

Research School of Astronomy and Astrophysics The Australian National University School Review 2016

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Review Group

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Executive Summary

The Research School of Astronomy and Astrophysics is very successful with a world ranked research programme. The faculty have been awarded an impressive array of accolades and awards and international impact is strong. Staff and students are loyal to the RSAA and proud to be part of it. The Director is popular and held in high regard. There is a strong sense of community and mutual support. The budget is moving towards break-even in 2017 and is structured by activity to aid strategic planning. Much progress has been made in recent years in streamlining the administration, making it more efficient and accountable. RSAA hosts and supports a series of exemplary and highly effective outreach programs.

The School is at a critical juncture, with one-third of the faculty likely to retire in the coming 5-10 years. Planning for national and international leadership in traditionally strong areas will require retaining a critical mass of activity, while making appointments to develop new capabilities that exploit forthcoming opportunities is also essential. Developing such a Strategic Plan will require commitment from the entire faculty. The plan should include measures to further increase diversity and equity.

The relative isolation of the site from the main campus gives rise to some problems. Many university services are remote. Efforts need to be made to ensure that staff and students at RSAA have equivalent access to central university services as those on the main campus. The availability of affordable, appropriately frequent, transport to and from Mount Stromlo could help to mitigate these problems.

There is an aspiration to significantly expand the graduate programme, which we endorse and commend. This will require greater engagement by faculty in both graduate education and welfare. We see the potential to make improvements in graduate education. The quality of taught graduate courses should be subject to the same scrutiny as larger courses on the main campus. Formal processes for graduate student progression and preparation for careers beyond academia could be improved.

Several possible directions have been identified for developing the core programme of the AITC. Developing partnerships with other organisations, both astronomical and otherwise, will be key to building successful proposals in response to announcements of opportunity. A key facet of the future success of the AITC will be close integration of instrumentation work with the astronomical aspirations of RSAA faculty. Proactive measures to foster the alignment of the instrumentation and astronomical aspects of RSAA are needed.

The reliance of the School on NIG for a large fraction of its core budget is a significant weakness/risk. We identify a number of measures that can increase income and to make savings. The strategic use of the NIG should be a major component in the Strategic Plan.

All organisations of the size of RSAA need to keep the requirement for efficient communication under constant review. Communication at all levels in RSAA could be improved. Regular faculty meetings will provide a forum for discussing new directions and strategic planning. Greater transparency and inclusiveness in decision making throughout RSAA will help to align all staff and students with the core mission of the School.

1. Introduction

The review of the Research School of Astronomy and Astrophysics (RSAA) took place on November 14-16 2017. The Terms of Reference for the review are attached as Appendix A. The review committee considered all aspects of RSAA's activities including the academic programme at both the undergraduate and graduate level, the School's research portfolio, the instrumentation programme in the Advanced Instrumentation and Technology Centre (AITC), the infrastructure on Mount Stromlo, the observing facilities at Siding Spring Observatory (SSO), and the public outreach programme and Visitors Centres (at both sites).

The review committee was provided with a thorough self-evaluation report of the school 3 weeks ahead of the meeting, which provided an excellent basis for the preparation of the visit. The review committee was given the wider ANU perspective through meetings with the DVC for Research, Margaret Harding, and College of Science General Manager, David Akers. The Chair was briefed ahead of the meeting by the Dean of the College of Science, Andrew Roberts. We met with the Director, the School Executive group, the AITC leadership, the Education Committee and the Access and Equity Committee. We had the opportunity for discussion with personnel from all sectors of the School's activity. We met collectively with the graduate student body and the professional technical and administrative staff and we met in small groups with the faculty and emeriti. Members of the School were given the opportunity to have confidential input into the review both through written submissions and face-to-face meetings. Scattered throughout the programme were talks from faculty, postdocs and graduate students on their research work through which we gained an up-to-date sense of the research underway in the School.

We encountered a very positive approach to the review amongst members of the School and our business was conducted in a relaxed atmosphere conducive to effective communication between members of the School and the Committee. The Agenda for our visit is attached as Appendix B. This report is structured in sections reflecting the specific items listed in the Terms of Reference (sections 2-7) and recommendations are recorded in each section. Overall cross-cutting conclusions and additional recommendations are listed in section 8. A complete list of recommendations is given in Appendix C.

The committee would like to thank Michelle Cicolini who managed the logistics of our visit with friendly efficiency, and Sarah Withers who supported the review effectively, providing written notes for each of our sessions, and answers to the many questions that arose in the course of our visit.

2. Research and Teaching Performance

Assess the School's performance in research and teaching programs compared to the top astronomical institutions in the world, and in view of future trends in astronomy and astrophysics and associated technologies and facilities

Research at RSAA is of the highest quality and international competitiveness throughout the school with a particular focus in the research areas of Cosmology, Galaxy Evolution, Black Holes and AGN, Galactic Astrophysics, Stellar Astrophysics and Exoplanets. Further, RSAA runs an internationally renowned optical/infrared instrumentation programme. Research highlights of the reporting period include accurately modelling the foreground emission from the Milky Way as a step towards using the Murchison Widefield Array to measure the Epoch of Re-ionisation, the most detailed map to date of the local Universe with the 6dF Galaxy Survey, the performance of large integral field surveys like SAMI, and the detailed chemical analysis of hundreds of thousands of stars (the GALAH survey). Members of the School at all levels have received prestigious fellowships and awards, most notably, of course, the Nobel Prize 2011 to Prof. Brian Schmidt for the discovery of the accelerated expansion of the Universe.

The review committee was provided with a thorough overview of the research activities by a series of 12 highlight talks and 10 further contributions by students and postdocs, all of exceptionally high quality. Compared to the size of the academic body at RSAA, we note that the portfolio of research topics under investigation at RSAA is broad. RSAA is clearly positioned as one of the top departments in Australia, a country where, on the international research landscape, astronomy has stood out as a particular research strength for many decades.

Recommendation 2.1: The RSAA should consider, in particular in the context of upcoming faculty hires, the potential advantage of a greater focus on a smaller number of areas of particular strength, to ensure achieving a critical mass of faculty appointments in recognized strengths of the School and/or particularly promising upcoming fields.

We discussed criteria for assessing the quality of the faculty research, with mention of metrics such as the ISI or Google scholar compilations of highly-cited researchers. The committee understands the need for such criteria, but cautions against over-reliance on such simple metrics and urges a more considered and wider approach. The criteria should also take into account contributions to national and international astronomical organizations and to teaching, mentoring and outreach activities.

2.1 Approach to RSAA Undergraduate Research Training

Compared with other Universities there has been traditionally very little involvement of RSAA faculty in the training of undergraduate students. The review panel sees unexplored opportunities for increased engagement, for example offering an undergraduate survey course for general majors. This would give additional access to the excellent undergraduate student body at ANU and also increase the exposure of the RSAA to the ANU as well as to the general public including, potentially, future policy makers.

Recommendation 2.2: RSAA should investigate setting up an undergraduate survey course for general majors.

2.2 Approach to RSAA Graduate Research Training

RSAA has had a long and proud tradition of astronomy research training in Australia. The graduate student body is generally happy and has a strong sense of community and loyalty to both the School and their research group. This coherence of the graduate community also

reflects the relative isolation of this group of graduate students from their colleagues on the main campus and from the academic and welfare provisions available there. RSAA is also to be much commended on the gender distribution of the student body.

There are at least eight universities in Australia offering comparable research training in astronomy and astrophysics, covering a wide range of topics. The future career aspirations of current and future graduate students are likely to be broad, with a minority becoming professional astronomers in Australia or elsewhere. Thus the rationale for research training needs to be broader than simply professional astronomy and astrophysics careers. Australia is now firmly focussed on developing a highly educated and technically adept workforce, directed towards high tech industries. Astronomy and Astrophysics graduates have excellent physics and mathematics training together with first rate problem-solving and programming skills. Thus they are ideally suited to a wide range of new emerging careers both in the private and public sectors. RSAA should orient its research graduate training program to embrace these market realities, without compromising its commitment to excellence in astronomy and astrophysics.

Many of the courses taught by the School have very small enrolments, just a handful of students. This puts them below the threshold where the ANU quality assurance mechanisms operate. ANU needs to ensure that graduate education at RSAA is of the highest quality so formal assessment of courses should be implemented. It appears that some RSAA staff are reluctant to take on the responsibility for teaching courses, yet the School aspires to expand the number of PhD students by 50-100%. This will require the entire faculty to be much more active and engaged in graduate teaching.

There is a perception amongst graduate students that their opportunities, for example to participate in national/international conferences and/or go observing, depend on whether their supervisor holds a grant that can fund such activities. Our understanding is that the School has a fund to support such activities if supervisors are unable to. It is important that this is effectively communicated to graduate students.

We commend RSAA on the development of the Thesis Oversight Committee (TOC) to review graduate student progress. However a single committee cannot realistically review all students and provide detailed feedback. An alternative, that could provide the students with more robust feedback, should be implemented. For example, the Supervisory Panel for each student could meet formally each year to review the student's annual written report. Their assessment could then be fed back to the TOC with recommendations for action.

The committee concluded that the Education Oversight Committee is too large and several individual members have responsibility for only a small portfolio within its remit. This leads to a fragmented approach and risks no-one having a strategic overview. Further we were concerned that some committee members seem to have a passive attitude to the programs they oversee. The committee needs to be more effective and engaged, probably with a smaller, more focused membership.

Recommendation 2.3: Research students and postdocs should be provided with opportunities to learn about a range of future careers outside of academia. Their research training should explicitly include the underpinning skills to transition into such jobs.

Recommendation 2.4: RSAA should consider increasing its graduate program by up to 100%. As part of this RSAA should consider expanding the number of international students and including a broader representation of local students. This would have two benefits: a modest increase in income, and more potential to develop a vision for the training that is being provided. A mechanism should be found to apply the ANU course quality assurance standards to the RSAA graduate courses.

Recommendation 2.5: A more formal structure should be developed for annual feedback to PhD students, including annual written reports and interviews.

Recommendation 2.6: The Education Committee should be re-formed with a significantly smaller number of members who take much more responsibility for the day-to-day teaching and mentoring of student activities and have a complete overview of undergraduate and graduate education at RSAA. They should report on their activities at each faculty meeting. One model would be to identify two key roles on the Committee : (i) a Graduate Student Convener, who ensures that the students' academic work is proceeding satisfactorily, is aware of emotional and social issues, and expands and oversees the graduate courses: and (ii) an Undergraduate/Master's Convener, who oversees these educational programs and will lead expansion of the undergraduate courses. Those assuming these roles will need an appropriate level of administrative and organisational support, where the value of these contributions is recognized.

2.3 Approach to RSAA Training of Postdocs

In general, postdocs at RSAA find excellent research conditions with access to top facilities worldwide. The RSAA postdoc community is generally also happy and also forms a reasonably coherent community (perhaps not quite to the same extent as the students) but simply by virtue of working away from the central campus they are less engaged with the service and welfare provisions provided by ANU.

Like postdoc communities everywhere, there is considerable concern over career development and how to go about getting a job either in astronomy or beyond. Provision of regular mentoring in RSAA and access to career advice (probably available on campus?) would be beneficial.

Regular participation at international conferences is usually ensured, but, as with the graduate students, there is the perception that such opportunities depend on the funding situation of the supervisor.

Recommendation 2.7: It should be made clear to postdocs and graduate students that they have equal opportunities to attend conferences, go observing and take up other training needs regardless of the funding situation of the supervisor.

Recommendation 2.8: RSAA should ensure that the system of annual appraisals for postdoctoral researchers is implemented properly and that its effectiveness is regularly reviewed by the School leadership.

3. Strategic Objectives and Future developments

Assess the School's strategic objectives and their appropriateness as future directions.

The strategic objectives of the RSAA are clearly articulated in the documentation provided to the review committee and are appropriately ambitious for an Astronomy and Astrophysics program aspiring to be among the top 20 in the world. To effectively prosecute these strategic objectives support from faculty in continuing positions is a minimum requirement and will be critical in aligning the efforts of researchers, technical and administrative staff, and students behind these goals. Our discussions with faculty indicate that their collective commitment to these objectives it is not yet secured. This does not appear to arise from a particular hostility to the goals themselves, but rather that some senior staff do not see the need to be actively engaged in setting the future priorities and direction of the School.

A carefully planned open dialogue with staff would not only provide the opportunity to engage them in the process and capture their support for the School's objectives but might also provide a forum to develop new and innovative approaches to the core objectives of the School.

One strategic objective that is not articulated is 'leadership within the Australian and international astronomical communities'. While individuals within the School play, and have played, key leadership roles within the Australian and international communities, there is not a collective sense that this is an expectation of all individual faculty within the School.

ANU occupies a unique position within the Australian university system. It is provided with a substantial National Institutes Grant (NIG). This is currently allocated on a historical basis and the outcomes expected as a result of this investment are not clearly articulated. Since the School relies so heavily on the NIG it should develop a better understanding of the likely factors that will bear on the future of this funding stream.

The strategic priorities make no mention of the role of RSAA within the Australian community and linkages both with the research and instrumentation portfolios. Of particular importance is the relationship with the Australian Astronomical Observatory. As the AITC develops a broader brief, we would encourage the development of an explicit relationship with AAO, with a view to developing a long-term sustainable instrumentation industry in Australia.

RSAA has led the development of policies on equity and diversity in the university. Implementation within the School has been effective, with an active Access and Equity Committee. However, this topic is not mentioned in the core strategic objectives. In order to ensure collegial and diverse community, it is recommended that an appropriate strategic objective be framed. While RSAA's record with regard to the engagement of women scientists at all levels is exemplary, there is a need to widen this to include members of other groups traditionally disadvantaged in the wider society, on the basis of "race", economic status etc.. This situation varies from country to country, and gaining an understanding of how it operates in Australian society, how that society, including RSAA, might become more inclusive, and taking steps to make this happen, would be a major contribution.

Recommendation 3.1: The School should put in place a means of engaging the faculty, and perhaps some senior research fellows, in the development of the strategic plan for the next 5-10 years, together with the key elements of its implementation. We encourage all senior staff to engage with, and contribute to, this process. Perhaps the most straightforward way to do this is to organise a strategic retreat over 2-3 days managed by a facilitator. To be successful, considerable preparation will be necessary and the retreat is likely to be the culmination of a series of preparatory sessions for the faculty. Two key issues for the retreat will be justification of the \$4.5M NIG, and future hiring strategy. We recommend that a sound basis for future posts is to focus on scientific excellence recognising the necessity to build or retain a critical mass of staff in areas of strength. Account needs to be taken of emerging areas, including those that arise as a result of developments in RSAA's instrumentation programme and RSAA's participation in national and international facilities.

Recommendation 3.2: Leadership within the Australian astronomical community, and internationally, should be considered a core strategic objective of RSAA.

Recommendation 3.3: Diversity and equity objectives should be included in the core strategic aims of RSAA.

4. Competitiveness and position in the field of instrumentation and space technology

Assess the School's competitiveness and position in the field of instrumentation and space technology, including the strategies and business plan for the Advanced Instrumentation and Technology Centre (AITC).

There has been an important tradition at RSAA of building innovative astronomical instrumentation that has enabled major advances in astronomical understanding. Initially these were focused on the ANU's own facilities (most recently WiFeS), but increasingly these efforts are aimed at use on extra-national 4-metre and 8-metre telescopes. The scale of these projects has grown to be many \$10Ms, with multi-year timescales. Now a major activity at AITC is GMTIFS for the 25-metre GMT. The other major strand of activity at AITC is the adaptive optics (AO) programme, which produced GSAOI for the Gemini-S telescope and has since developed innovative programmes (with EOS and within SERC) for imaging and even potentially manipulation of space debris. These two major strands, IFU spectrographs and AO, have the potential to be unique selling points for AITC that can sustain a world-leading instrumentation programme. These activities are also tightly woven with the aspirations of RSAA faculty for new instrumentation capabilities, ensuring a tight link between instrument development and science exploitation. The review committee believes this is a key criterion for the success of future instrumentation programmes.

Funding opportunities for these specific activities come infrequently and in general as large contracts. It is necessary to develop strategies for maintaining a critical mass of personnel across the disciplines of instrumentation over periods when there is a gap in funding from the large core programmes. This inevitably requires some diversification of activities at AITC and the challenge is to achieve this while minimising the dilution of the focus on the core mission of advancing astrophysics. The move into space instrumentation has the potential to fulfil this role and will require building on the successful relationship with EOS to make strategic partnerships with the significant players in space science & instrumentation in Australia.

The AITC has assisted a few university groups in the testing of their CubeSats and several others have aspirations to build and fly them. AITC could provide technical leadership in critical aspects of these programs and become the national integration and testing centre for CubeSats. The panel sees that this is perhaps the AITC activity furthest removed from RSAA astronomy programme. It is therefore less attractive to pursue than finding space based applications, probably in earth observation, for its IFS expertise. While pursuing this has been frustrating so far, the potential synergy with the astronomy programme makes it a very attractive route for diversification.

AITC will need to differentiate itself from other similar instrument providers. Further co-operation with AAO and collaboration on proposals is likely to prove to be a successful strategy for both institutions. The Committee believes that close co-operation will avoid the danger that the two groups could find themselves on competing proposals in response to the same opportunity.

It is unrealistic to expect to move into areas where there are already successful, experienced players in Australia such as the provision of radio astronomical instrumentation, where CSIRO dominates.

The panel views the appointment of Anna Moore to the key post of AITC Director very positively. We have seen that staff at all levels are keen to contribute to her success. In planning for her arrival, the ANU has underwritten the AITC for three years.

The committee noted that professional staff in the AITC (and the administrative staff of RSAA) are required to account for their time using the Clarizen time card system. Discussions with professional staff revealed that this system is operated at different levels of rigour in different groups in AITC. When applied in the most rigid way there is a perception amongst staff that their professional development and freedom to innovate is compromised. The review committee recognises the contractual obligations on AITC and that staff have the responsibility to ensure that these contracts are honoured so that AITC can continue to secure external funding. However, we see benefit to RSAA in managers adopting a uniform, lighter touch, in the implementation of Clarizen.

Like many University-based instrumentation groups, some mission-critical skills are vested in just a single individual, which exposes the programme to the risk that key capabilities can be lost through the indisposition of a single staff member. One way to mitigate this risk is to promote staff training so that professional staff become multi-skilled, enabling them to carry out the tasks of others when they are on leave or sick.

In addition to AITC matters, we discuss in this section the status and future of Siding Spring Observatory.¹ The small staff stationed at SSO are a close-knit and committed team. While they would appreciate more direct interaction with the Mount Stromlo HQ over future planning, they are content and feel well supported in their role. They offer a remarkably comprehensive technical support service given their small numbers and they have been encouraged by the investment made in the site after the January 2013 fire.

The main facility at SSO is the 2.3-metre telescope, which is used for research programmes, training graduate students and postdocs, and as a testbed for instrumentation. During our visit we heard concern from a number of constituencies over the future of the 2.3m telescope, as it is widely understood that in January 2017 the SSO site will move to an operations model, where the 'user pays' for access. This prospect, and its implementation on a short time scale, has generated concern, and not a little anxiety, amongst those who are using the 2.3m for projects and who do not have access to a source of funding to cover the projected \$2000 full cost of a night. We understand that the Director has an implementation plan that includes transitional provision for those without funds to continue and complete their projects.

It is the Committee's understanding that the AAO itself may seek to withdraw from, or significantly reduce its commitment to, the SSO site in about a decade (say, mid-2020s). It is not too early to be consulting and preparing plans for the future of the ANU facilities at SSO on that timescale.

Recommendation 4.1: AITC should establish and market its unique selling points that will make it the 'go to' place for those capabilities, e.g. IFS and AO.

Recommendation 4.2: In seeking to diversify sources of support for AITC, applications that are motivated by the potential to advance astronomy and astrophysics should be prioritised to retain the closest association with RSAA's scientific programme. Clearly this needs to be interpreted broadly and balanced by the need to retain technical capacity in the staff, and maintain the capabilities of the technical infrastructure. However the success of the RSAA instrumentation programme should be firmly rooted in astronomical investigations and be driven by the staff.

Recommendation 4.3: Complementarity and co-operation with AAO should be pursued further. The aim should be to combine capabilities to make the union of these two efforts

¹ There were some technical difficulties during our scheduled discussion with SSO which prevented us having a video link; we nevertheless had an effective discussion with SSO staff.

greater than the sum of their parts, so that together they will be more competitive on the global stage.

Recommendation 4.4: RSAA should continue to make strategic alliances with other players in the Australian instrumentation scene to build competitive teams that can effectively respond to funding opportunities. The partnership with EOS and SERC looks particularly successful and where possible similar arrangements with others should be nurtured.

Recommendation 4.5: We warmly welcome the appointment of Anna Moore as AITC Director and recommend that she should have access to discretionary funds e.g. to attract matching funding

Recommendation 4.6: In re-casting the RSAA finances to reflect the developing strategic priorities, consideration should be given to using the NIG to invest in the AITC both to develop specific capabilities, and to address the problems generated by the 'lumpiness' of the funding sources available to it.

Recommendation 4.7: There should be greater integration between RSAA staff primarily motivated by the instrumentation research programme and those with mainly astronomical research interests. The panel sensed that AITC staff are regarded in some respects as separate and different from 'academic staff'. In so far as possible these differences should be set aside to encourage the day-to-day interaction between staff members that can stimulate the creative spark needed to develop novel instrumentation ideas that will advance astrophysics and give AITC a competitive advantage.

Recommendation 4.8: We recommend that some additional flexibility in time-card keeping for AITC staff is needed to ensure that their professional development and creativity is not hindered unnecessarily. This will need to be balanced by the requirement to ensure that the AITC's contractual obligations are met. Implementation of a uniform, light-touch approach to Clarizen may achieve this.

Recommendation 4.9: We recommend that professional staff should be encouraged to become multi-skilled through the provision of appropriate training. This is a realistic way of mitigating, to a limited degree, the risk that key skills are vested in just a single person.

Recommendation 4.10: The implementation plan for the 'user pays' operations model for the 2.3m telescope, together with the transitional provisions for those without a source of funds, should be communicated to the staff and students as soon as possible. Proper measures to ensure a smooth science exploitation during a transition period should be implemented.

Recommendation 4.11: As part of the development of an overarching strategic plan, RSAA should start consulting and preparing plans for the future of the facilities at SSO once AAO decides to significantly reduce its commitment to SSO.

5. Governance

Assess whether the current governance, organization, and administration of the School is appropriate and effective.

The overall organisational structure of the RSAA seems to be working well and the governance and administration is functioning effectively. In general staff and students are happy, loyal to RSAA and proud to be part of it. The Director is popular and held in high regard. There is a good sense of community and of pursuing common goals. The School has been at the forefront of promoting access and equity at ANU. All these things are apparent

from the surveys of staff and students which are themselves a sign of a healthy community. The review committee noted that in recent years the administrative structure has been reformed and restructured in a way that is widely regarded as having streamlined and improved the administrative processes. RSAA hosts and supports a series of exemplary and highly effective outreach programs. The Committee commends these efforts and the plans to extend them.

However, improvements could be made to enhance the performance of the School and to engage the staff and students better. For example, regular Faculty meetings will help in engaging the faculty in developing the strategy for the School as well as in strategic decision making. The School has significant opportunities in the coming decade, when approximately one-third of the faculty will retire and be replaced. Faculty meetings should be the forum for discussing new directions and ensuring that the research leaders in RSAA support the new strategy. Better engagement of AITC staff with the rest of the School will create more cohesiveness in the School. Ideally all parts of RSAA need to engage with AITC activities to assist in identifying and developing instrumentation opportunities.

More widely the review committee identified the need for greater transparency and inclusiveness in decision making within RSAA. This is essential to align all staff and students with the core mission of the School. For example, the anxieties created by the prospect of charging a user fee for the 2.3 m telescope could have been avoided by earlier, more open discussion with staff and students. Clear communication of plans for mitigating the potentially negative effects for ongoing research projects would have been helpful. Throughout the School better communication will enhance the sense in the RSAA community of working towards common goals. In an institution of the scale of RSAA, communication and consultation by, and with, the Executive requires constant vigilance and regular review. It may be time to re-instate the Weekly Bulletin.

We heard evidence of the consequences of RSAA's isolation from the main ANU campus from staff and students alike. An immediate specific concern of students and postdocs is the imminent demise of the daily bus service to and from Mount Stromlo. This is a very serious issue because many postdocs and students do not own a car, and some do not possess a driving license. Even those who do own cars may need to leave them with partners during the day. The review committee senses that the withdrawal of this service could significantly erode the positive atmosphere that pervades RSAA. The review committee recognise that the cost of this service is a significant burden on RSAA's budget and so it cannot simply be absorbed without having an impact elsewhere. However we see this as one aspect of the isolation of RSAA. The committee believes that ANU itself should put in place a variety of actions to mitigate the isolation of RSAA from the main campus and that the provision of affordable transport to and from Stromlo at appropriate times should form part of this.

More generally, not being part of the main campus community limits the access staff and students have to a range of services provided centrally, notably HR and welfare. The University should develop policies to ensure that Stromlo-based staff and students can be well integrated into the campus activities and that campus services are accessible to them. This would include provision of administrative service for graduate students: e.g. a formal process of induction; HR services including dispute reconciliation, harassment & bullying; and the physical health and mental health services. We applaud the appointment of a part time HR person to work at RSAA and see this as a good start to the provision of University services at RSAA that otherwise cannot, in practice, be accessed from Stromlo. It is unlikely to be practical to provide all these services locally on Mount Stromlo, but the route to accessing them needs to be clearer to all potential users. Practical implementation of this provision might require transport to and from the main campus to be more than once per day.

Recommendation 5.1: We recommend that regular faculty meetings of academic staff are held to discuss strategic issues of importance to the School, including policy decisions. These are likely to form an essential preparation for the development of a strategic plan for RSAA.

Recommendation 5.2: We recommend better integration of AITC and ‘academic’ aspects of the Research School, so that developments in instrumentation and astronomy research are brought together to achieve optimum outcomes for both areas and leverage on strengths of both areas

Recommendation 5.3: We recommend enhanced transparency and inclusiveness in decision making as well as improved communication with staff and students (e.g. Weekly Bulletin to record staff and student events).

Recommendation 5.4: The University should develop policies to ensure that Stromlo based staff and students can be well integrated into the campus activities and that campus services are accessible to them. Regular and reliable transportation between the main campus and Mount Stromlo needs to be addressed as a priority.

Recommendation 5.5: We recommend that the School institutes formal policies and procedures to ensure that students and staff benefit from the facilities and services available to them (e.g. induction of students and staff, mentors) as well as get proper feedback on their performance and giving them the opportunity to raise issues of their concern in a formal setting.

6. Funding

Assess the current level of external funding, identify new opportunities for funding, and other actions that might enhance the School’s financial sustainability.

Within the ANU system, the responsibility for most of the operational costs are devolved to Schools, with overhead taxes levied to pay for the central ANU administration and the College infrastructure. Thus RSAA is responsible not only for its staff salaries but also for all the overheads associated with its core activities. Broadly, these are the operation and management of the Siding Spring site and observatory, the AITC, and the academic activities at Mount Stromlo. The budget for each of these units is managed separately, which provides a mechanism for assessing the value of each particular activity. While the committee takes a positive view of the division of the budget along these lines, it also believes that there may be excellent strategic reasons to cross-subsidise from one unit to another.

Broadly, income is derived from three sources: academic activities, which includes teaching and HDR supervision, instrumentation and other contracts for technical activities, and the National Institutes Grant. We discuss these separately below.

Academic Activities: Under the current budget, academic activities bring in about \$2.7M to the School budget. The funding model to the university is about to change, and so this sum may also vary, depending on the allocation formula adopted within the university. There are opportunities to increase this source of revenue, e.g. starting to teach an undergraduate astronomy survey course (see recommendation 2.2), and potentially doubling the PhD student intake. Together these might attract several \$100,000 per annum. This would require a focussed effort, including a greater commitment to teaching by the faculty and a more efficient use of teaching effort along with a significantly augmented HDR recruitment effort.

Instrumental and other technical contracts: At the present time, the major component of income is from the GMT contracts. This is projected to expire in 18 months. While a range of options has been canvassed to source new income in this area², there are no concrete commitments, other than those arising from an unfreezing of further GMT funding. The vision and energy of the new head of the AITC will be critical to the success in developing this facility and should be not only strongly supported, but provided with enough funding to develop prospective opportunities. We note that potential losses for this unit have been underwritten by the University for the next 3 years, provided the AITC develops and pursues an appropriate Business Plan.

NIG grant: Currently this grant of \$4.5M per annum is largely used for core salary costs. The amount of this allocation is based on historical precedent alone. It does not increase annually to reflect increasing salary costs. The committee views this as a serious potential risk to RSAA. A re-assessment of the purpose of the NIG could de-stabilise the School's budget. We recommend that the School start to re-structure the budget so that the NIG is used more directly to achieve the goals that will be identified in the Strategic Plan.

There is unlikely to be a single large upward change to the budget that will provide long-term viability. A prudent approach is one of making modest gains in a number of areas. We encourage RSAA to consider creative options that might deliver increased income or decreased outgoings.

The ANU and Australian membership of GMT has been funded by a capital grant of \$88M from EIF, which has underpinned some of the development and activity at the AITC. When GMT is operational, expected 2022 at the earliest and more realistically 2024, ANU will need to fund its share of the operating cost, currently estimated to be US\$35M p.a. (in current dollars). This assumes that a night of GMT time will cost US\$100k, the same as the current cost of Keck time; it remains to be seen whether this model is realistic. ANU's 5.3% share of the projected operations cost is US\$1.86M or AU\$2.5M p.a. at current exchange rates. Although this includes a modest allocation for new instruments, it seems very likely that additional funds of a similar scale will be required for an instrumentation development effort if the telescope is to remain competitive. Furthermore a vigorous GMT instrumentation programme is likely to be part of the long-term business plan for AITC. ANU is currently buying 15 Keck nights per year at an annual cost of US\$1.5M p.a.. ANU intends to continue to buy Keck (or other 8m-class) telescope time at this level up until GMT comes online, and plans to switch that funding to GMT operations. There are potentially two challenges here: (i) will the funding sources currently in place to purchase Keck time still be available in 2022-24? and (ii) how will the balance of funds needed to make up the total of the operations and instrumentation budget be raised? The review committee heard about the nascent efforts at fund-raising in RSAA and strongly endorses this effort. It is currently on a modest scale and focuses on funding alumni and outreach events. A significant expansion of this effort and re-orientation towards funding instrumentation and RSAA's anticipated ongoing costs associated with GMT membership may prove fruitful.

Recommendation 6.1: We commend the Director and administration for guiding RSAA towards a sustainable balanced budget. Further, we see merit in separating the budget into elements representing different activities to enable strategic decision-making. We encourage a flexible approach to this allocation process so that cross-subsidy is possible if it is strategically sensible.

² We comment on specific proposals in section 4.

Recommendation 6.2: In the context of other universities in Australia, income earned through teaching is relatively low. We encourage the School to take a pro-active stance to initiate further undergraduate teaching (e.g. through a large enrolment non-science major astronomy course) and significantly expand the graduate programme.

Recommendation 6.3: The current utilities expenditure is ~\$520k. Is there any possibility to generate significant amounts of solar or wind power at both Mount Stromlo and Siding Spring? Capital investment might be funded using grants for infrastructure to generate renewable energy.

Recommendation 6.4: RSAA should begin to plan for the funding of the ongoing costs for GMT, including the ongoing costs of an instrumentation programme. Consideration should be given to significantly expanding the fund-raising effort and re-orientating it towards funding instrumentation projects and RSAA's anticipated ongoing costs associated with GMT membership.

7. The future

Identify and assess factors that might have a positive or negative impact on the School, together with responses that exploit the opportunities or mitigate the threats.

The School's activities are carried out in a relaxed, informal and positive atmosphere. Staff and students are loyal to the RSAA and proud to be part of it. The Director is popular and held in high regard. There is a strong sense of community, common cause, and mutual support. In part this arises from the relative isolation of the site from the main campus which itself gives rise to some problems. University health and welfare services are remote, formal HR processes are not always clear (e.g. induction of new students has not always been timely). Enrolment for taught graduate courses is small, and course quality is not always subject to the same scrutiny as larger courses on the main campus. Progress of graduate students' research is monitored rather informally and their preparation for careers beyond academia could be more extensive. There is a risk that RSAA's ability to attract the best domestic and international graduate students could be compromised by these factors. Greater engagement by faculty in both graduate education and welfare is needed. Together with more formal processes for progression, and focused feedback to students, these issues can be addressed. The availability of affordable, appropriately frequent, transport to and from Mount Stromlo could also help to mitigate some of these problems.

The research programme at RSAA is very successful. Faculty have been awarded an impressive array of accolades and awards and international impact is strong. However astronomy is a strong discipline in Australia and competition from other institutions is fierce. The School finds itself at a critical juncture, with one-third of the faculty likely to retire in the coming 5-10 years. Planning for national and international leadership in traditionally strong areas will require retaining a critical mass of activity, while making appointments to develop new capabilities that exploit forthcoming opportunities, such as might arise from developments in the AITC or new facilities, is also essential. We suggest that hiring should prioritise scientific excellence in the context of an overall Strategic Plan for the School. Developing such a plan will require commitment from the entire faculty. The plan should include measures to further increase diversity and equity. Such planning could culminate in an extended retreat that will require significant preparation, including discussions at regular faculty meetings.

In its next phase of development, the AITC will seek to achieve financial sustainability under the leadership of a new Director. Several possible directions have been identified for developing the core programme and for diversifying activity to retain key skills and technical

capabilities in times of fluctuating budgets. Developing partnerships with other organisations, both astronomical and otherwise, to augment the capacity of the AITC, will be key to building successful proposals in response to announcements of opportunity. A key facet of the future success of the AITC will be close integration of instrumentation work with the astronomical aspirations of RSAA faculty. Proactive measures to foster the alignment of the instrumentation and astronomical aspects of RSAA are needed. The degree to which opportunities to diversify the work in the AITC are of interest in developing capabilities needed to advance the astronomical programme will play a key role in determining their desirability.

The budget is moving towards break-even in 2017 and is structured by activity to aid strategic planning. The reliance of the School on the NIG for a large fraction of its core budget is a significant weakness/risk. A re-allocation of the NIG, or prioritisation of particular outcomes, could leave the School's budget vulnerable. There are a number of measures that can increase income such as expanding the graduate programme and potentially offering a survey astronomy course to non-science majors. Measures to save money might include generating electricity through the installation of solar panels or wind turbines. The involvement of the School in GMT is a significant advantage for the research programme and planning for ongoing funding for operations and instrumentation is needed. The strategic use of the NIG should be a major component in the ongoing planning process. We also recommend that the fund-raising effort should be augmented and re-focused on strategic goals.

Much progress has been made in recent years in streamlining the administration and making it more efficient and accountable. However communication at all levels in RSAA could be improved. Regular faculty meetings will provide a forum for discussing new directions and strategic planning. Greater transparency and inclusiveness in decision making will help to align all staff and students with the core mission of the School. As in all organisations of the size of RSAA efficient communication needs constant review.

Appendix A: Terms of Reference

1. Assess the School's performance in research and teaching programs compared to the top astronomical institutions in the world, and in view of future trends in astronomy and astrophysics and associated technologies and facilities.
2. Assess the School's strategic objectives and their appropriateness as future directions.
3. Assess the School's competitiveness and position in the field of instrumentation and space technology, including the strategies and business plan for the Advanced Instrumentation and Technology Centre (AITC).
4. Assess whether the current governance, organization, and administration of the School is appropriate and effective.
5. Assess the current level of external funding, identify new opportunities for funding, and other actions that might enhance the School's financial sustainability.
6. Identify and assess factors that might have a positive or negative impact on the School, together with responses that exploit the opportunities or mitigate the threats.

Appendix B: Agenda

RSAA School Review Agenda

Day	Date	Time	Session	Personnel	Location		
Mon	14-Nov	08:30	<i>Bus departs hotel for Mount Stromlo</i>				
		09:00	Welcome, introduction, & panel session	Matthew Colless, Milica Symul, John	CSO Board Room		
		09:30	Strategic overview	Matthew Colless	CSO Board Room		
		10:00	Tour of Mount Stromlo facilities	Matthew Colless, Milica Symul, Di	Mount Stromlo		
		11:15	<i>Morning break</i>		CSO Board Room		
		11:30	Virtual tour of Siding Spring Observatory & discussion with SSO technical team	Matthew Colless, Milica Symul, Peter Verwayen, Ian Adams, Peter Small	CSO Board Room		
		12:30	<i>Lunch with students</i>		Possum Hall		
		13:15	Research talks: Galactic stars & gas, dwarf galaxies, adaptive optics (4 x 10min)	Ken Freeman, Naomi McClure-Griffiths, Helmut Jerjen, Francois	Duffield Lecture Theatre		
		14:00	RSAA Executive	Matthew Colless, Milica Symul, Mark Krumholz, Geoff Bicknell, Dave Bundy	AITC1 Meeting Room		
		15:00	<i>Afternoon break</i>		AITC1 Meeting Room		
		15:15	AITC leadership	Matthew Colless, Milica Symul, Dave Bundy	AITC1 Meeting Room		
		16:15	Access & Equity Committee		AITC1 Meeting Room		
		16:45	Panel session		AITC1 Meeting Room		
		17:30	<i>Bus returns to hotel</i>				
		Tue	15-Nov	08:30	<i>Bus departs hotel for ANU campus</i>		
				09:00	Deputy Vice Chancellor - Research	Margaret Harding	Science Conference Room, Peter Baume Building #42
09:30	College of Science Dean & General Manager			Andrew Roberts (video), David Akers			
10:00	<i>Bus departs ANU for Mount Stromlo</i>						
10:30	<i>Morning break</i>				CSO Board Room		
10:45	Research talks - cosmology, black holes & AGN, galaxy evolution, AO lasers (4 x 10min)			Matthew Colless, Geoff Bicknell, Lisa Kewley, Celine D'Orgeville	Duffield Lecture Theatre		
11:30	Faculty and emeritus faculty				Duffield Lecture Theatre		
12:15	<i>Lunch with faculty and postdocs</i>				Possum Hall		
13:00	Education Committee				AITC1 Meeting Room		
14:00	Non-faculty academic staff				Duffield Lecture Theatre		
14:45	Graduate students			PhD & Masters students	Duffield Lecture Theatre		
15:15	<i>Afternoon break</i>				CSO Board Room		
15:30	Professional staff			All MSO & SSO admin & technical staff	Duffield Lecture Theatre		
16:15	Postdoc & student talks (10 x 3min)				Duffield Lecture Theatre		
16:45	Panel session		CSO Board Room				
17:30	<i>Bus returns to hotel</i>						
Wed	16-Nov	08:30	<i>Bus departs hotel for Mount Stromlo</i>				
		09:00	Panel session		CSO Board Room		
		10:30	<i>Morning break</i>		CSO Board Room		
		10:45	Outreach & advancement	Matthew Colless, Milica Symul, Brad Tucker, Kellie Takenaka (as desired)	CSO Board Room		
		11:30	Private consultations with staff & students		CSO Board Room		
		12:30	<i>Lunch with professional staff</i>		CSO Common Room		
		13:15	Research talks - stellar astrophysics, star formation, exoplanets, GMTIFS (4 x 10min)	Martin Asplund, Mark Krumholz, Mike Ireland, Rob Sharp	Duffield Lecture Theatre		
		14:00	Panel session		CSO Board Room		
		15:00	<i>Afternoon break</i>		CSO Board Room		
		15:15	Panel session		CSO Board Room		
		16:00	Private session with Director	Matthew Colless	CSO Board Room		
		16:30	Preliminary findings & recommendations	RSAA Executive	CSO Board Room		
		17:30	<i>Bus returns to hotel</i>				

Appendix C: Review Recommendations

Recommendation 2.1: The RSAA should consider, in particular in the context of upcoming faculty hires, the potential advantage of a greater focus on a smaller number of areas of particular strength, to ensure achieving a critical mass of faculty appointments in recognized strengths of the School and/or particularly promising upcoming fields.

Recommendation 2.2: RSAA should investigate setting up an undergraduate survey course for general majors.

Recommendation 2.3: Research students and postdocs should be provided with opportunities to learn about a range of future careers outside of academia. Their research training should explicitly include the underpinning skills to transition into such jobs.

Recommendation 2.4: RSAA should consider increasing its graduate program by up to 100%. As part of this RSAA should consider expanding the number of international students and including a broader representation of local students. This would have two benefits: a modest increase in income, and more potential to develop a vision for the training that is being provided. A mechanism should be found to apply the ANU course quality assurance standards to the RSAA graduate courses.

Recommendation 2.5: A more formal structure should be developed for annual feedback to PhD students, including annual written reports and interviews.

Recommendation 2.6: The Education Committee should be re-formed with a significantly smaller number of members who take much more responsibility for the day-to-day teaching and mentoring of student activities and have a complete overview of undergraduate and graduate education at RSAA. They should report on their activities at each faculty meeting. One model would be to identify two key roles on the Committee : (i) a Graduate Student Convener, who ensures that the students' academic work is proceeding satisfactorily, is aware of emotional and social issues, and expands and oversees the graduate courses: and (ii) an Undergraduate/Master's Convener, who oversees these educational programs and will lead expansion of the undergraduate courses. Those assuming these roles will need an appropriate level of administrative and organisational support, where the value of these contributions is recognized.

Recommendation 2.7: It should be made clear to postdocs and graduate students that they have equal opportunities to attend conferences, go observing and take up other training needs regardless of the funding situation of the supervisor.

Recommendation 2.8: RSAA should ensure that the system of annual appraisals for postdoctoral researchers is implemented properly and that its effectiveness is regularly reviewed by the School leadership.

Recommendation 3.1: The School should put in place a means of engaging the faculty, and perhaps some senior research fellows, in the development of the strategic plan for the next 5-10 years, together with the key elements of its implementation. We encourage all senior staff to engage with, and contribute to, this process. Perhaps the most straightforward way to do this is to organise a strategic retreat over 2-3 days managed by a facilitator. To be successful, considerable preparation will be necessary and the retreat is likely to be the culmination of a series of preparatory sessions for the faculty. Two key issues for the retreat will be justification of the \$4.5M NIG, and future hiring strategy. We recommend that a sound basis for future posts is to focus on scientific excellence recognising the necessity to build or retain a critical mass of staff in areas of strength. Account needs to be taken of emerging

areas, including those that arise as a result of developments in RSAA's instrumentation programme and RSAA's participation in national and international facilities.

Recommendation 3.2: Leadership within the Australian astronomical community, and internationally, should be considered a core strategic objective of RSAA.

Recommendation 3.3: Diversity and equity objectives should be included in the core strategic aims of RSAA.

Recommendation 4.1: AITC should establish and market its unique selling points that will make it the 'go to' place for those capabilities, e.g. IFS and AO.

Recommendation 4.2: In seeking to diversify sources of support for AITC, applications that are motivated by the potential to advance astronomy and astrophysics should be prioritised to retain the closest association with RSAA's scientific programme. Clearly this needs to be interpreted broadly and balanced by the need to retain technical capacity in the staff, and maintain the capabilities of the technical infrastructure. However the success of the RSAA instrumentation programme should be firmly rooted in astronomical investigations and be driven by the staff.

Recommendation 4.3: Complementarity and co-operation with AAO should be pursued further. The aim should be to combine capabilities to make the union of these two efforts greater than the sum of their parts, so that together they will be more competitive on the global stage.

Recommendation 4.4: RSAA should continue to make strategic alliances with other players in the Australian instrumentation scene to build competitive teams that can effectively respond to funding opportunities. The partnership with EOS and SERC looks particularly successful and where possible similar arrangements with others should be nurtured.

Recommendation 4.5: We warmly welcome the appointment of Anna Moore as AITC Director and recommend that she should have access to discretionary funds e.g. to attract matching funding

Recommendation 4.6: In re-casting the RSAA finances to reflect the developing strategic priorities, consideration should be given to using the NIG to invest in the AITC both to develop specific capabilities, and to address the problems generated by the 'lumpiness' of the funding sources available to it.

Recommendation 4.7: There should be greater integration between RSAA staff primarily motivated by the instrumentation research programme and those with mainly astronomical research interests. The panel sensed that AITC staff are regarded in some respects as separate and different from 'academic staff'. In so far as possible these differences should be set aside to encourage the day-to-day interaction between staff members that can stimulate the creative spark needed to develop novel instrumentation ideas that will advance astrophysics and give AITC a competitive advantage.

Recommendation 4.8: We recommend that some additional flexibility in time-card keeping for AITC staff is needed to ensure that their professional development and creativity is not hindered unnecessarily. This will need to be balanced by the requirement to ensure that the AITC's contractual obligations are met. Implementation of a uniform, light-touch approach to Clarizen may achieve this.

Recommendation 4.9: We recommend that professional staff should be encouraged to become multi-skilled through the provision of appropriate training. This is a realistic way of mitigating, to a limited degree, the risk that key skills are vested in just a single person.

Recommendation 4.10: The implementation plan for the 'user pays' operations model for the 2.3m telescope, together with the transitional provisions for those without a source of funds, should be communicated to the staff and students as soon as possible. Proper measures to ensure a smooth science exploitation during a transition period should be implemented.

Recommendation 4.11: As part of the development of an overarching strategic plan, RSAA should start consulting and preparing plans for the future of the facilities at SSO once AAO decides to significantly reduce its commitment to SSO.

Recommendation 5.1: We recommend that regular faculty meetings of academic staff are held to discuss strategic issues of importance to the School, including policy decisions. These are likely to form an essential preparation for the development of a strategic plan for RSAA.

Recommendation 5.2: We recommend better integration of AITC and 'academic' aspects of the Research School, so that developments in instrumentation and astronomy research are brought together to achieve optimum outcomes for both areas and leverage on strengths of both areas

Recommendation 5.3: We recommend enhanced transparency and inclusiveness in decision making as well as improved communication with staff and students (e.g. Weekly Bulletin to record staff and student events).

Recommendation 5.4: The University should develop policies to ensure that Stromlo based staff and students can be well integrated into the campus activities and that campus services are accessible to them. Regular and reliable transportation between the main campus and Mount Stromlo needs to be addressed as a priority.

Recommendation 5.5: We recommend that the School institutes formal policies and procedures to ensure that students and staff benefit from the facilities and services available to them (e.g. induction of students and staff, mentors) as well as get proper feedback on their performance and giving them the opportunity to raise issues of their concern in a formal setting.

Recommendation 6.1: We commend the Director and administration for guiding RSAA towards a sustainable balanced budget. Further, we see merit in separating the budget into elements representing different activities to enable strategic decision-making. We encourage a flexible approach to this allocation process so that cross-subsidy is possible if it is strategically sensible.

Recommendation 6.2: In the context of other universities in Australia, income earned through teaching is relatively low. We encourage the School to take a pro-active stance to initiate further undergraduate teaching (e.g. through a large enrolment non-science major astronomy course) and significantly expand the graduate programme.

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