SATELLITE COMMUNICATIONS

THE OPERATION AND MAINTENANCE OF COOBY CREEK

A.T.S. GROUND STATION

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SATELLITE COMMUNICATIONS

OPERAT1ON AND MAINTENANCE OF COOBY CREEK

A.T.S. GROUND STATION

Some aspects are discussed of the operation and maintenance of the experimental Applications Technology Satellite Communications Station at Cooby Creek, Queensland.

A.T.S. PROJECT

The Applications Technology Satellite (A.T.S.) Project is a successor to, and expansion of, the Advanced Syncom Project which was essentially intended to be an evaluation of international communications systems via orbiting satellites. The A.T.S. Project incorporates a number of other scientific and engineering experiments in addition to communications. These experiments fall into the following main categories:

* Spacecraft Evaluation
* Multip1e Access Communications
* V.H.F. Communications
* Precision Ranging
* Meteorology
* Navigation
* Materials Research
* Spacecraft Control
* Video and Data Transmission

The programme calls for the launching of five spacecraft over a period of approximately three years and involves both medium altitude and geosynchronous satellites. The techniques being investigated include both spin stabilisation and gravity gradient stabilisation. In general, earlier satellites in the programme were used as test platforms for techniques to be used in later missions.

In Australia, the general public has been able to see some of the results of the project in the form of live telecasts from overseas of the programmes "Expo 67", "Our World" and the "America's Cup", all of which have been received by and relayed from the A.T.S. Station at Cooby Creek, Queensland.

In return we have transmitted overseas, portions of "Our World, the "Holt Memorial Service" and the "Davis Cup" as well as visits of Heads of Government – Mr. Saragat of Italy and Mr. Sato of Japan.

These demonstrations, although spectacular, are a comparatively small segment of the overall project. Another striking example of the of application of satellite technology to everyday communications is not so readily appreciated by the man in the street. The V.H.F. communications experiment has enabled continuous voice contact to be maintained with an aircraft flying from Australia to the West Indies, both while in the air and on the ground. Similarly, V.H.F. contact can be made with ships at sea from Alleutian Islands to the Antarctic.

It is not intended, nor is it possible, to report in a paper of this nature, the results of the numerous experiments involved. Full details of the project and the results obtained to date are given in the A.T.S. Technical Data Report (1) which was first issued 90 days after launch of the first spacecraft and which is updated each 30 days.

PROJECT CO-ORDINATION

The National Aeronautics and Space Administration (NASA) of the United States of America administers the project from the Goddard Space Flight Centre at Greenbelt in Maryland. The A.T.S. Operations Control Centre (ATSOCC) controls the activities of all three primary ground stations in the network. These stations are located at Rosman in North Carolina, Mojave in California, and Cooby Creek in Queensland.

At the former two ground stations, the A.T.S. installations are additions to existing permanent ground stations, while at Cooby Creek the Installation is a self—contained transportable ground station. With a few exceptions, the basic electronic equipment at all three stations is identical.

Communication between all four centres is by means of a permanent open voice conference circuit and by permanent teletype circuits.

In addition to the NASA owned stations, there are participating stations in a number of other countries. In Asia, stations located at Kashima in Japan and Ahmedabad in India maintain a liaison with ATSOCC. Normal communication with these stations is by teletype only. Stations In Europe will join the project later.

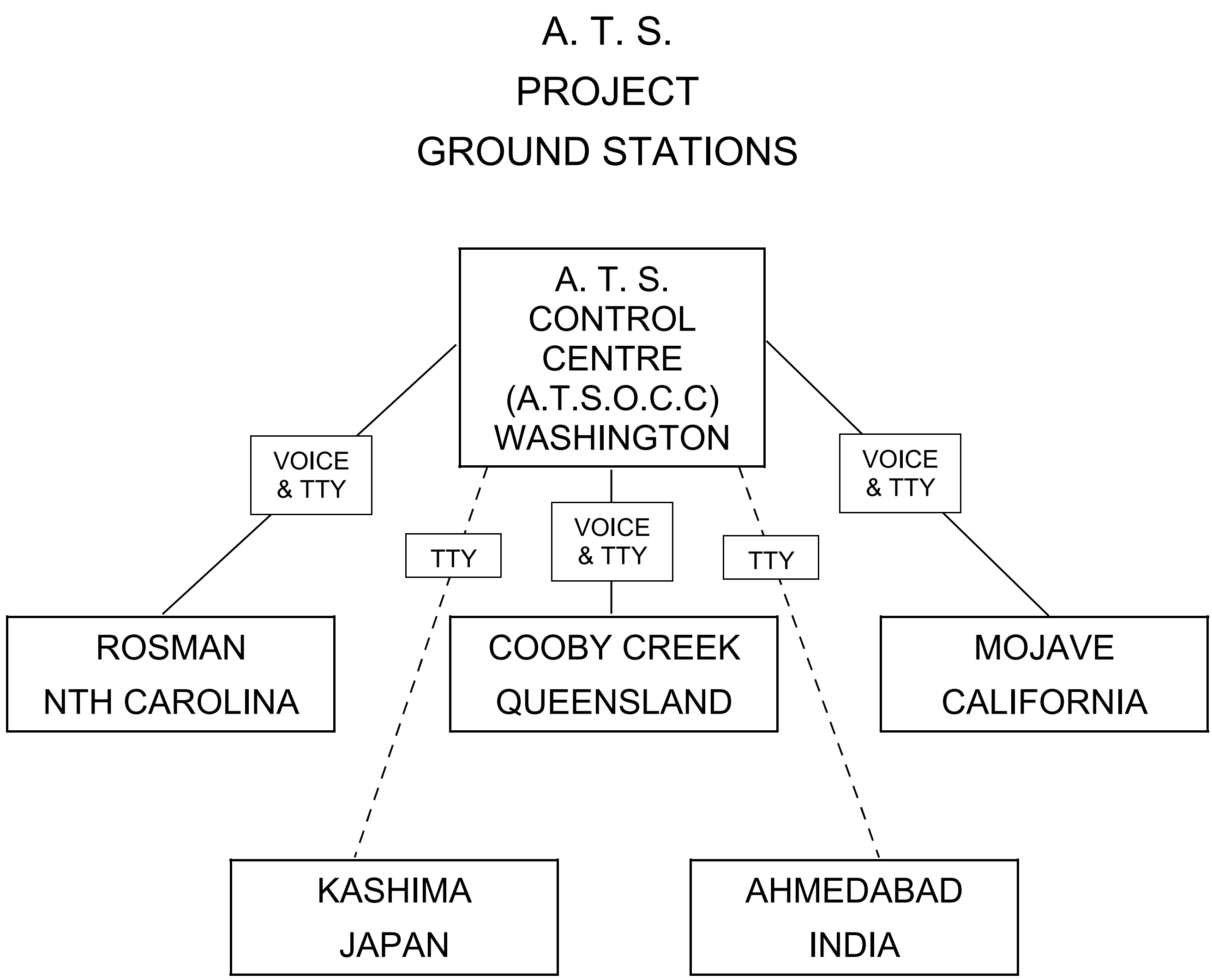
The lines of communication In the Pacific area are shown in Figure 1.

COOBY CREEK GROUND STATION

This station overlooks the lake behind Cooby Creek dam approximately fifteen miles north of the City of Toowoomba on the Darling Downs of Queensland. Being a transportable station, all the electronic equipment is installed in four vans each approximately 4Oft. long and 8ft. wide. Each van is designed to be drawn by a prime—mover at road speeds up to 50 m.p.h. and is capable of being airlifted by aircraft such as the C133 or larger. Two further vans of the same size each house two gas turbine driven alternators; two of 250 KW and two of 125 KW capacity. Power is supplied from three phase 60 Hz 208V/120V busbars; normally, separate machines are used for the supply of technical and utility power (2).

The Operations Control Complex is formed by integrating three vans, the centre one of which has both sides removed, the others one side each, to form a working area of approximately 40 ft. by 24 ft. The Telemetry and Command van is adjacent to and joined to the others by a covered way and the Shift Supervisor’s office.

Two trailers provide office accommodation; two are equipped as stores; one is used for test equipment maintenance; another houses teletype machines and documentation. Other Australian made prefabricated transportable buildings at the site are used for offices, canteen and a crew change room. Two other prefabricated buildings were erected on site. One


A. T. S.
PROJECT
GROUND STATIONS
A. T. S.
CONTROL
CENTRE
(A.T.S.O.C.C)
WASHINGTON
VOICE & TTY
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VOICE & TTY
ROSMAN
NTH CAROLINA
COOBY CREEK
QUEENSLAND
MOJAVE
CALIFORNIA
KASHIMA
JAPAN
AHMEDABAD
INDIA

Fig. 1.

houses two diesel alternators each of 250 KW capacity; the other a facilities workshop and store. For external lighting of the site, and for cooking, power is supplied at 50 Hz by the local supply authority.

The 40 ft. diameter parabolic antenna was supplied dismantled on two trailers of similar dimension to the electronic equipment vans. It was assembled on site, and erected on a concrete pad using two hydraulic rams built into the main trailer. The antenna is hydraulically driven in both azimuth and elevation, power being supplied from a pump electrically driven by a 100 h.p. motor. Provision is made for manual positioning or slewing about both axes as well as for auto—tracking.

The V.H.F. telemetry and command array also assembled on site, is hydraulically controlled, but is positioned by manually operated slew switches, there being no provision for auto—tracking.

Approximately two miles to the north of the site across the dam is a precisely surveyed collimation tower used for antenna boresight alignment. At the base of this tower, an unattended equipment hut houses a 8.H.F. transponder and V.H.F. command facility, thus simulating the major spacecraft functions. Power for this equipment is supplied at 60 Hz by a rotary converter operating from the local 50 Hz supply mains. A 5 KW diesel alternator provides back—up power.

STATION EQUIPMENT

Microwave Receivers and Transmitter.

The low noise receiver pre—amplifier employs a ruby travelling wave maser in three sections, operating at 4 GHz. Following the maser are two parametric amplifiers and a tunnel diode amplifier. Overall bandwidth of the front end is approximately 130 MHz and the gain is normally set to 50 db. The system may also be operated with maser and one parametric amplifier or with two parametric amplifiers, giving an overall gain of 40 db.

Both parametric amplifiers and the maser are installed in a cryogenic package cooled by liquid helium. The maser is mounted on a cold plate operating at a design temperature of 4.2°K, while the parametric amplifiers are at a 10°K heat station. An overall system noise temperature of 50°K can be achieved with the antenna at zenith on a fine day. At lower antenna elevations, the temperature increases, being of the order of 70°K at the elevation of ATS—1 (20° above the horizon).

Weather has a marked effect on system noise temperature, which has been observed to rise by 50°K within the space of several hours under the influence of heavy storm clouds followed by torrential rain.

Two similar communications receiver channels are provided, each with an identical down—converter. Up to this stage, all equipment is mounted in the antenna feed cone. The 70 MHz I.F. frequency is carried by co—axial cable to the receiver bay in the electronics van. Here it is amplified, limited, and fed to a FM demodulator for operation in the multiple access mode or to an FM demodulator for operation in the frequency translation or wide band data modes.

The tracking receiver employs a pseudo—monopulse system, having a single channel antenna—mounted down—converter of 400 MHz I.F. frequency. A stripline lobing switch alternately samples azimuth, elevation and polarisation vectors of the received signal. In the van mounted equipment. further down conversion to 57 MHz takes place before a synchronous demodulator separates azimuth, elevation and polarisation error signals for the approximate antenna servo loops.

The transmitter for the 6 GHz uplink employs a klystron power amplifier driven by a travelling wave tube amplifier. The high power and high frequency stages, together with frequency translation stages, are antenna mounted. Input from the van mounted stages is again at an I.F. frequency of 70 MHz, and here again two separate channels are employed. The multiple access mode uses single sideband transmission, while frequency modulation is used for the frequency translation mode.

An output power of 10 KW is available on FM; on SSB the average power is 1 KW with a peak of 10 KW, the SSB uplink being converted to PM for the downlink.

Range and Range Rate.

The A.T.S. ranging equipment is a secondary radar system using coherent doppler techniques for range rate determination, and sidetone ranging for range measurement. It differs from previous ranging systems in that the doppler information is extracted from the sidetone rather than from the carrier itself. This enables the use of a wideband frequency translator at the spacecraft without the need for sidetone processing in the transponder.

In its primary mode, using a 5 MHz side tone, the system has a resolution of ± 1.5 metres in range and ± 0.01 metres/sec. in range rate. Secondary modes are available as a back up with a lower order of resolution. These modes may also be used in systems with restricted bandwidth.

The ranging system is normally used in conjunction with the S.H.F. communications system, having an I.F. frequency of 70 MHz. The I.F. is translated to 6 GHz in the FM transmitter and the received 4 GHz is down-converted to 70 MHz as for FM communications.

The various sub—systems of the ranging equipment include timing; signal generation; modulation; receiver and demodulation; and data extraction.

The precision timing standard is crystal controlled with a long term stability of one part in 10^{-10} per day. In the event of a power failure, it will automatically switch to battery supply to ensure continuity. All station digital clocks are driven from this standard which may be synchronised to within one milli—second to a HF standard transmission from WWVH.

Telemetry and Command.

A separate self contained van houses the telemetry and command electronic equipment. The basic elements of the telemetry system are:—

* Two V.H.F. dual channel phaselock diversity receivers.

* Two demodulation and diversity combining systems.

* A PCM data handling unit for signal conditioning and display of telemetry signals.

* A seven channel tape recorder, with an identical recorder as back—up.

The command system elements are:—

* A 2.5 KW V.H.F. transmitter with an identical transmitter as back—up.

* A command encoder to generate command signals and execute tones.

* A synchronous controller for generating pseudo sun pulses used in spacecraft control.

An integrated antenna array uses a single crossed yagi with again of 14 db for command, surrounded by eight telemetry crossed yagis with a total gain of 21 db. Selector switches enable the following choice of polarisation for either telemetry or command: left or right hand circular; vertical or horizontal linear. An antenna mounted pre—amplifier provides 30 db of gain before the transmission line to the telemetry receivers.

At the collimation tower, a spacecraft simulator enables on site checkout of the command and telemetry functions.

Communications Test and Evaluation.

For evaluation of multi—channel telephony, there is a 240 channel frequency division multiplex terminal, the baseband of which may be transmitted either by means of single sideband modulation for multiple access working, or by frequency modulation for point—to-point communications via a spacecraft in its frequency translation mode.

When high density of data is required an SDS—910 computer is used to automatically sequence communications tests and to record the data on magnetic tape. The computer also serves to convert telemetry data to engineering units and to prepare messages on punched tape suitable for direct teletype transmission.

The essence of the system is flexibility and, unlike a normal communications terminal, the configuration changes from day to day or from hour to hour, depending on the nature of tests being performed. Changing from multiple access to frequency translation mode is achieved by interchanging completely patched panels in the automatic data processor. Certain test configurations are selected manually by push—button, but in addition, a considerable amount of patching via jackfields is necessary.

Echo suppressors and compandors are available and may be patched into any circuit as required.

A cross section of the available equipment in the test console includes:—

* Signal generators, audio and video

* Noise generator and receiver
* Audio delay measuring set
* Wave analyser
* Distortion and noise analyser
* Group delay test set
* Electronic sweep generator
* Vacuum tube voltmeter
* True RMS voltmeters
* Oscilloscopes
* Counters
* Spectrum analyser
* Chart recorders
* X - Y plotter
* Polaroid camera
* Waveform monitors
* Video monitors
* Pulse and bar generator
* Stairstep generator
* Slide scanner

Two video tape recorders are available for recording and replay of T.V. test transmissions. A seven channel tape recorder is used for audio or data recording.

STATION ADMINISTRATION

The station is administered for N.A.S.A. by the Australian Department of Supply with a staff structure as shown in Figure 2.

Both the Station Director and Deputy Station Director are engineers. Four systems engineers are supplied by a United States contractor to N.A.S.A. Four Australian systems engineers represent the Commonwealth Government Departments of Supply and Civil Aviation; the Australian Post Office and the Bureau of Meteorology.

The systems engineers are primarily concerned with the overall performance of the system, including the various spacecraft in the project.

A. T. S.
GROUND STATION
COOBY CREEK

DEPARTMENT OF SUPPLY ADMINISTRATION & SYSTEMS ANALYSIS

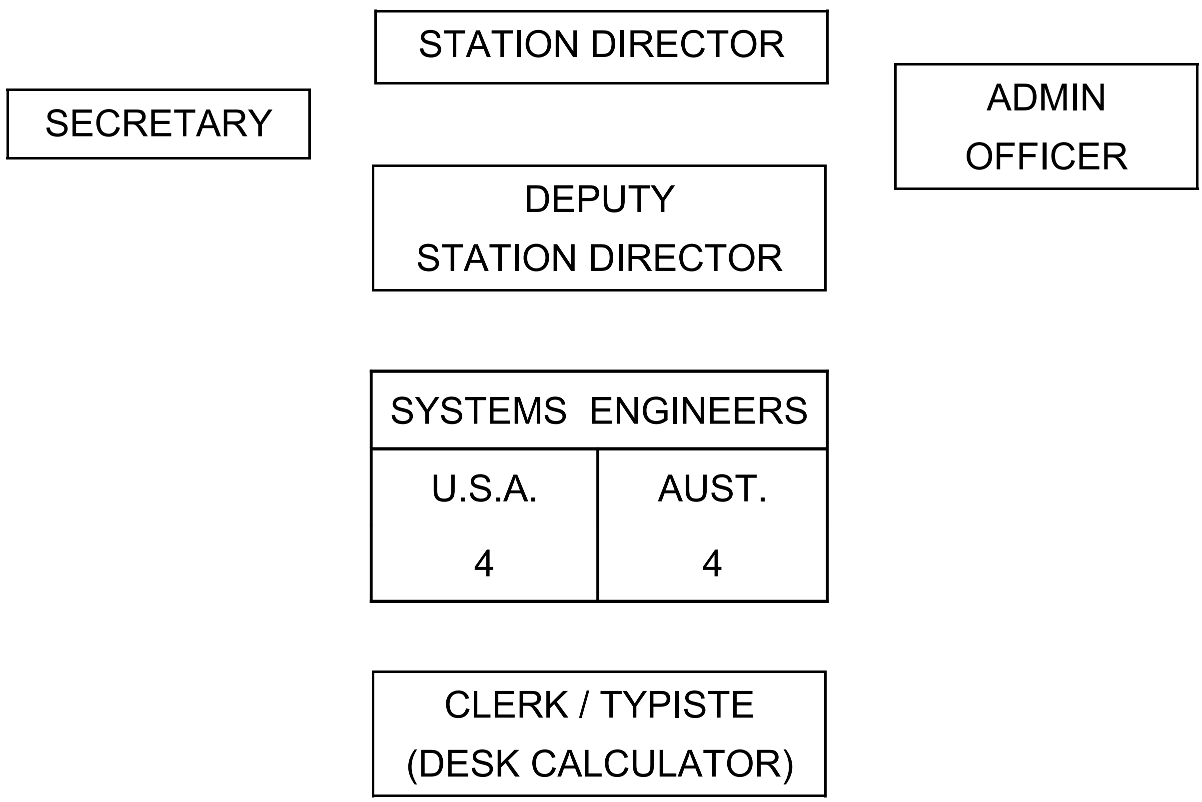

Fig. 2

One of the Australian systems engineers is attached to each of the operational shifts and provides a liaison between the shift and the remainder of the team.

OPERATION AND MAINTENANCE

The station is operated and maintained by the Field Projects Division of Amalgamated Wireless (Australasia) Limited under contract to the Department of Supply.

An engineer fills the position of Company Senior Representative (Station Manager) with an administrative and support staff as shown in Figure 3. Office staff responsible to the Administrative Officer occupy an office in the City of Toowoomba close to business houses and banks. All other staff work at the site and are transported daily by buses of twelve (12) passenger capacity.

Responsibilities of the Facilities Engineer include operation and maintenance of gas turbine and diesel powered generating equipment; air conditioning equipment; a closed cycle helium cryogenic system; antenna mechanical and hydraulic components and station vehicles. He is also responsible for the maintenance of all site roads, trailers, station utilities Ind electrical services.

The ratio of technicians to engineers on the staff of the O & M Contractor is eleven to one.

Operational Shift Structure

Each operational shift is supervised by a Shift Engineer who is responsible to the Company Senior Representative for the operation and maintenance of the station while he is on duty. At the conclusion of his shift, he submits a teletyped report of shift activities to ATSOCC and hands responsibility to the oncoming Shift Supervisor.

A full operational shift structure is outlined in Figure 4. This chart is designed to indicate levels of technical responsibility rather than lines of authority. In most cases, the designations indicate functions rather than titles of positions as in most cases the terms used ("Sync. Controller", "CTEC", "MCC", "PCM", etc..) would not convey any meaning to those outside the station.

The Shift Engineer has on his staff, three Senior Technicians, two of whom, designated "Telemetry and Command" and "Operations Control", are permanently assigned to him. Also permanently assigned to individual Shift engineers are the technicians designated "Antenna", "Computer", "Range and Range Rate" and the operators "Data Recording" and "Console". These personnel work only on operational shifts and do not form part of a maintenance team. There are three such teams. The remaining personnel in Figure 4 work both operational and maintenance shifts, there being four such teams.

As there are three "Operations Only" teams working two shifts, and four "Operations and Maintenance" teams working three shifts seven days a week, there will be a slip in phasing and, over a period of several weeks, each Shift Engineer will have had four different teams working under his supervision.

A. T. S.
GROUND STATION
COOBY CREEK

OPERATION & MAINTENANCE
ADMINISTRATION & SUPPORT

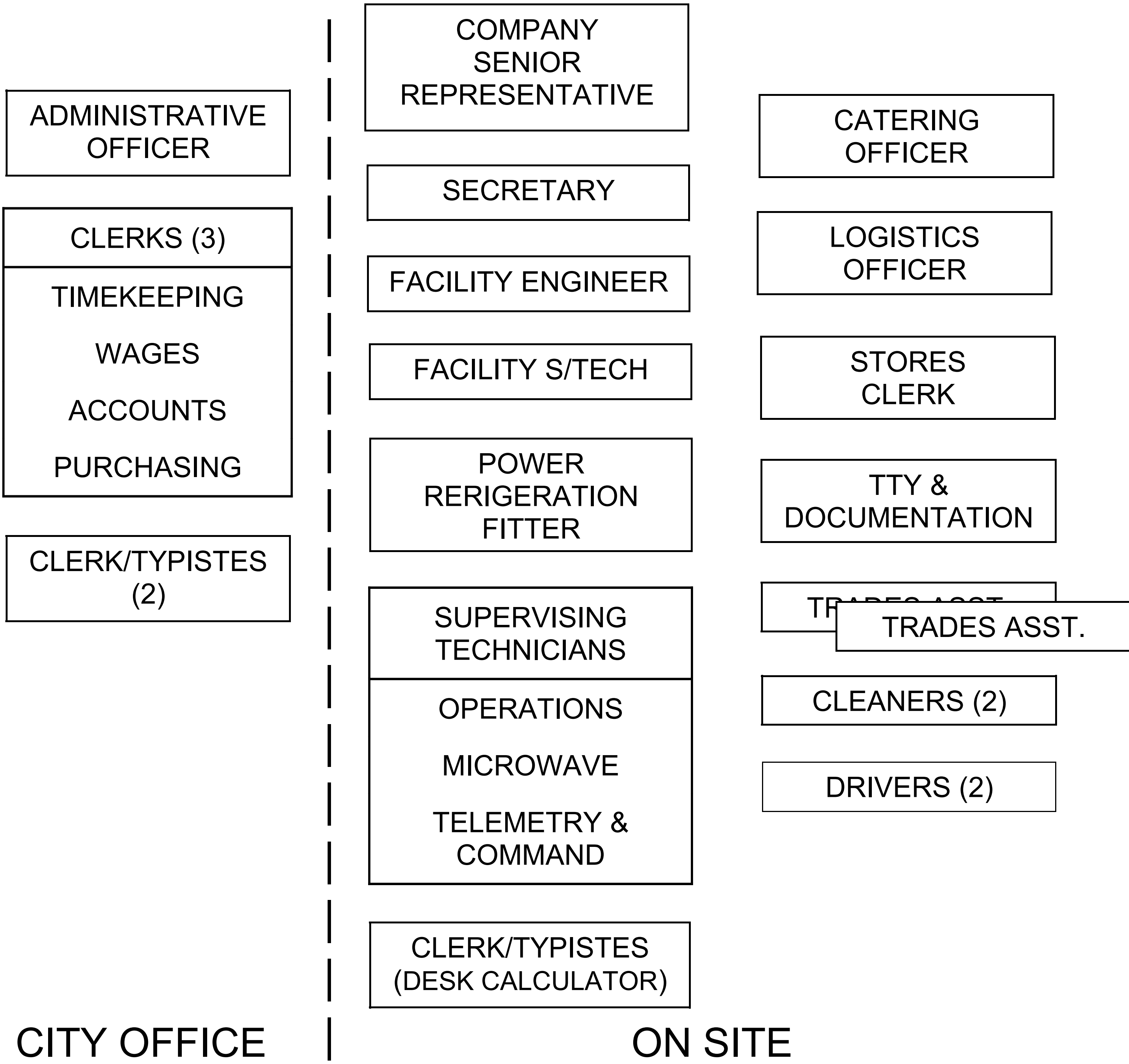

Fig.3

A. T. S.
GROUND STATION
COOBY CREEK
OPERATION & MAINTENANCE SHIFT STRUCTURE

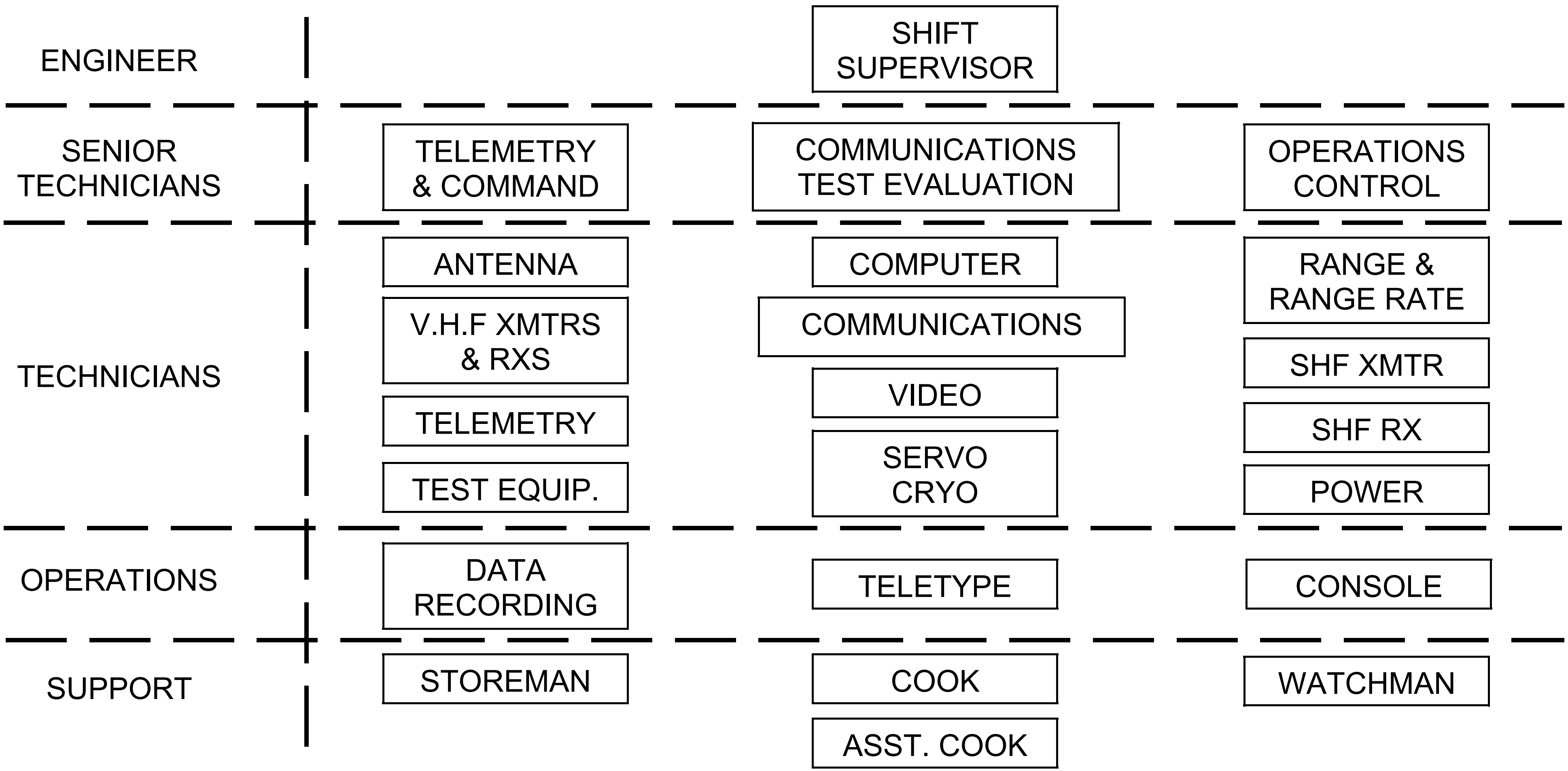

Fig. 4

Included In these teams are three technicians whose work is almost exclusively of a maintenance nature, regardless of whether they are working during an operational or maintenance period. They are:—

* "Test Equipment", whose function is to check and calibrate all test instruments at regular scheduled intervals and to repair any faulty instruments.
* "Servo/Cryo", who maintains the hydraulic servo equipment and helium cryogenic system.
* "Power", who ensures that an uninterrupted supply of power is available on both the technical and utility bus. }~chines are changed as required for regular inspections and overhauls, or if performance is suspect.

The present operational requirements call for the first operational shift to arrive on site at 7 a.m. local time (2100 hours G.M.T.), one hour before commencing the first scheduled operation of the day. This works through until they have handed over to the second oncoming operational shift at 3.30 p.m. local. This latter team arrives on site at 3 p.m., allowing 30 minutes of hand—over time. The third changeover of the day (11.00 p.m. to 11.30 p.m.) differs from the previous ones in that at this time, only a maintenance crew comes on site under the supervision of a senior Technician ("Communications and Test Evaluation" in Figure 4).

<u>Missions</u>

Mission type operations are held to a critical time schedule and sequence of events. They usually involve co—ordination of the activities a number of stations or facilities and require the precise determination of control of spacecraft orbital parameters. These operations fall into the following categories:—

* Spacecraft launches.
* Spacecraft station keeping manoeuvres.
* Eclipse control of spin stabilised satellites.
* Spacecraft attitude experiments.
* Passes of non-synchronous satellites.

The Shift Supervisor's key men in this type of activity are the two Senior Technicians, "Operations Control" and "Telemetry and Command".

<u>Launches</u>

A launch is the most critical of all operations as it involves the success or immediate failure of a whole project. Station preparations for a launch start well before the actual date of launch is announced.

A rehearsal of the launch activities on an accelerated time scale is usually held 30 days before the launch and serves to check out data and message handling capabilities of all stations and the network control centre.

Seven days before launch, a full scale simulation is held. In this case, the events prior to the launch are scheduled in accelerated time; all events after launch are simulated in their real time sequence. Subject to the results of these rehearsals, any problem sections of the sequence may be re-programmed for rehearsal until such time as the difficulties are ironed out.

Three days before launch, the countdown starts with the submission of a five day weather forecast and an operational Readiness Report from each station. From this time onwards, readiness reports are sent with increasing frequency until the actual lift—off. V.H.F. acquisition occurs approximately hour after lift—off from Cape Kennedy and immediately telemetry is fed to recorders and a data line direct to the Control Centre (ATSOCC).

Although a number of NASA tracking stations along the initial spacecraft trajectory support each launch, Cooby Creek is the first A.T.S. station to make contact and has the responsibility of turning on the S.H.F. transponder.

The times listed for turn—on commands in the countdown sequence are nominal for a normal launch and acquisition. In practice, the Control Centre will authorise commanding as soon as a sufficiently strong signal is available for telemetry verification. Once the S.H.F. transponder is turned on, tracking data may be taken at regular intervals and transmitted to a central computer for an early orbit determination.

The ranging message contains information on range; range rate; antenna AZ and EL pointing angles; spacecraft identification number; and station identification number. Data is normally sampled once per second for a period of five minutes. Every alternate line of data carries the full GMT date and time.

The polang message carries ten readouts of S.H.F. received signal polarisation angle and signal strength at one second intervals, together with spacecraft "housekeeping" information obtained from V.H.F. telemetry.

Both messages are sent direct to line as the punched tape comes from either the Range/Rate equipment or the SDS—910 computer.

Station Keeping Manoeuvres

A synchronous satellite orbits around the earth in the same direction and at the same angular velocity as the earth itself, thus retaining a fixed position over the earth's surface. In order to maintain this position, the spacecraft must be placed in an equatorial orbit at a "synchronous altitude" of 22,240 miles (orbit radius 26,200 Miles). A lower altitude results In a higher angular velocity — the spacecraft thus "gains" the earth and drifts towards the east. Conversely, a higher altitude will result in a drift towards the west.

It is more convenient to place the satellite in an orbit slightly higher than synchronous and allow it to drift slowly to the west. Periodic manoeuvres can then be made to return it to the east. Precision of station—keeping is a compromise between frequency of manoeuvres and conservation of fuel. A drift of say $\pm$ 1° of longitude about a specified point on the earth's equator is not unreasonable.

A change of position of a spin stabilised satellite is achieved firing a redial jet to produce a velocity vector in the required direction.

For a given time of manoeuvre, the angle of rotation between the sun sensor pulse and the jet firing can be determined from the spin rate and spacecraft geometry. The jet is fired once per revolution until the required number of pu1aes has been executed.

In order to ensure the success of a manoeuvre, two ground stations are required, one of which has prime command responsibility; the other acts as a back-up and must be prepared to take over the operation at any stage. Both stations configure for the operation one hour before the scheduled time. All manoeuvre parameters required by each station, such as commands, jet start angle, number of pulses, etc., are authorised by teletype before the start of set-up time and are verbally confirmed by the station five minutes before the start of commanding. Spin rate is measured before and after the manoeuvre; polang and sun angle, both of which can indicate a change in spacecraft attitude, are called verbally each 30 seconds from five minutes before until five minutes after execution. The readings are confirmed later teletype.

Eclipse Control

Twice each year, around the vernal and autumnal equinoxes, a synchronous satellite passes into eclipse once each day for a period of about a month. The duration of each daily eclipse varies from a few minutes on the early and late days to somewhat more than one hour at the peak, i.e., on the actual equinox date. During this period, power is supplied solely from the batteries; there being no charging current available from the solar cells.

For a spin stabilised satellite of the A.T.S. programme, the eclipse has a further significance in that some means must be provided of synchronising the antenna array (whether It be electrically or mechanically despun so that it still points toward the earth. Synchronisation is normally obtained from a pulse generated once per revolution as a photoelectric sensor points towards the sun. During eclipse, of course, no output is obtained from this sensor and a "pseudo sun pulse" has to be generated from a ground control station. At each A.T.S. station there is a Synchronous Controller which enables pulses to be generated and synchronised with the actual sun pulses before the start of eclipse. Once the eclipse has started, the loss of sun pulses deprives the station of a means of measuring the spacecraft spin rate.

A factor which was not realised until the first eclipse of ATS—1, is that the spacecraft spin rate increases while it is in eclipse. This is caused by a shrinkage in diameter of the structure due to decreased temperature, with a consequent change in moment of inertia. The result is that the antenna array is now no longer synchronised with the spin rate and will slip in position. An automatic correction system has been devised at Cooby Creek which uses the received SHF AGC voltage as indication of change in antenna pointing angle and as an error correction for the rate of pseudo sun pulse generation.

Stable control of the antenna beam pattern enables one or more stations to perform communication experiments during eclipse.

Communications Experiments.

At S.H.F., experiments involve the transmission of multi—channel telephony, vision and data. At V.H.F., the experiments involve data transmission; duplex and simplex voice communication with aircraft, ships at sea and other ground stations.

For co-ordination of these activities, the Shift Supervisor relies on the Communications and Test Evaluation Senior Technician.

In order to assess the contribution of different parte of the tam to overall performance, each test can be performed in a number of loop configurations. For example, loops may be completed at baseband or video; I.F. frequency; at R.F. by sampling transmitter output to a dummy load; through the collimation tower; or through the spacecraft. In every case before a test is performed through the spacecraft, the same test is performed in an R.F. loop to ensure satisfactory station performance.

Related tests are scheduled to be performed in groups so that good correlation of data is obtained in the final analysis. Grouping of similar tests also considerably reduces the time spent in set—up. All test results are accompanied by a detailed weather observation sheet.

In order to obtain large samples of data, automated communications tests are programmed by the SDS—91O computer and the data recorded on magnetic tape. A typical multiple access automated teat acquires the following data:-

* Ground transmitter power output.
* Received carrier level, satellite and ground.
* Multiplex channel S/N ratio (top and bottom of spectrum).
* Baseband response, level stability and frequency stability.
* Baseband idle noise level and loaded noise power ratio.
* Baseband short term discontinuities and/or noise disturbances (data channel error count).
* Doppler measurement.
* Station time.
* Ground station antenna co—ordinates and polarisation.
* Satellite attitude.

The computer will reduce the data to plot against the time such variables as: Signal/Noise (idle and loaded slot noise power ratios); Channel Level; Frequency Error; Propagation Losses (up and down links.) etc..

Similar tests are performed both in the Frequency Translation mode and in the Multiple Access mode, with additional tests which may be unique to one mode or the other. For example, all T.V. tests are performed in the Frequency Translation mode only. They include:

* Weighted Noise
* Video Differential Gain
* Video Insertion Gain

* Video Low Frequency Response

* Video Transient Response

* Video Channel Noise, Power Supply Hum and Intermodulation Distortion.

* Monochrome Test Pattern Analysis

Multi—station tests require close co-ordination between stations, particularly in the Multiple Access mode. A multi—station automated test requires considerable set—up time.

An automated test is normally preceded by a group of relevant manual tests in order to detect any possible problem areas before embarking on large scale data acquisition.

V.H.F. tests follow the pattern of baseband tests at S.H.F. on a smaller scale. Here, the emphasis is more on establishing voice contact and data transmission with mobile stations (ship or aircraft) having limited power and antenna flexibility.

Another successful application of the V.H.F. experiment is the transmission of weather charts and cloud cover pictures by facsimile.

Periodically, special tests of T.V. transmission are scheduled between two or more of the stations at Rosman, Mojave, Cooby Creek and Kashima. Ahmedabad is not within range of the synchronous satellite ATS—1, the T.V. transmission in which that station has taken part was in the medium altitude satellite ATS—2.

Tests originating in Australia and Japan have resulted in very successful transmission of data via ATS-1.

In one particular test, communications were established between Japan and an airliner over the Pacific, the return route being at S.H.F. from Kashima to Mojave via ATS—1 and at V.H.F. from Mojave to the aircraft via ATS-1 again.

<u>Corrective Maintenance</u>.

When the performance of scheduled operations is affected by a fault condition, corrective action is taken immediately, whether it occurs during an operational or maintenance period. Any such fault, or any other fault which persists for more than 30 minutes, is the subject of a teletyped Status Report to ATSOCC. The report lists operations affected and gives an estimated time of return to operation so that schedules can be suitably modified.

Each station in the A.T.S. project includes the other two stations as an information addressee on its Status Reports to assist in trouble shooting should a similar fault occur elsewhere.

A fault which does not affect scheduled operations may be left for correction during the maintenance shift if personnel cannot be released during an operational period.

On restoration of the equipment to service, a further Status Report is sent by teletype.

For every fault involving the replacement or repair of a component a Fault Report form is completed. These reports form a basis for a comprehensive computer compilation of faults at all N.A.S.A. stations. Listings are available in order of station; in order of equipment; and in order of component type.

At the conclusion of each GMT day, an Activity and Equipment Evaluation Report Is sent by teletype, listing any scheduled operations which have not been supported and all equipment which has been inoperative during the preceding 24 hours.

Preventive Maintenance.

Each of the three Supervising Technicians (Figure 3) prepares daily schedules of preventive maintenance for equipment in his area of responsibility: Microwave, Communications, or Telemetry and Commend. Maintenance of power plant and antenna is scheduled by the Facilities Engineer or Facilities Senior Technician.

The schedules cover performance checks, calibration, alignment, lubrication, etc., and are based on N.A.S.A. Maintenance Control Directives and locally generated Station Directives. This work is performed a Maintenance shift under the supervision of a Senior Technician who furnishes an internal written report of activities at the conclusion of his shift. In addition, any faults or incipient faults revealed by feedback from the operational shifts are scheduled for repair by the maintenance shift.

Equipment performance data is gathered from operational log books and, where relevant, is plotted to indicate trends which may point to the need for maintenance in a particular area.

A check is made, in a back—to-back mode, of equipment required for the following day’s communications tests to ensure operational readiness.

Once weekly, computer look—up tables are prepared for the performance of automated tests.

One of the Supervising Technicians Is responsible for integrating the ATSOCC Daily Operations Plan (prepared by computer for all stations) with the locally generated maintenance schedule.

Logistics

Spare stocks are held on site for the commonly required replacement components and assemblies as well as for some major critical parts.

Replacement items not normally held in stock are requisitioned as required from a N.A.S.A. central logistics store in the U.S.A.

SPECIAL INVESTIGATIONS

From time to time special investigations are instigated in a particular area of the system, ground station, or spacecraft performance. The investigation may be the result to problems encountered in the course of routine system tests or it may result from a requirement to provide new facilities or to improve existing performance levels. Both long term and short term projects are involved.

Such investigations are the responsibility of the Systems Engineers (Figure 2) and are usually pursued jointly by engineers at all three stations under the co—ordination of ATSOCC. Operation and maintenance staff take part where relevant.

Progress reports on each phase are transmitted to other stations by teletype and a comprehensive report is written at the conclusion of the investigation.

CONCLUSION

The maintenance and operation of the Cooby Creek A.T.S. Station is an engineering undertaking wide diversity in equipment and technology. Wide scope is available in the branches of electronic, electrical and mechanical engineering applied to a project which is making an immediate contribution to the field of international communications.

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