TIDBINBILLA

DEEP SPACE TRACKING STATION ○ DSIF 42

COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF SUPPLY

UNITED STATES OF AMERICA
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

OPERATIONS AND MAINTENANCE CONTRACTOR
SPACETRACK PTY., LTD.

TIDBINBILLA
DEEP SPACE TRACKING STATION
DSIF 42

INFORMATION BROCHURE

Issued with the compliments of the
Department of Supply on the occasion
of the official opening by the

Prime Minister,
The Right Hon. Sir Robert Menzies,
K.T., C.H., Q.C., M.P.

March 19, 1965.

POSTAL ADDRESS: The Secretary, Department of Supply
339 Swanston St., Melbourne, C 1
(or Box No. 2288U, G.P.O. Melbourne C 1, Vic.)

This is another day of achievement for the U. S. National Aeronautics and Space Administration in its great scientific attack on the mysteries of space and for Australia whose area of cooperation in the great adventure continues to expand.

I offer you a warm welcome to Deep Space Instrumentation Facility No. 42 which today officially joins the world deep-space network and which, with two more stations yet to be built, will scan the limitless reaches of space from the Australian Capital Territory.

It is altogether fitting that these stations should operate from this Nation's capital, for the conduct of these stations in Australia by Australians illustrates the growing association between Australia and the United States in the field of scientific endeavour.

But the exercise encourages still wider development of international cooperation and understanding. I recall a few months ago we had the pleasure of welcoming to Australia members of the United States House of Representatives Committee on Science and Astronautics who expressed themselves as being well pleased with the installation and the standard of conduct of their stations at Woomera, Carnarvon and here in Canberra.

So the programme goes with two-way benefits: to the United States in access to our geography peculiarly essential to their peaceful scientific endeavours in space and to Australia in access to the most advanced technology in space research and related activities.

The Department of Supply is proud to carry the responsibility for the efficient management of this new and important installation but, as a matter of policy, we believe that the scientific benefits and the experience of operating in the most sophisticated electronics field in the world offers great opportunities to Australian industry.

We are therefore happy to acknowledge a consortium of private enterprise companies under the name SpaceTrack Pty. Limited as the successful tenderers for the operation of this Tidbinbilla Space Tracking Station. Thus, to the value of Government-to-Government cooperation, there is added, for Australia, the benefit of Government-to-Industry association.

May all who are associated in any way with D.S.I.F. 42 derive great satisfaction from this effort to expand the frontiers of human knowledge.

Allen Fairhall.

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1. AUSTRALIAN/AMERICAN COOPERATION IN SPACE EXPLORATION

An agreement entered into in February 1960 between the Governments of Australia and the United States of America was aimed at further cooperation in the field of space flight operations.

The National Aeronautics and Space Administration (NASA) in the United States and the Department of Supply (DOS) in Australia are the government agencies responsible for fulfilling this agreement. The construction and operation of tracking facilities in Australia is financed by NASA and the DOS provides design, construction, management and operational effort from Australian resources.

The Deep Space Instrumentation Facility (DSIF) at Tidbinbilla has been erected to provide another link in the world-wide network which supports the prime control centre of the deep space research programme in America, and is one of a number of tracking facilities to be established to date by NASA in Australia.

Others are the Space Research Station located at Island Lagoon (Woomera), which includes a Deep Space Instrumentation Facility (DSIF 41) similar to this station, a Baker-Nunn Satellite Tracking Camera and a Satellite Tracking Facility; the Carnarvon (Western Australia) Station for the Manned Space Flight Programme and Scientific Satellites and the Manned Space Flight Installations at Muchea (Western Australia) and Red Lake (Woomera).

Tidbinbilla is also the first of three NASA Tracking Installations programmed for the Australian Capital Territory. The second installation for tracking the larger and more complex of the scientific satellites is under construction in the Orroral Valley. The Australian Government has also agreed to the establishment of a station at Honeysuckle Creek to support the United States Lunar Manned Spaceflight Project (APOLLO) and construction of that station is expected to begin shortly.

The DOS is responsible for implementing Australia's commitment in respect of the Australian stations and this responsibility is discharged through the Weapons Research Establishment within the Department.

2. STATION LOCATION

The station is located in the Tidbinbilla Valley only eleven air miles from Canberra, the national capital of Australia. The Tidbinbilla Valley provides an ideal environment for a DSIF station because the high ridges surrounding the valley provide masking from man-made interference (particularly radio-frequency

noise) which would seriously reduce the performance of equipment. This, together with the site's proximity to the city of Canberra, which gives support in the way of accommodation, communications, personnel, engineering and commercial services, was one of the primary considerations in selecting the site.

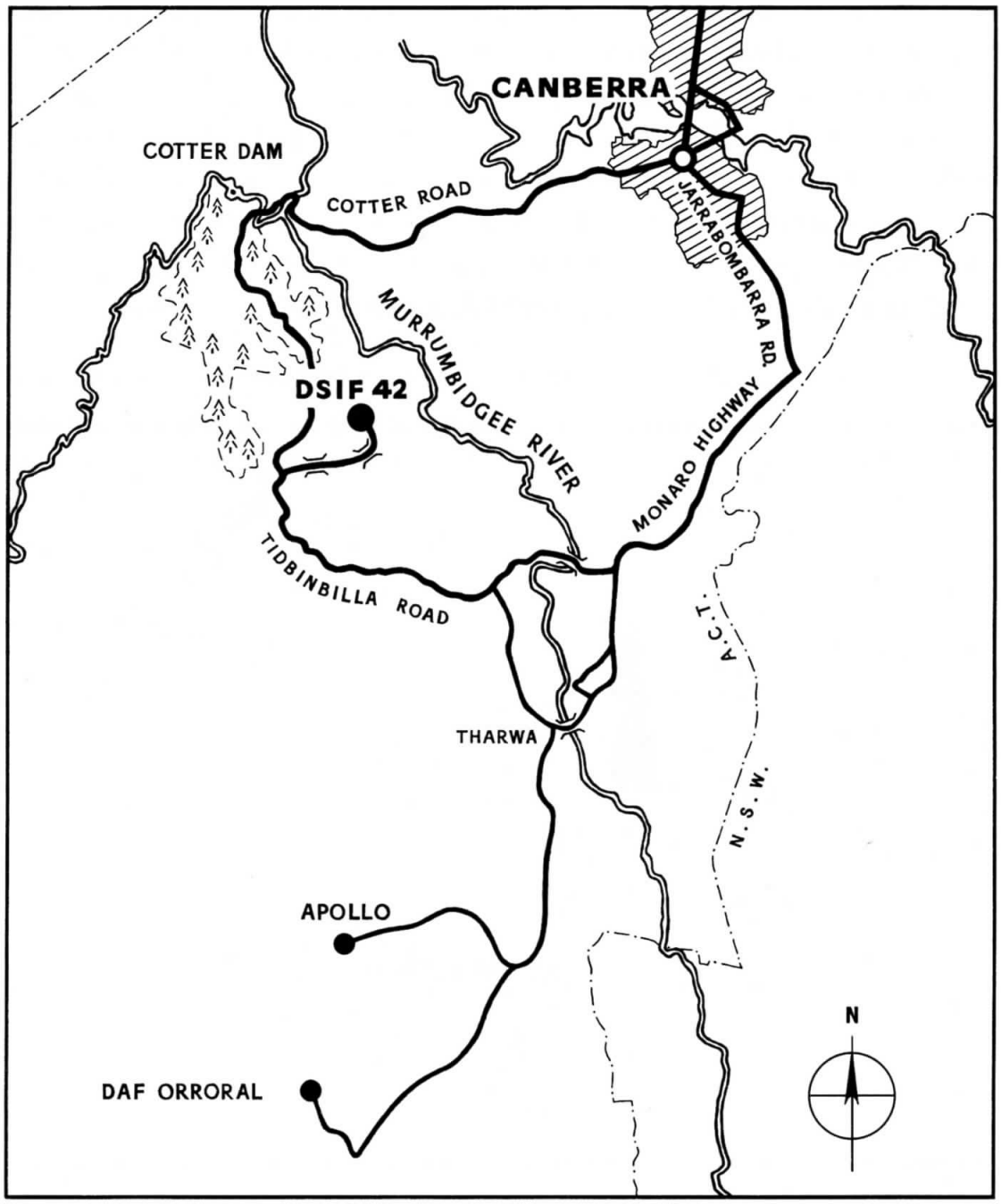


FIGURE 1. STATION LOCATION

3. STATION LAYOUT

The station is contained within an area of about ten acres. The 85 ft diameter antenna is located at the northern end of the valley to give it an unobstructed view of the sky and the station buildings have been so arranged within the area to cause the least possible interference with the performance of the antenna and associated equipments. Landscaping and the planting of trees and lawns, as well as reducing the risks of fire and soil erosion, provide pleasant surroundings at the station.

Construction was commenced in June 1963 and completed in December 1964 at a cost of about £750, 000. The equipment supplied by the Jet Propulsion Laboratory of Pasadena, California, which is responsible to NASA for implementing the deep space programme, cost about £4, 000, 000. The annual operating cost is expected to be about £600, 000 when the station becomes fully operational.

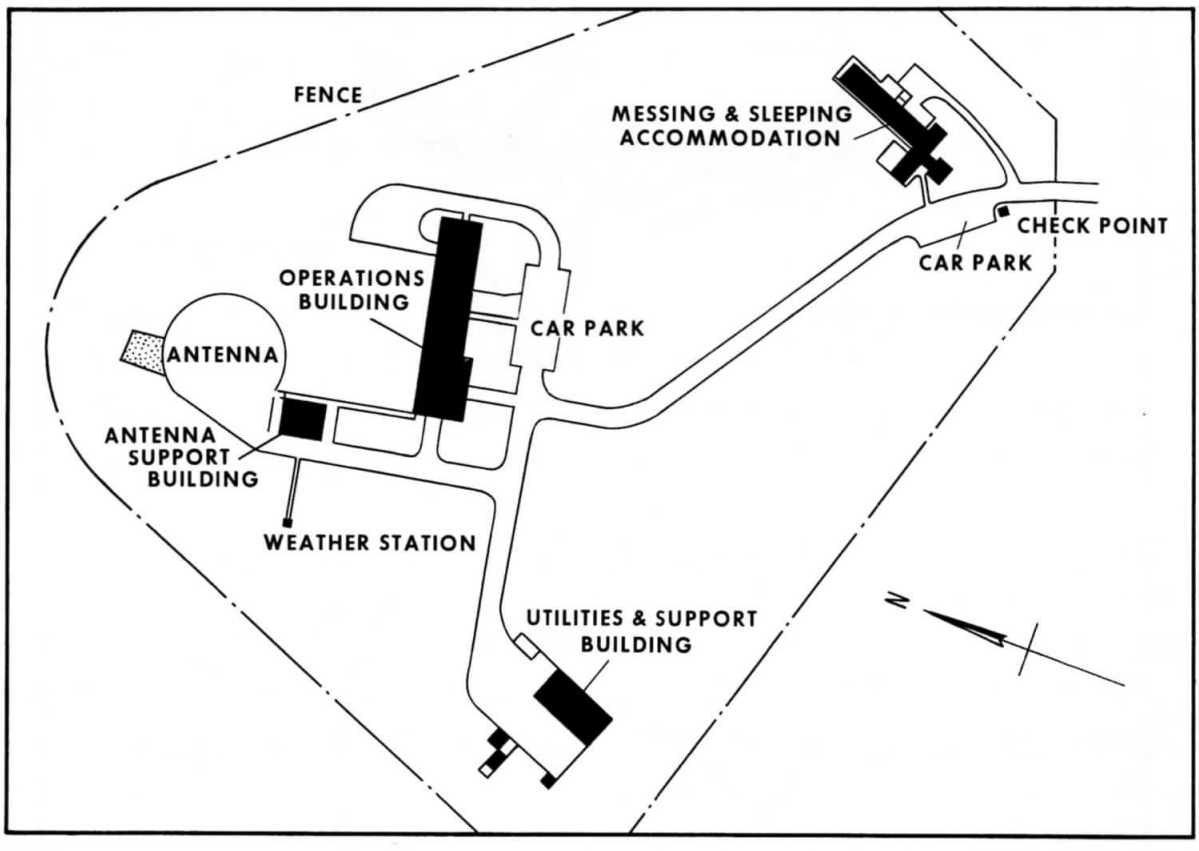


FIGURE 2. STATION LAYOUT

4. SPACE PROGRAMME

The present NASA programme has three major aspects, namely, near-earth scientific investigations, manned spaceflight and deep-space exploration. In the brief description which follows, it will become apparent that although the programmes are conducted in the space environment, their specific requirements vary considerably and, consequently, different ground stations are needed for each aspect.

Earth Satellites

These unmanned vehicles orbit the Earth generally in elliptical paths, which are usually just inside or just outside the Earth's atmosphere, but which may approach lunar distances away. They provide the means by which valuable scientific data is obtained. Because of their comparatively close proximity to the Earth, orbit times are generally only about two hours and the satellites require ground stations at frequent intervals around the Earth to track and communicate with them. One typical station of this type is being constructed at Orroral Valley, about 16 miles south of Tidbinbilla. Other major stations already exist at Woomera (South Australia) and Carnarvon (Western Australia).

Manned Space Vehicles

Because human lives are at stake this aspect of the space programme is the most critical of all. The Project Mercury programme established the feasibility of launching men into space and effecting a safe recovery. The future development in this field is to prepare for lunar and planetary exploration by man. The high degree of equipment reliability called for in this aspect of space flight requires its own special techniques and procedures and the duplication of essential services as an insurance policy. The distance from Earth of the presently planned manned missions varies from about 150 miles during orbital flights to about 250,000 miles during lunar flights. The Carnarvon Tracking Station, and the Apollo Tracking Station, to be established at Honeysuckle Creek about 12 miles from Tidbinbilla, will be used for communicating with and tracking manned vehicles on lunar journeys. The Tidbinbilla station will be used as a back-up to the Apollo station during these missions.

Deep Space Probes

This aspect is confined to exploration of the moon and the solar system using unmanned spacecraft, and involves distances up to hundreds of millions of miles from the Earth and periods up to several months for any one mission. To maintain contact with the spacecraft maximum sensitivity must be achieved in all aspects of the ground and spaceborne instrumentation by using the most highly developed techniques in the design and engineering of the equipment.

It is possible to maintain communications with these probes from three stations located equidistant in longitude around the Earth's surface, because after a probe has reached a distance of approximately 50,000 miles from Earth, overlap between the three stations occurs. The degree of overlap continues with increase in the probe distance. Unlike satellites which normally cross the sky in a period of minutes, these probes cross the sky at much the same rate as a star and are visible from any one station for periods of many hours.

This brief outline of the space programme indicates why three outwardly similar stations with 85 ft diameter antennas will be installed near Canberra and how they will each have their own special role to fulfill.

5. THE DEEP SPACE NETWORK

The solar system is vast compared with the Earth. Although the orbits of Earth's closest planets, Venus and Mars, are only tens of millions of miles distant, the planets' different periods of revolution around the Sun and the fact that the present technique of launching a probe involves a curved trajectory may cause the actual distance of a probe from Earth at pass-by of a planet to reach several hundred million miles. To reach the farthest planets would involve distances of several thousand million miles. The relative distances from the Sun of the orbits of the various planets within the solar system are shown in the diagram overleaf.

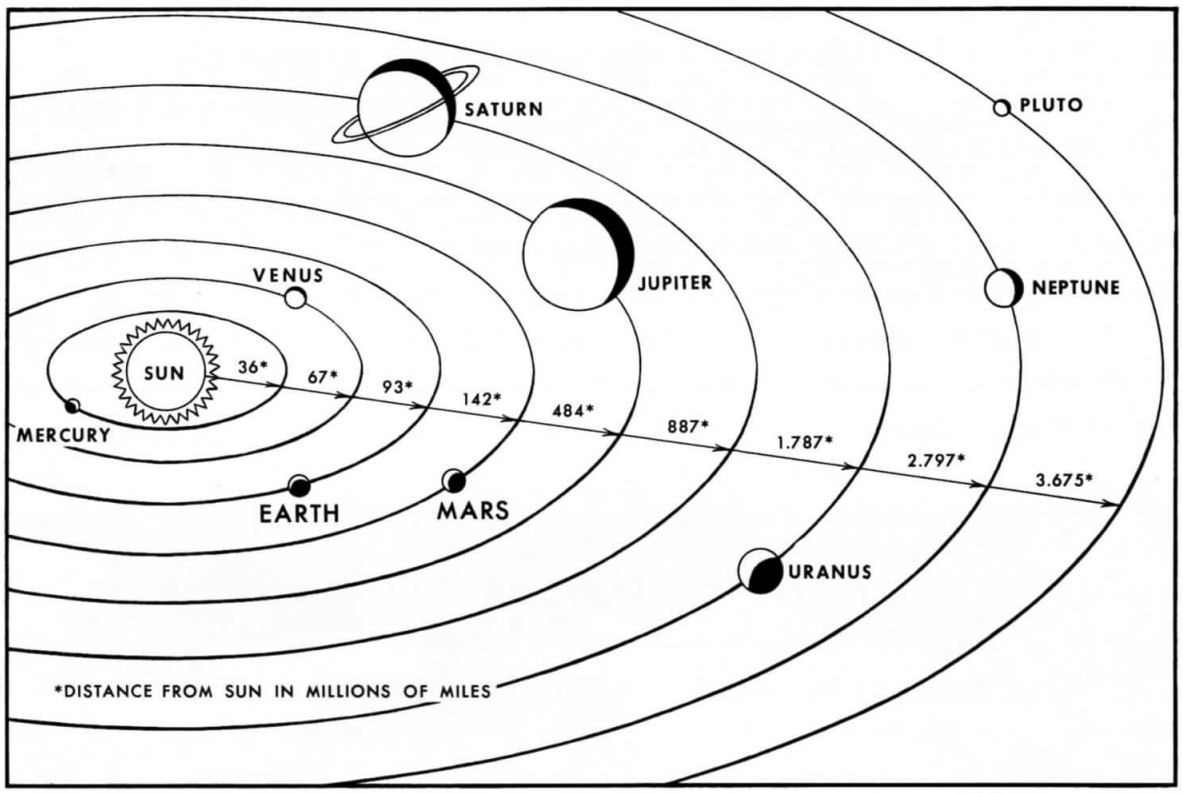


FIGURE 3. SOLAR SYSTEM

Because of the immense distances over which communications must be maintained in deep space missions, freedom from man-made radio frequency interference is essential at a DSIF station. In such a low-noise environment, the signal-gathering capability of a large antenna and a highly sensitive receiving system can be fully exploited in dealing with the weak signals that have to be handled.

In the recent Ranger mission to the moon, thousands of excellent television photographs were obtained commencing about 15 minutes prior to impact of the spacecraft on the moon's surface, the distance from Earth then being approximately 250,000 miles. In the final stages of the present Mariner-Mars mission (when the probe will be about 140 million miles away) the probe's TV equipment will photograph the Martian surface 20 times in approximately 20 minutes, these pictures being stored on magnetic tape and transmitted back to Earth over a period of 20 days as the probe proceeds beyond Mars.

Another facet of the stations' operations involves tracking the space probe to determine its path for navigation purposes and commanding it to apply corrections to its course and to switch certain spacecraft functions as required.

It has been shown earlier in this text that only three stations are required to provide communications with a deep space probe. While this is true, the present projected commitments of the space programme are such that duplication of the stations in each sector is necessary to cope with the load, and Tidbinbilla has been erected in support of the Woomera station in this sector of the world.

Two stations already exist at Goldstone (California) and one at Johannesburg (South Africa). In support of the latter station, a new station is under construction at Madrid (Spain).

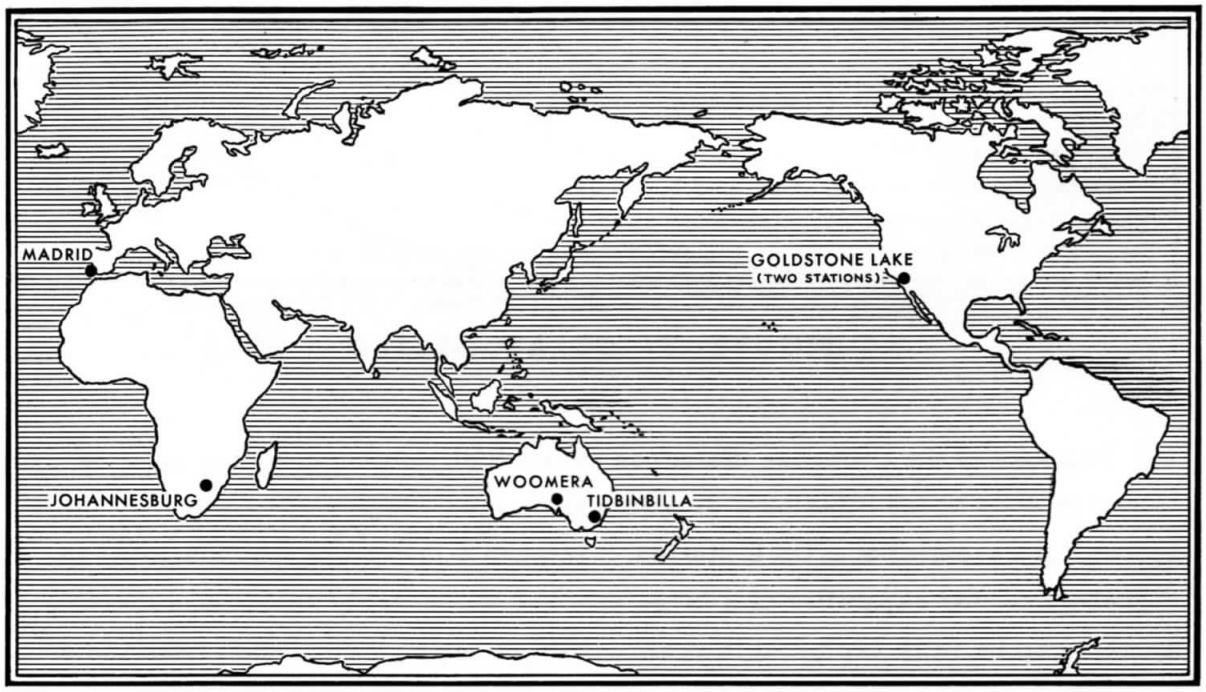


FIGURE 4. DEEP SPACE NETWORK STATIONS

The operational control of the Deep Space Network is vested in the Space Flight Operational Facility (SFOF) located at Pasadena, California, to which information received from the space probes is forwarded by each station for data processing and analysis. It is from this centre that all commands are generated before being passed to the appropriate station for transmission to the probe. The SFOF is operated by the Jet Propulsion Laboratory, Pasadena, California to which NASA has allotted the task of implementing the deep space programme.

6. STATION APPLICATION

The present commitment of Tidbinbilla DSIF is to continue tracking the Mariner-Mars probe (which it took over from the Woomera station on 1st February, 1965) until 20 days after the probe passes Mars on 15th July, 1965. This task will require 9 hours tracking a day for 7 days a week until the probe passes out of range of the station.

The primary objective of the Mariner mission is to obtain TV pictures of the surface of the planet Mars and scientific measurements of basic features such as the Martian magnetic field, etc. It is also hoped to identify organic characteristics of the Martian atmosphere and the surface of Mars. Secondary objectives are to obtain experience and knowledge of the behaviour of the basic spacecraft and its payload during a long flight in space and to obtain certain field and particle measurements in interplanetary space.

A diagram of the Mariner trajectory to Mars is shown below to illustrate the curved path departure from Earth, the relative positions of Earth and Mars throughout the mission, and portion of the orbit the Mariner will ultimately take up about the Sun.

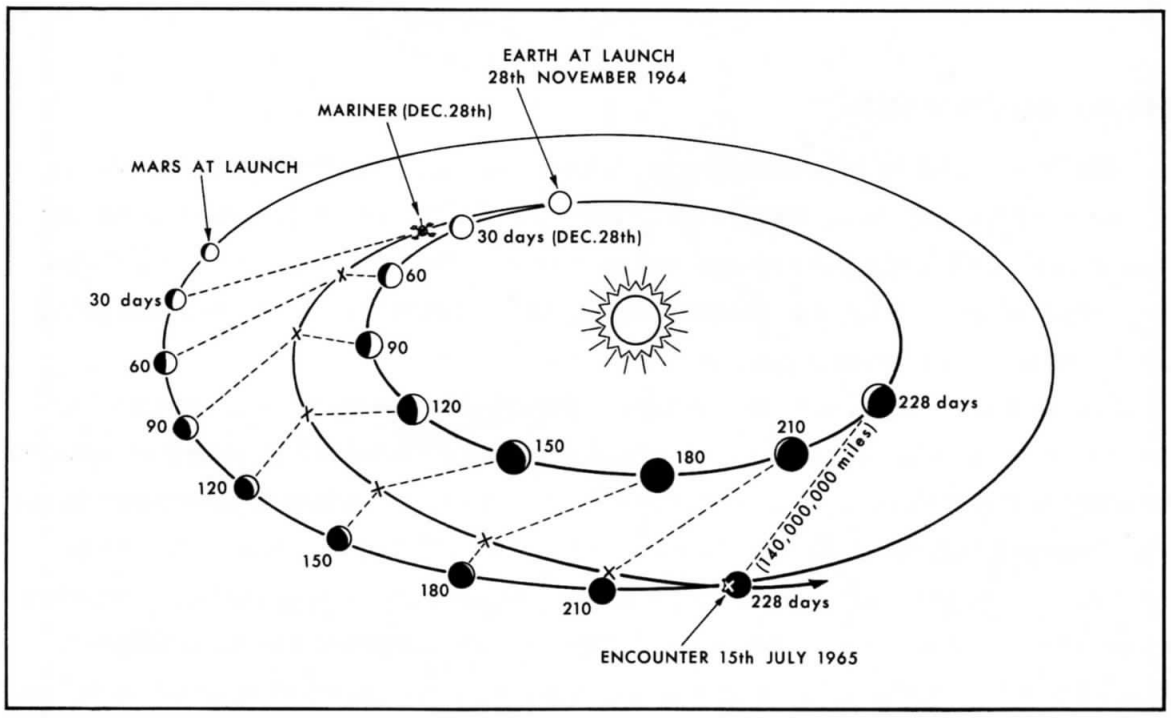


FIGURE 5. MARINER TRAJECTORY TO MARS

Later in the year, Tidbinbilla DSIF 42 will participate in the Surveyor programme which is designed to carry out a soft landing (i.e. a controlled landing) on the moon to extend exploration of the lunar environment prior to the Apollo manned vehicle exploration. The station will track the space vehicle for periods of up to 9 hours each day during its three-day flight and continue to receive TV pictures and scientific data from the stationary vehicle on the moon's surface when conditions are favourable. As these vehicles obtain their power through solar panels, they will not transmit when in shadow. An extensive programme of Surveyor missions is planned, and it is expected that each vehicle will have a life of two months.

Concurrently with the Surveyor programme, the station will be involved in tracking and communicating with a spacecraft during a Pioneer mission in which a deep space probe will be put into orbit about the Sun to carry out scientific investigation of interplanetary space. Its penetration of space will be the deepest yet made and it is expected to remain in orbit for an indefinite period. The first of the Pioneer probes was launched in association with the International Geophysical Year in 1958 during a period of maximum solar activity (sun spots), while the projected mission will be launched in a period of least solar activity. The Pioneer spacecraft is a relatively simple vehicle with no command facilities. The station will maintain an intermittent watch on this vehicle.

7. SYSTEM EQUIPMENT

The DSIF system is a complex of subsystems with ability to communicate with spacecraft over long distances. This is mainly due to the antenna having great signal-gathering powers and the microwave feed and low-noise amplifier (the temperature of which is maintained at minus 269°C by liquid helium) being able to handle very weak signals.

The antenna dominates the station. The 200-ton structure is designed and built to extremely close tolerances which must be maintained in order to provide accuracy and efficiency. An indication of the tolerance allowed is evident in the 85 ft diameter reflector surface (commonly called the "dish") which has to be accurately paraboloidal to within $\pm\frac{1}{8}$ inch. The antenna is equatorially mounted and is free to rotate about two axes. The lower axis (hour angle) is aligned parallel to the earth's axis while the upper axis (declination) is aligned at 90° to the hour-angle axis. The antenna is capable of being driven at two speeds, the maximum of which is one degree per second.

Signals from the low-noise amplifier on the antenna are passed to a receiver in the operations building. From the output of this receiver, the signal is fed to a telemetry/TV decoder which relays the data to magnetic tape recorders or to a direct teletype link to the SFOF at the Jet Propulsion Laboratory. Similarly, tracking data handling equipment accepts information from the same receiver and from the antenna angular readout to provide information on spacecraft range, velocity and angular direction. This information is also sent directly to JPL by the teletype link.

A 10 kilowatt transmitter, which is part of the command link, is mounted directly in an instrumentation room on the underside of the antenna reflector to ensure maximum efficiency. From information supplied by the SFOF, command data is processed through a command coder and thence to the transmitter.

Data received from the spacecraft would be of little use unless it is related accurately to time and, to provide this reference, the station has a rubidium primary frequency standard the accuracy of which is equivalent to gaining one second in 4,000 years.

8. OTHER ASSOCIATED EQUIPMENT

Ground Communications

Permanently rented circuits for teletype and voice are provided directly between Tidbinbilla and the United States. The flow of information between the world-wide network of tracking stations and the operations centre (SFOF) prior to and during a mission is extensive and the success of a mission is dependent on the ability to transmit information quickly. The voice circuit enables the SFOF in the United States to brief all the stations simultaneously on mission requirements and subsequent changes. It also enables the stations and other units of the network to discuss problems relating to the work. The circuits within Australia are provided and maintained by the PMG Department, while those between Sydney (N.S.W.) and the United States are the responsibility of the Overseas Telecommunication Commission (Australia).

Power Supplies

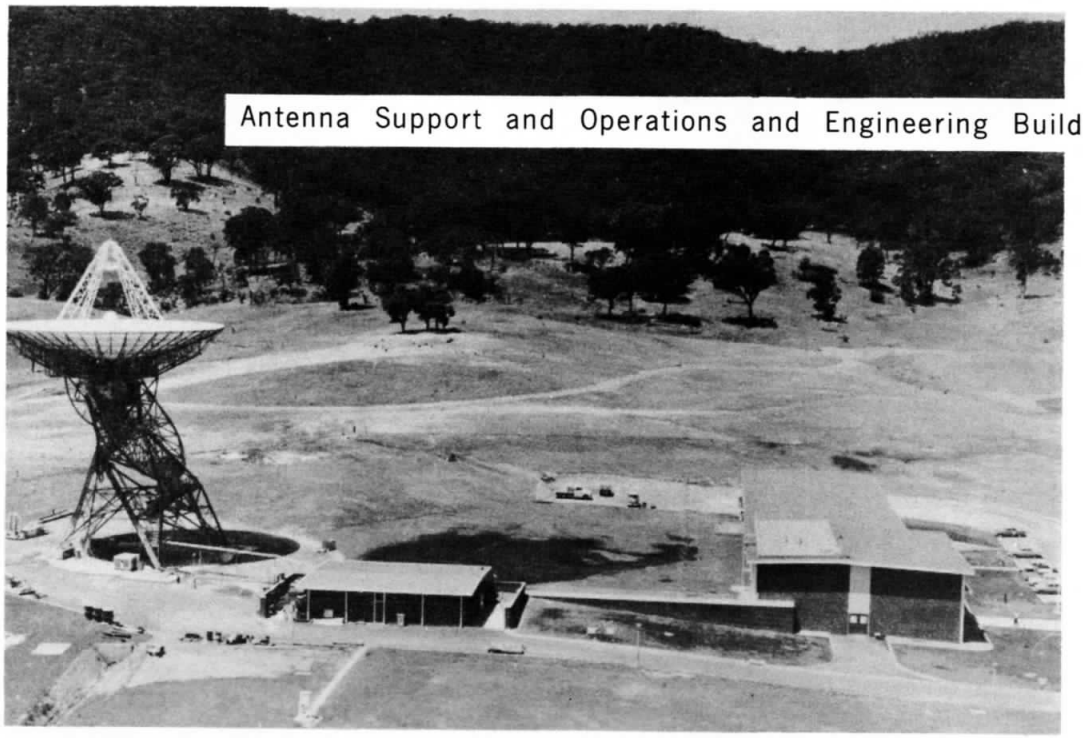
The continuity of power supplied to the station equipment is vital to the operation of the tracking and communication system. Even a brief power failure could cause a deterioration in efficiency which could last for several hours.

The power is generated on site by diesel-driven alternator units with sufficient capacity to provide full power for essential services in the event of one unit failing. The present installation consists of three units with an output of 850 kilowatts. A fourth unit will be installed shortly to increase this to 1,000 kilowatts.

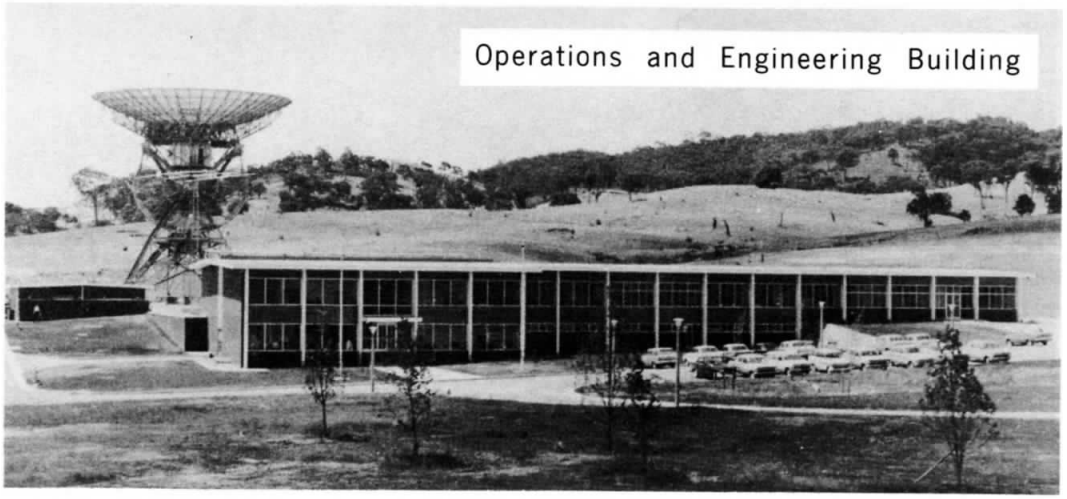
9. STAFFING THE STATION

The Department of Supply has responsibility for establishment and operation of NASA tracking and communication stations within Australia. This function is exercised through the agency of the Weapons Research Establishment (WRE). In the early days of space exploration, when the requirement was comparatively small, the management and operation was conducted wholly by WRE staff.

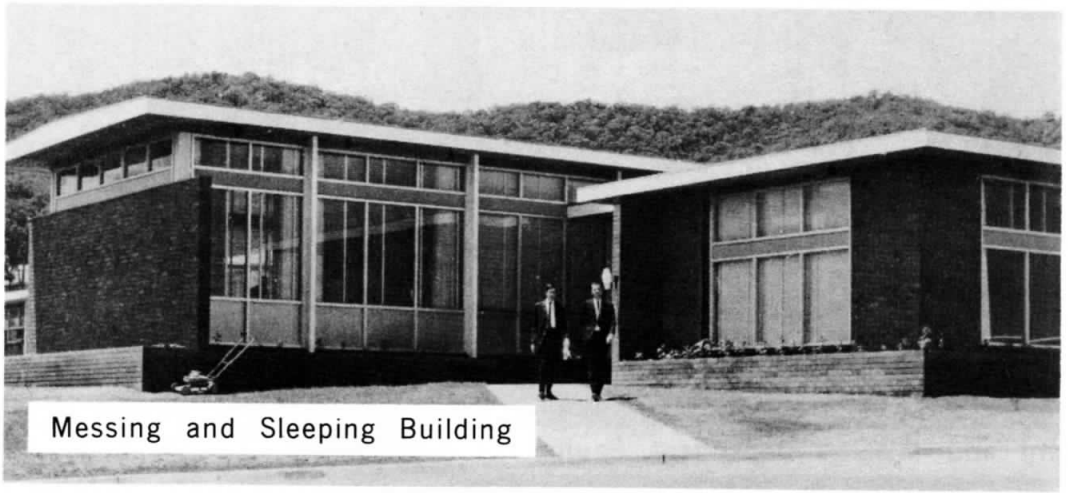
However, it is the policy of the Australian Government to utilise the resources of private industry and enterprise in the space research activities being carried out in Australia on behalf of NASA. This arrangement is now working satisfactorily at other tracking installations, and has been extended to Tidbinbilla. A contract has been let to SpaceTrack Pty. Ltd., a jointly owned subsidiary of Hawker de Havilland (Australia) Pty. Ltd., Elliott-Automation (Pty.) Ltd., and Australian Electrical Industries Pty. Ltd., for the operation and maintenance of the station under the direction of a Department of Supply station director who is a senior officer of the Weapons Research Establishment. The contractor employs about 100 people at the Tidbinbilla station.



Antenna Support and Operations and Engineering Buildings

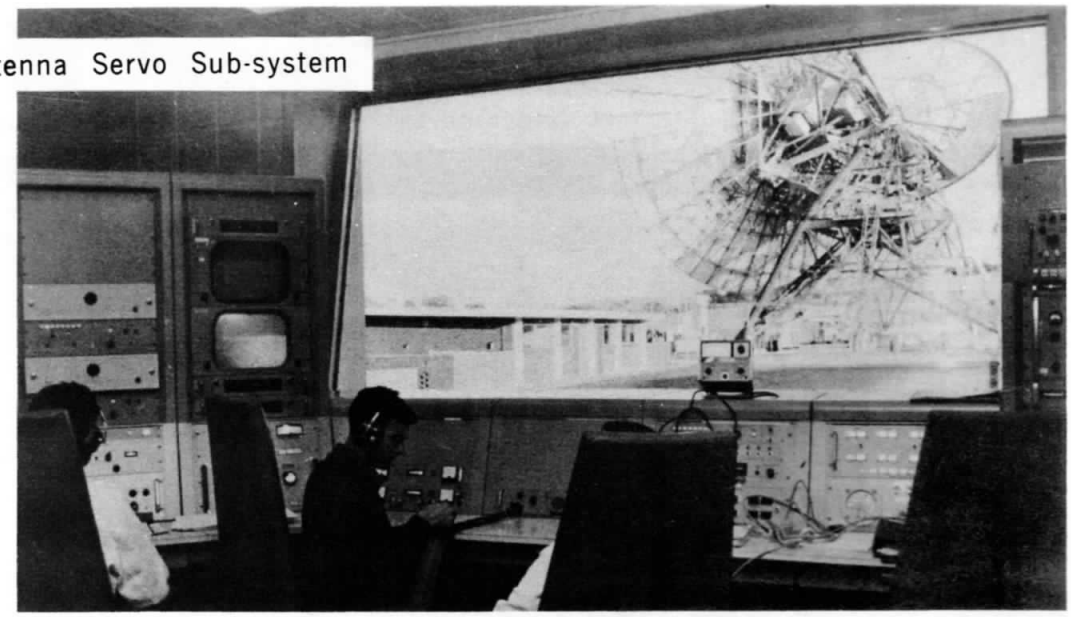


Operations and Engineering Building

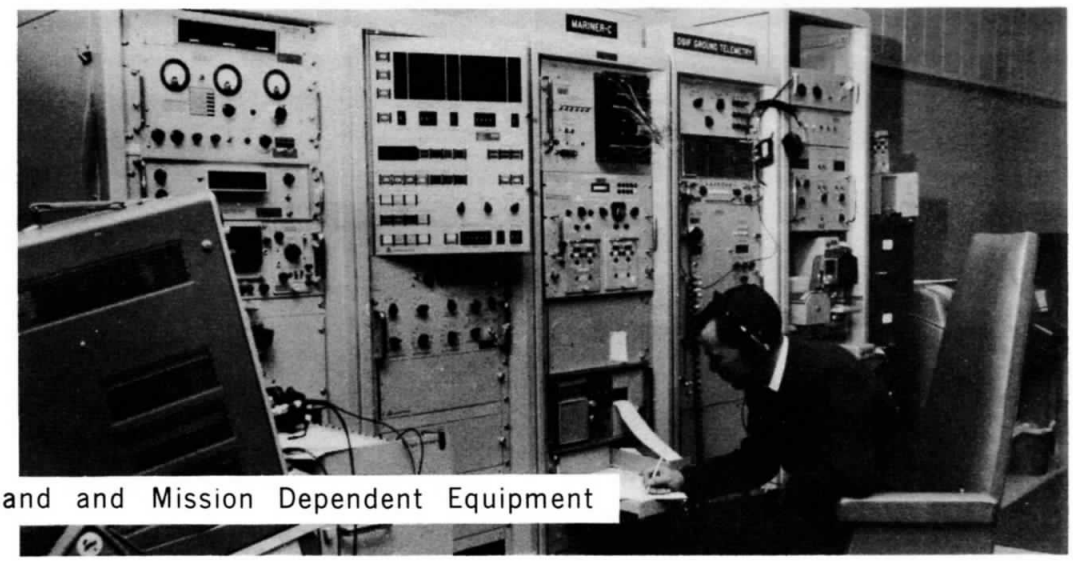


Messing and Sleeping Building

Antenna Servo Sub-system



Operations Room



Command and Mission Dependent Equipment

DESIGNED AND PRINTED BY TECHNICAL SECRETARIAT GROUP, W.R.E.