RECOVERING HIGH RESOLUTION LUNAR ORBITER IMAGES FROM ANALOG TAPE. D. R. Wingo[1] and K. L. Cowing[2], [1]Skycorp Incorporated, 603 Dement St. N.E. Huntsville, AL 35801 wingod@earthlink.net, [2] Spaceref Interactive P.O. Box 3569, Reston, VA 20195-1569, kcowing@spaceref.com .

Introduction: In 1966-67 NASA Flew five spacecraft to the Moon, ostensibly to recoinoitter and map landing sites for the Apollo program. The image quality of the high resolution (610 mm telescope) was approximately 1 meter, which has not been equaled or exceeded to date. On a global basis the image resolution from the 610 and 80 mm medium resolution images was between 40-80 meters.[1]

The Lunar Orbiter Image Recovery Project (LOIRP), was formed as a result of the acquisition of the last surviving Ampex FR-900 Instrumentation tape recorders that can play the predetection recorded analog analog image data from the LO spacecraft.[2] The project's purpose is to refurbish the FR-900 drives, read the analog data, convert to grey scale images, and recover images with higher dynamic range and resolution than is available from the orginal film based GRE data.

The purpose of this paper is to describe the process for refurbishing the hardware, deriving an image, and the results of our initial image analysis of LO-102-H, the famous image of the Earth with the Moon in the foreground.

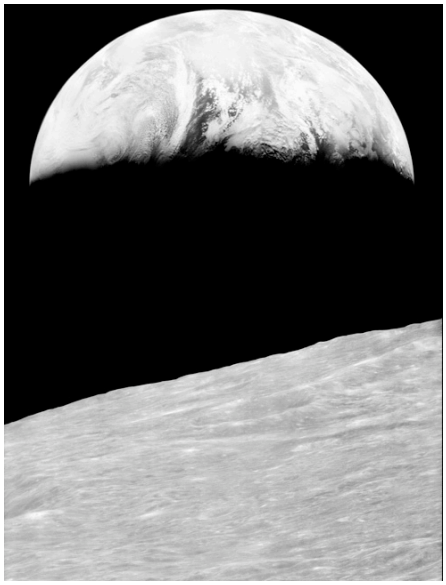
Project Origin: After being sequestered for twenty years, the original DSIF (Deep Space Instrumentation Facility, the predecessor of the Deep Space Network) tapes from Goldstone, Madrid, and Castle Island (Woomera), were released to JPL. In 1986 the Ampex FR-900 tape drive, the only machine capable of playing the tapes, had passed from use. A JPL employee, Nancy Evans, in charge of the tapes, acquired from surplus, four FR-900 series drives to recover the original images from the analog tapes.

The undemodulated analog data is of higher intrinsic quality than the 35mm film GRE tapes that forms the basis of the USGS and LPL image database.[3]

LOIRP Project: In July 2008, with funding from NASA ESMD and private organizations, the refurbishment of the FR-900 tape drive began. This required and extensive search of documentation such as the Ampex archive at Stanford University, interviews of LO program team members, former Ampex employees, and NASA extensive use of the NASA Technical Reports Server.

With the participation of a nationwide team, students from San Jose State University and other students doing summer internships at NASA Ames, the project moved rapidly forward. The drives were first exensively cleaned, subsystems tested, and then troubleshooting of circuits unpowered for decades commenced. After three months of testing and evaluation, NASA DSIF tapes were played on the drive and digitzed using a high speed digitizer linked to an Apple computer.

Initial Results: In October 2008 a first generation (circa 1968) duplicate demodulated tape was used to digitize and reconstruct image LO-102-H1 and H2. This famous first image of the Earth as seen from the Moon was reconstructed completely in the digital domain. Based upon analyzing the calibration strips from the original LO spacecraft film, also present in the analog data, we have determined that the image quality is very close to that of the orignal 70mm spacecraft film and considerably superior to the image from the LPL database. A portion of this image is reproduced here.



A preliminary qualitive analysis is that the recovered LO-102-H2 image has four times the dynamic range of the GRE film image and up to twice the ultimate resolution.

Project Status: The LOIRP project is currently reconstructing, from the original equations found in the literature, a demodulator that will allow us to at will convert all of the images from the tapes. We have one functional FR-900 drive and are in the process of refurbishing a second drive. In addition, refurbished heads are being procured before the end of 2009 when the last company doing this work will end for all time the ability to acquire these images. Results will be presented in appropriate forums.

Lessons for Future Data Retention: It is not enough to have 100 year recording medium. Without the retention of the specific era equipment that images are archived on, it will be impossible for future generationsl to recover older NASA or other satellite data. This is a general issue, not specific to the Lunar Orbiter program and the retention of critical hardware should be a requirement for flight efforts. The original historic Apollo 11 slow scan images have been lost due to inattention to this critical detail.

[1] Hansen T. P. (1970) *Guide to Lunar Orbiter Photographs,NASA SP-242* 3. [2] Allen W. C. (1967) *DSIF FR-900 Video Tape Recorders., Space Programs Summary,* NO.37-42 VOL. III. [3] Byrne C. J. (1965) *Tape Recording of Lunar Orbiter Pictures,* NASA TM-65-1012-6/NASA-CR-156208.