



# The Apollo 11 Telemetry Data Recordings: A Final Report



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When astronauts landed on the moon on July 20, 1969, the Eagle lander carried a small, unconventional television camera affixed to the inside of the door. It had one mission. Once astronauts opened the door and activated the camera, it would begin shooting live images of the historic event, transmitting the raw footage by way of an antenna to Earth below. There, engineers at three tracking stations would tape the original signals onto one-inch telemetry tapes for backup and then also convert the raw feed into a conventional format compatible with American broadcast standards.

The camera did its job.

As Neil Armstrong descended from the ladder to take that historic first step, hundreds of millions of viewers watched spellbound as the drama unfolded. NASA had given them something they had never seen before: a man walking on the moon via live television.

What most people did not realize, however, is that the television footage they viewed was actually inferior to what ground station engineers saw as the raw footage arrived from the moon 250,000 miles away. While the public saw blurry, ghostlike images, the engineers working at NASA's tracking stations in California and Australia saw clear, crisp video on special television monitors capable of displaying the unconventional video. Although NASA engineers knew that the scan converter would degrade the original picture quality, they viewed it as an engineering trade-off. NASA wanted live television and the only way to provide it at the time was with scan-conversion technology, despite the degradation.



In the triumph of the day, no one at the tracking stations considered these differences and certainly the public was unaware. The engineers boxed the one-inch telemetry tapes wound onto 14-inch canister reels—which served no other purpose than to provide backup if the live relay failed—and shipped them to the Goddard Space Flight Center. From there, the tapes were sent to the Washington National Records Center (WRNC) in Suitland, Md.

The engineers never saw the back-up telemetry tapes again.



## Fast Forward to the Present

Much has happened over the ensuing years. Today, it is hard to imagine life without the Internet, cell phones, and high-definition television—innovations made possible by the revolution in digital technology. What was impossible nearly 40 years ago is now possible. The Apollo 11 telemetry tapes certainly provide a case in point. Using digital technology, technicians today could convert the raw signals into high-quality video, allowing the world to see what only a handful of engineers saw in 1969.

The desire to show the Apollo 11 moonwalk as it originally was received and recorded is what catalyzed a core team of U.S. and Australian Apollo enthusiasts, former NASA contractors, and a current Agency employee to find the one-inch telemetry backup tapes. They wanted to give the public a clearer picture of that iconic moment in American history. Enlisting the support of current Goddard Space Flight Center employees, these individuals spent thousands of hours tracking down and interviewing former NASA employees, pouring over memos, telex messages, and databases, and visiting possible storage sites.

Each had a special role in the effort:

- *John Sarkissian*, an operations scientist and the de facto historian of the Parkes Radio Observatory in Australia, initiated the search;
- *Colin Mackellar*, an avowed Apollo enthusiast, fanned interest through his posting of images on a website that paid tribute to those who worked at Australia's Honeysuckle Creek tracking station before the facility closed in 1981;
- *Stan Lebar*, a retired Westinghouse Electric program manager who oversaw the development of the special Apollo 11 camera, volunteered his time to search for the tapes;
- *Bill Wood*, a retired Bendix engineer who served as the crew supervisor at the Goldstone tracking station in California, assisted in contacting retired NASA officials who may have known of the tapes' whereabouts; and
- *Richard Nafzger*, who oversaw television processing at the ground tracking sites during the Apollo 11 mission, is today a Goddard employee who was able to access resources at the Center to help in the search. He soon became a pivotal figure, the team's unofficial leader.

## Unexpected Outcome

By all accounts, the epic-like search has not ended as anyone had expected. The searchers never found what they set out to uncover. Aside from a few canisters of Apollo 9 telemetry tapes still stored at the WNRC, the Apollo-era telemetry tapes no longer exist—anywhere. However, this disappointing discovery does not mean the Herculean effort that spanned more than eight years ended in vain. The team uncovered the best television-formatted recordings of the Apollo 11 moon landing and

has secured NASA funding to apply modern-day digital technology to dramatically enhance the quality of these tapes.

Will the public truly experience what just a handful of engineers witnessed 40 years ago? The answer is probably no, says Nafzger. “However, our search for the original tapes gave rise to the restoration of what we do have. Now that the 40<sup>th</sup> anniversary is upon us, it is fitting that we release the enhanced video and explain why the raw-feed tapes are not with us today.”

## **Starting at the Beginning**

To fully understand the loss of the original telemetry tapes, one needs to consider the technology of the day and appreciate the fact that live broadcasts from remote locations were difficult. No one was even sure it could be done from the surface of the moon.

Given the importance of the Apollo 11 mission, however, mission planners understood the necessity of television. But because they did not know whether a live broadcast was technologically feasible, they stipulated that voice, telemetry, biomedical data, and television all share the same transmission link from an antenna atop the Lunar Module. Consequently, the Agency budgeted only 500 kHz of the available bandwidth to television—far less than the 4.5MHz then used by the commercial broadcast television industry.

To cope with this reduction in bandwidth, NASA hired the Westinghouse Electric Corporation in Baltimore, Md., to develop a special television camera that used a non-standard scan format of 10 frames per second and 320 lines of resolution, compared with the U.S. television standard of 30 frames per second and 525 lines.



Because commercial television could not broadcast the slow-scan format, NASA hired the RCA Corporation to build a scan converter to optically and electronically adapt these images to a standard U.S. broadcast TV signal. The tracking stations converted the signals and transmitted them by way of microwave links, Intelsat communications satellites, and AT&T analog landlines to Mission Control in Houston. By the time the images appeared on international television, they were substantially degraded.

But at the time, who noticed? Certainly not the hundreds of millions of people worldwide who sat mesmerized by the fuzzy images on their television sets.

But Lebar, who managed Westinghouse's lunar camera project, noticed. Now in his 80s, Lebar said he sat stunned watching the drama unfold on the television monitors in Houston. "I kept thinking it just doesn't look as clear and crisp as I expected. What's going on here?" From testing, he knew the camera was capable of producing good television, despite the reduced bandwidth. What he did not know, however, was that the converter used to reformat the signal would degrade the quality of the video to the extent that it did. Furthermore, long-distance transmission of the video from the tracking stations to Houston further reduced the quality.

Though disappointed, he let his initial emotions pass and allowed himself to be caught up in the moment. "No one was unhappy," he said. "We were all in seventh heaven." America had pulled off the impossible. In less than 10 years, the Nation had landed a man on the moon and showed the world, via live television, that it could be done.

NASA never again used the camera Lebar created. In addition to pulling off one of the most important triumphs of the 20<sup>th</sup> century, NASA discovered from Apollo 11 that it could broadcast live video using standard, higher-bandwidth television formats. It no longer needed to convert the signal to make video accessible to the public. In other words, viewers would see the broadcast in clear, sharp focus just as a conventional video camera captured the event.

But no one knew then. Consequently, only those working at the three tracking stations—Goldstone, Honeysuckle Creek, and Parkes—saw the feed as it came directly from the moon and was played on their slow-scan television monitors. As the converted signal made its way to Houston, the engineers at the tracking stations recorded the raw feed onto one-inch magnetic tapes using M-22 recorders, as required by NASA protocol. They stored the backup tapes in metal canisters, placed the canisters in boxes, and then shipped them by airfreight to Goddard. After a months-long holding period, during which Goddard personnel reviewed the tapes' content and determined that the Apollo program no longer needed the data, employees sent the canisters to WNRC for storage.

### **The Australian Connection**

Sarkissian, the operations scientist and the de facto historian of the Parkes station, began researching the whereabouts of the slow-scan tapes in 1997 when a British author called him to get information about Parkes's role in the Apollo 11 mission. Had the author not queried Sarkissian, it is conceivable that the search for the tapes would not have begun.

But in his relentless quest to confirm which of the three tracking stations actually provided the first steps video, Sarkissian discovered in 2001 the existence of a Polaroid image taken as the raw-feed video played on the special slow-scan monitor. Even on a Polaroid print, it was obvious to Sarkissian that the images were far better than those broadcast in 1969.

One year later in another part of Australia, John Saxon, a retiree who formerly served as the operations supervisor at Honeysuckle Creek, attended a reunion picnic. Another Honeysuckle retiree brought along a magnetic-tape canister and passed it around for others to see. The retiree claimed he dubbed the tape from the original M-22 recording as a keepsake of the historic day. For 36 years, the tape languished in the garage of his Canberra home.

According to Saxon, no one thought much of the tape then. An interesting piece of memorabilia, yes, but without a player, no one would ever know what the tape actually contained or whether the data survived the less-than-ideal storage conditions. Furthermore, NASA had stored the originals safely away in the U.S. At least, that is what he figured at the time.

By mid-2003, however, interest began to take on a life of its own. Another set of photos had surfaced; this time they were scanned and posted on the Honeysuckle Creek Web site managed by Mackellar, an Apollo enthusiast who created the site in tribute to those who worked at the station before it closed in 1981. Within six months, the Australians had launched an all-out search for the original recordings and a machine that could play the tape found in the Canberra garage.

### **The American Contingent**

Across the Pacific Ocean, Wood also had begun his own research. The retired senior engineer at the Goldstone tracking station in California was gathering information for an article to appear in the *NASA Apollo Lunar Surface Journal* about how NASA used television during the Apollo program. Like his Australian colleagues, with whom he had communicated via email, he, too had obtained a Polaroid image taken from the slow-scan television monitor at Goldstone. What he wanted were the original recordings from which to make screen captures to help illustrate his article.

After several calls to current and former NASA employees as well as a video producer who had made a DVD set about Apollo 11, he learned that the scan-converted 16-mm kinescope stored in the National Archives offered the best available video quality. Not ready to give up, he also contacted Lebar—the man who had made television possible in the first place—to enlist his support in the search effort.

“When Bill showed me the photograph, I immediately said yes,” Lebar recalled. He knew what the Westinghouse camera was capable of producing. He also understood the possibilities promised by digital technology. “I felt there was enough proof.”

### **The Dub**

At least initially, hopes ran high. The Australians had located Nafzger at the Goddard Space Flight Center. Nafzger told them that the world’s last remaining seven-foot-tall analog machine capable of playing the slow-scan tapes still existed at Goddard’s Data

Evaluation Lab (DEL). He also told them time was running short. Even though the Center planned to mothball the facility within the next few months, Nafzger convinced management to maintain the facility until he and his team could play the Australians' tape.

Anxious to deliver the tape as quickly as possible, Saxon contacted Neal Newman, the NASA Representative to Australia and Southeast Asia. Newman not only guaranteed "110 percent support from himself and the U.S. Embassy," but even offered to hand deliver the tape to Nafzger on June 10, 2004. After having the tape "conditioned" by Australia's National Film and Sound Archive, a film company, and allowing the tape to acclimate in the lab for 24 hours, Nafzger and DEL Manager Dick Bouchard reported to work the next day. As millions of other Americans watched President Reagan's state funeral on television, they fed the tape into the machine and discovered almost immediately that it contained chatter and simulation data from October 1967.

When told of the results, the tape's owner said that in the confusion of the day he must have picked up the wrong reel. For 36 years, he kept a tape that contained nothing but chatter.

Though disappointing, the playback made the retirees and volunteers more determined to find the original recordings, recalled Saxon. It proved that the antiquated DEL could still play the magnetic tapes—even those stored under less-than-optimal conditions. "If other tapes are discovered, there may be all sorts of possibilities for space historians and others to study data from one of the most defining moments in 20<sup>th</sup> century scientific history," he said.

Also buoyed by the possibilities, Wood and Lebar agreed to focus their efforts on the Goddard Space Flight Center now that their Australian counterparts had exhausted the search there, finding nothing in the way of one-inch Apollo 11 tapes. From conversations with retirees, they knew Goddard received the tapes; they just were not sure which organization in particular. It would take them nearly two years before they found out.

## **The Initial Search**

Imagine people's garages, basements, and attics. Across America, people store all manner boxes, containing a life's worth of possessions and keepsakes. Now just imagine what an agency as large as NASA would generate in a single day. Those belongings, which include everything from video, written correspondence, photography, and reports, often go to the National Archives, especially if they serve an important historical purpose. Other materials go to the WNRC or to privately operated facilities for temporary storage. Some are even kept in buildings on campus. Regardless of where they go, all must abide by records-keeping procedures.

Wood, Lebar, and Nafzger, who agreed to support the retirees' efforts to the extent that he could be given his job responsibilities, were novices to NASA's storage policies and procedures — especially those carried out four decades ago. Without documentation, they knew they would never find what they were looking for.

In mid-2005, Lebar and Nafzger contacted Goddard's Public Affairs Office and the Information and Logistics Management Division (Code 270), the Center's official records-keeping organization, to inform these groups of the informal search and to see if they could enlist their help. Nafzger also set up a meeting with the Information Technology and Communications Directorate and others to develop a strategy. By this point, Lebar and Wood also had signed a government contract volunteering their services to help Nafzger with the search.

"Basically Stan and Dick said they were looking for historic magnetic telemetry tapes," recalled a records management employee. "They had no idea of the mountain of stuff here."

While Lebar searched Goddard's library for documents, Code 270 employees combed the filing cabinets looking for Apollo-related documentation—a task made more difficult because Goddard has not automated old records due to budget constraints. Lebar also contacted the National Archives in College Park, Md., to determine if the "Nation's attic" had a copy of the tapes. Confirming what Wood discovered months earlier, the tapes were not there. The only video contained in that collection was the broadcast film that hundreds of millions of people saw on July 20, 1969.

The first break came when Code 270 employees located seven green ledger books listing the accession numbers issued since 1963 to transfer materials to the WNRC. "I had always been under the assumption that every Goddard accession was listed in these books," an employee said. She was mistaken.

## **Gaps in Documentation**

Although Goddard policy now requires organizations to work through Code 270 when storing and withdrawing records from the WNRC, it was not always that way. Records-keeping personnel said that in the past, several organizations with large data holdings managed their own records and their own paperwork—the so-called SF 135s needed to transfer records to the WNRC and the Form 11s to withdraw them. The practice stopped in the late 1990s when NASA Headquarters became concerned that important data could be lost without a stricter accounting of what these organizations shipped and withdrew.

After examining the green ledger books, employees began to suspect that the organization responsible for the Apollo tapes enjoyed the same working arrangement. The accession numbers listed in the ledger books were not in sequential order. In fact, employees found large gaps, indicating that the records office had assigned those



numbers to other organizations. “My reaction was that the processes obviously were different then,” an employee recalled. “Some type of agreement must have allowed people to send records outside of the normal records process.”

When employees scoured the filing cabinets for the forms needed to transfer and withdraw Apollo-era records, again they found gaps. Although the paperwork described in detail the contents of boxes containing correspondence, reports, and memos, the forms lacked details for other types of records. Accessions and corresponding paperwork assigned to tapes, for example, were simply labeled “magnetic tapes,” with no further identification of the mission or whether the tapes contained audio, commercial video, telemetry, or computer data.

Whether the Apollo 11 backup telemetry tapes ever flowed through Code 270, no one could tell from the vague “magnetic tape” descriptor. Even so, employees gave the accession numbers to Nafzger and Lebar and they met with the Smithsonian Curator for Space History and the WNRC Chief of the Accessions Branch to learn how to best proceed with the information they had.

### **The Proverbial Needle in a Haystack**

Looking back, Lebar’s first foray into WNRC’s vast holdings was like finding the proverbial needle in a haystack, he said. WNRC personnel had printed the complete listing of Goddard accessions stored at the WNRC, including those for which the Goddard’s records department had no documentation. After about two weeks, though, he realized the futility of the task.

Although he limited his effort to the 1969-1975 timeframe, the list of accessions for magnetic tapes still involved tens of thousands of boxes. “I realized this was going to take a lot of time and I needed a way to narrow down the search,” said Lebar. “We all agreed that to blindly recall tape boxes for examination would be an exercise in futility.”



### **Oversized Boxes**

On a hunch, Lebar asked if the WNRC used a standard-size box to store the materials it received. WNRC employees advised him that WNRC used a one cubic-foot standard box. Lebar then asked Nafzger to give him a sample of the M-22 tape reel. It became immediately apparent that a 14-inch tape reel, when packaged inside a metal canister and then an outer cardboard box, would never fit inside the standard storage box. WNRC staff members told Lebar that boxes larger than the standard were called “Z”

boxes, which WNRC stored on specially designed shelves to accommodate their larger size.

At last, Lebar felt he was making progress. He then asked the WNRC staff to produce a printout only of those accessions stored in the “Z” boxes. He gave the file to Wood, who further massaged the list by date, narrowing down candidate boxes to about 5,000. From that printout, Lebar and Wood developed a more manageable accession list.

### **A Trip Through the Stacks**

In January 2006, Lebar returned to WNRC, this time armed with a map showing the location of all the oversize shelves, a printout of the magnetic-tape accessions stored in these areas, and permission from the Goddard records department to open the boxes. Having never seen the stacks before, Lebar was overwhelmed by what he saw. Each stack contained up to 20 shelves, separated by two-foot aisles. “It goes on forever,” he said. “If there was ever a time when I thought no one would find anything it was then.”

Accompanied by a WNRC staff member who joined the organization in 1974 and was familiar with the operation there, Lebar spent days sampling the contents of boxes stored under every accession created during the Apollo era. The good news was that each accession dealt with a specific mission or experiment. In other words, the contents were not mixed, which would have made a search infinitely more difficult and time consuming. He also confirmed that the magnetic tapes used during the Apollo program fit roughly five to a box.

After several days, though, he still had not found a single Apollo tape.

Just to make sure he and the WNRC staff member had not overlooked anything, they went through the stacks again. On the second pass, they came to a bottom shelf that was supposed to house two boxes stored under accession 255-69A-4099. The shelf was empty. This time, though, the WNRC employee got down on his hands and knees to peer into the back of the shelf.

That is when he found a single, slightly damaged box containing nine tapes labeled “NCG-721.” “Immediately, I knew it was Apollo,” Lebar said.

Although they contained Apollo 9 mission data recorded at the Canary Island tracking station in 1969, the accompanying paperwork listed the 255-69A-4099 accession number—apparently the number Goddard had assigned to the storage of Apollo magnetic tapes. Lebar finally had something to work with.

### **Another Dead End**

Back at Goddard, Code 270 personnel searched through the green ledger books to see what they could learn about that particular accession. They found nothing, confirming

their suspicions that the organization responsible for the tapes had worked outside the records department. The WNRC, meanwhile, had better luck finding the original paperwork. On May 4, 2006, a WNRC employee reported her findings to Lebar by way of email:

“This was originally quite an extensive accession in our holdings, 2,614 magnetic tape containers. But over the years, mostly in the 1970s, most of the containers were permanently withdrawn by NASA. Currently, only two containers remain in our possession. Besides the original SF 135, we also have the original charge cards from when the boxes were being withdrawn. Unfortunately, there’s very little information on the charge cards beyond the date and the box numbers. Often even the name of the person doing the withdrawal is not included, with ‘NASA Goddard’ being written in its place.”

Once the boxes left WNRC, NASA determined their fate, the employee added. Goddard could have destroyed them, returned them as part of a different accession, or even offered them to the National Archives as part of a direct offer, she said.

In the weeks to come, the news would not get better. An analysis of the WNRC accession files also indicated that in 1981–1983, “NASA Goddard” had withdrawn 42,996 boxes of magnetic tapes—25,443 in 1981 alone. Even if the Center had returned the Apollo tapes as part of another accession, it was conceivable that they were later withdrawn as part of the massive recall a few years later.

Without knowing the identity of those responsible for the withdrawal, no one could say what happened or why. The search continued.

### **An Appeal for Help**

In May 2006, Sarkissian wrote a report updating readers on the status of the search and published it on the Parkes website. The report also was linked on the Honeysuckle Creek website. One month later, Mackellar and Lebar issued an appeal for information, preparing a flyer that included photos showing the differences in quality. They posted the piece on the Honeysuckle Creek website.

National Public Radio saw these reports and interviewed Lebar and Nafzger, airing the program on July 31, 2006. The story caught the attention of the *Sydney Morning Herald*, which published a front-page article on August 5, 2006 under the headline—“One giant blunder for mankind: how NASA lost moon pictures.” Within a few days, the story had spread worldwide.

## **The Official Search**

Understandably concerned about the sensationalized headlines, then Goddard Center Director Ed Weiler tasked Deputy Director Dolly Perkins, who has since retired, to pull together a formal search team, including the U.S. retirees who initiated the search years earlier. In addition to revisiting Goddard records and possible storage sites on and off Goddard's campus, the team agreed to carry out more extensive interviews with current and former employees.

Nafzger and Lebar returned to the WNRC to determine whether Goddard had returned the tapes under different accessions. They found nothing. However, a long-time WNRC staff member recalled that from 1970–1973, two Goddard contractors worked in the stacks Monday-Friday, receiving and storing trucked shipments of “Z-type” boxes from Goddard.

Meanwhile, Wood began contacting retired Goddard and contractor employees. To aid in his research, he obtained all available Goddard telephone directories from 1968 to 2000 and the current issue of the *Goddard Retirees and Alumni Association Membership Directory*.

“Initially, the search concentrated on finding out if any slow-scan recordings were still at Goddard,” Wood said. Working from his home in California, he followed up on a tip that the tapes were stored in a private facility called Iron Mountain. He concluded from talking with employees familiar with the operation, however, that neither Iron Mountain nor any other previously used storage facility had ever held the Apollo tapes. Goddard's Manned Space Flight Network, which supported the Apollo program in the late 1960s and 1970s, managed its own tape-handling operation, these employees said. Even so, Nafzger and Lebar arranged visits with Iron Mountain to sample its magnetic-tape collection. Eventually, they came to the same conclusion: the Apollo tapes were not stored there.

The team hit pay dirt in September when Lebar and Nafzger found a supplement to the Manned Space Flight Network Operations Directive—NOD for short—spelling out what Apollo recordings would be made and where they would be shipped. After nearly two years of looking, Lebar and Nafzger found one of the most important pieces to the Apollo-tape puzzle—the name of the Goddard organization responsible for receiving the Apollo tapes—the Data Services Section (Code 824.3)—and the name of the employee who managed the operation.

## **Tracking Down Employees**

Did the manager know what had happened to the Apollo tapes? No one will ever know. He died in 1997.

However, Wood's diligence in creating searchable PDF files of phone books and organizational charts gave the team other venues to investigate. In 1974, one year before Goddard withdrew the Apollo accession, another employee assumed control of the operation, which also became known as the Data Evaluation Section or Code 863.1. Wood consulted Internet-based locator services and found him living in Delaware.

Over the course of several telephone interviews with Wood and Nafzger, the former employee confirmed that his organization received and stored Manned Space Flight Network tapes and that he kept detailed logbooks listing each tape received, the station that provided it, and the accession number needed to transfer the tapes to WNRC. The logbooks made it possible for the organization to recall any tape for later use, he said.

However, the employee did not know what became of the detailed logbooks or the Apollo tapes. He simply could not remember if they had been recalled, degaussed, and recertified for other uses.

### **Digging Deeper**

Although the employee who headed the organization could not recall details, his supervisors did. A former chief of Goddard's Network Procedures and Evaluation Division (Code 860) recalled instructing personnel to strip all identification from the magnetic tapes slated for recycling and to degauss them. However, the former employee stressed that Code 863.1 never would have destroyed data on a particular tape without first getting approval from the Johnson Space Center, which had full control of the Apollo data. Neither he nor anyone else, however, could recall the name of the person who would have made that call.

Given the vast number of tapes involved, something must have triggered the recycling operation. Wood and Nafzger would soon have a clue.

### **Motivation for Recycling**

By the mid 1970s, the magnetic-tape industry had begun using a synthetic product to apply magnetic oxide to tapes. However, the new binder proved troublesome. After only a couple years, many of these tapes became unusable because the oxide would stick to tape heads and strip off when the tape was played back, a condition known as "Sticky Shed Syndrome."

By the early 1980s, NASA was experiencing a critical shortage of magnetic tape. The Associate Chief for Goddard's Network Procedure and Evaluation Division recalled someone from Goddard's Network Logistics Depot calling him to request additional recycled magnetic tapes to make up for procurement shortages caused by manufacturers failing to meet NASA's minimum quality specifications.



To see if he could obtain more details about the shortage, Nafzger visited Goddard's library in February 2007 to review old copies of the Center's weekly management reports. Knowing that Goddard had withdrawn 25,443 boxes of magnetic tape in 1981, Nafzger examined that year first. It did not take long to find a reference to the tape shortage.

On January 8, 1981, the Network Operations Division (Code 850) reported: "Landsat magnetic tape requirements have increased substantially over the originally provided projections for 1981. Recent increases of 10 reels per day for DOMSAT and 50 per day by the Image Processing Facility have severely strained both new and recertified tape supply systems." Furthermore, the report said that Goddard's magnetic-tape recertification facility had added a third shift to recertify Landsat tape.

And then on May 7, 1981, Code 863.1 reported that it needed to procure 164,220 reels of magnetic tape required by the Network Logistics Depot, the Jet Propulsion Laboratory, and three other NASA centers over an eight-month period. Sitting in the library that day, Nafzger could only think, "Wow, it looks like there's a rational connection between the pull out of tapes and the shortage of one-inch magnetic tapes. I didn't find a smoking gun and they didn't reference the WNRC in name, but they did reference the need for tapes."

The day Neil Armstrong and Astronaut Buzz Aldrin walked on moon, the tracking stations faithfully recorded the event. Nafzger figures that each of the three stations used 15 one-inch tape reels to record the actual event, meaning that Goddard received a total of 45 tapes documenting the history-making occasion. Because the WNRC no longer stored the Apollo-era tapes, Nafzger could draw only one conclusion based on what he read in the weeklies: The 45 Apollo 11 tapes were degaussed, recertified, and reused to satisfy a NASA-wide shortage of one-inch tapes more than a decade later. NASA's M-22 recordings of the Apollo 11 moonwalk likely were gone forever.

### **Hope Still Remains**

A few months before Nafzger learned the details of the tape shortage, he also made another discovery that could prove providential for those who want to make the raw-feed recordings available to the public via modern-day technology.

When he and Lebar visited the WNRC in early fall of 2006, they decided to search the documentation files related to the Apollo 11 mission. In one dusty box, they uncovered a Goddard Teletype message indicating that NASA had hired the Applied Physics Laboratory (APL) near Baltimore to modify another tape recorder—an Ampex VR-660C that used two-inch magnetic tape—to handle the slow-scan television signals received only at the Parkes tracking station. Nafzger had no knowledge of this experimental program even though he was in charge of the Apollo 11 television ground-support effort.

Sarkissian, meanwhile, already had found a letter and a photo showing two Ampex VR-660C recorders and a man who may have operated them. The letter, written by the former Parkes director, suggested the operator worked for APL.

## **The Search at APL**

At the request of Goddard Deputy Director Perkins, the APL Office of Communications and Public Affairs contacted retirees, and the organization's records group searched its archives to see if they could discover the man's identity and whether APL still had the recording.

By December, after finding back issues of APL's employee newsletter and its quarterly progress reports, APL personnel had an answer. They uncovered the identity of the man who had indeed modified the Ampex VR-660C.

From additional sleuthing, Wood and Lebar found the man's son who provided his father's phone number at his home in Arkansas. Now also in his 80s, the former APL employee confirmed he had modified the recorders and recorded the original moonwalk signal. At the time, no one asked him to make a dupe of the tapes; so he did not. Whether he packed the tapes and personally delivered them to APL, he does not recall. However, he distinctly remembered seeing the tapes at APL after his return from Australia.

## **APL Tapes Found**

In early January, the APL Archivist called Nafzger to say that she found five two-inch videotapes, along with some 16mm films.

Before team members could play the tapes, though, they had to find a VR-660C. Wood found a company in California that agreed to ship its legacy machine to Goddard. After it arrived, Nafzger loaded the tapes and lived yet another déjà vu experience. Although he confirmed that the tapes had been previously recorded in a format consistent with a VR-660C, the two-inch tapes were blank and the film contained unrelated television footage.

Although a search for the VR-660C recordings at the National Archives and the WNRC has yielded nothing, Nafzger, Wood, Lebar, and other members of the Goddard search team are hopeful that APL will one day find them in its holdings. If APL finds the recordings, NASA will be ready: it is maintaining its capability to playback and view one- and two-inch tapes if they are ever found.

## **Never Say Die — The Restoration Effort**

Despite the twists and turns, the emotional highs and lows, the search team never lost its passion for giving the world a glimpse of what the historic landing really looked like

as the signal played on the slow-scan television monitors at the three tracking stations. That motivation compelled the team to take another tack in its quest.

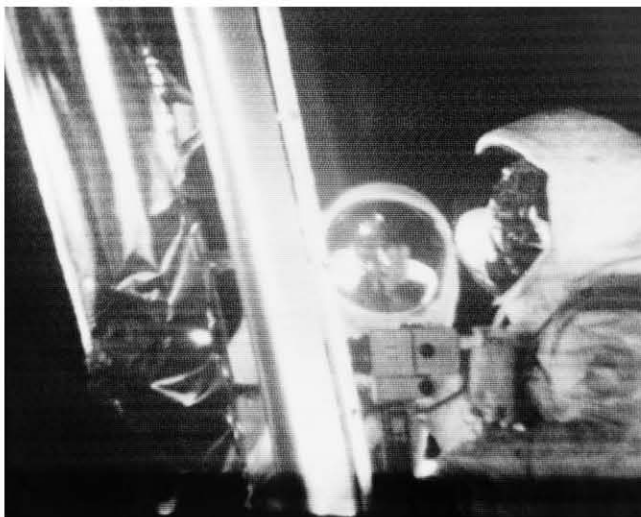
On two continents, team members started looking for what might be the best of the broadcast-format video. In Australia, searchers had already made two significant finds. One was a copy of a tape recorded at NASA's Sydney video switching center where downlinked television from Parkes and Honeysuckle Creek was received for transmission to the U.S. The other was a Super 8 film a technician at Honeysuckle Creek had made of the slow-scan monitor showing details that had been lost by the time the television arrived in Houston.

In the U.S., Lebar and Nafzger visited CBS News Archives and found original broadcast tapes recorded via direct microwave and landline feeds from the Johnson Space Center. At Johnson, they also found kinescopes that no one had viewed for 36 years.

Nafzger viewed and evaluated each available recording, and selected the best for digitization. One company, Lowry Digital, which has restored aging Hollywood films, demonstrated how it could use its proprietary software technology to significantly enhance these tapes. After seeing Lowry's demonstration, NASA Headquarters hired the company to restore the various video clips for the sole purpose of providing the public, future historians, and the National Archives with the highest quality video of this historic event.

Under the initial restoration effort, Lowry restored 15 scenes and included on the tape several before-and-after comparisons. That tape was released for the 40<sup>th</sup> anniversary of the Apollo 11 moon landing. The restoration, however, is ongoing and may produce even better video by this fall.

## Observations



In the case of the missing Apollo 11 moonwalk tapes, hindsight is indeed twenty-twenty. Had NASA known what it knows today, the one-inch magnetic telemetry tapes used to record the raw-feed images of Neil Armstrong's first steps on the moon would be available today, stored safely in the National Archives. Though NASA certainly understood the historic significance of man's first steps on the moon, it did not anticipate the ability to digitize the unconventional television signal into high-quality video 40 years later. In an era of

slide rules, carbon copies, and computer punch cards, the lack of foresight is perhaps understandable.

Even so, some might believe that NASA and its employees—some of them long dead—should have recognized the tapes' importance and preserved them for posterity. But before coming to judgment, one needs to put the issue into perspective and consider the role that these tapes played in the Apollo 11 mission.

Among other data, they recorded an unconventional television signal, which had to be converted and repackaged to make viewable—and only then with significant degradation. “They were telemetry tapes; it’s as simple as that,” Nafzger said. “NASA has always backed up mission data and that’s the role these tapes played. In all honesty I don’t think they would have passed the test,” he added. “The technology didn’t exist to do anything with them other than what was already done at the time they were made.”

Perhaps there are no clear answers. All that can be said with any certainty is that NASA and the Goddard Space Flight Center followed all procedures in storing the Apollo telemetry tapes, the search team has concluded. After reviewing their content and determining that Apollo program managers no longer needed the data, Goddard personnel shipped the telemetry tapes to WNRC for storage. Over the ensuing years, Goddard recalled them and either reused the one-inch tapes to meet a network shortage in the early 1980s or disposed of them because of the high cost of storing them. At no time did anyone recognize the unique content on roughly 45 tapes containing the actual moonwalk video. At no time did anyone ever consider what could be possible nearly 40 years into the future with the advent of new technology.

While current leaders can do nothing to reverse decisions made 40 years ago, they can redouble their efforts to make sure historically important recordings and paperwork find a permanent home within the National Archives, particularly now as they prepare to take the Nation back to the moon.

## **Final Search Report Credits**

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