History of Rocketry and Astronautics

Proceedings of the Fifty-First History Symposium of the International Academy of Astronautics

Adelaide, South Australia, 2017

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AAS History Series, Volume 50

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 37

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2020

ISSN 0730-3564

ISBN 978-0-87703-667-8 (Hard Cover Plus CD ROM)
ISBN 978-0-87703-668-5 (Digital Version)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 17

From Fresnedillas Apollo Station to Europe's Only Lunar Museum*

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Abstract

Fresnedillas-Madrid Station was one of the three prime Apollo stations, along with Goldstone (California, USA), and Honeysuckle Creek (Australia), that formed NASA MSFN and later became part of the STDN. It was the primary tracking facility in Europe, which was operative from 1965 to 1985, when its 26 m antenna was deactivated. This station hosted a multidisciplinary set of workers who not only supported the main Apollo missions, but also received the first words after landing LM *Eagle* on the Moon's surface. The history of the Madrid station did not finish with the Apollo program, as other missions such as Apollo-Soyuz, Skylab and the first Space Shuttle flights were supported. For those milestones, "Museo Lunar" was inaugurated seven years ago by the first Spain-born astronaut Miguel López-Alegría, after the commemoration of the 40th anniversary of the first men on the Moon.

* Presented at the Fifty-First History Symposium of the International Academy of Astronautics, 25–29 September 2017, Adelaide, South Australia. Paper IAC-17-E4.3B.2.

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Acronyms

DSN	Deep Space Network
GSFC	Goddard Space Flight Center (GSFC)
CSM	Lunar Module Command and Service Module
ALSEP	Lunar Surface Experiments Package
MSFN	Manned Space Fight tracking Network
INTA	National Institute of Aerospace Technique
STADAN	Satellite Tracking and Data Acquisition Network
STDN	Spaceflight Tracking and Data Network

I. Introduction

Fresnedillas de la Oliva Station, known as MAD in NASA terminology, belonged to the NASA MSFN, which operated under NASA GSFC in cooperation with the Spanish INTA. It was built fifty years ago in order to maintain good communication with astronauts at lunar distance and hence, it was the primary tracking facility in Europe, which was operative until 1985 when its last antenna was deactivated. This station was operated by a variety of technicians who not only worked to communicate the transport of a crew to the Moon, but they also gave instructions to return them to the Earth.

The history of Fresnedillas station [1] did not end with Apollo. From this site, technicians were tracking other manned missions, such as Skylab, ASTP (Apollo-Soyuz), and the first Space Shuttle flights with *Columbia*. For that reason, the 26-diameter antenna was turn into a permanent monument of space missions.

As seen in Figure 17–1, MSFN radar stations with large antennas were placed strategically around the world (approx. 120 degrees apart in longitude) for continuous tracking and communications coverage. Sites were placed at Goldstone, California; Madrid, Spain; and Canberra, Australia.

It is the intent in this chapter to provide a general description of the Apollo Madrid Station, touching only briefly on the more detailed technical and operational aspects in Section II, and focusing on the role played of this station. No effort is made to describe the manned missions or the Apollo project.

Also, we provide a small guide to Europe's unique museum dedicated to the Moon exploration in Section III.

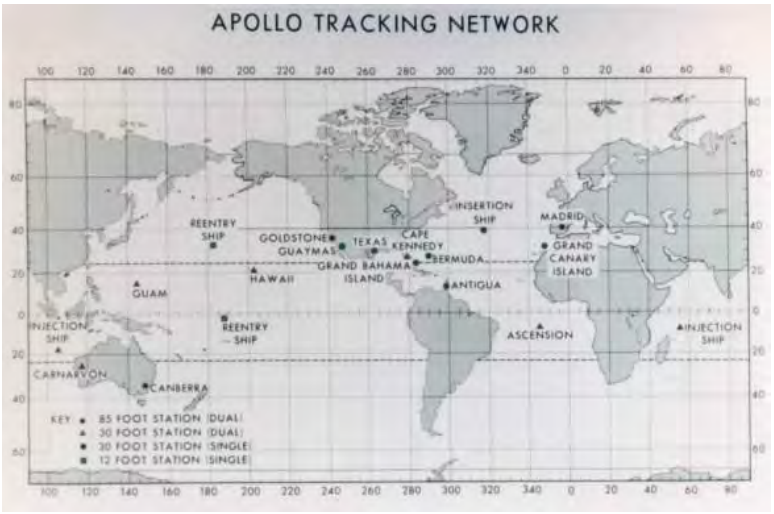


Figure 17–1: Apollo tracking network in 1966.

II. Fresnedillas Apollo Station

Figure 17–2: Fresnedillas Station for MSFN main entrance [2].

The Station (Figure 17–2) was located in 40°27'19.6"N 4°10'06.4"W with the objective of being one link in the worldwide chain of the MSFN in order to provide support to the successful lunar program of manned flights. The site was selected in a natural bowl-shaped area far enough from Madrid to avoid any possible interference, but close to an important airport that could provide NASA's items.

The Fresnedillas-Navalagamella location, approximately 50 km west of Madrid, was the site chosen. Its wing station was located 10 km away, in Robledo at JPL DSS No. 61.

II.1. Missions and Highlights

The missions during the heroic age were:

1965–1966: Station works and staff hiring and training for DSN missions and practical purposes: Lunar Orbiter and Pioneer.

1967: Apollo 4. First launch of Saturn V rocket.

1968: Apollo 6. Second launch of Saturn V with the injection into orbit of the CSM.

Apollo 7 was the first manned flight of the capsule in Earth Orbit and first support of the antenna called "Dino" in popular site slang.

Apollo 8 was the first crew to see the dark side of the Moon (ten times). Also, they broadcast a live TV program from the six filmed during this mission in the second lunar revolution by an RCA black and white, slow-scan TV camera, on Christmas Eve [3].

*II.1.1. **1969**: The Historical Year*

From March 3 to 13, Apollo 9 LM orbited Earth for the first time. Apollo 10 completed its round-the-Moon trip. Also, they were the first to be tempted to land to the Moon during testing for descent probe, which was prevented by the use of substitute ballast for the equivalent. From July 16 to 24, the Apollo 11 historical mission with Neil Armstrong, Buzz (Edwin E.) Aldrin, and Michael Collins. Though Madrid missed out on the Apollo 11 EVA (the Moon was below the horizon at Madrid, 22:18 CET), those at the station had their share of those glory days. Despite the 9 hours of rest time as the Apollo 11 Flight Plan suggested [4], Armstrong's descent took place 6.5 hours after landing, already over Goldstone Station.

Apollo 12: A repetition of the previous flight landing near Surveyor 3.

II.1.2. The Post-Apollo Decade

During this decade, Fresnedillas station kept in touch with the ALSEP, duplicating its infrastructures and staff, and finished the operations on Apollo program:

1970: Apollo 13 The famous risky and aborted mission.

1971: Apollo 14 and 15 were the third and fourth successful completed missions, with the novelty of including the Lunar Roving Vehicle (LRV) on the last one for longer rides on the Moon.

1972: Apollo 16 and 17 were similar to the previous mission and the last of the program despite of the fifteen manned missions planned. Apollo 18 to 20 were canceled since the Apollo program had fulfilled its priority political mission and budget for the space Administration plummeted.

After the Apollo lunar missions, the wisdom for having a separate network specifically for human spaceflight was questioned. It was in this era of change that GSFC merged its two networks (the STADAN for satellites in terrestrial orbit and the MSFN) in **1975** into a single and more cost-effective network called STDN [5].

Henceforth, the MAD station started to form part of the STDN that provided critical support to the Orbital Maneuvering System burns. During the orbital phase, the S- and C-band stations that saw the Space Shuttle orbiter at 30 degrees above the horizon provided appropriate tracking, telemetry, air-ground, and command support to the NASA JSC Mission Control Center through GSFC.

The Network turned its focus to supporting the reusable Shuttle [6].

From 1979 to 1988, the Ground Network reduced the number of tracking stations while adding to the facilities and increased the capabilities at the remaining stations. The STDN relinquished its Goldstone, Madrid, and Canberra stations and transferred their operations to closer DSN sites. MAD (renamed RID in 1984) was transferred to DSN in 1985 and all staff and non-retired equipment in Fresnedillas were moved to Robledo DSN; The 26 m antenna was redesignated as DSS 66 [7].

Reusing the material left over from the Apollo program and with the propulsion of the Saturn V last flight, America's first space station Skylab was launched on May 14, **1973**. From then until February 8, **1974**, Fresnedillas performed contact with the astronauts in the lab several times per day.

Figure 17–3: The 85-foot Madrid Apollo Tracking Station at Madrid [2].

Note the antenna for Skylab—the Teltrac antenna at left and the UHF command antenna and associated van in the foreground at center.

1975: Two new parabolic antennas of 6 m and 5 m, and other two "Yagi" types were installed in order to perform experiments of communications and TV via ATS terminal.

MAD collaborated for a few days to establish contact with Apollo-Soyuz. This experimental test project was performed via the ATS-6 GEO satellite as relay and the mobile terminal providing more than half the orbital period. The success of that Tracking and Data Relay Satellite System (TDRSS) was the beginning of the end for these kinds of stations.

II.1.3. The Unmanned Missions

Human spaceflight suddenly became very quiet in the late 1970s. Nonetheless, the Fresnedillas Station took charge of other unmanned missions, namely: RAE, LANDSAT, AE, GEOS, OSO, ISEE, HCMM, NIMBUS, MAGSAT, HEAO, SAGE. Characteristics of these missions and any other features are shown in the Table in the Results Section.

II.1.4. The 1980s. The End of an Era

Thanks to the new 9 m dish moved from Maspalomas (See II.2.4) and the continuous delays in the TDRSS and the Shuttle programs, a few more years of work were guaranteed.

And that was how, after six years, new manned missions returned to be managed from Fresnedillas, playing a critical role on the first Shuttle flight of *Columbia* (STS-1) in April **1981**.

Nine more Shuttle missions were launched, including the 1983 *Challenger* (STS-6) payload with the first TDRS, which provided coverage at the same time as the utility of STDN Station. Until 1985, with the deactivation and removal of the 26 m Big Dish, Fresnedillas remained fully operational, work continued with the operation of the last satellites of Table 17–1 by means of the 9 m antenna. It focused on the Solar Maximum Mission (SMM), which was the first unmanned satellite to be repaired in space by the *Challenger* (STS-41-C), and the Japanese National Space Development Agency (NASDA) (now JAXA) Geosynchronous Meteorological Satellite (GMS).

It is also remarkable that the same day the 9 m antenna was disabled, the 26 m (DSS 66 now in DSN) started operations with the same staff without losing a single pass on the schedule.

Fresnedillas Station was officially closed and transferred to the Spanish Ministry of Defence (MoD) in June of **1987**. The end of an era had arrived.

II.2. The Facility and Equipment

The MSFN Stations would provide continuous communications coverage of the Moon. One MAD set was equipped with the more advanced unified S-band system that tied the signals for tracking, telemetry, telecommand, voice, and television into a single radio carrier for direct communication between the astronauts and the Mission Control Center in Houston. This failure-free communications system had to be consolidated specially for manned flights. For that reason, a part of the equipment reliability required they were always through the tracking station, which has them sight throughout the NASCOM network. The NASA Communications System network, previously used for the Mercury program and the beginning of the Gemini program, was a huge and more sophisticated ground

intercom global network that transmitted signals by means of terrestrial landlines, geosynchronous satellites or undersea cables.

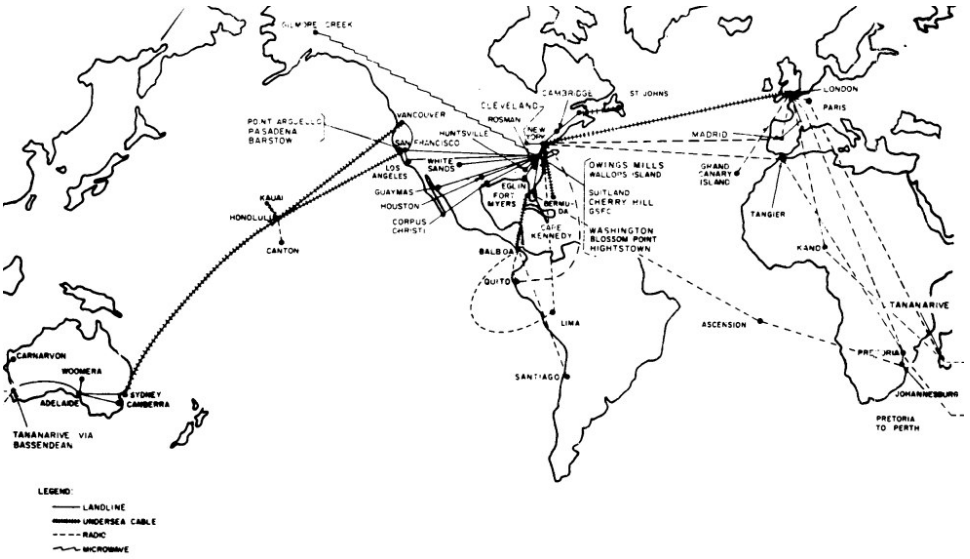


Figure 17–4: Map on NASCOM Network in the early 1960s [8].

All this highly specialized equipment was distributed in Fresnedillas facilities in three buildings and the hydro-mechanical building into the antenna [9].

II.2.1. The Operations Buildings

This building housed the offices and the station's electronic equipment: the data recording equipment, solid-state digital computers, microwave communications equipment. Modular construction and a complete inventory of spare modules permit early detection and expeditious isolation and replacement of a malfunctioning unit. For critical comms with the spacecraft, redundant and/or parallel circuits were provided.

The major electronic systems are depicted to the right, from left to right, up to down:

Figure 17–5: Fresnedillas indoor facilities.

- **Unified S-band (USB) system** to provide the communications with the spacecraft, redundant two-way link between the ground and the and/or parallel circuits were provided. spacecraft. It consisted of the tracking data processor and the necessary equipment for Tx and Rx; antenna control and driver, timing, and ranging.

Figure 17–6: An undated photo of the Madrid USB area [2].

- **Telemetry system** to decode Rx data acquired by the S-band system and to prepare it for recording or for processing by the computer system.
- **Recording system** to record wide-band (video data) and narrow-band (audio and low-speed data).
- **Computer system** for processing Rx and Tx data and sometimes to command the antenna. Perhaps the most historically interesting equipment item, due to the tremendous technological evolution it has undergone, was the 642 B (UNIVAC 1230 in the commercial version) with 96 KB memory of 32,000 words of 30 bits.

Figure 17–7: This picture was taken before I got to Madrid and right after the station opening in 1967. Photo Larry Haug [2].

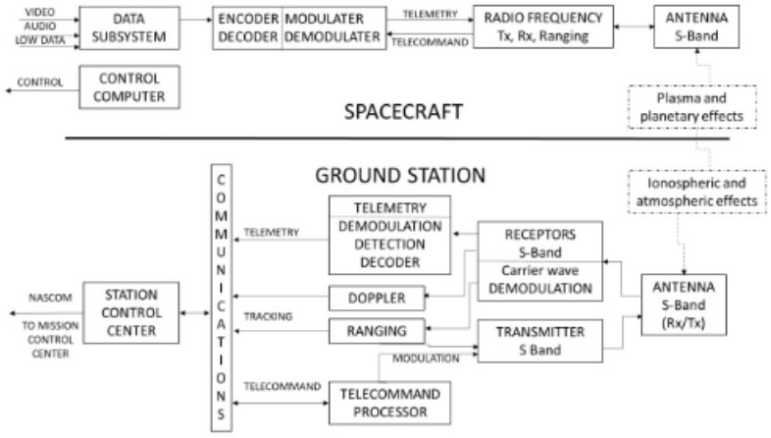
II.2.2. The Utilities Support

The utilities support building hosted:

- The primary power generating equipment, which supplied electrical power by means of seven different diesel generators (3x500 kW, 2x350 kW, 3x250 kW).
- The power distribution center with different devices to assure that high-quality power was delivered to the technical bus that supplied the mission critical electronic equipment, and for the maintenance power.

II.2.3. The Residence (Cafeteria and Dormitory)

This building contained the dining room, serving area, lounge, and bunks for sleeping during overtime mission periods.



II.2.4. The "Big Dishes"

The most important object was the DSS-61 "Dino" antenna It was one of the three, 85-foot diameter antennas purpose-built for Apollo translunar and lunar phases at distances greater than 15,000 km from the Earth. It was an S-band parabolic antenna over a X-Y mount with high-speed movement in order to support launches at low orbits, like its equivalent Stations of the MSFN, with which it shared the Apollo spacecrafts' ground connection. It was operational from 1967 until 1984, when it was dismantled. In 1975, the old quadrapod was removed and replaced with a self-supporting sub-reflector in the GSTDN retrofit as the last modification of the 26-meter dish. After almost 20 years of operation in Fresnedillas, it was reinstated into DSN in 1985 as DSS-66 at the Robledo de Chavela DSN complex by Joe Kuberth of GSFC GSTDN Engineering. Robledo also was site of the MAD Apollo "wing" (back-up) station. It was decommissioned in 2008.

In 1978, a 9 m antenna was installed following the closure of the Maspalomas Station in the Canary Islands (first Spanish NASA Station). Thus, MAD had two independent links, letting to simultaneously operate with two satellites, or having a redundant link.

Figure 17–8: Photo Larry Haug. Color restoration Colin Mackellar [2].

III. The Museum

Entrance to the museum begins through the patio area enjoying both a high-fidelity Saturn V rocket and the historic antenna mock-ups. From the original antenna was collected the famous Armstrong quote: “Houston, Tranquility Base here. The Eagle has landed.” This announced the Apollo 11 *Eagle* LM had successfully landed (July 20, 1969).

III.1. Room I: Main Entrance

A brief summary is presented of manned Apollo missions by means of dynamic roll-ups which point out the main highlights of each mission. Furthermore, people can observe racks, connection wires and harnesses from communications equipment; and several showcases where are placed milestone items such as the Apollo 17 Eugene Cernan’s original glove and Lunar Rover seat, among others.

III.2. Room II: Space Room

Visitors are in contact with a great number of space mission material as the original X-ray of the extravehicular gloves from Fred Haise Jr., Apollo 13 LM pilot. The compendium of the original Soyuz seat, commemorative medals and planet illustrations give the room a space atmosphere. Additionally, visitors can read a perfect reproduction of the 1969 Apollo 11 Flight Plan, reissued in 2017; and the original Apollo 10 Flight Plan notebook.

III.3. Room III: Aerospace Suits Room

After going through the "hall of fame," a breathtaking room appears, showing original historic space suits from different space agencies. People can perfectly visualize the clothes evolution from Emilio Herrera's space suit concept, which was the first designer in the history, to Pedro Duque's ESA training one, passing through several M. L. Alegria NASA space suits.

The last information that visitors can obtain comes from an audiovisual interview, which tells true experiences of veteran workers who took part in this milestone stage of our history. They were the hidden protagonists but the true honorees in this small but great museum.

IV. Results

Results of this chapter are a compendium of the total missions managed from Fresnedillas Station.

Mission \ to	Moon	Earth	L1	Sun
Lunar Orbiter	O			
Pioneer		O		O
Apollo 4	O			
Apollo 6		O		
Apollo 7*		O		
Apollo 8*	O	O		
Apollo 9*		O		
Apollo 10	O			
Apollo 11*	O, L			
Apollo 12*	O, L			
Apollo 13*	X			
Apollo 14*	O, L			
Apollo 15*	O, L			
Apollo 16*	O, L			
Apollo 17*	O, L			
Skylab*		O		
Apollo-Soyuz*		O		
TTS satellite				
RAE	O			
LANDSAT[1-5]		O		
AE		O		
GEOS		O		
OSO				O
ISEE[1-3]		O[1,2]	O[3]	
HCMM		O		
NIMBUS		O		
MAGSAT		O		
HEAO[1-3]		O		
SAGE		O		
Shuttles STS[1-9]		O		
Nimbus 7		O		
DE		O		
SMM		O		
GMS		O		

* Manned mission, O = Orbiter, L =Landed, X = Failed

Table 17–1: Major data of the orbit/landings of Venus, Earth, Mars and Jupiter with special attention to the Apollo program.

In idle moments, practice continued with DSN missions, with the Test and Tracking Satellite (TTS) and always in contact with the Early Apollo Surface Experimental Package (EASEP) seismometer left behind by Apollo 11 and the scientific instruments of Apollo 12 ALSEP.

V. Conclusions

Due to the extraordinary significance of these masterpieces, Museo Lunar of Fresnedillas must be a mandatory stop for every aerospace lover who wants a realistic experience of being in contact with original pieces of the Moon exploration history. More info in: museo.fresnedillasdelaoliva.es.

Acknowledgments

This museum is possible thanks to Robledo MDSCC and CNI—National Intelligence Centre, item donations and Jordi Gasul collections and the effort of Fresnedillas de la Oliva Council funding: http://museo.fresnedillasdelaoliva.es/.

Special thanks to Tomás, Pablo and Barbara Alonso and their family who made the germination of the museum project possible in order to pay tribute to and remember +140 Fresnedillas station workers listed in https://www.honeysucklecreek.net/images/other_stations/madrid/Madrid_Roster_1972.pdf.

Also, thanks to INTA for the library archives including a brief literature survey, NASA's Lunar Portal and The International Observe the Moon Night support for the outreach and data used for the Museum volunteers and staff.

Also, thanks and greetings to the developers of the www.honeysucklecreek.net, website, Colin Mackellar, Mike Dinn, John Saxon and Glen J. Nagle. For the research, photos and kindness contact in this antipode country.

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