Tidbinbilla Deep Space Communication Complex

AUSTRALIAN CAPITAL TERRITORY

Established and directed by the Australian Department of Supply

On behalf of the United States National Aeronautics and Space Administration

Maintenance and operational services provided by Hawker Siddeley Electronics Ltd. Systems Division

Issued with the compliments of the Department of Supply

COMMONWEALTH OF AUSTRALIA

TIDBINBILLA DEEP SPACE COMMUNICATION COMPLEX

1. INTRODUCTION

In February, 1960, the Governments of Australia and the United States of America formally agreed to co-operate in space flight programs being conducted by the U.S.

Australia undertook to establish and operate a number of tracking stations which would form part of a world-wide network under the control of the U.S. National Aeronautics and Space Administration (NASA).

The Department of Supply is responsible for fulfilling the Australian commitment under this agreement.

The construction and operation of these tracking facilities in Australia is financed by NASA.

Management and operation are provided from Australian resources.

The first major station was built in 1960 at Island Lagoon, about 14 miles from Woomera. It is concerned with deep space probes.

Since then other stations have been established at :

- Carnarvon (W.A.), for manned space flights and scientific satellites (officially opened June, 1964).
- Tidbinbilla (A.C.T.), for deep space probes and manned space flights (March, 1965).
- Orroral Valley (A.C.T.), for scientific and applications satellites (February, 1966).
- Cooby Creek (near Toowoomba, Q'ld.), for applications technology satellites (October, 1966). - Ceased operations in 1970.
- Honeysuckle Creek (A.C.T.), for manned space flights (March, 1967).

Outside the U.S., Australia has the largest number of space tracking and communications stations in the world. NASA's capital investment in Australia is about $71m. - $58m. for equipment and $13m. for buildings, communications and roads.

The cost of operating the Australian stations is currently about $16 m. a year.

Together, the five stations employ more than 700 Australian engineers, technicians and supporting staff.

2. LAYOUT AND DESCRIPTION OF COMPLEX

The original purpose of the Tidbinbilla Complex was to augment NASA's world-wide network of tracking and communications stations concerned with unmanned deep-space probes seeking environmental information at distances from earth from 10,000 miles to hundreds of millions of miles into interplanetary space.

Later the building facilities were extended to house additional instrumentation equipment associated with the Manned Space Flight Network, in support of the Apollo Project.

This multiple capability considerably increases the scope of the Complex, in that the single 85-ft. antenna must be capable of being switched from one configuration to another, involving many intricate electronic interfaces.

NASA's Deep Space Network is managed by the Jet Propulsion Laboratory (JPL). The Manned Space Flight Network (MSFN) is the responsibility of Goddard Space Flight Centre (GSFC).

Construction of the Complex started in June, 1963, and it first became operational in December, 1964. Initial construction costs were about $1.5m. and the technical equipment, supplied by JPL, cost about $5m.

The new MSFN wing was constructed in 1966 for about $400,000; the additional technical equipment, supplied by GSFC, cost about $3m.

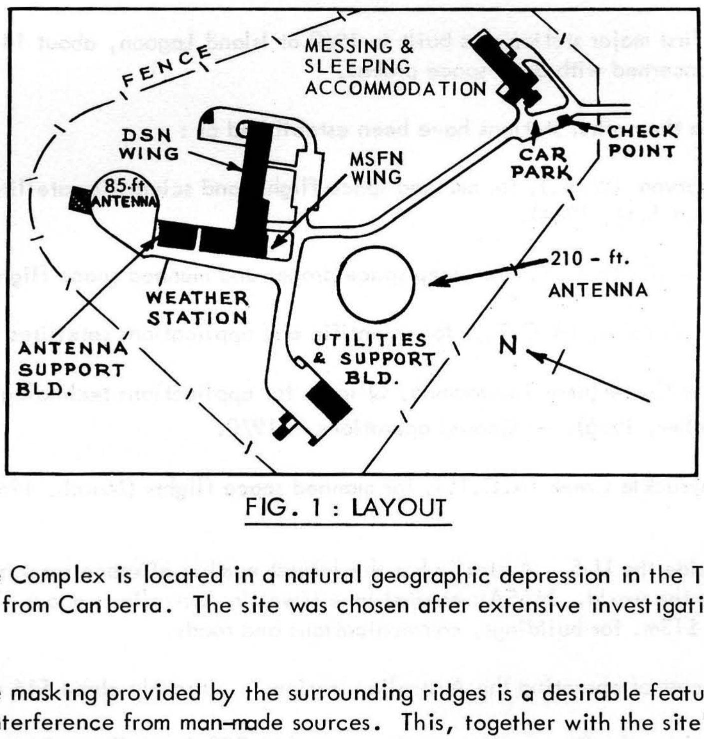


FIG. 1 : LAYOUT

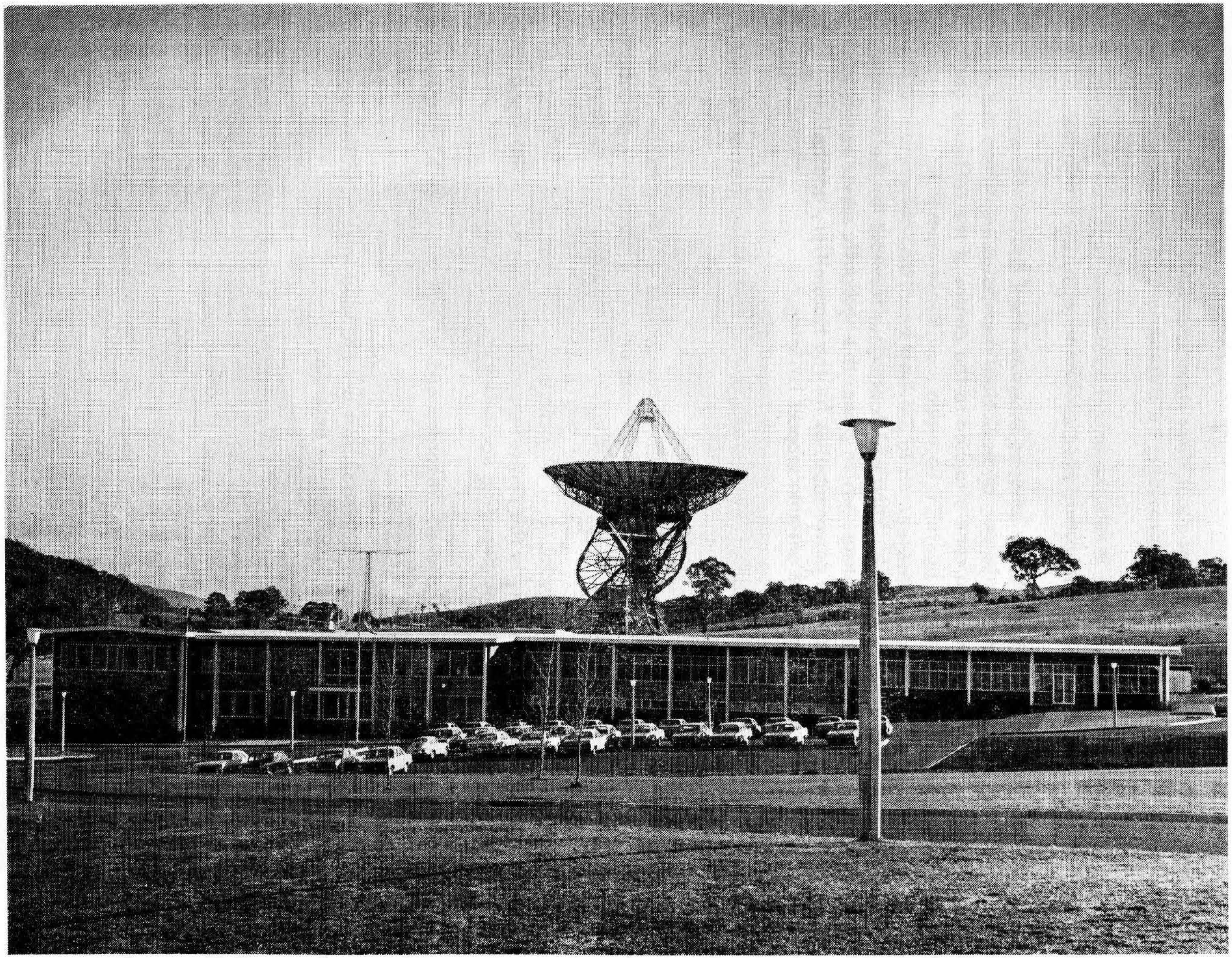
The Complex is located in a natural geographic depression in the Tidbinbilla valley, only 11 air miles from Canberra. The site was chosen after extensive investigations were made of likely areas.

The masking provided by the surrounding ridges is a desirable feature in restricting radiofrequency interference from man-made sources. This, together with the site's proximity to Canberra, makes it almost ideal for a tracking station.

The Complex occupies about 10 acres, in which landscaping has been effectively used to control soil erosion and to provide a fire-break and a pleasing environment.

At present the predominant feature of the Complex is the 85-ft. - diameter antenna. This 200 - ton structure is located at the northern end of the station area, where it has an unobstructed view of the sky.

Under construction on the southern side of the main building is a 210-ft. - diameter antenna, details of which are given on page 7.



A VIEW OF THE COMPLEX

The 85-ft. antenna is free to rotate about two axes. The lower one, the hour-angle axis, is aligned with the earth's axis; the upper one, the declination axis, is perpendicular to the hour-angle axis.

Thus, the antenna can be driven about these axes to provide hemispherical coverage. Two drive speeds are available, the maximum providing an angular rate of one degree a second.

One other point worth noting is that the antenna reflector, commonly known as "the dish", is required to be maintained accurately paraboloidal to within $\pm$ 1/8 inch.

In the interests of efficiency, the antenna structure itself housed the maser (Microwave Amplification by Simulated Emission of Radiation) low-noise amplifiers and the transmitters. This equipment is housed in a cone attached to the centre of the reflector and in rooms under it.

Near the antenna is a support building which provides services for the antenna and equipment mounted on it. The hydraulic pumps, which power the hydraulic servo-motors mounted on the antenna structure, the high-voltage power supplies for the transmitter, and helium compressors for the masers are housed in the antenna support building.

The operations building, south of the antenna, serves as the administrative centre of the Complex and houses the main electronic equipment.

Two operations rooms house the equipment. They can be switched to the 85-ft. antenna as required. The building is connected to the antenna area by a walk-through underground cable tunnel which carries the complexity of signal cable from the operations rooms to the equipment in the antenna structure.

Extremely sensitive receivers in the control rooms detect the down-link signal from the spacecraft and pass it to data-handling and decoding equipment.

This information is either displayed recorded and/or sent direct by high-speed data links or teletype to the control centres in the U.S.

Conversely, up-link signals to the spacecraft are encoded in the control room equipment and then passed to the 20 - kW transmitters in the antenna.

The utilities-support building houses the diesel-driven electrical alternators, of capacity 1700 kW, which supply electrical power to the Complex. Continuous operation of the power house is essential as this is the power source supporting mission operations.

The messing and sleeping quarters comprise Tidbinbilla's other major building. It is used to provide meals for personnel and contains some emergency sleeping accommodation.

3. THE 210-FT. ANTENNA

The 210-ft. antenna, now being constructed, will be similar to the 210-ft. antenna at Goldstone, California, which became operational in 1966. The design is based on the 210-ft CSIRO radio telescope at Parkes, NSW.

It is expected that the antenna will become operational in 1973. Cost of construction will be about $10m.

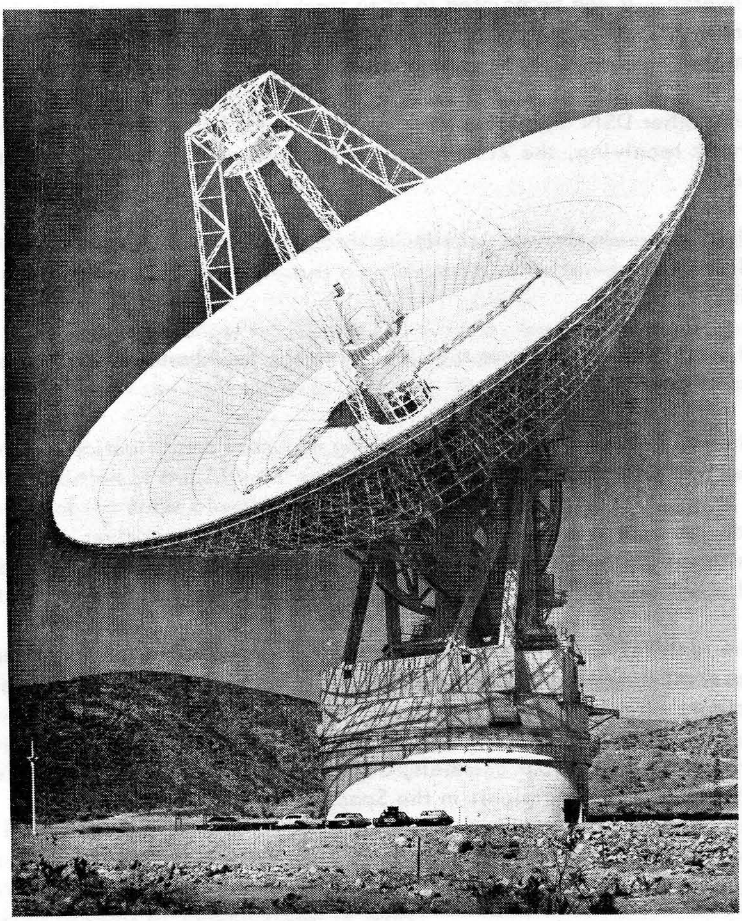
With a total weight of 16 million lb. (including foundations), and over 240 ft. high, it will be the second antenna of this type to be erected by JPL for NASA's Deep Space Network.

A similar antenna will be erected in Madrid, Spain. The three 210-ft. antennas are at approximately equal intervals around the globe.

It is planned that these antennas will support future NASA planetary missions which require increased data rates, receiving sensitivity and transmitting power.

The 210-ft. antenna permits either the extension of communication distances in space or the acquisition of more data from spacecraft at the same range.

It is more sensitive - about 6-1/2 times - than the 85-ft. antenna. An example of this is its ability for continued tracking of Pioneer spacecraft, now in orbit around the sun. Using the 85-ft. antenna, the spacecraft could be followed for six months. The 210-ft. antenna extends the tracking period, and hence the useful lifetime of the craft, to 14 months.



210-FT ANTENNA

How the antenna works

The operating and signal-processing techniques used in the 210-ft. antenna are basically the same as those used in the existing DSN 85-ft. antennas.

The huge reflector is tuned to collect spacecraft signals coming from such distances that their energy is measured in billionths of a billionth of a watt. These signals are amplified and fed into receivers, and the data are forwarded to the Space Flight Operations Facility in Pasadena, California.

Tracking of the spacecraft is begun as it rises above the horizon. Frequency, time and angle data of the predicted trajectory are supplied by teletype from the Space Flight Operations Facility and other DSN tracking stations.

Signal acquisition and lock-on are normally achieved in four to ten minutes. The antenna is then switched to the automatic mode and tracks until the spacecraft disappears below the horizon.

The 210 can operate in either of two pointing modes, depending on the nature of the mission being covered. It can be pointed so as to track the spacecraft signal automatically, as do the 85-ft. antennas, or the pointing information can be sent to the 210's master equatorial reference system, which then leads the antenna across the sky.

Like other DSN antennas operating at frequencies of 2100 megahertz transmitting, and 2300 megahertz receiving, the 210 incorporates a Cassegrain cone feed, mounted at the centre of the reflector.

The Cassegrain design is similar to that of an optical telescope. Signals reflected from the main dish hit a sub-reflector mounted on a truss-type support extending outward from the centre of the dish.

The sub-reflector focuses the signal into the feed horn in the Cassegrain cone, where it is amplified by a maser.

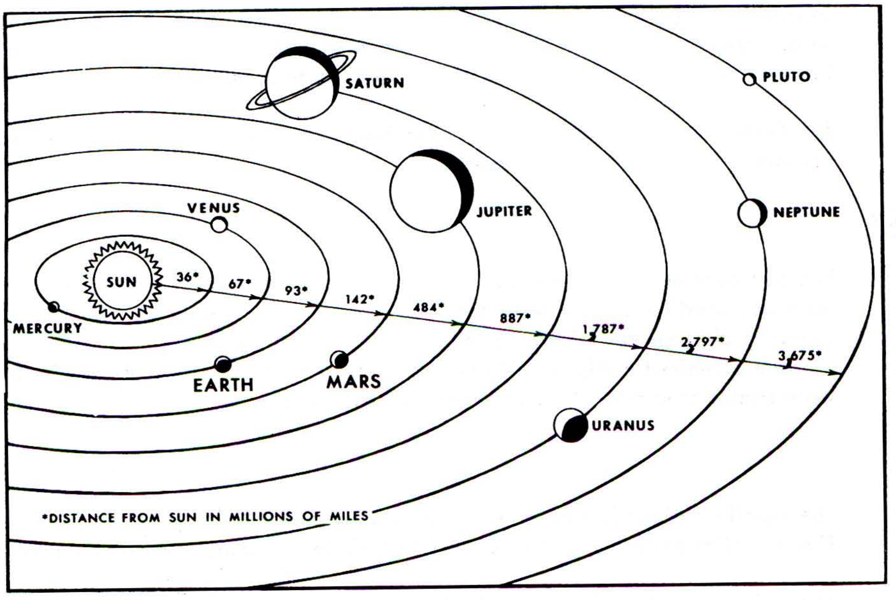
The maser is capable of accomplishing maximum amplification of the signal while generating a minimum of background noise.

Because heat is a major source of noise in any radio receiver, the maser is immersed in liquid helium to maintain its temperature at 4.2^{o}K (-270^{o}C). The spacecraft signal is usually maser-amplified about 40,000 times before it is fed into the receiver, where it is further amplified.

The receiver uses four separate channels: two reference (or sum) channels for doppler information, spacecraft telemetry and TV signals; and two channels carrying angle-tracking data for automatic antenna pointing.

The data from all four channels, depending on the information they convey, are transmitted to the appropriate recipients in the Space Flight Operations Facility.

FIG. 2: SOLAR SYSTEM



4. FUNCTION OF COMPLEX

The Complex is involved in the NASA deep space program whose projects all extend beyond 10,000 miles from earth.

Thus it presently ranges from lunar exploration, both manned and unmanned, to deep into the solar system, where unmanned probes carrying scientific equipment investigate the environmental conditions of the nearer planets, such as Mars and Venus, and of the the sun itself.

The addition of the 210-ft. antenna will increase Tidbinbilla's capability to include exploration of the outer planets.

The major projects, in which the Complex has participated, are:-

MARINER:

The Mariner program calls for the unmanned investigation of the near-earth planets, mainly Venus and Mars. To date there have been five missions: Mariner II flew by Venus in 1962, Mariner IV flew by Mars in 1965, Mariner V flew by Venus in 1967, Mariners VI and VII flew by Mars in 1969.

Tidbinbilla participated in the Mariner IV and Mariner V missions and was instrumental in receiving 20 good quality photographs of the Martian surface from Mariner IV. Mariner VI and Mariner VII were both supported by the Complex during the cruise phase of their successful flight to Mars.

Mariner V, which was a non-photographic mission because of the perpetual cloud cover of Venus, carried sophisticated measuring equipment to determine the planet's temperature and atmospheric composition.

PIONEER:

There have been a number of deep-space probes in this series of mission. They are in solar orbit and engaged on investigation of, among other things, solar flares and solar flares and solar winds, the knowledge of which is vital to manned space flights because of the possible hazards to man from these phenomena.

The Deep Space Network stations have been involved in long-term tracking and communications with these missions.

SURVEYOR:

The Surveyor series of seven missions was in support of the Apollo Project. They were designed to land on unmanned spacecraft on the moon and relay back to earth close-up photographs of the moon's surface, to gather data on soil mechanics and perform chemical analysis. Many tens of thousands of excellent-quality photographs were transmitted from the five successful spacecraft.

APOLLO:

The Apollo Project is a follow-on from the successful Mercury and Gemini programs. These earlier experiments proved the techniques to launch and recover manned vehicles.

They also proved man's capability to withstand the rigours of the space environment for long periods, and his capability of exercising exacting control in docking a spacecraft and in extra-vehicular activity.

Support by the Complex for the Apollo program began with Apollo 6 (launched April, 1968) and has continued through the two moon-landing missions Apollo 11 (July, 1969) and Apollo 12 (November, 1969). Further manned missions are planned for 1970.

5. STAFFING THE COMPLEX

At Tidbinbilla the operational responsibility is vested in the Director, who is a senior officer of the Department of Supply.

The Australian Government policy of using the resources of private industry in this sphere of activity has been extended to Tidbinbilla by the award of a contract to Hawker Siddeley Electronics Ltd., for operating and maintenance services.

About 140 professional, technical and administrative people are engaged on this task.

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