

THIRD ANNUAL REPORT OF THE AUSTRALIA TELESCOPE

ADVISORY COMMITTEE

TO THE MINISTER FOR SCIENCE

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Cover: A September 1986 evening view of the first 22-m AT antenna under construction.

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Summary of Progress

Construction of the Australia Telescope (AT), a \$43 million advanced radio astronomy facility, began in 1983. It is on schedule for a planned completion in 1988 as an Australian bicentennial activity.

The construction is under the control of CSIRO Division of Radiophysics. In broad terms, the AT project consists of the design and construction of two basic antenna arrays. One, the Compact Array, involves six movable 22-m antennas and associated railtrack at a site near Narrabri. The other, the Long Baseline Array, consists of the Compact Array, another 22-m antenna at a site west of Coonabarabran, and the already existing Parkes radio telescope. The project is being overseen by the AT Advisory Committee, which has had two meetings since the last Annual Report was prepared. The Committee advises the Project Office and its technical groups, working groups, etc.

There has been considerable progress since the last Annual Report. The main areas of activity are as follows:

- The civil works at Culgoora, the main AT site, were completed at the end of 1985. They consisted of the construction of railtracks, concrete antenna pedestals, access roads, and associated drainage channels for surface water control
- As part of a \$15.2 million contract, Evans-Deakin Industries Ltd. (EDI) is erecting the first two antennas at Culgoora. The first should be completed by February, 1987, the second two months later. All seven antennas (the last at a site west of Coonabarabran) are expected to be complete by the end of January, 1988.

• EDI are constructing the reflecting surface panels to be installed on the antennas, using construction and test equipment developed by CSIRO. The r.m.s. errors of the panels produced (0.10 and 0.20 mm for solid and perforated panels respectively) are 0.05mm below the specified values.

- The radioheliograph control building at Culgoora is being modified considerably for its role as the main control centre of the AT. The modifications include the repair of cracks in the cement flooring, waterproofing of the roof, extensions at one end of the building, construction of a cable entry pit, and internal painting with RF-absorbing paint.
- In a \$156,000 contract, the State Dockyards at Newcastle will provide two demountable buildings for the Culgoora site. These will be used by the 'front-end' AT groups, and will be in place by the end of 1986.

• The site of the seventh 22-m antenna, at the base of Siding Spring Mountain, has had some development. In a \$133,000 contract, the Coonabarabran Shire Council diverted and upgraded an access road from the site to the main road to the Warrumbungle National Park, and carried out some preparatory work on the site. A control building for the site has been designed, and a \$232,000 contract awarded to N.E. & J. Webber for the construction. Completion is expected by the end of 1986.

• The present budget provides for the development of systems for four wavelength bands - centred near 20, 13, 6, and 3 cm wavelength. They will be contained in two dual-frequency, dual polarization feed and cooled

receiver combinations (20/13 cm, 6/3 cm).

• The seven 20/13 cm horn feeds have been finished and tested. To minimize cost and weight, an innovative lightweight construction technique was used. The 6/3 cm horns will be complete and tested by the end of 1986. The design of a 20/13 cm polarizer of manageable size has proven difficult; a promising version is now under test.

• The low-noise amplifiers forming part of the receiver packages are in various stages of production. All 20 cm units are finished and tested, while the 13 cm units are under production. For the 6 and 3 cm amplifiers,

prototype versions are under test.

• The sapphire-loaded cavity oscillators under development at the University of Western Australia (under contract to Steedman Associates) have not proven sufficiently stable to be used as reference standards at the long baseline array sites. An alternative system using AUSSAT for the transmission of reference signals is being explored.

• All the Very Large-Scale Integration (VLSI) chips required for the complex correlators have been delivered. Prototype correlator modules

have been constructed which have performed successfully.

• It is proposed to purchase two VAX 8200 computers for the AT control, monitoring, and data editing and reduction work at Culgoora. The major computer for the offline reduction network at Epping has not yet been chosen. However, a VAX 8800 processor is being seriously considered.

Considerable effort is being put into the production of suitable software to control and monitor the AT and its electronic equipment, and

the subsequent processing of the observations.

• The appointment of an AT Director is currently under consideration. The appointee will be involved with the commissioning of the telescope, and in the planning of the start of its operational phase. In addition, the Director will be responsible for the scientific direction of the Astrophysics Group at Radiophysics.

 The AT Project Office has been enlarged to include members concerned with the coordination and interfacing of the various AT

subsystems to produce an overall working system.

• By the development of innovative techniques, the transfer of expertise developed within CSIRO to industry, and the letting of contracts, the AT project is already stimulating local manufacturing, particularly that associated with space communications industries.

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1. The Australia Telescope Concept

The Australia Telescope (AT) will begin operation as part of Australia's bicentennial celebrations in 1988. It will herald a new era of scientific capability for Australia, being an advanced radio astronomy facility planned to satisfy the major research requirements of Australian radio astronomers into the 21st century.

In total performance the AT will be unique. It will probe both the near and far reaches of the Universe at the most important radio astronomy wavelengths between 20cm and 3 cm initially, and eventually between 90 cm and 2.6 mm. The design features include:

- an ability to map large fields of view with high sensitivity and a maximum detail that will far exceed that seen with conventional optical telescopes,
- a specially-designed spectral-line capability, for the study of the narrow-band signals from the multitude of atoms and molecules (ranging in type from simple to exotic) that inhabit the interstellar medium between the stars, and
- a capability for accurate measurement of polarization, by means of which magnetic fields, important constituents of galaxies, can be traced.
- the ability to observe at two widely-spaced wavelengths simultaneously.

The AT will be able to combine with other radio telescopes in Australia, overseas, and even in orbit, to form vast networks able to map radio sources with unprecedented high detail. At the same time, it will complement the new generation of telescopes that operate in other parts of the electromagnetic spectrum. This includes the ground-based instruments in Australia such as the Anglo-Australian Telescope, the Australian National University's 2.3-m optical telescope, the United Kingdom 48-inch Schmidt Telescope, and the recently-funded stellar interferometer of Sydney University. It also includes several satellite-borne instruments (such as the Space Telescope) that USA and Europe will launch into orbit within the next decade.

The AT has been planned with a confidence in Australian expertise. It was designed in Australia to make effective use of Australian resources. The Australian content will be at least 80 %.

2. An Overview of the Australia Telescope Design

Broadly speaking, the AT is a collection of eight radio antennas simultaneously mapping the same region of sky. These antennas will be operated in two basic groups.

One group is a 6-km Compact Array of six identical antennas, each of diameter 22 m, which is being constructed at the Paul Wild Observatory (formerly the Culgoora Solar Observatory) at Culgoora near Narrabri. Five of the antennas will be movable along a 3-km east-west railtrack; during periods of observation each will be set (to an accuracy of a few mm) on to one of 35 stable concrete pedestals. By choosing different combinations of pedestals, the distances between the antennas can be varied from one observing period to the next. The sixth antenna, located 3 km to the west of the western end of the 3-km track, will have a short (75 m) railtrack and two pedestals.

The signals received by the individual antennas will be transmitted to a control centre for correlation. By combining extended observations taken with different sets of antenna spacings, images of the sky will be produced with the same high degree of detail that would be provided by a single antenna 6 km in diameter. For instance, for operation at a wavelength of 3 cm, the 'angular resolution' will be about one second of arc, that is roughly equivalent to the angular size of star images when viewed with ground-based optical telescopes through the Earth's atmosphere.

It is envisaged that a choice of three sets of configurations will be available - with maximum baselines of 1.5, 3 and 6 km. A complete synthesis of an area of sky using the 3-km series would require at least 25 configuration changes. However, with the application of sophisticated image processing techniques in the reduction of the observations, four-day periods will suffice for many observing programs.

The other configuration will be a **Long Baseline Array**, involving three locations in NSW. It will contain the compact array antennas, another 22-m antenna being built in a valley at the base of Siding Spring Mountain (the Australian home of the giant optical telescopes), west of Coonabarabran, and the existing 64-m radio telescope near Parkes. The array will extend over 320 km in a north-south direction, and will provide a 50-fold increase in resolution compared with the compact array.

Even higher resolution will be possible by using the AT in conjunction with other radio telescopes - for example the 64/70-m

antenna operated by the United States National Aeronautics and Space Administration (NASA) at Tidbinbilla, and the 26-m antenna recently installed near Hobart by the University of Tasmania. Later extensions would involve links with overseas Very Long Baseline Interferometry arrays (VLBI) and even orbiting antennas planned independently by USSR and ESA/NASA (with Australian participation).

The AT will operate in a series of spectral bands at approximately octave intervals between the wavelengths of 90 cm and 2.6 mm. Many of the bands were selected to include the frequencies of the most abundant interstellar atoms, ions, radicals, and molecules. Other bands include the wavelengths used by overseas VLBI networks. However, receiving equipment for only four bands can be developed within the current budget; only bands between 20 cm and 3 cm will be covered. The coverage will be subsequently extended to the limits quoted above. The short wavelength limit, 2.6 mm, corresponds to the wavelength of the ground-state spectral line of carbon monoxide, one of the most abundant interstellar molecules.

Detailed specifications of the AT are contained in Attachment No. 1, the updated AT Systems Definition.

The AT will be well-suited to support research into many of the specific outstanding problems in radio astronomy (see previous Annual Reports for a detailed description). At the same time, the ability to carry out accurate astrometry with the AT will provide opportunities for geodetic applications.

3. The Australia Telescope Construction Project

Following a review by a Parliamentiary Standing Committee on Public Works, the Australian Government gave final approval to the construction of the AT in November 1983. The construction is currently on schedule for a planned opening as a bicentennial celebrations activity in late 1988. It is being carried out by the CSIRO Division of Radiophysics. On completion, the Division will operate the AT as a national facility, under the conditions outlined by the Australian Science and Technology Council (ASTEC) in 'Guidelines for the operation of national research facilities'; the telescope will be available for use on merit by scientists from all over Australia. The project is already stimulating local manufacturing by the development of innovative construction techniques, the transfer of expertise developed within CSIRO to industry, and the letting of contracts. It is particularly timely because of Australia's growing involvement in space communication industries.

The project was recosted during 1985 to take into account increased antenna costs, inflation etc. The current value of the project is \$43.094 million in March 1985 dollars.

3.1 Project Management

The construction project is being steered by the Australia Telescope Advisory Committee. It consists of three scientists from the Division of Radiophysics (including the Chief of the Division, who acts as Committee Chairman), three non-CSIRO Australian astronomers, and four overseas experts (see Attachment No. 2). There have been two changes in the last group during the last twelve months. Dr R.D. Cannon, recently appointed Director of the Anglo-Australian Observatory, has replaced the previous Director, Dr D.C. Morton (who has now taken up a position as Director of the Herzberg Institute in Canada). Dr W.N. Brouw of the Netherlands Foundation for Radio Astronomy, Dwingeloo has been added to the Committee to augment the expertise in the area of computing.

The Committee has been meeting twice yearly, on each occasion for a week during which the critical areas of the project are reviewed and critical decisions are made. General policy guidance on construction is also provided by the Committee. The Actions, Recommendations, and Decisions eventuating at the two meetings held during the last twelve months are listed in Attachment No. 3.

The Advisory Committee is advised on detailed scientific matters by a sub-committee, the **Australia Telescope Scientific Objectives Committee**. Its membership is widely representative of Australian astronomers at universities and other institutions (see Attachment No. 4).

A management structure has been set up that is divided into three areas - policy and planning groups, technical and construction groups, and advisory and working groups. It is shown in Attachment No. 5.

The Director of the project is the Chief of Radiophysics, Dr R.H. Frater. Directly responsible to him is the Project Office, which oversees all design and construction. Heading the Project Office is the Project Manager (Mr J.W. Brooks). Also included are an Antenna Manager (Dr D.N. Cooper), a Project Scientist (Dr J.R. Forster), a Project Secretary (Dr J.B. Whiteoak), and three members involved with the overall system: a Systems Coordinator (Dr G.J. Nelson), a Systems Advisor (long baseline array) (Dr J.A. Roberts), and a Systems Consultant (Mr A. Watkinson). The last two (Systems) positions were created during the last twelve months to meet the increasing demands for expertise in coordinating the total AT system. The Project Scientist's role is to monitor the design and development from the point of view of scientific objectives, and to act as an interface between the Project Office and the scientific community. Dr A.J. Pik, formerly in charge of AT public relations, has left the project to take up a position with the CSIRO Institute of Physical Sciences in Canberra. A Technical Manual Coordinator, Dr R.A. Duncan, has recently

been added to set up the production of all the technical information associated with the project.

Responsible to the Project Manager is the Technical Management, consisting of individual groups concerned with specific sections of the project - antennas and site development, receiving systems, signals distribution, digitizers and correlators, and computing (both off-line and on-line). Working groups containing people not directly involved with the project are associated with the individual sections.

The activities of all the groups are monitored and coordinated at regularly-scheduled AT Progress meetings, AT Antenna Consultant (Management) meetings, AT Management meetings, and section and working group meetings. Other ad-hoc meetings are held as the need arises. One important meeting this year was a workshop on the long baseline array, held at Culgoora in March. Its purpose was to better define the system design for this array, which in some areas had fallen behind the planning for the compact array.

Thirty-eight new positions were created for the design and construction phases; in all, forty-six positions are associated with the project. Many of these positions are short-term appointments; although this practice affects the continuity of the project it is nevertheless consistent with CSIRO policy of training young tertiary institute graduates and passing them and their expertise on to industry. Moreover, it allows some flexibility in planning for the operational phase of the AT, for which only twenty-eight positions will be retained. Included in the turnover of personnel was Dr R.H. Wand, head of the computing section; Dr M.J. Kesteven has now taken over the position.

Many of the existing staff of the Division of Radiophysics have been seconded to the project. In addition, most of the remaining staff have at one time or another been involved on a part-time or consultancy basis.

The appointment of a Director of the Australia Telescope is a critical issue. It is generally agreed that this should take place before the end of the construction project, so that the appointee can be involved with both the commissioning of the telescope and the planning of its operation. It is also intended that the Director would be responsible for the scientific direction of the Astrophysics Group currently associated with the Division of Radiophysics. There is a strong viewpoint among Radiophysics scientists that the Astrophysics Group should be transferred to the AT Program.

The position of Director was advertised both locally and overseas in February (see Attachment No. 6). For the latter, all the major overseas astronomy institutions were notified. Several applications have been received and they are being evaluated by a committee composed of the following:

Dr R.H. Frater, Chief, CSIRO Division of Radiophysics Dr B.J. Robinson, CSIRO Division of Radiophysics Dr N.H. Fletcher, Director, CSIRO Institute of Physical Sciences Dr J. Lowke, Chief, CSIRO Division of Applied Physics Professor D.S. Mathewson, Mt. Stromlo and Siding Spring Observatories, ANU

Professor D.B. Melrose, Head, Dept. of Theoretical Physics, University of Sydney

3.2 Progress with Construction

3.2.1 Site Development

The progress at the main AT site (Culgoora) is more or less on schedule if delays due to bad weather are taken into account. The Civil Works, consisting of the construction of rail tracks, concrete antenna pads, access roads, and associated drainage channels for control of surface water, was undertaken by Roberts Construction Ltd. (RCL). The work was completed by the end of 1985 and within the contract price of \$3.5 million. As part of the contract, RCL will later return to realign and retamp the rails. A small amount of money left over from the contract will be used for a final resealing of the roads at the end of all construction.

In July 1985 a \$15.2 million contract was awarded to a Brisbane company, Evans Deakin Industries Ltd. for the construction of six 22-m antennas at Culgoora and a seventh 22-m antenna at the Siding Spring site. The official signing of the contract took place in a ceremony held at the Division of Radiophysics on 12th September, 1986.

EDI began setting up a construction site at Culgoora towards the end of February, 1986. At present, the first antenna is nearing completion, while a second is well on the way. The original schedule calls for completion of the first two antennas during November, 1986 and January, 1987, and barring additional delays due to bad weather etc, actual completion should take place within 2-3 weeks of scheduled times. The planned completion date of the last Culgoora antenna is September, 1987. On completion of each antenna, Macdonald Wagner, the project's consulting engineers, will carry out tests before handing the antenna over to CSIRO for the installation of firstly servo control equipment, and then the receiving, signal distribution, and computer equipment. Most of this installation and the associated system tests will require a period of about 7 months.

The planned date of 'First Fringes', when two of the antennas are used together as an interferometer for the first time, is December, 1987.

Electrical reticulation is being carried out at the Culgoora site by Division of Radiophysics staff. This includes the provision of

underground power cables and electrical transformers for the concrete antenna sites. Other cabling, e.g. for telephone links, is under way.

The Culgoora radioheliograph building, which will become the AT control centre, has been renovated for its new role. The modifications include repairs to the cement floor; waterproofing the roof; the addition of a northern extension, cable-entry pit and 'screened' room; and the coating of internal walls with radiofrequency-absorbing paint. Additional space will be needed, and in August, 1986 a contract valued at \$156,000 was awarded to the State Dockyards at Newcastle for the supply of two demountable buildings. These buildings will be installed in December.

The site of the seventh 22-m antenna is near the base of Siding Spring Mountain, on land currently owned by Mr L.C. Denning of 'Mopra', Timor Road, Coonabarabran. Surrounding mountains provide good geographical protection from interfering radio signals from microwave links, TV repeaters etc. in the general area.

An upgrading of the road from the main road to the site was required to enable usage by large vehicles. In particular, there was some concern about the safety of the point of exit from the main road. This was finally overcome by the acquisition of a parcel of land on a neighbouring property and a subsequent redirection of the road through this land. The roadwork together with some preparatory work on the AT site was carried out by the Coonabarabran Shire Council in a \$133,000 contract. Power and water are now available at the site.

The Siding Spring installation includes a control building. A suitable building was designed by architect Mr P. Zalai. and a contract valued at \$232,000 let to N.E. & J. Webber for the construction. The building should be completed by the end of 1986. The contract includes the construction of the antenna foundations and cable tunnel to the control building.

Macdonald Wagner, through their site engineer Mr R. Haggart, have been supervising the activities at both sites.

3.2.2 Antenna Developments

The 22-m antennas are alt-azimuth mounted. The Culgoora antennas have an open alidade design combined with a large azimuth slewing ring, and will be mounted on a heavy base equipped with bogies for movement along the railtrack. The specified pointing precision is 11 seconds of arc under average wind conditions. For the Siding Spring antenna, the base will be fixed, and a stiffer 'wheel-on-track' design can be used. This will result in a better high-frequency performance and lower pointing errors compared with the Culgoora antennas. These will be needed for the later operation of this antenna in a high-frequency, standalone mode. On the basis of detailed designs prepared by Macdonald

Wagner, the antennas are being fabricated in the Brisbane factories of EDI and then transported to the Culgoora site for erection in pairs.

Each antenna contains six concentric rings of reflecting panels backed with circumferential ribs. In the workshops of the Division of Radiophysics relatively low-cost techniques of panel construction which could be used by semi-skilled labour were developed. In these, accurately-shaped ribs were formed using a simple 'stretch-bend' machine. These were then bonded and riveted onto the rear of the reflecting panels, the shape of which was defined with a unique 'bed-of-bolts' mould. Semi-automatic panel-checking software and hardware was also developed. All these techniques have now been passed to industry as valuable spinoffs of the AT project.

The panels are being manufactured by EDI using the equipment developed by CSIRO. The inner four rings of panels (out to a diameter of 15.3 m) consist of solid aluminium sheeting; because of wind-loading and weight the sheeting of the outer panels will be perforated with 2.9 mm holes. The rms surface fluctuations specified in the antenna design were 0.15 mm and 0.25 mm for the solid and perforated surfaces. The fluctuations for the panels being produced by EDI are 0.05 mm lower than these values.

The servo-mechanism control systems for the antennas are being produced as a separate project. It began in 1984 with a contract let to the University of Newcastle to produce computer-aided servo designs. A system complete with associated manuals, program listings, circuit drawings etc. should be ready by the end of November. Tests of servo-simulation software will be undertaken as soon as the main computers are installed at Culgoora.

The antenna design is essentially Cassegrain, the signals reflected from the main surface being focussed by a secondary reflector (the 'subreflector') to a location near the centre of the main surface. The subreflectors, 2.75 m in diameter, are being machined out of cast aluminium by Sydney Engineering (Sales). The first has been completed and has an rms error below 0.10 mm, which is within the specifications. This company is experienced in this type of work, having recently manufactured subreflectors for OTC antennas designed by CSIRO Division of Radiophysics.

The work on antenna design has already resulted in industrial spinoffs. For example, one of these is an OTC contract for the supply of three earth stations, recently awarded to a consortium consisting of the Division of Radiophysics, Macdonald Wagner, and Johns Perry Engineering of South Australia.

3.2.3 Feed Systems

For each of the 22-m antennas a feed system is located at the center of the reflecting surface; it collects the signals from the subreflector. Details of these feeds are listed in Attachment No. 1. For wavelengths below 30 cm innovative feed horns will be used to enable simultaneous observation (with two linear or two circular polarizations) in widely separated wavelength bands - the Division of Radiophysics has developed compact corrugated horns that can operate over more than an octave in wavelength range. A series of such horns are set into a rotatable turret set off axis - an appropriate rotation brings the selected feed to the focal point of the antenna.

Within the current budget the antennas will be outfitted with dual 20/13 cm and 6/3 cm systems. With a width of 1 m at the input aperture and a length of 2 m, the 20/13 cm horn would be extremely heavy, not to mention expensive, if constructed according to conventional techniques. The Division of Radiophysics developed a new lightweight construction method, using bands and rings of sheet aluminium. These were assembled on a series of concentric polystyrene disc formers with progressively varying radii, and held together mechanically by external bonding with fibreglass and epoxy. All seven of these horns have now been constructed and tested. The 6/3 cm horns have been manufactured by conventional machining from cast aluminium billets. All will be finished and tested by the end of 1986.

To achieve operation in a simultaneous dual-polarization, dual-frequency mode the signal received at the feed must be split firstly into orthogonal, linearly-polarized components and then into two frequency bands. The design of an adequate 'polarizer' for the 20/13 cm system has been a problem. To have the best possible low-noise systems on the antennas the polarizer must be cooled to minimize its insertion loss. However, it has been difficult to design a device small enough to fit into a dewar of reasonable size. A version incorporating tapering fin-guide technology, and bent-over in shape to reduce the length, is now being tested; the preliminary results appear promising.

The selection of AT bands for wavelengths above 30 cm has been of some concern. It now appears that bands centred near 50 cm and 90 cm may be the most suitable. The latter band has some measure of protection in the international radio regulations. The other is located amongst bands that will be used by the Department of Communications for an Australia-wide UHF TV plan. In the radio regulations it is allocated to radio navigation, but its future use in Australia for radio astronomy is being negotiated. A Cassegrain 'bedstead' feed may be used at 50 cm, while at 90 cm a feed located at the prime focus will be required.

3.2.4 Receivers and Cryogenics

The signals received by the horn feeds are transmitted through waveguide to receiver systems. For operation at wavelengths below 30 cm, each 22-m antenna will be equipped with dual-polarization, dual-frequency receiver packages. Each will be housed in a separate cryogenic system installed directly below the the appropiate feed horn. For wavelengths above 30 cm, simpler uncooled receiver packages will be constructed. The receiver specifications are listed in Attachment No. 1. Construction priorities have been imposed because of time and budgetry restrictions. These are consistent with those for feed construction - emphasis is on the production of 20/13 cm and 6/3 cm systems.

Low-noise field-effect-transistor (FET) amplifiers form part of the short- wavelength packages. All the required 20 cm units have been completed and tested; the noise temperatures are 15 - 20 K. The 13 cm units are under production - noise temperatures around 20 K at 2.3 GHz are expected. The 6 cm design is still undergoing prototype testing - a recent revision of the amplifier casing has resulted in a significant improvement in noise temperature. Attempts are underway to modify the passband to improve the performance near 4.8 GHz. It is hoped to obtain final noise temperatures below 25 K for these amplifiers. The 3 cm development is further downstream - a prototype system is under test.

To yield the maximum sensitivity, these amplifiers must be cooled, and cryogenic systems are being developed for this purpose. Dewars for the 6/3 cm systems are currently under production. They are in two sections, the bottom section cylindrical, the top section of 'maltese cross' shape to provide easy access to the contents. Construction of the 20/13 cm dewars is awaiting final definition of the associated polarizer system. Cooling down to -263 C will be effected using helium gas. The plumbing, flexible lines, manifold boards etc. associated with the distribution of the gas have been designed and partially completed; kits of the required items are being set up for each antenna.

As part of the testing procedure of the AT amplifiers, monitor systems, and associated electronics, a multi-wavelength prototype receiver system has been constructed for operation at 3, 6, 13 and 20 cm, and was recently tested using the Parkes radio telescope. In future, it will be used for on-going observations at Parkes, and later for the first antenna tests at Culgoora until the final receiving systems for these antennas are ready.

3.2.5 Local Oscillators, Signal Distribution, and Monitoring

Considerable effort has been put into the design of IF conversion systems which are free from unwanted 'image' frequency components in the IF bands. Systems for the 20/13 cm and 6/3 cm combinations have

been successfully tested. Prototype computer interfaces have been built and successfully controlled and monitored using a prototype dataset. They are now ready for final production.

Tracking the 'natural fringe phase' of the interferometer, which changes with the radio source position in the sky, is an essential part of the aperture synthesis technique used for the AT. The digital phase rotator development has been completed, resulting in a design with sufficient flexibility to handle the compact array baselines as well as all potential linked sites in Australia. By means of a prototype computer interface and data set, computer control of the rotator has been successfully accomplished.

Wide-frequency bands (of widths up to 256 MHz) will be available for the compact array operation. Each antenna will provide four digitized IF streams, each of 512 Mbaud, for transmission to the control centre. Conventional coaxial cable is unsuitable for the transmission of these wide bands, and wideband optical fibre will be used for this, as well as the transmission of control signals from the control building to each antenna. The requirements are at the forefront of fibre-optic technology, making selection and procurement of critical components quite difficult. In particular, robust connectors capable of repeated connection and disconnection will be needed, because the optical fibre links will have to be rearranged whenever the antennas are moved to different positions.

There are unfortunately reciprocity and phase problems associated with the use of optical fibres. While these do not degrade the digitized signals, the transmission and control of reference frequency signals sent from the control centre to each antenna would be adversely affected. Therefore, coaxial cable will be used for this task. Suitable cable is currently being laid underground alongside the compact array. A Queensland company, MITEC, will develop and supply some of the components associated with the cabling (e.g. directional couplers). This company will be the only Australian commercial source for the components.

For operation of the long baseline array, the IF signals at each site will be stored on magnetic tape for subsequent correlation with the signals recorded at the other sites. The playback will probably be carried out at the control centre at Culgoora. It is intended to use tape-recording systems under development for the US Very Large Baseline Array (VLBA), although some modifications will be needed to adapt the units to the IF system of the AT. These systems would however restrict the total signal output (i.e. for all outputs) from each antenna to 128 MHz.

Different frequency reference schemes for the long baseline array are still being evaluated. Originally, it had been planned to locate a reference at each site, using an ultra-stable cavity oscillator under development at the University of Western Australia under contract to Steedman Associates. However, it was recently decided that these devices are not at

the moment sufficiently stable, and this option is no longer being considered. An alternative system involves using AUSSAT to transmit the reference signals to the various sites, and preliminary work has begun to identify the requirements of such a system.

3.2.6 Correlator

The IF signals reaching the Culgoora control centre from pairs of antennas (either via optical fibres or magnetic tape) will be processed in large correlators. The correlator specifications are listed in Attachment No. 1. The goals of large bandwidths and high resolution in frequency imposed great demands on the initial design. In fact the feasibility of a system to cope with the enormous stream of data (for each baseline pair there will be up to 8192 correlations per cycle period of 5 to 20 s) depended largely on the development of a suitable Very Large-Scale Integration (VLSI) chip. A satisfactory XCELL chip was designed at the Division of Radiophysics, and an order for 6000 chips placed with AUSTEK Microsystem Ltd. The final delivery was made recently, and the chips are now undergoing tests.

The XCELL chips will operate at 16 MHz in parallel-processing groups of 16. A prototype correlator has been constructed, and it has performed satisfactorily in all modes of intended operation.

There will be three separate correlators at Culgoora. Two will be involved with on-line spectral-line and continuum observations with the compact array. The third will be used for processing the signals recorded on magnetic tape during operation of the long baseline array. A MicroVax II computer in conjunction with a Sky Warrior array processor will be used to control the correlators; these items have now been delivered.

Ultra-fast digitisers, digital delay circuits, and data transmission and reception circuits are under development; prototype digitisers have been constructed and evaluated using the prototype correlator.

3.2.7 Computing for the AT

At Culgoora, two main computers will be used for overall AT control, monitoring, and data collection. One will serve as a 'synchronous' control computer, responsible for all tasks synchronized to the array control and all tasks synchronized to the data-sampling cycle as set by the correlator; the specifications for this are now complete. The other, the 'asynchronous' computer, controls the data collection and preliminary processing. Originally, it was intended to use VAX 11/750 processors, but it is now proposed to purchase two VAX 8200 computers.

A PDP 11/73 processor will be installed at each antenna to provide individual antenna control. Tenders for the supply of these units have

just closed. A system of datasets has been developed for communication between the main and antenna computers, and for the collection of monitor data for the antennas and associated receiving equipment. Prototype datasets have been built and are being tested.

An extensive data reduction centre is being developed at the Epping headquarters of the Division of Radiophysics. It will include the existing network, to which will be added another major processor (a VAX 8800 is being seriously considered), together with other ancilliary equipment (array processors, disk storage, etc.). 'Benchmarking' tests involving expected AT tasks were recently carried out on current computer models at Digital Equipment Corporation headquarters in USA.

A considerable amount of effort is being put into the development of appropriate software for the computer networks. This involves software for the array control system, ephemeris routines, single baseline analysis, and astronomical image analysis. For the last, the Astronomical Image Processing System (AIPS) developed at the US National Radio Astronomy Observatory for the processing of VLA observations has been adopted as the standard reduction package. It is in current use at Epping, and is being constantly updated and improved.

3.2.8 The Parkes-Tidbinbilla Interferometer (PTI)

An interferometer system has been set up using the 64-m radio telescope at Parkes, NASA's 64-m radio telescope at Tidbinbilla, and a connecting Telecom microwave link. The main purpose of the PTI is to test out techniques (including the computer software mentioned in the previous section) that are intended for the AT. At the same time, because two large antennas are involved, the PTI is a potentially powerful instrument for carrying out research on the southern skies.

4. Budget

Attachment 7 shows the financial status of the AT construction project up to 30th September, 1986 (in terms of the recosted budget effective 1st July, 1985). Expenditure prior to 1st July, 1985 is listed in the Second Annual Report of the Australia Telescope Committee to the Minister for Science. The attachment contains details of the construction budget, plus a summary and status of the major construction contracts.

Attachment 8 shows bar charts of quarterly and cumulative expenditure (in 'day-to-day' dollars) in various areas of the project (antennas, electronics, salaries, works and service, and combined).

5. Publications and Publicity

A paper 'The Australia Telescope - Spinoffs for Space-Related Services' was presented by Mr J.W. Brooks at the Second National Space Engineering Symposium, held in Sydney during March, 1986.

A paper 'The Australia Telescope Project: Going Along Nicely, Thank You!' was presented by Dr J.B. Whiteoak at the 1986 Annual General Meeting of the Astronomical Society of Australia, held in Hobart during May. This will be published in the Proceedings of the Astronomical Society of Australia.

Dr J.B. Whiteoak has prepared an article 'The Australia Telescope: a Fine Example of "Made in Australia" ', for publication in the Department of Science publication ASCENT.

The publication of AT Countdown is continuing under the control of Dr B.J. Robinson. Numbers 5 and 6 appeared in January and July, 1986.

Numerous technical reports have been prepared on different aspects of the AT, and these have been distributed to interested parties in Australia and overseas.

A video documentary of the AT construction is underway. In an \$82,500 contract, Northbridge Films of Lindfield, NSW are producing an archival-style record of the project up until the opening in 1988. Approximately 50% of the cost will be provided from communication grants from the CSIRO Bureau of Information and Public Communication.

Project Office members and other scientists at the Division of Radiophysics have given numerous talks and colloquia (both in Australia and overseas) on the AT to other scientific groups, Rotary and Apex clubs, schools etc.

ANGLO-AUSTRALIAN OBSERVATORY

P.O. BOX 296, EPPING, N.S.W. 2121, AUSTRALIA

In reply please quote:

RDC/jf

31 October 1986

EPPING LABORATORY Phone (02) 868 1666 Telex: 23999 AAOSYD AA

AT/16.1.2/002

The Honourable Barry O Jones, MP Minister for Science Parliament House CANBERRA A C T 2600

Dear Mr Jones

As in previous years, the external members of the Advisory Committee take this opportunity of commenting on the progress of the Australia Telescope Project.

Substantial progress has now been made in the construction phase of the AT project. During the last year the civil works at the Culgoora site have been completed and work on two of the antennas is well advanced. This together with successful tests of the feeds and receivers confirms our high opinion of the quality of the research and development teams and of the strength of the management which have kept the whole project on schedule.

We note that the project has been successful in promoting the transfer of expertise of technology developed for the AT to Australian industry, particularly in areas such as the design and construction of antennas which are relevant to Australian involvement in space communications; the digital correlator which is essential for processing the vast amounts of data from the telescope, and for which the AUSTEK chips represent the state of the art in Very Large Scale Integrated chip (VLSI) development; and the design and innovative construction techniques for the wide band feed systems. These developments put the AT at the forefront of radio telescope design in the world and show the success and importance of the interaction between the CSIRO Radiophysics groups and the AT team. The proposed use of AUSSAT for the essential high precision time link between the long baseline antennas across Australia is unique, and should be followed up vigorously.

Overall we are very favourably impressed by the progress of the project, and look forward to the exciting new scientific results which the Australia Telescope promises to yield.

J E Baldwin

Cavendish Laboratory, Cambridge UK.

R D Ekers

National Radio Astronomy Observatory Socorro N M. USA

J Davis

University of Sydney

D S Mathewson

Australian National University

R D Cannon

Anglo-Australian Observatory

W Brouw

Netherlands Foundation for Radio

Astronomy. Dwingeloo

AT/01.13.1/008 Systems Definition Date: 3rd November, '86 Previous Update: 6/6/86

Version No.: 8

AT SYSTEMS DEFINITION

A. **CONFIGURATION**

A. 1. Compact Array

- a) Six antennas, each 22m in diameter, alt/az mounted Cassegrain optics.
- (b) East-west grating array, maximum baselines 1.5, 3, 6km.
- (c) Antennas relocatable on rail track between stations as follows:
 - (i) A 3km section from 0 to 3km containing 35 stations and 5 antennas.
 - (ii) 75m section at 6km containing 2 stations and 1 antenna. Provision for future third station.
- (d) Grating increment 15m, shortest spacing 30m.
- (e) Provision for a future spur track for a north-south extension of array.
- (f) Minimum redundancy solutions optimised for pseudo-regular coverage of the uv plane after 2, 4, 8, 12, 16, 24 observing periods of 12 hours.
- (g) All 4-period subsets of the 24-period solution optimised for pseudo-regular coverage of the uv plane.
- (h) All baselines with the 15m increment in the 3km array available after 27 observing periods.
- (i) Pseudo-zoom arrays available after 1, 2, 4, 8 observing periods.
- (j) Approximately scaled arrays available for 1.5/3km and 3/6km.

A. 2. Long Baseline Array

- (a) The long baseline array includes:
 - (i) One or more compact array antennas in "tied" mode.

- (ii) A 22m diameter antenna near Siding Spring Mountain in Coonabarabran Shire. N.S.W.
- (iii) The Parkes 64m telescope.
- (b) Tape recording capability at the three sites to enable data correlation.
- (c) Provision for inclusion into the array of an antenna at the NASA Deep Space Station, Tinbinbilla (with up to two 140 Mbits/s channels to Parkes on a real time radio link) and an antenna at Hobart.
- (d) Provision for future extensions of the array with:
 - (i) One or two additional antennas in the Culgoora/Siding Spring area.
 - (ii) An antenna at or near Epping

B. ANTENNA ELEMENTS

- B. 1. New Antennas (6 x 22m dishes at Culgoora, 1 x 22m dish at Siding Spring).
 - (a) Alt. Az mounted.
 - (b) At Culgoora the antennas will be self-propelled on rail track at a minimum speed of 3 km/hr: Siding Spring antenna fixed.
 - (c) Subreflector to be provided with 50 mm axial motorised adjustments.
 - (d) Access and space (a cube of side 0.3 metre approximately) at Prime Focus provided for possible future use (maximum additional weight approximately 15 kg).
 - (e) Full dish operable at 50 GHz with aperture efficiency approximately 0.5. Central 15.3 metres operational to 116 GHz with aperture efficiency approximately 0.3.
 - (f) Optics: Cassegrain or Prime focus.
- B. 2. Existing Parkes 64 Metre Radiotelescope (AT/15.7/013)

Optics: Prime focus all frequencies.

C. FEEDS

- C. 1. Feeds for New 22m Antennas
- C. 1.1 All feeds (except at 327 MHz) designed for Cassegrain focus.

C. 1.2 Feeds above 1 GHz are wideband (> octave) corrugated feeds to cover:

(i) 20/13 cm (L/S): 1.25 - 2.70 GHz (ii) 6/3 cm (C/X): 4.4 - 10.8 GHz (iii) 12/7 mm (K/Q): 20.0 - 50.0 GHz (iv) 3.5/2.6 mm (W/F): 84.0 - 116. GHz

- C. 1.3 Dichroic system for simultaneous observation at 13 & 3 (S & X) bands to be provided.
- C. 1.4 All Feeds to operate on-axis, except 3cm X band when simultaneous with 13cm (S) band.
- C. 1.5 Wideband feeds and receivers to be mounted near vertex on rotating-turret (remotely controlled).
- C. 1.6 Low frequency (<1 GHz) feeds will be dipoles or arrays of dipole at least covering the bands:-

(i) 90cm: 322-328.6 MHz (Prime focus)(ii) 50cm: 582-603 MHz (Cassegrain focus)

- C. 1.7 The above feeds will be linearly polarized at 45 and 135 degrees.
- * C. 1.8 Feeds for stand alone operation of the Siding Spring antenna dual opposite circularly polarized feeds may be interchanged with the normal single feeds at 12, 7, 3.5 and 2.6mm. In this mode beam subtraction will be performed in a correlation receiver.
 - C. 2. Feeds for Parkes 64 Metre Radiotelescope
 - C. 2.1 All feeds to be for prime focus operation.
 - C. 2.2 Feeds currently under development: single frequency feeds covering receiver bands as defined in D1.1(a) and dual frequency feeds covering parts of 20/13cm, 6/3cm, 13/3cm (L/S, C/X, S/X) bands will be provided.
 - C. 2.3 The above feeds will be linearly polarized at 45 and 135 degrees.
 - C. 2.4 For some parts of the receiver bands circularly polarized feeds will be available.
 - C. 2.5 For stand alone operation dual oppositely circularly polarized feeds will be provided at 6cm (C) and 3cm (X) bands. Beam subtraction will be performed in a correlation receiver.

Denotes changes since last version

- C. 3. Feed Priorities
- C. 3.1 First priority design and construction of 20/13cm (L/S) and 6/3cm (C/X) feeds for 22m antennas.
- C. 3.2 Second priority feeds for Parkes and provision for dual beam operation.
- C. 3.3 Third priority low-frequency feeds and 13/3cm (S/X) optics.
- C. 3.4 Fourth priority provision for dual beam operation above 3cm (X) band on Siding Spring 22m antenna.

D. **RECEIVERS**

- D. 1. Receivers for New Antennas
- D. 1.1 (a) High Frequency Systems (greater than 1 GHz)

Optics: Cassegrain.

Frequency: Each dual frequency, dual polarization receiver system will be housed in a common cryogenic package and operate from a single wide-band feed.

The following bands will be covered:

20 cm (L): 1.25 -1.78 GHz) Common cryogenic 13 cm (S): 2.2 -2.5 GHz) package 6 cm (C): 4.4 -6.1 GHz) Common cryogenic 3 cm (X): 8.0 - 9.2 GHz) package 3 cm (X): 8.0 - 10.7 GHz) Off axis 12 mm (K): 20.0 - 25.5 GHz) Common cryogenic 7 mm (O): 42.0 - 50.0 GHz) package 3.5 mm (W): 84.0 - 98.5 GHz) Common cryogenic 105.0 - 116.0 GHz) 2.6 mm (F): package

NOTE: (a) These are design goals. Present technology would restrict us to approximately 15% bandwidth.

- (b) These frequency bands are "clear" bandwidths, i.e. system performances should not deteriorate significantly up to the band edges, particularly where spectral lines are involved.
- (c) Within the budget a minimum of 20/13cm, 6/3cm (L/S, C/X) systems will be provided.
- D. 1.1 (b) Low Frequency systems (less than 1 GHz)

Optics: Cassegrain or Prime focus.

Frequencies:

(i) 90 cm: 322-328.6 MHz (Prime focus) (ii) 50 cm: 582-603 MHz (Cassegrain)

Receiver bandwidths greater than these should be provided initially. Suitable filters to be inserted later when interference becomes a problem.

D. 1.2 Environment -

- (i) LNA's above 1 GHz will be cooled together with as much of the polorization, bandsplitting and feed waveguide as practicable.
- (ii) Low frequency LNAs will operate at room temperature.
- D. 1.3 The four on axis receiver systems (8 frequency bands) in D1.1 (a) will be operational at all times as far as practicable.
- D. 1.4 Space to be provided on turret for all 4 on axis feeds mentioned in C1.2 and the associated dual channel receivers.

D. 2. Receivers for Parkes 64 Metre Radiotelescope

D. 2.1 (a) High Frequency systems (greater than 1 GHz)

Optics: Prime focus.

Frequency: Multi-frequency systems will be provided.

The following bands will be covered:

20 cm (L): 1.25 - 1.78 GHz) 13 cm (S): 2.2 - 2.7 GHz)

6 cm (C): 4.4 - 6.1 GHz) 3 cm (X): 8.0 - 9.2 GHz)

NOTE These are design goals. Present technology would restrict us to approximately 15% bandwidth.

Initially a single dewar containing dual receivers at each of 20, 13, 6 and 3 cm (L,S,C and X) bands will be constructed. This will be followed by a second dewar providing more optimum operation in 20 and 13 cm (L and S) bands.

D. 2.1. (b) Low frequency systems (less than 1 GHz)

Optics: Prime focus.

Frequencies:

(i) 90 cm: 322-328.6 MHz (Prime focus) (ii) 50 cm: 582-603 MHz (Cassegrain) Receiver bandwidths greater than these should be provided initially. Suitable filters to be inserted later when interference becomes a problem.

D. 2.2 Environment -

- (i) LNA's above 1 GHz will be cooled together with as much of the polarization, bandsplitting and feed waveguide as practicable.
- (ii) Low frequency LNAs will operate at room temperature.

D. 3. Receiver Priorities

- D. 3.1 First priority provision of 6/3 and 20/13 cm (C/X, L/S) receivers for the 22m antennas.
- D. 3.2 Second priority provision of 6/3 and 20/13 cm (C/X, L/S) receivers at Parkes (including stand-alone operation).
- D. 3.3 Third priority provision for stand-alone operation with the Siding Spring antenna.

E. SYSTEM

- E. 1. Compact Array (Max R.F. frequency 116 GHz)
- E. 1.1 IF digitized antenna.
- E. 1.2 Two pairs of IF channels available from each antenna: selected from within the operating frequency bands. Each pair of IF's contains signals of the same frequency but of orthogonal linear polarizations.
- E. 1.3 For each antenna only two independent LO's will be provided. Provision will however be made to offset the phase between members of each pair of IF's. Circular polarization can then be generated for the tied array.
- E. 1.4 Fringe stopping at antennas.
- E. 1.5 Signal transmission via optical fibres.
- E. 1.6 Each IF data stream (512 MBits/sec capacity) shall be composed of one of the following:
 - a) 1 bit sampled, 256 MHz bandwidth.
 - b) 2 bit sampled, 128 MHz bandwidth.
 - c) 4 bit sampled, 64 MHz bandwidth.
- E. 1.7 The 4 bit sampled 64 MHz bandwidth signals will be processed at the centre as follows:
 - (1) 4 bit to 2 bit digital conversion to provide 64 MHz bandwidth inputs to the continuum correlator and/or to the line correlator.

- (2) 4 bit to analogue conversion to provide:-
 - (a) an analogue signal for filtering in factors of 2 from 32 MHz down to 0.5 MHz. The filtered signal will be redigitized (2 bit) for input to the line correlator.
 - (b) analogue signals corrected in gain and phase that can be combined to give tied array signals in 2 linear and 2 circular polarizations with a maximum bandwidth of 16 MHz.
- E. 1.8 "Tied" array capability for 1 to 6 antennas. Prividing up to 4 I.F. channels either linearly or circularly polarized.

E. 2. Long Baseline Array

(Max RF frequency 116 GHz where possible)

- E. 2.1 I.F. digitized at antenna.
- E. 2.2 4 J.F. channels available from each antenna.
- E. 2.3 Provision of 2 independent, simultaneous LO's per antenna.
- E. 2.4 Fringe stopping at antenna.
- E. 2.5 Signal data collection using tape recording.
- E. 2.6 Maximum I.F. data rate (to suit VLBA tape recorders) 256 Mbits/sec., i.e. for 2 bit sampling, 4 channels 16 MHz wide.
- E. 2.7 Narrowband filtering of I.F. will be available in factors of 2 down to 0.5 MHz in CA style receivers or to 62.5 kHz in VLBA tape recorders.
- E. 2.8 Where possible both linear and circular polarizations will be made available for recording.

E. 3. LO Switching

All LO frequencies must be capable of being switched at rates of up to 0.2 Hz.

- E. 4. Priorities
- E. 4.1 First priority Compact Array operation.
- E. 4.2 Second priority Long Baseline Array.
- E. 4.3 Third priority Siding Spring Stand-Alone operation.

F. CORRELATORS

- F. 1. Culgoora
- F. 1.1 Provision for simultaneous operation in the following four modes:
 - a) Compact Array Line OR Wideband Continuum.

15 Baselines, with up to 8 products per baseline, providing a minimum of 16 frequency channels per product for 1 bit correlation at 256 MHz bandwidth or for 2 bit correlation at 128 MHz bandwidth. Recirculation up to a factor of 64 if possible.

Minimum bandwidth 0.5 MHz. For fewer products per baseline, proportionally more channels per product.

b) Compact Array Narrowband Continuum.

Operating at 64 MHz bandwidth, providing up to 8 products for each of the 15 baselines: with at least 8 frequency channels per product.

c) LBA Line OR continuum.

Uses the same modules and blocks as in a) above but with more flexible input arrangements so that if desired more baselines can be obtained with less products per baseline.

For 4 antennas, a maximum of 6 baselines and 8 products per baseline are possible.

For 5 antennas, a maximum of 10 baselines and 4 products per baseline are possible.

For 6 antennas, a maximum of 15 baselines and 2 products per baseline are possible.

For 7 antennas, a maximum of 21 baselines and 2 products per baseline are possible.

- F. 1.2 Compatible with future addition of FFT pre-processors at each antenna to obtain more frequency channels.
- F. 1.3 Includes delay tracking systems for both arrays.
- F. 1.4 Includes FFT processing, Doppler tracking, Van Vleck correction, Hanning and output selection.
- F. 1.5 Tape playback system and interface to correlator for LBA correlations.
- F. 1.6 Provides phase differences between antennas and between polarized IF's to allow "typing of the array".
- F. 1.7 Provides sample statistics for level control at the digitizers.

F. 2. Parkes and Siding Spring

F. 2.1 Provision of auto-correlators. Eight modules (1 Block) for Line and two Modules for continuum. This is identical to one baseline of the CA correlator

F. 3. Priorities

- F. 3.1 First priority Compact Array correlator.
- F. 3.2 Second priority Parkes stand-alone correlator.
- F. 3.3 Third priority Long Baseline Array correlator.
- F. 3.4 Fourth priority Provision of a stand-alone correlator for the Siding Spring antenna.

G. CONTROL MONITOR AND VIDEO DATA

- G. 1. Compact Array: via Fibre Optics.
- G. 2. Long Baseline Array: Control and monitor data including digitised video data for semi-realtime fringe check, via Telecom links. Normal digitised video data via tape recorders (US VLB Array compatible.).

H. LOCAL OSCILLATOR DISTRIBUTION

- H. 1. Compact Array: via coaxial cable.
- * H. 2. Long Baseline Array: via AUSSAT.

I. COMPUTING

- I. 1. ON-LINE Computing
- I. 1.1 The ON-LINE computing system for the CA will be located at Culgoora and consist of:
 - a) At the control centre:
 - (i) A μVAX II correlator control computer and associated SKY-WARRIOR 15 M flop array processor.
 - (ii) A VAX 8200 asynchronous computer.
 - (iii) A VAX 8200 asynchronous computer.
 - (iv) Shared disk, tape and optical disk units.
 - (v) Control console.
 - b) At each antenna element:

- (i) An LSI 11/73 antenna control computer to perform coordinate conversion and control/monitor functions.
- (ii) A microprocessor antenna position computer which performs servo control and other antenna functions.
- I 1.2 ON-LINE computing for the LBA yet to be defined.
- I. 2. OFF-LINE Computing (CA and LBA)
- I. 2.1 Off-line processing will utilize the NRAO AIPS software system.
- I. 2.2 Wide field mapping and the processing of large spectral line data cubes will require considerable computer power. At the same time provision must be made for simultaneous interactive processing of a number of smaller tasks.

No decision has been made at this stage but machines such as the CONVEX C-1 or VAX 8800 are possible choices.

LIST OF ADVISORY COMMITTEE MEMBERS

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Very Large Array Site Socorro NM USA

Dr. R.H. Frater (Chairman)

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Dr. R.N. Manchester

Senior Principal Research

Scientist and

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CSIRO Division of Radiophysics

Prof. D.S. Mathewson

Mt. Stromlo and

Siding Spring Observatories

Dr. P.J. Napier

Chief Engineer

National Radio Astronomy

Observatory

Very Large Array Site Socorro NM USA

Decisions and Action Items Instigated by the AT Advisory Committee

Twelfth Meeting of 17th April, 1986

Decisions:

- (i) The design and construction of a C/X dewar sufficiently large to contain the most recently designed polarizer should proceed.
- (ii) A tested local oscillator phase servo (or even a prototype of the servo) should be available for the first interferometer tests.
- (iii) Performance characteristics of the L/S polarizer will be sent to Advisory Committee members as soon as the information becomes available, so that a decision on the polarizer can be made before the next meeting.
- (iv) A decision concerning the location of the LBA computer will be withheld until after the appointment of the AT Director.
- (v) The AT systems should have the capability of unattended operation for periods of up to two weeks.
- (vi) A monitor program with associated system checks should be kept running all the time on the AT computer network.
- (vii) An AT frequency band will be centred within the frequency range 582-603 MHz.
- (viii) A designation based on wavelength, recommended by ATSOC, will be used for all AT frequency bands.
- (ix) The Committee noted the priorities, recommended by ATSOC, (AT/16.3/011) for the future development of frequency band (1: 3.5mm/2.6mm; 2: 1.3cm; 3: 90cm; 7mm: 50cm).
- (x) The date of the first call for AT observing proposals will be reviewed at later Advisory Committee Meetings.

Action Items:

- (i) Manchester will investigate the possibility of using longer integration times in bandwidth synthesis, in conjunction with pseudo-random frequency variations. He will also consider the implications of the system servo rates on mosaic-type observations.
- (ii) Smith will investigate the options concerning accommodation that could be financed within an operating rather than capital budget.
- (iii) Cooper will investigate the consequences of constant periodic slewing, as would be required for mosaic operation.

- (iv) Brooks will investigate the ramifications associated with testing as much as possible of the integrated system at Epping without affecting too drastically the program schedule.
- (v) Napier will telex over information concerning the US contract for the procurement of LBA tape recorders.
- (vi) Brooks will provide Advisory Committee members with information concerning the insertion loss, load performance characteristics, and operational impact of the various options, that are associated with the use of the L/S polarizer.
- (vii) Brooks will investigate whether currently-planned manual controls might be operated on an automatic basis.
- (viii) Cooper will investigate the implications of unattended AT operation on antenna control and antenna safety.
- (ix) Brooks will provide information concerning the tradeoffs between receiver broadbanding and performance.
- (x) Forster and ATSOC will consider the implications of the tradeoffs provided in (ix).
- (xi) Cooper will look at the implications of a frequency step of, from 8 GHz to 80 GHz in the development of AT frequency bands (as suggested by ATSOC in AT/16.3/011).

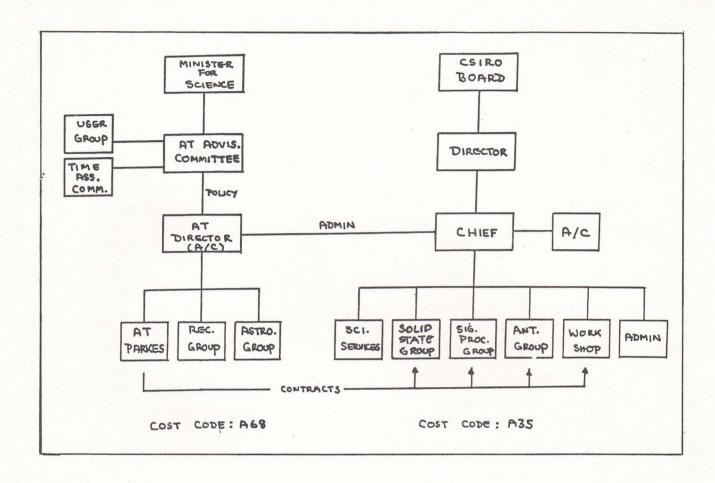
Thirteenth Meeting of 29th October, 1986

Decisions:

- (i) The Committee recommends that by September 1987 a case should be put together in support of extra funding to provide rental or leased accommodation at Narrabri.
- (ii) The Committee recommended that all efforts should be made to ensure that the system tests at Epping are given priority over the first fringes' operation.
- (iii) The Committee recommends that work on the polarizer design should continue for another month.
- (iv) The Committee recommends that the composition of the AT Steering Committee should be: 3 CSIRO representatives (including the Chief of RP and AT Director), 3 Australian non-CSIRO representatives, and 3 overseas advisors.
- (v) The Committee agrees that the AT Director should be responsible (at least in terms of scientific direction) for the RP Astrophysics Group.
- (vii) The Committee agrees with ATSOC that the AT receivers should be capable of operation in the radio astronomy bands near 2.7 and 10.6 GHz, but without compromised performances in the currently-designated 13 and 3 cm bands.

Action Items:

- (i) Brooks will investigate the possibility of organizing long-term rental accommodation as it becomes available at Narrabri.
- (ii) Brooks will investigate the implications of frequent turret moves during telescope operation, and of ways of making such moves less harmful to the turret control.
- (iii) ATSOC will provide some estimate of the predicted frequency of turret movement during typical AT operation.
- (iv) Brooks will investigate the possibility of providing AT manpower to construct LBA tape recorders at Haystack.
- (v) AT Management will communicate with Haystack and NRAO on the question of sending AT personnel to Haystack to participate in the production of VLBA tape recorders (for use with the AT).
- (vi) Brooks will request Jim Roberts and Max Komesaroff to investigate the suitability of the latest design for making accurate polarization observations with the AT.
- (vii) Brooks will obtain further answers to the implications of unattended AT operations on antenna control and antenna safety, and inform the Committee of his findings.
- (viii) Brooks will investigate whether the Computing Section is taking into account the need for software to enable such operations as measurement of primary beamshapes, carrying out pointing observations, displaying and plotting of monitor point information etc.
- (ix) ATSOC will request Art Stolz and Dave Jauncey to document the reasons why the 13/3 cm combination is favoured above other wavelength combinations.
- (x) Brooks will prepare a suitable advertisement for post-doctoral positions assocated with the AT.
- (xi) An item for the agenda of the next Advisory Committee Meeting will concern the implications of ASTEC guidelines on the allocation of AT observing time. Whiteoak will request information on time allocation practices from the major institutions Parkes, AAO, NRAO, MSSSO, etc.
- (xii) Young will seek an allocation of AUSSAT transponder bands for use in the LO stabilization of LBA antennas. He will also advise CSIRO Division of Applied Physics and the Division of National Mapping on this action, so that some co-ordination might be planned.
- (xiii) Nelson will provide University of Adelaide with cost estimates of an LBA backend. Brooks will discuss the use of an AT antenna design and pricing with MW; when this information is available, Frater will discuss the results with the University.
- (xiv) ATSOC will provide an input on feed priorities, to complete Section C.3 of the Systems Definition.



LIST OF AT SCIENTIFIC OBJECTIVES COMMITTEE (ATSOC)

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Department of Physics
University of Wollongong
PO Box 1144
EPPING NSW 2121

HOST INSTITUTION CSIRO Division of Radiophysics PROJECT DIRECTOR ADVIS. COMMITTEE Chief of Division J.E. Baldwin R.H. Frater W.N. Brouw R.D. Cannon J. Davis PROJECT SCIENTIST R.D. Ekers J.R. Forster R.H. Frater (Chair) R.N. Manchester PROJECT MANAGER D.S. Mathewson J.W. Brooks P.J. Napier B.J. Robinson PROJECT OFFICE Antenna Manager D.N. Cooper SCI. OBJECTIVES Project Scientist J.R. Forster COMMITTEE Project Secretary J.B. Whiteoak G.V. Bicknell Syst. Coordinator G.J. Nelson W.G. Elford Systems Advisor A. Watkinson K.C. Freeman LBA Syst. Coord. J.A. Roberts P.D. Godfrey Tech. Man. Coord. R.A. Duncan R.W. Hunstead D.L. Jauncey Admin. Officer P.J. Howson R.N. Manchester (Ch) L.F. Carrig Stenosecretary P.M. McCulloch J.G. Robertson J.E. Ross MANAGEMENT SUPPORT A. Stolz Culgoora Coord. B. Wilcockson J.W.V. Storey Tech. Assistance G.A. Manefield A.E. Vaughan Mech. Expediter V.M. Harrigan J.B. Whiteoak

TECHNICAL GROUPS

TECHNICAL GROUPS

| Antennas: D.N. Cooper | | | |
|-----------------------|----------------------------|--|--|
| MWP Contract | | | |
| Servo Systems | (Newcastle Uni) | | |
| Panels | B.F. Parsons | | |
| Feeds | G.L. James S.J. Skinner | | |
| Culgoora Site | W.J.Payten | | |

| Correlators: | W.E. Wilson |
|--------------|---|
| | K.A. Cambridge C.N. Carter E.R. Davis J.H. Gates A.J. Hunt D.G. Loone M.W. Willing S. Rajan |

| Sig.Distribution:A.C. Young | | | |
|---|---|--|--|
| IO Systems Fibre Optics IBA T.Record. | S.T. Ables M.J. Anderson R.G. Gardyne M.G. McCulloch G.A. Lee N.V.G. Sarma R.C. Ticehurst | | |

| Receivers: | M.W. | Sinclair |
|-------------|--|--|
| Cryogenics | | Sykes Hoyle |
| FET Amps. | R.J. | Gough Bolton Rasmussen |
| Radiometers | G.J. G.F. G.R. H.P. M.R. R.G. | Moorey Gay Gerard Graves Kanoniuk Leach Mercer Smith |
| Model Shop | P.H. | Seckold |
| Computing | MT | Voctoron |

| Computing: | M.J. Kesteven |
|------------------------------|--|
| Online Comp. Control Desk | K.W. Anderson R.J. Beresford G.W. Crapps R.H. Ferris L. Newton K.C. Taylor B.J. Whitelaw |
| Data Reduction | R.P. Norris J.D. Argyros M. Calabretta J.F. Deane H. May P.T. Rayner |

ANCILLIARY STAFF

DRAWING OFFICE - K.W. CORKERY
WORKSHOP/S - B.A. EGAN

AT STAFFING

| YEAR/STAFF | AT POSITIONS | DIVISIONAL POSITIONS | |
|------------|--------------|----------------------|--|
| 1982/83 | 8 | 16 | |
| 1983/84 | 24 | 32 | |
| 1984/85 | 38 | 22 | |
| 1985/86 | 38 | 22 | |
| 1986/87 | 38 | 22 | |
| 1987/88 | 38 | 22 | |
| 1988/89 | 28 | 22 | |
| | | | |

what is this?

CSIRO

DIRECTOR

THE AUSTRALIAN TELESCOPE DIVISION OF RADIOPHYSICS EPPING, N.S.W.

GENERAL: Applications are invited for the position of Director of the Australian Telescope, a new radio astronomy facility due to be operated as either a 6 km Compact Array or a 310 km Long Baseline Array. Future use in conjunction with other antennas in Australia and elsewhere as a VLBI network is envisaged.

DUTIES: The appointee will be responsible for operation of the Australian Telescope as a National Facility, and for the scientific direction of the Astrophysics Group currently associated with the CSIRO Division of Radiophysics. Prior to the end of the construction phase the appointee will be involved in commissioning of the Telescope and planning its operation. Initially, the appointee will be located at the Division's Headquarters at Epping, N.S.W., and will work in close liaison with both the Australia Telescope Project management and the Division.

QUALIFICATIONS: Applicants should possess a PhD or equivalent qualifications, with an extensive background of relevant research experience and a record of outstanding achievement in scientific research. Leadership experience in radio astronomy or related fields is highly desirable.

TENURE: Appointment to CSIRO is for an indefinite period and carries Australian Government superannuation benefits, subject to normal conditions. The position as Director is offered for an initial term of seven years, with subsequent options for a further term, if mutually desired, or for another senior position in the Organisation. The salary will not be less than \$50,194.

APPLICATIONS: Stating relevant personal particulars, including details of qualifications and experience, the names of at least three professional referees and quoting reference No. A6514, should be directed to:

Dr R. H. Frater, Chief CSIRO Division of Radiophysics, P.O. Box 76, Epping, N.S.W. 2121 Australia.

by March 28, 1986.

Further information can be obtained from the Administrative Officer, Australian Telescope Project, at the above address.

CSIRO IS AN EQUAL OPPORTUNITY EMPLOYER.
ABI No. HS3566.

1. AT Construction Budget, 1 July 1985 to 30 September 1986

i) Expenditure

| | Allocation (in Mar '85 dollars) | Expended (%) 1/7/85 to 30/9/86 | Balance (in Mar '85 dollars) | Balance (in June '86 dollars) |
|------------------------|---------------------------------------|--------------------------------|------------------------------------|-------------------------------------|
| Antennas | \$21426.7 | \$42.81 | \$12253.0 | \$13547.4 |
| Macdonald Wagner | 850.9 | 45.39 | 464.7 | 503.8 |
| Electronics | 11032.0 | 8.26 | 10120.8 | 11451.2 |
| Salaries | 3302.2 | 32.75 | 2220.6 | 2396.4 |
| Other Works & Services | 1869.5 | 52.87 | 881.1 | 1003.7 |
| TOTAL | 38481.3 | 32.59 | 25940.2 | 28902.5 |

ii) Liabilities:

At 30 September 1986 liabilities totalled \$11,512,918.

Notes:

1.) The provision for Macdonald Wagner has been re-estimated to reflect the current requirements. Funds (436.1) are available form the antenna contingency.

2. Construction Contracts @ 30 September 1986

- 1) Civil Works Culgoora Roberts Construction.

 Contract complete except for realignment of rails required number of telescope runs are made.
- Antenna Contract Evans Deakin Industries Ltd.
 Value of contract \$15,200,000 which includes a contingency amount of \$500,000.

Payments:

As per schedule

\$5,275,338

Escalation

1,068,374 (includes exchange rate variation)

Variations 22,714

6,366,426

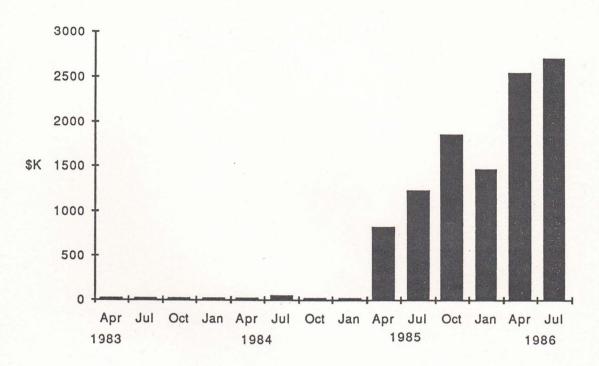
3) Civil Works Siding Spring - Coonabarabran Shire Council.

Value of Contract \$133,460 Payments to date \$126,260

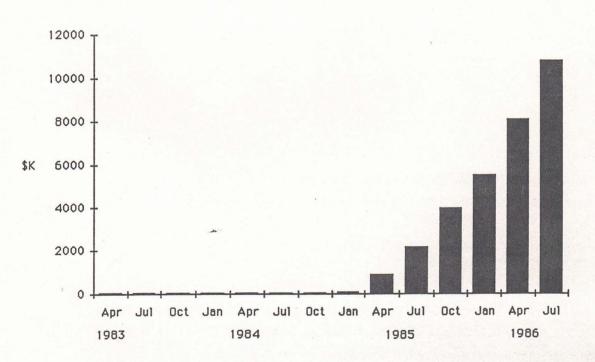
Contract complete - final payment pending approval of work.

 Control Building Siding Spring - NE & J Webber. Value of Contract \$231,837. Which includes a contingency sum of \$10,000. Work has commenced. Payments to date - NIL.

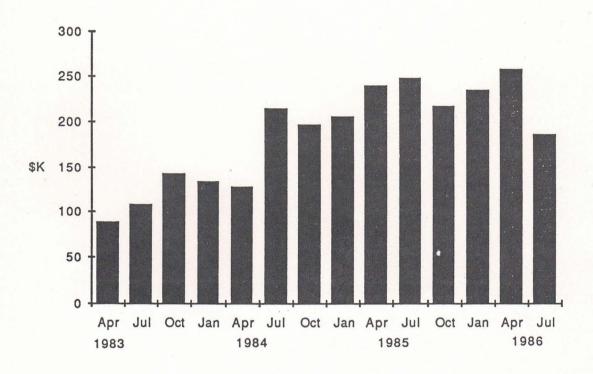
Antennas



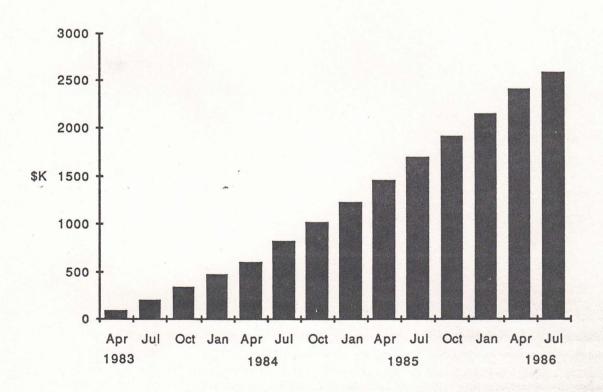
Antennas (Cumulative)



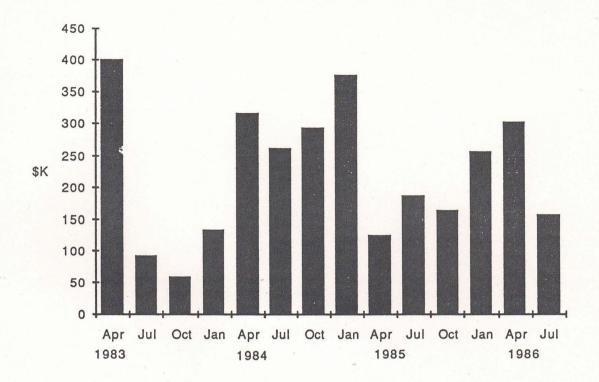
Salaries



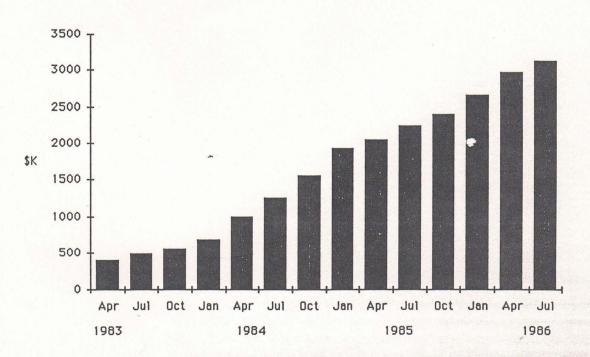
Salaries (Cumulative



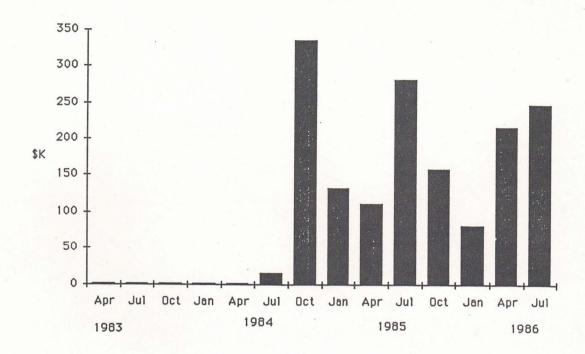
Works & Services



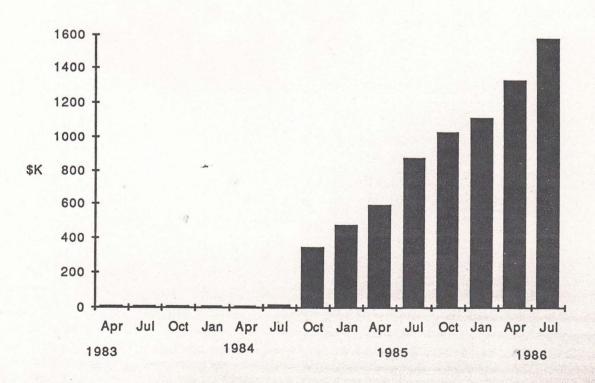
Works & Services (Cumulative)



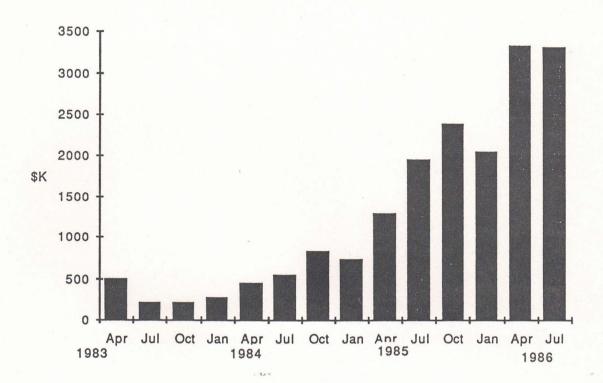




Electronics (Cumulative)







Combined (C)

