Submission
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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Context for this submission

The *ARC Centre of Excellence for All-sky Astrophysics* (CAASTRO) brings together almost 200 researchers from seven Australian Universities (The University of Sydney, The Australian National University, Curtin University, The University of Melbourne, The University of Queensland, Swinburne University and The University of Western Australia) and our national and international partner organisations.

CAASTRO's researchers address fundamental unsolved questions about the Universe using the dramatic capabilities of next-generation telescopes and advanced instrumentation. Our Centre also has a strong focus on training and mentoring the next generation of scientists. We have developed new and effective initiatives to foster gender equity and advance the careers of female scientists, and our innovative education and outreach programs inform the wider community about our research findings as well as promoting Australian science more broadly.

This submission has been prepared by members of the CAASTRO Executive Committee, which includes the leaders of all seven of the Australian University-based CAASTRO Nodes. The submission draws on our research community's long-term vision for astronomy research infrastructure, as laid out in the most recent *Australian Astronomy Decadal Plan*[1], as well as the joint submission on the Issues Paper made by Astronomy Australia Ltd (AAL) and the National Committee for Astronomy (NCA).

This CAASTRO submission has a particular focus on the area of research training. Part of CAASTRO's mission is to link astronomy research infrastructure with research training and capacity building. Over the past five years CAASTRO has built world-class research capabilities in low-frequency radio astronomy, optical integral-field spectroscopy, and time-domain astronomy – all areas where NCRIS-funded research infrastructure has given Australian scientists a strong international advantage. CAASTRO provides 'hands-on' research training led by outstanding scientists using world-class facilities, and over 80 research students and early-career scientists are currently trained and supervised by CAASTRO Chief Investigators.

Response to the questions posed in the Issues Paper

Below, we provide our response to (i) *questions Q1—Q8* and (ii) *questions Q21-Q23 and Q30* of the Issues paper, which cover areas of particular relevance to CAASTRO.

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[1] *"Australia in the era of global astronomy: The decadal plan for Australian astronomy 2016-2025"*, Australian Academy of Science 2015, available for download from https://www.science.org.au/supporting-science/science-sector-analysis/reports-and-publications/decadal-plan-australian

The joint submission from Astronomy Australia Limited (AAL) and the National Committee for Astronomy (NCA) addresses *questions Q9-Q14* and *questions Q30-Q32* from the perspective of the wider Australian astronomy community, and we are broadly supportive of the views expressed in that submission.

Question 1: Are there other capability areas that should be considered?

Not from our perspective - the Issues Paper does a good job of capturing the issues relevant to national and international astronomy infrastructure.

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure.

The governance characteristics listed in the Issues Paper are appropriate, and the strategic focus on whole-of-life costs (i.e. both construction and operations) is very welcome.

The long (often > 50-year) lifetime of major astronomy facilities means that long-term stability of the governance arrangements is also important. We strongly believe that the governance arrangements for Australian astronomy infrastructure should include a *long-term* focus on providing world-class research capabilities, and be protected as far as possible from short-term changes in policy and funding arrangements.

In our view, any future governance arrangement for Australian astronomy infrastructure should satisfy the following principles:

- optimise the ability to secure the stable, long-term funding required to deliver and operate world-class infrastructure;
- optimise the ability to effectively manage investments in astronomy research infrastructure;
- include appropriate mechanisms for strategic direction setting, including responsiveness to priorities determined by the astronomy community;
- be able to make effective operational decisions, consistent with strategic directions, and to deliver world-class telescopes and instruments and best practice merit-based access, IP management, and research translation;
- have the capacity to meet Australia's international astronomy facility obligations (such as operations of the Square Kilometre Array);
- have the ability to negotiate and manage Australian membership of overseas-based facilities effectively;
- have a clearly differentiated role of delivery of national/international infrastructure that is distinct from, and not competitive with, the role of universities.
- be consistent with the strategies and objectives of the main institutional stakeholders; and
- be cost-effective for ongoing operations.

These principles are similar to those developed in early 2015 by a Working Group on Australian Astronomy Governance set up by the (then) Department of Industry.

Question 3: Should national research infrastructure investment assist with access to international facilities?

Yes. In astronomy, access to international facilities is vital. We are entering an era in which major astronomy research infrastructure is global in nature and is constructed and operated by international partnerships and consortia.

These global facilities are built in places where geographic and other considerations allow the best possible performance to be achieved. In radio astronomy, Australia has one of the world's best

radio-quiet sites and so the international Square Kilometre Array (to be built by a consortium of ten or more countries) will be co-sited in Western Australia. In contrast, high-mountain sites overseas provide the best observing conditions for the largest optical telescopes. Membership of international partnerships and consortia will often be necessary to gain long-term access to world-class facilities.

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

In our view, any judgement on priorities should be based around the excellence (and international competitiveness) of the facility concerned and not just its geographic location.

Question 5: Should research workforce skills be considered a research infrastructure issue?

Yes! A skilled and innovative research workforce is essential to extract maximum value from Australia's investment in national, international and global research infrastructure. When scientists from many countries have access to the same research infrastructure (as will happen with the Square Kilometre Array), countries with an innovative and highly skilled research workforce (including groups with well-connected research, engineering, software and data analysis skills) have a significant advantage.

Question 6: How can national research infrastructure assist in training and skills development?

Australia's sustained national investment in high-quality research infrastructure makes it possible to provide 'hands-on' training in astronomy, astronomical instrumentation and data analysis of a quality that very few other countries can match. A key component of this training and skills development is the strong, long-term partnership between Australian University groups and the organisations operating the national research facilities for radio and optical astronomy (CSIRO and the Australian Astronomical Observatory (AAO) respectively). Joint activities include co-supervision of students, training workshops, and joint University-CSIRO and University-AAO positions for early-career researchers. Small to medium University-run facilities can also play a valuable training role for postgraduate research students, as well as in education and public outreach.

One indication of this quality of this research training is the number of Australian-trained astronomers who have gone on to lead major research facilities overseas. For example, Dr Tony Beasley (PhD, University of Sydney) is currently Director of the US National Radio Astronomy Observatories (NRAO) and Prof. Steven Tingay (PhD, ANU) was recently appointed as Director of the Osservatorio di Radio Astronomia of the Italian Istituto di Nazionale Astrofisica (INAF).

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

As indicated in our response to Q6 above, this needs to be a joint responsibility of universities and other research institutions.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

We support the principle of open, merit-based access to national research infrastructure.

Advanced Physics, Chemistry, Mathematics and Materials

Question 21: Are the identified emerging directions and research infrastructure capabilities for Advanced Physics, Chemistry, Mathematics and Materials right? Are there any missing or additional needed?

The information on capabilities and emerging needs for astronomy and cosmology (section 7.2.1) sets out a reasonable overview of the current and likely future landscape for our discipline.

We note that the Murchison Widefield Array (MWA) radio telescope needs to be added to section 7.2.1 alongside the Australian SKA Pathfinder (ASKAP). MWA is a low-frequency SKA precursor telescope and has been operating successfully on the designated SKA site in Western Australia since 2013. CAASTRO researchers have been closely involved with the MWA, which is operated by Curtin University as a national research facility and is also part of an international university partnership. This partnership has allowed Australia to develop a new and very strong research capability in low-frequency radio astronomy, as well as a growing international leadership role in this area.

In section 7.3.3 ('Desirable new capabilities: Space Science'), we note that CAASTRO (through the University of Sydney) currently has a Memorandum of Understanding with the German Max-Planck Institut for a research collaboration based around the German-Russian 'eROSITA' X-ray satellite. This collaboration will provide Australian scientists with access to data from a space-based astronomy research facility that would otherwise be unavailable to us, and will facilitate joint Australian-German research programs using eROSITA data in conjunction with data from Australia's radio and optical telescopes. The amount of research funding needed to develop and sustain initiatives of this kind is modest, but can sometimes be surprisingly difficult to find. A long-term national funding program for international research collaboration (rather than the current set of short-term and often *ad hoc* funding schemes) would make it easier to set up collaborations of this kind in the future. This is an issue for many disciplines, not just astronomy and space science.

Question 22: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

The major priorities for Australia in this area are laid out in the *Australian Astronomy Decadal Plan* for 2016-25, and are appropriately captured in section 7.2 of the Issues paper.

Question 23: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Advanced Physics, Chemistry, Mathematics and Materials capability area?

No, the Roadmap document has good coverage of the issues relevant to research infrastructure for astronomy and astrophysics.

Underpinning Research Infrastructure

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

We are pleased that the Issues Paper recognises (in sections 10.1.1, 10.2.1 and 10.2.2) the increasing importance of high-performance computing and high-capacity networks in underpinning research. From CAASTRO's perspective, access to high-performance computing and fast data links has been absolutely essential for many of our research projects, and it is important that our national infrastructure in these areas is able to meet future requirements.

As a distributed research centre spread across five Australian states and territories, CAASTRO makes extensive use of videoconference facilities – this allows our own researchers to communicate regularly and effectively, but we also use these facilities for education through our 'CAASTRO in the

Classroom' program (see http://www.caastro.org/education-and-outreach/school-engagement/caastro-in-the-classroom). It would be good to explore ways of improving future connectivity between the broadband network connecting Australian universities and research institutions and future networks that connect schools across the country. Such links make it possible to 'level the playing field' between city schools and those in rural and regional areas by allowing our best scientists to speak directly to Australian children in classrooms across the country, regardless of their geographical location.

One piece of 'missing' infrastructure is a national centre for collaborative meetings and research workshops, similar to the Lorentz Center in the Netherlands (see http://www.lorentzcenter.nl/). A centre of this kind would provide an ideal venue for discussion and planning of current and future research projects.

Other comments

If you believe that there are issues not addressed in this Issues Paper or the associated questions, please provide your comments under this heading noting the overall 20 page limit of submissions.

We have no other comments.