International Facilities

A report to the National Committee for Astronomy for the Australian Astronomy Decadal Plan 2006-2015
By Working Group 3.1

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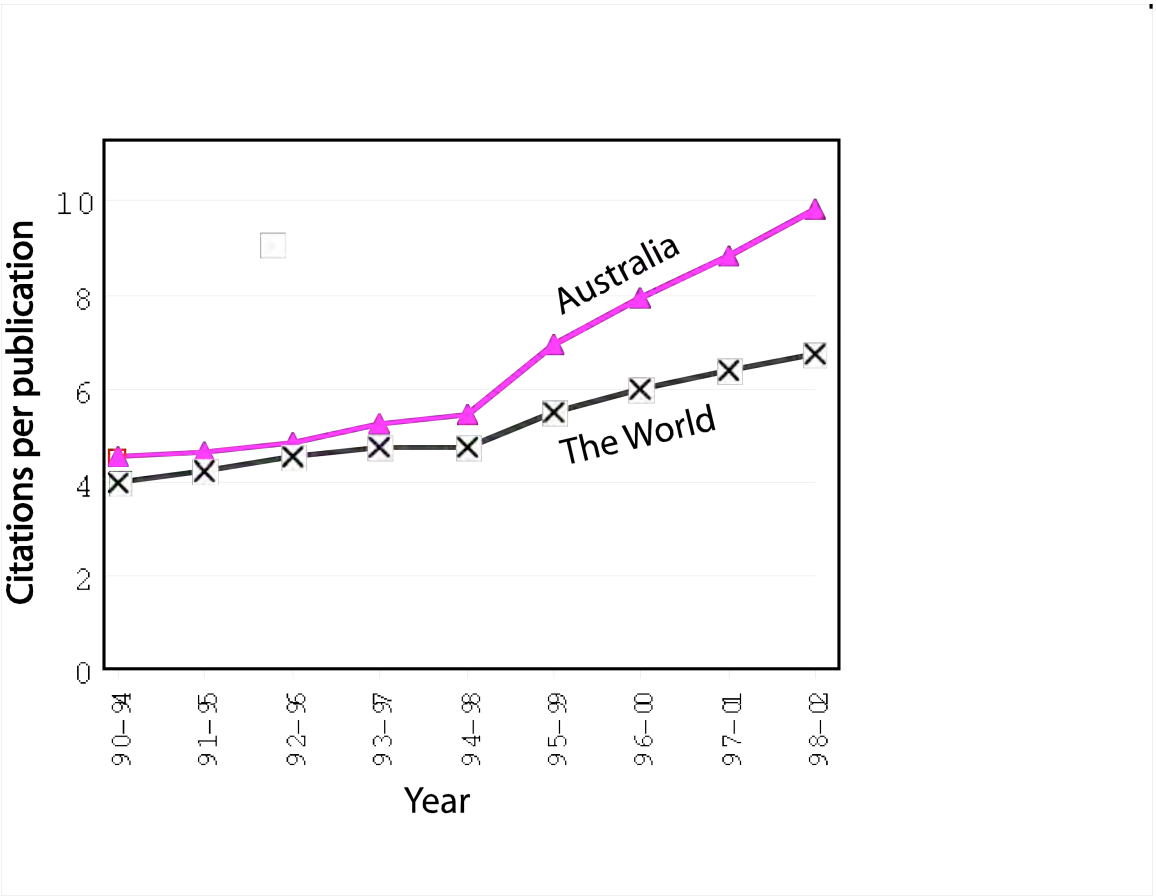
Executive Summary

Over the past decade Astronomy has been among Australia's most successful sciences internationally (Figure 1, adapted from *the ANU Capabilities & Performance Statement 2004*). This is largely due to significant investment in infrastructure in the 1950 – 1980s, including the Molonglo Synthesis Telescope (Mills' Cross), Parkes Telescope, Mount Stromlo and Siding Spring Observatories, the Anglo-Australian Telescope, and the Australia Telescope, which has attracted many world-class scientists to undertake their work in Australia.



Australian Astronomy impact is based primarily around facilities in the optical (taken here to mean 100 nm to 100 microns) and radio (taken here to mean 10 MHz to 1

Terahertz), but has significant impact in areas such as theory, airshower astronomy, and gravity wave astronomy (See full description in Appendix 1).

The next decade is critical for Australian Astronomy. Over the past decade, the world has invested heavily in new facilities, and Australia has not. Figure 2 shows the fraction of the collecting area of the world's optical telescopes that is Australian owned, from 1960 to the present. Investment in the Anglo-AustralianTelescope and Mount Stromlo and Siding Spring Observatories' telescopes in 1950 – 1980s gave Australia more than a 5% of the share of the world's telescopes, but this share has now fallen to below 1.8% – well below Australia's GDP fraction of the world. Australia's investment in 6.2% of Gemini (12.4% of a single 8m telescope) was well behind the investment undertaken by the rest of the world taken on a GDP basis. During this decade, the US invested in Keck I & II, Gemini, the MMT, and the Magellan Telescopes – an equivalent of six1 8 meter telescopes (49 times Australia's investment, while the GDP ratio is only 19:1). Eleven European countries invested through ESO in four 8m telescopes (32 times Australia's investment, GDP ratio 16:1), Canada invested in 15% of Gemini (2.4 times Australia's investment, GDP ratio 1.6:1), and Japan invested in its own 8m, Subaru, (8 times Australia's investment, GDP ratio 6:1).

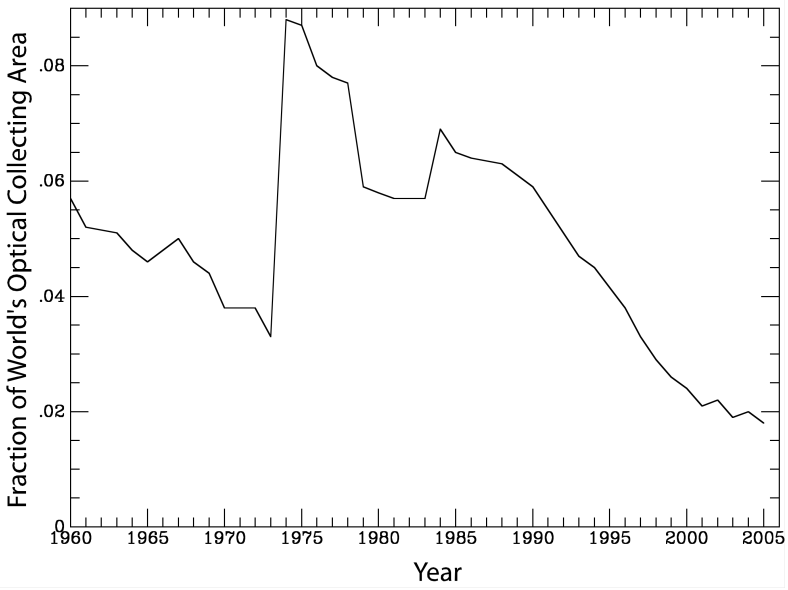


Figure 2: Australia's Fraction of World's Optical Collecting Area

At radio wavelengths, while Australia currently has a competitive share of large facilities, this strong position will erode away in the coming decade unless significant investment is made in new forefront facilities. The competing overseas facilities include US-Canada-Europe-Japan's investment in ALMA, the Netherland's investment in LOFAR, the US's recent investment in the GBT, India's recent investment in GMRT, and the Canada-US investment in e-VLA.

Australia has the opportunity to host the billion-dollar SKA telescope, backed by our scientific abilities in all relevant subject areas, our technical expertise, and a great site in Mileura, Western Australia. To maximize our benefits from SKA, we recommend spending on R&D in SKA at an accelerated rate. This will help Australia to drive the SKA project, and help ensure that it comes to our shores. Investment in optical astronomy will need to made in facilities located off-shore, but much of the money will actually be spent within Australia. Much of Australian Astronomy's scientific impact is currently derived from optical facilities, and the legacy of this work will be the scientific programs which, in 10 years time, will use Extremely Large Telescopes and the SKA together to answer the Big Questions. Funding only the optical or the radio stream of facilities during the next decade invites collapse of our current wide-ranging research capabilities that have taken Australian Astronomy to the position of excellence it now has.

In order for Australia to keep its leading science, astronomy, at the international forefront, this DPWG3.1 recommends a broad spectrum investment over the next 10 years that is focused on our strengths in optical and radio, but that also includes investments in theory and airshower astronomy, which provide a very cost-effective scientific return. In addition, we are supportive of funding of international gravity wave facilities – research undertaken principally within physics departments – despite this research area not currently falling within the mainstream astronomy domain.

Radio

- Australia must be positioned to have access to a SKA telescope at the end of the coming decade at a 10% level. To ensure that SKA is built, and to maximize its chances of its construction on an Australian site, Australia must be proactive in developing the technology and science cases that go along with the SKA.

- As a prelude to the SKA, the new facility which has the largest potential for scientific discovery is the SKA Pathfinder, planned to be approximately 10% of the collecting area of the complete SKA. The pathfinder will be a front-line science instrument that can carry out all-sky surveys to a sensitivity limit that is orders of magnitude better than currently achievable. It is anticipated that the SKA-Pathfinder will be an internationally funded instrument, but will require significant Australian investment. Achieving 10 – 30% share of the SKA pathfinder is critical to Australian Astronomy in this decade.

- As a first step towards SKA, Australia needs to be ready to use technology developed in the NTD to develop the xNTD, and the Mileura site in Western Australia. This xNTD would be used to develop dish and feed technologies for producing a very wide field instrument.

- During this decade, ALMA will become a major new facility at mm wavelengths, and the nature of Australian access to the facility is currently unclear. It is very desirable to have access to ALMA, either by an open access agreement, or by trading time with existing Australian facilities such as the Australia Telescope.

Optical

- By 2015 the Australian community must be positioned to have access to an ELT (functionality of a 20m or larger telescope). Possible facilities include the Giant Magellan Telescope, Thirty-Metre Telescope (TMT), OverWhelmingly Large Telescope (OWL), or Antarctic-GMT (AGMT). A 20% share in an ELT like the Giant Magellan Telescope is considered the appropriate level of access, with a 10% share as the bare minimum useful level of participation.

- There is a general acknowledgement that the Australian community has not achieved the progress that it desired (as set out in the last Decadal Plan) in terms of access to 8m-class telescopes. The strong consensus is that our overall goal is to reach the equivalent of ~20 – 25% access to an 8m telescope facility as soon as possible during the coming decade. This should be achieved by maintaining at least our current 6.19% share in the twin Gemini telescopes (12.38% of an 8m telescope), and either diversifying our access to include other 8m telescopes, preferably with a 'wide-field' capability or high-resolution capability, or increasing our share in Gemini.

- The current way that our membership of Gemini is funded (through the ARC LIEF scheme) is awkward and unsatisfactory. We strongly support the NCRIS approach of fully supporting a facility over its lifetime, which in the case of Gemini means proper funding for operations and instrumentation.

- The Working Group supports a new role for the AAO to manage Australia's international optical facilities.

Theory

- Australia should incorporate theoretical infrastructure into every stage of the life cycle of our international facilities: setting science goals, selecting and designing instruments, handling and interpreting scientific data.

Airshower Astronomy

- Australia should remain a member of the Pierre Auger Observatory and participate in the northern observatory. This membership needs to be made more formal than current arrangements.

- Consistent funding for the Cangaroo Project at its current level is required for effective use of the facility probing the highest energy gamma rays.

Gravity Wave Astronomy

- Australian Astronomy is supportive of Australian gaining a partnership in Advanced LIGO. Until gravity waves are detected, they remain in the realm of experimental physics, rather than astronomy. However, Advanced LIGO seems likely to detect astronomical sources via gravity waves for the first time, and therefore becoming partners in Advanced LIGO is timely and relevant.

- Upgrading AIGO to an intermediate baseline detector. A 1 – 2km advanced technology interferometer, which could contribute to the global array over a tunable frequency range by providing greatly improved directional information as well as improved sensitivity in a limited frequency band, would be especially valuable to astronomy.

- Ultimately, for maximum exploitation of the gravity wave spectrum, the global gravity wave network will require a full size (4 – 5km) detector in Australia. A 1 – 2 km interferometer in this decade will provide essential infrastructure towards the full scale detector.

- Upgrading AIGO to an intermediate baseline detector. A 1km advanced technology interferometer which could contribute to the global array over a narrow frequency range and provide a directional information would be especially valuable, once sources are detected.

Spending profile for initiatives.

	Funding in Millions of Dollars per annum											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	total
SKA proactive	7	7	7	7	8	8	8	8	8	8	8	84
ELT (GMT)	3.5	3.5	3.5	3.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	109
Gemini+Inst	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	42.5
Extra 8m-time	1	1	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	23
Auger	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.2
Cangaroo	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.2
A-LIGO		1.4	1.4	1.4	1.4	1.4						7
AIGO				3	5	5	5	5	7	10	2	42
Total	15.8	17.2	18.5	21.5	34.5	34.5	33.1	33.1	35.1	38.1	30.1	311
SKA-even	2	2	3	4	4	4	5	7	8	10	13	62
ELT-10%	1.75	1.75	1.75	1.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	54.3

These figures in 2005 Australian Dollars. $1AUD=0.75USD=0.6EUROS