APOLLO 11: WHERE THEY WERE WHEN – A NEW SPATIOTEMPORAL EVA MAP. N.R. Gonzales, M.R. Henriksen, R.V. Wagner, M.S. Robinson, School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287 (ngonzales@ser.asu.edu).

Introduction: Accurate temporal and geolocation knowledge of sample collection sites, photo acquisition locations, hardware, and landforms are critical to unraveling the geologic history of the Apollo landing sites, as well as future lunar surface activities. We used Apollo data and subsequent studies [**1-10**] to spatiotemporally locate sample sites, camera stations, and astronaut geologic commentary.

Background: *Extravehicular Activity (EVA) Timeline.* The tasks of the Apollo 11 crew, Neil Armstrong and Edwin Aldrin, EVA included acquisition of stereoscopic images (Apollo Lunar Surface Closeup Camera; ALSCC), synoptic photography, collecting samples, and deploying instruments – including the Passive Seismic Experiment Package (PSEP) and the Laser Ranging Retroreflector (LRRR). Armstrong investigated and photographed Little West crater (**Fig. 1**). The TV and 16-mm sequence cameras captured most of the astronaut EVA activities (camera locations in **Fig. 1**).

Referenced Studies. Prior work documenting the Apollo 11 EVA [1] focused on the locations of the equipment seen in the Lunar Reconnaissance Orbiter Camera (LROC) and Hasselblad EVA [**2**] photography, and Preliminary Science Report (PSR) traverse maps [**3**]. The PSR included Hasselblad images marked with preliminary sample collection locations [**3**]. Locations of contingency sample collections were refined in recent work [**1**]. Pustynski [**4**] located the astronauts' positions while acquiring the Hasselblad images with respect to the Lunar Module (LM).

Methodology: From the EVA voice transcripts [**1, 5**] and synchronized audio-video tracks [**6**], we created a chronologic list of astronaut movements and events. Prior to mapping, we organized photo [**2**], and sample [**7, 8**] ID numbers into an in-depth chart of events and time-stamps. We derived a shapefile of astronaut locations as a function of time (**Fig. 1**) from synchronized audio-video tracks [**6**], surface photography [**2**] including reconstructed panoramas [**9**], a prior photogrammetry study [**4**], and the 0.25 m/pixel LROC NAC images M175124932L/R.

Shapefile points are labeled with Ground Elapsed Time (GET), to create a spatiotemporal map of events. GET does not correct for the 1.25 s delay required for the transmissions to reach Earth [**1**]. We estimate the GET values linked to specific locations and activities are accurate to within ±1 s when the astronauts are within view of the TV camera, and an average of ±14 s when out of view.

The LROC NAC basemap images M175124932L/R, has a warping offset averaging ±0.4 m in latitude and ±0.2 m longitude [**10**]. We intend to adjust out LROC NAC basemap to match known hardware coordinates [**10**] before publication.

In cases where the astronauts were not within view of either the sequence or TV cameras, we drew on tracks seen in the Hasselblad photographs [**2**] and LROC images. For the ALSCC sequence, which occurred mostly out of view of the video cameras, we also cross-referenced the ALSCC images [**2**] to determine the locations at which the stereoscopic images were taken. This process was also used to reconstruct events near the LRRR and PSEP, (**Fig. 2**), as well as Armstrong's visit to Little West crater.

Conclusion: This new spatiotemporal traverse map includes the 18 locations of ALSCC photos, 6 sampling group collection areas, all Hasselblad photo stations, updated fields of view of the TV and sequence cameras, and updated preliminary sample sites. Several preliminary sample sites, initially mapped in the PSR and ALSJ [**1, 3**], were corrected in this version. This new spatiotemporal map and timeline will be released on the LROC website (https://www.lroc.asu.edu/featured_sites/view_site/59), providing for a moment-by-moment traverse reconstruction of the Apollo 11 EVA.

References: [**1**] Jones, E. M. *ALSJ,* (https://www.history.nasa.gov/alsj/a11/a11.html). [**2**] March to the Moon, (http://tothemoon.ser.asu.edu/gallery/apollo). [**3**] Apollo 11 PSR (1969) *NASA-SP-214*. [**4**] Pustynski, V. *ALSJ: Photogrammetric Analysis*, (https://www.history.nasa.gov/alsj/a11/a11Photogrammetry.html). [**5**] Bailey, N. G. and Ulrich, G. E. (1974) *NASA Tech. Report*. [**6**] Gray, M. (2013) *Apollo 11: Men on the Moon. Spacecraft Films*. [**7**] Meyer, C. *Lunar Sample Compendium: Apollo 11*, (https://curator.jsc.nasa.gov/lunar/lsc/index.cfm). [**8**] Kramer, F. E. and Twedell D. B. (1977) *JSC 12522*. [**9**] Jones, E. M. *ALSJ: Image Library*. [**10**] Wagner, R. V. et al. (2017) *Icarus, 283,* 90-103.

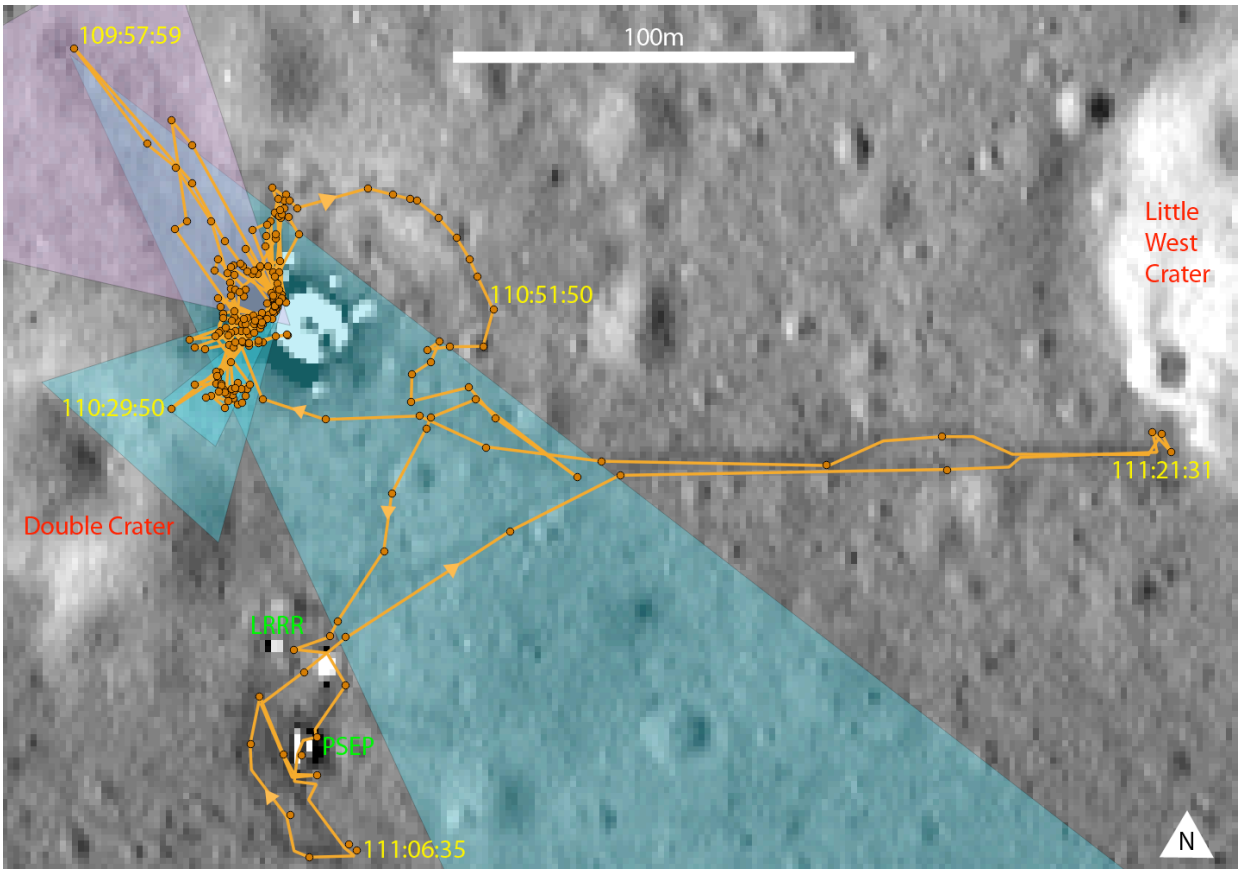

Fig 1. *Armstrong's traverse, with orange dots indicating stops (overlain on M175124932L/R; 0.25 m/pixel). Sequence camera and TV camera FOVs indicated in teal. TV camera has 3 FOVs: two point to SE from the LM equipment table and show the differences between the lens used when Armstrong exited the spacecraft and when he unveiled the commemorative LM plaque. The third position looking SE is from where the camera was re-positioned to record astronaut EVA activities points. The purple triangle shows the FOV of the 16-mm sequence camera from the LM Pilot's window. Traverse retraces near the PSEP and LRRR (see* ***Fig. 2****) can be seen just outside all FOVs. The GET of some points is indicated in yellow.*

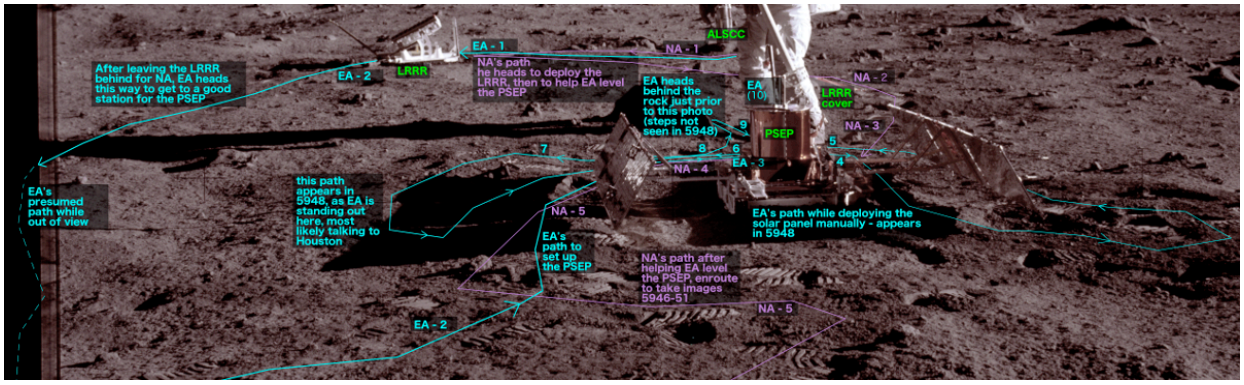

Fig. 2. *Annotated portion of Hasselblad image AS11-40-5949, showing how the Hasselblad image sequences were used to determine the chronological order of the footpaths out of view of the TV camera, in the area of the PSEP and LRRR. The numbers along the lines indicate the chronological order in which the footstep paths occurred. In the annotations in the image, Armstrong is specified as NA in purple, and Aldrin (seen in photo) as EA in teal. The numbers 5946-5951 in some notations refer to other Hasselblad images, AS11-40-5946 to AS11-40-5951.*