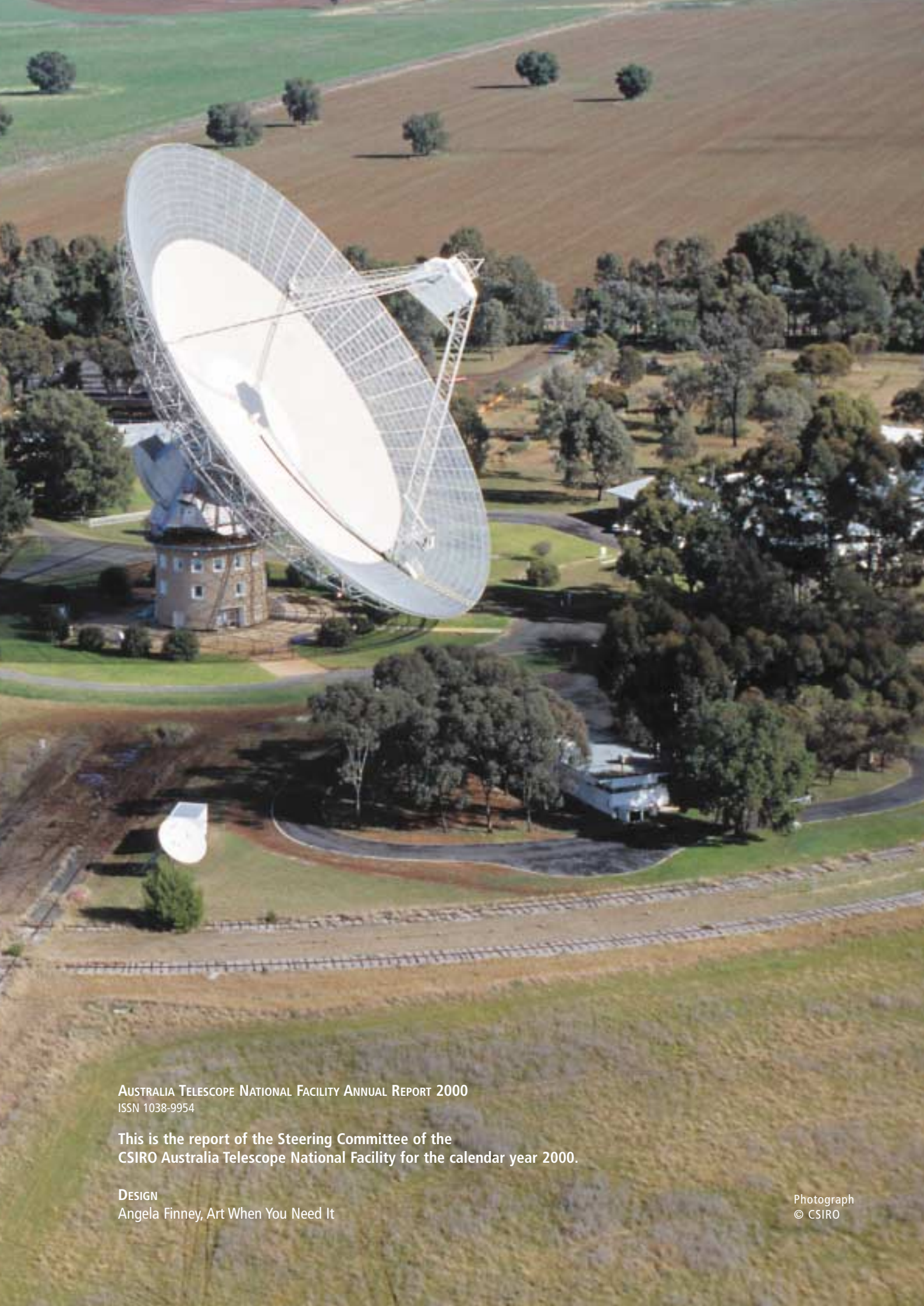
AUSTRALIA TELESCOPE NATIONAL FACILITY
CSIRO

Annual Report 2000

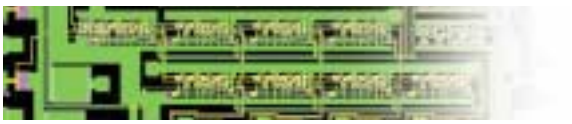


Australia Telescope National Facility Annual Report 2000
ISSN 1038-9954

This is the report of the Steering Committee of the CSIRO Australia Telescope National Facility for the calendar year 2000.

Design
Angela Finney, Art When You Need It

Contents



Overview

Science highlights in brief

First millimetre light for upgraded Australia Telescope page 16

After three years of designing, building and testing, first light at millimetre wavelengths for the upgraded Australia Telescope Compact Array occurred on 30 November 2000. Two of the six antennas were fitted with the new 3-mm receiving systems and were used to observe silicon monoxide maser emission from the Orion nebula.

Massive proto-planetary disks detected at radio wavelengths page 18

Observations taken with the Australia Telescope Compact Array reveal the presence of three sources in the starburst cluster NGC 3603, identified as proto-planetary disks on images from the Hubble Space Telescope and the ESO Very Large Telescope. The radio sources are 20–30 times larger than their counterparts in the Orion nebula and are much brighter than expected.

New discoveries of millisecond pulsars in globular clusters page 20

Globular clusters are a rich source of millisecond pulsars. These are compact neutron stars in binary systems that have been "spun up" by mass accretion from the companion stars. In a study of 60 globular clusters, ten new millisecond pulsars have been discovered in four clusters which were not previously known to contain pulsars. The new discoveries were made from sensitive observations taken with the Parkes radio telescope.

A very young pulsar discovered in the Parkes Multibeam Pulsar Survey page 24

In the past four years, the Parkes radio telescope and its multibeam receiver have been used to scan the Milky Way for pulsars. The Parkes survey has nearly doubled the number of known pulsars. Among the discoveries is the pulsar J1119-6127 which rotates just over twice per second. Its spin parameters show that it is only 1,600 years old, making it the fourth youngest pulsar known in the Milky Way. Observations taken with the Australia Telescope Compact Array show that the pulsar is at the centre of a previously uncatalogued supernova remnant.

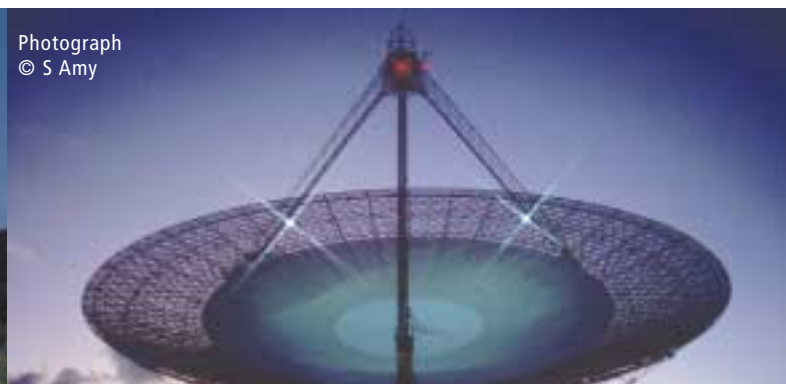
A new test for general relativity page 26

A team of Australian and US astronomers have used the Parkes radio telescope to measure the distortion of space-time near a star 140 parsecs from Earth, confirming a prediction of Einstein's general theory of relativity. They measured the arrival times of the pulses received on Earth from the bright millisecond pulsar, PSR J0437-4715, to within a tenth of a millionth of a second.

The HI environment of superbubbles in the Large Magellanic Cloud page 28

One of the most important processes that drives the evolution of galaxies is the injection of energy into the interstellar medium from the winds and supernova explosions of massive stars. In starburst

Photograph
© CSIRO



Photograph
© S Amy

Overview

regions, groups of massive stars may blow "superbubbles" of hot ionized gas which extend over large distances. A team of researchers has used the Australia Telescope Compact Array to study the neutral hydrogen environment around three young superbubbles in the Large Magellanic Cloud. They find that while the ionized gas shells are similar for the three regions, the neutral hydrogen distributions are strikingly different.

The HIPASS Bright Galaxy Survey page 30

The HI Parkes All-Sky Survey has provided the first ever survey of extragalactic neutral hydrogen over the southern sky. The survey was completed in March 2000 and the data were released in May 2000. One of the first survey products is the HIPASS Bright Galaxy Catalogue, a catalogue of the 1,000 brightest HI galaxies in the southern hemisphere.

HIPASS turns up new gas in the NGC 2442 group page 32

The HI Parkes All Sky Survey has revealed a huge cloud of neutral hydrogen gas, near the bright spiral galaxy NGC 2442. The gas cloud, designated J0731-69, contains a thousand-million solar masses of hydrogen but shows no evidence for any stars or star formation activity. The cloud may have been torn out of NGC 2442 during a tidal interaction with another galaxy.

Recurrent activity in giant radio galaxies page 34

Giant radio galaxies have linear sizes of millions of light years. Observations taken with the Australia Telescope Compact Array for the giant radio galaxy B0114-476 reveal a "double-double" structure with two outer diffuse lobes and two inner jet-like features. Such a structure suggests that the galaxy may experience recurrent nuclear activity.

The gaseous halos of three spiral galaxies page 36

Observations of three southern edge-on spiral galaxies, taken with the Australia Telescope Compact Array, show that the galaxies have extended gaseous halos. The radio emission occurs from relativistic electrons which are released during multiple supernova explosions. The radio data provide new insights into the star formation history of the observed galaxies.

Technology highlights in brief

MNRF Upgrades

First results at 3 mm page 16

A major milestone was reached in November 2000 with the first 3-mm observations of the upgraded Australia Telescope Compact Array, taken using two antennas. The success of the millimetre observations highlights the excellence of the MNRF engineering.

Australia Telescope Compact Array local oscillator distribution page 62

Almost all of the optical fibres for the local oscillator distribution network have been

Overview

laid between the Control Room and the antenna station posts.

Extra stations and the north spur page 63

Civil engineering works associated with four new stations on the east-west track and five new stations on the north spur of the Australia Telescope Compact Array were completed in 2000.

MMICS page 64

Monolithic microwave integrated circuits (MMICs) are an essential component of the high-frequency receiver upgrades. After bonding and packaging, 3-mm and 12-mm indium phosphide MMICs were retrofitted to two prototype receivers on the Australia Telescope Compact Array. Both the system temperatures and bandwidths achieved were outstanding.

High-speed two-bit sampler page 64

Considerable progress was made with the development of a high-speed two-bit digitiser using indium phosphide heterojunction bipolar transistor (InP HBT) technology. This is designed to sample astronomical signals at up to eight Gigabits per second.

InP HBT technology was also used to develop a digitiser with integrated photo-receiver circuits which allow the digitiser's output to be passed to optical fibres via externally bonded laser diodes.

The Square Kilometre Array

Antennas for the SKA page 67

Work continued on assessing the feasibility of using spherical refracting antennas (Luneburg lenses) for the Square Kilometre Array.

Interference Mitigation page 67

The ATNF has developed successful new techniques for the removal of interference signals from correlated radio astronomy data.

SKA site testing page 69

Work has continued to identify possible sites for the SKA in Australia and the feasibility of establishing a radio-quiet reserve.

The ATNF in Brief

The Australia Telescope National Facility (ATNF) supports Australia's research in radio astronomy, one of the major fields of modern astronomy, by operating the Australia Telescope, a set of eight individual radio telescopes.

Mission

- To operate and develop the Australia Telescope as a national research facility for use by Australian and international researchers.
- To exploit the telescope's unique southern location and technological advantages to maintain its position as a world-class radio astronomy observatory.
- To further the advancement of knowledge.

Overview

Size and funding

The ATNF employs 135 staff. In 1999–2000 the organization's total funding was $16.64M, of which $12.23M was direct appropriation from CSIRO.

Status within CSIRO

The Australia Telescope National Facility is managed as a National Facility by Australia's largest national research institution, CSIRO. Formerly part of the CSIRO Division of Radiophysics, it became a separate Division in January 1989. The Australia Telescope Steering Committee, appointed by the Minister for Science to advise the ATNF Director, also acts as the Advisory Committee for CSIRO's Radio Astronomy Sector.

Status as a National Facility

The ATNF became a National Facility in April 1990. As a National Facility, the Australia Telescope provides world-class observing facilities in radio astronomy for astronomers at Australian and overseas institutions. The Australia Telescope is operated as a National Facility under guidelines originally established by the Australian Science and Technology Council.

Users of ATNF telescopes

Observing time on the ATNF's telescopes is awarded to researchers on the basis of the merits of their proposed research programs by a Time Assignment Committee appointed by the Steering Committee. More than 80% of the telescopes' users come from outside ATNF.

In 2000 the telescopes were used by:

38 researchers from the ATNF;

77 researchers from 16 other Australian institutions; and

243 researchers from 98 institutions in 23 overseas countries.

The ATNF in the Australian context

The ATNF is the largest single astronomical institution in Australia. Ninety per cent of Australian radio astronomy is carried out through the ATNF. The organization has strong links with its primary user base, the university community; the interests of telescope users are represented by the Australia Telescope Users Committee.

The ATNF's Sydney headquarters are co-located with those of the Anglo-Australian Observatory, an independent bi-national facility that provides world-class optical and infrared facilities. This close association is unique, in world terms, and promotes valuable collaboration between the two organizations.

The ATNF in the global context

Of the fields of modern astronomy—X-ray, ultraviolet, optical, infrared and radio, Australia's most important contribution to the global practice of astronomy is through radio astronomy. This is a result of Australia's early lead in the field, continuous technological advances, and southern hemisphere location. The Australia Telescope is the only major radio telescope of its kind in the southern

Photograph

Overview

hemisphere, and thus can view part of the sky which is out of reach of northern hemisphere telescopes. It provides one of the most powerful radio astronomy facilities in the world.

Australian and international observers use the telescope without access charges. This is in accordance with a general practice of the worldwide astronomical community, in which telescope users from different countries gain reciprocal access to facilities on the basis of scientific merit. This allows Australian astronomers to use telescopes in other countries and international facilities such as space-based instruments. Such access provides Australian scientists with a diversity of instruments and leads to a rich network of international collaborations.

The ATNF's observatories

The Australia Telescope consists of eight radio-receiving antennas, located at three sites in New South Wales.

Six of them make up the Australia Telescope Compact Array (ATCA), located at the Paul Wild Observatory near the town of Narrabri. Five of these antennas sit on a 3-km stretch of rail track running east-west; they can be moved to different points along the track to build up detailed images of the sky. A sixth antenna lies three kilometres to the west of the main group. Each of these antennas has a reflecting surface 22 m in diameter. After the radio signals from space are "collected" by the antennas' surfaces they are transformed into electrical signals, brought together at a central location, and then processed. The end result is usually a picture of the object being studied—a picture equivalent to a photograph, but made from radio waves instead of light.

A further 22-m antenna, known as the Mopra telescope, is located near Mopra rock, in the Warrambungle mountains near Coonabarabran, New South Wales.

The other key component of the Australia Telescope is the Parkes 64-m radio telescope, located near the town of Parkes. This telescope has been successfully operated since 1961 and is famous as a national symbol for Australian scientific achievement. Recent upgrades to accommodate a 13-beam focal-plane array have maintained its world-class position as a state-of-the-art instrument.

The eight ATNF telescopes can be used together as a Long Baseline Array (LBA) for a technique known as Very Long Baseline Interferometry (VLBI) which is used to obtain high-resolution images of small areas of sky. The Long Baseline Array is used as part of an Australian network of radio telescopes which includes the NASA satellite tracking antennas at Tidbinbilla, near Canberra, and radio antennas in Tasmania, South Australia and West Australia. The LBA is also regularly used as part of the Asia-Pacific Telescope which links radio telescopes in Australia, Japan, China, South Africa, Hawaii and India, and the VLBI space observatory program (VSOP).

Overview

Figure 1 *VLBI telescopes in Australia*

Engineering and technology development

The advance of radio astronomy depends crucially on exploiting the latest technological developments in a range of areas which include electronics, receiver technology, signal detection and processing, control systems, data processing and information technology. The ATNF provides a platform for the development of cutting-edge technology in Australia.

ATNF Steering Committee

ATNF policy is determined by the ATNF Steering Committee, an independent committee appointed by the Minister for Science and Technology. The Committee helps CSIRO to develop the ATNF's long-term strategy. The inaugural meeting of the ATNF Steering Committee was held in May 1989. Since then it has met at least once a year, to define the broad directions of the ATNF's scientific activities and the development of the Australia Telescope. It is also responsible for promoting the use of the Facility and, indirectly, for allocating observing time.

The ATNF's host organization, CSIRO, is composed of business units called Divisions; the ATNF has the status of a Division. These Divisions are grouped into 22 research sectors. The ATNF is the sole member of the Radio Astronomy Sector, and the ATNF Steering Committee acts as the CSIRO Sectoral Advisory Committee for radio astronomy.

The Steering Committee appoints an Australia Telescope Users Committee (ATUC) to provide feedback and advice from the user community, and a Time Assignment Committee (TAC) to review proposals and allocate observing time. The committee memberships for the year 2000 are listed in Appendix C.

Australia Telescope Users Committee

The Australia Telescope Users Committee (ATUC) represents the interests of the Australia Telescope's users. In 2000 it consisted of a total of 19 scientists, drawn from eleven institutions. This committee provides feedback to the ATNF Director, discussing problems with, and suggesting changes to, AT operations; it also discusses and ranks by scientific merit various future development projects. As well, ATUC meetings are a forum for informing AT users of the current status and planned development of ATNF facilities, and recent scientific results. ATUC discussions can be found on the Web at http://www.atnf.csiro.au/overview/atuc.

Photograph
© CSIRO

Members of the ATNF Steering Committee in March 2000. From left to right: Prof P. McCulloch, Dr D. Cooper, Prof K. Menten, Dr E. Sadler, Dr P. Scaife, Prof B. Boyle, Prof J. Storey, Prof K. Lo, Prof P. Goldsmith, Prof R. Ekers, Dr R. Sandland and Prof R. Cannon.

Time Assignment Committee

The ATNF receives more applications for observing time than it can accommodate: proposals for time on both the Parkes and Narrabri telescopes exceed the time available by a factor of approximately two. The proposals are assessed, and time allocated to them, by the Time Assignment Committee (TAC). The TAC meets three times a year and reviews approximately 90 telescope applications at each meeting.

Strategic objectives

The ATNF is one of the world's leading radio astronomy organizations. The strategic objectives for the ATNF are:

- To continue to operate the Australia Telescope in such a way as to maintain a leading international position

  The ATNF will provide access to its facilities to satisfy the needs of Australian and overseas users. At least 70% of time on the Parkes and Narrabri telescopes will be used for astronomy. Time lost during scheduled observing periods will be kept to below 5%.

- To upgrade the Australia Telescope to maintain its competitiveness in the medium term (3–8 years)

  The Narrabri and Mopra telescopes are now being upgraded, under the Major National Research Facilities (MNRF) Program, to work at shorter (millimetre) wavelengths. The upgraded telescopes will use innovative devices for the detection of extremely weak millimetre-wave signals from space. These are being jointly designed by the ATNF and CSIRO Telecommunications and Industrial Physics, a project funded by the CSIRO Executive Special Project. The MNRF upgrade will also extend the Australian network of telescopes used for very long baseline interferometry (VLBI), which has both astronomical and geodetic applications. The MNRF upgrades will be completed in 2002.

- To position the ATNF to participate in major international radio astronomy projects developing over the next decade

  The MNRF upgrade will allow the ATNF to maintain a leading position for the next eight to ten years. Beyond that, radio astronomy will be dominated by two major international developments: the Atacama Large Millimeter Array (ALMA) and the Square Kilometre Array (SKA). These instruments will allow astronomers to pursue key questions about the early evolution of the Universe. For Australia to maintain its position in

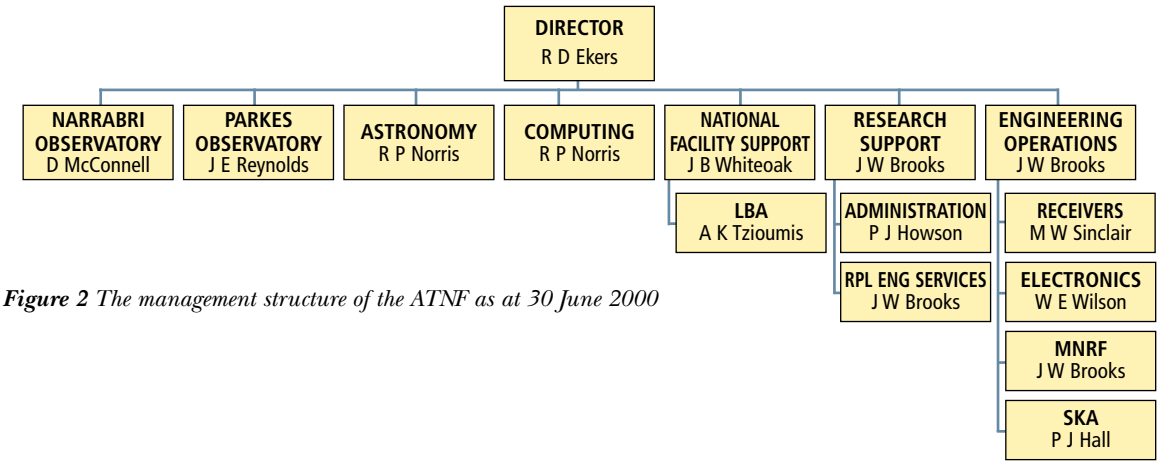


Figure 2 *The management structure of the ATNF as at 30 June 2000*

radio astronomy, it needs to have a significant role in at least one of these projects. The SKA is a billion-dollar project, the "next generation" radio telescope with a collecting area of one square kilometre. Its construction is expected to start in around 2010. Australia is well positioned to play a key role in the development of the SKA. In some respects Australia offers an ideal location for the SKA as it has a number of regions of low population density which are relatively free from radio interference. The technology development required for the SKA will have wide industrial applications and the construction will involve significant industrial contracts.

A preliminary research development program for the SKA, funded by CSIRO, was initiated in 1999.

- To conduct an effective outreach program

  The ATNF operates Visitors Centres at the sites of the Parkes and Paul Wild Observatories and has an active public outreach program which has several goals: to raise the national profile of astronomy and related technology in Australia; to encourage the next generation of scientists by providing educational resources targeted at high school students and their teachers; and to maintain good community relationships.

Photograph