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APOLLO TRACKING STATION
HONEYSUCKLE, A.C.T.

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APOLLO TRACKING STATION

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1. INTRODUCTION

1.1 General

The Australian and United States Governments have entered into a co-operative agreement to facilitate space flight operations being conducted by the U.S. and under which Australia has undertaken to establish and operate a number of tracking stations. These stations form integral parts of worldwide tracking networks set up under the auspices of the U.S. National Aeronautics and Space Administration (N.A.S.A.). The Weapons Research Establishment (W.R.E.) is the responsible agency within the Department of Supply for implementing Australia's commitment with regard to the Australian stations.

Stations have been established for some years at Woomera, South Australia; Carnarvon, Western Australia, and Tidbinbilla, A.C.T., another has been completed recently at Orroral, A.C.T. and yet another is being planned for Honeysuckle, A.C.T.

Whereas some of the Woomera stations are manned and operated by W.R.E. personnel, the assistance of private industry has been sought in the cases of Carnarvon, Tidbinbilla, Orroral and one Woomera station and suitable contracts have been arranged. It is proposed that a contract be negotiated with private industry for the performance of this task at the Honeysuckle station, which is expected to be fully operational by 1 October 1966.

1.2 Programme

The Honeysuckle station will form part of the worldwide Apollo Tracking Network which will consist of nine permanent stations and five instrumented tracking ships equipped with 30 ft diameter antennas and three permanent stations equipped with 85 ft diameter antennas. The 30 ft antenna stations will support, primarily, the near earth phases of the Apollo mission and the 85 ft antenna stations will support the lunar phases. One of the main features of the Apollo station will be the unified S-band tracking system (USB) which will be used to implement the tracking and communications requirements of the Apollo program. In this system, all data such as communication, telemetry and ranging information will be modulated on a single carrier operated at S-band (approximately 2 000 megacycles).

The three 85 ft antenna stations will be located approximately 120° apart on the earth's circumference, at Madrid in Spain; California, U.S.A.; and Honeysuckle, A.C.T. These three stations will provide continuous coverage of the spacecraft after its injection into the trans-lunar trajectory.

2. LOCATION AND STRUCTURAL FEATURES

2.1 Location of Site

The Apollo Tracking Station will be situated at Honeysuckle, 33 miles by road south-south-west of the city of Canberra, approximately 12 miles due south of the Deep Space Instrumentation Facility at Tidbinbilla, A.C.T. and 3 miles north of the Data Acquisition Facility at Orroral. The station will be readily accessible by means of a sealed access road which will be constructed from the Tharwa to Naas road. This latter road has already been significantly upgraded to provide access to the Orroral station. Figure 1 shows the location of the station.

2.2 Structural Features

2.2.1 The main features at the Apollo Tracking Station will be the following:

An 85 ft diameter parabolic antenna and collimation tower.

An operations building.

A power building.

Figure 2 shows the station layout and figure 3 the operations building layout.

2.2.2 85 ft Parabolic Antenna

The antenna will be erected on a large massed concrete foundation. A small building will be provided at the base of the antenna structure to house the hydraulic control equipment and the transmitter power amplifier.

2.2.3 Collimation Tower

The 75 ft high collimation tower will be erected approximately 10 000 ft south-west from the 85 ft antenna. There will be an unobstructed line of sight between the two structures. A small equipment building will be located at the base of this tower to accommodate the r.f. source transmitter and calibration equipment.

2.2.4 Operations Building

The operations building will accommodate the technical and administrative functions of the station. In the technical area on the ground floor, three large rooms will be provided, one for the USB operations, one for telemetry equipment, and the third for computing equipment and flight control operations. In addition, there will be a number of laboratories, an electronic components and general store, a wire room, and a station communications room. Office accommodation and facilities for station staff will constitute the remainder of the ground floor.

A basement floor, with approximately half the area of the main floor, will consist of a large air-conditioning room, a crew room and kitchen, an electrical switch room, and emergency sleeping accommodation for 6 people. The latter will be provided for use by personnel unable to leave the station due to extended operational requirements.

2.2.5 Power Building

The power building, which will have an output of about 2 700 kilowatts (kW), will accommodate the diesel generators and associated switchgear. Workshop facilities for the station will also be available and will include an area for servicing and overhauling the generators.

3. INSTRUMENTATION, EQUIPMENT AND STAFFING

3.1 Antenna System

The antenna consists of an 85 ft diameter paraboloidal reflector and a Cassegrain sub-reflector, hydraulically driven through an X and Y gimbal mechanism. The reflector surface is a solid aluminium face and has a focal length of 36 ft. The height of the antenna is approximately 120 ft and the whole structure weighs about 400 tons. There is a weathertight room behind the reflector in the Y-axis wheel structure to house electronic equipment and the optical boresight and calibration package. A wide beam acquisition horn is mounted on the 85 ft antenna for use with the acquisition aid system.

The antenna mount axes have an overall pointing accuracy of ± 40 seconds of arc and are capable of tracking at rates from zero to 3° per second with accelerations up to 5° per second/per second. The antenna beamwidth is 0.4°.

3.2 Antenna Electronics

The control system turns the antenna simultaneously about two axes of rotation in accordance with data received from the antenna position programmer, the acquisition system, or the tracking receiver. The control console allows eight modes of operation in addition to the stow and brake operations and has indicators that display time and required control data. The antenna control and drive system is capable of following the error signals which are generated by equipment, instruments or transducers.

3.3 Antenna Position Programmer System

The computer accepts prediction data from Goddard Space Flight Centre (G.S.F.C.) and produces punched-paper tapes representing drive signals which cause the antenna to point towards the predicted spacecraft position. The antenna position encoder sub-system accurately measures the antenna axes shaft positions and feeds this data to the programmer sub-system and to the tracking data processor. The programmer sub-system receives X and Y angle data from the computer and compares this with the real X and Y angle data from the antenna position encoder sub-system. The programmer sub-system then generates the analog signals from these differences and sends them to the servo system which drives the antenna.

3.4 Parametric Amplifier

This unit receives the incoming signal from the antenna feed and provides low noise amplification of greater than 40 dB with an overall noise figure of 2 dB. The three-channel monopulse amplifier and converter, complete with circulators, pump, attenuators, input monitor couplers and klystron pump source is contained in a waterproof, temperature controlled package for antenna mounting.

3.5 Acquisition Receiver

The acquisition receiver receives spacecraft signals from the acquisition horn and associated paramp (PARametric AMPlifier). This receiver acts on the carrier component of the received signal to initially point the 85 ft main antenna at the spacecraft. It may also be connected to the 85 ft antenna and to the data demodulation system as backup for the primary tracking receiver.

3.6 Primary Tracking Receiver

The primary tracking receiver receives spacecraft signals from the 85 ft antenna and associated paramp, and furnishes signals to keep the antenna aimed at the spacecraft. It also supplies doppler information to the tracking data processor and ranging information to the ranging sub-system.

In addition, it supplies the telemetry, voice, video and bio-medical data signals to the data demodulator system.

3.7 Range and Range Rate System

The r.f. carrier from the ground transmitter is phase modulated with a pseudo-random binary code generated by the transmitter coder. This code is detected by the spacecraft transponder and sent back to the station for comparison in the receiving section. When the codes suitably compare, range and doppler measurements commence and continuous range data is transferred to the tracking data processor system. Two sets of codes are provided in the ranging sub-system. The long code, which permits ranging on lunar and circumlunar missions has a maximum unambiguous range of 800 000 kilometres (km). The short code, which permits more rapid range determination, is used for earth satellite ranging missions and has a maximum unambiguous range of 10 000 km.

3.8 Tracking Data Processor System

The system accepts time, X and Y angles, and range and range rate information and changes it into proper formats for both high speed data and teletype transmission to G.S.F.C. In addition it provides the required heading information and an interface between a future computer and the source data, as well as magnetic recording, paper tape and teleprinting facilities.

3.9 Data Demodulator System

The function of the data demodulation system is to demodulate the many transmission modes of the USB communication down-link (spacecraft to station). After demodulation, the system will filter, amplify, and distribute the data to appropriate reception points in the overall USB system.

3.10 PCM Telemetry System

The function of the system is to accept demodulated telemetry data from the data demodulator and convert it to suitable form for display and transmission. Output data from the signal conditioner and bit synchronizer is noise free and has an accompanying timing train in synchronism with the incoming data rate. Code recognition circuitry locks on the synchronising codes in the data train, thereby minimizing the amount of data loss. Decommutated telemetry parameters are distributed to local displays and site consoles. Selected parameters are accepted by the telemetry summary processor which prepares summary messages in the required format for transmission to G.S.F.C. by teletype. Message acceptance pulses and clock returns are routed to the Digital Command System. Built in test equipment is used in conjunction with a signal simulator to determine the operational status of the system and for trouble-shooting.

3.11 Digital Command System (DCS)

The purpose of the DSC is to receive, store and forward commands in digital form to the spacecraft. The unit operates in the following manner: data (commands) are accepted by the DCS input sub-system, via teletype from the G.S.F.C. computers, checked for transmission errors and stored in the memory sub-system. Under local operator or remote console control, the data is read from memory and transmitted on the USB up-link, being validated continually during transmission by the use of dual transmission paths to the transmitters, with appropriate checking and sub-bit encoding.

After transmission of a command, the DCS waits a nominal time for a message acceptance pulse from the PCM telemetry system. If the command was successfully received by the spacecraft, that fact will be indicated via telemetry, and the DCS prepared for the next command. If the last command was not successfully received it will be automatically retransmitted.

3.12 Data Subcarrier Oscillators

Two subcarrier oscillators operate at 30 kilocycles per second (kc/s) and 70 kc/s centre frequencies for voice and command modulation. The modulated subcarriers are then fed to the exciter-modulator for carrier modulation.

3.13 Exciter - Modulator

This unit accepts the 22 megacycles per second (Mc/s) output of the transmitter frequency synthesizer and multiplies it 96 times to the 2 112 Mc/s transmitter frequency. The modulator accepts the outputs of the data sub-carrier oscillators and an output (range code) from the ranging sub-system. This data modulates the carrier which drives the 10 kW power amplifier.

3.14 10 Kilowatt Power Amplifier

The power amplifier is capable of 10 kW continuous output over a 10 Mc/s bandwidth, with a minimum input signal of 500 milliwatts (mW). The amplifier includes power supplies, cooling equipment, control circuits and protective devices.

3.15 Frequency Standard

The frequency standard consists of dual rubidium standards coupled to two slaved crystal secondary oscillators. The output frequency is 1 Mc/s. The rubidium standard short term stability is 1 part in 10^{10}, and the uncorrected crystal secondary standard short term stability is 5 parts in 10^{10}. This unit supplies the reference frequency for the transmitter frequency synthesizer and provides an alternate standard for the timing system.

3.16 Timing System

The timing system provides all timing frequencies and codes for the tracking data processor system as well as other systems which require standard timing control. The timing system consists of:

3.16.1 W.W.V. time standard comparator, which includes a receiver, antenna, propagation delay correction unit and necessary comparator and display circuitry to obtain accurate time and frequency standards from W.W.V. broadcasts.

3.16.2 Emergency power system.

3.16.3 Frequency divider and digital display clocks.

3.16.4 Time code generator and binary coded decimal (BCD) to binary converter.

3.16.5 Signal distribution chassis and patch panel.

3.17 Boresight System

The boresight system consists of an antenna and optical target mounted on a 75 ft tower, an r.f. source transmitter located in an equipment room at the base of the tower, and a remote control panel in the operations building.

This equipment is used in conjunction with the optical system in the 85 ft antenna structure to determine the pointing direction of the radio axis of the 85 ft antenna relative to its physical axis. It is also used to determine the operational status of the antenna tracking system and of the communications transmitting and receiving systems.

The optical target and the r.f. source antenna are mounted on the tower in the same relative positions as the optical package in the 85 ft antenna and the physical axis of the paraboloid. The r.f. source transmitter exhibits high degrees of phase, long term frequency and amplitude stability, as well as the high degree of reliability required for continuous unattended operation.

3.18 Ground Communications

Communications facilities include both on-site and external systems. On-site system will probably be via a Kellogg Crossbar PABX which is a system providing communication with all operators by telephone or intercommunication facilities either individually, or in conference mode. Teletype and voice frequency systems will provide communications with G.S.F.C. and other stations on the network.

3.19 Power Generating Equipment

Power for the site will be generated locally. A power building will be constructed to house the necessary diesel generators and associated switchgear. The installation will allow dual bus operation with the capability of switching generators to either bus. One bus will provide power to the critical station equipment and the other power to the station utilities such as air-conditioning etc. Sufficient backup capability will be provided in the system to ensure that electrical requirements are automatically maintained during missions without interruption.

3.20 Staffing

The Apollo Tracking Station will not be required to be operated continuously except during actual missions, which are expected to occur at three-monthly intervals and to last for about one month. The anticipated number of technical personnel required to man the station is approximately 40. In addition approximately 20 personnel will be required for clerical, cleaning, transport, plant maintenance and other support purposes.

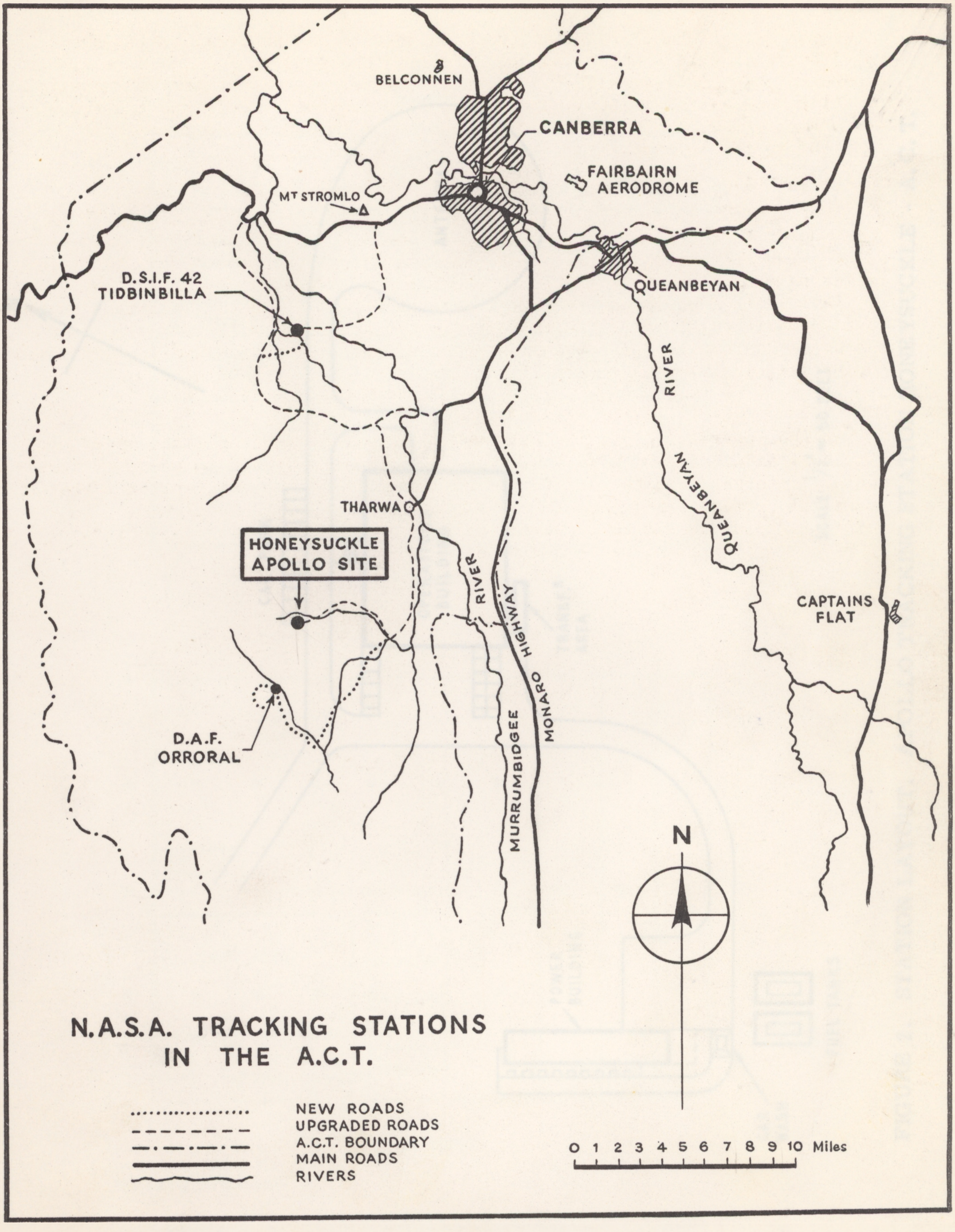
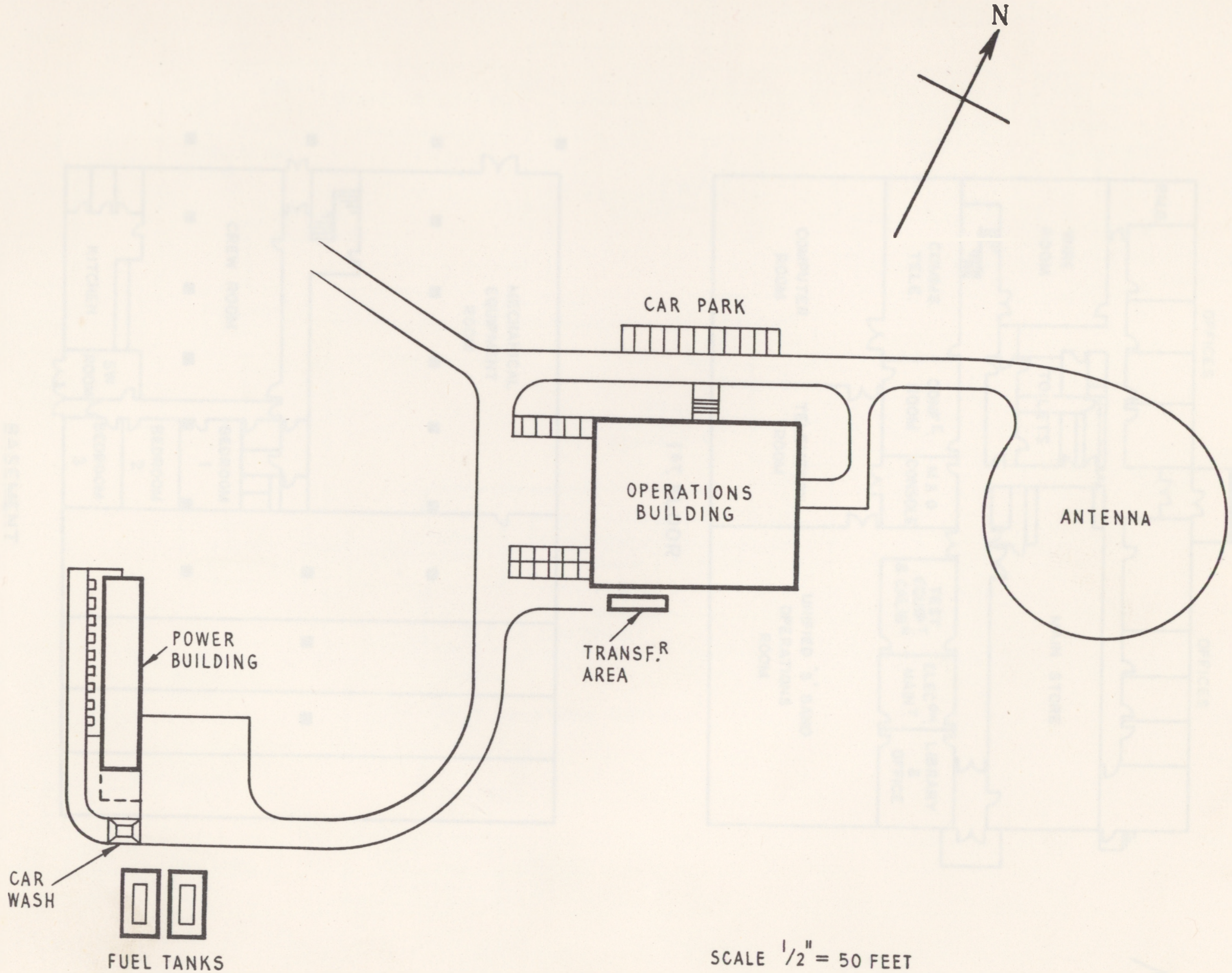


FIGURE 1. LOCATION OF STATION AT HONEYSUCKLE, A.C.T.



SCALE 1/2" = 50 FEET

FIGURE 2. STATION LAYOUT. APOLLO TRACKING STATION HONEYSUCKLE - A.C.T.

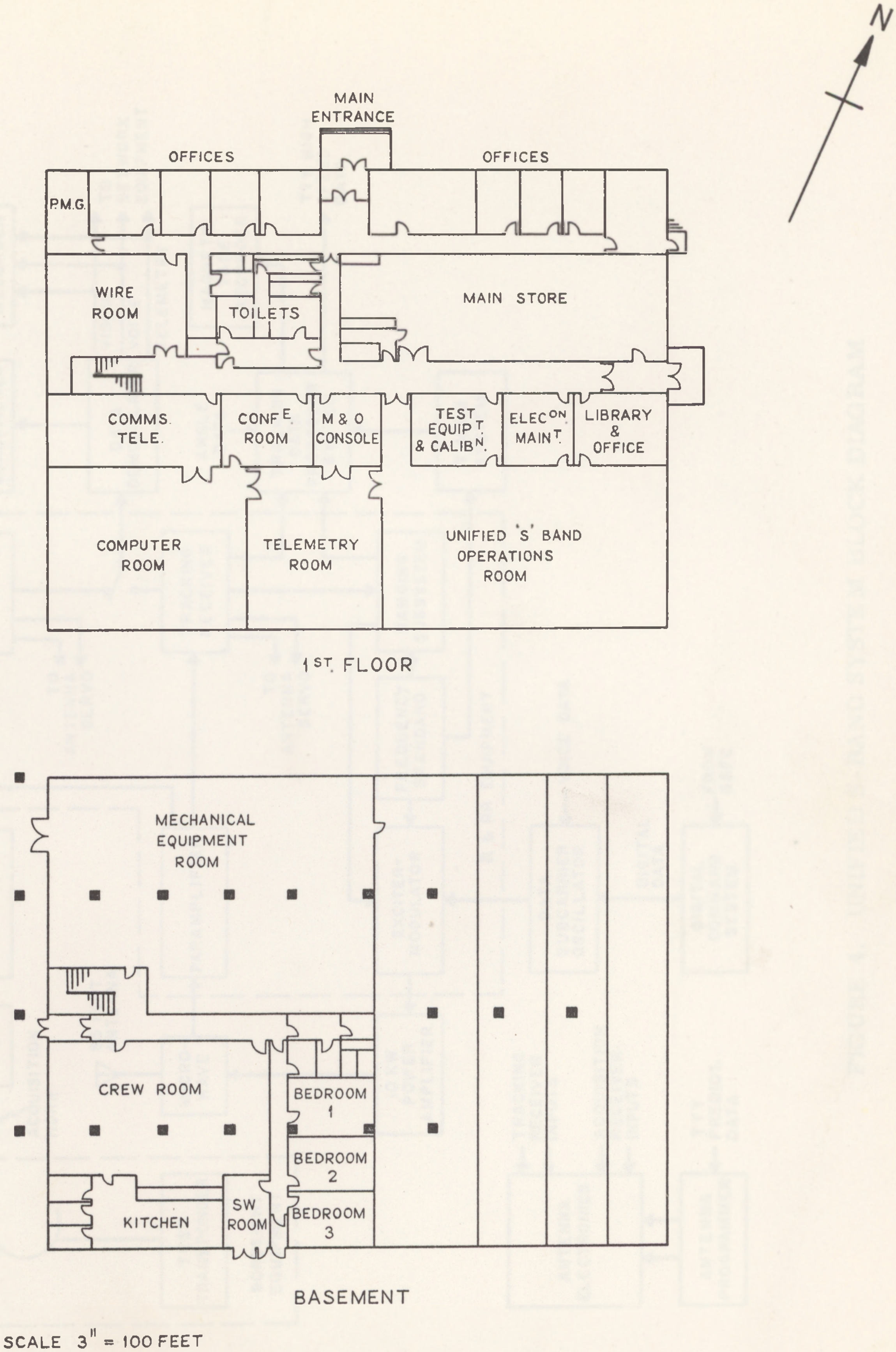


FIGURE 3. OPERATIONS BUILDING LAYOUT

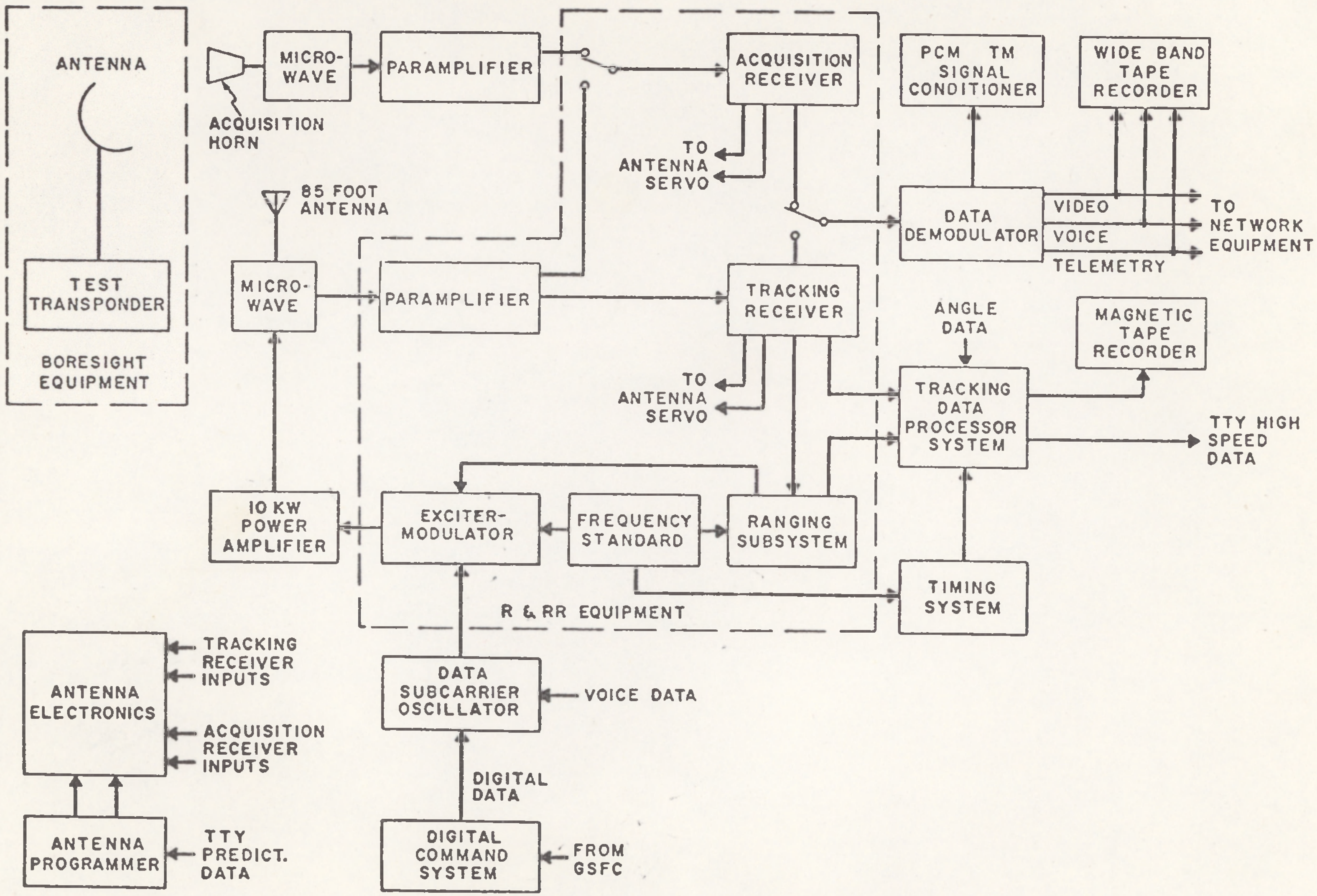


FIGURE 4. UNIFIED S-BAND SYSTEM BLOCK DIAGRAM