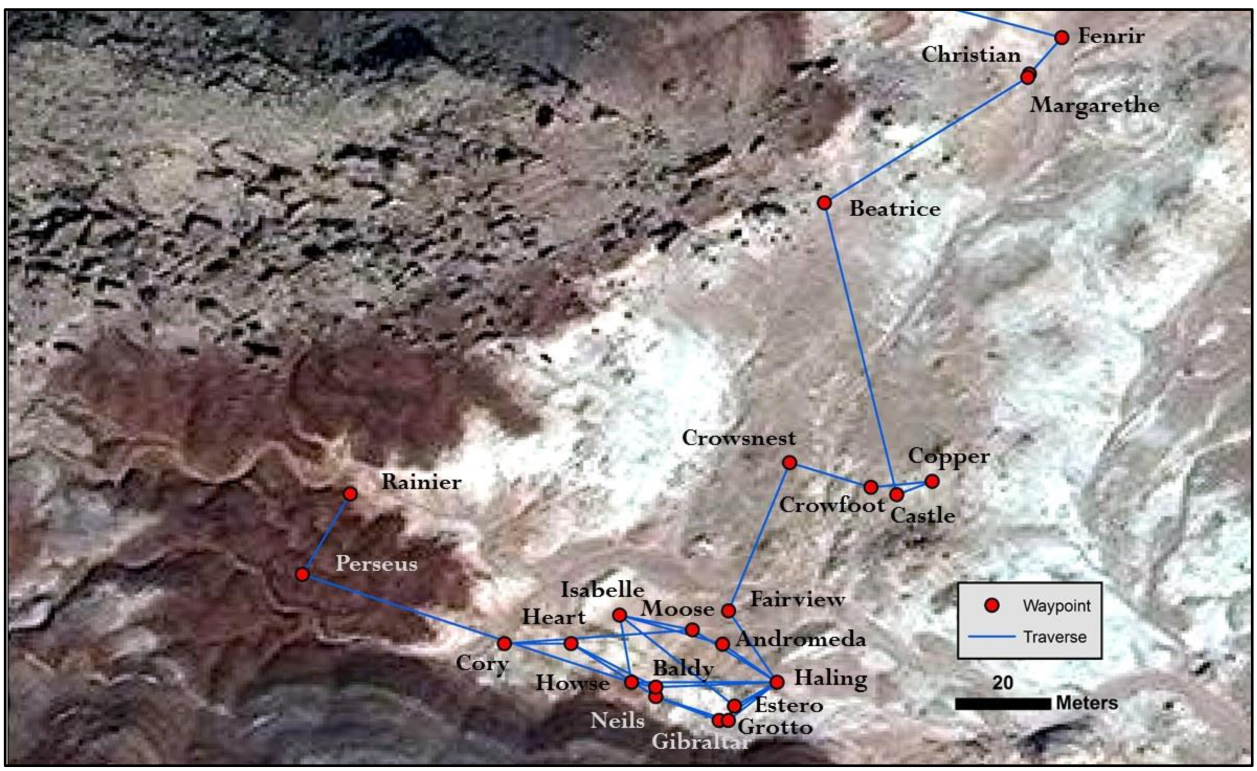

Fig. 1 Area covered by the CanMars 2016 rover traverse, Utah (-110.78, 38.42). Traverse began sol 12 at waypoint Fenrir, and ended on Sol 39 at waypoint Rainier. In ArcGIS, user may click on any waypoint to see the sol science experiments performed by the rover at that waypoint.