UK SPACE AGENCY "MARS UTAH ROVER FIELD INVESTIGATION 2016" (MURFI 2016): PRELIMINARY LANDING SITE ANALYSIS. P.M. Grindrod[1] P. Fawdon[1], J.M. Davis[2] J.C. Bridges[3] S. Gupta[4] M.R. Balme[5], and the MURFI Science Team[6]. [1]Birkbeck, University of London, [2]University College London [3]University of Leicester, [4]Imperial College London, [5]The Open University, [6](see LPSC2017 Abstract #1837).

The 2016 Mars Utah Rover Field Investigation (MURFI 2016) [1] was a rover deployment and commanding field test intended to demonstrate the capacity of the UK Space Agency (UKSA), in collaboration with international partners, to deploy a rover analogue mission and carry out a geologically-focused field investigation. A key part of the mission was that the Mission Operations Centre team could only use Mars-like data and remained "in-simulation" throughout the mission.

Here, we report on the "in-sim" parts of the mission conducted before landed operations: the preliminary assessment of the "landing ellipse" from orbital data and setting up working hypotheses as a starting framework to meet the science goals of the mission [2].

Preliminary Landing Site Assessment. The protocol constraints and science objectives of the mission simulation were based on the constraints of the ExoMars landing site selection [3]. To do this we processed a range of terrestrial data sets to create Mars-equivalent data sets (Table 1). No additional knowledge (e.g. higher resolution aerial photographs) of the mission landing site were allowed. Similar to the ongoing assessment of ExoMars landing sites, we used these data to (1) create a reconnaissance photo geological map, (2) assess slope and other traversability hazards and (3) identify potential science targets from our Current Working Hypotheses (CWH).

Table 1: *Mars like data sets. Resolution in m/px in parentheses.*

Mars dataset	Earth data	'Mars like'
HiRISE, *RED, RGB (0.25)*	World View 2, RGB *(0.39)*	RED (0.39) RGB (0.39)
HiRISE DTM *(1)*	NAIP DTM (5) [4]	DTM (5)
CTX, *Panchromatic (6)*	NAIP RGB (1)	Panchromatic (6)
CTX DTM *(~20)*	NAIP DTM (5) [4]	DTM (20)
HRSC, Panchromatic *(12.5), RGB (50)*	LANDSAT 8 *bands 4; Red 3; Green, 2; Blue, (30) and 8; Panchromatic (15)*	RGB (15)
THEMIS IR day *(12.17 µm – 12.98 µm; 100)*	LANDSAT 8 *band 11 (11.5µm – 12.51um, 30)*	11.5µm-12.5um (100)
CRISM *(400 nm – 4000 nm; 16)*	HYPERION *(250 nm – 2500 nm; 30)*	½ spectral range & spatial resolution

Note: NAIP = National Agriculture Imagery Program

Photo-geological mapping. The photo-geological map, covering an area of 2 x 1.75 km and digitized at 1: 1,000 scale, was produced in 3 days (Figure 1). We used a RED HiRISE-equivalent base layer, with RGB only in the central portion. CTX, HRSC, and THEMIS equivalents were used for regional context. The stratigraphy was divided into four formations: upper and lower layered formations, a resistant formation and a dark formation.

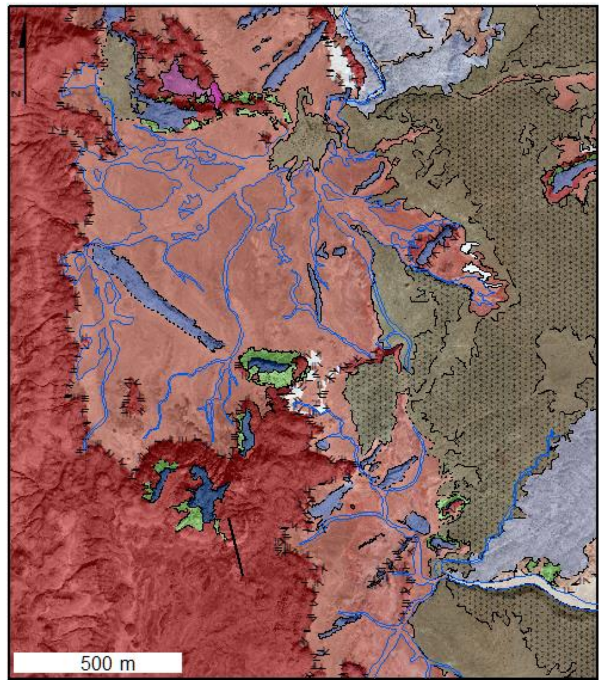

Figure 1: *Subset of the photogeological map of the landing site region. Reds = upper and lower layered scarp and plains formations, Blues = resistant formation, Browns = dark formation, Green = out of situ boulders, blue lines = modern alluvial areas.*

Observations and Stratigraphy. The stratigraphy (Figure 2) was divided into four formations and ten units, the most important of which are described here:

(1) Units in the layered formation (red units) crop out as multi colored layered scarps (Uls/Lls) and plains (Ulp/Llp)

(2) Within the resistant formation, the resistant plateau (Rp) formed contiguous outcrops on top of regional scarps. The interbedded resistant unit (Ri) was spatially discontinuous and found on ridges, interbedded with the layered formation units.

(3) The anomalously bright unit (Ab) was interbedded with Lp/Ls, and associated with Ri stratigraphic levels.
(4) Blocky rubble (Br) of meter-scale angular blocks was found at the base of scarps, mesas, and ridges

The resistant formation. Consisting of several different units, characterized by forming ridge outcrops or as flat caps to mesas, suggesting more resistance to erosion compared to the layered formation. The resistant units form spatially discontinuous outcrops occurring intermittently within what appears to be an otherwise conformable stratigraphy. The units are smooth, often with a rectilinear fracture pattern and erode out into blocky rubble which collects at the base of scarps.

The layered formation. Forming the majority of the study area and cropping out as both scarps and in plains. The layered formation is likely made up of multiple units, alternating between bright white to dark red material. These color layers are 1-10 m thick and gently dip to the west. When exposed in a scarp, the color layers within the stratigraphy express differential erosion suggesting differences in lithology correlating with color.

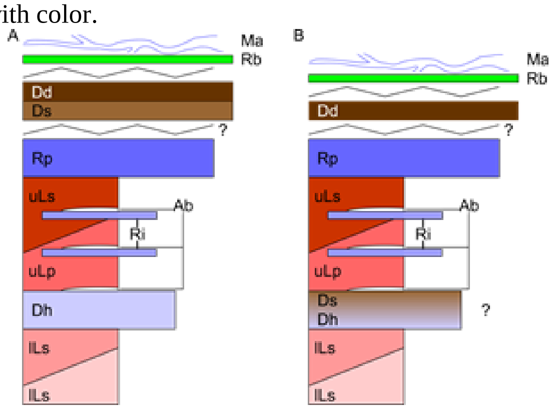

Figure 2: *Two initial stratigraphic models of the "landing site" based on the preliminary mapping. It was not clear if both dark units occurred after an unconformity (A) or (B) the lower dark area was conformable with the layered units.*

Science targets. Four different categories of science target were identified from the photo-geological mapping:
(1) Resistant outcrops: identified to test the CWH that the resistant interbedded unit is an inverted channel and generally explore their sedimentology.
(2) Edges of layered scarps: strata had geochemistry varying between darker (red/Fe^{3+}) and brighter (white/less Fe^{3+}). This might reflect changes in environment or depositional style.
(3) Anomalously bright regions associated with resistant materials but within the layered formation: might represent diverse paleo-environments.
(4) Resistant float rocks: provide opportunities to investigate the sedimentology of outcrops that are otherwise inaccessible.

Hazards assessment. Three categories of hazard were identified. These placed constraints on traverse routes and access to targets.
(1) Slopes: we identified areas of steeper ground where it is either not possible to drive the Rover, or where it was likely to encounter impassable breaks in slope below the 5 m resolution of the DTM (Table 1; Figure 3).
(2) Modern alluvial channels (Figures 1, 3): Found across the layered plains unit [2], these presented a loose sediment "trap" hazard and possible 10 – 50 cm "steps" at channel margins.
(3) Individual boulders: fields of boulders and (rarely) bushes both posed navigational hazards.

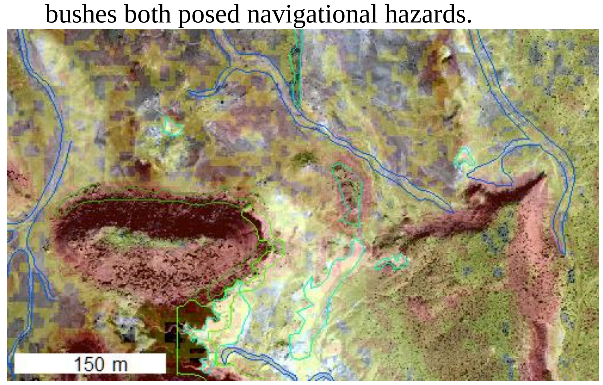

Figure 3: *A portion of the remote sensing hazard map and target map of the 'landing site'. Science targets are outlined in greens, modern alluvial hazards are outlined in blue. Slopes 2° - 5° are colored yellow, slopes of 5°-10° are orange, and slopes >10°are red.*

Conclusions. We developed the following current working Hypotheses (CWH) to be tested by the in-situ operations detailed in [2].
(1) Resistant outcrops represent a lithified sediment unit of either aeolian, volcanoclastic or fluvial origin. Accessible for study in fall rocks.
(2) The layered scarps represent a geochemically variable strata of a material weaker than the resistant outcrops; possibly mudstones, clays or marls.
(3) The anomalously bright regions (white/less Fe^{3+}) are some end members in the layered formation.

References: [1] M.R. Balme et al., *(2017), LPSC 48,* #1837. [2] L.J. Preston et al., *(2017) this conf.* [3] Vago et al., *Astrobiology (in press),* [4] https://gis.utah.gov/data/elevation-terrain-data/5-meter-auto-correlated-elevation-models/.