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Chapter 20

ARIA—NASA's Apollo Airborne Fire Brigade*

Stanley E. Anderson†

Abstract

April 14, 1970, 3:20 AM, Patrick AFB, FL. In nearby Indian Harbour Beach a telephone rings, "Major, this is Stan. There's been an explosion on the spacecraft." "I'll be right there. Get a message to the aircraft, STAND DOWN. DO NOT TAKE OFF." 4:00 AM, "ARIA CONTROL, NETWORK", "Roger, Network." "Where can you get the planes?", "How long have we got?", "Four days." "Anywhere in the world you want them." "Thanks ARIA, we'll get back to you." Thus, began the response of the eight US Air Force Apollo Range Instrumentation Aircraft to the explosion on Apollo 13."—NASA's Manned Space Flight Network's "Fire Brigade."

As the Non-Commissioned Officer-In-Charge of ARIA Control, 1968–1971, MSgt. Anderson relates his experience of the little-known history of the United States Air Forces' fleet of eight Apollo Range Instrumentation Aircraft (ARIA—a-RYE-a) that supported Project Apollo 4 through Apollo 17 and more than fifty other military, commercial, and scientific space projects for some thirty-three years. At the conclusion, readers should be able to articulate the history, purpose, function, operations, and control of the ARIA fleet.

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The need for a fleet of high-speed instrumentation aircraft to record telemetry and relay astronaut voice communications to augment NASA ground stations and instrumentation ships around the globe supporting Project Apollo was identified in 1963 and formalized in 1964. In 1966–1967 NASA contracted for the conversion of eight USAF C-135 (Boeing 707) aircraft. Turned over to the Air Force in late 1967, the ARIA, operated by Air Force technicians, deployed to military and civilian airports around the world to cover mission events pre-selected by NASA. Most of these events took place over many hundreds of miles of trackless ocean beyond the range of NASA's Manned Space Flight Network ground stations and instrumentation ships. In case of an unplanned mission event, such as Apollo 13, the aircraft could be redeployed with little or short notice to provide telemetry recording and astronaut voice relay as necessary. ARIA were routinely used for orbital, pre- and post-Trans-Lunar Injection, and reentry telemetry and voice relay coverage over remote ocean locations. The story of how the ARIA provided initial voice contact following reentry blackout between the astronauts and Houston for Apollo 7 through 17, is part of space program history, now largely lost, is the subject of this chapter.

Acronyms/Abbreviations

Air Force Eastern Test Range (AFETR) based at Patrick AFB, Florida, operated the range use for rocket launches from Cape Canaveral some 4,000 miles southeast down the Atlantic Ocean between Africa and South America.

Aircraft Operations Control Center (AOCC) located at Patrick AFB, Florida.

ARIA Control—an alternate, interchangeable name for the AOCC.

Prime Mission Electronic Equipment (PMEE) operated by ARIA technicians.

S-IVB—The third stage of the Saturn V rocket, housed the Lunar Module and supported the Command and Service Module (CSM).

Trans-Lunar Injection (TLI), the S-1VB ignition that would send the CSM from Earth orbit to the Moon.

Test Support Point (TSP), the geographic latitude and longitude over the Earth's surface where mission support was required.

Unified S-Band (USB), the 2–4 GHz frequency range used for voice and telemetry between the Apollo Command and Service Module, Lunar Module, and the ground.

I. Introduction

Project Apollo was the third phase of NASA's charter to put a man on the Moon. Lessons learned during Phase I, Project Mercury, and Phase II, Project Gemini, along with technology advances were applied to each succeeding phase, not the least of which was the communications network, the Manned Space Flight Network (MSFN) NASA's very specialized "telephone company."

Two specific incidents in the earlier phases pointed to the need for a high-speed, long-range, mobile communications platform. In the first incident, the fourth Project Mercury flight on May 24, 1962, Aurora 7 piloted by astronaut Scott Carpenter, overshot its landing zone by 250 miles resulting in loss of radio contact with the spacecraft for almost an hour after landing.

The second incident, during Project Gemini, March 16, 1966, on Gemini 8 a malfunction of the Orbit Attitude and Maneuvering System (OAMS) while the spacecraft was out of contact with ground or ship stations nearly spelled disaster for the crew. Fortunately, spacecraft commander Neil Armstrong was able to recover control of the capsule.

NASA's solution was to modify eight US Air Force C-135 (Boeing 707) aircraft, designated EC-135N, to relay astronaut communications and record telemetry during the launch, orbital and reentry/recovery phases of each Apollo mission. This chapter will relate the history, purpose, description, operations, and control of the ARIA fleet.

II. History

The ARIA "fleet" was originally conceived as twelve aircraft to cover Apollo capsule reentry in both the Atlantic and Pacific Oceans. When the decision was made by NASA to use only Pacific Ocean reentry the number of aircraft was reduced from twelve to eight with six ARIA to cover each mission with two standby backups. Accordingly, eight C-135 aircraft from the Air Force inventory were selected for modification: tail numbers 60-372, 60-374, 60-375, 61-326, 61-327, 61-328, 61-329, and 61-330. In practice, the aircraft were referred to by the last three digits of their tail numbers (372, 374, 375, etc.). Douglas Aircraft was selected as the prime contractor for the ARIA program with work to be done at their Modification Center in Tulsa, Oklahoma. Bendix Radio was selected as the electronics subcontractor with work beginning in 1964–1965.

Modifications to the airframe included adding a ten-foot nose housing for a 7-1/2 foot gimble mounted dish antenna (see Appendix 1), three eight-foot High Frequency antennas—one on each wing tip and one at the top of the vertical stabilizer—and a pod housing a 120-foot trailing wire antenna. Electronics installed included the dish antenna and 30,000 lbs of electronic equipment necessary to track, record data, and retransmit voice from the aircraft. Value of the installed equipment was $8 million in 1969 dollars.

Normal staffing for and ARIA was the flight deck crew consisted of the Aircraft Commander, a co-pilot, navigator, and an enlisted flight mechanic. In the body of the ARIA a Mission Coordinator and six enlisted technicians operated the electronic equipment.

The ARIA were assigned to the AFETR, Air Force Systems Command and based at Patrick AFB, Florida, about thirty miles south of Cape Canaveral. Delivery of the modified aircraft started in late 1967. On November 9, 1967, ARIA 375 flew its first mission on Apollo 4, an "All-Up" test of the Saturn V rocket. An "All-up" test was having all live stages and spacecraft modules as complete as possible. An orbital flight, the final stage was to drive the command module back into that atmosphere at 25,000 mph to duplicate the speed returning from the Moon. After reentry blackout, ARIA 375 received and tracked a 5khz signal broadcast by the Command Module, effectively a "proof of concept" of the ARIA capability.

Although NASA modified the ARIA for Project Apollo, throughout their operational life span they supported other military, scientific and commercial projects, providing telemetry support for launch, orbital events and reentry as needed. Following the end of Project Apollo in 1972 they were renamed from Apollo to Advanced Range Instrumentation Aircraft—different name but same acronym and telemetry mission.

In 1976 the ARIA and their crews were reassigned from the AFETR, Patrick AFB, Florida, to the 4590th Test Wing, Wright Patterson AFB, Ohio. On May 6, 1981, ARIA 61328 crashed in Walkersville, Maryland, while on a training flight killing all twenty-one aircrew and observers on board.

In 1994, the ARIA and their crews were reassigned from the 4590th Test Wing to the 412th Test Wing, Edwards AFB, California.

Over some thirty-five years the original ARIA were continually upgraded, both electronics and airframe, to improve performance and capabilities. They staged from airports and bases around the world and supported more than fifty Apollo, military, scientific, and commercial projects (see Appendix 2) the original eight ARIA were transferred to other organizations, modified for new missions or retired (see Appendix 3) being replaced by new generations of aircraft to continue the high standard of work ethic they had set.

III. Purpose

The ARIA fleet was primarily used by NASA to supplement ground stations and three Instrumentation Ships by filling in “gaps” in global coverage providing telemetry recording and astronaut voice relay. While launch coverage was adequately supported by ground stations and the ship Vanguard in the middle of the North Atlantic Ocean, more distant locations coverage in the South Atlantic, Indian, and Pacific Oceans was extremely sparse once the spacecraft was in orbit. It was in these areas that the ARIA were in their element providing support for various orbital events such as pre- and post-TLI communications and following reentry blackout. In addition, a secondary purpose was to provide a rapid response capability to supplying coverage for unanticipated mission events.

While the ARIA fleet were primarily used for Project Apollo, individual aircraft were used to support telemetry requirements for launch, orbital and reentry of various military, scientific and commercial projects between Apollo missions. This support became their primary mission following the close of the Apollo program in December 1972.

IV. Function

In many respects, each ARIA duplicated some of the functions of ground stations, particularly voice relay between the astronauts and MCC Houston, and recording telemetry from the spacecraft. Many of the positions on the ARIA had comparable positions to ground stations (see Appendix 4).

Mission Coordinator—a Commissioned officer who coordinated the activities of the PMEE operators who were experienced electronic technicians, Sergeant Non-Commissioned-Officers. Among the PMEE positions were:

Antenna—Operated the dish antenna in the nose of the aircraft.

HF—Operated three sets of High Frequency Receive/Transmit radios and two onboard 60 and 100 word/minute teletype machines.

Telemetry—Operated the VHF/UHF S-Band telemetry receivers from the spacecraft.

Voice—Operated the VHF/UHF, S-Band voice receivers/transmitters from/to the spacecraft.

Recorders and Timing—Operated two 1-inch, 14-track, 120 in/sec recorders and the Rubidium-87 clock. One channel on each recorder was used for a timing code from the onboard clock.

Systems Analyst—Senior NCO assistant to the Mission Controller, a "floater" available to assist any of the PMEE operators.

While the ARIA could duplicate many of the functions of a ground station, they could not uplink data to the spacecraft, particularly commands to the spacecraft onboard computer because this required precise latitude/longitude positioning which in the era before GPS was not possible for the ARIA. However, whereas the ground stations could track the orbiting spacecraft for up to six minutes horizon-to-horizon, about 1350 miles, the ARIA flying at 35,000 feet could track the spacecraft for up to ten minutes horizon-to-horizon, about 2270 miles. Moreover, the ARIA flying at 500 mph could reposition themselves over 700 miles with a spacecraft in a 90-minute orbit to cover multiple passes of the spacecraft.

During the early manned missions, Apollo 7 through Apollo 12 the astronaut voices were received through the antenna in the nose of the ARIA and retransmitted by 1,000 watt High Frequency radio transmitters by long wire trailing from the belly of the ARIA and the two eight-foot probe antenna mounted on the wing tips (see Appendix 5). The signal was received by three ground stations in Hawaii, Guam, and Bringelly, Australia. The three signals were forwarded to the ARIA Communications Technician at Cape Canaveral and the best signal sent on to MCC Houston. The audio from Houston to the spacecraft would follow the reverse route. While the receive and transmit stations at Hawaii and Guam were co-located, the transmit station in Australia was located at Doonside some distance from Bringelly. Both Australian stations were operated by the Overseas Telecommunication Commission on Australia (see Appendix 6). While Apollo 13 also used HF, the audio from the reentering spacecraft was retransmitted to Houston by a newly installed satellite terminal in the ARIA aircraft. On the following Apollo 14 mission, during the TLI sequence, the astronauts' biomedical data was transmitted to Houston by satellite.

V. Operation

Prior to each Apollo mission, NASA would tell the AOCC where and when they wanted ARIA support. The "Where" was the Test Support Point

(TSP), the geographic latitude and longitude over the Earth's surface they wanted an ARIA supporting the spacecraft. The "When" was the Ground Elapsed Time (since launch) they wanted the ARIA at the TSP. It was the AOCC's job to get the ARIA there as scheduled.

The TSP was the point-of-closest-approach, generally 100 miles, to the ground track of the spacecraft. The ARIA would start its data run about 30–45 degrees offset from the ground track in the same direction as the spacecraft about five minutes from the TSP, acquiring the spacecraft as it came over the horizon using the VHF antennae on each quadrant of the nose dish. When the signal strength of the four VHF antennae was balanced the S-Band antenna was pointed directly at the spacecraft and then "locked" on the signal, gyroscopes were started initiating an "Autotrack" capability to follow the spacecraft throughout its pass, regardless of aircraft movement. At the TSP the ARIA would commence a turn to 30–45 degrees away from the ground track and follow the spacecraft to the horizon. The typical pass of a spacecraft in orbit was ten minutes, about 2460 miles.

The ARIA would leave Patrick AFB, Florida, for their staging bases or airports closest to their TSPs about seven days prior to scheduled launch of the rocket. Each one or two ARIA would be accompanied by a support aircraft carrying maintenance staff and spare parts. During the orbital Apollo missions, Apollo 5, 6, 7, and 9, an ARIA could be tasked to support more than one TSP on successive orbits of the spacecraft. During Apollo 7, for example, two ARIA staging out of Perth, Australia, were tasked to support Revolutions 134 and 135 of the Command Module over the Indian Ocean. The nature of orbital missions required the ARIA be dispersed over many airports around the world. During Apollo 9 ARIA had overflight and landing clearances for thirty-one countries around the world.

In contrast to the orbital missions, the lunar missions, Apollo 8 and 10 through 17, the parameters of timing and location for sending a spacecraft to the Moon required far fewer staging bases and airports. Particular coverage was required for the TLI burn (see Appendix 7). The "Go for TLI" and TLI burn of the S-IVB engine was passed to the spacecraft through the NASA Carnarvon site in northwest Australia on Revolution 3. NASA required communications coverage for ten minutes prior to TLI, through the 5 minute 47 second burn and two minutes following S-IVB shutdown; a total of some 18 minutes. The ground station at Carnarvon could only cover about six minutes of that period. The solution was to use ARIA over the Indian Ocean to provide pre-TLI coverage and another ARIA to provide post-TLI coverage. Accordingly, two ARIA were staged at Cocos Island in the Indian Ocean (with Perth, Australia, as an alternate staging base) to cover the pre-TLI period and an ARIA staged at Darwin, Australia, for to cover the post-TLI period. Additional ARIA were staged at Townsville in northeast Australia, Guam, and Hawaii. The Guam ARIA was to be used for post-TLI coverage if the TLI was delayed until Revolution 4.

Following the TLI, the ARIA would stand down during the Lunar phase of the mission. A couple of days after landing the ARIA from TLI support, they would be repositioned to staging airports to support Command Module reentry/recovery providing coverage following reentry blackout (see Appendix 7). With reentry planned for the South Pacific Ocean, three ARIA would be staged at Nadi, Fiji Islands, and Pago Pago, American Samoa. For reasons of redundancy, the planned reentry coverage always called for two ARIA for the Apollo TSP splashdown. They were positioned on either side of the extended ground track on a course converging on the splashdown point and executing a fishhook maneuver before reaching it. This proved to be well justified in the case of Apollo 13 because the prime aircraft, ARIA 3, was out of commission at the time of reentry and ARIA 4, the backup, provided the coverage. The positioning of an ARIA 250 miles up track from the planned splashdown was unique to Apollo 13 owing to the uncertainty of the reentry angle. Upon locking on to the Command Module S-Band signal, the landing zone ARIA would take up a 60-mile diameter "race track" pattern around the Command Module relaying astronaut communications to MCC Houston until communications was established by the recovery ships.

With two notable exceptions, ARIA support for the Apollo missions closely followed pre-planned guidelines. The two exceptions were during Apollo 5 and Apollo 13.

The orbital Apollo 5 mission, January 22, 1968, was the first in which the ARIA fleet was deployed around the world and the ARIA proved their value. During a test of the Lunar Module Descent and Ascent engines in Earth orbit, problems arose when the Descent engine shut down after only 4 seconds of a scheduled 39-second burn north of Australia during the third revolution. A full burn would have had the effect of shifting the Lunar Module to a ground track close to that of the previous orbit down the west coast of Africa, while the S-IVB second stage ground track came down the east coast of South America. Two ARIA staging from Ascension Island were tasked to record telemetry; ARIA 4 flying several hundred miles north of Ascension off the "hump" of Africa would track the Lunar Module while ARIA 5 flying several hundred miles southwest of Ascension would track the S-IVB second stage. The shortened burn of the Descent engine was sufficient to displace the Lunar Modular ground track enough that NASA ground stations could not acquire the spacecraft with their 9-meter (30-foot) antennas on the next pass over the United States. Based on "best guess" information from MCC Houston, the AOCC directed ARIA 4, about to start its data run off Africa, to turn about 135 degrees “coming up over Cuba” and attempt to locate the Lunar Module near South America using its VHF wide beam acquisition antennae. ARIA 4 managed to locate the Lunar Module at 1,100 miles and verbally reported its “look angles” (antenna azimuth, elevation, and aircraft direction) to ARIA 5. The ARIA 5 Mission Controller, using ARIA 4’s look angles, determined that the Lunar Module was close to the S-IVB ground track and acquired the Lunar Module. This information was reported to MCC Houston and allowed the NASA site at Carnarvon, Australia, to reestablish contact with the Lunar Module so that further tests with the Ascent engine could be completed. In addition to locating the Lunar Module, ARIA 4 recorded six minutes of USB telemetry while ARIA 5 radio operators reconfigured twenty-six data channels from S-IVB to Lunar Module frequencies and recorded a full ten minutes of data from the Lunar Module.

The second abnormal mission was Apollo 13. Although alerted to the possibility of having to move the ARIA to other staging bases to cover a possible reentry point yet to be determined, the actual recovery occurred in the general area of the South Pacific Ocean originally planned. Other than changed recovery TSPs there was no significant deviation from pre-planned landing zone.

Compared to Apollo 5 and Apollo 13 the other missions, Apollo 6 through 17, were comparatively “routine” with a variety of airframe and electronic equipment failures that required rapid repairs or even “creative” solutions. Throughout the program, airframe upgrades were performed, and the electronic equipment evolved. In particular, the voice and data relay capabilities were significantly upgraded.

Aircraft Markings. In recognition of the ongoing Cold War during the Apollo program, it was deemed necessary for political reasons to change the paint scheme of the ARIA fuselages. Early photos of the ARIA show the standard military “U.S. Air Force” on the front side of the aircraft. In the 1968–1969 period this was changed to the diplomatic paint scheme of white fuselage tops with “United States of America” emblazed on the white background. The reason was that with ARIA traveling to various countries around the world, it could be diplomatically sensitive having an airplane with “U.S. Air Force” landing in some of the countries involved. For example, during the orbital mission of Apollo 9, we had overflight and landing clearances for thirty-one countries around the world. The need for this change was further emphasized by an incident during the Biafran Civil War in Nigeria (1967–1970) when one of the ARIA off the Nigerian Coast was tracked by a MiG fighter aircraft.

VI. Control

Throughout the Apollo program operational control of the ARIA was the responsibility of the AOCC located in Building 629 at Patrick AFB, Florida, about thirty miles south of Cape Canaveral. Known in the MSFN as “ARIA Control,” the AOCC consisted of two rows of consoles, one for the ARIA Controllers and Command Staff, the second for the Advisory staff. The command row consisted of positions for the Commander, AFETR, the Division Chief of the Aircraft Operations Division, three ARIA Controllers (all rated C-135 pilots) and a Contractor Liaison. The Advisor Row had positions for a computer coordinator, two aircraft navigators, two instrumentation advisors, a ground communications coordinator, Department of Defense Liaison, and a Status position to monitor aircraft status and maintain pre-pass checklist for each ARIA. Not all positions were staffed by military but also by civilian contractors. Each Apollo mission had a support Mission Coordinator and his PMEE crew to provide technical assistance and occupy the Instrumentation console positions. Toggle switches on each console allowed the staff to monitor “Net 1” the NASA Spacecraft-to-MCC (Mission Control Center, Houston) circuit, “Net 2” the NASA Communications Coordination Network and various other internal networks for ARIA mission coordination.

As originally laid out for the early missions, Apollo 4, 5, and 6, the AOCC had two rooms separated by a large glass window with the Controller row in first room and the Advisor Room immediately behind. In a throwback reminiscent of an earlier generation, at the front of the Controller room was a worldwide map covered with acetate to which ground tracks could be taped and aircraft icons could be moved around. Over the maps were eight clocks showing the local times at various bases and airports where the ARIA were staged. This proved to be an unworkable model because the two-room structure hampered direct interaction between the controllers and the advisory staff. In preparation for the upcoming Lunar Missions the AOCC was upgraded. The upgrade was scheduled to take place during Apollo 7, so NASA opened the closed Mercury Control Center bunker at Cape Canaveral to use as a temporary AOCC.

Following the upgrade, the front room was converted to hold both rows of consoles with the controller row on a raised platform and the advisor row on the main floor below and in front of the controllers. This greatly enhanced the interaction between the controllers and the advisor staff. The former “back” room was converted to visual support room with the original glass window replaced by a large screen with rear projection display maps and real-time tracking images driven by the tracking computers in Houston. In addition, a large lighted board was constructed to display each ARIA with its various PMEE systems status shown by green, yellow, and red lights.

Immediately adjacent to the control room was the teletype room with 60 and 100 wpm teletype machines patched to the various aircraft and half inch tape recorders to record control center activity.

Between Apollo missions, a series of simulations with simulated ARIA would be conducted by the AOCC Staff and a "Sim Team" in another building who could emulate MCC and other NASA sites and the aircraft. It became the practice that when the AOCC was going to be simulating events with a specific ARIA, the PMEE crew from that aircraft would be invited to watch the simulation from inside the control room. In this way they would see how the AOCC would be handling their problems while they would be "boring holes in the sky" half a world away.

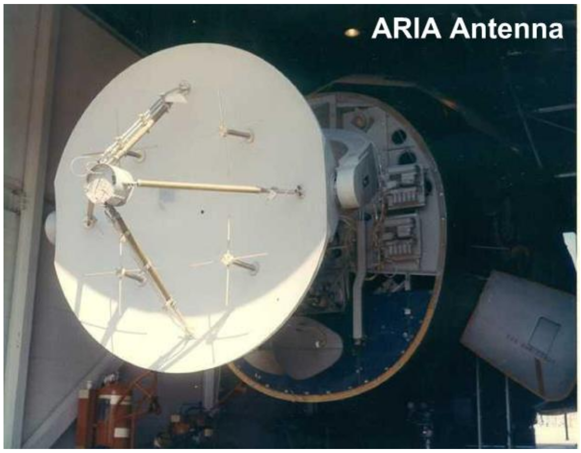
VII. Summary

The ARIA "little brothers" to the larger ground stations and ships of the NASA communications network worked in anonymity to the general public and the agencies they served. There can be no doubt that the dedication and commitment of their aircrews, ground maintenance, control and support staff completing hundreds of missions and thousands of hours supporting Project Apollo, military, scientific contribution to America's space program for more than thirty years. To quote the late Winston Churchill, "Never was so much owed by so many to so few."

Acknowledgments

This chapter would not have been possible without input from emails, text messages, and telephone calls with Project Apollo and ARIA alumni in Australia and the United States. In Australia: Mike Dinn, Colin Mckellar and his website www.honeysucklecreek, John Saxon, and Neil Yakalis. In the United States: Bob Beach (photos), David Botto, David Dunn, Tim Hart, Jim Steward, and Richard "Doc" Weaver. Diagrams for Appendices 4 and 7 are taken from an uncopyrighted booklet "Apollo Range Instrumentation Aircraft," *Air Force Eastern Test Range, 1969*.

Appendix 1—ARIA Antenna



Appendix 2—ARIA Projects Flown

ARIA Projects Supported

1968–1975—Air Force Eastern Test Range, Patrick AFB, FL

Apollo
Apollo-Soyuz
Chevaline
Hawkey/NPE
HELIOS
IMP
Intelsat
Lunar Sounder
Mariner Mars
Mariner Venus-Mercury
Minuteman
NATO III
NOAA
Pioneer
Polaris
Poseidon
SATCOM
Skylab
Skynet
SMS
Viking
Westar

1976–1994—4590th Test Wing, Wright Patterson AFB, Ohio

Advanced Cruise Missile
Air Launched Cruise Missile
Airborne BiStatic Radar
AMRAAM
B-1B
COBE
Delta II
Galileo Mission to Jupiter
HEAO
LANDSAT
Magellan Venus Mapper
Mars Observer
NAVSTAR GPS
Peacekeeper
Pershing I and II
Pioneer Venus
Polaris
Poseidon
RCS SATCOM
SEASAT
Space Transportation System
TIROS
Titan III-C
Titan IV
Tomahawk
Trident
Voyager I and II
X-ray Time Explorer

1994–2000—412th Test Wing, Edwards AFB, CA

X-Ray Timing Explorer
Solar and Heliospheric Observatory
Titan IV
FAST
Conventional Air Launched Cruise Missile

ARIA Operating Locations (Very Partial List)

Ascension Island	New Zealand
American Samoa	Senegal
Australia	Seychelles Islands
Barbados	South Africa
Brazil	Surinam
Cocos Island	Tahiti
Fiji Islands	United States
Guam	Venezuela
Mauritius	Wake Island

Compiled by Tim Hart and S. E. Anderson

Appendix 3—ARIA Disposition

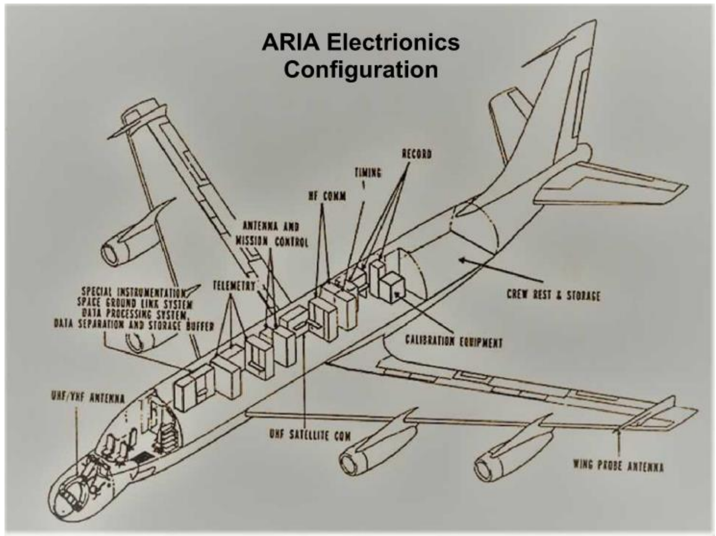
Tail #	To	Date
60-372	Edward AFB Storage	3/17/2005
60-374	USAF Musum, Dayton, OH	11/2/2000
60-375	*AMARC, Davis-Monthan AFB, AZ	4/18/2001
61-326	*AMARC, Davis-Monthan AFB, AZ	6/1/1998
61-327	#Museum, Robins AFB, GA	2003
61-328	Crashed, Walkersville, MD	5/6/1981
61-329	Battle Damage/Fire Trainer, Tinker AFB, OK	6/1/1996
61-330	Scrapped, Kirtland AFB, NM	2007

* AMARC—Aircraft Maintenance and Regeneration Center ("The Boneyard")

Modified to Abn CP used by Generals Norman Schwarzkopf and Tommy Franks

Compiled by S. E. Anderson

Appendix 4— ARIA Electronics Configuration



Appendix 5—ARIA HF Radios
David Dunn, ARIA Mission Controller, Scottsdale, Arizona

The Probe antennas were all HF antennas.

The dish antenna had PMEE VHF and UHF antennas along with a sprinkling of antennas all over the aircraft. Engineers kept trying out various combinations and locations. The TACSAT was mounted on the top near the navigators sighting dome.

There were only 3 sets of HF PMEE radios, 3 transmitters and 3 receivers. this meant that there were only 3 Duplex links available at any one time. For an Apollo Relay, one set was used for the Houston-Spacecraft circuit and one set was used for coordination between the Cape Com and the PMEE crew. The 3rd set was backup for either. Then later, of course as in the case of Apollo 13, there was the TACSAT link.

The PMEE transmitters were high power, like 1000 Watts, that used the Wing mounted probe antennas and the trailing wire antenna.

The cockpit HF radios were low power—something like 200 Watts- that used the Tail mounted probe antenna and operated independently from the PMEE radios- this was the standard equipment for all C-135 aircraft.

Procedures called for the flight crew to stay off their HF radios when there was an active Apollo relay. When not being used for PMEE Apollo relay, the flight crew could access the PMEE HF radios using an internal link, but they usually only would do so when their HF circuits were poor.

Appendix 6—The OTC Role of Radio in the Apollo Moon Missions
Neil Yakalis, Marsfield, Sydney, NSW, Australia
(Formerly Overseas Telecommunications Commission)

Following my OTC traineeship, I started work at Doonside in December 1968 just in time for Apollo 8.

NASA paid OTC to install additional transmitters in Sydney at Doonside & receivers at Bringelly. They paid for three 200-foot-high STC rotating log periodic aerials at Doonside. Also, three AWA CLH30J (30Kw) valve transmitters driven by solid state high stability Marconi ISB drive units. Bringelly received two AWA ISR22A valve rack receivers & two STC rotating log periodic aerials. Installation work on both these sites was finished on December 8, 1967. At the completion of Aria missions, we were free to use the equipment on other HF radio services.

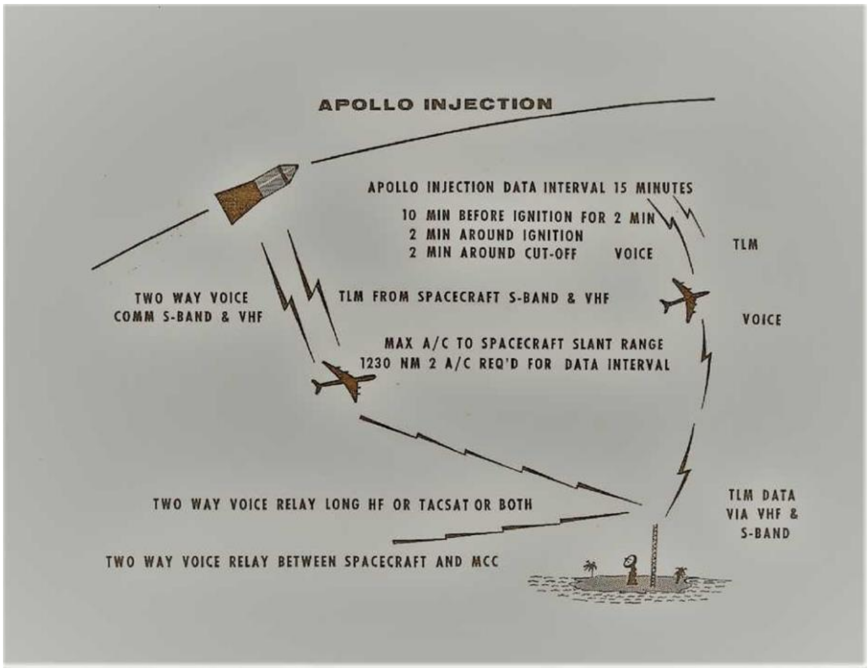
During all Aria missions the Doonside station load was run off the two synchronized Lister diesels. This was a precaution against a possible power failure. An additional technical officer was rostered on & required to log all diesel readings hourly. These Aria lead up missions to Apollo 11 were always taken very seriously by our technical staff.

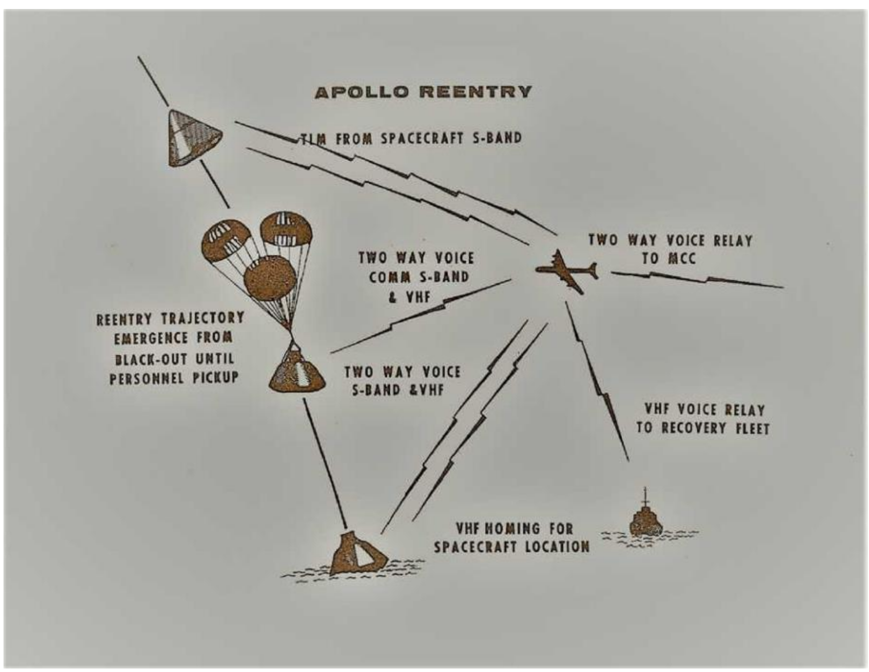
We communicated with US Aria aircraft using Paddington as our ZAL control station. I remember the dedicated order wire phone we used was a modified red 800 series PMG house phone. It had the rotary dial replaced by a push button which lit on incoming calls.

Many of the US Aria aircraft operating in the Pacific Ocean region had flown out of Hawaii.

Aria missions continued after Apollo 11 until the mid-1970s. However, at the completion of the 1969 Apollo 11 moon landing, NASA awarded framed certificates to Paddington, Doonside Transmitting & Bringelly Receiving Stations.

Appendix 7—Apollo Injection-Reentry Requirements





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