Australia Telescope National Facility (ATNF): balancing basic and commercial research

The Australia Telescope was opened in 1988, one of the national projects to mark the bicentennial of European settlement in Australia. The ATNF is an array of eight antennas located at three different sites in New South Wales. Six dishes, 22 metres in diameter, are in an East-West line at the Paul Wild Observatory near Narrabri. These form a Compact Array. The seventh dish (the Mopra antenna) is also 22m in diameter and is a few kilometres west of Coonabarabran. The 64m-diameter Parkes antenna completes the collection to form the Long Baseline Array, 320km long. (A map?)

Costing $50 million, the telescope was an ambitious endeavour to keep Australia at the forefront of southern hemisphere radio-astronomy.

The challenge for the AT has been to keep Australia's seat at the international table of radioastronomy. It has proven itself by the strong demand for observation time coming from overseas researchers, the quality of the research output and the reciprocal access Australian astronomers have received from overseas facilities.

The AT was designed and built in Australia, with a high content of locally built components. The leading edge engineering that went into it has had spin-off benefits for local industry, especially in communications and the space industry.

The Australia Telescope's status as a world-class centre for radio astronomy research did not come simply from its unique asset – being the only advanced radio telescope network in the Southern Hemisphere. The advanced equipment, designed and constructed in Australia, created a natural demand from researchers, and has been critical to success. But to win credibility with the international community, it had to deliver high quality research outcomes and balance the competing interests of researchers and external contracts. This was achieved by a management program that focused strongly on maintaing the quality of the research program, attracting the best researchers to use the telescope, keeping them satisfied with the services and facilities, and efficiently allocating observing time between them.

Today there is a high demand for telescope time both from Australian and international researchers, and the ATNF Director, Professor Ron Ekers, already has visions for the telescope up to 2010. He envisages a next-generation facility costing around half-a-billion dollars, a significant component of which would be built in Australia, and managed by an international consortium in which Australia would play a leading role.

Project origins: tightly managed construction

Australia has been at the forefront of radio astronomy since the end of World War II. Pioneering work was carried out by scientists from CSIR, the forerunner of CSIRO,

who were previously engaged in wartime radar research. The group's achievements, along with the construction of a number of fine radio telescopes by CSIRO and some universities, kept Australia at the leading edge of radio astronomy for the next 30 years.

However, by the 1970's, the existing telescopes could not operate at the high frequencies required by leading-edge research at the time. Other countries were also building a new generation of telescopes, threatening the vitality of Australian research. In 1975, CSIRO and a group of universities developed a proposal for a high-resolution radio telescope, the Australian Synthesis Telescope. The Federal Government, however, did not fund this proposal.

In 1981, the proposal was redeveloped, following widespread consultation with the science community. Dr Bob Frater, then Chief of CSIRO's Division of Radiophysics, initiated the new proposal, which was underpinned by a front-line instrument capable of keeping Australia at the forefront until the turn of the century. This proposal was accepted as a Bicentennial project, and was allocated $25 million (in 1982 dollar value) in the August 1982 Budget of the Fraser Government.

Being the largest facility CSIRO has had to build, the construction management team had to develop a planning and management methodology never before used at CSIRO. Dr Frater, the Project Director, set up a management group which, at the start of the project, drew up a system definition document. This set the project's priorities and the goals against which progress could be measured. The management team also helped the working groups to produce 'critical path charts' to define the scope of each group's work and the sequencing of tasks. Regular meetings were held to review management and contractual issues, and to monitor and coordinate progress.

Construction lasted five years, during which inflation and currency fluctuation took the project cost to $50 million. The Australia Telescope formally opened during the 1988 Bicentennial celebrations and began full operations as a National Facility in April 1990.

Australian industry benefits from basic research funding

Dr Frater, the Project Director during the development phase, had made a commitment that the telescope should be built in Australia with high local content. As a result, the Division of Radiophysics and its consultants designed an innovative, high efficiency parabolic antenna for receiving microwave signals.

Professor Ekers says this technology was picked up by OTC (Telstra's predecessor) and has been successfully marketed to South East Asia as a communication antenna. "This spin-off alone, as analysed by the Bureau of Industry Economics, has recovered the cost of building the Australia Telescope," he says.

Another company that benefited during the development stage was Austek Microsystems, which was a newly established company at the time. Its first major contract was to manufacture an array of 5,000 signal processing chips especially designed for the telescope's correlator.

According to Professor Ekers, the development phase of the Australia Telescope has demonstrated how government funding of basic research can stimulate industry. "This is a concept that hasn't been used to great advantage in Australia. In many developed countries, basic research is funded vigorously by the government. Often, much of the funding goes straight to industry to custom-design and build ground-breaking instruments, equipment or software for a new technology or a new facility. This gives companies the opportunity to do leading edge work and puts them in a very competitive position. They may not make any money on designing or manufacturing the ground breaking instruments, but the research and development work that went into it, equips them with the skills necessary for the next step towards profitability."

Professor Ekers, who directed the 27-dish Very Large Array radio telescope in the US before returning to Australia, believes that a competitive culture within Australian industry can flourish if more resources were placed in the conduct of basic research.

Operating strategy: researchers as a 'market'

There was no doubt that the new facility was leading edge, technically. But as Professor Ekers points out, delivering a leading edge output from the facility required first rate management and first rate researchers. This was the real test of whether the ATNF would keep Australia within the global network of users and providers of leading astronomical research facilities. Membership of this network gives Australian scientists – including those working on basic research in areas other than radio astronomy – reciprocal access to major international facilities. Australia simply couldn't support these on its own, but they are important to maintaining the nation's knowledge and technology base.

There were other worthwhile objectives to be pursued as well. The ATNF could earn revenue in its own right; and as one of Australia's most technologically sophisticated facilities, there were potential spin-off benefits to Australian industry from ongoing operations and not just during construction . For example, a research contract with the US-based SETI Institute not only returned $2 million to the ATNF, but also gave valuable flow-on work to CSIRO's Division of Radiophysics (now Telecommunications and Industrial Physics). SETI (Search for Extra Terrestrial Intelligence), which 'listens in' on stars in the hope of hearing signals from another civilisation, contracted the Division to build the advanced wideband receivers and the feeds associated with these receivers. The project had such a high profile that the Division won subsequent contracts to build similar feeds for other telescopes around the world.

Professor Ekers considers both groups – those doing basic and astronomical research and those doing research on a cost-recovery basis, as the 'market' for ATNF's services and facilities. But the time available on the ATNF is limited and so the interests of these groups can clash. Consequently, Professor Ekers and his team developed an operating strategy to meet the requirements of their customers, with three key elements:

- a sustained marketing program to keep up the facility's profile within the research community;

- a user feedback system to ensure that the facility meets users' demands and requirements;
- a judicious system of allocating observation time between Australian and international researchers, and between basic researchers and commercial users.

Maintaining a high profile

The ATNF is managed by CSIRO, but its operating policies and guidelines are set by an independent Steering Committee. The Committee is composed of representatives from users, industry and international research institutions drawn from Australia and overseas. Professor Ekers says that this Committee provides advice on balancing the demands of different groups and feedback on performance. "The Committee is comprised of eminent individuals who can help us set priorities. By listening to them, we can avoid some potential conflicts and they, in turn, help explain some of our decisions to key stakeholders. In fact, they become our champions".

Although global demand for time on the telescope is already high, the ATNF maintains a 'marketing agenda' to sustain its visibility among users and to attract the best researchers. According to Professor Ekers, first on this agenda is the publication in respected international journals of results of exciting research at the facility. Also on the agenda is sponsorship of international seminars and specialised workshops that further raise the centre's profile. The ATNF has also used the Internet to great advantage. Its *ATCA Live!* page, updated every 10 seconds, shows routine information such as what the Compact Array is doing at the moment, the weather, the source being observed, array configuration, and monitor data and images.

Professor Ekers adds that word-of-mouth from satisfied users has also served as testimonials for the ATNF. "This has actually turned out to be a most valuable marketing tool for us. The international astronomy community is cohesive and strongly networked, and people who use the ATNF and go away satisfied, spread the word about this fantastic research facility in Australia. They become our ambassadors – walking promotion for the ATNF and CSIRO," he says."

Focusing on the Customer

To keep those researchers satisfied, the ATNF has put in place a user-feedback mechanism similar to those employed by commercial organisations. "This involves keeping our ears on the ground as to what researchers think and say about the facility, and getting them to fill in comment forms at the end of their research. We then take action on the comments, to the extent possible," says Professor Ekers.

User representatives are also consulted on major changes being introduced at the facility. For instance, an ongoing $11 million upgrade involves an external advisory committee which includes some key engineers from research institutions around the world. "This helps strengthen our indirect networking; the overseas advisers are very good sources of information for us, while on the other hand, they are seeing first-hand the capabilities of Australian science and industry."

Judicious allocation of time: basic research and commercial contracts

With heavy demand for observation time, the facility's reputation depends on how well competing interests are balanced.

The ATNF has a policy of opening 30% of available basic research time to international users. Professor Ekers: "This ensures that some of the very best science is conducted here. Some of the international proposals are leading edge, and this pushes up the quality of Australian research competing for time. The competition is quite tight, which helps us maintain very high standards of research."

The ATNF allocates observation time according to the scientific merit of the research proposals. Three times a year, a scientific peer review committee selects the proposals that will get observation time.

Research time is also made available on full-cost recovery basis. This may apply, for instance, to research projects that need unusually large blocks of time. An example was the SETI Institute project, which used the Parkes antenna for six months to look for signs of extra-terrestrial radio communications. Another such project, which also had an element of urgency, was the tracking of NASA's crippled Galileo spacecraft.

Galileo was launched in 1989 to study Jupiter and its moons. However, its primary antenna failed to open after its launch and severely disabled data-transmission. Under a $2.1 million contract with NASA, ATNF's Parkes telescope will be used until December 1997 to catch the reduced data stream from the spacecraft.

Professor Ekers says that commercial contracts like those with the SETI Institute and NASA can enable the ATNF to raise enough funding to keep the telescope operating. However, the ATNF does not want to be dominated by 'paying' customers. Professor Ekers: "Commercial projects don't always necessarily involve leading edge research. If we started taking on more of these project types, we'd slowly stop being a world-class national facility. We have to keep a healthy balance between leading edge fundamental research and commercial-oriented projects "

Continuous improvement

The ATNF is based on information processing and telecommunications technologies, probably the fastest changing technologies in the world today. Computing and image resolution are improving rapidly and this presents a challenge for the ATNF to remain world class. Professor Ekers has responded by constantly upgrading the facility. He tries to keep spending on upgrades at 10% of annual funding, which is extremely difficult in times of tight budgets.

"Its tempting to put off upgrades to meet short term needs, but we resist this. If we were to maintain our status, it's absolutely necessary to spend significant amounts to keep ahead in technology, equipment and software. Besides the 10% budget allocation for upgrade, we also use all our earnings from commercial contracts to

continuously upgrade the facility. For example, the $2 million fee from the SETI Institute was used mainly to develop new systems that has now improved communications between the Parkes antenna and the Mopra antenna. The Mopra antenna can now be controlled remotely as a result of this upgrading."

The NASA contract to track Galileo also yielded $2.05 million, which was used for the largest structural change since the Parkes telescope was built. To allow the telescope to switch quickly between tracking the spacecraft and doing normal astronomy, the equipment cabin at the telescope's focus was replaced by a larger cabin. The new cabin was outfitted with a 'translator system' which takes only a few minutes to swap over different receivers. Most of the receivers in the cabin are for doing normal astronomy, but one is a high-performance 2.3-GHz which was required to capture Galileo's signals. This upgrade reduces operating costs and provides the frequency agility which is a big benefit for normal astronomy.

The ATNF also keeps its profile with the Australian Government, taking the time to explain to politicians and their advisers the benefits of their work. This has paid off and the ATNF had an upgrading boost from the previous Labor Government, which in late 1995 granted it $11 million to further the capabilities of all the eight antennas. The upgrade involves extension of the wavelength and angular resolution of the telescope, by a factor of ten.

The future

Professor Ekers says the $11 million upgrade will help maintain the ATNF's edge for at least the next five years. The work will extend its operating frequency to millimetre-wavelengths, to cover the 12-mm and 3.5-mm bands.

But he knows that to be truly at the leading edge, the ATNF needs to be one of the facilities that is pushing that edge further out. Maintenance and upgrades of the existing facility will only go so far. From 2005, the ATNF Director sees Australia having a significant involvement in the next-generation facility, with a collecting area that's about 100 times that covered by the eight existing antennas. "To realise this, we'd need to use a whole range of emerging technologies – integrating sophisticated electronics into reproducible chips; making solid state amplifiers work at very high efficiencies; building antennas that combine the radiation in ways that allow observers to look at different directions at the same time; and developing clever software that can remove disturbances in the atmosphere," Professor Ekers says.

"It might look unimpressive – a large flat area of tiles, for instance, but inside are all the sophisticated electronics and software that put signals together in ways that have never been done before. Because of its sheer magnitude and sophistication, it would almost certainly need to be built and managed by an international consortium. And because of Australia's current leading expertise, we would be in a very good position to take the leading role in such a consortium," he adds.

Professor Ekers believes that with all the ongoing research at various CSIRO divisions, it can be done. "One of CSIRO's greatest strengths, which sets it apart

from other countries, including the US, is its ability to do the overall system design and to build a unified, working system from a range of very complex elements. And that is partly because of the diversity of talent within CSIRO and partly because of necessity, arising from Australia's relative geographical isolation. If the technology is not available locally, we try to develop it ourselves. And that is helping drive the country's international competitiveness."