Report from Working Group 2.2 National and Institutional-Scale Facilities

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Version 1.3	Updated by Executive and released on 7 July 2014 to Working Group 2.2 and Chairs of other Working Groups.
Version 1.4	Updated by Executive and released to community on 11 July 2014.

1 Executive Summary

The National and Institutional-scale astronomy facilities make up a broad portfolio. The facilities offer capabilities from optical to radio wavelengths and are a mix of long-standing telescopes, such as Parkes and the AAT, to brand new projects such as MWA, ASKAP and SkyMapper.

Within the Australian astronomy community there is:

- Crucial importance of ongoing funding for AAO operations beyond mid-2019; for ASKAP and Australia's participation in the SKA; and the Siding Spring and Murchison Radio Observatory sites.
- Strong support for funding on-going MWA operations and upgrades; securing both continuing high-impact scientific roles and new funding injections for Parkes and ATCA; and astronomical capabilities in Antarctica and Gravitational Wave observatories.
- Recommendation to review at mid-term point existing facilities once current science missions have been completed and in light of ELT and AAO/ANU developments, including the ANU facilities at SSO.
- Positive acknowledgement of Mopra, Molonglo and the University of Tasmania facilities.
- Discussion on evolving observing and funding models for observatories and the benefits that a Centre of Excellence brings to the community.

2 Summary of submissions

In response to an open call, a total of 13 submissions were received and are available at:

https://sites.google.com/site/australiandecadalplanwg22/submissions-received

For the purpose of this report the submissions have been categorised as follows:

1. Facility Directions – submissions that have been received by the Director (or equivalent) of a Facility.
2. Interest Groups – submissions that have been received by community members that describe their work with facilities.
3. For other working groups – submissions that are better placed for review in other working groups.

Table 1 summarises the submissions received according to these three categories.

Table 1: List of submissions received

Facility Directions	National	AAO
		ATNF
		ANU/SSO
		MWA
		TAO
	University-scale	Molonglo
		University of Tasmania
Interest Groups		Antarctica
		Gravity Waves
		Astrophotonics
		Centres of Excellence
For other working groups		gStar (for WG 2.3 eScience)
		UWS (for WG 3.2 Education, Training and Careers)

3 Priorities and Recommendations

3.1 Facility Directions - National Facility Directions

The role of national facilities is threefold:

(1) To allow the Australian community to produce high impact scientific outcomes in their own right;

(2) To support instrumentation and technical developments that benefit the community both scientifically as well as to leverage access to facilities that Australia otherwise does not have access to; and

(3) To serve as a platform for building national research capacity and developing strategic directions toward Australian partnership in the largest high impact facilities internationally.

Within this context Australian partnership in the SKA and the GMT, as flagship international facilities, are supported by National Facility activities through ATNF/CASS, AAO and ANU.

3.1.1 Optical and infrared facilities

In the area of large and high impact optical and infrared telescope facilities for the coming decade, Australia is a partner in the international GMT project, as well as aspiring to maintain access to 8m class telescope facilities internationally. These activities and aspirations are supported to a substantial degree through the National Facilities owned and operated by ANU and AAO, and through the instrumentation groups at those institutes. AAO and ANU both operate high impact national telescope facilities and support world-leading instrumentation groups. The ANU owns and operates the Siding Spring Observatory (SSO) site, which is crucial to the ongoing success of national optical and infrared facilities.

With major ongoing survey programs at the AAT and with SkyMapper, these facilities will continue to be scientifically productive and world-leading for the coming decade. New instrumentation planned for the AAT, and a refurbished and upgraded UKST, will ensure the scientific impact of these facilities over this period.

During this time the AAO will support the increasing importance of 8m and ELT-class telescopes for the Australian community, through expanding and diversifying the AAO's International Telescope Support Office capabilities. This will be further supported through the strong instrumentation programs at both AAO and ANU. The AAO is also developing a new e-research capability designed to fully support the curation and global distribution of major survey data for projects of national significance.

The AAO's operational funding is currently secure through to FY2018/19, but funding beyond 30 June 2019 is not assured, and will need a New Policy Proposal requiring cabinet approval. To maintain ongoing international leadership by the Australian astronomy community in the areas of optical and infrared astronomy, and to ensure that the Australian community can capitalise on the substantial national and international investments in optical astronomy infrastructure, *it is of the highest priority to ensure that AAO continues to receive ongoing operational funding*.

Recommendation: That the Decadal Plan highlight the crucial importance of ongoing funding for AAO operations beyond mid-2019.

Over the next five years the UK Schmidt and Skymapper will be carrying out major surveys supporting a wide range of Australian-led programs with secured operational funding. The UK Schmidt has a long and proud record of such service in the past; this will hopefully continue. Operational funding for the 2.3-m telescope beyond the next few years is uncertain.

Recommendation: That the future of SkyMapper, UKST, and the 2.3-m telescopes be assessed for on-going operations, in the context of ANU/AAO/SSO developments and ELT developments, at the mid-term point of the decade, following completion of their current primary science goals.

3.1.2 Radio Facilities

The Australia Telescope National Facility (ATNF) is currently undergoing a significant expansion to incorporate the Australian SKA Pathfinder (ASKAP) into its suite of existing radio facilities, Parkes, Australia Telescope Compact Array (ATCA) and the Mopra Telescope. It is anticipated that ATNF will evolve to a facility supporting Australia's participation in the SKA and continue in its role as operator and provider of the largest scale world-class radio astronomy facilities in Australia.

In the coming decade, a substantial fraction of the funding that supports the current ATNF telescopes will necessarily be redirected to SKA operations; this could impact on the current facilities even before SKA Phase 1 begins science operations. ATNF must act now to maximize science impact with Parkes and ATCA in a constrained funding environment and find new scientific roles for Parkes and ATCA that complement emerging capabilities on the International scene (MeerKAT, SKA Phase 1, and ALMA). To be sustainable in the SKA era, Parkes and ATCA will likely require new international or national funding injections for operating costs and instrumentation upgrades.

The Mopra radio telescope is currently operated by the ATNF with its funding received through external contracts with the Australian and international communities. Future operational arrangements are under discussion, and ownership may be transferred to an independent consortium. Mopra is a productive and cost-effective telescope that is operated completely remotely. There is broad support in the Australian astronomy community for the work that it is doing and a strong desire for this to continue.

Recommendation: That the Decadal Plan highlight the crucial importance of ongoing funding for ASKAP and Australia's participation in the SKA.

Recommendation: That the Decadal Plan show strong support for securing both continuing high-impact scientific roles and new funding injections for Parkes and ATCA.

Recommendation: The Decadal Plan positively acknowledge Mopra as an important and productive facility that should continue to be operated, either within the ATNF or under alternative arrangements.

The Murchison Widefield Array (MWA) project commenced its operational phase in July 2013 and should be recognised as a significant success emerging from the 2005-2014 Decadal Plan. It now serves a large and growing research community and is fulfilling a critical role in the development of SKA-low, the large portion of the SKA to be built in Western Australia in SKA Phase 1 and Phase 2.

The MWA is currently seeking funding to continue its operational phase beyond the end of 2015 and formulating options for the upgrade/extension of the instrument.

Recommendation: That the Decadal Plan highlight strong support for funding on-going MWA operations. Appropriate instrument upgrades/extensions for the MWA are also a high priority for funding.

3.1.3 Virtual Observatory Infrastructure

The All-Sky Virtual Observatory (ASVO) provides a modular and scalable infrastructure for storing, curating, and serving datasets of national significance that enhance the scientific resources of the broader community. The long-term goal is to establish a National Data Federation, allowing interoperability across all datasets of national significance, seamless access to distributed datasets, and consequently to enable a new class of scientific investigation of a scale and mode not otherwise possible.

Existing archives such as the Australia Telescope Online Archive (ATOA), the Australian Antarctic Data Centre (AADC), along with numerous other datasets (including legacy datasets such as 2dFGRS, 6dFGS, and many others) will need extra functionality to ensure they are interoperable with ASVO.

The ASVO already has two nodes deployed, the SkyMapper node at ANU and the Theoretical Astrophysical Observatory (TAO) node at Swinburne. Two new nodes are planned, to serve datasets from the MWA and AAT. These new nodes will be developed over the 2015-2016 timeframe. The ASVO facility provides a natural and scalable infrastructure that can serve to underpin all the major national facilities Australia operates, and to add value to the international facilities in which we are partners or to which we have access.

If Australia chooses to position itself as the "Custodian of the Southern Skies", the addition of publicly available survey datasets, and others that Australia has access to through collaborative agreement, could also find a natural home within ASVO. This would add value to the Australian-led archive resources, and provide leverage to support Australian participation in further international facilities and projects.

Recommendation: That the Decadal Plan identify the ASVO as a key infrastructure development to be supported and developed over the course of the decade. ASVO can and should serve, through nodes hosted at appropriate National Facilities and Institutions, as the repository for datasets of national significance, allowing the Australian community to maximise the scientific exploitation of existing and anticipated major astrophysical datasets.

3.1.4 Murchison Radio-astronomy Observatory and Siding Spring Observatory

CSIRO's Murchison Radio-astronomy Observatory (MRO) is the site of the Australian Square Kilometre Array Pathfinder (ASKAP), the Murchison Widefield Array (MWA), and the future core site of the Australian component of the international Square Kilometre Array (SKA) telescope project. The MRO is

situated inside the Australian Mid West Radio Quiet Zone (RQZ), an area 260km in radius that is protected by Federal Government legislation and regulations over a frequency range from 70 MHz to 25 GHz to control activities that can cause radio-frequency interference to the telescopes.

The MRO is an excellent radio quiet environment and it is important for the coming decade to continue with the stringent radio-quiet protection requirements.

SSO is a well-equipped site with the infrastructure to support small to medium size telescopes, including the AAT, various university-owned facilities, and international projects. It provides a unique facility in Australia for hosting optical telescopes requiring access to the southern hemisphere or Australia's longitude (e.g. global telescope networks), and benefits from infrastructure managed by the ANU and paid for by the facilities using the site.

It will be important for the coming decade to ensure the protection of the Siding Spring site, considering in particular challenges posed by encroachment of lighting and dust associated with mining activities in the broader area, with mines up to several hundred kilometres away having the potential to have a substantial negative impact on observing conditions at SSO.

Recommendation: That the Decadal Plan note the crucial importance of the Siding Spring and Murchison Radio Observatory sites to the ongoing success of our National Facilities, and recommend continued support and monitoring of the observing conditions.

3.2 Facility Directions – University Scale

University facilities consist of instruments run by Australian universities and whose primary purpose is to enable university staff and students to do unique science and provide hands-on training opportunities, in contrast to the more general-purpose role of National Facilities. Working Group 2.2 supports the ongoing operations of these facilities and, where appropriate, upgrade plans put forward. In all cases, these are expenses that are within the range of ARC grants and the two submissions received, where the information was detailed, cites ARC schemes as the possible source of future funds.

The Molonglo Radio Observatory has recently commenced an upgrade of its signal processing backend hardware, through collaboration between The University of Sydney and Swinburne University of Technology. The upgraded system will be used for pulsar astronomy, a new search for Fast Radio Bursts, and eventually for imaging science. The proposal for the continued operation and upgrade of Molonglo is to source funding from the ARC via LIEF and DP schemes over a six-year period, to undertake these specific science activities.

University of Tasmania owns and operates radio telescopes in Tasmania, the Northern Territory, and South Australia, and an optical telescope in Tasmania.

The radio telescopes are used as part of VLBI arrays for astronomy and geodesy, as well as single dish science. The optical telescope will primarily participate in microlensing observations. Moderate upgrade paths for the radio telescopes are suggested in the next decade. No specific cost is attached to these upgrades but will be in the scope of ARC funding.

Recommendation: That Molonglo and the University of Tasmania facilities be positively acknowledged in the Decadal Plan, with the expectation that they will continue to play the role they currently play, complementary to the national facilities.

3.3 Emerging Opportunities

It is essential to continue to ensure that capability levels are maintained across a range of activities in order to position Australia to be able to take advantage of emerging opportunities that arise during the next decade. This requires investment opportunities to be maintained through national competitive research grant programs and national infrastructure programs schemes that are accessible to the whole Australian research community. The funding needs to be appropriately balanced between supporting core activities and enabling future opportunities.

3.3.1 Astronomy in Antarctica and Gravitational Wave Astronomy

There is strong support for continuing to pursue opportunities in the high profile activities of astronomy in Antarctica and gravitational wave astronomy. These are strongly linked to international activities in which Australia currently plays a leadership role, and where our contributions leverage access to and involvement in substantive international ventures. The continued investment in the Australian facilitator activities underpinning these international activities will position Australia to be able to capitalise on ground-breaking developments that may occur in these arenas in the next decade. In turn, this provides a commensurate opportunity for Australia to then play a leadership role in the resulting major international endeavours.

In Antarctica, these activities are in the development of observatories on the Antarctic plateau for optical/infrared and THz-radio astronomy, in particular with China and the USA. The Australian-developed autonomous PLATO modules underpin the operation of these observatories. The priority is to complete the current prototype instrumentation phase and then begin participation in the facility phase of the Antarctic astronomy strategic plan.

In Gravitational Wave astronomy there is activity in developments aimed towards building the first observatory capable of the direct detection of

gravitational waves, in particular through the instrumentation capable of supporting Advanced LIGO and in analysing its datasets.

Recommendation: The continued development of astronomical capabilities in Antarctica and in instrumentation supporting gravitational wave observatories remains a priority that should be strongly supported in the Decadal Plan. Funding through national competitive grant and infrastructure schemes provides a means of maintaining Australian involvement and influence in these arenas, and positions Australia to play a lead role if opportunities arise to move these endeavours to full-scale facilities in the coming decade.

3.4 Discussion and reflections

3.4.1 Evolving observing model

The past decade has seen a substantial change in the model for observational astronomy. It is no longer the case that individuals or small teams manually observing with general-purpose facilities drive the highest impact science. Rather, large teams that lead either legacy survey projects, or directed large-scale experiments, are needed to take the next big steps forward. This results in a model where observatory facilities become progressively larger in scale and less amenable to the "general user" mode, combined with an expectation from users for a higher degree of "end-to-end" product in terms of the "science-ready" data provided.

In this regime, there is less need for the community to train students as "observers", but a greater need to provide them with the skills to understand the provenance of data from a variety of facilities, together with the skills for data mining, statistical analysis of large datasets, and an appreciation of the links between theory, simulations and observations. This evolution over the recent decade has led the community to develop a variety of workshops, such as the Astroinformatics School, the AAO/AusGO Observational Techniques workshop, the ATNF Synthesis Imaging school, the ANITA theoretical astrophysics schools, and others. This trend will need to be strongly supported, to ensure that new generations of Australian astronomers can maximally exploit the new style of survey facilities that will become the mainstay of astronomy over the coming decade.

Recommendation: That the Decadal Plan identifies the importance of providing the community with ongoing training workshops and schools to accommodate the shift away from "hands-on" observing at the telescopes, toward analysis of a panchromatic data-rich resource.

3.4.2 Evolving funding models

Increasing funding pressures and increasing operating costs for our National Facilities mean that external funding arrangements will become more prevalent and may change the models used for assigning telescope observing time. At the same time, if national funding becomes available to support facilities then opening up time on that facility to the community would be warranted.

Recommendation: Facilities should pursue external funding arrangements to ensure ongoing operations. While Open Skies policies remain desirable it is recognised that new funding arrangements may require different access arrangements to be negotiated.

3.4.3 Case study – Centre of Excellence CAASTRO supports the development of an SKA Precursor

The ARC Centre of Excellence for All-sky Astrophysics (CAASTRO) has been a major factor in the scientific success of the first operational SKA Precursor and only SKA-low Precursor, the Murchison Widefield Array (MWA). The establishment of CAASTRO provided a skilled, young, and enthusiastic workforce that assisted with the science commissioning of the MWA, following completion of construction. These same CAASTRO postdoctoral researchers are now leading major MWA science programs, based on the knowledge they built due to their involvement in science commissioning. Further, these people are developing into the cohort that will be science leaders in the era of the SKA in Australia. Thus, CAASTRO funding and people have intimately complemented the infrastructure funding that established the MWA, to the benefit of the MWA project, Australia's SKA readiness, and individual researcher productivity. This is an excellent example of how a balanced investment in infrastructure and personnel can achieve world-class returns in multiple dimensions.

Recommendation: That the Decadal Plan acknowledges the benefits that a Centre of Excellence brings to the community.

4 Financial Summary

Some financial information was included in the submissions. However, the information is by no means complete and can be summarised as follows:

- The projected annual operating costs for the ATNF is $23m, $11m of that for ASKAP operations alone.
- The annual operating budget for the AAO is $11m, supplemented by income from instrumentation projects.
- Both the ATNF and AAO have reported shortfalls with future budgets.

- The operating budget for MWA is secured until end 2015. Upgrade/extension options have been identified for beyond 2015, with costs in the range of $1m - $3m or $5m - $10m, depending on option and exact scope of work. An operating budget beyond 2015 would need to be secured.
- Antarctic protoypes (such as AST3-IR and HEAT) require Australian capital contributions at the $1m level. Facility-level participation in KDUST and DATE5 will require Australian capital contributions over the next decade between $1.5m per year (10% participation level) and $4m per year (25% participation level).
- Proposed future partnerships and collaborations between Australia and the International Gravitational Wave projects amount to $2.25m pa over the next decade. It is possible that an opportunity for Australia to host an internationally funded next-generation GW detector might appear during the latter part of the 2016-2025 Decadal Plan. It would be expected that Australia would have to contribute 10-20% (ca. $50-100m) of the cost of such a detector.
- The annual operating costs for Molonglo are about $0.4m pa. Some upgrade work, at a cost of at least $3m spread over 3 years, is required to keep the telescope's competitive status.

It is expected that the Editorial Board will work with the facilities over the coming months to collect the final figures to be published in the Decadal Plan.

5 Appendix A - Summary of key documents

Submissions Received	
AAO	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/AAO-WG2.2-submission.pdf
ATNF	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/ATNF%20submission%20v1.6.pdf
ANU/SSO	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/SSO%20%26%20ANU%20Facilities%20for%20WG2.2%20v3.pdf
MWA	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/NCA-MWA-submission.pdf
TAO	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/SSO%20%26%20ANU%20Facilities%20for%20WG2.2%20v3.pdf
Molonglo	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/WG2.2_Molonglo_Observatory-RWH-AJG.pdf
University of Tasmania	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/University%20of%20Tasmania%20Facilities.docx
Antarctica	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/antarctica_decadalplan_2016.pdf
Gravity Waves	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/Gravity%20Wave%20Decadal%20WG%202.2%20submission.pdf
Astrophotonics	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/Astrophotonics_white_paper_DecadalPlan_final.pdf
Centres of Excellence	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/wg2.2_3.4_centres.pdf
	http://www.astronomyaustralia.org.au/files/publications/astac/Supercomputer_Resources_v2-1.pdf
gStar (for WG 2.3 eScience)	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/gstar_facility_report_2014.pdf
UWS (for WG 3.2 Education, Training and Careers)	https://sites.google.com/site/australiandecadalplanwg22/submissions-received/DECADAL.PLAN.2014.University%20of%20Western%20Sydney%20Penrith%20Observatory.docx
Working Group Meeting Summaries	
21 February 2014	https://sites.google.com/site/australiandecadalplanwg22/documents/wg-meetings/Summary%2021%20Feb%202014.docx
10 March 2014	https://sites.google.com/site/australiandecadalplanwg22/documents/w

	g-meetings/WG2.2%20Summary%2010%20March.pdf
17 March 2014	https://sites.google.com/site/australiandecadalplanwg22/documents/wg-meetings/WG2.2%20Summary%2017%20March.docx
12 June 2014	https://sites.google.com/site/australiandecadalplanwg22/documents/wg-meetings/WG2.2%20Meeting%20Summary%2012%20June%202014.pdf
Call for submissions (12 March 2014)	https://sites.google.com/site/australiandecadalplanwg22/call-for-submissions
WG2.2 Action Plan	https://sites.google.com/site/australiandecadalplanwg22/action-plan
List of HPC Facilities and HPC access (AAL website)	http://www.astronomyaustralia.org.au/files/publications/astac/Supercomputer_Resources_v2-1.pdf