

AVAILABILITY OF PREVIOUSLY UNPROCESSED ASLEP RAW INSTRUMENT DATA AND DERIVATIVE DATA AND METADATA PRODUCTS. S. Nagihara¹, Y. Nakamura², D. R. Williams³, P. T. Taylor³, W. S. Kiefer⁴, M. A. Hager⁴, and H. K. Hills⁵, ¹Department of Geosciences, Texas Tech University, Lubbock, TX 79409 (seiichi.nagihara@ttu.edu), ²Institute for Geophysics, University of Texas at Austin, Austin, TX 78758, ³Goddard Space Flight Center, Greenbelt, MD 20711, ⁴Lunar and Planetary Institute, Houston, TX 77058, ⁵ADNET Systems, NSSDC, Greenbelt, MD 20711.

Introduction: The astronauts on Apollo 12, 14 through 17 deployed the scientific instruments collectively known as the Apollo Lunar Surface Experiments Package (ALSEP) in 1969 through 1972. In total, 14 experiments were performed at the 5 landing sites. The principal investigators assigned to the individual instruments/experiments processed and analyzed the data as they were transmitted from the Moon. Powered by radioisotope thermoelectric generators (RTG), these instruments continuously operated until September 1977 [1]. However, by early 1975, NASA had ended PI contracts with most of these experiments. Some of the instrument PIs delivered the data they had processed by that time to the National Space Science Data Center (NSSDC) for permanent archiving. Data acquired on the Moon afterwards were left unprocessed.

Throughout the ALSEP operation, the raw telemetry data from the Moon were recorded on open-reel magnetic tapes for archival purposes (Fig. 1). However, the vast majority of the tapes were never delivered to NSSDC at the conclusion of the observation program in 1977 and have been lost in the decades since. Until last year, NSSDC had ALSEP raw instrument data for only the last 19-month period of the ALSEP experiments (March 1976 – September 1977).

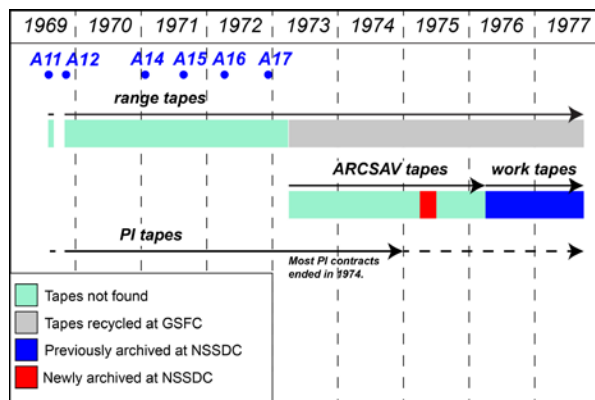


Figure 1. The production timeline of the ALSEP raw data archival tapes and their current availability.

Here, we report new availability of another set of ALSEP raw instrument data from April through June 1975. These data have been extracted from the original archival tapes recovered from the Washington National

Records Center (WNRC) in 2010 [2]. We also report our progress in processing the existing raw data into higher-order data products.

The New ALSEP Raw Dataset Collection: The tapes that were found at WNRC in 2010 are called ‘ARCSAV tapes’. Each ARCSAV tape contains 24-hour, time-edited, raw recordings from all the instruments for one ALSEP station [3]. NASA’s Johnson Space Center (JSC) recorded these tapes from April 1973 to February 1975. In our estimate, ~5000 such tapes were made in this period, but so far, only 439 of them have been found.

The ARCSAV tapes are 7-track, open-reel magnetic tapes. Not many contemporary data-recovery service providers maintain capability of reading them. We worked with two such companies; John Bordyniuk Inc. (JBI) in Ontario, Canada and DataBank Data Services in Texas. We have delivered NSSDC the binary files extracted from the tapes ‘as is’. The two companies use different file formats for the extracted data. We have also made the data extracted by DataBank available in the JBI format so that future users of these datasets need to deal with only one format. Users can refer to the document describing their bit organization [3] in extracting the data packets of the experiment of their interests.

These 7-track tapes are 40 years old, and their physical conditions vary. However, the vast majority of them yielded very low rates of parity error ($\ll 0.01\%$) in our first attempt to read them. We are currently cleaning up the data by correcting bit errors resulted from tape-reading errors and telemetry errors.

Processing of Higher-Order ALSEP Data Products: NSSDC now has raw data from all the ALSEP instruments for two periods: April through June of 1975 and March 1976 through September 1977 (Fig. 2). For some of the experiments such as the Passive Seismic Experiment (PSE) and the Dust Thermal and Radiation Engineering (DTREM), NSSDC has raw data for the entire observation period. We are currently processing them into higher-order, more user-friendly data products. These data products will fill considerable portions of the data gaps in 1975 through 1977, which resulted from the early termination of the PI contracts.

We define 4 levels of data products (Table 1). They will be made available through NSSDC and the Planetary Data System in coming years [e.g. 4].

Table 1: Definition of the ALSEP data product levels.

Data Product	Description
Level 0	Raw binary files extracted from the ARCSAV tapes, the work tapes, or the PI tapes without any modification.
Level 0a	Level 0 data quality-controlled for obvious bit errors resulting from tape-reading errors and data transmission errors (from the Moon to the Manned Space Flight Network stations).
Level 1	Level 0a data repackaged for individual ALSEP experiments in formats appropriate for modern computers.
Level 2	Individual experimental data fully processed (or translated) into scientifically meaningful numbers.

Recovery and Cataloging of ALSEP Metadata: A byproduct of our efforts for processing ALSEP data products is an extensive digital catalog of related documentations and metadata. Thousands of science and engineering reports/memos on the ALSEP instruments were generated at JSC and by the instrument PIs in the period leading up to the launches and during the operation on the Moon. At the conclusion of the Apollo program, large portions of these documents were moved to the Lunar and Planetary Institute (LPI) in Houston, TX and the National Archives of Fort Worth, TX. We have now completed a digital catalog of the LPI documents. Since October 2013, users have been able to search and download digital copies of ~700 documents totaling ~40,000 pages at LPI's Lunar Science and Exploration web portal (www.lpi.usra.edu/lunar/ALSEP). We are currently upgrading the database management software for advanced search capability.

We are now cataloging the ALSEP documents kept at the National Archives in Fort Worth. These documents have been previously sorted into ~20 groups by the Archives staff. One of the most notable of these groups is the Acceptance Data Package (ADP) reports. They give detailed description of the hardware system architecture, sensor calibration, and data processing workflow for the individual flight models for the individual ALSEP experiments. We estimate that the ADP reports alone have more than 100,000 pages. However, large portions of these documents may not be of immediate interests to contemporary data users. Therefore, our current effort focuses on deciding which of these documents to catalog and add to the existing LPI web portal.

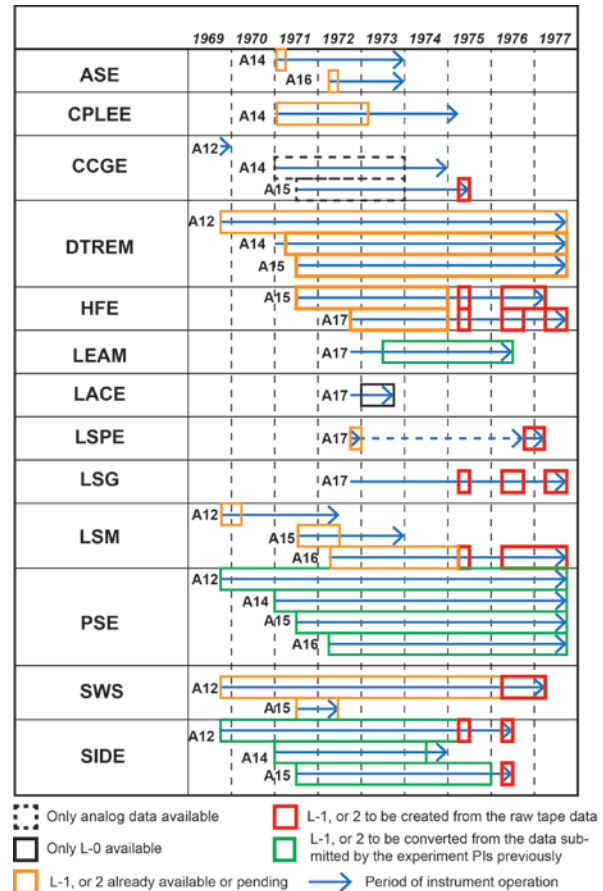


Figure 2: Data availability at NSSDC for the individual ALSEP experiments by Apollo flights. There are many gaps. The red boxes indicate the high-order data products to be archived by processing the raw data during this project. The green boxes indicate the high-order data products to be converted from the Level-0 data already archived at NSSDC. Refer to [3] for the abbreviations of the experiment names.

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References: [1] Bates, J.R. et al. (1979) ALSEP Termination Report, *NASA Ref. Pub. 1036*. [2] Nagihara, S. et al. (2011) *LPSC XXXII*, abstract #1103. [3] Lockheed Electric Co. (1975) ALSEP Archive Tape Description Document, *JSC-09652*. [4] Nagihara, S. et al. (2015) *LEAG* abstract #2019.