Apollo/Range Instrumentation Aircraft Support of Apollo 17

Michael Zeitfuss, ARIA Communication System Engineer,

Pan American World Airways, Aerospace Services Division

Summary

Apollo 17 (Figure 1) was the final manned lunar landing mission of the United States National Aeronautics and Space Administration (NASA) Apollo program. There were several unique characteristics of the Apollo 17 mission. (1) Apollo 17 was the first and only nighttime liftoff of the Saturn V launch vehicle (Figure 1). (2) Apollo 17 was the only mission to have a launch delay caused by an equipment malfunction of the Saturn V rocket (two-hour and forty-minute delay). (3) The trans-lunar injection (TLI) burn for Apollo 17 was the latest of the nine manned lunar missions occurring at 3:18:37 GET (all other Apollo lunar missions were 2:18 to 2:56 hr: min GET). (4) Apollo 17 was the only Atlantic area TLI; the other eight Apollo lunar missions had TLI in the Pacific.

Figure 1: The huge, 363-feet tall Apollo 17 (Spacecraft 114/Lunar Module 12/Saturn 512) space vehicle was launched from Pad A, Launch Complex 39, Kennedy Space Center (KSC), Florida, at 12:33 a.m. (EST) on December 7, 1972. Flames from the five F-1 engines of the

Apollo/Saturn first stage developed 7.5 million pounds of thrust and brilliantly illuminated the nighttime launch area. Aboard the Apollo 17 spacecraft were astronaut Eugene A. Cernan, commander; astronaut Ronald E. Evans, command module pilot; and scientist-astronaut Harrison H. Schmitt, lunar module pilot (official NASA photo)

The ARIA requirements for Apollo 17 were to provide telemetry and voice relay coverage during two of the critical phases of the mission, trans-lunar injection (TLI) burn and reentry. The TLI coverage requirement was from 1 minute prior to start of Trans-lunar injection (TLI) burn to 1 minute after burn shutdown for all launch azimuths between 72 degrees and 108 degrees.

The reentry requirements were to provide coverage from earth interface (defined by NASA as 400k ft altitude) minus 1 minute to communications blackout and then exit blackout to splashdown, with continuing coverage after splashdown until released by NASA.

Pre-mission analyses of the Apollo 17 trajectory showed that five ARIA would be required in order to fully meet the TLI coverage requirements for the Saturn V launch azimuths of 72-100 degrees (reduced from 108 because of the weight of the Lunar Rover).

ARIA's #1 and #2 were planned to support the Apollo 17 TLI if the launch occurred at the original planned time of 0253Z/7December at an azimuth of 72 degrees... However, because of the launch delay of 2+40 and the ten minute shift in the time of TLI burn, #1 and #2 provided orbital pass support and #3 and #4 provided TLI coverage of the actual launch azimuth of 95.5 degrees. All telemetry data recording and astronaut voice relay requirements were fully met for the TLI burn period. After mission support all five ARIA returned to PAFB arriving either 7 or 8 December 1972.

Pre-mission analysis of the Apollo 17 lunar return reentry trajectory showed that three ARIA would be required to meet the data and voice relay requirements. ARIA's #3 and #4 departed PAFB on 10December 1972 arriving Fiji Islands on 13 December. ARIA #2 departed PAFB on 11 December and arrived at Hickam AFB on 13 December.

ARIA#2 provided coverage from earth interface (400K ft) to enter blackout, ARIA #3 provided coverage from exit blackout to near splashdown, and ARIA #4 provided overlapping coverage with ARIA #3 to splashdown support until release by NASA. All telemetry and voice relay requirements were met for reentry. Splashdown occurred at 19:24:59Z/ 19December 1972.

ARIA #2 staged and recovered to Hickam AFB. Luna samples and astronaut bio-material was transferred to ARIA #2 at Hickam and then these samples were flown to Ellington AFB outside of Houston for transfer to NASA. ARIA #3 & #4 staged and recovered Nanda. By 22Dec 1972 all three of the ARIA that had supported reentry had recovered to Patrick AFB.

Thus ended the United States manned lunar landing program. The eight ARIA had successfully provided telemetry and astronaut voice relay coverage for all of the Apollo missions.

Introduction

The Apollo Range Instrumentation Aircraft (ARIA) shown in Figure 2, were a fleet of eight specially modified USAF K/C-135 aircraft. After modification the aircraft were redesignated as EC-135N. The ARIA were an airborne telemetry and voice relay station designed and developed to supplement land and marine stations in support of Apollo and other DOD and NASA space and missile programs. The principal modifications included: very large nose mounted radome that housed the 7 ft steerable and autotracking multi-frequency antenna, additional HF antenna mounted on the wing tips, trailing wire HF antenna, additional (fourth) electrical power generator system, new closed loop air conditioning system for cooling the Prime Mission Electronic Equipment, new sound proofing in the fuselage to decrease the noise level in the PMEE crew compartment, and 24 racks of electronic equipment for telemetry receiving, recording, and astronaut voice relay via HF.

Figure 2: ARIA 61-0327 (Boeing C/N 18234) in flight off Patrick Air Force Base (note: "A"model engines, USA flag carrying diplomatic paint scheme, HF wing tip probes, ALOTS radome)

By the time of Apollo 17 a standardized seven phase protocol had been developed and successfully employed for all missions:

1. The plan
2. Pre-mission: Sterilization, calibrations, and simulations
3. Deployment for TLI
4. TLI, orbital support, and recovery
5. Deployment for Reentry support
6. Reentry support
7. Return to Patrick AFB

The Plan

ARIA support of the NASA Apollo missions required the development of two different plans. One plan for the support of the trans-lunar injection burn (TLI) and a second plan for ARIA support of the spacecraft reentry when it returned to earth from the moon.

For the Air Force Eastern Test Range (AFETR) Test # 2475 was the ARIA support of the Apollo 17 launch and reentry coverages under Operations Directive (OD) 48000A. The launch window opened at 0153Z/7Dec1972 for a launch azimuth of 72 deg and closed 3+38 (hr-min) later at 0631Z for a launch azimuth of 100 deg. The TLI could occur on rev's 1, 2, or 3 in the Atlantic sector.

Planning for TLI began with the arrival of the trajectory information in the form of magnetic tapes, the telemetry and voice relay coverage requirements, the launch date/time information, the launch azimuths limitations, if any, and finally the time/locations of TLI.

For the Apollo lunar missions, the combination of launch azimuth limits, earth parking orbit duration constraints, and the geometry of the moons orbit confine the location of the TLI positions to two geographical sectors. These areas were generally centered over the South Atlantic Ocean and the Pacific Ocean, and for this reason are distinguished by these names. The bounds, as illustrated in Figure 3, are defined by the first orbit for a 72° launch azimuth and the third orbit of a 108° launch azimuth.

Apollo 17 TLI was defined as an Atlantic TLI burn. From Figure 2 you can see that the coverage area extended from central Africa on the east to central Brazil on the west and from 30 deg N latitude to 30 deg S latitude. The total area is approximately 23 million sq miles.

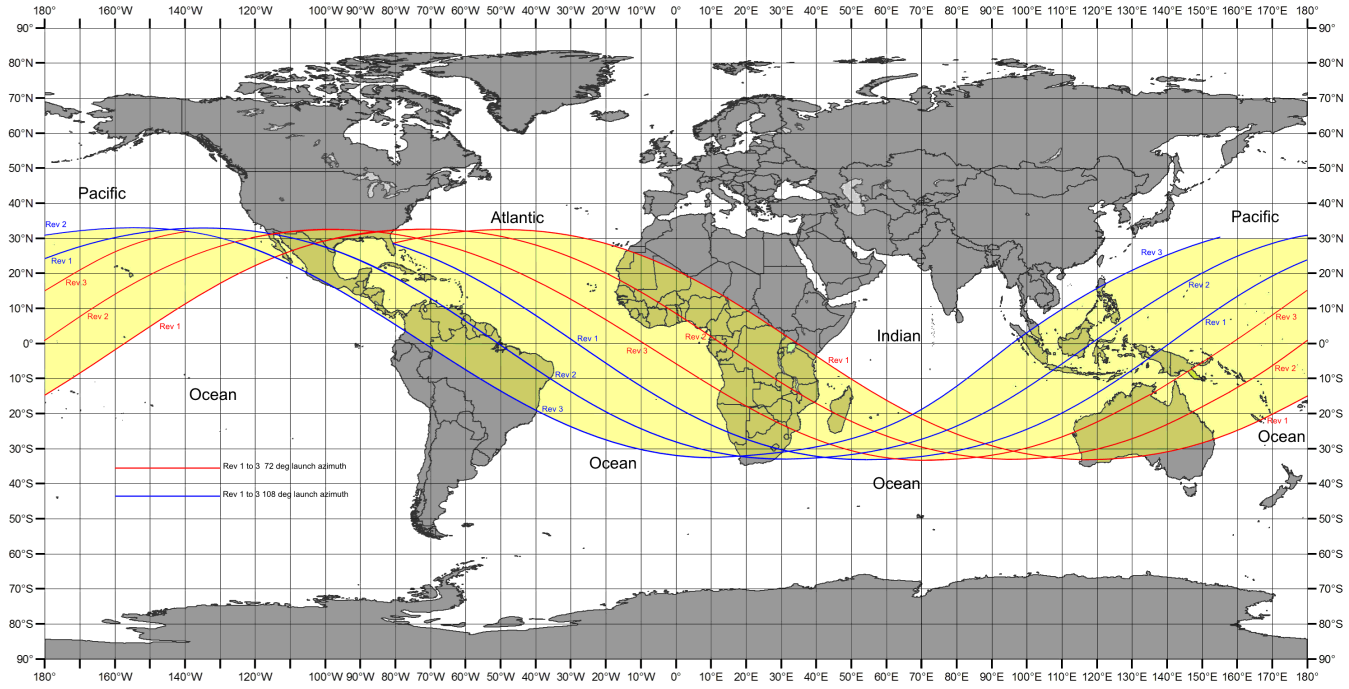

Figure 3: Apollo TLI locations for 72 deg launch azimuth and revolutions 1,2 &3 (red) and TLI locations for 108 deg launch azimuth for revolutions 1, 2, and 3 (blue). (NASA, Robin Wheeler)

ARIA coverage requirements for Apollo 17 TLI were from 60 seconds prior to TLI ignition to 60 seconds after SIV-B 2nd burn shut-down. The astronauts had a checklist that they went through after launch that nominally required an hour and 15 minutes to execute. Theoretically it was possible to complete on Rev Zero and have the TLI on Rev 1. However, the most probable TLI event would take place on Rev 2. A delay in readiness for TLI could also result in the TLI event taking place on Rev3. From an ARIA support perspective; these variables resulted in planning for Rev's 1, 2, or 3 for the TLI event.

The planning process began with getting ground track computer printouts from the computer lab in Bldg 989, plotting the locations on a Mercator projection map (obtained from the map room located on the 2nd floor of hanger 800), and then determining possible staging bases, test support positions (TSP), and recovery bases that ARIA could use in order to be in the proper position for the required coverage over the full launch window. Ground tracks were plotted for every two degrees of launch azimuth and for Rev's 1, 2, and 3. The process was iterative. Not all TSP's were within the range capability of the ARIA and a different staging and recovery base had to be selected or a different TSP had to be selected or both. Further complicating the process was the need to obtain foreign over-flight and landing clearances through the Department of State. Eventually a set of: quantity of ARIA, their staging bases, their TSP's, and recovery bases was

obtained. For Apollo 17 five ARIA were required. Three would stage from Roberts Field in Liberia and two would stage from Ramey AFB, Puerto Rico. Roberts Field was selected because at the time of Apollo 17 Roberts Field had the longest runway (11,000 ft) in Western Africa. Recovery airports would depend on the launch azimuth, but would be somewhere in the Caribbean.

Once the Test Support Positions for the five ARIA were defined then look angle data sheets were created for each aircraft for each TSP for every two degrees of launch azimuth, and for Rev's 1, 2 and 3. These look angle sheets of TSP (lat/long, altitude), time, and azimuth/elevation angle were assembled into almanacs for each ARIA. Each of the five aircraft's almanac consisted of a set of 54 look angle sheets.

The next step in the planning process was to define the configuration of the ARIA for TLI support. During TLI the spacecraft transmitted telemetry data on six different link frequencies as shown in Table 1. The ARIA had 4 tracking receivers, 7 data receivers, two 14-track data recorders, and one 7-track voice recorder. Each receiver had to be configured with the: proper plug-in frequency tuning head, crystal, 2nd IF filter, Demodulator, and have various receiver front panel control switches specified.

Table 1: Apollo 17 SIV-B & CM/SM Link Frequencies, Formats, and Locations

Frequency (MHz)	Modulation	Location
2287.5	PCM/PSK/PM	CM
2282.5	PCM/PSK/PM	IU
2272.5	PCM/FM	CSM
258.5	PCM/FM	S-IVB
250.7	FM/FM	IU
245.3	PCM/FM	IU

Each of the eleven receiver outputs had to be assigned to one of the two 14-track tape recorders. All of this data was given to the Prime Mission Electronic Equipment (PMEE) operators to properly configure the ARIA.

Once the TLI support plan was completed then the same set of variables went into the ARIA support plan for the lunar return reentry of the Command Module. The ARIA coverage requirements for reentry were telemetry and voice relay from: earth entry interface (defined by NASA as 400kft altitude) to entry blackout, exit blackout to CM splashdown, and continued

voice relay until release by NASA. The support plan for reentry was three of the five TLI ARIA would return to Patrick AFB and then redeploy to the Pacific to support reentry. One ARIA would stage from Hickam AFB, Honolulu, Hawaii and two ARIA would stage from Nandi International airport in the Fiji Islands.

Pre-mission: Sterilization, calibrations, and simulations

The output of the plan was a comprehensive set of documentation that fully defined the configuration of the ARIA required to support TLI and reentry. Each of the four tracking receivers and the eight data receivers had to be configured with plug-in frequency tuning head (and crystal), demodulators (phase or FM), 2nd IF filter (3.3MHz, 500 KHz, 300 KHz, etc), and video switch settings. The RF patch panel had to be configured with the necessary jumpers to route the antenna polarizations to the receivers and the various receiver outputs to the two wideband data tape recorders and to each of the 14 tracks on each recorder. Additionally, the 7 tracks of the ½ inch voice recorder had to be properly configured.

Once the ARIA were properly configured the aircraft were frozen (sterilized) and were then ready to proceed with the necessary pre-mission calibrations. Aircraft and prime mission electronic equipment (PMEE) sterilization for Apollo 17 formally began on 20 November 1972. For pre-mission calibrations the ARIA were re-spotted on the PAFB tarmac to face south as shown in Figure 4. This alignment gave the ARIA a look angle to the engineering/spacecraft simulator lab located on the top of Bldg 989. This orientation allowed the ARIA to receive a signal from the lab that allowed the operators to verify equipment operations and in particular to practice/verify proper tracking system performance. Calibrations were scheduled and completed in a timely manner during daylight hours.

Figure 4: Five ARIA on the tarmac at Patrick AFB facing south. Hangar 800 and Atlantic Ocean in background (photo by Bob Burns). Note ARIA TN 375, ARIA #1 for Apollo 17 TLI, has the special paint scheme for calibrating the ALOTS while in flight. ARIA TN 328, ARIA #2 for Apollo 17 TLI and reentry is ALOTs capable with special radome on top of fuselage located at FS 600. The ALOTS radome was successfully used for realtime satellite retransmission of telemetry data

During the period 7Nov to 29 Nov a series of ARIA/Houston simulations were conducted.

1. On 7 and 17Nov the ARIA Operations Control participated in simulations with Houston (MSC) and in particular Houston track.

2. A total of four simulations were run for TLI support. On 12 Oct simulations were run for the nominal case of TLI and provided familiarization training for ARIA Ops. Then on 18Oct, 7 Nov and 28Nov additional simulations were run where problems were injected into the mission support requirements that required changes to the ARIA Test Support Positions (TSP's) and equipment configurations. These simulations provided excellent

training for ARIA Ops personnel and proved to be very valuable in supporting the actual Apollo 17 TLI when the launch was delayed by 2 hours and 40 minutes.

3. Reentry simulations were run on 17 Nov. Both nominal case and problems were injected in order to exercise the ARIA Ops personnel and planning capabilities.

4. Flyby simulations were run on 28 and 29 Nov 1972 between the NASA C-121 aircraft (Figure 5) and two of the five ARIA on the ground. Two of the 5 ARIA and their PMEE crews were sequentially tested so that all five aircraft and crews participated in the simulations. Four spacecraft simulation passes were made on each of the two days. Full telemetry reception, astronaut voice relay (space to ARIA and ARIA to ARIA Ops) were simulated like those that would be used for the actual mission.

   The simulations proved to be very beneficial to the ARIA Ops and PMEE operators.

Figure 5: One of the two (TN 420 and 421) Super Constellations that were used for Network simulations and training by NASA for the Manned Spaceflight Network tracking stations (NASA TN 420 taxis past the Perth, Australia control tower on 29 June 1968; Picture by Geoff Goodall). For Apollo 17 NASA 421 flew simulations for the Pacific tracking stations and 420 did the Atlantic station simulations including ARIA. Note for Apollo 16 Pacific sector TLI, ARIA 3 & 4 staged from Perth and ARIA 1 and #2 staged from Darwin for mission support.

Deployment for Translunar Injection Burn (TLI)

The transition from the Pre-mission Phase to the Deployment Phase was marked by a series of briefings for all ARIA personnel. All meetings were conducted at Patrick Air Force Base (PAFB) except the Flight Readiness Review with NASA which was held at the Kennedy Space Center (KSC).

1. 31 Oct 1972: Air Operations Group (AOG) Meeting
2. 12 Nov 1972: Flight Readiness Review
3. 20 Nov 1972: Support Personnel Briefing
4. 20-24 Nov 1972: ARIA Navigator Briefings
5. 20 Nov 1972: Prime Mission Electronic Equipment Mission Coordinators Briefing
6. 27 Nov 1972: ARIA Pilots Briefing
7. 29 Nov 1972: Aircrew Briefing
8. 2 and 4 Dec 1972: C-141 Air and Maintenance Crew Briefings'
9. 5 Dec 1972: F-1 Briefing

Aircraft assignments, staging and recovery bases for Apollo 17 TLI were:

ARIA 1: TN 375-Patrick AFB-Ramey AFB-Roberts Field-Barbados-Patrick AFB

ARIA 2: TN 328-Patrick AFB-Ramey AFB-Roberts Field-Piarco Trinidad-Patrick AFB

ARIA 3: TN 326-Patrick AFB-Ramey AFB-Ramey AFB-Patrick AFB

ARIA 4: TN 329- AFB-Ramey AFB-Roberts Field-Piarco Trinidad-Patrick AFB

ARIA 5: TN 374-Patrick AFB-Ramey AFB-Patrick AFB

ARIA #4 departed PABF at 1259Z/3December 1972 for the short hop (1135nm, 2+30) to Ramey AFB arriving at 1515Z. ARIA #2 departed PAFB at 1416/3December 1972 arriving at Ramey AFB at 1645Z. Approximately 15 minutes later at 1450Z ARIA #1 departed PAFB and arrived at Ramey AFB at 1710Z/3Dec1972. After a RON at Ramey, ARIA #4 departed Ramey AFB at 0439Z/4December 1972 for the long flight (3335nm, 7+30) to Roberts Field Liberia, arriving at 1210Z/4Dec1972. ARIA #2 departed Ramey at 0503 and arrived at Roberts Field at 1250Z. ARIA #1 departed Ramey at 0623Z and arrived at Roberts at 1355Z. A thorough verification of the Prime Mission Electronic Equipment (PMEE) required for Apollo support was accomplished by each ARIA during the long leg from Ramey to Roberts.

ARIA #3 departed PABF at 1530Z/4December 1972 for the short hop (1135nm, 2+30) to Ramey AFB arriving at 1915Z. An hour later, ARIA's #5 departed PAFB at 1630Z/4December 1972 and arrived at Ramey AFB at 1843Z.

By T-2 days the 5 ARIA were in position at their staging bases and all systems were status "green" to support the Apollo 17 TLI.

ARIA Support of Translunar Injection (TLI)

The ARIA Operations Control Center (AOCC) went to 24/7 operations when the aircraft entered pre-mission sterilization on 20November 1972.

The original planned T-0 for Apollo 17 was 0253Z/7December 1972.

At T-4.5 hours the AIROPS computer advisor position was manned in the AOCC and in the Technical Laboratory (Bldg 989) AIROPS-IS. The Cape Canaveral Air Force Station Realtime Computer System was also brought on line as backup. By T-3.5 hours all network systems between the AOCC, Bldg 989, and the Cape RTCS were status "Green" and the system was turned over to the AIROPS senior navigator.

Four ARIA departed their staging bases in accordance with the pre-mission plan as shown in Figure 6.

After initial climb-out each of the ARIA went through their standard post take-off checklists. All of the PMEE was turned on to get ready for the mission. The first of the PMEE operators was the HF operator. Contact was made with Cape Canaveral Air Force Station Communications using HF on the guard frequency of 13.218 MHz. The Cape then assigned new frequencies for ARIA control, primary astronaut voice, and a third frequency for astronaut backup. The HF operator then began running "Fox" tapes with the Cape to confirm the TTY system was working properly in anticipation of potential data traffic The Mission Coordinator then contacted ARIA control to report aircraft status. The timing and recorder PMEE operator set the on-board clocks using synchronization signals from WWV. Once the on-board clocks were set then the two data recorders were loaded with the 2-inch magnetic tapes. Then the ½ inch voice recorder was loaded with magnetic tape. The voice and tracking operator checked the operation of the four tracking receivers, made ready the astronaut uplink transmitter (aircraft to Apollo Command Module) and verified that the USB downlink signal data demodulators were ready for astronaut downlink voice and telemetry. The receiver operator verified that the 8 data receivers were working properly. The antenna operator unstowed the 7 ft antenna, then verified proper operation using the hand wheels and the joystick controls. Once all of the PMEE was verified, the Mission Coordinator contacted ARIA Control to report the aircraft status as "Green" and ready for mission support.

T-02:48 (0005Z/7Dec)—ARIA 1 (375) departed Roberts Field heading for its assigned Initial Position (IP)/Test Support Position (TSP) for 72deg launch azimuth

T-01:38 (0115Z/7Dec)—ARIA 4 (329) departed Roberts Field heading for its assigned Initial Position (IP)/Test Support Position (TSP) for 90 deg launch azimuth

T-00:48(0205Z/7Dec)- ARIA 3 (326) departed Ramey AFB heading for its assigned Initial Position (IP)/Test Support Position (TSP) for 90 deg launch azimuth

T-00:23 (0230Z/7Dec)—ARIA 2 (328) departed Roberts Field heading for its assigned Initial Position (IP)/Test Support Position (TSP) for 72deg launch azimuth

ARIA 5 (374)—was held on the ground at Ramey AFB in accordance with pre-mission planning in the event of a launch at end of window or late rev TLI.

T-00:00:30—at T-30 seconds the Apollo 17 launch countdown was halted. For the first time in the history of the Apollo program a launch countdown was halted because of a Saturn V equipment problem. The count was recycled to T-8.5 minutes, the start of the automated sequencer, while NASA went into a fault isolation and corrective action mode.

Four ARIA had completed their step-climb to their assigned altitude of 33-35K, were in long duration cruise of 450 ktn, and were proceeding toward their assigned support positions when the countdown was halted.

For the next two hours NASA determined the root cause of the problem and implemented the necessary corrective actions.

All of the training, all of the simulations, all of the contingency planning that had been part and parcel of the previous eight lunar missions suddenly became very real for the ARIA team.

At 0400Z NASA notified the AOCC that they were going to pick up the count. At about this same time the AOCC transferred responsibility for TLI coverage from ARIA #1 and #2 to ARIA #3 and #4.

T-0 for Apollo 17 occurred at 0533:01Z/7December 1972, 2 hr +40 minutes later than originally planned. The launch azimuth was 091.51 degrees. The RTCS generated new ARIA look angle almanacs for all aircraft. An examination of the data showed that the pre-mission 92 degree azimuth look angle almanacs were satisfactory. All of the ARIA provided full coverage of telemetry and astronaut voice relay of the Apollo spacecraft without any problems (Figure 7).

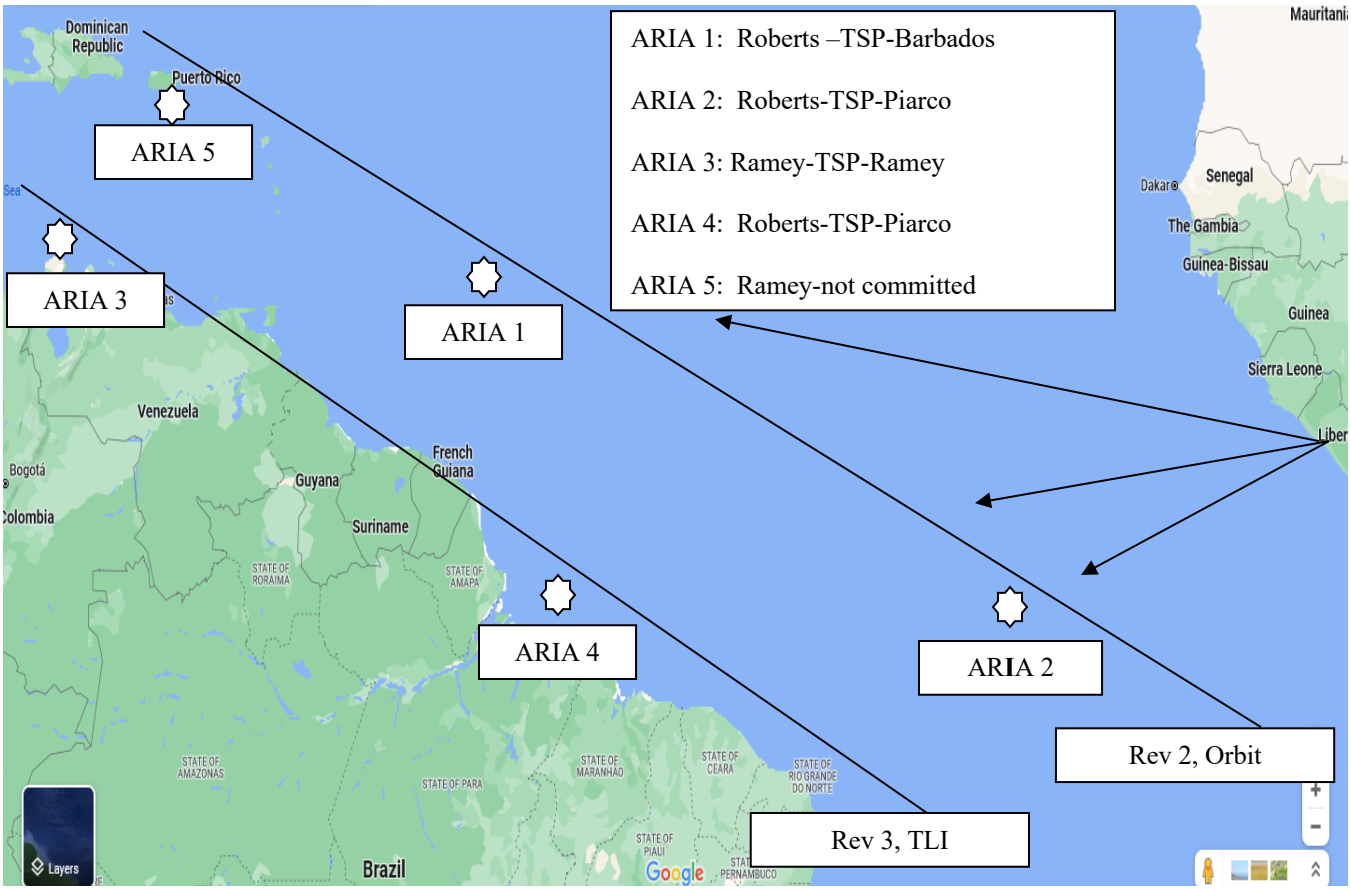

Figure 6: Relative positions of the five ARIA for support of Apollo 17 TLI

Table 2: ARIA 3 and 4 Test Support Positions (TSP) and data runs for Apollo 17 TLI

ARIA #3: TLI Test Support Positions	
Start of run	**End of run**
Time: 0839Z	0850Z
14 deg 00 min N	14Deg 30m N
78 deg 00 min W	77Deg 37m W
TH: 307 deg	090 deg
Alt: 35K	35K

ARIA #4: TLI Test Support Positions	
Start of run	**End of run**
Time: 0842Z	0859Z
04 deg 50 min N	05deg 30m N
60 deg 16 min W	60deg 41min W
TH: 308 deg	119 deg
Alt: 35K	35K

ARIA #1 (TN 375) took a pass of the Apollo 17 spacecraft while it was still in its 93.5nmx89.5nm orbit. Acquisition of signal (AOS) occurred as predicted at 0715Z (T+01:42) and continued until loss of signal at 0723Z. Primary tracking was on the Command Module Unified S-Band (USB) link of 2287.5MHz. Good quality data was recorded for the almost 8 minute orbital pass. After taking the orbital pass, ARIA #1 was released from further support and recovered to Barbados landing at 0805Z/7December 1972 after being airborne for eight hours.

ARIA #2 (TN 328) also took an orbital pass on the same revolution as ARIA #1. Acquisition of signal (AOS) occurred as predicted at 0718Z (T+01:45) and continued until loss of signal at 0727Z. Primary tracking was on the Command Module Unified S-Band (USB) link of 2287.5MHz. Good quality data was recorded for the almost 9 minute orbital pass. Realtime retransmission of the USB downlink was sent via LES-6 to the AFETR GBI ground station, then to Cape Canaveral, and then to Houston with excellent results. Houston capcom made several calls thru ARIA #2 at ~T+1:48. After taking the orbital pass, ARIA #2 was released from further support and recovered to Piarco, Trinidad landing at 1115Z/7December 1972 after being airborne for 8 hours and 45 minutes.

ARIA #3 (TN 326) became the primary aircraft covering the beginning of the Trans-Lunar Injection (TLI) burn of the S-IVB upper stage of the Saturn V rocket. Primary tracking was on the Command Module Unified S-Band (USB) link of 2287.5MHz. AOS occurred at 0841:30Z and continued until loss of signal (LOS) at 0850Z. Good quality data was recorded for the 8 minute pass. Astronaut voice relay between ARIA and the Apollo spacecraft using the USB link and then HF from ARIA to the AFETR ground station was excellent quality. The four other downlink telemetry links were also excellent quality for the entire pass. After taking the TLI pass, ARIA #3 was released from further support and recovered to Ramey ABF, Puerto Rico landing at 1020Z/7December 1972 where they had departed 8 hours and 15 minutes earlier.

ARIA #4 (TN 329) became the primary aircraft covering the end of the Trans-Lunar Injection (TLI) burn of the S-IVB upper stage of the Saturn V rocket. Primary tracking was on the Command Module Unified S-Band (USB) link of 2287.5MHz. The tape recorders were started at 0845:30, AOS occurred at 0846Z, with tracking, voice relay, and downlink telemetry recording continuing until end of tape recording capability at 0859:59Z. Good quality data was recorded for the 13 minute pass. Astronaut voice relay between ARIA and the Apollo spacecraft using the USB link and then HF from ARIA to the AFETR ground station was excellent quality. The four other downlink telemetry links were also excellent quality for the entire pass. After taking the TLI pass, ARIA #3 was released from further support and recovered to Piarco, Trinidad landing at 0948Z/7December 1972 after being airborne for 8 hours and 33 minutes.

The ARIA coverage requirement for Project Apollo was from 60 seconds before S-IVB 2nd burn (start of TLI) to 60 seconds after S-IVB cut-off (end of TLI). The Apollo 17 start of burn began at 0845:34.6Z and cut-off occurred ~350 seconds later at 0851:26.1Z on 7December 1972.

ARIA 3 and ARIA 4 provided coverage from 0841:30Z to 0859:59Z significantly exceeding the coverage requirements.

ARIA #1 (TN 375) departed Barbados at 1100Z/7December 1972 and landed at Patrick AFB 1440Z. Total for 7 December was: Roberts Field-TSP-Barbados-Patrick for 13hr+35min crew duty day.

ARIA #2 (TN 328) departed Piarco, Trinidad at 1410Z/8December 1972 and landed at Patrick ABF at 1753Z.

ARIA #3 (TN 326) departed Ramey AFB at 1130Z/7December 1972 and landed at Patrick AFB at 1358Z/7December1972. Total for 7 December was: Ramey-TSP-Ramey-Patrick AFB for 11 hr + 53 minute crew duty day.

ARIA #4 (TN 329) departed Piarco, Trinidad at 1515Z/8 December 1972 and landed at Patrick AFB at 1915Z.

ARIA #5 (TN 374) departed Ramey AFB at 0511Z/7December 1972 and arrived at Patrick AFB at 1155Z.

By 1915Z/8 December 1972 all five ARIA that had deployed to cover TLI had successfully recovered back to Patrick AFB.

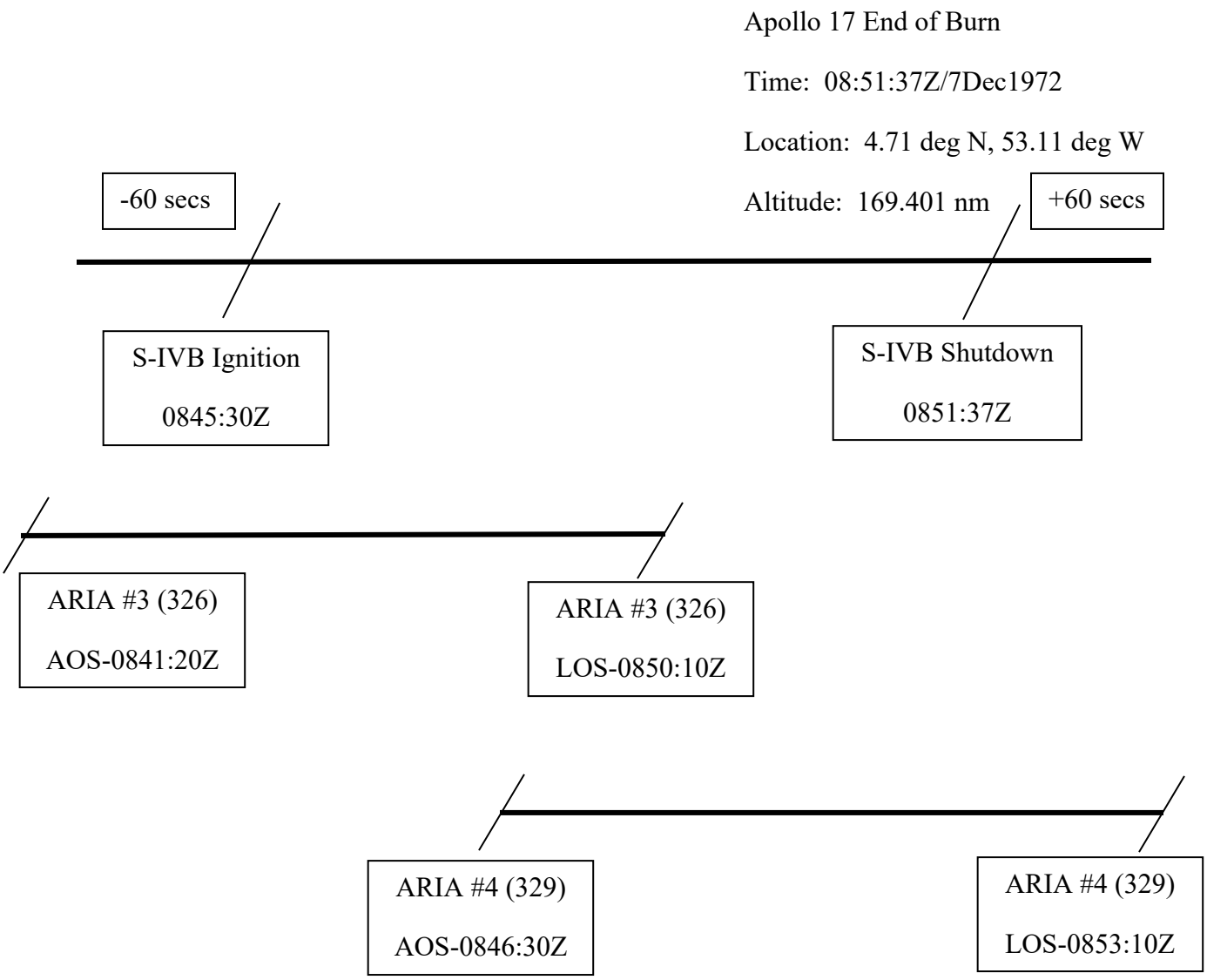

Figure 7: ARIA #3 and #4 Telemetry and Voice Relay Coverages for Apollo 17 Translunar Injection Burn (TLI)-7December 1972

Deployment for Reentry Support

Three ARIA were required to provide support for Apollo 17 reentry.

ARIA #2 (TN 328) departed Patrick AFB 1438Z/11Dec1972 and landed at McClellan AFB 5+12 later at 1950Z (~2130nm). After RON, ARIA #2 departed McClellan at 2215Z/12Dec1972 and arrived at Hickam AFB at 0350Z/13Dec1972 (~2270nm). ARIA #2 staged from Hickam on 19Dec for reentry support from 400K earth interface until enter blackout.

ARIA #3 (TN 326) departed Patrick AFB 1910Z/10Dec1972 and landed at McClellan AFB 5+15 later at 0025Z/11Dec1972. After RON, ARIA #3 departed McClellan at 1650Z/11 Dec 1972 and landed at Hickam AFB 5+20 later at 2210Z/11 Dec. After RON, ARIA #3 departed Hickam AFB at 2105Z/12Dec and landed at Nandi International airport, Fiji Islands, 7 hours later at 0405Z/13Dec1972 (~2800nm). ARIA #3 had traveled ~7,200 nm from PAFB to Nandi. ARIA #3 staged from Nandi on 19 Dec for reentry support.

ARIA #4 (TN 329) departed Patrick AFB 1440Z/10Dec1972 and landed at McClellan AFB 5+20 later at 2020Z/10Dec1972. After RON, ARIA #4 departed McClellan at 2250Z/10 Dec 1972 and landed at Hickam AFB 5+30 later at 0420Z/11 Dec. After RON, ARIA #4 departed Hickam AFB at 1945Z/12Dec and landed at Nandi International airport, Fiji Islands, 7 hours later at 0245Z/13Dec1972. ARIA #4 staged from Nandi on 19 Dec for reentry support.

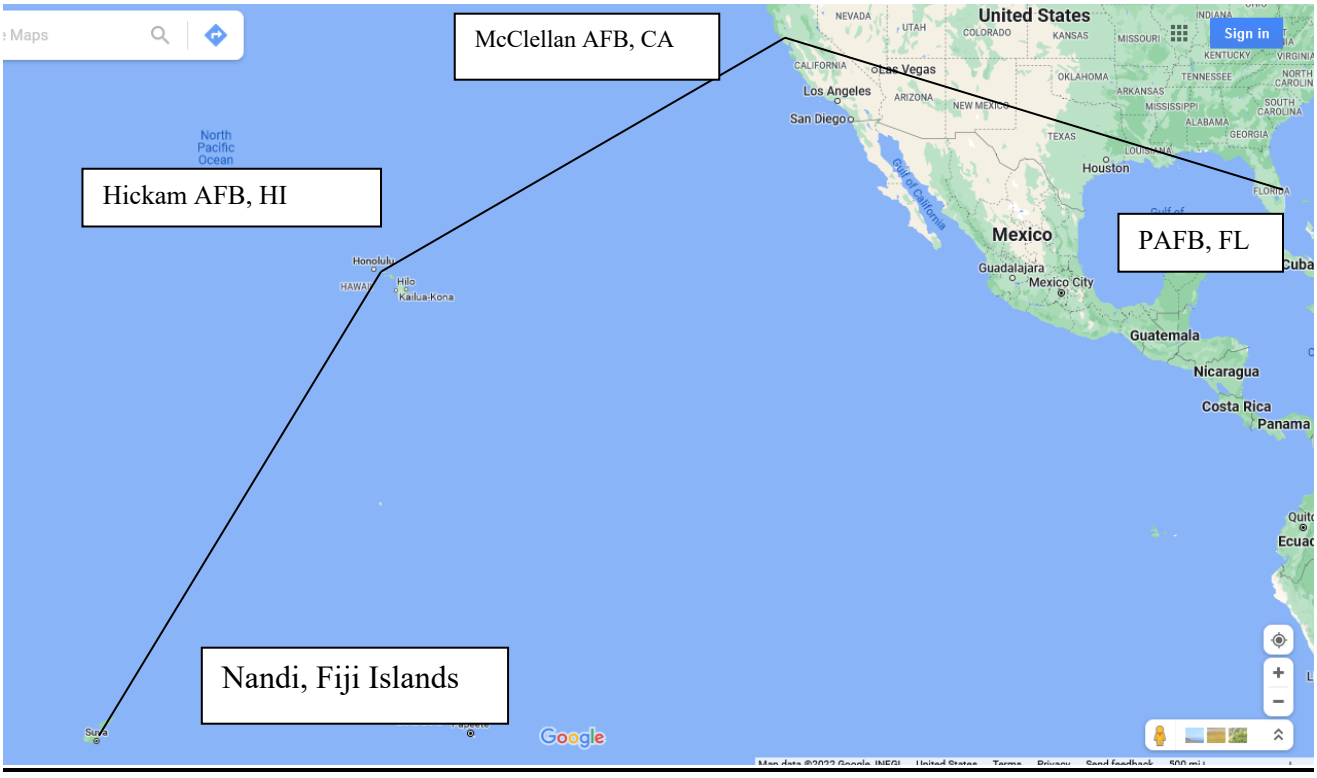

Figure 8: ARIA Deployment from Patrick AFB to Staging Bases for Apollo 17 Reentry Support

ARIA Support of Apollo 17 Reentry

ARIA #2 (TN328) was assigned responsibility to cover Apollo 17 reentry from earth interface (defined as 400kft altitude; approximately 1200 miles up-range from splashdown) to entry of blackout. ARIA #2 departed Hickam AFB at 1455Z/19Dec1972 and proceeded to its Test Support Position (TSP) located 1160nm southwest of Honolulu at 06-42N/172-37W. Links 2287.5 MHz (USB) and 243.0MHz were recorded from the Apollo 17 Command Module (CM). Acquisition of signal (AOS) occurred as planned at 1859:30 Z. Good quality data and voice relay was obtained until abrupt loss of signal (LOS) at start of blackout at 1911:56Z. ARIA #2 recovered to Hickam AFB landing at 2205Z/19Dec1972. ARIA #2 was on the ground at Hickam awaiting the recovery of the moon rocks and astronaut bio-samples until 21Dec. ARIA #2 departed Hickam at 1425Z/21Dec and landed at Ellington AFB outside of Houston, TX where the bio-samples were transferred to NASA. ARIA #2 then departed Ellington AFB for PAFB, but the aircraft lost its APN-59 weather radar as it was approaching a severe line of thunderstorms. The pilot in command decided to make a precautionary landing at Barksdale AFB to get the radar fixed, landing at 0512Z/22Dec1972. ARIA #2 departed Barksdale at 1715Z/22Dec and landed at Patrick AFB at 1905Z/22Dec1972 (28+40 after departing Hickam).

ARIA #3 (TN326) was assigned responsibility to cover the Apollo 17 reentry from exit blackout to near splashdown when the CM would be over the horizon to their location. ARIA #3 departed Nandi International at 1620Z/19Dec1972 and proceeded to its assigned Test Support Position (TSP) located ~1000nm NNE of the Fiji Islands at 12-24S/166-20W. ARIA #3 started its data and voice relay support run at 1910Z. Acquisition of signal (AOS) occurred at 1915:59Z. Good quality data and voice relay was obtained from the 2287.5 and 243.0 links until LOS at 1920:20Z. ARIA #2 recovered to Nandi International landing at 2145Z/19Dec1972. After RON ARIA #3 departed Nandi at 1455Z/20Dec and proceeded to Hickam for refueling and then continued non-stop from Hickam to Patrick AFB landing at 1440Z/21Dec1972.

ARIA #4 (TN329) was assigned responsibility to cover the Apollo 17 reentry overlapping coverage with ARIA #3 from exit blackout to CM splashdown and continuing coverage of the CM until released by NASA. ARIA #4 departed Nandi International at 1610Z/19Dec1972 and proceeded to its assigned Test Support Position (TSP) located ~1000nm east of the Fiji Islands at 18-13S/165-08W. ARIA #4 started its data and voice relay support run at 1909Z. Acquisition of signal (AOS) occurred at 1916:35Z. Good quality data and voice relay was obtained from the 2287.5 and 243.0 links until LOS at 1924:43Z. At the request of NASA ARIA #4 remained on station for an additional 42 minutes after splashdown in order to provide astronaut voice relay. ARIA #4 recovered to Nandi International landing at 2226Z/19Dec1972. After RON ARIA #4 departed Nandi at 1713Z/20Dec and landed at Hickam at 0100Z/21Dec. After 17 hours on the ground in Hawaii, ARIA #4 departed Hickam AFB at 1800Z/21Dec and proceeded non-stop to Patrick AFB (~4200nm) landing 8h+22m later at 0222Z/22Dec1972.

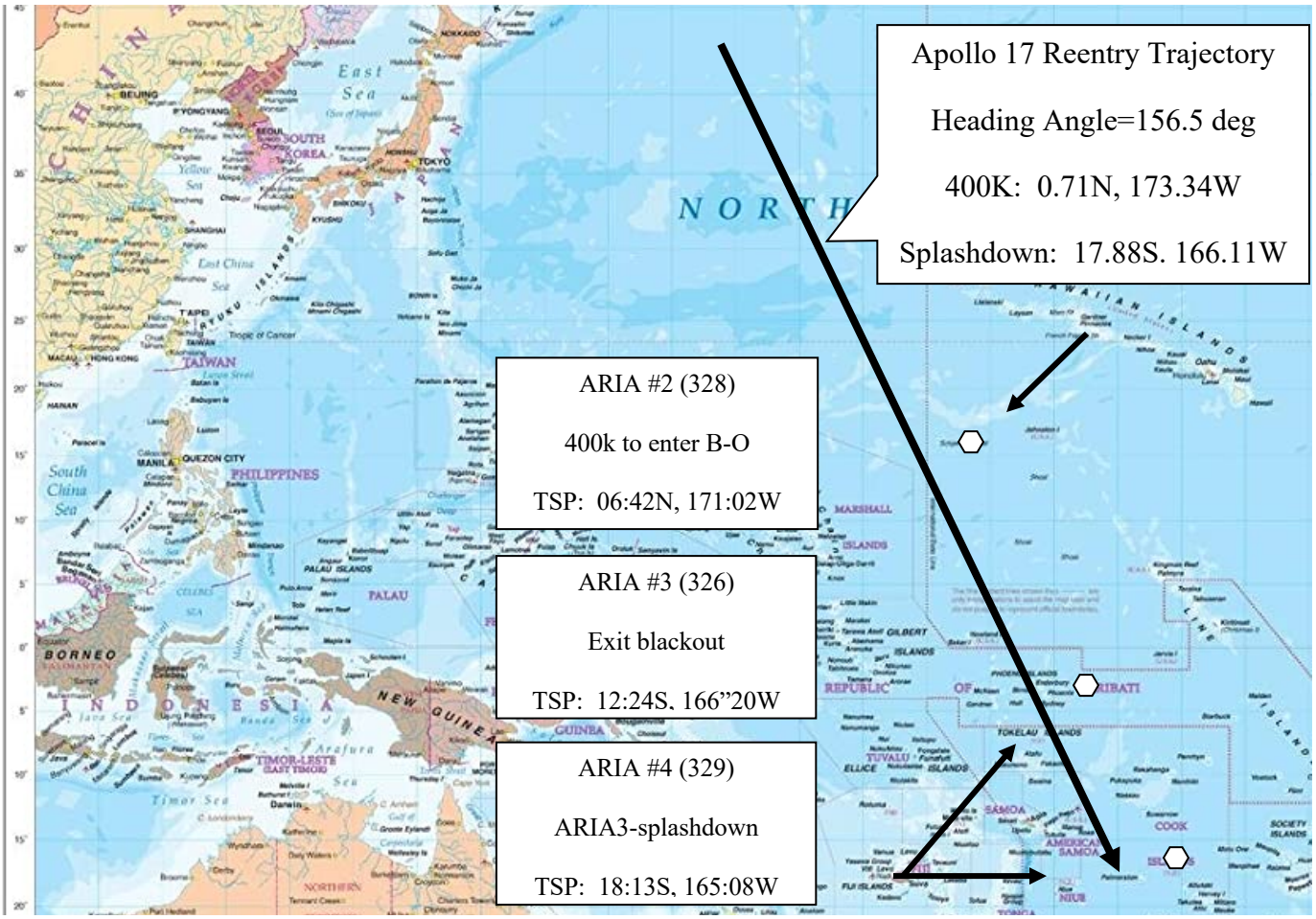

Figure 9: Relative positions of the three ARIA for support of Apollo 17 reentry (19Dec 1972)

ARIA # 2: Hickam-TSP-Hickam

ARIA #3: Nandi-TSP-Nandi

ARIA #4: Nandi-TSP+42min-Nandi

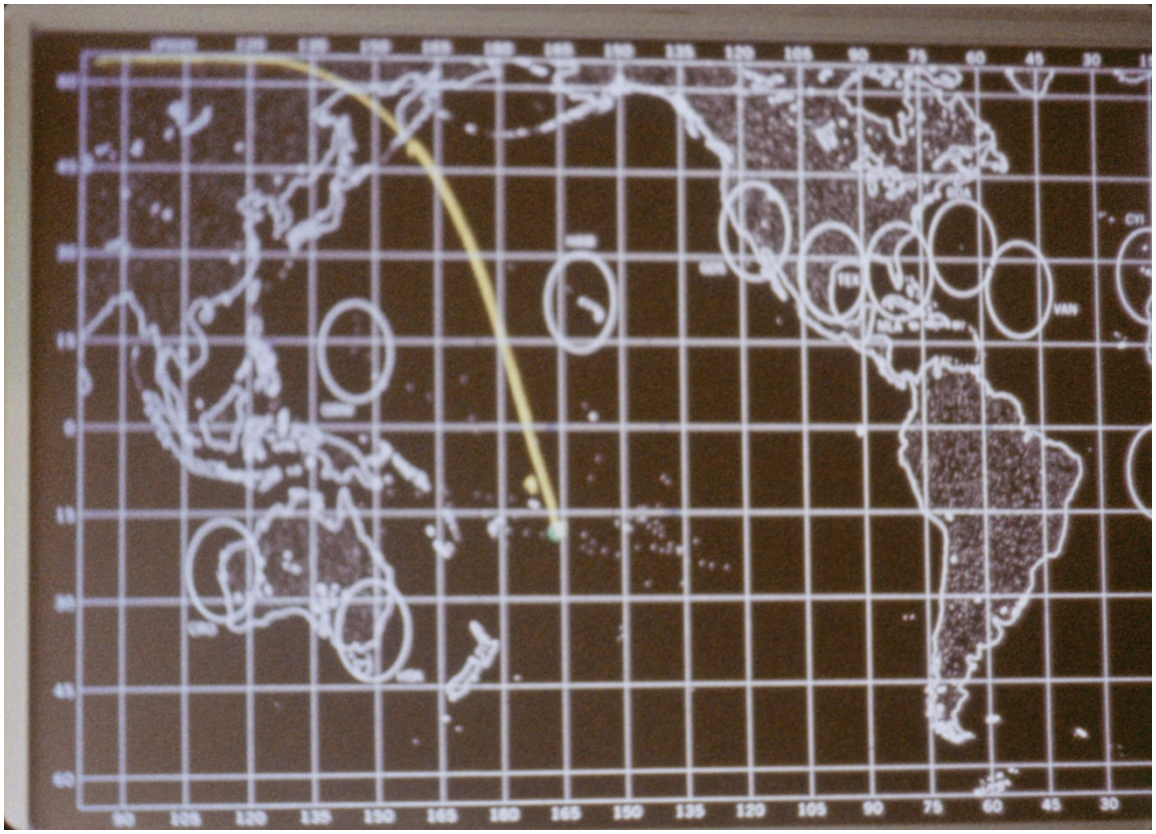

Figure 10: NASA Houston Mission Control plotboard shows the path of Apollo 17 reentry to splashdown

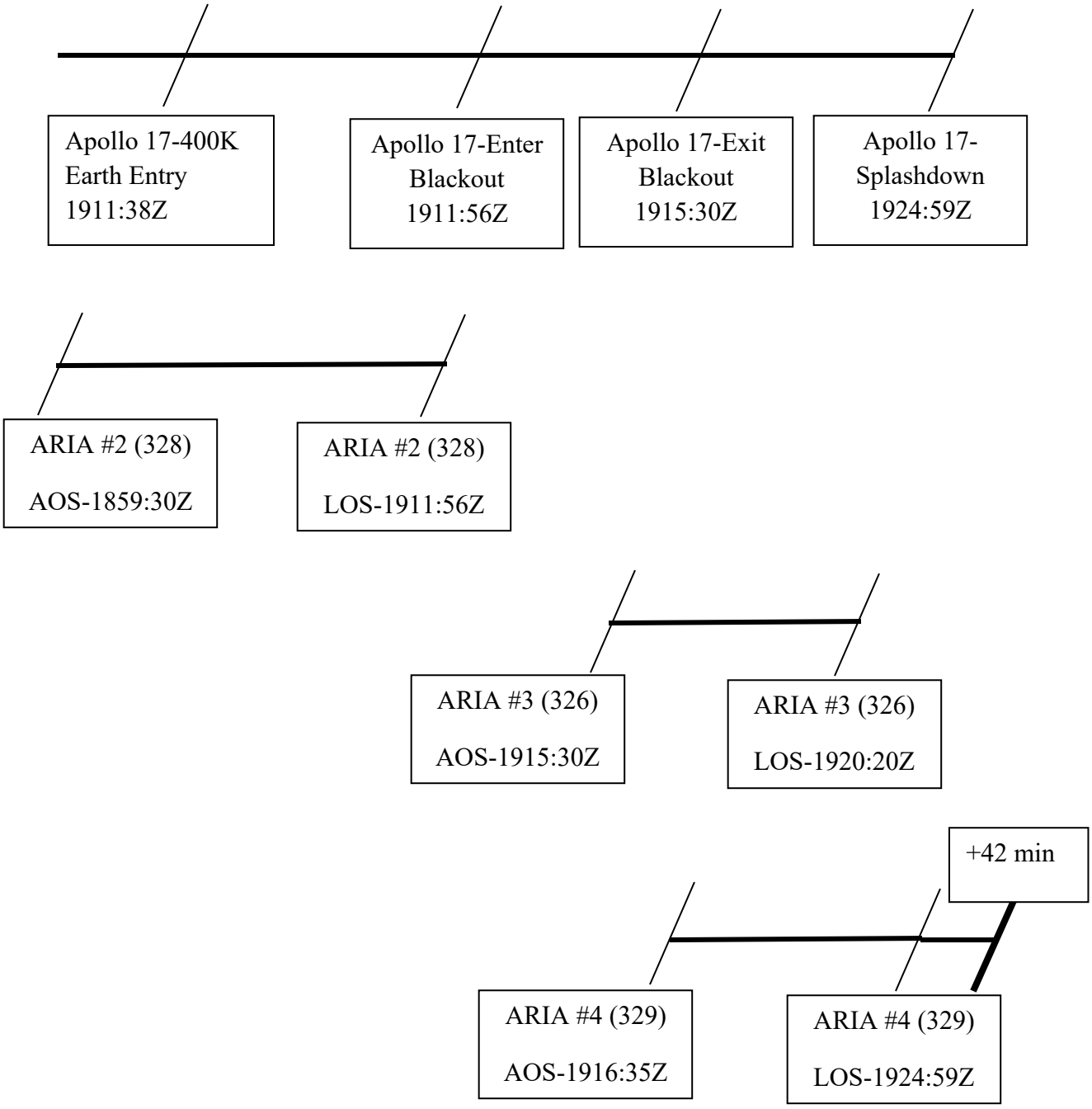

Figure 11: ARIA #2, # 3, and #4 Telemetry and Voice Relay Requirements and Coverages for Apollo 17 Reentry (19December 1972)

Splashdown of the Apollo 17 Command Module (Figure 11) ended what was arguably one of the most ambitious, technologically challenging, and successful efforts in the history of man. The ARIA supported all of the Apollo missions. The ARIA program never lost a crewman, never lost an aircraft, supported all of the missions, and met all of the data requirements. By any measure the ARIA program was a success.

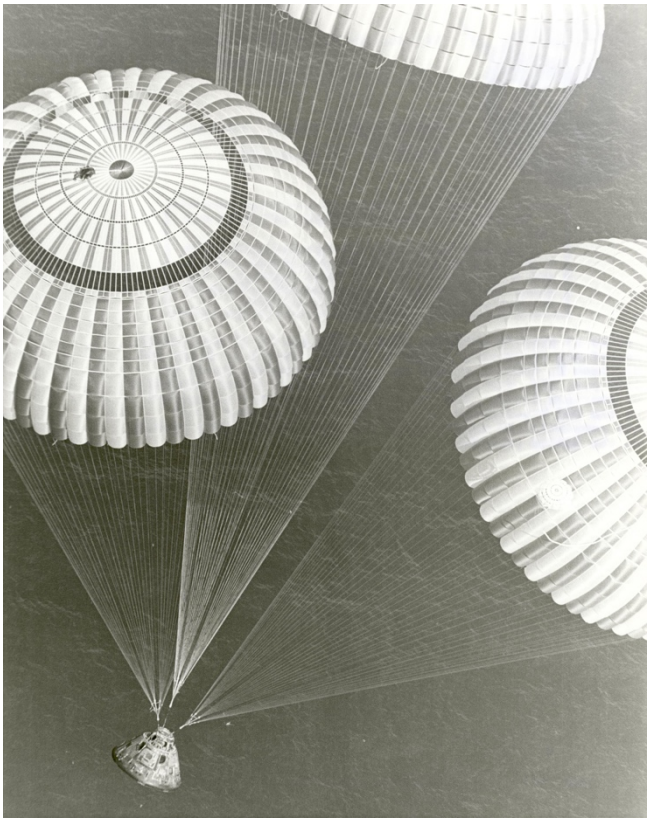

Figure 11: The Apollo 17 spacecraft, containing astronauts Eugene A. Cernan, Ronald E. Evans, and Harrison H. Schmitt, glided to a safe splashdown at 2:25 p.m. EST on Dec. 19, 1972, 350nm southeast of American Samoa. (NASA)