RECOVERING LUNAR ORBITER FRAMELETS FROM DIGITIZED MAGNETIC TAPE RECORD. A. D. Epps[1] and M. Sandler[2], [1] Skycorp, Building 596, NASA Ames Research Park, Moffett Field, CA 94035, austin.epps@gmail.com, [2] Atirsa, 3679 Enochs St #2, Santa Clara, CA 95101, msandler@atirsa.com.

Introduction: The goal of the Lunar Orbiter Image Recovery Project (LOIRP) is to digitize and archive the magnetic tape records generated by the five Lunar Orbiter spacecraft in the mid-1960s. The readout scanners utilized onboard the Lunar Orbiter spacecraft employed a phosphor-covered anode bombarded by an electron beam to focus a spot of light on 70mm film developed onboard the spacecraft. This light was modulated by the density of the image and read by a photomultiplier tube. Each individual pass of this scanning procedure across the 70mm film produced a thin strip of a larger image, referred to as a "framelet". The product of the spacecraft's readout system was a video waveform that was modulated and transmitted to three DSIF stations and recorded onto 2-inch magnetic tape via Ampex FR-900 data recorders. This document discusses the process by which these video signals are converted into digital image files.

Process: Achieving this goal required the development of a software equivalent of the Ground Reconstruction Equipment utilized during the 1960s. This process starts with the analog waveform from the tapes digitized at 5×10^6 samples per second at 16-bit resolution and concludes with digitized framelets in a format that can be assembled into complete frames. Although individual lines are nominally 1250μs (6250 px) wide, this dimension varies drastically between tapes and noticeably within tapes (see figure 1). A fully automated method of correcting line-to-line drift and rescaling utilizing custom software is currently being employed. When attempts were made to exactingly cue off of the composite video signal's synchronization pulses (added by the spacecraft's readout system), ringing in the data produced extreme visual artifacts. The automated method iterates over each line with a box filter kernel, takes a set of estimates over a sample of approximately 1000 lines, rejects outliers, and performs a least squares fit over the inliers. The data is corrected and resampled to square pixels for an entire tape. The file is then displayed as a 'virtual film strip' in a custom slicing application, allowing the operator to define cut points by clicking the mouse at the beginning of each framelet. At this point the framelets can be assembled either manually, or could be integrated into an automated assembly process developed by Charles Byrne for use with archival film that was digitized by the United States Geological Survey [1].

Results: Unlike the archival film record, the digitized LOIRP record eliminates the film-based Ground Reconstruction Equipment. The GRE's inaccuracy in recovery of synchronization led to the introduction of a horizontal skew of a fraction of a degree along the length of an entire framelet. When scanned at high resolution by USGS (970 px width by 16,550 px height) this skew exhibited deviations of as much as 30 pixels between the top and bottom edges of a framelet [1]. This skew has been completely eliminated by the LOIRP process's more sophisticated recovery of synchronization. Additionally the full dynamic range of the composite video signal is preserved by the LOIRP process, unlike the GRE process that clipped density ranges below and above certain thresholds [2], allowing LOIRP images to better duplicate the spacecraft film.

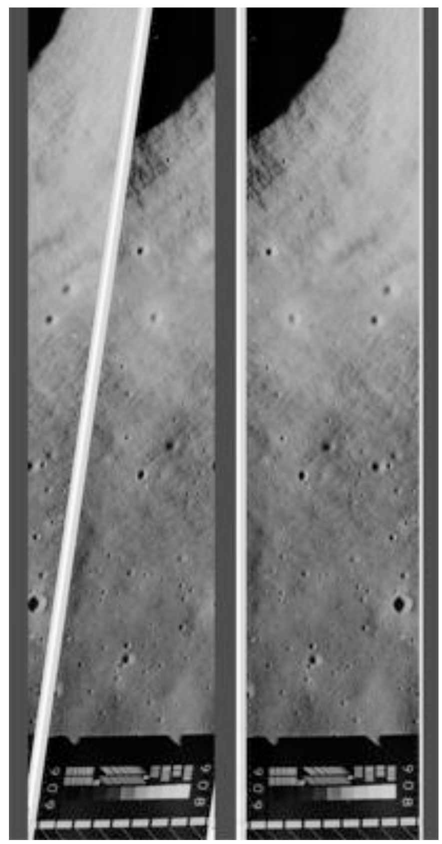

Figure 1: Assuming constant line width of 1250μs (left). Corrected version using automated synchronization extraction method (right).

References: [1] C. J. Byrne (2009) *Analysis and Correction of Artifacts in Lunar Orbiter Photographs,* 07-LASER07-0005 [2] The Boeing Company (1967) *Lunar Orbiter I Photography*, NASA CR-847, 112.