The Search for the Apollo 11 SSTV Tapes

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Executive Summary

For the past several years a group of dedicated former Apollo 11 personnel have been searching for the original magnetic data tapes that contain the high quality Slow-Scan TV of the Apollo 11 EVA. This report is a detailed justification of their efforts to date. In summary, the key points are:

- In July 1969, three tracking stations received the TV signals of the historic Apollo 11 EVA. They were the DSN 64 metre antenna at Goldstone, California, the MSFN 26 metre antenna at Honeysuckle Creek, Australia, and the 64 metre CSIRO Parkes Radio Telescope in Australia.

- The TV signals transmitted from the Moon were high quality Slow-Scan TV (SSTV).

- When received on Earth, they were scan-converted to the commercial TV standards before being broadcast to the public at large.

- The scan-converted TV signals, from each of the three stations, were then relayed via landline, microwave relays and geostationary satellite to Houston before being released to the TV networks for general broadcast.

- The signal, as sent from the Moon, was initially degraded by the scan-conversion process, producing lower resolution images and introducing additional signal noise. Also, the transmission of the scan-converted TV to Houston caused additional signal degradation. This lower quality TV is currently all that is available of the Apollo 11 EVA.

- ***The SSTV was of superior quality to the scan-converted pictures viewed by the world***.

- As the raw SSTV signals were received at the three tracking stations, they were recorded onto 1-inch magnetic data tapes. Following the EVA, procedures required that these tapes be shipped to the Goddard Space Flight Center (GSFC).

- In 1970, the tapes were placed in the US National Archives in Accession #69A4099. By 1984, all but two of the over 700 boxes of Apollo era magnetic tapes placed in the Accession, were removed and returned to the GSFC for permanent retention. These tapes are now missing.

- These missing data tapes include the raw Apollo 11 SSTV tapes. For the past several years, a search for these tapes has been undertaken by several former Apollo 11 personnel. To date, no Apollo 11 SSTV tapes have been found.

- When the tapes are found, it is hoped to recover the original, high quality SSTV of the first lunar EVA and to release it to the public for the first time.

- The Data Evaluation Lab (DEL) at the Goddard Space Flight Center is the only known place that has the equipment and expertise to playback the tapes and to recover the data.

- The DEL is slated for closure in October 2006.

- Efforts are underway to assure the future of the DEL (the critical hardware located in the DEL that would be required for tape evaluation and processing is being removed and retained through the efforts of the former Apollo engineers).

- It is vital that the DEL (or some elements of it) remain open and functional, otherwise none of the Apollo data tapes can ever be played back and the historic information recovered.

- This report details the reasons why the search for the tapes was undertaken, how much better the SSTV was to the scan-converted TV and the progress of the search to date.

1. Introduction

It was one giant leap for mankind, and it was taken at 02:56 on Monday 21 July 1969 (GMT).

Six hundred million people, or one fifth of mankind at the time, watched Neil Armstrong's first steps on the Moon. Three tracking stations were receiving the signals simultaneously. They were NASA's Goldstone station in California, the Honeysuckle Creek tracking station outside Canberra, Australia and the CSIRO's Parkes Radio Telescope in Australia.

The signals were relayed to Mission Control in Houston. During the first few minutes of the broadcast, NASA alternated between the signals from its two stations at Goldstone and Honeysuckle Creek, before settling on the Parkes TV pictures for the majority of the 2 ½ hour telecast.

From an analysis of the videotapes of the EVA and of a recording of the NASA NET 2 communications loop (the communications loop that controlled the TV reception), the following timings for the TV switches were obtained:

Time (mm:ss)	Video Transmission
00:00	TV on (upside down) Picture is from Goldstone (GDS). Time is 02:54 (GMT)
00:27	Picture is inverted and is now the right way up. Very dark, high contrast image.
01:39	Houston TV switches to Honeysuckle Creek (HSK)
02:20	Armstrong steps onto the Moon. The time is 02:56:20 (GMT)
04:42	Houston TV switches back to GDS. Picture is negative
05:36	Houston TV switches back to HSK
06:49	Houston TV switched back to GDS. Picture is positive again
08:51	Houston TV switches to Parkes (PKS). Remains with Parkes for the remainder of the EVA

From these timings, and other evidence, it is clear that at the start of the EVA, Goldstone was experiencing problems with its TV, resulting in high contrast, dark images. The Honeysuckle Creek pictures were better but suffered from a lower signal-to-noise ratio, producing grainier images. The Parkes pictures were the best of the three and it was these that NASA broadcast for the majority of the EVA.

Remarkably, the TV pictures watched live by the world were of poorer quality than those actually received by the three tracking stations. The B/W Apollo Lunar Surface Camera (ALSC) was capable of transmitting high quality pictures, but in scan-converting the images on Earth for public broadcast, a considerable amount of image quality was lost.

This report endeavours to demonstrate the superior quality of the original slow-scan TV images received in July 1969 and to describe the efforts of several dedicated individuals in searching for the missing magnetic data tapes containing the raw slow-scan TV signals. In addition, background material is presented that will be of value to others who may assist in the search.

With the use of modern image processing techniques, it is hoped that the original high quality TV images can be restored for public viewing before the magnetic data tapes deteriorate beyond repair.

2. Background: The Apollo 11 Television Plan

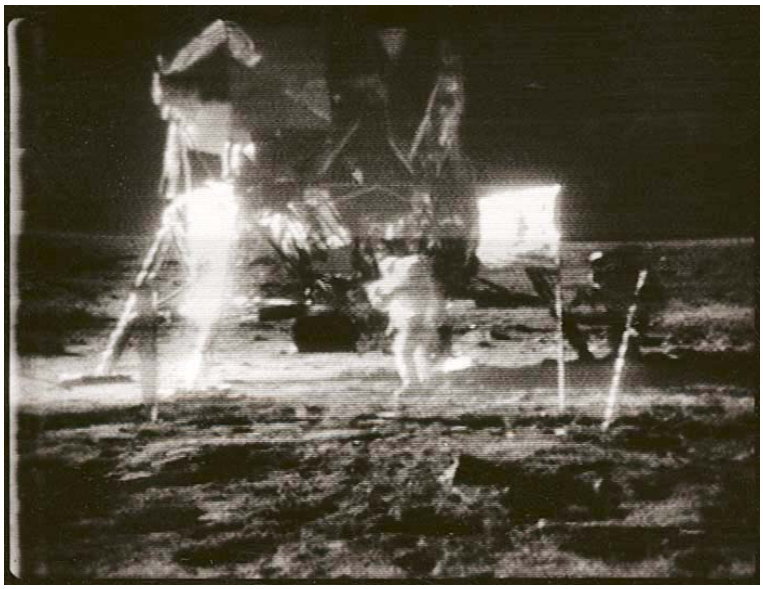
The original mission plan of Apollo 11 had the astronauts performing the Extra Vehicular Activity (EVA), or moonwalk, shortly after landing at 20:16 on 20 July (GMT). Two NASA tracking stations were to receive the TV signals during the EVA. They were the 64 metre dish at Goldstone in California, and the 26 metre dish at Tidbinbilla near Canberra, Australia (later switched to Honeysuckle Creek, also near Canberra). Since the Moon would not rise at Parkes until 03:02 on 21 July (GMT), Parkes would act as a backup in case of a delayed moonwalk, or some other reason.

All this changed some two months before the mission. In May 1969 it was decided to alter the Apollo 11 mission plan and allow a rest period before commencing the lunar EVA. This would have given the astronauts an opportunity to adjust to the Moon's 1/6th gravity, and to start the EVA refreshed. The new plan had the EVA starting about ten hours after landing at 06:21 on 21 July (GMT), which was some twenty minutes after the Moon had set at Goldstone, but which had the Moon high overhead at Parkes.

On the day itself however, Armstrong opted to forgo the sleep period and to start the EVA early. The TV broadcast began just as the Moon was rising at Parkes and while it was still above the horizon at Goldstone at 02:54 on 21 July (GMT).

The TV transmitted from the Moon was high quality B/W slow-scan TV (SSTV). These pictures had to be scan-converted on Earth to the commercial television standard before being broadcast to the world. An RCA optical scan-converter was used for this purpose. Richard Nafzger was the Goddard Space Flight Center engineer responsible for all the systems hardware in support of the Apollo 11 TV.

For many years it was feared that the low quality of the initial Goldstone images was a result of poor signal reception at Goldstone. However, according to Bill Wood, a USB Lead Engineer stationed at Goldstone, it now appears that a less than ideal brightness setting on the scan-converter monitor may have been the reason the initial pictures from Goldstone suffered from high contrast, dark images. A subsequent Polaroid image taken at Goldstone later in the EVA, and only recently found by Bill Wood, shows this to be the case. The Polaroid shows a substantially improved image to those from the start of the EVA. This means that the signals received at Goldstone were perfectly fine after all.



Polaroid image from Goldstone taken off the slow-scan monitor showing just how good the Goldstone pictures were.

3. Background: The Apollo 11 lunar surface television camera (ALSC)

The lunar television camera was a black-and-white, slow-scan TV (SSTV) with a scan rate of 10 frames-per-second at 320 lines-per-frame. It weighed 3.29 kg (7.25 lb) and drew 6.5 watts of 24-32 volts of DC power. The camera body was 26.9 cm long, 16.5 cm wide and 8.6 cm deep (10.6 x 6.5 x 3.4 inches). The bayonet lens mount permitted lens changes by a crewman in a pressurised suit. Two lenses were provided: a wide-angle lens for close-ups and large areas, and a lunar day lens for viewing lunar surface features and activities in the near field of view with sunlight illumination.

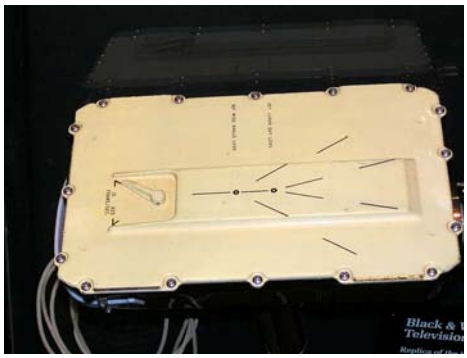
The camera was stowed in an instrument pallet known as the MESA (Modular Equipment Stowage Assembly) in the LM descent stage. The MESA was to the left of the ladder when viewed facing the front of the LM. When Armstrong was at the top of the ladder, he pulled a lanyard to swing open the MESA, which was hinged at the bottom. The TV camera, which was attached to it, would also swing down. It was mounted upside-down so as to secure it firmly to the MESA with vibration isolators and to also simplify its removal by the astronaut. Aldrin switched on the camera by pushing in the TV circuit breaker in the cabin of the LM. The camera was pointing at the ladder of the LM, so that TV pictures of Armstrong's initial steps on the Moon could be relayed to the world. Later, after Aldrin had descended to the surface, Armstrong mounted the TV camera on a tripod, and placed it about 15 metres from the LM. The camera was left unattended to cover the crew's activities during the remainder of the moonwalk.

The camera was also capable of operating in a high resolution mode which was 5/8 frames-per-second with 1280 lines-per-frame (non-interlaced). This mode was designed to telecast high resolution, still images in case the astronauts were not able to return to Earth with photographs. The camera had a switch located on the top surface that would allow the astronauts to operate it in either mode. Back on Earth, standalone, 10-inch Fairchild monitors with yellow, high persistence phosphor screens were equipped with Polaroid cameras for shooting the high resolution images directly off the screens. However, because of time constraints this high resolution mode was never used in flight.

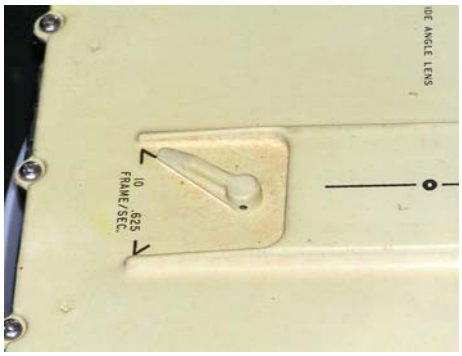
The Apollo lunar television camera was built by Westinghouse Electric Corp., Aerospace Division, Baltimore, Md., USA. Mr Stan Lebar was the Program Manager in charge of its development.

Details of the Apollo 11 Lunar Surface Camera (National Air & Space Museum, Washington)

The Backup Apollo 11 Lunar Surface Camera on display in the Air & Space Museum



Close up of the top of the camera showing the switch and lens angles



Close up of the switch from 10 frames-per-second to 5/8 frames-per-second high resolution mode.

4. Background: Scan-converting the TV pictures

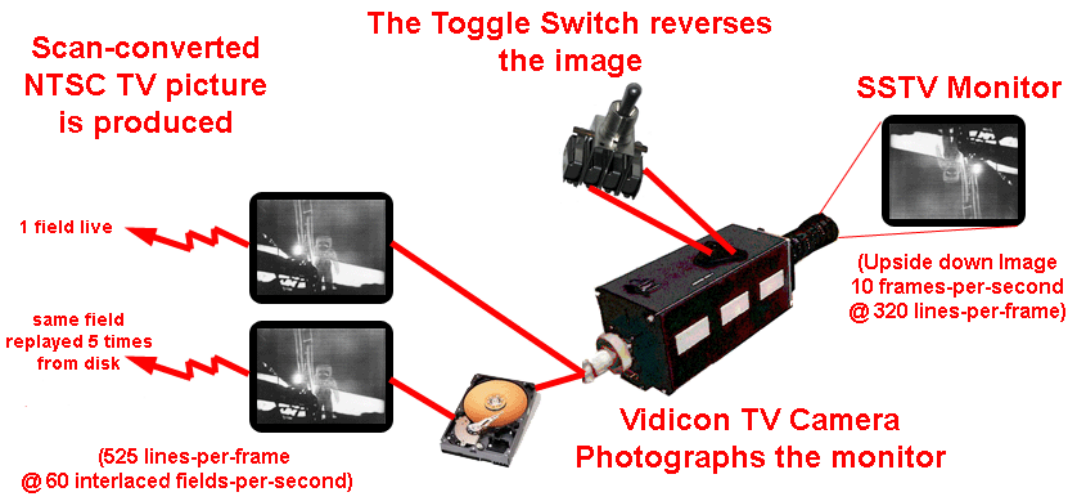
Because of the limited power and bandwidth available on the Lunar Module (only 500 KHz bandwidth), the TV pictures from the Moon were narrow band, slow-scan TV, that is, 10 frames-per-second (non-interlaced) and 320 lines-per-frame. In order to broadcast them to the waiting world, the pictures had to first be converted to the commercial TV standards. This was the EIA (NTSC) standard of 30 frames-per-second (60 interlaced fields-per-second) at 525 lines-per-frame.

For Apollo 11, an RCA scan-converter was used which operated on an optical conversion principle. The pictures were displayed on a 10-inch white phosphor, slow-scan monitor and a Vidicon TK22 camera was pointed at the screen. As each frame of the 10 frames-per-second picture was received, it was displayed on the monitor and imaged by the camera. The camera was gated to scan a single field of 262.5 lines at the EIA (NTSC) rate of 1/60th of a second, that is, it did not take a picture until the 10-inch monitor had completed displaying a full frame. The output of the camera was transmitted and simultaneously recorded on magnetic disc. The disc recording was then played back a further five times with the appropriate delays to shift the lines in the second field of each frame and transmitted. While the disc recorder was playing back, the monitor screen was blacked out and the next frame displayed to repeat the process. In this way, a 30 frames-per-second (60 interlaced fields-per-second) TV was produced. ***This scan-conversion process produced lower resolution images than the SSTV (down from 320 to 262.5 lines) and introduced additional signal noise.***

While the TV camera was upside-down in the MESA, the pictures were also upside-down. When Armstrong removed the camera to plant it on the lunar surface, the pictures would be the right way up again. A simple technique was employed to invert the images during the scan-conversion process on the Earth. This involved modifying the scan-converter by installing a toggle switch on its front panel. The switch was connected to the deflection coils of the Vidicon camera by means of a relay, which then inverted the picture by the simple expedient of reversing the vertical scans. The images at Goldstone and Honeysuckle Creek were scan-converted on-site but the Parkes pictures were relayed to Sydney, Australia, and scan-converted there.

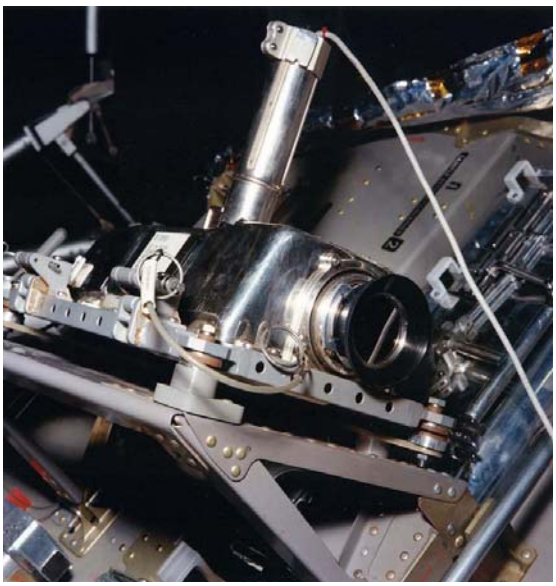
As the video and telemetry downlink was being received, it was recorded onto 1-inch magnetic tapes on Mincom M22 or Ampex FR-1400 instrumentation recorders at a rate of 120 inches-per-second. These tapes had to be changed every 15 minutes for the entire period of the moonwalk.

The scan-converted pictures were relayed to Mission Control in Houston via microwave links, geostationary satellite and then by land lines. From there, the pictures were passed on to the television networks for international broadcast. At each stage of this relaying and broadcasting process, the image quality of the received TV pictures was further degraded. The raw SSTV images were therefore superior in quality to the scan-converted broadcast images.

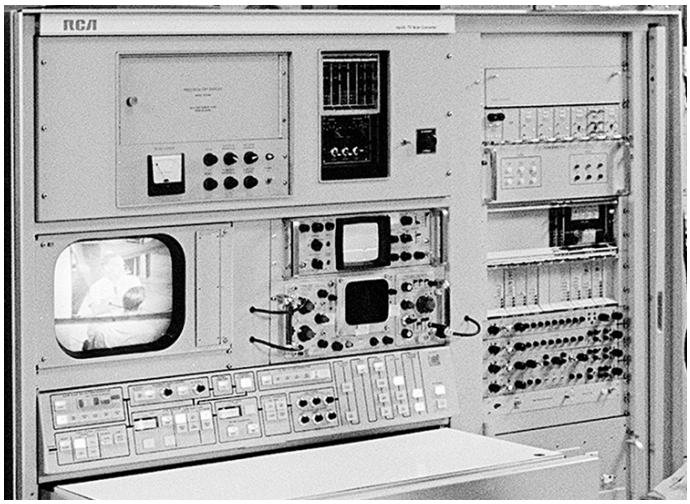


The Optical Scan-Conversion Process

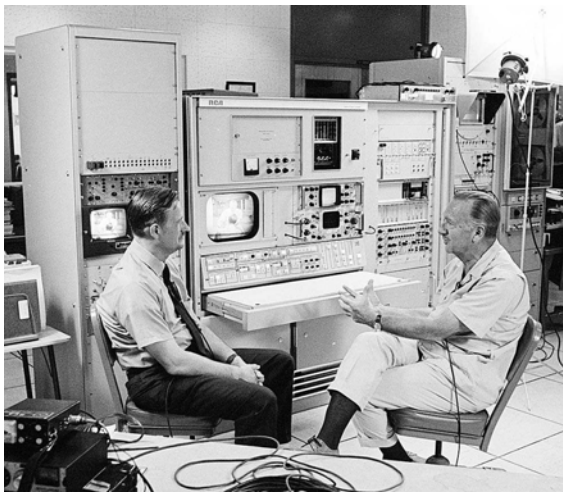
The location of the ALSC in the MESA (training photo)



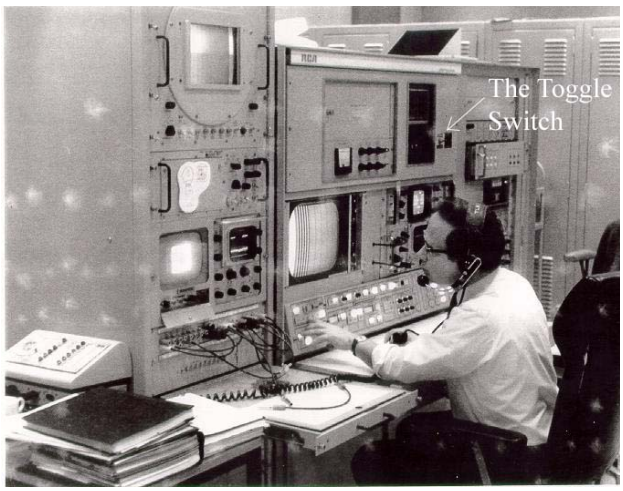
Close-up of the ALSC showing it stowed upside-down



The operating console of the RCA scan-converter at Goldstone.



Walter Cronkite interviewing Goldstone Assistant Director, Bill Gill, on 4 July 1969, beside the Goldstone scan-converter



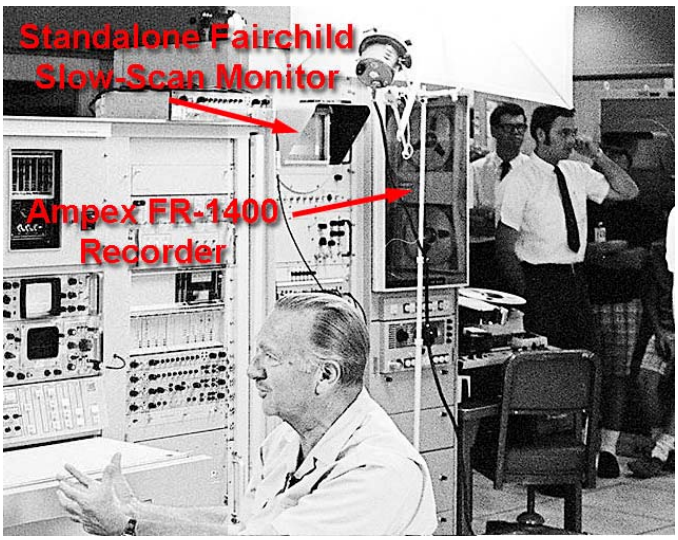
The Honeysuckle Creek scan-converter with the toggle switch indicated (Ed von Renouard operating it)

The Parkes scan-converter in Sydney. In the centre is the operator, Richard Holl, celebrating at the end of the EVA with his colleagues Ted Knotts (L) and Elmer Fredd (R).

5. The Magnetic Data Tapes

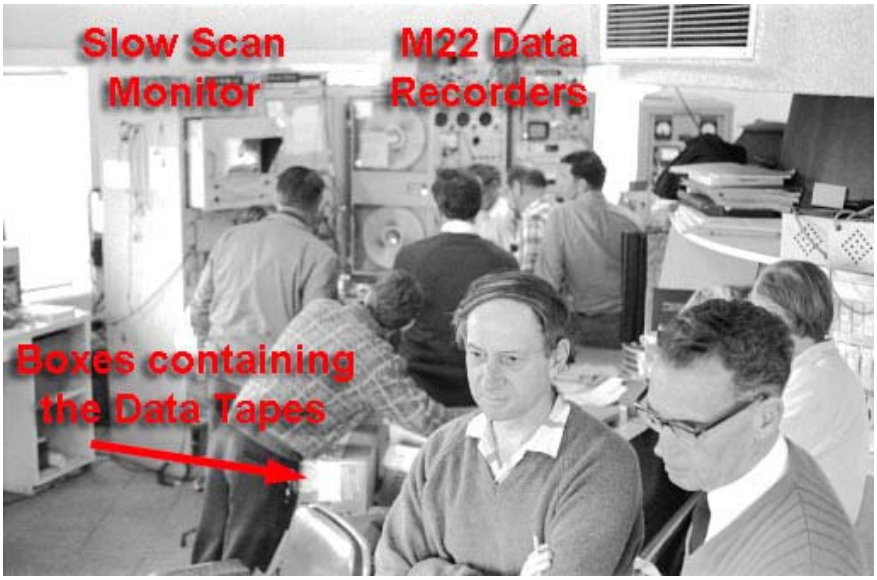
According to Bill Wood, a USB Lead Engineer stationed at Goldstone in 1969, the unconverted Apollo slow-scan TV signals were recorded on wide-band analogue tape recorders at each of the prime receiving stations. The video output of the Unified S-band Signal Data Demodulator System (SDDS) was routed to Mincom M-22 or Ampex FR-1400 analogue recorders running at 120 inches-per-second to capture the full bandwidth of the downlink TV signal.

The recorders were loaded with 9200 foot reels of one-inch wide instrumentation recording tape. Each recorder would run only 15 minutes at this high speed. As a result, two recorders were run alternately so that one could be unloaded and reloaded with a new reel of tape while the first recorder was being used.



Photograph taken on 4 July, 1969, while Walter Cronkite was taping an interview. Clearly shown above is the Ampex FR-1400 Instrumentation Recorder used at Goldstone to record the raw SSTV during Apollo 11.

The data tapes piled up ready to be used during the EVA at Parkes.



At Parkes, Mincom M22 data Recorders were used to record the raw SSTV signals. The boxes that most probably contained the data tapes are indicated.

The above images show the recording setup at Goldstone and Parkes. The data tapes containing the raw SSTV signals from all three stations are now missing and these images illustrate clearly what we are searching for. Examples of the boxes that are likely to contain the tapes are clearly visible in the bottom right-hand image. The tapes are likely to have been shipped back to Goddard Space Flight Center in boxes like these and stored in archives. Where are they now?

6. The Slow-Scan TV Quality Was Superior

The images below illustrate the superior quality of the slow-scan TV from each of the three tracking stations compared to the best of the scan-converted TV broadcast from Parkes. The camera angles and lighting conditions are the same for each pair of images.

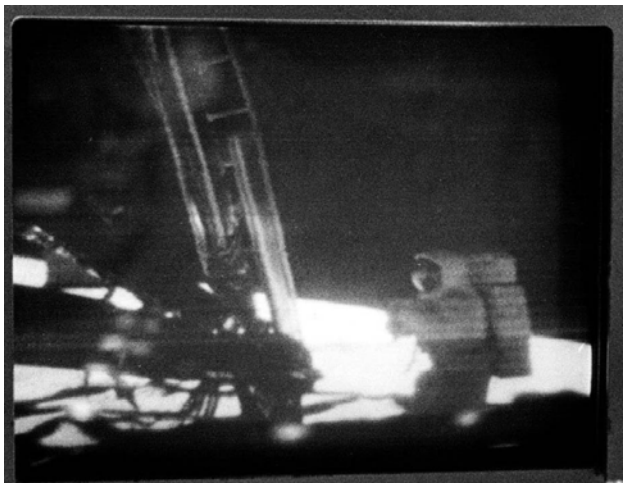
Example 1:

PKS: Scan-converted broadcast image from Parkes.

PKS: Polaroid of the raw SSTV image received at Parkes.

Example 2:

PKS: Scan-converted broadcast image from Parkes.



HSK: A 35mm photograph of the SSTV image from Honeysuckle Creek.

Example 3:

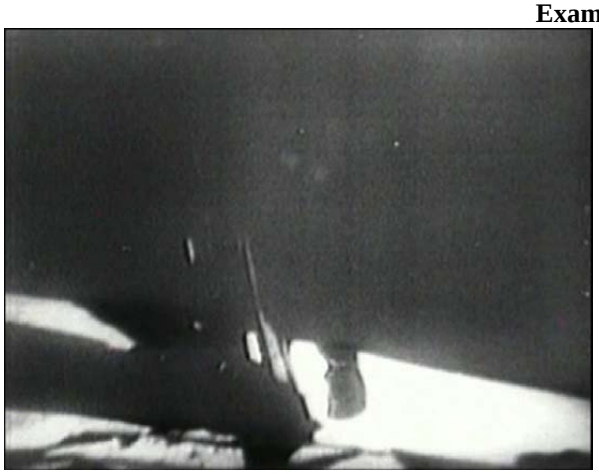
PKS: Scan-converted broadcast image from Parkes.

GDS: Polaroid of the SSTV image from Goldstone.

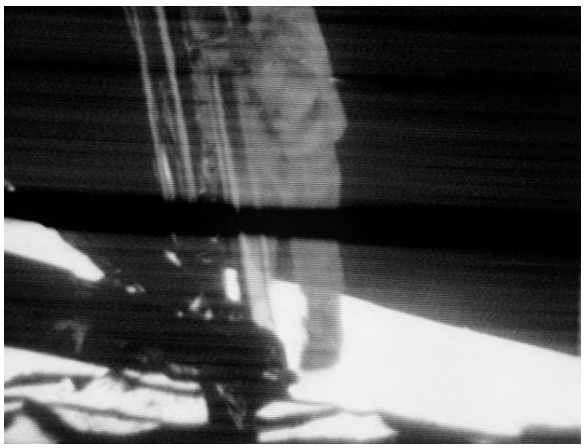
The comparisons in examples 1 to 3 above, demonstrate how much the TV images were degraded by the scan-conversion process. According to Dick Holl, the Parkes scan-converter operator and one of the designers of the RCA scan-converter, the difference in quality was also partly due to the resolution of the slow-scan monitors. The standalone Fairchild monitor could display high-resolution still images. It had a yellow phosphor that could retain the image longer than the smaller slow-scan white phosphor monitor in the scan-converter. It was never used in that mode during the flight, but the monitor was capable of higher resolution than the one in the scan-converter. There was a huge loss of resolution in the conversion process but the contrast stretch was still good. On a scale of 1-10, the scan-converter slow-scan monitor would be a 4 and the stand alone monitor a 6 or 7. In other words, there was a noticeable difference. With modern equipment, this dependence on the resolution of the slow-scan monitors can be removed entirely, and the high quality of the slow-scan format can be recovered fully.

During the Apollo 11 EVA, Stan Lebar, who was the Program Manager for the ALSC at Westinghouse, was stationed at the Manned Spacecraft Centre, Houston. While viewing the broadcast, he was surprised to see how much the TV quality had degraded. When testing the camera prior to the mission, he had only ever seen the TV in its original slow-scan format, not the scan-converted images.

Example 4:



GDS: Scan-converted broadcast image of Armstrong descending the LM ladder from Goldstone. This was the image the world saw of Armstrong descending the LM ladder.



GDS: Polaroid of the SSTV image of Armstrong descending the LM ladder sourced from Goldstone. Compare this to the image on the left.

According to Bill Wood, Goldstone had two stand-alone Fairchild slow-scan monitors, one located next to the RCA scan-converter and the second in a small caravan parked on the west end of the operations building. The Fairchild monitor in the caravan was installed for the use of the GSFC PAO representative who was assigned to Goldstone during the Apollo 11 mission. The above right-hand image was most probably taken there. The pair of images in example 4 clearly demonstrates that Goldstone had a good signal all along and could have produced a great picture of Armstrong stepping onto the lunar surface. It's fascinating to know that if the tapes are found, it may still do so.

It is now evident that the initially poor Goldstone TV images were a result of improper scan-converter settings and not due to poor signal reception at Goldstone, as was previously thought. Consequently, the magnetic data tapes from Goldstone can be used to extract the SSTV to the same high level of quality as the Parkes SSTV because the two antennas were of the same size and sensitivity. Likewise, the Honeysuckle Creek tapes can also be used to extract the SSTV to a higher quality than the Parkes scan-converted TV. Therefore, finding any of the tapes from Goldstone, Parkes or Honeysuckle Creek would suffice to restore the TV of the first lunar EVA to its original high quality, slow-scan format. This will substantially improve on what is currently available.

7. The Longevity of the Tapes – Time is Critical

In 2002, a magnetic data tape recorded at Honeysuckle Creek was discovered and thought to contain some of the raw SSTV from the Apollo 11 mission. In 2004, the tape was shipped to the Goddard Space Flight Center's Data Evaluation Lab (DEL) in Greenbelt, Maryland, where it was processed by Richard Nafzger and his colleagues. Unfortunately, the tape proved to contain data from a simulation flight dating from 1967, that is, from 37 years earlier. For 35 years, since 1969, this tape had been stored in less than ideal conditions in the garage of a former employee of Honeysuckle Creek. None-the-less, the tape had not deteriorated and still contained recoverable data. This boded well for the prospects of recovering the Apollo 11 SSTV since presumably the missing tapes are properly stored in air-conditioned archives somewhere. In 2006, the Apollo 11 magnetic data tapes will have been in storage for 37 years. We know from the above experience, that the tapes can survive at least this long, but for how much longer we cannot be certain. It is imperative that these tapes be found as soon as possible before they deteriorate irreparably. Time is critical.

John Saxon, the former Operations Supervisor at Honeysuckle Creek, describes the history of the mistaken tape. The lessons gleaned from the experience will be vital in the recovery of the SSTV when the tapes are eventually found.

Here's the story:

1. In April 2002 we first became aware of this tape, a 14 track 1" 9200 ft instrumentation tape recorded at 120 inches-per-second. It was believed that the tape covered the 15 minutes surrounding Armstrong's first step onto the lunar surface, dubbed shortly after that track at Honeysuckle Creek tracking station and later kept for over 30 years as an interesting piece of memorabilia.

2. In January 2004 we decided to see if we could locate any 1" 14 track analogue instrumentation recorders in Australia. The objective was to dub all the tracks onto one or more tapes, then later to try and extract the data - timing, voice, telemetry, biomedical and the 'Raw TV'. Naturally there might be unique data which could considerably improve those first fuzzy images and other data using modern processing techniques. But after an extensive search we found none (although we discovered numerous 14 and 28 track 1" recorders in Australia - they are all for exclusively digital data recording and playback).

3. Along the way we were advised that there are suitable 'legacy' recorders at NASA's Goddard Space Flight Center (GSFC) Data Evaluation Lab (DEL) and also much processing and distribution equipment. After some tentative approaches, the DEL expressed a willingness to see what could be done with the tape.

4. Also in January this year (2004) we first made contact with Screensound Australia (formerly the National Film & Sound Archive) who are experts in the rehabilitation of old film and magnetic tapes, first for advice and later they kindly agreed to run the tape through several weeks of rehabilitation at < 5% relative humidity and 40 degrees Celsius.

5. Early in May 2004, we made contact with Neal Newman the NASA Representative to Australia and SE Asia and things started to move into high gear. Neal guaranteed "110% support from himself and the US Embassy". He was due to visit Washington in early June and offered to hand carry the tape with him - better than the 'Diplomatic bag'! Neal also contacted NASA HQ and got enthusiastic agreement to support the effort, and authorisation for the DEL to spend some significant time and effort.

6. The tape was given to Screensound in Mid-May and rehabilitation/rejuvenation started - ably overseen by Viktor Fumic. On 5 June 2004, Victor handed the tape over to Neal - packed in a special carry case with correct desiccants, etc.

7. On 10 June 2004, Neal delivered the tape to the DEL at GSFC and after 24 hrs acclimatising in the lab - the first dub was made (staff came in especially on the holiday for ex-President Reagan's funeral). The team at the lab was led by Dick Nafzger (THE GSFC slow-scan and other spacecraft TV expert) and Dick Bouchard the DEL manager. Ominously, it was discovered almost immediately that there were pre-calibrations on the tape recorded at 15"/sec, voice annotation stated that the tape was for "NCG750 simulation of October 23, 1967"! This was very bad news - but it was still possible that the tape was wound on past the pre-cals and dubbed on the 21st July 1969 over that famous time period. However on 16th June our worst fears were confirmed and the serial time code from near the middle of the tape had been recorded on a strip chart recorder and decoded as DOY 296/297 and that agrees with the October date. Also the tape data appeared to be "too good quality for a live spacecraft at lunar distance". So that confirmed it and the tape 'owner' agreed, "All I can say is that, all this time, I thought that I had a dub of the EVA. I must have picked up the wrong tape at the end of a hectic day."

8. After some 450 emails on this subject alone - has anything been achieved? I think the answer is an emphatic YES!

a) It sparked renewed interest in the possibilities of data improvements that could be made if other tapes are found. Along the way we made extensive enquiries about the possibilities that other similar original data tapes might have survived. In particular, if tapes made at the Goldstone complex on 20 July 1969 could be found, they would contain GREATLY improved quality TV and other data recorded from the 210' antenna there. So far, no data tapes have been located at the most likely NASA centres, and it appears that most/all of the thousands of tapes sent to GSFC and Houston during Apollo were re-used after the data requirements of the time were satisfied. But hopefully the search goes on and something might turn up at the National Archives of the USA or some other centre.

b) The techniques to replay and extract the data and time codes have been refined at the DEL and if other tapes are discovered, there may be all sorts of possibilities for space historians and others to study data from some of the most defining moments in 20th century scientific history.

John Saxon
28 June 2004

8. The Search for the SSTV Tapes

It is now clear that if the 1-inch magnetic data tapes containing the raw SSTV can be found, then with modern digital imaging techniques, the original high quality TV of the historic first lunar EVA can be recovered for modern audiences. But until recently, the true nature of the images was not realised and the whereabouts of the tapes was a mystery.

For the past two years, a search has been undertaken by several former Apollo 11 personnel (many since retired) to locate these tapes and extract the original SSTV images. At one point it was feared that the tapes were simply erased and re-used on subsequent Apollo flights. Fortunately however, due to the outstanding efforts of Stan Lebar and Richard Nafzger, some good news has come to light on the whereabouts of the tapes. It now appears that the tapes were not erased as previously thought, but were in fact placed in storage at the National Archives in Washington. In 2005, some Apollo 9 tapes, recorded at the Canary Islands tracking station, were located in the archives with indications that the Apollo 11 tapes may also have been placed there in 1970. The nature of the way the Apollo 9 tapes were stored provides an invaluable guide on how the Apollo 11 tapes were stored and how they may be found. Briefly, the tapes are stored in non-standard sized, cardboard boxes. Each box contains about five tapes in canisters. This means that the Apollo 11 tapes from each station should be contained in just three or four such boxes. The recently found Apollo 9 tapes contained accession papers and other documents which can be used to guide the search for the Apollo 11 tapes.

Apollo 9 tapes found in non-standard sized boxes in the National Archives, Washington

Apollo 9 tapes in canisters. These were found in non-standard sized boxes in the National Archives.

Boxes Stored in the National Archives, Washington.

The brown non-standard sized boxes compared to a white, standard storage box in the National Archives.

Stan Lebar, in February 2006, showing the nature of the tapes being searched for and the size of the boxes that contain them. It is hoped that the height of the shelving required to store the boxes can be used to find the tapes. Stan believes that the people who originally stored the tapes would be the best source of information on where the tapes may be now.

9. Stan Lebar Describes His Search Efforts

In 2005, the current search for the tapes was initiated by Stan Lebar through Richard Nafzger of the Goddard Space Flight Center. This search has resulted in several promising leads. Richard Nafzger concurs with Stan's findings described below, and has requested that he continue the effort with his approval, and that of other NASA management. Stan describes his search to date:

I understand that there are those at JSC who are presently engaged in the new program effort to return to the moon and are seeking the very same tapes that we have been looking for these past couple of years. Rightly so, they want to review the Apollo lunar EVA telemetry data that was produced by Apollo in the 1969-70 time period, as indeed they should.

Below is a summary of the National Archive search for the Apollo 11 Lunar surface telemetry tapes I performed under the direction and support of Richard Nafzger, of NASA Goddard that was completed in March, 2006.

1. The three tracking sites which received the 10 frame rate Apollo 11 lunar camera television signal, as transmitted directly from the moon during the lunar EVA, were Goldstone, CA, Honeysuckle Creek, Australia and Parkes, Australia. The M-22 tape recorder, using 14 inch tape reels recording at 120 inches per second, was primarily used to record the transmissions. The procedures for shipping the original recorded tapes were defined by a NASA document. Each site was to prepare dupes of the processed tapes, send the original boxes of tapes (on the order of 12-15 tape reels with five tape reels per box) to Goddard and retain the dupes until so advised by Goddard. Upon receipt of the original tapes, Goddard was to verify that each tape received contained the original data as recorded at the tracking sites. When Goddard had verified that the original M-22 tapes from the sites contained data, each site was so notified and the dupes that were being retained by each site could then be erased and used for other purposes.

2. A search for documentation at Goddard that would show either the present stored location for the Apollo 11 tapes or disposition was never located. No reference documentation was ever found that referred to any of the Apollo mission telemetry data tapes. When the National Archives was queried about the transfer of the Apollo data tapes from Goddard, they indicated that they had received large transfers of tapes from Goddard during the 1970 period but could not attest to the fact that they were Apollo data tapes. They recommended that we contact the National Records Center (NRC) at Suitland, MD and initiate a search of their Goddard Accession documentation that was created for the transfer of all material to the National Archives.

3. My search at the National Archives was concentrated on finding the original Apollo 11 M-22 tapes as recorded at the tracking sites. Since all tapes stored by Goddard were identified by only the term "Magnetic Tape". I concentrated our search in the area where the non-standard boxes were stored. Special size shelving had been located throughout the non-standard storage area to hold boxes that contained the M-22 tape reels (and other tape reels of the same size). Although I came across large quantities of the non-standard boxes of data tapes identical to what we were searching for, none of the data tapes contained Apollo data and many were recorded in the late 1970's beyond the Apollo program time frame. The Accession for these tapes (and all other tapes stored at the Archives) are defined as "Magnetic Tapes" without reference to type (audio, telemetry data, experimental test data or PAO video). Nor was there any designation with regard to mission such as Apollo program or experimental test program ever stated or inferred. With the assistance of a member of NRC's staff, I was permitted to go directly to the stacks which stored these non-standard tape boxes to locate the stacks where these special shelves were located and examine the contents of these large tape boxes. We made detailed examinations of many of these boxes of tapes within an Accession and I was able to verify by the labels on the tape reels that the tapes were not Apollo related and in many instances the date of recording was beyond the date period when Apollo was active. What I did confirm and conclude was that each Accession was used to store tapes related to

a particular program or test effort and at no time did I find any mixing of tapes with regard to program, purpose or tape type. I felt confident that if we could find an Accession that contained any Apollo mission telemetry data that we would more than likely find the Apollo 11 M-22 telemetry data tapes within that Accession.

4. Our NRC records indicated that two boxes, each containing five reels of tape, were located in the Accession #69A4099 dated July 1970, were stored in the Oversize Box storage area in the Archive. We located the shelf space listed for these boxes and a large somewhat damaged box that was labelled Apollo with the 69A4099 Accession number. The box contained ten tape reels packed loosely in the box and believed to be the combined contents of the two boxes in the Accession #69A4099 that had not been recalled by Goddard. According to the labels, the telemetry recordings were made during one of the Apollo Earth orbits and received at the CYI Tracking Site (Canary Island) between March 3 and March 13, 1969. Copies of the labels were sent to Bill Wood (one of the retired Goldstone managers who worked the Apollo missions) and he along with retired personnel from the Australian sites identified the tapes as the result of scheduled data dump by Apollo 9 during the pass over the CYI Tracking Site. These ten tapes had been stored at the National Archives in Accession #69A4099 which was established on January 13, 1970 and was active between 1970 and 1984.

5. The documentation history for this Accession indicates that large quantities of tapes were continually being added to Accession #69A4099 during the period Apollo was active, and Goddard was continually requesting return of many of these tapes for evaluation during the same time period. At one point this Accession contained over 700 boxes of tapes that were in storage at the National Archive which could have been Apollo related telemetry data (on the order of 3500 tape reels). The National Records Center Documented History with regard to this Accession also shows that **all** of the tape boxes included in this Accession, were returned to Goddard by 1984 for permanent retention by Goddard.

6. Based on the pattern of information that I was able to ascertain from sampling the numerous other tape Accessions, it is my firm belief that Accession #69A4099 was indeed the Accession that was used to store all of the Apollo mission telemetry data tapes including the Apollo 11 tapes.

7. A subsequent search by Goddard found no record of Goddard having received these tapes back from the National Archives, nor any record of disposition of these tapes or any reference to the subject Accession. However, the National Record Center at the National Archives has formal records that attest to the fact that **all** of the many hundreds of tape boxes which had been listed in Accession #69A4099 had been returned to Goddard at Goddard's request for permanent retention.

8. On occasion, I did come across the Archives' smaller standard-size boxes that contained tapes that were related to one of the many Apollo experiments. However these tapes were undoubtedly of a different type and size tape reel than the M-22 tape reels that I was searching for and the M-22 reels could not possibly have fitted into those smaller boxes and I did not investigate the contents of these boxes. The Accession for these tapes listed them as "Magnetic Tapes" with no indication of type (data, audio etc.) or related program as was the case with all Accessions that were used for "Magnetic Tapes". However, it was apparent that the Accessions that referred to boxes that stored text documents, unlike those that were used for magnetic tapes, usually included some summary reference to the nature or purpose of the stored documentation.

9. None of the larger non-standard tape boxes, that were identical to the M-22 tape boxes, contained any Apollo tape data except for the ten Apollo 9 tape reels in Accession #69A4099. I would suspect that there are reports that include data evaluation of the mission telemetry data that was performed under a subcontract to JSC that is more than likely stored at The National Archives in standard text documentation boxes.

10. Conclusion:

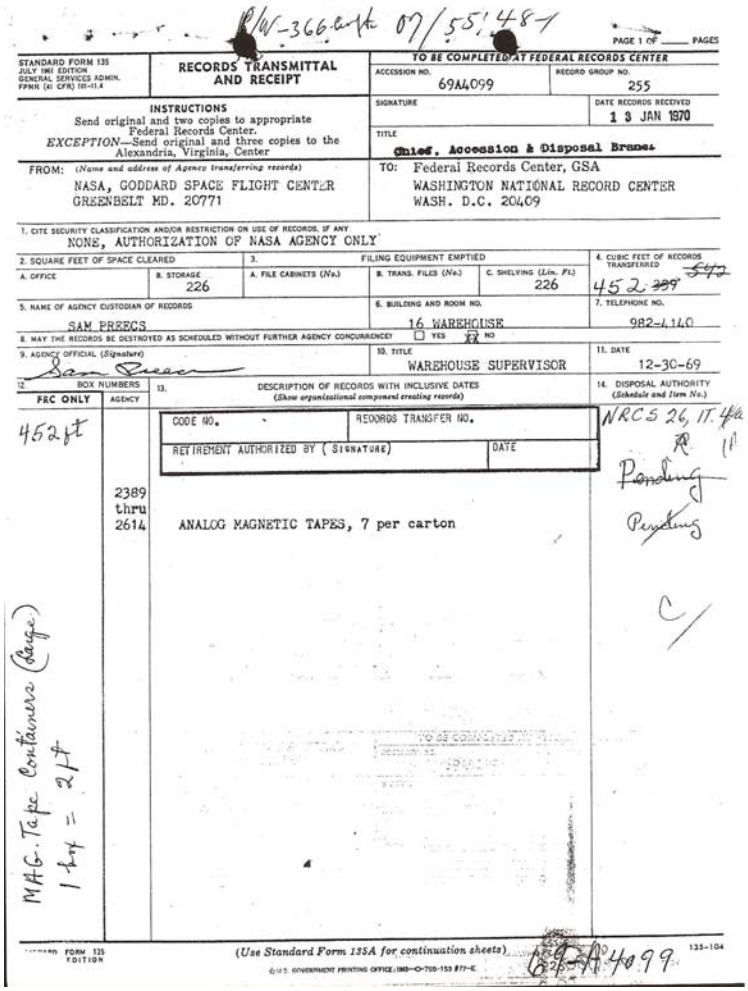
The tapes we are searching for were most likely stored in Accession #69A4099 which according to the National Archives records, were transferred back to Goddard. The answer as to what became of the tapes can only be determined by Goddard. In a like manner, answers as to where these tapes might reside today can only be determined by digging into the Goddard organization and procedures of the time period during which the Accession #69A4099 was active, and trying to contact some of the members who were at the time responsible for managing this particular activity. The organization that exists at Goddard today is very much different from what was in effect thirty-seven years ago, as well as the methodology with regard to the handling of this type of material. The information, if it does exist, resides with those who managed these efforts during the 1970's. If we want to find out where they are, that's where we must go if these treasured archival tapes are to be located. The search has shifted back to Goddard and, under the leadership of Dick Nafzger, a new phase of the search is being discussed within Goddard to determine the organization that is best qualified to oversee and continue the search.

These tapes represent the unprocessed original television recorded presentation of mankind's first steps on a celestial body other than Earth. It is important that the very best recording of this remarkable NASA achievement be passed on for the benefit of all mankind. We know that the original video as produced by the Lunar Television Camera was far superior to the converted imagery as received in Houston on that fateful evening and with today's digital techniques, the video can be digitized and the type of conversion process that existed in 1969 can be bypassed using today's technology. The end product would be a DVD whose video presentation would be brighter and consist of far greater detail definition than NASA's low resolution 1969 archival kinescope which represents our only official recording of mankind's first adventure on the surface of our Moon.

The above referenced search for the Apollo tapes could not have been accomplished without the help and support of some very dedicated people at NASA Goddard and the NARA's National Record Center, as well as many retired and dedicated Tracking Site personnel at Goldstone, CA, Honeysuckle Creek, Australia and Parkes Observatory, Australia and those who are active members of the HSK Group in Australia. I would particularly like to thank the following for their help and unlimited patience with my many requests:

National Record Center:
Judith Barnes, Chief Accession and Disposal Branch
Micheal Waesche
Krista Donnelly
NASA Goddard:
Richard Nafzger
Elizabeth Booker
Patricia Sutherland
Dick Bouchard
Smithsonian Institute:
James David, Curator Space History
Others:
Bill Wood, Goldstone, CA Retired
Mike Dinn, Honeysuckle Creek, Aus., Retired
John Saxon, Honeysuckle Creek, Aus., Retired
Colin Mackellar, Aus., HSK Group
John Sarkissian, Parkes, Aus. Active

Stan Lebar
4 April 2006 (revised 19 May 2006)



STANDARD FORM 135 JULY 1961 EDITION GENERAL SERVICES ADMIN. FPMR (41 CFR) 101-11.4

RECORDS TRANSMITTAL AND RECEIPT

PAGE 1 OF ____ PAGES

TO BE COMPLETED AT FEDERAL RECORDS CENTER

ACCESSION NO. 69A4099 | RECORD GROUP NO. 255

SIGNATURE | DATE RECORDS RECEIVED 1 3 JAN 1970

TITLE Chief, Accession & Disposal Branch

INSTRUCTIONS
Send original and two copies to appropriate Federal Records Center.
EXCEPTION—Send original and three copies to the Alexandria, Virginia, Center

FROM: (*Name and address of Agency transferring records*)
NASA, GODDARD SPACE FLIGHT CENTER
GREENBELT MD. 20771

TO: Federal Records Center, GSA
WASHINGTON NATIONAL RECORD CENTER
WASH. D.C. 20409

1. CITE SECURITY CLASSIFICATION AND/OR RESTRICTION ON USE OF RECORDS, IF ANY
NONE, AUTHORIZATION OF NASA AGENCY ONLY

2. SQUARE FEET OF SPACE CLEARED		3. FILING EQUIPMENT EMPTIED			4. CUBIC FEET OF RECORDS TRANSFERRED
A. OFFICE	B. STORAGE 226	A. FILE CABINETS (No.)	B. TRANS. FILES (No.)	C. SHELVING (Lin. Ft.) 226	452 ~~339~~ ~~542~~

5. NAME OF AGENCY CUSTODIAN OF RECORDS	6. BUILDING AND ROOM NO.	7. TELEPHONE NO.
SAM PREECS	16 WAREHOUSE	982-4140

8. MAY THE RECORDS BE DESTROYED AS SCHEDULED WITHOUT FURTHER AGENCY CONCURRENCE? ☐ YES ☒ NO

9. AGENCY OFFICIAL (*Signature*)	10. TITLE	11. DATE
Sam Preecs	WAREHOUSE SUPERVISOR	12-30-69

12. BOX NUMBERS FRC ONLY	AGENCY	13. DESCRIPTION OF RECORDS WITH INCLUSIVE DATES (*Show organizational component creating records*)	14. DISPOSAL AUTHORITY (*Schedule and Item No.*)
452ft		CODE NO. · RECORDS TRANSFER NO. · RETIREMENT AUTHORIZED BY (SIGNATURE) · DATE	NRCS 26, 11.4a R 11 Pending Pending
	2389 thru 2614	ANALOG MAGNETIC TAPES, 7 per carton	

MAG. Tape Containers (large) 1 ft = 2ft

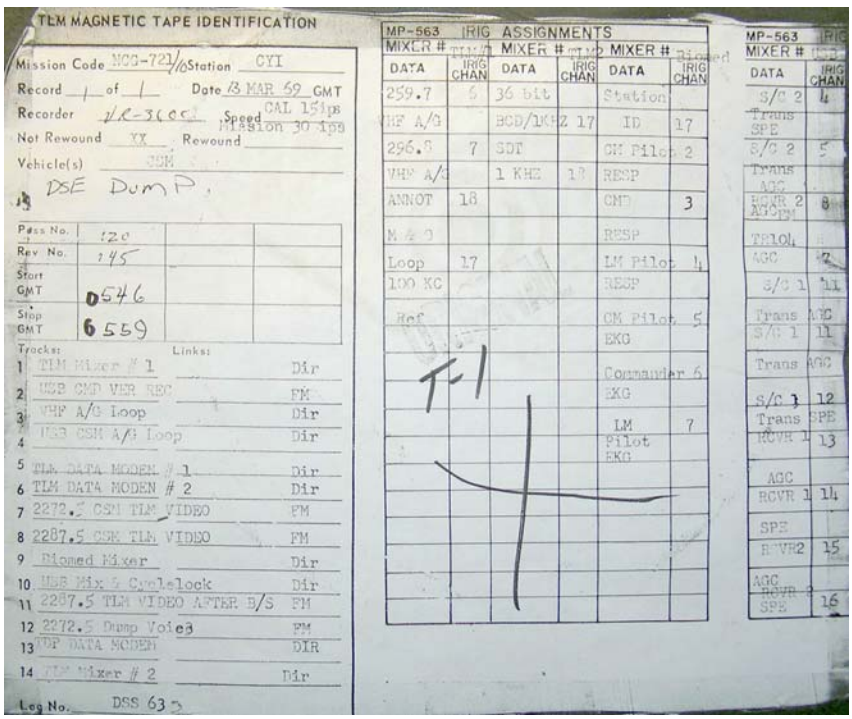
C/

NSN 7540-00-634-4032 FORM 135 EDITION (*Use Standard Form 135A for continuation sheets*) 135-104

U.S. GOVERNMENT PRINTING OFFICE: 1965—O-755-153 877-E

69A4099

Accession Document #69A4099. Note: Sam Preecs is the Agency Official who signed the Accession. He is the most likely person to know where the tapes are. Where is Sam today?



TLM MAGNETIC TAPE IDENTIFICATION

Mission Code MCC-721/10 Station CYI
Record 1 of 1 Date 13 MAR 69 GMT
Recorder VR-3600 Speed CAL 15ips Mission 30 ips
Not Rewound XX Rewound
Vehicle(s) CSM
DSE Dump.

Pass No.	120		
Rev No.	145		
Start GMT	D546		
Stop GMT	6559		

Tracks: Links:

1	TLM Mixer # 1	Dir
2	USB CMD VHF REC	FM
3	VHF A/G Loop	Dir
4	USB CSM A/G Loop	Dir
5	TLM DATA MODEM # 1	Dir
6	TLM DATA MODEM # 2	Dir
7	2272.5 CSM TLM VIDEO	FM
8	2287.5 CSM TLM VIDEO	FM
9	Biomed Mixer	Dir
10	USB Mix 5 Cyclelock	Dir
11	2287.5 TLM VIDEO AFTER B/S	FM
12	2272.5 Dump Voice	FM
13	VDP DATA MODEM	DIR
14	TLM Mixer # 2	Dir

Log No. DSS 63

MP-563 IRIG ASSIGNMENTS

MIXER #		MIXER #		MIXER #	
DATA	IRIG CHAN	DATA	IRIG CHAN	DATA	IRIG CHAN
259.7	5	36 bit		Station	
VHF A/G		BCD/1KHZ	17	ID	17
296.5	7	SDT		CM Pilot	2
VHF A/G		1 KHZ	17	RESP	
ANNOT	18			CMD	3
M & O				RESP	
Loop	17			LM Pilot	4
100 KC				RESP	
Ref				CM Pilot EKG	5
				Commander EKG	6
				LM Pilot EKG	7

T-1

MP-563 IRIG MIXER #

DATA	IRIG CHAN
S/C 2 Trans SPE	4
S/C 2 Trans AGC	5
RCVR 2 AGC	8
TP101 AGC	9
S/C 1 Trans AGC	11
S/C 1 Trans AGC	11
S/C 1 Trans SPE	12
RCVR 1 AGC	13
RCVR 1 SPE	14
RCVR 2 AGC	15
RCVR 2 SPE	16

The magnetic tape identification document found with the Apollo 9 tapes. Note the date of 13 March 1969 identifying it as Apollo 9.

10. The Data Evaluation Lab (DEL) at Goddard Space Flight Center

Finding the Apollo 11 SSTV tapes is just half the problem. A method of playing back the tapes and decoding the data is essential. Richard Nafzger of the Goddard Space Flight Center was the engineer responsible for all the systems hardware in support of Apollo 11 TV in July 1969. He is currently one of the engineers responsible for the Data Evaluation Lab (DEL) at the Goddard Space Flight Center where the SSTV tapes will be processed if they are ever found.

The DEL is currently the only known place that has the capability and expertise to replay original Apollo data. Sadly, because of budget cutbacks, the DEL is slated for permanent closure. This was to have happened on 27 January 2006, but it received a temporary reprieve and will now be shutdown in October 2006.

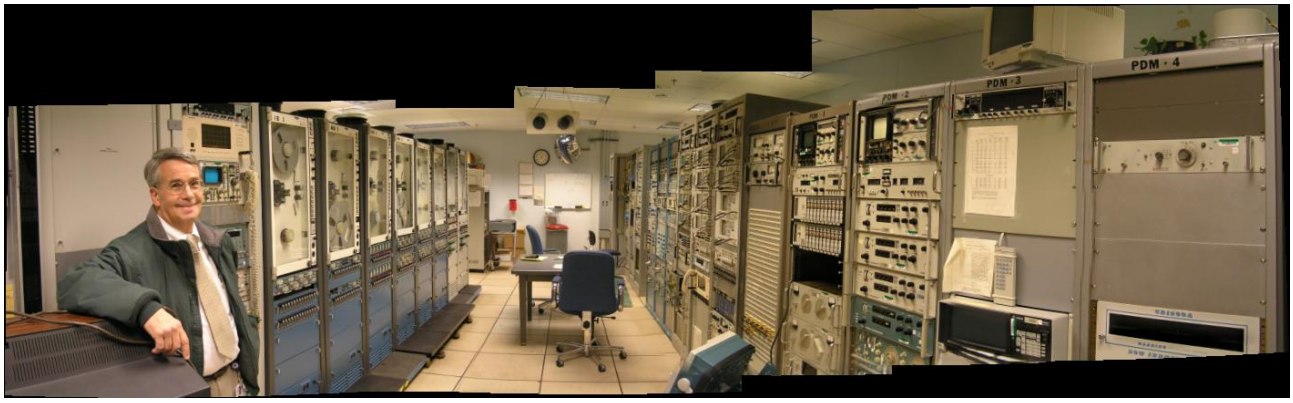
It goes without saying that the loss of the DEL would be a severe blow to the efforts to recover and restore the TV from the Apollo 11 mission. It will also mean the near impossibility of playing back much of the media that NASA has deposited in the National Archives - so future generations will not be able to study the expensive and wonderful achievements of previous generations. If it is eventually shutdown, then all efforts should be made for some of the equipment to be transferred to other departments and held there for later use. The Goddard Space Flight Center's Richard Nafzger and Dick Bouchard, the manager of the DEL, agree that the hardware in the DEL needs to be preserved since it is critical to be able to process and view data from past Apollo missions. They are attempting to assure the future of the DEL and its equipment.

The DEL contains several magnetic tape players and recorders as well as the decoders. It is hoped that the SSTV tapes can be found before the lab is closed.

The DEL in Building #25 at GSFC

The entrance to the DEL

11. Richard Nafzger Describes the DEL



Panoramic view of the DEL (tape players on the left near Richard, demodulators on the right)

"Hi I'm Dick Nafzger at Goddard, and we're looking in the DEL lab at a Bell and Howell VR-3700 recorder which is the same as the Mincom recorders used for recording the slow-scan television from the Apollo 11 and subsequent lunar missions. These recorders had 14 tracks and recorded video as well as data at 120 inches-per-second. Once these were played back, they were played to demodulators which you'll see are located on the other side of this room. These are preserved from the Apollo days, so it's a very rare piece of hardware, and they're all operating at 100%. These demodulators are now located in racks across from here and this is where we take all 14 tracks, demux them, either display them if they're video or listen to them if they're audio or again print them out as telemetry data. This is all equipment that's been preserved at DEL to look at old science and video from past missions and is the heart and parcel of what we're trying to preserve in order to look at the Apollo 11 and other Apollo missions if we do get lucky and come up with the tapes that we've been searching for through archives."

Richard Nafzger
28 February 2006.

Richard Nafzger with the Bell and Howell VR-3700B recorders

Richard with the demodulators

A movie and audio of the above can be downloaded from the following web site:
http://www.parkes.atnf.csiro.au/people/jsarkiss/del/del.mpg and;
http://www.parkes.atnf.csiro.au/people/jsarkiss/del/del.mp3

12. Conclusion

Over the past few years, a search for the missing Apollo 11 SSTV tapes has been conducted by several former Apollo 11 personnel. The purpose of the search is to recover the original high quality TV of the first lunar EVA. To date, the tapes have not been found.

Remarkably, the Apollo 11 TV pictures watched live by the world were of poorer quality than those actually received by the three tracking stations involved in their reception. The signal as sent from the Moon was initially degraded by the scan-conversion process, producing lower resolution images and introducing additional signal noise. There is also evidence that the transmission of the scan-converted TV to Houston caused additional signal degradation. Sadly, it is this degraded TV that is the only version currently available to the public and historians.

However, as has been demonstrated, the unconverted slow-scan TV, received directly from the Moon, was of superior quality and resolution to the scan-converted images broadcast live to the world. If the tapes could be located, then by using modern digital image processing techniques, it is possible to recover the original high quality TV of the first lunar EVA and to make it available to the public for the first time.

In July 1969, only a fortunate handful of people at the three tracking stations, and in Sydney, viewed the moonwalk in its original, high quality format. With the renewed effort and interest in returning to the Moon, we owe it to future generations to find the data tapes in order to witness the first moonwalk as it was originally intended to be seen - with the greatest possible clarity.

The Apollo 11 mission represents a defining moment in human history. For the sake of posterity and for the benefit of future generations, it is imperative that the search for the Apollo 11 magnetic data tapes be more vigorously pursued so that the slow-scan TV can be restored to its original form before the tapes deteriorate beyond repair.

Thanks to the efforts of a dedicated few former Apollo 11 personnel, working with limited resources in the United States and Australia, the search for the Apollo 11 SSTV tapes continues. If the full resources of NASA could be brought to bear on this enterprise, the fate and whereabouts of the tapes can be very quickly determined. It is hoped that this report will contribute a little toward this goal.

Where are the tapes?

John Sarkissian
CSIRO Parkes Observatory
21 May 2006.

John.Sarkissian@csiro.au

References

1. "On Eagle's Wings: The Parkes Observatory's Support of the Apollo 11 Mission" by John Sarkissian. *Publications of the Astronomical Society of Australia (PASA)*, Vol. 18, 2001, pp 287-310.
See the web version of the report at URL: http://www.parkes.atnf.csiro.au/apollo11/

2. Conversations with, and correspondence received from, Stan Lebar, Westinghouse ALSC Program Manager (retired).

3. Conversations with, and correspondence received from, Richard Nafzger, Goddard Space Flight Center (still active).

4. Conversations with, and correspondence received from, Bill Wood, Goldstone USB Lead Engineer (retired).

5. "Apollo Television". Essay by Bill Wood on the Apollo Lunar Surface Journal edited by Eric Jones.
See the report at URL: http://www.hq.nasa.gov/alsj/alsj-TVEssay.html

6. Conversations with, and correspondence received from, Mike Dinn, Honeysuckle Creek Deputy Station Director in charge of Operations (retired).

7. Conversations with, and correspondence received from, John Saxon, Honeysuckle Creek Operations Supervisor (retired).

8. Correspondence received from Richard Holl, the Parkes scan-converter operator in Paddington, Sydney, in July 1969 (retired).

9. Images of the Parkes Control Room in July 1969 supplied courtesy of the CSIRO Australia Telescope National Facility.

10. Polaroid image of the Parkes SSTV supplied courtesy of Bob Goodman, OTC International Co-ordinator for all the transmissions between Australia and the USA during the Apollo 11 mission in July 1969 (retired)

11. Images of the tape search in the US National Archives, Washington, supplied courtesy of Stan Lebar.

12. 35mm photograph of the SSTV picture from Honeysuckle Creek by Ed von Renouard, Honeysuckle Creek Video Engineer (retired), supplied courtesy of Colin Mackellar, space enthusiast and webmaster of the Honeysuckle Creek web site at URL: http://www.honeysucklecreek.net/

13. Images of the Parkes and Goldstone scan-converted TV pictures provided courtesy of Colin Mackellar from his report at URL: http://www.honeysucklecreek.net/Apollo_11/Apollo_11_TV_comparisons.pdf

14. Images of the Goldstone scan-converter and Polaroid image of the improved Goldstone SSTV supplied courtesy of Bill Wood.

15. Image of the Honeysuckle Creek scan-converter supplied courtesy of Hamish Lindsay, Honeysuckle Creek USB Engineer (retired).

16. Image of the Parkes scan-converter supplied courtesy of Richard Holl.

17. Improved Goldstone image of Armstrong descending the LM ladder (NASA image S69-42583)

18. Images of the ALSC stowed in the MESA during training taken from the Apollo Lunar Surface Journal. NASA Images S69-31575 and S69-31585. Scans by Kipp Teague.

19. All other images are provided by the author.

Acknowledgments

I thank the following individuals for their support in helping me in my researches and in allowing me to assist in the search for the Apollo 11 SSTV tapes.

My gratitude to Dr John Reynolds, Officer-in-Charge of the CSIRO Parkes Observatory, for extending continued support over nine years and allowing me to research the role of the Parkes Observatory in the Apollo 11 mission and to conduct the initial search for the Apollo 11 SSTV tapes in 1999.

My gratitude to Mr Marshall Cloyd for giving me the opportunity to visit the United States and meet Mr Stan Lebar and Mr Richard Nafzger to assist with the search a little closer to the source.

My gratitude to Mr Stan Lebar and Mr Richard Nafzger for their patience and wise counsel. Their knowledge, dedication and enthusiasm for the search of the tapes is encouraging to all involved.