Education Investment Fund

# Investment Plan

# Astronomy

April 2010

Contents

# 1 Strategy

The strategy used by AAL to allocate the EIF funds was to recognise the significant astronomy infrastructure investments made by the Australian Government in recent years, to identify remaining gaps in astronomy infrastructure, and to distribute the EIF funds to address some of those gaps. This resulted in some of the funds being used to enhance existing infrastructure, and some funds put towards investing in new areas.

## *1.1 Priorities*

A Gap Analysis was undertaken by the AAL Board to identify current gaps against the infrastructure priorities identified in the Decadal Plan for Australian Astronomy ("*New Horizons: Decadal Plan for Australian Astronomy 2006–2015"*).

This analysis found several areas of note. These included Antarctic Astronomy, and computational access for dedicated astrophysical supercomputing facilities. In addition the Decadal Plan identified continued funding for AAO and ATNF as a priority, including the provision of new instrumentation to maintain scientific output and impact. Adequately funding a low-frequency SKA demonstrator as Australia's candidate SKA site was also determined to be a priority.

A clear potential future gap was found to be access to 8 metre class telescopes such as Gemini and Magellan. This gap cannot be substantially addressed by EIF because it primarily involves funding for operations. The software tools necessary to maximise the scientific return from the Australian Government's investments in high-performance computers and telescopes is also an area that should be considered for future funding opportunities.

## *1.2 Process*

AAL invited proposals from relevant research institutions to give the Board of AAL the benefit of the latest thinking from the astronomy community.

The AAL Board considered the proposals with consideration to the Gap Analysis, strategic significance, project maturity and scientific return for the proposed investment. Eighteen project proposals were received and eight projects were chosen for funding. A ninth project specified by AAL, focused on data management and access, was also funded.

# 2 AAL Program Management

As with the Optical and Radio Astronomy NCRIS programme, AAL will be responsible for the overall management for the portfolio of projects to be funded from this EIF grant. AAL will be responsible to DIISR for all contractual arrangements, including project reporting and financial management.

AAL will contract with the most appropriate organisations to deliver on the eight projects, with first-level project management and technical teams based at those organisations. These organisations will report to AAL at three-monthly intervals against agreed plans, milestones and payment schedules. In many cases the AAL directors and staff will have the necessary skills and knowledge to critically assess project progress; however, as necessary, AAL will create and/or consult with expert advisory committees.

# 3 Project Overview

## *3.1 National Facilities*

The Australian-based National Facilities that will receive EIF funding are the Anglo Australian Telescope (AAT) and the Australia Telescope Compact Array (ATCA). These facilities will receive funds to expand the design of forthcoming instruments or to upgrade existing facilities.

### 3.1.1 HERMES - $1,670,000

The AAT's new instrument HERMES is a multi-object high spectral resolution spectrograph. Its primary goal will be the elucidation of the evolutionary history of the stars in our own Galaxy, what is often referred to as Galactic archaeology (GA). This facility is well matched to the expertise of Australian astronomers and also to future complementary projects, such as the GAIA project of the European Space Agency, which will provide the motions of billions of stars in the Galaxy.

HERMES current funding is sufficient to implement a three wavelength channel instrument which achieves most, but not all, of the GA survey objectives. EIF funding will allow a fourth wavelength channel ("arm") to be added to the design to increase the wavelength coverage and allow all the major objectives of the GA survey to be pursued. The HERMES design effort has produced a baseline 3-channel design with the option of implementing a 4th channel with minimal impact on the rest of the system. The HERMES project is now well developed, and underwent Preliminary Design Review in February 2010. Following a successful PDR, the project has entered the final design and construction phase.

### 3.1.2 AAOmega - $710,000

The AAOmega fibre-fed optical spectrograph is currently the most-used facility on the AAT, and EIF funds will be used to upgrade AAOmega to provide the capability to extend the current generation of large multi-object spectroscopic surveys to an earlier epoch in cosmic history. This improved efficiency will translate not only into new and better science but also greater effective availability of the AAT's premier instrument.

The upgrade to AAOmega will also allow both the measurement of redshifts to complement the Dark Energy Survey (DES), addressing the question of the nature of dark energy, and the study of the properties of the galaxies themselves at this epoch, addressing the question of galaxy formation and evolution. DES is a US-led program using the Cerro Tololo Inter-American Observatory (CTIO) 4m telescope in Chile and will be a premier cosmological survey in the coming decade. A golden opportunity for the Australian community comes from the fact that DES has no current plan for large-scale spectroscopic follow-up observations, and AAOmega at the AAT is the only facility able to provide the wide-field multi-object capability at the sensitivities required. A particular synergy for Australia would be the overlap of this southern deep imaging (and good photometric redshifts) with the ASKAP radio surveys.

### 3.1.3 ATCA - $1,471,000

In the Decadal Plan the continued role of the ATCA in the SKA pathfinder era was recognised as critical to ensure the success of the SKA Pathfinder projects. EIF will fund an upgrade to the ATCA C/X receiver systems.

The ATCA C/X receiver upgrade is the third and final stage of the ATCA receiver upgrade project. The concept for this ambitious project, to enable a broadband capability for the original Compact Array L/S and C/X receivers, dates back to 2004. The construction and deployment of this stage of the ATCA upgrade has been planned in detail and is fully costed but was not previously funded. In concert with the broadbanding of the L/S receiver, this stage of the upgrade will provide almost continuous frequency coverage of the entire 1–12 GHz band. The sensitivity will improve over that currently available by more than a factor of two and, in conjunction with the new CABB system, enable a factor of more than four improvement in the survey speed.

This upgrade provides significant scientific gains in the areas of deep, wide-band polarimetric continuum imaging. This will be crucial for several research areas including identifying and understanding ASKAP transients, probing star formation processes and understanding magnetic field origins in both galaxy disks and Active Galactic Nuclei. Furthermore, the upgrade will give much improved access to areas of the spectrum that are not currently well covered.

## *3.2 International Facilities*

### 3.2.1 Gemini - $688,160

A priority from the Decadal Plan is to maintain Australia's access to 8 metre class telescopes. In addition, the 2008 NCRIS Strategic Roadmap for Australian Research Infrastructure defines 8 metre telescope access as a priority for Australia.

The twin Gemini telescopes provide the majority of Australian access to 8 metre class instrumentation, and EIF funds will be used to contribute to Australia's share of the Gemini instrumentation program. AAL will propose to the Gemini Board that the funds be used to fund the upgrade of GMOS-S CCDs, though the ultimate use of the funds will be decided by Gemini.

GMOS-S is the most heavily used instrument on Gemini, with more than 25% of all time assigned to Australia using this instrument. The GMOS-S CCDs are nearly a decade old, and suffer from several defects relative to new generation detectors, including poor quantum efficiency and severe fringing beyond 750nm, and subtle cosmetic defects that make nod-and-shuffle observations difficult over large fields-of-view.

The range of science that would be improved by this upgrade spans the breadth of Australian optical astronomy. The GMOS-S CCDs upgrade is a straightforward procedure for which designs exist for all parts, and thus is an efficient way to improve Australia's access to a high quality science instrument.

### 3.2.2 Pierre Auger Observatory - $50,840

Pierre Auger Observatory, located in Argentina, is a non-traditional type of telescope to which Australia is a partner. The Observatory is actively investigating the origin of the highest energy cosmic rays with a 3000 $km^2$ detector, providing unprecedented sensitivity for this long-standing mystery in astrophysics. The Observatory is operated by a collaboration of over 400 physicists from 15 countries. Australia, through the University of Adelaide, was a founding member of the collaboration 15 years ago, and continues to take a leading role with responsibilities in data analysis, atmospheric monitoring and astrophysical interpretation of the data.

The University of Adelaide will receive EIF funding to provide replacement cloud monitoring equipment for the Observatory, which has been one of Australia's responsibilities as a member of the collaboration.

This equipment will monitor the night-time cloud conditions over the whole active area of the Observatory, a critical activity for the successful operation of the telescope.

## *3.3 New Opportunities*

The Board of AAL considered funding new opportunities in Australian astronomy to be an important priority. As a result, two new projects were chosen to expand astronomy into new areas: next-generation supercomputing and Antarctic exploration.

### 3.3.1 gSTAR - $1,040,000

The NCRIS Roadmap outlines the ICT requirements needed to support Australia's astronomical capabilities. One of these requirements is the ongoing and developing demand for high performance computing. Next-generation supercomputers are essential for theoretical astrophysics applications. Theoretical astrophysics represents one of three core research capabilities underpinning Australian astrophysical research and is a major research effort in Australia, with a growing reliance on High Performance Computing (HPC) to solve some of the most complex problems in the field.

As outlined in the Decadal Plan, the synergies with ground-based optical and radio astronomy allow Australia to continue to be a world leader in astrophysical research. The demographics report commissioned as part of the Decadal Plan revealed that theoretical astrophysics represents a third of the professional Australian astronomers. Research involving HPC Computing is now critical for this community.

To protect our significant investments in computational resources for radio, optical and theory (including the new Pawsey Centre and NCI machines) Australia must move now to develop the expertise to use the next generation of HPC technology and maintain the pace of development. The gSTAR project was chosen for EIF funding because of this.

gSTAR is a GPU (Graphics Processing Unit) machine, and offers the ability to perform highly efficient computations on a range of problems in theoretical and observational astronomy. The gSTAR project provides a major step in the development of a more strategic approach to the requirements of theoretical astrophysics, by providing the facilities necessary to further enhance and grow Australia's international standing.

Access to this emerging tool in computational astrophysics will bring prestige to Australian theoretical astrophysics, and enhance the community's capacity to undertake world-leading research and provide scientific innovation. Access to gSTAR will also facilitate training of postgraduate students in this important new area, ensuring they emerge with the best possible opportunities for future employment.

### 3.3.2 Antarctica - $1,000,000

An EIF-funded project for Antarctica was also chosen to expand Australian astronomy into new areas and strengthen international collaborations on the continent. This project addresses the recommendations of the Astronomy NCRIS Strategic Options Committee (ANSOC) to increase Australia's international partnerships in Antarctic astronomy. EIF funds will be used to support the continued site qualification of the high Antarctic plateau.

Interest in Antarctica has progressed to include new locations, in addition to the established sites at South Pole and Dome C. China has commenced the construction of a US$37M station, *Kunlun,* at Dome A, and is currently hauling over 500 tonnes of instruments and equipment to the site each year. China

has devised an ambitious astronomical program for *Kunlun*, and is pursuing it with an aggressive schedule. Prior to the opening of *Kunlun* (currently scheduled for 2015), site characterisation, and even astronomical science, has already been made possible by the autonomous PLATO laboratory – designed and built at the University of New South Wales (UNSW). As a result, China regards Australia, along with the USA, as its closest collaborator in Antarctic astronomy.

Japan has made a similar decision to develop its own high-plateau site, Dome F, for astronomy. Like China, Japan has asked Australia to partner them in the deployment of robotic facilities to characterise the site, and to carry out preliminary astronomical observations.

Following the past two years of successful operation of PLATO at Dome A, EIF will fund one of the next-generation PLATOs, PLATO-R, as well as contributing to three new AST3 wide-field telescopes at Dome A. These projects will maintain Australia's position as a key partner with three of the most important international players in Antarctic astronomy, thus ensuring that future opportunities are not lost. This project is not only consistent with some of the most important themes in Australia's astronomical roadmap, but creates a pathway towards future international facilities on the high Antarctic plateau.

## *3.4 SKA pathfinder - $3,070,000*

Part of the EIF grant is to support projects associated with Australian SKA (Square Kilometre Array) activities. One such project is to contribute to the extension of the MWA (Murchison Widefield Array) telescope to a 512 tile array.

The MWA project is an existing activity and has been underway since 2005 as an international collaboration between partners in Australia, India and the USA. The MWA, as an early deployment at the Murchison Radio-Astronomy Observatory (MRO), has already been used to promote the qualities of the MRO as a world-class location for radio astronomy.

The MWA connects strongly to Australia's current Decadal Plan for astronomy. As a low frequency SKA pathfinder and the first SKA pathfinder to be operational on one of the two international SKA candidate sites, the MWA occupies a highly strategic place in Australia's preparations to host the SKA.

On the timescale of the international SKA site decision in 2012, MWA will be producing important scientific data from the MRO for Australian and international user communities, showcasing the features of the MRO that make it attractive as a location to host the SKA. MWA will also demonstrate the superior radio frequency interference environment that is the great advantage of the MRO.

The MWA project has been underway for 4 years and has recently revised the project scope, budget and schedule, as well as deploying a prototype 32 antenna array at the MRO. The project was also reviewed by Astronomy Australia Limited (AAL) and the National Science Foundation (NSF) during 2009.

The 32 antenna prototype array, constituting a major milestone as stipulated by both AAL and the NSF, has been completed. A full suite of prototype hardware has been assembled and integrated at the MRO and is currently being debugged and verified in situ.

## *3.5 Data Access Infrastructure for Astronomy EIF projects - $300,000*

Developing computing infrastructure, both software and hardware, was seen as important component of the various EIF funded projects. Funding allocated to this project will be used to explore options for a long term data management infrastructure solution for data generated by EIF astronomy projects.