NATIONAL COLLABORATIVE

RESEARCH INFRASTRUCTURE STRATEGY

Investment Plan

For the research capability

Radio and optical astronomy

INSTRUCTIONS

Purpose

This Investment Plan is to be completed in respect of funding to support Australian research infrastructure under the National Collaborative Research Infrastructure Strategy (NCRIS).

Guidance on issues related to the development of this Investment Plan can be found in the NCRIS Roadmap and NCRIS Investment Framework.

GST

The Department will not provide funding to cover any amounts of GST incurred by any Party to the Investment Plan in circumstances where the applicant is entitled to claim input tax credits for those GST amounts. Therefore, budget figures should be the GST exclusive costs of all items in respect of which any Party is entitled to an input tax credit.

Confidential Information

No confidential information should be included in this Investment Plan.

If it is considered necessary to provide certain confidential information to the Department or the NCRIS Committee in association with this Investment Plan, then only a non-confidential summary explaining the nature and ownership of the information should be provided in Attachment J. DEST will then contact relevant parties to obtain access to the confidential information in an appropriate manner.

Consideration of Investment Plans

Investment Plans will only be considered by the NCRIS Committee and DEST if they have been prepared by the Facilitator identified for the relevant NCRIS Research Capability.

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PART ONE – FACILITATOR'S DECLARATION

I, [Facilitator's name], confirm that I have prepared this Investment Plan in accordance with the NCRIS principles as set out in the NCRIS Investment Framework.

……..
Signed

……..
Name

……..
Date

PART TWO - OVERVIEW

Details of the organisation that will contract with the Commonwealth:

Organisation Name:	
Ultimate parent organisation *(if appropriate):*	
Organisation Type *(please select one of the following)* - Higher Educational institution; - Australian Government research institution; - State or territory research institution; - Private sector research organisation; - Other (Please state)	
Contact Officer *(name and position held)*:	
Phone number:	
Fax number:	
Email Address:	
Website:	
Physical Address:	
Postal Address for all correspondence*:*	

Details of all other organisations that will contribute resources to this Investment Plan:

Organisation Name:	
Organisation Type *(please select one of the following)* - Higher Educational institution; - Australian Government research institution; - State or territory research institution; - Private sector research organisation; - Other (Please state)	
Contact Officer details (please include Name, Position, Phone Number and Email Address):	

Organisation Name:	
Organisation Type *(please select one of the following)* - Higher Educational institution; - Australian Government research institution; - State or territory research institution; - Private sector research organisation; - Other (Please state)	
Contact Officer details (please include Name, Position, Phone Number and Email Address):	

Organisation Name:	
Organisation Type *(please select one of the following)* - Higher Educational institution; - Australian Government research institution; - State or territory research institution; - Private sector research organisation; - Other (Please state)	
Contact Officer details (please include Name, Position, Phone Number and Email Address):	

Funding Summary:

Table 1: Outline of the overall funding (GST exclusive) for the Investment Plan.

	2006-07	2007-08	2008-09	2009-10	2010-11	Later Years	TOTAL
NCRIS cash contribution						N/A	
Non-NCRIS cash contribution							
In-kind contribution							
TOTAL							

Table 2: Summary of the contributions to be made by each participant organisation.

		2006-07	2007-08	2008-09	2009-10	2010-11	Later Years	TOTAL
Org 1	Cash							
	In-kind							
	Total							
Org 2	Cash							
	In-kind							
	Total							
Org 3	Cash							
	In-kind							
	Total							
TOTAL								

Table 3: Breakdown of expenditure (the totals should match those in Table 1):

	2006-07	2007-08	2008-09	2009-10	2010-11	Later Years	TOTAL
Capital Expenses							
Operating expenses							
International access expenses							
TOTAL							

Project Description

In no more than five pages, please provide a summary of the Investment Plan that addresses the recommendations of the NCRIS Roadmap and the Investment Criteria set out in the NCRIS Investment Framework.

PART THREE – RESEARCH INFRASTRUCTURE

In this part, you are required to show how the proposed infrastructure facilities meet NCRIS Investment Criterion 1, ie:

> **An investment plan must result in excellent research infrastructure that addresses the national requirements of the relevant capability area described in the NCRIS Roadmap.**

In addressing the criterion, you should fully address:

- all issues relevant to Criterion 1 that are identified in the NCRIS Roadmap; and
- the requirements of Section 3.1 of the NCRIS Investment Framework 'Content of Investment Plans'.

This part should detail all infrastructure that is to be funded by this Investment Plan, including any elements that relate to Platforms for Collaboration.

The assets that will be funded by this Investment Plan should be detailed in Attachment A.

……..

National Requirements – the Australian Astronomy Decadal Plan 2006-15

The Australian astronomy community has been characterized over the last decade by coherent strategic planning across all wavelength bands and sub-disciplines, exemplified by the unified plan for major optical and radio facilities funded under the MNRF-2 program. In 2005, the Australian astronomical community, in 2005, mapped out its strategic vision in *New Horizons: A Decadal Plan for Australian Astronomy 2006-15*. The Decadal Plan identifies the national requirements relating to astronomy and proposes a strategic roadmap that addresses these requirements and is well supported across the astronomy community. Although the Decadal Plan pre-dates the finalisation of the NCRIS process, the strategic aims of both the Decadal Plan and the NCRIS process are highly aligned. This includes a strong focus on world-class science outcomes and on a national, collaborative (integrated) approach to achieving those outcomes. NCRIS funding has a central role to play in delivering the Decadal Plan strategy, and the infrastructure investments proposed in this Investment Plan are consistent with the strategy proposed in the Decadal Plan.

National Requirements - Science Focus

The primary focus of most astronomy research – and the proposed application of the research infrastructure for which NCRIS support is being sought – is knowledge derived for its own sake. Knowledge of the universe is a public good, one in which there is substantial interest and which provides substantial cultural value. While we have identified scope for significant tangible benefits from the proposed infrastructure investment, we are not arguing that this should constitute the primary rationale. We are proposing support for truly excellent science directed at the most fundamental questions about our universe.

The Decadal Plan sets out, and discusses, 9 big questions yet to be satisfactorily answered, and where the emerging tools of modern astronomy have good prospects for making a major contribution:

- What is the nature of the dark energy and dark matter that appears to make up about 95% of the universe? – by any standards, a significant gap in our understanding of the world in which we live.
- How and when did the first stars form in the early universe?
- How are galaxies assembled and how do they evolve?

- Is our understanding of gravity correct?
- How do the super-massive black holes in the cores of galaxies work?
- What is the origin and evolution of cosmic magnetism?
- How do stars and planetary systems form?
- How common are planetary systems and conditions suitable for life? How do stars produce and recycle the elemental building blocks of life?

All are concerned with the basic conditions that shape, and have shaped, us and the world in which we live. The same astronomy that probes the limits of our universe is also probing the limits of our understanding of many of the laws of physics and the very nature of matter and energy. The suite of infrastructure proposed for investment will enable Australian astronomers to continue to make leading contributions internationally to answering these questions.

National Requirements - International focus

The Investment Plan focus is on a small group of major research infrastructure investments that will support Australia continuing to play a key role at the forefront of international astronomy. Astronomy is a truly international science that is now highly dependent on internationally funded and operated major infrastructure facilities. Sophisticated systems for sharing costs and for managing access to ensure that the best science is undertaken by the best scientists – with appropriate technical support in, and development of, the facilities – have been developed by the international astronomy community[1]. Over the past 30+ years, the Anglo-Australian Telescope has been an Australian-based example of this approach in optical astronomy, while the ATNF has served as the exemplar in radio astronomy for almost 20 years. Closely analogous systems apply to the Gemini telescopes and are planned for the Giant Magellan Telescope, the Antarctic PILOT telescope and the Mileura International Radio Array (MIRA).

The principles embodied in these systems closely parallel the vision developed in the NCRIS Roadmap – in relation to both the collaborative design and development of facilities and the basis on which access is provided.

Several principles have been central to the development of the investment proposition set out in this document:

- A predominant consideration through the strategy development has been its focus on supporting *excellence in science* – internationally competitive, involving deep international collaboration and in many cases operating at the world leading edge – in astronomy.
- We focus on areas where Australia has an established presence and capability in international astronomy of a very high order, and thus real competitive advantage.
- In two items of proposed infrastructure, one currently more developed than the other, Australia appears highly competitive in the *location* of prospective new facilities:
    - A next generation radio telescope, the Mileura International Radio Array (MIRA), capable of internationally competitive science breakthroughs, and with good prospects for enhancing Australia's competitive advantage for siting the proposed Square Kilometre Array facility in Australia. The strategy has been designed to deliver a major upgrade to Australian radio astronomy capability while being consistent with the cost-effective/risk-mitigated option of progressive upgrading of the investment out to the full SKA. The strategy maximizes Australia's prospects for playing a leading role in the technology development in SKA in addition to being selected as the site for this facility
    - The first major Antarctic optical/infrared telescope, with Australia well placed to support such a facility in the Australian Antarctic Territory, with the viability of this strategy having been enhanced recently with the construction of airport facilities.

- The strategy also recognises the scientific and economic benefits of combining support for Australian facilities, with obtaining access to large international facilities at the best off-

[1] 77% of Australian astronomy papers over the past decade have international co-authors (New Horizons: A Decadal Plan For Australian astronomy 2006-2015, Australian Academy of Sciences)

shore sites. Thus we can maintain Australia's high international standing in astronomical science across many wavelength bands.

- Excellence in the skill set is a central element of competitive advantage in a field that is increasingly competing for access to facilities located around the world. Australia has in the past proven highly competitive in this way, and a key element of the strategy is designed to maintain this competitive advantage. These skills include those relevant to the cost-effective delivery of capability to telescopes via smart instrumentation and data capture and analysis capabilities.

More fundamentally, the strategy offers the collective capability to continue to compete and contribute at the leading edges of international astronomy, while ensuring that the full range of capabilities Australia offers in relation to future astronomy – from sites for telescopes, through main instrument design and other instrumentation through to the planning and execution of great science using the instruments – is able to compete on merit. Under these circumstances, we fully expect Australia to continue to 'punch well above its weight class' in astronomy for many years to come.

The strategy as developed does offer very substantial opportunities for leverage. NCRIS investment will make significant contribution to building Australia's case as a location for future very large astronomy facilities that will draw on international funding.

The prospects for NCRIS investment in radio astronomy are already attracting substantial state and international interest in co-investment in the facility. In addition, Australian scientists will gain access to internationally leading-edge facilities that are only made possible by the level of leverage of funds from other countries, and by the ability of Australian institutions to bring considerable additional resources to both the planning and the use of the facilities[2]. There are now very large size economies in both optical and radio astronomy. The strategy is designed to exploit these economies and the commitment of other countries and other institutions to this major area of research to deliver a dramatic increase in the capability of the facilities to which Australian astronomy has access.

The budgeting sets out later the extent to which other funding sources are sought even for the specific infrastructure items for which NCRIS funding is sought. Just as importantly, these facilities with add greatly to the strength of the case for even wider leverage in relation to future investments in the SKA, in the Giant Magellan Telescope and in a much larger Antarctic instrument. In two of these three cases, the chances of an Australian location being chosen by the international consortia is substantial – which would increase dramatically the effective level of leverage in relation to total Australian benefits.

National Requirements – Likely Demand and Encouraging Collaboration

[needs content for optical wavebands]

The unique combination of fast mapping speed with high angular resolution ensures that MIRA will provide a surveying capability at least ten-fold greater than any existing radio telescope. National and international demand for this telescope is likely to significantly exceed recent over-subscription rates on the Australia Telescope Compact Array (approximately 2:1). Within its first year of operation MIRA will produce a catalogue of HI emission in more than 500,000 galaxies to unprecedented redshifts, while simultaneously cataloguing 10 million continuum sources in the deepest all-sky continuum survey to date. Previous, much shallower catalogues, such as the HIPASS HI galaxy catalogue and particularly the Northern VLA Sky Survey (NVSS) continuum catalogue, are among the most highly cited astronomy papers of the past decade (from ADS citations). All indications are that with the increasing concentration of large telescopes (including ALMA) in the south, catalogues with at least an order of magnitude more sources will carry similar weight. But what is perhaps even more exciting is that the MIRA will image the entirety of the

[2] 33% of Australian astronomy citations arise from international astronomy facilities to which Australia makes no direct financial contribution (ibid.)

atomic gas cosmic web in the nearby universe - not just in galaxies but also between galaxies - allowing a full mapping of the history of gas and galaxy evolution in a way that has never before been possible. This will extend near-field cosmology from the optical domain, which primarily traces stars, into the domain where radio and optical data can be synthesised to reveal the stellar and gas evolution history of the recent universe.

National Requirements - Industry and Education Links

[needs optical content]

Technological advances in radio astronomy are driving:

- close links between radio astronomy and ICT developments in signal processing
- developments in remote operations for radio telescopes, and
- national and international bandwidth upgrades to communications infrastructure.

Due to its extreme demands for sensitivity and data processing power, future radio astronomy technology represents transformational technology for ICT. Involvement in future radio astronomy R&D will link Australia's technologists to the most innovative in the world in these areas, and provide a unique training ground for tomorrow's technicians. 80% of work cited in patents as inspiration for the patents is basic academic research.

The Australian Electronics Industry Action Agenda has been established in recognition of the need to assist and update the Australian electronics industry. In June 2005 the Electronics Industry Action Agenda Implementation Group endorsed the SKA as a signature project. With support from AEEMA (the Australian Electrical and Electronic Manufacturers' Association), an "SKA cluster mapping project" has been developed to identify the potential benefits for Australian industry from the SKA-related projects and SKA-related R&D.

Four SKA cluster events have already been held; in Sydney, Perth, Geraldton (to a large local audience) and more recently Brisbane. Over 180 company representatives have attended these meetings. Awareness and interest of Australian industry has been raised, with more organisations (eg HP, GHD, SA Government, CMD) seeking to join an 'outer core' of the existing Consortium. The Western Australian Government has signalled its intention to be part of the Consortium.

The accessibility of astronomy gives it a high public profile. This awareness and interest in the community makes it particularly valuable in demonstrating science in action. Astronomy's appeal makes it a valuable way in which to engage and educate students and the public about science and technology.

By exciting young people's interest in the Universe and how we study it the astronomical community and educators can take an important role in strengthening scientific education and skills in Australia. NCRIS funding for new astronomical facilities will lead to many new exciting technologies and discoveries. Experienced, well-supported educators can use these to produce stimulating educational case studies. Relevant, engaging examples support the effective teaching of science and technology and will help promote careers in these fields.

National Requirements - Links to other Sciences

[more required here, space weather, space debris tracking with PILOT, sensor networks, ICT]

The Australian Astronomy Decadal Plan highlighted the importance of astronomy as an attractive science, technology and innovation education tool in Australia. The development work required for the astronomy infrastructures will support research in a very large group of universities throughout Australia, due to the large number of groups actively involved and the range of work-packages available for development of the instruments. The infrastructure thus will provide inspiration and training for a very wide range of students, providing essential training for future generations of wealth creators for the country.

Proposed Package - a balanced suite of infrastructures

The investment portfolio is balanced across five major items of infrastructure, providing a mature balance of support for existing facilities and developing options to invest in future facilities.

The investment strategy is viewed by the astronomy community as a *package*, with strong synergies available through the cross-spectrum features (higher and lower frequency radio, infrared and optical) of the proposed package and through the coherent whole-of-astronomy-community support that has emerged from the planning processes.

In respect of a number of the major questions to which the proposed infrastructure will be applicable, there will be growing scope to exploit these cross-spectrum synergies, especially those available from the next generation of much larger radio and optical instruments, to deliver a fuller understanding of the phenomena being observed. None of the leading countries in astronomy has focused on one part of the spectrum at the expense of the others – astronomy is advancing using a range of types of instruments whose costs are such that sharing the costs of individual instruments internationally allows access to the package of instruments appropriate to addressing the major questions in astronomy.

In terms of the Decadal Plan and the desire to host the SKA, this package character of the proposal takes on even greater significance. International perceptions of Australia's commitment and capability across the spectrum have a major impact on international perceptions of Australia as a suitable site for the SKA. This influence arises through a combination of considerations, ranging from true technical and scientific synergies, through to assessment of depth of commitment to a project with a very long planned life. It represents a clear differentiator relative to the most likely alternative site – and perceptions that Australian commitment across the spectrum may be diminishing could be expected to reduce substantially Australia's prospects for being chosen to host the SKA.

The 2005 DEST business case for Australian involvement in the SKA. including the possibility of being chosen as the host site, emphasised the value of preserving this hosting option. Indicatively, using the same parameter settings used then, a plausible reduction in Australia's prospects of being selected from 1:2 to 1:3 would entail a (very conservative) reduction in expected net economic benefits to Australia of the order AUD20M (NPV) – with the consistent conservatism used throughout the options modelling suggesting the true cost could be substantially higher. However, the costs to Australian astronomy and perceptions of Australia's position in astronomy, and the value of Australian involvement in this major international project, would we believe be very much greater than these tangible benefits alone. These strategic considerations are appropriately included in the assessment of alternative funding packages for this round of NCRIS.

NCRIS funding is required for maintaining access to existing optical world-class facilities, both on-shore (AAO) and off-shore (Gemini). In the radio astronomy domain, support for existing national facilities is provided through CSIRO, and it is proposed that this support be to some extent re-directed to the new infrastructure.

Infrastructure investment in the design phase of GMT and in PILOT is developing options for possible engagement in future large-scale optical facilities and for maximising Australia's ability to compete in the next stages of optical and infrared astronomy. This represents a sound approach to the considerable challenges inherent in planning for such complex instruments. As is discussed further in Attachment K, the nature of the science and its required infrastructure and the rapidly changing technologies really dictate that a level of adaptive strategy is going to be a sound part of any cost effective strategy for delivering these types of infrastructure.

While this NCRIS proposal concerns funding over the next 5 years, this strategy is about building Australian capacity to contribute at the leading edge of astronomy over many years to come. Astronomy is characterised by very rapid rates of technological development that becomes embodied in very large infrastructure projects that can take over a decade to roll out. It is not

possible to operate in this environment on the basis of deterministic planning, built around currently available technologies. To try to do so would ensure that funding from other countries and major institutions would be unavailable – for two basic reasons:

- It would guarantee that the facilities being built would be out of date long before completion – even though this is not necessary.
  - major astronomy facilities are well suited to adaptive development that incorporates modern principles for large investment planning and roll-out under uncertainty, and sensible investments in reducing project uncertainty and in providing access to evolving technologies are an inherent part of a sound infrastructure roll-out strategy.
  - New technologies can be incorporated into facilities during and after roll-out, provided that the design has built in scope for such flexibility.
- Attempting to build to a rigid strategy is not cost effective.
  - One of the major attractions to participation in these projects, and associated leverage of funds, lies in the opportunities to participate in leading edge technology development with application to the facility and with possibilities for substantial wider industry and application spin-offs from these technologies.
  - Australian involvement in an adaptive project development maximises the scope for Australia being part of the technology development, and being able to benefits from the skills and IP that follow.
  - Adaptive management of risks and opportunities offers scope for much better cost management without jeopardising long term objectives for the facility – while also retaining the opportunity of pushing out the value of the project as a result of technology developments that occur across the planning and roll-out phases.

At the same time, we recognise that NCRIS funds are not targeted at the funding of research programs. To manage the potential conflict here, we have relied heavily on piecing together a package of funding sources directed at different elements of the overall infrastructure need, reserving for NCRIS funding those elements that do fit clearly within the NCRIS criteria. Again, this does not mean that we can, or should, be absolutely definitive now as to the precise form of the package of infrastructure investment elements to which the NCRIS funds are to be applied. For the above reasons, it will be appropriate that this package be capable of adaptation to new information. However, we believe that all elements for which NCRIS funding is sought are appropriately viewed as investment in infrastructure and infrastructure options, not as astronomy research. Relevant research elements will be the subject of leverage from other countries and institutions, and these have been factored into the overall budgeting.

The major elements of this proposed investment package are:

The Anglo-Australian Observatory (AAO)

- The Anglo-Australian Telescope (AAT) is widely acknowledged to have been the most productive telescope for Australian researchers over the past decade. The AAT accounted for 15% of all Australian astronomy citations over the past eight years.
- Over the next five years the UK will gradually withdraw from the AAO, and by mid-2010 Australia will have sole ownership of the AAT and all the other assets of the observatory. The Decadal Plan envisages that the AAO will expand its role in the delivery of research outcomes to the Australian astronomical community by evolving into the national optical/infrared observatory.
- NCRIS investment of AUD10M is required to maintain the AAT as a world-class facility available to Australian researchers over the next decade.
- This investment will accomplish two major goals: (i) AUD4.1M will be used to refurbish the AAT to allow it to operate reliably and efficiently throughout the coming decade.
  (ii) AUD5.9M will be used to construct a new instrument to offer world-leading capabilities to Australian researchers and sustain very high levels of scientific productivity and impact.
  These 2 items are 'base-level' priority items for NCRIS funding.

Gemini and large telescope access

- The funding of Australia's existing 6.19% share of Gemini and the local support infrastructure costs will involve joint investment from NCRIS and by the Australian

Research Council (ARC). This requires AUD10.3M for Gemini operations and AUD4.3M for Gemini's 'Aspen' instrumentation program. These 2 items are base-level priority items for NCRIS funding.

- Through being Australia's signatory to the International Gemini Agreement the ARC has ultimate responsibility for Australian participation in Gemini and, as such, wishes to continue providing funding support. It will do so through its Linkages Infrastructure and Equipment Fund (LIEF) scheme. The expected level of this funding is AUD2.7M over the NCRIS period.
- A stated goal of the Decadal Plan is to increase access to large telescopes for Australian astronomers to a level corresponding to a 20% share in an 8-metre telescope over the coming decade. As a first step towards this goal, AUD1.9M in NCRIS funds is requested to acquire additional access (over and above the 12.4% access provided by Australia's 6.2% share in the two Gemini telescopes) to large telescopes to provide Australian astronomers with the equivalent of a 15% share in an 8-metre telescope. This additional share is a 'strategic-option' priority for NCRIS funding.

The Giant Magellan Telescope (GMT)

- Enabling access to the next generation of extremely large telescopes for all Australian astronomers is a high priority item of the Decadal Plan. The Giant Magellan Telescope is a 25-metre telescope, plans for which are being developed by a consortium of US institutions and the Australian National University. GMT is well matched to Australian astronomers scientific requirements and technical capabilities. The expected total capital cost of the GMT is USD550M.
- The GMT project is now entering its Design Development Phase (DDP), which will cost USD56M. Early entry to this next-generation facility will allow Australian astronomers to help set the scientific agenda through opportunities to participate in the design of the telescope and instruments, and will allow Australian industry to compete effectively for, and maximally benefit from, the technological developments and construction contracts.
- NCRIS funding of AUD4.8M would (with matching funds from the ANU) secure ground floor Australian membership at the 10% level in the consortium for the Design Development Phase. In the 'base level' priority list for NCRIS, it is proposed that AUD3.4M be allocated for the first 2 years of participation in the DDP. The AUD1.4M required for the final year of the DDP is a 'strategic option' priority.
- During this phase, Australian astronomers would also seek to establish the GMT Landmark Facility Committee to develop the business case for involvement in the full GMT, based on engagement with, and first outcomes from, the DDP.
- This approach to the GMT embodies its own access arrangements that would be managed at a high level by the international consortium in accordance with long-established and tested principles, with the Australian participants operating a merit-based system within its share of overall access.
- This approach would again ensure access by all Australian scientists, based on the scientific excellence and merit of the proposals developed.

PILOT

- The PILOT program involves the detailed design, construction and operation of a 2.4-metre optical/infrared telescope at Concordia Station, Dome C, in the Australian Antarctic Territory. PILOT is the first stage of a development path that provides the option of engagement in larger facilities in Antarctica, consistent with the high priority given Antarctic astronomy in the Decadal Plan and the Australian Extremely Large Telescope (ELT) Working Group Roadmap (2005).
- The initial timetable indicates a detailed design phase beginning in 2007, with a design review to occur after 12 months. Base-level priority NCRIS funding is requested for this detailed design phase for PILOT of AUD1.0M.
- Substantial additional investment is expected from the European partners and from Australian institutions. Preliminary discussions have already been held with overseas partners and these discussions will lead to firm agreements by the time of completion of the Design Review.

- The construction phase of PILOT would follow the satisfactory completion of the design review, and would be funded through a combination of NCRIS, Australian University and European resources. NCRIS resources of AUD5M are requested for a one third share in the construction of PILOT, as a 'strategic option' priority.
- The design, construction and operation of PILOT will be managed by a PILOT Board that is responsible to the Astronomy Research Australia Board, and to its European counterpart.
- Access to PILOT for end users will ultimately be managed via the existing Australian Time Allocation Committee (ATAC).

MIRA

- Base-level priority NCRIS funding of AUD19.2M is requested for radio astronomy infrastructure for construction of a world-leading next-generation radio telescope, the Mileura Radio Array (MIRA) at Mileura – the proposed central site for the SKA should it proceed in Australia.
- The MIRA builds on existing commitments to the CSIRO-funded extended New Technology Demonstrator, and the NSF and Australian funded Low Frequency Demonstrator (LFD) at Mileura. NCRIS funding will enable the enhancement and integration of these two facilities into a powerful next-generation radio telescope according to the international SKA Reference Design.
- The MIRA also builds on commitment by the Government of Western Australia to establish a Radio Astronomy Park at Mileura, to protect the site for the purpose of radio astronomy, and to provide infrastructure support to a level of AUD4.2M. The funding sources for the MIRA include CSIRO (~AUD30M), the US National Science Foundation (USD4.9M), Harvard University (USD0.5M), the USAFOSR (USD0.3M). In addition, an MOU is currently being prepared between CSIRO and Herzberg Institute of Astrophysics to further develop MIRA over the coming 5 years. NCRIS funding may also leverage further international investment.
- ARC LIEF grants may be used to support specific University research outputs of the LFD program
- The indicative timetable involves construction commencing in 2007, integration of the LFD into MIRA on a common-user basis in 2010 and full commissioning in 2011.
- Operating costs for the MIRA post-2011 would be sourced from re-prioritisation of existing resources within ATNF.
- Access for Australian researchers would be handled through a Time Assignment Committee managed through CSIRO ATNF using the existing merit-based approach.

NCRIS Funds and Funds Management

NCRIS funding will be managed by a new peak body to be established with appropriate legal status, Astronomy Research Australia Ltd (see section 4), that will allocate NCRIS funds to the various infrastructures according to agreed timelines and subject to satisfactory progress through critical review points. ARA will have some ability to re-prioritise and re-allocate funds to adapt to changing international circumstances. Decision points will be necessary for allocation of funds in the optical astronomy area. Depending on results of initial studies and participation in GMT, and PILOT, decisions will be made regarding which of these infrastructures to support beyond the first 2 years of GMT participation and based on the conclusions of the Design Review process for PILOT. Australia's level of participation in PILOT and the GMT DDP will depend on the level of NCRIS funding available after the first year of the NCRIS funding cycle.

AUD2M of NCRIS funds will be required to support the ARA Office over the life of NCRIS. This investment offers good value via the scope it will provide for adaptive management of the overall investment in order to maximise the value of the infrastructure options. ARA is discussed in substantially more detail in the context of the proposed governance arrangements, in Part 5.

AUD50M scenario
The anticipated call on NCRIS funds from the above package may be summarized thus:

Governance	AUD2.0M
Base Level	
Gemini (2 x 6.19%) share	AUD11.9M[3]
MIRA	AUD19.2M
AAO	AUD10.0M
GMT DDP Phase 1	AUD3.4M
PILOT Design	AUD1.0M
Strategic Options	
Increased access to 8m (15% share)	AUD1.9M
GMT DDP Phase 2	AUD1.4M
PILOT construction	AUD5.0M

All Base Level and at least one of the Strategic Options infrastructure items, based on strategic considerations, would be supported by the NCRIS AUD50M scenario.

AUD35M scenario
In the AUD35M scenario, the infrastructure would be reduced to the highest priority items of Gemini, MIRA and the AAO. Simply maintaining the current access to optical facilities would require between AUD17.6M and AUD21.9M (the uncertainty currently lying in the Gemini instrumentation package). With largely fixed overheads at AUD2M for the Governance, there will also be reduced support for the MIRA in this latter scenario. In priority order, this would result in no expansion of the proposed MIT-supported LFD collecting area (although the cost of integration into the National Facility would be included) and reducing the frequency coverage of MIRA.

For optical astronomy, the AUD35M scenario would mean covering only immediate needs and commitments, but no national investment over the next five years in the new generation of optical facilities, leaving Australia behind all other major astronomy nations. Once GMT or a large Antarctic telescope comes on-line in about ten years' time, the AAT will be phased out of operation. Until these new facilities are available, however, reducing access to the AAT or to 8-metre telescopes would be a serious reduction in capability.

The proposed reduction in the functionality of MIRA, would reduce the attractiveness of the MIRA to international collaborators by offering a more limited frequency range and therefore reduce siting prospects for, and options for technology leadership in, the Square Kilometre Array in the longer term. The value of these lost options, in terms of Australia's potential contribution to astronomy and the tangible economic benefits of having the SKA sited in Australia could be very large.

Unconstrained scenario
As stated in the Decadal Plan in an unconstrained scenario the infrastructure priority goals would be rounded out to include 20% access to an 8m-class optical/infrared telescope (an additional AUD4.1M) and increasing Australia's share in PILOT to 50% (an additional AUD3.6M). Including all base level and strategic options items bring the total in the NCRIS unconstrained scenario to AUD63.5M.
The demand for 8m telescope access within the Australian astronomy community is projected to grow relative to present levels (equivalent to ~12% of an 8m) over the period of the investment plan, to the extent that it would be highly desirable for its access to increase into the 15-20% range. This will not only allow this increasing demand to be met, but also provide the community with access to a broader suite of instruments on a variety of 8m telescopes in addition to those of the Gemini partnership.

[3] AUD4.3M of this is for Australia's share of Gemini's 2nd-generation instrumentation program, which is currently under review by the Gemini Board.

This increased share of PILOT would provide Australia with the majority share in the telescope, more effectively influencing the strategies for the deployment of future large Antarctic telescopes.

For completeness, although they fall out outside the purview of NCRIS, the indicative construction costs for capability's proposed landmark facilities are: (i) AUD75M for a minimum 10% share of GMT (AUD75M: 2008-16) and AUD150M for a 10% share in SKA (2012:2020).

Platforms for Collaboration

In all the scenarios described above, there will be a requirement to access the research fibre-optic network at 1Gbps, rising to 10Gbps rates by the 2008/09. The latter is required to support Very Long Baseline Interferometry with the ATNF telescopes. International connectivity at 1Gbps is required to enable international access to data products obtained with the MIRT and Australian access to data products from Gemini and other international telescopes.

Over the coming 5 years, it is likely that the capability will have an ongoing, although modest, requirement for open access to High Performance Computing. Astronomical usage of APAC for theoretical calculations in support of observational astronomy is likely to remain at the 2-3% level. Much of the HPC, including data storage, analysis and visualisation requirements for astronomy are in the form of dedicated infrastructure, and as such are costed in the capability's infrastructure requirements above.

PART FOUR – ACCESS AND PRICING

In this Part, you are required to show how the arrangements for the proposed infrastructure meet NCRIS Investment Criterion 2, ie:

> **An investment plan must result in research infrastructure that is accessible by researchers on the basis of merit, at reasonable prices, and that encourages collaboration in research.**

In addressing the criterion, you should fully address:

- all issues relevant to Criterion 2 that are identified in the NCRIS Roadmap; and
- the requirements of Section 3.2 of the NCRIS Investment Framework 'Content of Investment Plans'.

……

Access to the various infrastructure components of this investment plan would be via the existing well-established time assignment mechanisms, already identified as exemplars of best-practice access policies by the NCRIS committee[4]. Access to all – both existing and proposed (– infrastructure would be co-ordinated via the AAO Australian Time Assignment Committee (for the optical/IR) and the ATNF Time Assignment Committee (for the radio). This is consistent via the Decadal Plan strategy of AAO and ATNF acting as the national observatories for optical/IR and radio astronomy respectively. Initiated by the proposed NCRIS Governance body, the capability may in future look towards combining the time assignment committees to foster yet further cross-capability collaboration. For the present, the existing structure works well and provides transparent merit-based access for all researchers to the major Australian astronomical facilities.

AAT

Applications for access to the Anglo-Australia Telescope (AAT) are made to a single bi-national time assignment committee - the Anglo-Australian Time Assignment Committee (AATAC), which ranks all proposals for observing time on the AAT, from both Australian and UK astronomers, on the basis of scientific merit and technical feasibilty, and assigns each successful proposal an appropriate number of nights observing time.

AATAC is an ARC committee whose Australian members are apponted based on the recommendation of a 3-person appointment committee comprising the Australian Gemini Board member, the lead Australian AAT Board member and the President of the Astronomical Society of Australia. The members of AATAC are a subset of the members of the Australian Time Assignment Committee (ATAC) that awards access to all Australian national optical astronomy facilities.

Calls for proposals are made twice a year, and proposals are submitted via a WWW-based application systeem. All researchers, irrespective of nationality, are able to apply. Full sectarial support for the proposal submission and review process is provided by the AAO. Technical evaluation and scheduling of the proposals is also carried out by the AAO.

No charge is made to users of the facility allocated time under this process. Basic costs associated with travel/accomodation to carrry out the observations at the AAT are provided by the AAO, although some costs are borne by the users. Data archive/management costs are borne by the Observatory. All data is freely available to the international scientific community via a WWW-based archive, following a proprietary period of 18 months.

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[4] Based on the document *Guidance on access and charging issues* submitted to the NCRIS facilitators' meeting 9 June 2006.

Gemini

Applications for access to the Australian share of the Gemini Telescopes are made to a single national time assignment committee - the Australian Time Assignment Committee (ATAC), which ranks all Australian proposals for observing time on Gemini, on the basis of scientific merit and technical feasibilty, and recommends an appropriate number of nights observing time to each successful proposal. These successful proposals are them passed on to the Gemini international TAC (on which Australia has a representative) to make the final scheduling recommendations, taking into account possible multi-partner participation programs (each national TAC having provided its assesment of the scientific merit of any particular program) and any program conflicts/duplication. The ITAC is careful to maintain appropriate parnter-share balance in its final assembly of the telescope schedule.

Applications for observing time on the Gemini Telescopes are made via a WWW-based application form. Call for proposals are made twice a year. Full sectarial support for the proposal submission and review process is provided by the AAO, as a component of its contribution to the Australian Gemini Project Office.

No charge is made to users of the facility allocated time via this process. Time on the Gemini telescopes is awarded on both a 'classical' and 'queue' basis. Observers are classical status are expected to travel to the telescope to conduct the observations, and bear the costs associated with this. Observers awarded queue time will have their observations conducted for them and the resultant data distributed to them.

Data archive/management costs are borne by the observatory. All data is freely available to the international scientific community via a WWW-based archive, following a proprietary period of 18 months.

Additional 8m Time/PILOT

Any further 8m time on a telescope other the Gemini and the Australian share of PILOT would also be accessed via ATAC in exactly the same fashion as defined above. Indeed, time of the Magellan optical/IR facility (accessed via MNRF funds) is currently ranked and allocated via ATAC.

MIRA

Applications for observing time on the MIRA facility (either the extended New Technology Demonstrator or Low Frequency Demonstrator) would be made via a single Time Assignent Committee, which will operate along similar lines to the exising Australia Telescope National Facility Time Assignment Committee (TAC). Membership of the MIRATAC will reflect international investment in the MIRA. The ATNF would take on the overheads associated with managing the MIRATAC.

In their full operational mode, the goal will be to have 80% of the telescopes available for scientific research (on a 24/7 basis), the remaining 20% reserved for maintainance and commissioning. Currently, the TAC review proposals for the Australia Telescope Compact Array, the Parkes radio telescope, the Mopra radio telescope, the Long Baseline Array and the Tidbinbilla antenna (5% science access via host coutry agreement). The TAC ranks all proposals received for observing time on these telescopes, on the basis of scientific merit and technical feasibilty, and assigns each successful proposal an appropriate amount of observing time.

The TAC is appointed by the ATNF Steering Committee and comprises Australian researchers principally from outside the ATNF. Application to the TAC are made via a WWW-based application form. Call for proposals are made twice a year, and proposals are submitted via a WWW-based application systeem. All researchers, irrespective of nationality, are able to apply. Full sectarial support for the proposal submission and review process is provided by the ATNF. Technical evaluation and scheduling of the proposals is carried by the ATNF.

No charge is made to users of the facility allocated time via this process. Users are expected to cover costs associated with travel/accomodation to carrry out the observations at the telescopes.

Data archive/management costs are borne by the observatory. All data is freely available to the international scientific community via a WWW-based archive, following a proprietary period of 18 months.

PART FIVE – OWNERSHIP AND MANAGEMENT

In this Part, you are required to show how the ownership and management arrangements for the proposed infrastructure meet NCRIS Investment Criterion 3, ie:

> **An investment plan must include a facility ownership and management structure that will result in the efficient and effective operation of the infrastructure**

In addressing the criterion, you should fully address:

- all issues relevant to Criterion 3 that are identified in the NCRIS Roadmap; and
- the requirements of Section 3.3 of the NCRIS Investment Framework 'Content of Investment Plans'.

Any company constitution, memorandum of understanding or other agreement relating to entities that will own or operate the NCRIS facilities should be provided in Attachment B if available. Otherwise, a detailed description should be provided of the arrangements that are proposed to be implemented.

Organisation charts explaining the relationships between entities involved in the project, or showing the management structure within relevant organisations should be provided in Attachment C.

Where possible, curriculum vitae for key personnel (maximum of 2 pages per person) involved in the management of the NCRIS facilities should be provided in Attachment D.

……

The major elements of this strategy involve international cooperation in the funding, planning, construction, prioritisation of access and operation of major facilities. With the exceptions of the AAO beyond 2010, they will not be solely Australian owned and there will be international ownership and governance arrangements suited to such facilities.

In this section we summarise the characteristics of these arrangements, as a backdrop to the proposed arrangements for appropriate governance in respect of the investment from NCRIS that is sought here.

The governance model proposed here seeks to be consistent with the principles outlined in the Decadal Plan i.e. that of a peak body for Australian astronomy with the AAO and ATNF playing a role as the national optical and radio observatories respectively, linking into international organizations as appropriate. While this model has been developed for the purposes of the NCRIS governance, it would be intended that if successful, it would be enlarged over time to incorporate further elements of Australia's national/international optical and radio astronomy infrastructure.

Proposed NCRIS Governance

The Decadal Plan called for a peak body to coordinate Australia's astronomical activities. Consistent with this strategy it is proposed to create a public company limited by guarantee provisionally called "Astronomy Research Australia Limited" (ARA), which will initially be responsible for the governance of any NCRIS investment in the capability. ARA will be owned by a consortium of universities, educational and non-profit institutions. ARA's initial mission would be:

To oversee the administration of NCRIS funds for astronomy consistent with the Investment Plan and the Australian Astronomy Decadal Plan

A longer-term mission would be:

to act on behalf of the astronomical community of Australia to promote excellence in astronomical research through advocacy and efficient management of programs and facilities.

To become a member of ARA, an institution would have to demonstrate that it has goals consistent with the ARA mission, and pay a nominal annual fee for membership. The institutional contribution is meant to be a (small) barrier to make sure institutions are serious about joining, not a major revenue raising process.

Each institutional member of ARA will appoint a member representative to the annual meeting of ARA Ltd. These member representatives could as easily be DVC-Rs or university financial officers as astronomers. Indeed, it would important to get a mix of people and expertise. The member representatives elect Board members from nominations, possibly via a nominating committee, made by the astronomy and industrial community.

The Board of Directors should be small enough to be an effective decision making body, but large to provide an appropriate breadth of expertise in astronomy, management and finance. As a possible example, the Board of Directors may consist of four astronomers chosen for their research expertise and their balanced views of the strategic needs for the astronomy community, and three independent non-astronomers. The appointment of the Board, including the Chair, will be approved by formal vote of the member representatives (one vote per member institution).

The principal role of the Board is to progress the mission of ARA. Consequently, the Board members are not in any sense representatives of their institutions or employers. Consistent with this role, the Chair and members of the Board would be paid an annual fee. Given the small size of the astronomy community in Australia, the member representatives have a duty to ensure the independence of the Board and its members and in casting their votes for Board members the will need to ensure that members do not have conflicts of interest that would impede their ability to discharge their fiduciary duties. Membership terms of the Board will be staggered so as to ensure both continuity and rotation. The likely initial terms would be two and three years.

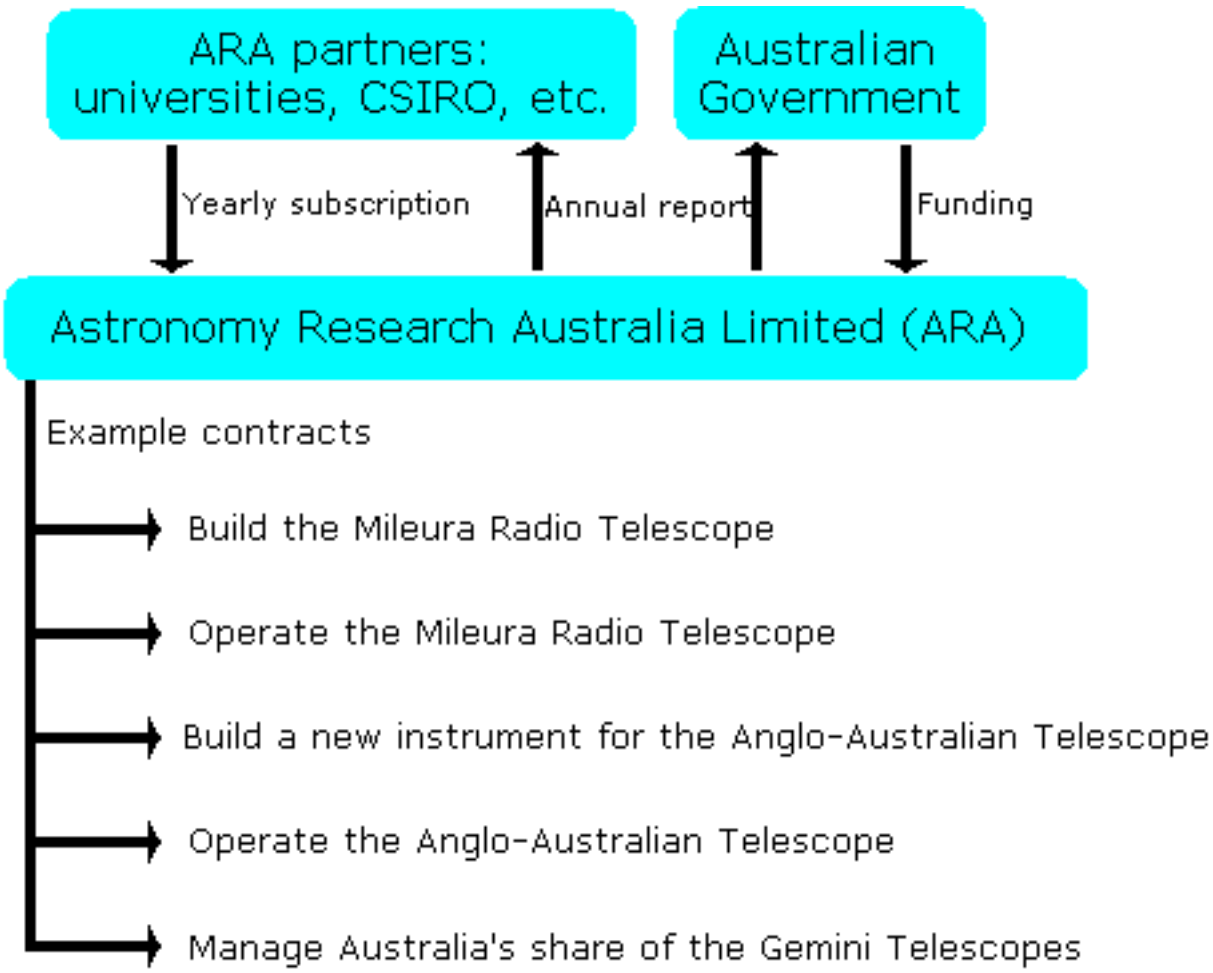
The Board would appoint through an open selection process a Chief Operating Officer (COO) and a Administrative Officer (AO), who would be ARA employees. The COO would be responsible for the day-to-day management, including financial management, and oversight of the programs under ARA's contractural arrangements, reporting to the Board on their status. The Board would likely meet quarterly to receive these reports, set strategic goals, approve financial allocations, etc. The COO might also be expected to play an advocacy role of behalf of the mission of ARA with government, industry, the university sector, etc. The Administrative Officer would be responsible for day-to-day administrative work, including the receiving and generating of project reports, audit and finance responsibilities, etc. The location of the ARA office is not specified at this stage. We note though that there may well be advantages in sharing physical location and resources with other peak bodies playing similar roles.

Within the NCRIS context, it is presumed that ARA, would contract with DEST to carry out the approved programs in the NCRIS Business Plan. The funding of the ARA Ltd., office, its employees and the activities of the Board would have to come principally from NCRIS monies. The expectation would be that approximately 4% of the NCRIS program allocation would be used in this way (i.e. ~AUD400k/yr for 5 years) with a small amount of additional funding from the ARA institutional membership dues. Any attempt to fund the full cost of ARA Ltd. by membership due is likely to make the entry bar too high for many smaller universities, thereby undermining the collaborative principle of the governance model.

NCRIS program funds would be paid to the organisations contracted to deliver particular components in the Business Plan, in accordance with project milestones and subject to satisfactory performance. The COO would monitor this performance independent of the institutions and organisations and report to the ARA Board. The Board receives these reports and acts

appropriately. In the longer term, ARA could take ownership of all of Australia's national astronomy facilities, and contract the operation of these facilities to the relevant organisations. The timeline for these longer term changes will undoubtedly vary from facility to facility, for example:

- ARC is currently the signatory Australian organization for the Gemini Partnership with funding flowing through a Trust Fund held by the University of Sydney, but this could be reviewed before June 2007 if future funding for Gemini was to flow through ARA;
- ARA could discuss with CSIRO options for managing existing radio astronomy facilities, under advice from DEST, before any new facilities become operational in WA;
- The AAT Board is the governing body for the AAO until the end of the current AAT Agreement in June 2010. ARA is potentially a suitable organization to take over the role of the AAT Board when the AAO reverts to wholly Australian ownership in mid-2010.'



The Board would take advice from existing advisory/governance structures e.g. from the AAT Board and AAO Users' committee for AAT/AAO activities, the Australian Gemini Steering Committee for Gemini and 8m issues, from the Australia Telescope Steering Committee for radio astronomy matters and from other similar steering and advisory committees as appropriate.

Below we sketch out the relationship between the funding routes, governance bodies and management organisations for the infrastructures proposed in this investment plan. Consistent with the strategies outlined in the Decadal Plan, we would see the AAO and ATNF increasingly acting as the National Optical and National Radio Observatories respectively in managing these infrastructures (or the Australian component of these infrastructures) and the corresponding access via their existing time assignment committees.

Operation of AAO and Gemini

The AAT and Gemini are the existing optical/infrared national facilities. For the AAO, funding flows directly from the Australian and UK funding agencies (DEST and PPARC), and NCRIS funding through ARA. From 2010, all Australian Government funding to the AAO could flow through ARA, which could take over the role of the AAT Board. For Gemini, both the NCRIS grant and the ARC LIEF grants should flow to ARA; most of the funds are then paid directly to the Gemini Observatory as Australia's subscription to the partnership, but a small amount is paid to AAO, which will manage the Australian Gemini Office, providing support to Australian users of the Gemini telescopes and running the telescope time allocation process on behalf of the community.

Development of GMT

The intent is that NCRIS and the ANU each provide half of the amount required for a combined 10% involvement in the Design Development Phase (DDP) of the GMT project. Currently, ANU is a signatory member of the GMT Project; when NCRIS monies flow from ARA to GMT, these arrangements will be revisited to appropriately reflect the ARA-ANU partnership. Within ARA, the ANU would have equal weight with all the other members of ARA combined in making decisions relating to GMT DDP matters. Like all other partners in the GMT project, Australia would have two representatives and one vote on the GMT Board. One of the two Australian members of the GMT Board would be nominated by ARA, and the other would be nominated by the ANU, with ARA and ANU each approving both nominees. Should Australian involvement in the GMT be supported by national funding for the subsequent construction and operation phases of GMT, this symmetry would likely be broken, so that new arrangements would need to be made. The ANU may consider selling its share, in which case its membership would be through ARA as for other institutions.

Overall management of the GMT project resides with the GMT Project Office at the Carnegie Observatories in Pasadena, California, which will award the contracts for the design and development work during the DDP. The ARA will contract an Australian GMT Project Office to assist Australian industry and astronomical institutions in winning GMT project contracts, and could provide top-level management of those contracts placed with Australian institutions.

Development of PILOT

PILOT is proposed to be a 50/50 Australian/European partnership. On the Australian side, PILOT will be funded by ARA; on the European side, it may be funded by the EU's Framework Program through ARENA. ARA and ARENA appoint equal numbers of members to the PILOT Board, which will be responsible for the overall management of the project. During the design phase, the work packages being carried out by Australian industry and astronomical institutions are managed by the Australian PILOT Project Office at AAO, while those carried out by European industry and astronomical institutions may be managed by the European PILOT Project Office at the European Southern Observatory (ESO). This arrangement is adequate for the design phase, but it is envisaged that the construction and operations phases would need a single management organization, which might be AAO, ESO or another entity.

Development and Operation of MIRA

MIRA will be sited on the WA Government-owned Radio Astronomy Park (RAP) being created at Mileura Station by the Government of Western Australia. Enabling infrastructure for the RAP is being provided by the Government of WA.

MIRA will be an international facility, primarily consisting of the combined LFD and xNTD. ARA, in conjunction with the International partners, will establish a MIRA management committee consisting of representatives from the partner countries. This is similar to how the Gemini telescopes operate. ARA will contract the operation of the MIRA to a separate organization; likely to be CSIRO in the first instance.

It is expected that there will be a single Time Assignment Committee for the different frequency components (LFD and xNTD) of MIRA, and it is proposed that CSIRO (in the first instance) will manage the time allocation under its existing process.

At the end of the NCRIS funding cycle, the expectation is that the Mileura radio telescope (including the LFD) will continue to be managed and operated as an international facility. Australia's share of the operational funding could come from the existing funding to operate the Australia Telescope. This would require the current funding supplied to CSIRO to be transferred to ARA, with the expectation that CSIRO would tender for the operation of these radio astronomy facilities.

LFD integration into MIRA

LFD phase 1 will be led by MIT in collaboration with a number of institutions. During this phase of LFD, access to the facility will be via the individual Science Collaborations, which scientists can apply to join. NCRIS funding during this early stage will provide infrastructure for LFD to enable its integration into MIRA, eg possible provision of access to high performance computing at Geraldton, optic-fibre infrastructure and digital signal processing infrastructure.

By 2010, the initial experiments with the LFD will be complete. It is the joint intention of the MIT and Australian partners that LFD phase 2 will include upgrading user support for the LFD and integrating LFD into MIRA. This is consistent with NSF guidance, assuming success of the first LFD phase.

A closer connection between the LFD and the xNTD, and their joint operation as the MIRA will be the primary component of the SKA pathfinder plan in Australia.

The major elements of this strategy involve international cooperation in the funding, planning, construction, prioritisation of access and operation of major facilities. With the exceptions of the AAO beyond 2010, they will not be solely Australian owned and there will be international ownership and governance arrangements suited to such facilities.

ARA would also be responsible for the development of any astronomy 'landmark' infrastructure proposals e.g. GMT or SKA construction.

PART SIX – IMPLEMENTATION STRATEGY AND BUSINESS CASE

In this Part, you are required to set out an implementation strategy and business case for the proposed infrastructure showing how these arrangements meet NCRIS Investment Criterion 4, ie:

> **An investment plan must include an implementation strategy and business case that will result in the efficient implementation and effective ongoing financial management of the infrastructure.**

In addressing the criterion, you should fully address:

- all issues relevant to Criterion 4 that are identified in the NCRIS Roadmap; and
- the requirements of Section 3.4 of the NCRIS Investment Framework 'Content of Investment Plans'.

A strategy for the implementation of the Investment Plan should be provided in Attachment E.

A financial plan including projected financial statements should be provided in Attachment F.

A risk management strategy should be provided in Attachment G.

……

This section has yet to be drafted in any detail, being heavily dependent on the details of the package. A major attachment, dealing with the strategic assessment, the major value propositions and the detailed budgeting – extending beyond the 5 years, is well under way and is intended to become the primary source for the material in this part.

In many ways, implementation has commenced. This is particularly true given the Decadal Plan perspective on what is being done and sought, with many processes already established for proceeding nationally and internationally. Of specific relevance to NCRIS are the processes that have reached a broadly based consensus as to the structure of the investment across different NCRIS funding levels; and the negotiations with international partners via the various already-established consortia and in relation to potential new partners and funding sources.

As has been noted, the established governance and access management arrangements that apply to facilities such as the AAO and Gemini means that the basis for on-going governance and access provisions is well-advanced.

However, approval of NCRIS funding will trigger the need to move rapidly on a range of fronts to ensure that maximum value is obtained from these funds and to satisfy NCRIS requirements in respect of accountability and efficiency of processes. Work is proceeding on the detail of this implementation strategy and the refinement of the associated business case.

The following comments are made on a number of matters of particular importance, which will be developed far more fully over the next few weeks.

Strategic Assessment

Every major item of infrastructure proposed here (including strategic options) had, even before the NCRIS process gained traction, been the subject of detailed assessment of needs and appropriate responses, both within the Australian astronomy community and across international partners. The Decadal Plan has provided strong guidance and focus to these strategic assessments and has played a role in firming up the cross-spectrum package perspective on needs that has now been further developed in this NCRIS proposal. The NCRIS process has underpinned valuable

assessment of trade-offs under different funding scenarios and between the short- and longer-term values of the key infrastructure investments.

These processes have delivered a high degree of coherence in the community's views as to the strategic role of each item of infrastructure and, just as importantly, on the role that can be played in advancing international astronomy through this package of infrastructure investments. This extends to a good understanding of the major questions to be addressed, of the areas in which these infrastructure investments and Australian skills are likely to be able to be competitive, and the way in which the facilities will underpin the progressive evolution of an astronomy capability well beyond the current NCRIS timetable – including strategies in respect of the SKA, the GMT and Antarctic astronomy.

The strategic assessment will include an evaluation of the areas in which Australian astronomy, wider technology and potential sites are competitive – and link this into key aspects of the investment strategy designed both to exploit this competitiveness and to prevent wasteful investment in areas where this competitiveness is not available.

In relation to MIRA and the SKA strategy, a lot of effort has already gone into the strategic assessment – ranging from core capability and array specification sites, approaches to remaining technological constraints and alliances. Similar processes are now well under way in relation to the GMT. The AAO has just been the subject of a major review. Gemini is now a mature facility, and the strategic issues relate to Australian access and Australia's role in future instrumentation to extend its capabilities. The strategic value of an Antarctic instrument is not in question – the PILOT process is direct more at practical implementation issues.

Investment value and value propositions

Of direct relevance to the strategic assessment, and also of direct importance to the investment proposal and the business case, is the value of the objectives of the infrastructure investment package. These matters have been addressed from an NCRIS perspective in Part 3. However, Attachment K and the business case will include a wider coverage, relevant to achieving a full understanding of the value propositions and in support of the implementation strategy – especially in terms of value propositions suited to wider leverage of investment.

Important elements of this value lie in the technology developments and communications infrastructure that will be needed to make these large projects work. The potential (indeed near certainty) of wider spin-offs from these developments – because of their close alignments other areas of industrial physics, ICT and telecommunications – and the regional implications of these facilities (both maintenance of existing facilities such as AAO and the creation of a facility such as MIRA) that are sited well away from capital cities needs to be recognised. The value of these features has already been instrumental in eliciting substantial support – for example from the WA Government – and the business case is being developed to support these processes across the implementation and through to sustainability beyond 2011.

Options-based planning as an integral part of the Business Case

For reasons already outlined, and developed further in Attachment G, cost effective investment in major astronomy infrastructure is necessarily done on an adaptive basis, precluding rigid deterministic roll-out strategies. The proposed investment plan embodies latest thinking – based around the principles of risk-based investment planning and management with a strong emphasis on maximising the value of the options created through the process. This is a logical extension of the thinking already used in the DEST business case for the SKA.

Specific option-based planning models are under development as an integral part of both the business case and the implementation strategy. They are not simply ways of asserting the value of the investment process, but perhaps even more importantly they will assist the community and the government in managing the process to deliver greatest value. As with most options-based planning, these approaches are expected to allow significant savings – through the avoidance of unnecessary investments – and the achievement of growth in the value of outputs via the efficient6

redirection of these funds and through the identification of more valuable ways of developing the infrastructure package over time. The implementation strategy makes explicit allowance for some flexibility between infrastructure classes in the deployment of funds, even during the life of NCRIS, and the methods are being developed to allow this flexibility to be exploited effectively.

The same methods have direct application to sound risk management – with options tools being designed to hedge downside risks while retaining access to upside opportunities in investment – and are discussed further in relation to risk management in Attachment G.

These concepts are absolutely central to the rationale for the PILOT and ELT strategies – both of which are essentially about securing infrastructure options relevant to the next generation of technologies – but also has a lot to offer in respect of the MIRA investment (of value in its own right and for the SKA options it sup-ports) and for the AAO and Gemini strategies, that are again of value in their own right and are expected to provide valuable support for Australia's role in the next generation of large astronomy projects.

Detailed financial plan

Detailed financial plans are currently being prepared. Development to date has been at a level of detail suited to the prioritisation and overarching financial perspective documented already. As timing and aspects of detail are firmed up, these will translate into detailed annual statements of financial performance, financial position and cash flow.

Again, for reasons discussed above, these will not sensibly be definitive. The options modelling will in fact require variants to be developed in relation to major uncertainties – and these models will tie together these alternatives in a coherent manner, analogous to the SKA planning. That said, a clear 'base case' set of financial statements will be developed as a summary – subject to the notes and investment management arrangements.

These accounts will relate to ARA. However, given the importance of the equipment and IP that will be contributed by a range of national and international collaborators, the accounts will be complimented by a summary of the major inputs from these collaborators.

Implementation – Timelines and institutional arrangements

In parallel with the development of the detailed financials and options models, investment timelines will be tightened up beyond the indicative structure now provided – but again retaining a level of optionality built into and managed by ARA.

A very early priority will be the process for establishment of Astronomy Research Australia. Steps are already under way to ensure this can be done rapidly and can bring in the best available skills to ensure this part of the process works well. The institutional requirements for ARA are largely independent of the level of NCRIS funds obtained (assuming they are significant), allowing these steps to commence.

The final proposal will document in detail what has already been done, along with a timeline for remaining steps. These steps relate not just to the legal steps and the appointment of personnel, but also to very early establishment of an appropriate set of arrangements for working effectively with the relevant national and international facilities governance groups.

This is going to be the key exercise through July/August and will need to be done fairly thoroughly. It will require planned timelines by facility (including timing of legal entities), with key steps clearly identified and a project management process set out.

ATTACHMENT A LIST OF ASSETS

The nature, ownership, value and expected date of acquisition of significant assets should be recorded.

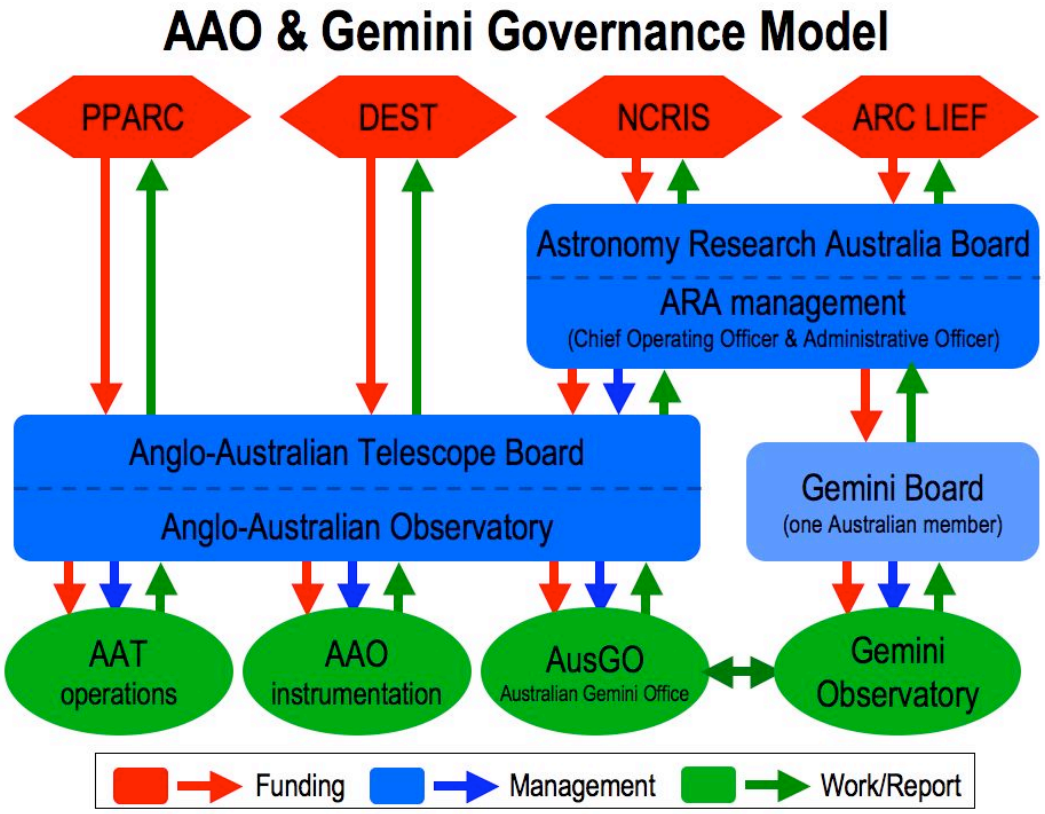
ATTACHMENT B CONSTITUTION / MEMORANDUM OF UNDERSTANDING

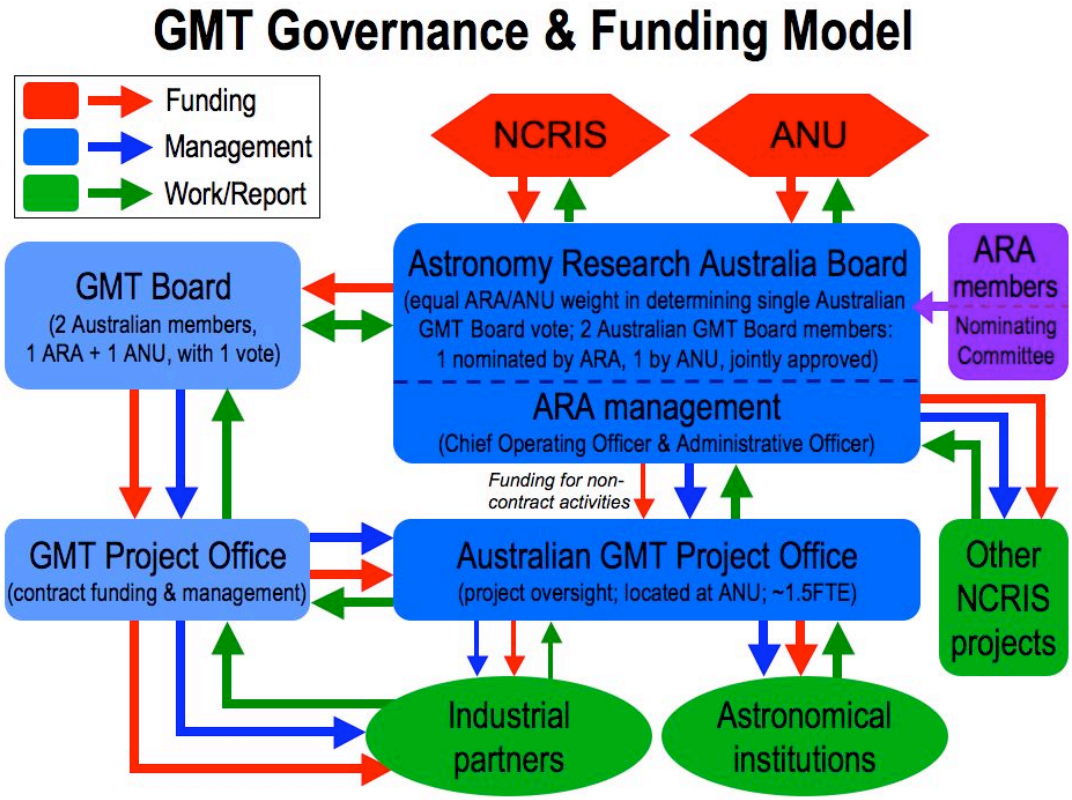
Any company constitution, memorandum of understanding or other agreement relating to entities that will own or operate the NCRIS facilities should be provided if available. Otherwise, a detailed description should be provided of the arrangements that are proposed to be implemented.

ATTACHMENT C ORGANISATION CHARTS

Organisation charts explaining the relationships between entities involved in the project, or showing the management structure within relevant organisations should be provided.

Draft organization charts are included for the Gemini, GMT and AAO. Other details organization charts (PILOT, MIRA) are still the subject of negotiation with international partners.





ATTACHMENT D CURRICULUM VITAE FOR KEY PERSONNEL

Where possible, curriculum vitae for key personnel (maximum of 2 pages per person) involved in the management of the NCRIS facilities should be provided.

ATTACHMENT E IMPLEMENTATION STRATEGY

Full attachment to be prepared, and forward reference to the consolidation document (Attachment K). Not required in detail as part of the progress report, but the fact that good progress has been made can and should be banked.

ATTACHMENT F FINANCIAL STATEMENTS

A financial plan including projected financial statements should be provided as specified in Section 3.4 of the NCRIS Investment Framework

ATTACHMENT G RISK MANAGEMENT STRATEGY

Both this proposed NCRIS investment strategy, and the wider Decadal Plan Strategy, involve large, high cost investments in long-lived research infrastructure assets – with substantial on-going operating, maintenance and upgrade costs, as well as up-front capital costs. Both of financial necessity and to ensure greatest value is extracted from the assets, the investment and access will be international in nature. The technologies underpinning astronomical research are developing rapidly, as is the underlying science. A corollary of the latter is that there is particularly high uncertainty regarding the particular way in which the infrastructure will be deployed in the future.

All of these factors involve important risks that need to be managed. These risks are multi-faceted and range well beyond financial risk. Important elements in the overall risk management include:

- The governance arrangements that will apply to the management of the proposed NCRIS investment, as documented in Part 5 of the application, and as discussed further in Attachment K. This includes reporting and accountability; performance and risk monitoring; and response strategies; adaptive planning; and allocation for responsibilities in respect of specific risk elements.)
- The planned high levels of international leverage, that has the dual effects of limiting the exposure of NCRIS and other Australian astronomy infrastructure investment (and allowing this investment to be spread over a more diverse 'portfolio' of such investments) and the valuable counterchecks provided by all the other participants in vetting the true value fo the proposed investments and their management.
- The presence of established arrangements for access to major astronomy research infrastructure, including for the AAO and Gemini and existing Australian experience with ATNF – and the track record of these arrangements in dealing with changing demands and consortium membership and shares; and
    - international acceptance and support for these arrangements as a basis for moving forward with consortia planning for new facilities.
- The fact that these infrastructure facilities are being designed for maximum flexibility over the planned operating lives – flexibility to accommodate new instruments and uses, and to switch to alternative functions in the future as later generation instruments become available.
- Reinforcing the last point, strong reliance throughout the implementation strategies on cautious project development with an eye to managing risks using state-of-the-art methods for planning, rolling out and managing long-lived investments under high uncertainty.
    - This incorporates strong elements of options-based planning as discussed in Attachment K – designed to manage downside risks while keeping access to upside opportunities, and with a very strong emphasis on the value of flexibility in the investments in skills and infrastructure.
    - A major example of this in relation to the Decadal strategy is the options model prepared as part of the SKA business case – with its demonstrated value in guiding major strategic investment decisions and in valuing the ability to reduce uncertainties before making irreversible commitments..
    - The MIRA project is in fact an integral part of the SKA options strategy.
    - A precisely analogous options approach is proposed for the PILOT project, avoiding irreversible commitment to major capital costs until the case has been fully developed and subject to close scrutiny, and incorporating strategic investments in better information to manage the risks of inappropriate investment. In this context, we see the risks of not properly assessing the option of a major optical instrument in Antarctica as being as relevant to risk management as the risk of building such an instrument and later regretting it.
- The package character of the proposed investments – covering internationally competitive capability across the spectral range. This alone offers substantial flexibility for adapting the investment emphasis over time, based on the insights and technologies then available, and

offers strong prospects for Australia being an important participant in major outcomes from international astronomy, regardless of where they fall.

- Sustainable funding beyond 2011, and the strategies that will be implement ahead of that time to secure adequate and appropriate funding consistent with the objectives of the infrastructure investment.
    - We anticipate that a sound case will emerge from this NCRIS round for a continuing function for a facility analogous to NCRIS. At the same time, it will be important that the strategy be robust enough to deal with loss of this source of funds.
    - Then international leverage built into the infrastructure projects, coupled with the above risk-based planning and management tools, offers a solid starting point but sound risk management will incorporate significant pre-emptive strategy direct at maintaining Australian funding where appropriate.

ATTACHMENT H LETTERS OF COMMITMENT

Letters of commitment should be provided by all parties that have committed any form of assistance or resources to the implementation or operation of this Investment Plan.

The letters should commence in the following fashion:

Dr Mike Sargent AM
Chair
NCRIS Committee
C/- Department of Education, Science and Training
GPO Box 9880
CANBERRA ACT 2601

Dear Dr Sargent

I am writing to confirm the commitment of [name of organisation] to participating in the operation and management of the research infrastructure, and providing the financial and other support, as specified in the National Collaborative Research Infrastructure Strategy Investment Plan for [name of research capability area].

……

Yours sincerely,

ATTACHMENT I FURTHER INFRASTRUCTURE NEEDS

The nature and value of research infrastructure that is required for this capability area, but not included in this Investment Plan should be detailed.

ATTACHMENT J CONFIDENTIAL INFORMATION

No confidential information should be included in this Investment Plan.

If it is considered necessary to provide certain confidential information to the NCRIS Committee in association with this Investment Plan, then a non-confidential summary explaining the nature and ownership of the information should be provided in this Attachment. DEST will contact relevant parties to obtain access to the confidential information in an appropriate manner.

ATTACHMENT K OTHER

Options-based planning: ACIL Tasman Strategy Document