Discussion Paper: The Next Decade of the AAO

Matthew Colless (Director, AAO)

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1. BACKGROUND

In 1969 the Australian and British governments decided to establish and operate a large optical telescope in Australia for use by Australian and British astronomers. The Anglo-Australian Telescope Agreement Act 1970 gave effect to this decision. The Act established the Anglo-Australian Telescope Board (AATB), a body corporate, which owns and operates the telescope.

The Anglo-Australian Telescope (AAT) was opened in 1974. In 1988, the operation of another telescope on Siding Spring Mountain, the UK Schmidt Telescope (UKST), was transferred to the AATB. These two telescopes, together with the Marsfield headquarters facility and instrumentation laboratory collectively form the Anglo-Australian Observatory.

The mission of the Anglo-Australian Observatory (AAO) is to provide world-class optical and infrared observing facilities that enable Australian and British astronomers to carry out excellent science. The AAO is a world leader in astronomical research and in the development of innovative telescope instrumentation. It also takes a leading role in the formulation of long-term plans for astronomy in Australia.

Detailed information on all aspects of the AAO can be found in the Annual Reports – see http://www.aao.gov.au/annual/.

2. THE ROLE AND ACHIEVEMENTS OF THE AAO

The AAO has been a major contributor to Australian and British astronomical research for the past thirty years.

2.1 Telescope Usage and Publications

Each semester the AAO telescopes typically provide observing time to between 50 and 60 observing programs involving between 150 and 250 astronomers (on average 40% Australian, 40% British and 20% other). Time on the AAT is typically over-subscribed by a factor between 2 and 2.5. The over-subscription rate is likely to increase after the AAOmega spectrograph becomes available in early 2006. Of the 318 astronomers or students currently located at Australian institutions, 114 (36%) have used the AAO's telescopes in the past 5 years.

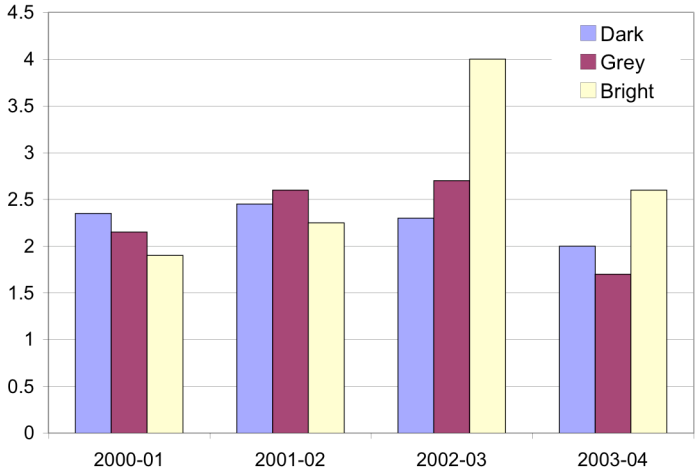

Figure 1: Over-subscription rate for the AAT.

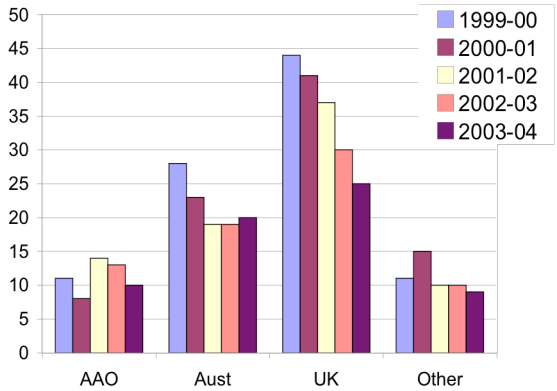

Fig.3: AAT programs by location of PI.

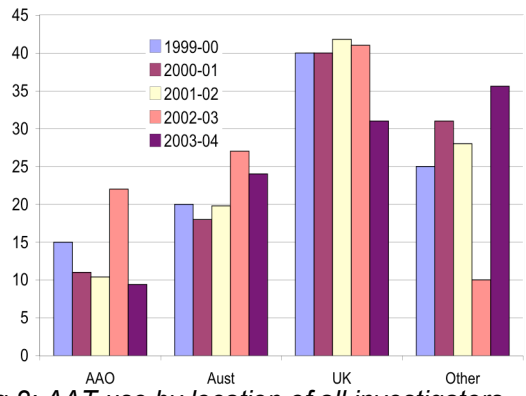

Fig.2: AAT use by location of all investigators.

From these observations, an average of about 140 papers are published each year (in total, Australian astronomers publish about 520 papers per year). A review in 2000 showed that of the eight 4-metre class telescopes in the world, the AAT had the highest publication rate.

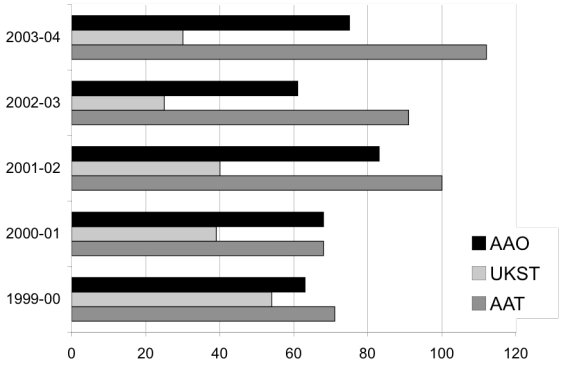

Fig.4: Publications from AAT and UKST data and by AAO staff.

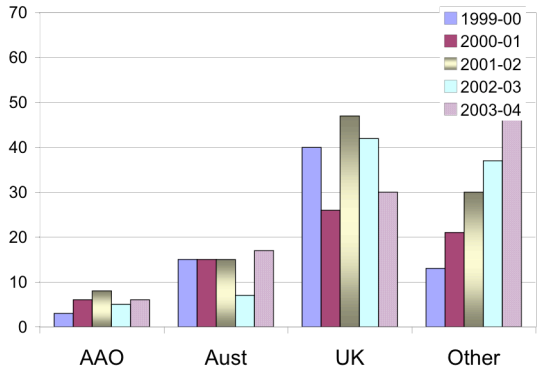

Fig.5: Publications from AAT data by location of first author.

Many of the papers based on AAT or UKST data are highly cited in the scientific literature. Of the 300 most-cited papers produced by the international astronomical community over the last three years (the top 0.5% of all papers), 17 made use of the AAO's telescopes.

2.2 Science Programs

High-impact projects recently carried out using AAO telescopes include:

- *The 2dF Galaxy Redshift Survey*, a map of 220,000 galaxies, which measured the amounts of dark matter, baryons and neutrinos in the universe and is one of the fundamental contributions to the standard model for the age, structure and constituents of the universe. The follow-up 2SLAQ survey will use 2dF and AAOmega to look at galaxies and QSOs at high redshift detected by SDSS to probe the evolution of large-scale structure.
- *The RAVE Project*, which over the next 5 years aims to measure the orbits for a million stars in the Milky Way to find out how, and when, our galaxy was formed.
- *The Anglo-Australian Planet Search*, which has discovered 20 planets around other stars and revealed the existence of worlds unlike any in the Solar System. As the AAPS time baseline increases over the next several years, the range of detectable planet types and the sample of stars searched will both be extended.

Other high-impact research from the past few years that used the AAO telescopes includes:

- The discovery of a new type of galaxy, the first in more than 70 years.
- The use of 'stellar seismology' to probe the interiors of stars.
- The discovery of some of the most distant objects in the universe.
- The identification of massive 'gamma-ray bursts' with exploding stars.
- The discovery of a satellite galaxy being torn apart by the Milky Way.

2.3 Innovative Technology and Instrumentation

The AAO has also excelled in innovative technology for astronomical instrumentation, winning Australian Engineering Excellence awards in 1993 and 2002 for instruments built for the AAT.

The AAO pioneered robotic optic-fibre spectrographs and is the acknowledged world leader in this field, building instruments for the AAT and UKST, the European Very Large Telescope, the Japanese National Large Telescope and a number of other telescopes around the world. The AAO also has active and internationally-recognized R&D programs in several other areas of astronomical instrumentation, including infrared spectrographs, tunable filters, innovative optic-fibres, micro-robotics and advanced technologies for extremely large telescopes.

External instrument contracts have brought in $7.1M to the AAO over the past 4 years. At present the AAO is leading a consortium studying the feasibility of the ambitious Wide-Field Multi-Object Spectrograph for Gemini, with an estimated total cost of $60M.

2.4 Communication and Public Outreach

The AAO is committed to communicating its research and other activities to both professional and public audiences. AAO staff publish about 110 scientific papers and give 70 conference talks per year. They also give around 60 popular talks and 200 media interviews each year on a range of astronomical topics. One staff member, Fred Watson, appears regularly on radio, writes a column for Australian Geographic, and this year published a popular book on the history of the telescope. In 2003 he was awarded the Astronomical Society of Australia's David Allen Prize for communicating astronomy.

3. CURRENT AND FUTURE FUNDING FOR THE AAO

Under the current AAT Agreement, the Australian and British governments each pay approximately equal amounts towards running the AAO, and Australian and British astronomers each have access to half the observing time on the telescopes. This year the recurrent contributions from the two governments amount to 82% of the total annual AAO budget of approximately $10M, with the remaining 18% coming from instrumentation contracts, research grants and other external income sources. About 36% of the total budget supports the direct operating costs of the telescopes, 42% goes towards the instrumentation and technology R&D programs (including the construction of the AAOmega spectrograph), and the remaining 22% covers IT, infrastructure and administration.

The current AAT Agreement is about to be changed by a new Supplementary Agreement that has been negotiated between the Australian and British governments and is currently undergoing the process of ratification. This Supplementary Agreement results from the desire of the British government to gradually reduce its funding to the AAO over the period up to 2010.

This desire is motivated by changing priorities, in large part flowing from the costs associated with Britain's recent decision to join the European Southern Observatory. The British government had the option of ending the AAT Agreement in 2006, but

chose instead to renegotiate the agreement to allow a progressive ramping down of British involvement, providing Australia with time to deal with the resulting changes.

The key features of the Supplementary Agreement are as follows:

- Funding from the British government will be reduced by 50% in FY 2006-7, and the remainder reduced again by 50% in FY 2007-8. The British contribution will then remain steady, at about $1M per year, until 2010.
- The relative contributions of Australia and Britain to the AAO's funding will determine the relative fractions of telescope time available to Australian and British astronomers – i.e. Australian astronomers will gain pro rata as the British funding contribution falls. Based on the minimum expected contributions, Fig.6 shows the likely shares of time out to 2010.

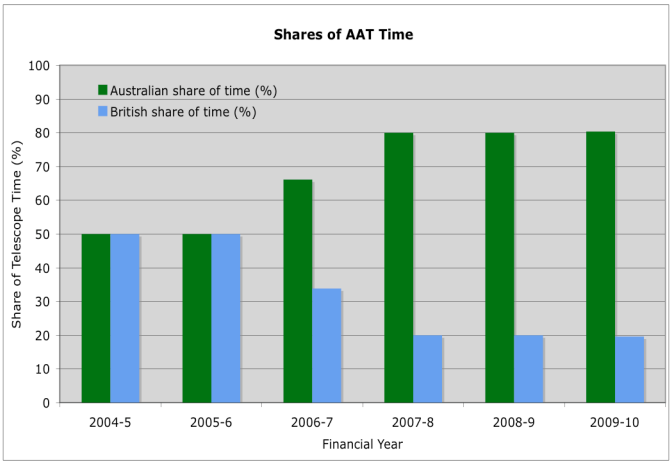

Fig.6: Australian and British shares of AAT time.

- While the possibility of extending the agreement beyond 2010 is left open, the expectation is that Britain will withdraw from the agreement, and cease all funding, after 30 June 2010.
- Once Britain withdraws, the Australian government will assume full ownership of the AAO.

4. THE NEED FOR THE AAO IN THE NEXT DECADE

4.1 Need for the AAT

The optical/infrared community in Australia currently has as-of-right access to 6.2% of the Gemini 8-metre telescopes, 50% of the AAT 4-metre telescope and to a range of smaller telescopes. Gemini access currently amounts to 36 nights per year, whereas AAT access amounts to 165 nights per year. As Britain withdraws funding over the next few years, access to the AAT will increase to 265 nights per year, supporting either an increased number of observing programs or (more likely) more ambitious observing programs. Although the number of papers based on Australian Gemini time will likely rise from its current low level, it is not likely to match the number of papers based on AAT data.

As well as being the workhorse optical/infrared telescope for research by Australian astronomers, the AAT will continue to be an excellent facility for training students. Gemini is limited in this respect, first by the need for Australia to use it entirely in queue-scheduled mode in order to efficiently use the small number of nights available, and second because of its remote locations.

The AAO has made a significant investment in new instrumentation that will pay off over the coming decade. At present the AAO is constructing the $3.7M AAOmega spectrograph as the successor to the highly productive 2dF facility. AAOmega will be the most powerful instrument in the world for survey spectroscopy when it begins observations in early 2006, and for several years thereafter. Complex and expensive instruments like AAOmega have productive lifetimes of at least 10 years – 2dF was commissioned in 1995 and is still the most-used instrument on the AAT today. It is expected that AAOmega will be used for several major observing programs involving large numbers of astronomers and resulting in high-impact science.

4.2 Need for the AAO's Instrumentation Program

The AAO's instrumentation program is valuable because:

- It provides innovative instrumentation for the AAT, keeping it ahead of the technology cycle and capable of doing high-impact research programs. 2dF, 6dF and IRIS2 are examples of instruments that have been very successful because they have delivered performance advantages well ahead of the competition. AAOmega will continue this tradition.
- It provides Australia with leverage in determining the science agenda on Gemini, as witnessed by the success of the WFMOS concept in being supported through the Aspen process. This means Australia is not just a passive user of the Gemini telescopes, but can to some extent shape the capabilities of the observatory in ways that are well-suited to the research interests of Australian astronomers.
- It makes connections to other observatories around the world, providing some access to powerful facilities (OzPoz on the VLT, FMOS on Subaru) and earning valuable income for the AAO that allows it to undertake other instrumentation programs of direct benefit to Australian astronomers (6dF emerged as the OzPoz prototype; WFMOS benefits from the AAO's experience with FMOS).
- It is a valuable research program in its own right, with a long history of seminal contributions to astronomical technology and instrumentation.

4.3 Need for an Independent Optical/Infrared National Observatory

The AAO is valuable as an institution, since:

- It provides truly independent services and facilities for all Australian astronomers; independent it that it is not a university and so is not competing with other universities in any way (and in particular for ARC funding).
- It is focussed on delivering facilities for optical/infrared astronomy, a field in which Australia is historically strong, which involves a large fraction of the research community, and which has a very exciting future. In this respect the AAO's complements the ATNF, which has a similar tight focus on radio astronomy.
- The AAO has a unique funding stream through DEST that is independent of the universities, of the ARC, and of the CSIRO. Diversity of funding sources has proved important to Australian astronomy in weathering budgetary vagaries in the past, and is likely to remain important for the foreseeable future.
- The AAO provides a natural home for all optical/infrared national facilities. At present this means just the AAT and UKST, but in future it might include the Gemini National Project Office and the national support facilities for Australian access to an ELT or an Antarctic telescope.

5. STRATEGIC RECOMMENDATIONS

Based on the above arguments, the following draft recommendations relating to the AAO are proposed for incorporation in the Decadal Plan:

1. ***The AAO should be the national organization that supports all of Australia's major optical/infrared astronomy facilities.***

   The AAO (as the Anglo-Australian Observatory up to 2010 and as the "Australian Astronomical Observatory" thereafter) should not only operate the AAT and UKST but also be the support organization for Gemini and other major new optical/infrared facilities in which Australia has a share (e.g. an ELT or an Antarctic telescope).

2. ***The AAT is required as a major facility for Australian astronomers throughout the decade 2006-2015.***

   This means Australia needs not only to maintain the AAT under the Supplementary Agreement for the first five years (2006-2010), but also take sole responsibility for the telescope after the end of the Agreement (2010-2015).

3. ***A major new optical/infrared facility [TBD] is required by the end of the decade. At the appropriate time, the AAO would transfer its resources from supporting AAT operation to supporting operation of this new facility.***

   Australia should be aiming to obtain access to an ELT, Antarctic 8m, or equivalent major new optical/infrared facility by around 2015. The AAO should re-direct the operations cost of the AAT to operating/supporting this new facility. This may mean operating the AAT in full-cost-recovery mode, converting it to other purposes, or closing it down. A plan for a graceful transition is required.

4. ***The AAO instrumentation program is a world leader and should be supported at least at its current level.***

   Australia needs the AAO's instrumentation program and should be prepared to invest in it. The AAO should remain a source of innovative technology that gives Australian astronomers access to the best instruments on the best telescopes.