Camelot on the Moon

The Real Story of How We Managed to Fulfill Kennedy's Promise and Put a Man on the Moon

by Donald E. Kimberlin, NCE

JFK said we would go to the moon before the end of the decade. As mid-1969 approached, the question arose as to whether it would all happen or not. In the end, it came down to hard work and improvisation by some intrepid engineers.

Most people do not know the last possible launch window in the decade nearly closed in failure, saved literally at the last moment by an amazing effort. Now, forty years later, the story is still exciting and intriguing.

[LANDIS, North Carolina] John F. Kennedy's truncated presidency has often been called "The Camelot Era." There had been an unspoken feeling the U.S. had gone to sleep while Eisenhower presided. Expectations now grew that America had to do something spectacular, especially as the glow of victory in World War II continued to dim.

Meanwhile, the charismatic personae of the Kennedy family seemed to say, "these are the ones who will bring glory to the nation." Compared to previous Presidents, JFK's relative youth – his brother Robert as his close aide, combined with his beautiful spouse and young children – made every day potentially a harbinger of great news.

There had been great news – but not happy news – from the Soviet Union. The launch of Sputnik shocked Americans and gave many people reasons to worry, considering the tensions of the time. Indeed, the Evil Empire might be able to rain down destruction and ruin on the United States. Nikita Khrushchev had shown on television during his United Nations visit self-confidence to the point of arrogance. The USA was losing the race for dominance in space. The Missiles of October were to drag JFK into a global poker game like none before.

THE PROMISE IS MADE

Given the world situation, JFK's promise to put an American on the moon was well received; the country needed an effort to rally behind. Further, he promised it would happen before the end of that decade. One can probably say there has not been any other single event since that has brought as much solidarity across the entire American population, indeed perhaps the whole world. Best of all, this rallying point in history developed with the promise of a peaceful objective.

It was the sort of promise of the Sixties that people really wanted. It was The Promise of Camelot.

What many people do not know is that it all came very close being a failure. At the very last moment the last possible launch window for a lunar mission in the 1960's was nearly missed.

POTENTIAL DISASTER LOOMS

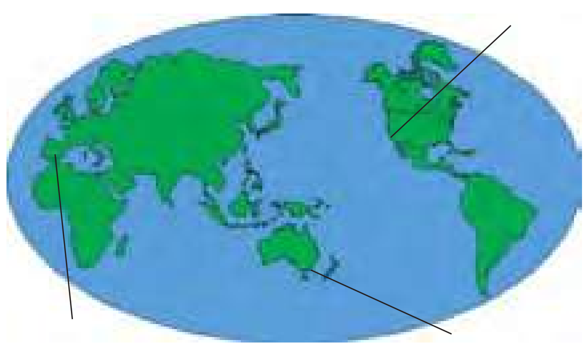
The near failure was not due to problems with rocket science or astrophysics or astronautics. Those had caused earlier program slippages, but had been solved. The ultimate problem that nearly ended this Final Tribute to Camelot was a telecommunications problem.

It was all related to the then relatively new technology of communications satellites. Only the massive efforts of telecomm people, contributing in ways we today might find impossible, actually made the mission possible. Some readers may know pieces of the story, but few have ever known the whole picture.

It all focused on NASA's Deep Space Network. The Deep Space Network was a subset of only three of the twenty-plus ground stations NASA built around the world for tracking and communicating with objects it launches. Most of the NASA stations were capable of communicating only with objects in earth orbit less than 100 nautical miles above the surface.

On the other hand, for the planned lunar mission, there was a need to construct three very large earth stations with 85-foot dishes that could sweep the horizon rapidly and track a point on the moon or anywhere between the earth and the moon.

These special stations were needed in order to maintain communication across the quarter million miles of space to the moon. The three were Robledo, Spain, about 37 miles west of Madrid; Goldstone, a ghost town in California's Mojave Desert; and Canberra, about 165 miles southwest of Sydney, Australia.



A look at the world map shows each is about one-third of the way around the earth. Of these three, only one at a time has a view of the moon for an eight-hour portion of each day. In order to maintain sufficient communication with the first humans to make the lunar journeys, all three stations would have to function perfectly and continuously during their eight-hour periods of lunar visibility.

THE FRAGILE TELECOM LINK

Humans had previously made occasional contact with the moon, bouncing radar off it as early as 1947. Radio amateurs later had made "moon bounce" communications demonstrations. However, maintaining a continuous link from the Earth to the moon for over a week had never been done before. Meeting the Promise of Camelot would require solid, secure communications for the entire mission.

The Deep Space Network was unique not only because of its stations' locations. The communications bandwidth required was larger than previously accomplished over such a distance. And networking the information together once it was back on earth was yet another new feat.

Intelsat was in operation and making intercontinental satellite communications available. However, there had been uncertainty about availability at the time NASA was planning the lunar project. Furthermore, the costs would be at levels beyond what NASA would prefer. And just to add one more level of complication: running a full color video baseband from the moon to earth with the electronics of the new discrete transistor era had not yet proved reliable.

All in all, a true technical challenge for the time.

THE ESSENTIAL LINK

Early in the lunar project, the decision was taken to combine all communications between the lunar module and earth into one 48-kilobit, multiplexed digital signal of video, speech communications, spacecraft telemetry and biomedical data using 2-gigahertz radio. That was the Deep Space Network's task.

Just getting that 48 kilobit stream created and transported back into NASA – and then put back out for the world to see – was in itself a risk. NASA called the link reaching those quarter million miles across space its Unified S-Band system. The combined signal would be fed through each Deep Space Station back to NASA's Communications Center at Greenbelt, Maryland for signal processing and distribution to the whole world.

It was critical for NASA to get the Deep Space Network built and any bugs shaken out. As the 60's passed, lunar launch opportunities frittered away one by one while various problems in the program were uncovered and solved. However, those slippages did allow time to make NASA's Deep Space Network operational.

BUILDING A 48 KILOBIT CONNECTION

Actually, until late 1968, the world's public telecom network did not have the means to transport a single data stream as large as 48 kilobits across the Atlantic or Pacific. The intercontinental state-of-the-art had reached only a maximum modem rate of 4800 bps. Intelsat was forecasting satellites that could provide whole 48-kilobit channels on which "wideband" analog modems could be used by the late 1960's, but NASA needed something sooner.

Meanwhile, NASA was not about to commit reliance on HF (shortwave) radio or submarine telephone cables across the Atlantic and Pacific. The cables themselves still had precious few channels in the late 1960's, prior to the digital fiber optic era. Integrated circuit devices to make tiny units with really low power consumption were only on the horizon; devices like micron-thick solid-state electronics were still *way* in the future. Indeed, vacuum tubes were really still more reliable in many uses than transistors had yet been proved to be.

NASA needed a rock-solid way bring lunar signals from Robledo, Canberra and Goldstone into the NASA communications center at Greenbelt. And that 48-kilobit path across the oceans had to be relatively proven technology – at least reliable enough upon which astronaut lives might be risked.

SCAMA

The interim method was called the Station Conferencing and Monitoring Arrangement (SCAMA). SCAMA included a form of inverse multiplexing (hyped as a recent development, the military already had employed SCAMA just after WWII). Telegraphers also had used inverse multiplexing on wire lines and HF radio for decades.

At least one NASA earth station achieved a 2400 bps digital link with Greenbelt using inverse multiplexing. (The serial data was converted into 24 parallel FSK streams riding on HF radio between Panama and Santiago, Chile; the portion from Greenbelt to Panama rode on submarine cable.) But that was only 2400 bps, and the lunar project needed 48 kilobits, especially if it was to give the world convincing proof of the lunar landing via live color video from the moon.

SCAMA was the largest inverse multiplexer built to date. It split the 48-kilobit data into twelve parallel paths of 4800 bps synchronized data for intercontinental transmission, and then recombined them into the original 48 kilobits at the receiving end. As you may imagine, the transport cost was enormous.

At that point in time, one analog voice channel across the Atlantic rented for $13,000 a month – and SCAMA used twelve. NASA was holding up a dozen circuits across each ocean all day and all night, just to be ready in case a launch window could be used. Of course, they also provided a test bed for the Deep Space Net-

Camelot on the Moon

The Real Story of How We Managed to Fulfill Kennedy's Promise and Put a Man on the Moon

work and the terminals that would go to the moon.

When not in mission use, Robledo and Canberra had a dozen telephone tielines back to Greenbelt. The "phone bill," approached a half million dollars a month (about $2.5 million per month in current dollars!), largely just to be ready to sustain the Promise of Camelot!

THE INTELSAT OPTION

When Intelsat's Series III satellites came into operational use in 1968, contracts were let to IT&T and RCA to provide 48-kilobit channels from Robledo and Canberra respectively back to Greenbelt. Goldstone was not such a serious problem, as it was in the U.S.

(With the satellites available, SCAMA could be relegated to "back-up" status. That would release a dozen sorely needed trunks across each ocean back to the world's telephone network. Dial telephone demand had soared far beyond capacity of the few cables installed to the time, and the released channels would immediately be given over to reach various nations from the U.S.)

It fell to me at IT&T to produce the system design for the first 48-kilobit circuit between Robledo and Greenbelt, while RCA took the contract across the Pacific a few months later. We used proved components from domestic "wideband data circuits" and rather routinely put it into operation. NASA achieved regular use immediately.

To our view, it was "business as usual." We foresaw no problems, and it appeared we at IT&T would have no concern whenever America launched an Apollo spacecraft. Our efforts turned toward other tasks. By late 1968, I was on a different assignment in Europe, knitting AUTOVON and AUTODIN into trunked networks reaching the U.S. from Europe – most on the new Intelsat satellite, some on cable.

CRISIS!

Everything seemed to work well until July 14, 1969, when Howard Briley from IT&T Geneva telephoned my office in Paris. He told me the lone Intelsat III over the Atlantic had suffered Intelsat's first failure in space. It had pointed its antennas out into space

and would not respond to telemetry commands.

The circuit from Robledo was the most critical to the moon landing because it would be the Deep Space station facing the moon in those critical first moments when the astronauts would step on the lunar surface for the world to see. Making them wait eight hours to proceed with the mission once on the moon would deplete life support supplies dangerously. Lacking a link with Robledo, the Promise of Camelot would fail!

Several possible recovery efforts were being pursued. However, if they did not work, it would be necessary to try getting twelve voice channels across the Atlantic between Robledo and Greenbelt working as 4800 bps data circuits and pressing SCAMA back into use. I got marching orders for Madrid.

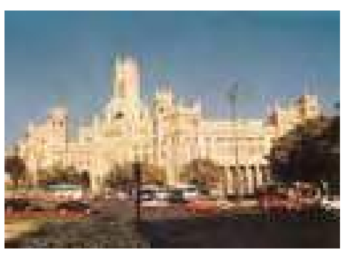
Meanwhile, the Early Bird satellite was considered, but it was questionable if the CTNE (Compania Telefonica Nacional de Espana) earth station at Buitrago, Spain had receivers to tune into its weakened signals. Early Bird's batteries were already running well down their power curve anyway.

Intelsat had one spare Series III satellite and launch rocket. It was rushed to a pad at Cape Kennedy to try meeting its one possible launch window before the last lunar shot window on the morning of July 16. Unfortunately, the satellite went into a huge looping orbit that would take more time than permissible to correct – plus using all its station-keeping fuel in the process. Thus, any notion of simply replacing the failed satellite in orbit was lost within minutes after launching the spare.

THE T-2 HOUR DEADLINE

Fortunately, there was an available commercial airline seat from Paris to Madrid, a rare commodity in European air travel at the time. The weather over Southeastern France and Spain on July 14, 1969 was sparkling clear. Even the cabin steward was impressed, pointing out land features and cities we passed over enroute, because they could be seen so clearly from six miles up.

Nevertheless, it was difficult to enjoy that scenery fully. My mind was on what orders awaited me at the Palacio de Telecomunicaciones, CTNE's rococo, modern Moorish reproduction HQ building. We knew the situation was critical, since Robledo's Deep Space station was the one that would be in view of the moon at the moment scheduled for an American to step onto the lunar surface.



Arriving in Madrid, I learned the NASA Mission Director had put a "hold and check point" in the countdown. He said the mission would be scrubbed if Robledo were not on line to Greenbelt by T minus two hours. I began to feel the pressure to make the mission succeed – it would live or die by what we accomplished in the next two days.

THE RACE AGAINST TIME ... AND RULES

At the Palacio, Senor Luis Terol, CTNE's Manager of International Services updated me on the situation.

Buitrago was not having much luck establishing a link via Early Bird. Intelsat's replacement satellite had been launched – and lost. The last-ditch backup – pressing SCAMA into use – was the only hope of keeping America's lunar launch on schedule for its last chance in 1969.

As with all the other Europeans I spoke to in the months preceding the launch, Terol wanted Kennedy's promise to come true. The free world had bought into to seeing it happen the way JFK committed. Terol told me that AT&T, IT&T and CTNE executives had already been working personal contacts with PTT (Post, Telephone and Telegraph) agencies all over Europe. But that did not necessarily make our mission easy.

Normally, in the world of international links verbal orders were unheard of. Each and every circuit order is a documented transaction connected with the accounting department for the resulting circuit. There is no way a verbal order – no matter how urgent or convincing – can get a technician in France, for example, to stick a patch cord into a panel that will cut off a transit trunk between the U.S. and Switzerland.

Considering that we required a dozen trunks – one or two each from England, Belgium, the Netherlands, Denmark, Germany, Switzerland, Spain and Italy – disconnecting and rerouting the various cables on manual patches down into Spain took a lot of coordination. Each and every one of these informal agreements required the personal intervention of top telephone executives in the affected nations. They promised paper orders in detail would follow to every affected point.

A CTNE staffer would handle negotiating reroutes from each disconnect point. He knew the European infrastructure in considerable detail, and could lay out a plan for getting the circuits to Madrid with the least number of negotiations. Simultaneously, he minimized the number of links, to try keeping noise levels down. (This was a major consideration in building circuits approaching 5,000 miles in length.) We would have to eat into the noise ceiling by adding some equalization for perhaps six sets of channel banks.

Meanwhile, I was sent out to see if there was any last hope for use of Early Bird at Buitrago and then to set up shop at nearby Robledo.

WORKING BOTH ENDS – AND THEN SOME

We were trying to engineer some quiet, clean data channels on the fly, using a somewhat random assortment of circuits. We would have to do it in record time, too.

While the bosses worked the system from the top down, our CTNE staffer worked it from the bottom up. When he would get road-blocked by a lethargic technician a country or two away, he would get out his own little black book of names and numbers he knew in that country. He would talk a supervisor or manager into the spirit of the effort, and get that boss to motivate his people or even go down to the office himself.

Again, we worked through the night. Channels were patched through, which is no mean feat in off-hours anywhere in the world. I was on a connection with IT&T's Technical Operations Center at New York, setting up and equalizing circuits as they became available.

One by one, we got the circuits established. We used some pretty dirty tricks to leave them just a bit loose on equalization, but with smooth curves in order to keep noise lower. Meanwhile, the NASA folk were starting up SCAMA. They would first run pattern data with their modems then add each channel to SCAMA. This was to establish operation proving in the reliability for the Mission Director.

FIVE MINUTES TO SPARE

Finally – at T minus 2 hours and 5 minutes – NASA accepted the twelfth circuit, declared SCAMA operational, and the Mission Director removed the hold. The launch for the moon was "on!"

We stayed at Robledo to hear the launch get off on the afternoon (Europe time) of July 16, and headed back to Madrid for some sleep, after two days without. I checked into another famous Madrid landmark, the Palace Hotel, all Spanish oak, brass and tile. The Palace was Ernest Hemingway's home while writing about the Spanish Civil War. The hotel had not changed much, but I did stop to appreciate it. I went directly to bed.

Memories are blurred, but I must have slept most of two days because the next thing I remember clearly was a pounding on my door in the middle of the night. Someone on the hotel staff – apparently the best English speaker the hotel had – was calling me to come to the hotel's one TV set and see the Americans on the moon! They had landed some hours before, but now they were going to walk outside on the moon.

Camelot on the Moon

The Real Story of How We Managed to Fulfill Kennedy's Promise and Put a Man on the Moon

WE MADE IT!

Standing there in my bathrobe, I suddenly realized there had been a second major problem related to the Intelsat failure across the Atlantic. Not only did it break the broadband data path to the US, but the broadcasters in Europe had lost their video channels back from the US as well. That was certainly important, for Kennedy's promise included showing pictures to the whole free world of the Americans being "first on the moon!"

How had they done it? I was probably the only person in the room who knew what it took to get video to the US so the mission could prodeed. Then I recognized the familiar face and sonorous tones of Walter Cronkite coming from the TV set at some time around 3 AM in Madrid. He was talking about the astronauts preparing to open the hatch and climb down the ladder. Then he said some words that cut into me a bit.

Cronkite spoke about the heroic effort of satellite engineers to get video for broadcast in Europe. It seems they had uplinked US broadcast video received in Australia onto the Indian Ocean satellite. From there, the video was downlinked into an 85-foot dish swung around at Raisting, Germany to receive from the Indian Ocean satellite. He went on at length about how Raisting was feeding the whole of Europe's terrestrial television networks, instead of the usual routes via the failed Atlantic satellite. Someone else had been busy getting European video channels rerouted, too.

It seemed nobody – not even Cronkite – knew what a fragile, last-minute thread was carrying the NASA color video and sound we were all observing from the moon back down through Robledo, splitting it into a dozen submarine cable channels across the Atlantic to Greenbelt, Houston and ultimately back to him at CBS before it got out to the world! No one even asked: if there was no satellite to send video across the Atlantic to Europe, how did it get to them in the first place?

But then, does not The Phone Company or NASA just "take care of things," as always?

EPILOG

Some months after the event, the Director of NASA Communications sent me a lovely citation. It bears a color photo of an astronaut looking at his own footprints on the lunar surface. Part of the text reads, "in recognition of contributions toward NASCOM support of Apollo XI, the first manned lunar landing, July 20 A.D. 1969." Looking at that certificate today, it is rather difficult to believe that it all worked 40 years ago, without current day wideband digital techniques, microprocessors to compress color video to a portion of 48 kilobits, or millimicron wafer devices to do it with.

IT&T's own corporate brochures carried the achievement of the first wideband data circuit across the Atlantic as an IT&T "first" for a number of years. Robledo is still there, mentioned occasionally as being involved in current NASA missions, but it is doubtful anyone knows that was the place the famous lunar pictures came down to earth, or what a tenuous thread connected it back to the outside world.

Telecommunications technology has evolved to the point that it may be a rather hum-drum part of the larger task. On the whole, America – and perhaps even NASA – did not even comprehend the drama in which we were engaged. They certainly had no notion of the geographic scope and depth of the infrastructure army being marshaled across the ocean in support of the Promise of Camelot.

Don Kimberlin

Donald E. Kimberlin is President of Telecommunications Network Architects, based in Landis, North Carolina, where he continues to design and implement technologies the world has come to casually call "WANs." You can reach Don at: donkimberlin@gmail.com

This article was updated from the July '04 issue of Radio Guide Magazine