DIGITIZATION AND REANALYSIS OF APOLLO SURFACE TRAVERSES. N. E. Petro[1], J. E. Bleacher[1], L. R. Gaddis[2], W. B. Garry[3,4], S. C. Mest[1,4], A. F. Abercromby[5], M. L. Gernhardt,[5] [1]NASA\GSFC, Code 698, Greenbelt, MD, 20771, [2]USGS Astrogeology, Flagstaff, AZ, [3]CEPS Smithsonian Institution, Washington, DC, [4]Planetary Science Institute, Tucson, AZ, [5]NASA\JSC, Houston, TX. [email: Noah.E.Petro@nasa.gov]

Introduction: The Apollo lunar surface activities are among the best-documented events in human history. The results of the Apollo astronauts' work on the lunar surface, especially the samples and *in situ* measurements they collected, have shaped our understanding of the geologic history of the Moon, and the earliest history and evolution of the inner Solar System. However, one problem that exists for using these data to understand and plan for future human exploration is that the data related to what the astronauts did on the lunar surface exist in multiple, non-linked formats and locations that make accessing, integrating, and analyzing the information cumbersome.

As part of a LASER-funded proposal, we have begun the process of digitizing in ArcGIS and georeferencing data from astronaut traverses and spatially associating them to available, coregistered remote sensing data. Digitizing and georeferencing Apollo surface traverse information with existing remote sensing data not only archives and centralizes EVA data and documentation, it also enables us to expand our understanding of their spatial and compositional context. In light of NASA's ongoing terrestrial field testing and planning for future *in situ* lunar exploration, the georeferenced traverse and ancillary data are timely in that they enable us to examine the Apollo traverses using modern metrics, which in turn provides context for how we will assess ongoing field technology tests.

Digitization and Georeferencing: In order to digitize Apollo traverse data (Figs. 1 and 2), appropriate base images and maps must first be imported into ArcGIS, then map-projected and rectified. In part because they have the highest available spatial resolution (~0.5 to 1.5 m/pixel), we will incorporate the publicly released narrow-angle camera (NAC) images of the Apollo landing sites from the Lunar Reconnaissance Orbiter Camera (LROC) as base images.

Using the georeferenced NAC image bases in ArcGIS, the Apollo traverses are 'sketched' by adding digital polylines and points. Each leg of each EVA will have its own line, so that detailed attribute data (start and stop times, duration, total distance) for major events can be directly tied to each segment of a traverse. Detailed chronologies for each Apollo mission are available in the *Apollo Lunar Surface Journal* [1] as well as *Apollo By The Numbers* [2]; we will select from those resources the times and locations that represent major EVA events. The length of each EVA segment, and of the EVA as a whole, will be automatically calculated within ArcGIS. When all legs of a traverse are complete, a single, all-encompassing EVA 'polyline' will be created from the smaller segments. This single EVA polyline for each landing site will then have a combination of all attributes associated with it.

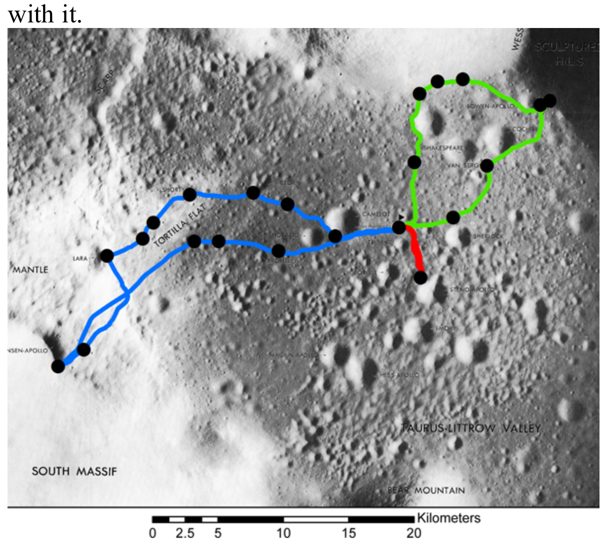

Figure 1. Example of the digitized version of the Apollo 17 traverses with each EVA and station/stop marked. Base image here is the Apollo 17 traverse map. EVA 1 is in red, EVA 2 in blue, and EVA 3 is in Green. Each station and LRV stop (black dots) will have attribute information (duration, arrival and departure times, etc.) associated with it, as will individual samples from each station and stop.

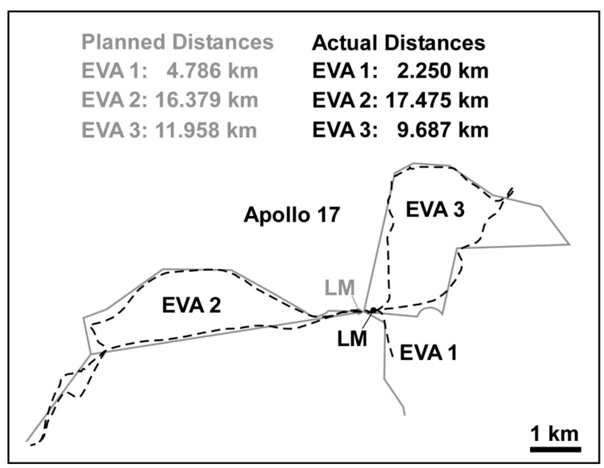

Figure 2. Comparison between planned and actual Apollo 17 EVA's [3] after digitization. Distance statistics are calculated within ArcGIS. Ultimately, finer resolution details of EVA activities at each station will be integrated (see Fig. 3).

Each station and LRV stop has points associated with samples and documentary images (Fig. 2). Digital images and compositional data for each sample at the Apollo sites are available at *The Lunar Sample*

Compendium [4] and the *Apollo Analyst's Notebook* [5] and these are 'hot-linked' directly from the ArcGIS project for direct association and attribution, as well as straightforward retrieval. We will also hotlink documentary images for each site, including surface panoramas, Apollo orbital metric and panoramic photographs, and written and audio voice transcripts.

Video clips such as those from the *Apollo Surface Journal* will also be linked via ArcGIS. All of these sources are highly stable web sites; hotlinks are expected to be equally durable for the GIS project. In addition to links to the rich amount of data associated with each Apollo station and stop, we will associate basic 'attribute' data for each station and for samples collected at all stops. An example of attribute data that would be associated with sample 71131 is given in Table 1. Links to publicly available lunar telescopic spectral data for the landing sites as well as laboratory (e.g., RELAB) spectra will also be included when relevant.

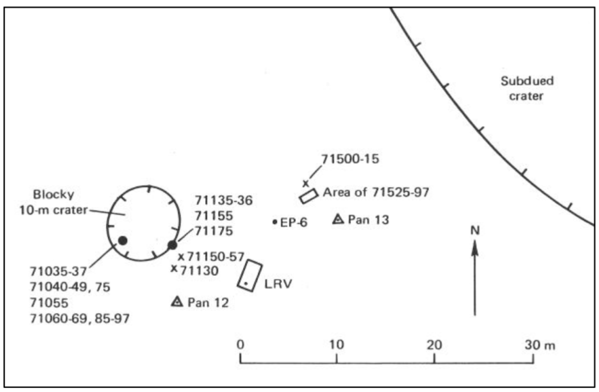

Figure 3. Detailed site map of Apollo 17 Station 1 (from [3]) showing the locations where individual samples and image panoramas were taken. Each sample location is given its own point in ArcGIS and the associated attribute table will contain the sample number and compositional information table (Table 1).

Analyses Enabled by Digitized Apollo Traverses: The digitization of Apollo surface traverses not only provides a single digital record of surface operations, but also serves as a source of comparison for terrestrial analog efforts. The Exploration Analogs and Mission project was initiated by the Directorate Integration Office and Lunar Surface Systems project in March 2009 with two objectives. First, to ensure a rigorous approach and the use of consistent operational products, tools, methods and metrics across all NASA analog activities to enable iterative development, testing, analysis, and validation of evolving lunar operations concepts. Second, to provide input into detailed EVA and surface operations analysis, development of assembly, maintenance and science tasks for selected lunar architecture scenarios.

Table 1. Example attribute data for Sample 71131, Apollo 17 Station 1.

Sample	71131
Notes	100 mg subsample from <1-mm size fraction from 71130 [6].
Mass	100 mg
Original Mass	144.03 g
Dimensions	N/A
Sample Description	Unconsolidated Soil (subsample from 71130)
References	[3, 6, 7]
Notes	Collected near samples 71135-36
Compositional Information *example*	from [6]
FeO%	17.9
Th (µg/g)	0.80
TiO_2%	10.0
MgO%	9.58
CaO%	10.8
Links	http://www.lpi.usra.edu/lunar/samples/atlas/detail/?mission=Apollo%2017&sample=71130
RELAB spectra	N/A

In recognition of the importance of optimizing surface systems and operational concepts for science and exploration, many recent NASA analog activities have attempted to compare different hardware and operational scenarios with respect to their ability to maximize the productivity of available science exploration time on the lunar surface. However, quantification of hardware and operational performance and productivity is necessary for these relatively costly and infrequent analog activities to yield anything more than qualitative and anecdotal findings. Absolute quantification of scientific productivity is neither possible nor necessary in meeting these objectives; however, careful, consistent, prospective definition of science objectives, priorities and success criteria enables relative comparison of scientific productivity in quantitative terms.

Availability: All GIS derived products created will be made available via the PIGWAD/Astropedia and PDS PILOT sites hosted by the USGS.

References: [1] Apollo Lunar Surface Journal, (http://history.nasa.gov/alsj/frame.html). [2] Orloff, R. W., (2004) *Apollo By The Numbers: A Statistical Reference*, 348 p. [3] Wolfe, E. W., et al., (1981) *The Geologic investigation of the Taurus-Littrow valley, Apollo 17 landing site*, [4] Lunar Sample Compendium, (http://curator.jsc.nasa.gov/lunar/compendium.cfm). [5] Apollo Analyst's Notebook, (http://an.rsl.wustl.edu/apollo/). [6] Korotev, R. L. and D. T. Kremser, (1992), *PLPSC*,Abst. #275-301. [7] Jolliff, B. L., (1999) *JGR*, 104, 14123-14148.