

**The Australian Astronomy
MNRF**

Annual Report 2002-3

Annual Report from the Australian Astronomy Major National Research Facility

Mission: To maximise Australia's engagement in the new generation of optical/infrared and radio telescopes, through world-class scientific research and innovative instrument development programs

Ray Norris, 22 April 2004

Executive Summary

The Australian Astronomy MNRF is a collaborative venture involving nearly all major astronomical institutions in Australia, with the aim of securing significant Australian participation in major new international astronomical facilities at both optical/infrared and radio wavelengths, represented by Gemini and the SKA (Square Kilometre Array) respectively, and adopting a unified approach under the Facility.

The specific objectives of the Facility are to:

- increase Australia's share of premier optical/infrared telescopes such as the Gemini 8-metre twin telescopes;
- develop enabling technologies for Australia to play a key role in, and host, the Square Kilometre Array, the centimetre-wave radiotelescope of the future; and
- use this position to develop the Australian astronomical instrumentation industry.

The MNRF is divided into ten Projects. One of these is the MNRF Office, three relate to Gemini, and six relate to the SKA.

In this first year of the MNRF, there have already been some significant successes, including:

- The negotiation of an additional 1.43% Australian share of Gemini
- The award of a contract from Gemini to RSAA to build the GSAOI instrument
- Development of a prototype Luneburg lens for the SKA, including the patenting of a new material with significant commercial applications
- The completion of the design for the continuum correlator for SKAMP
- The installation of supercomputers at Swinburne and Parkes
- The ranking of Australia as the best country, in scientific and technical terms, for LOFAR, which is a precursor to SKA. This occurred as a direct result of the SKA site selection processes and significantly increases the likelihood that Australia will host SKA.
- The development of a pre-concept study for a new Gemini facility (KAOS).

In summary, the MNRF is off to a good start, with significant advances on nearly all fronts. Although some elements of the MNRF Program have been a little slow in ramping up, no significant problems or setbacks to the goals of the MNRF have been encountered.

CONTENTS	ANNUAL REPORT FROM THE AUSTRALIAN ASTRONOMY MAJOR NATIONAL RESEARCH FACILITY	1
EXECUTIVE SUMMARY		1
1. BACKGROUND		7
2. DETAILED DESCRIPTION		8
2.1 PROJECTS		8
2.2 GOVERNANCE		10
3. PROGRESS AND ISSUES 2002-3		11
3.1 OVERVIEW		11
3.2 PROJECT STATUS SUMMARIES		11
3.3 ISSUES		20
3.4 VARIATIONS TO BUSINESS PLAN		21
3.5 FACILITY'S ACCESS REGIME		22
3.6 PROGRESS WITH ESTABLISHMENT		23
3.7 GOVERNANCE		23
3.8 MILESTONES		23
3.9 COLLABORATION AND LINKAGES		23
3.10 FACILITY'S CONTRIBUTION TO RESEARCH AND TRAINING		26
3.11 COMMERCIALISATION, AND CONTRIBUTION TO AUSTRALIAN INDUSTRY		26
3.12 MARKETING AND PROMOTION		26
3.13 COMPLIANCE WITH BIOLOGICAL & RADIATION SAFEGUARDS AND ENVIRONMENTAL ISSUES ...		28
4. FINANCIAL REPORT		29
4.1 GENERAL EXPLANATORY NOTES		29
4.2 OVERVIEW		30
TABLE 4.1: BUDGET VS. EXPENDITURE FOR 2001/3 BY PROJECT		30
APPENDIX A – PROJECT PLANS		31
APPENDIX A1: MNRF OFFICE PROJECT PLAN		32
SUMMARY		32
1. OVERVIEW AND GOALS		32
2. MAJOR MILESTONES AND PERFORMANCE INDICATORS		32
3. BUDGET		33
4. KEY PERSONNEL		33
APPENDIX A2: INCREASED SHARE OF GEMINI - PROJECT PLAN.....		34
SUMMARY		34
1. OVERVIEW		34
2 GOALS		36
3 MAJOR MILESTONES AND PERFORMANCE INDICATORS		36
4 BUDGET		37
5 KEY PERSONNEL		40
6 ISSUES		40
7 PROJECT PLAN		41
8 INTELLECTUAL PROPERTY AND COMMERCIALISATION		41
9 EDUCATION AND OUTREACH		41
APPENDIX A3: RSAA GEMINI INSTRUMENTATION - PROJECT PLAN		43
1. OVERVIEW		43
2. GOALS		43
3. TIMELINES AND BUDGET		45
4. KEY PERSONNEL		46
5. ISSUES		46
6. PROJECT PLAN		46
7. INTELLECTUAL PROPERTY AND COMMERCIALISATION		46
8. EDUCATION AND OUTREACH		46

APPENDIX A4: AAO INSTRUMENTATION - PROJECT PLAN.....	47
EXECUTIVE SUMMARY.....	47
1 OVERVIEW.....	47
2 MAJOR MILESTONES.....	48
3 TIMELINES AND BUDGET.....	48
4 KEY PERSONNEL.....	49
5 ISSUES.....	49
6 PROJECT PLAN.....	49
7 INTELLECTUAL PROPERTY AND COMMERCIALISATION.....	49
8 EDUCATION AND OUTREACH.....	49
9 KEY PERFORMANCE INDICATORS.....	49
APPENDIX A5: AUSTRALIA TELESCOPE COMPACT ARRAY BROADBAND BACKEND (CABB) - PROJECT PLAN.....	50
EXECUTIVE SUMMARY.....	50
1. OVERVIEW.....	50
2 GOAL.....	51
3. MILESTONES.....	51
4 TIMELINES AND BUDGET.....	52
5 KEY PERSONNEL.....	52
6 PROJECT PLAN.....	52
APPENDIX A6: NEW TECHNOLOGY DEMONSTRATOR - PROJECT PLAN.....	54
EXECUTIVE SUMMARY.....	54
1. OVERVIEW.....	54
2. GOALS.....	57
3. MAJOR MILESTONES.....	57
4. TIMELINES.....	58
5. KEY PERSONNEL.....	59
6. ISSUES.....	60
7. PROJECT PLAN.....	60
8. INTELLECTUAL PROPERTY AND COMMERCIALIZATION.....	61
9. EDUCATION AND OUTREACH.....	61
10. KEY PERFORMANCE INDICATORS.....	61
APPENDIX A7: MMIC DEVELOPMENT - PROJECT PLAN.....	62
EXECUTIVE SUMMARY.....	62
1 OVERVIEW.....	62
2 GOALS.....	62
3 MAJOR MILESTONES.....	63
4 TIMELINES AND BUDGET.....	63
5 KEY PERSONNEL.....	64
6 ISSUES.....	64
7 PROJECT PLAN.....	64
8 INTELLECTUAL PROPERTY AND COMMERCIALISATION.....	65
9 EDUCATION AND OUTREACH.....	65
10 KEY PERFORMANCE INDICATORS.....	65
APPENDIX A8: SKAMP (SKA MOLONGLO PROTOTYPE) PROJECT PLAN.....	67
EXECUTIVE SUMMARY.....	67
1 OVERVIEW.....	67
2 SCOPE OF THE SKAMP PROJECT.....	68
2 GOALS.....	70
3 MAJOR MILESTONES.....	70
4 TIMELINES AND BUDGET.....	70
5 KEY PERSONNEL.....	71
6 ISSUES.....	73
7 PROJECT PLAN.....	73
8 INTELLECTUAL PROPERTY AND COMMERCIALISATION.....	75
9 EDUCATION AND OUTREACH.....	75

10 KEY PERFORMANCE INDICATORS	76
APPENDIX A9: SKA SITING PROJECT PLAN.....	77
1 OVERVIEW	77
2 GOALS	77
3 MILESTONES, TIMELINES AND BUDGET	78
4 KEY PERSONNEL	80
5 ISSUES	80
6 PROJECT PLAN	80
7 INTELLECTUAL PROPERTY AND COMMERCIALISATION.....	80
8 EDUCATION AND OUTREACH.....	80
APPENDIX A10: SKA SUPERCOMPUTER SIMULATIONS AND BASEBAND PROCESSING (SKASS) - PROJECT PLAN	81
EXECUTIVE SUMMARY.....	81
1) SUMMARY STATEMENT OF WORK, DELIVERABLES & PAYMENT TABLE	82
2) PROJECT PLAN.....	86
APPENDIX B: INDIVIDUAL PROJECT REPORTS.....	97
APPENDIX B1: MNRF OFFICE - PROJECT REPORT FOR FY2002-2003	98
EXECUTIVE SUMMARY	98
1. MILESTONES.....	98
2. OTHER ESTABLISHMENT ISSUES.....	99
3. COLLABORATION AND LINKAGES.....	99
4. FINANCIAL REPORTING.....	100
APPENDIX B2: INCREASED SHARE OF GEMINI - PROJECT REPORT FOR FY2002-2003	102
EXECUTIVE SUMMARY	102
1. MILESTONES.....	103
2. OTHER ESTABLISHMENT ISSUES.....	103
3. FACILITY'S ACCESS REGIME.....	104
4. COLLABORATION AND LINKAGES.....	105
5. FACILITY'S CONTRIBUTION TO RESEARCH AND TRAINING.....	106
6. CONTRIBUTION TO AUSTRALIAN INDUSTRY	106
7. PROMOTION OF THE FACILITY	107
8. COMMERCIALISATION AND INFORMATION TRANSFER.....	108
9. FINANCIAL REPORTING.....	109
APPENDIX B3: RSAA GEMINI INSTRUMENTATION - PROJECT REPORT FOR FY2002-2003.....	110
EXECUTIVE SUMMARY.....	110
1. MILESTONES.....	110
2. OTHER ESTABLISHMENT ISSUES.....	111
3. RESEARCH, ACCESS & COLLABORATION	111
4. PROMOTION OF THE FACILITY.....	112
5. COMMERCIALISATION.....	113
6. FINANCIAL REPORTING.....	113
APPENDIX B4: AAO INSTRUMENTATION - PROJECT REPORT FOR FY2002-2003.....	115
EXECUTIVE SUMMARY	115
1. MILESTONES.....	115
2. OTHER ESTABLISHMENT ISSUES.....	115
3. RESEARCH, ACCESS AND COLLABORATION	115
4. PROMOTION OF THE FACILITY	116
5. COMMERCIALISATION.....	116
6. FINANCIAL REPORTING	116
APPENDIX B5: AUSTRALIA TELESCOPE COMPACT ARRAY BROADBAND BACKEND (CABB) - ANNUAL REPORT FOR FY2002-2003.....	118

1. OVERVIEW	118
2. MILESTONES	118
3. OTHER ESTABLISHMENT ISSUES	119
4. COLLABORATION AND LINKAGES	119
5. FINANCIAL REPORTING	119
APPENDIX B6: NEW TECHNOLOGY DEMONSTRATOR - PROJECT REPORT FOR FY2002-3	122
EXECUTIVE SUMMARY	122
1. MILESTONES	122
2. OTHER ESTABLISHMENT ISSUES	123
3. RESEARCH, ACCESS & COLLABORATION	123
4. FACILITY'S CONTRIBUTION TO RESEARCH AND TRAINING	124
5. PROMOTION OF THE FACILITY	124
6. COMMERCIALISATION	125
7. FINANCIAL REPORTING	125
8. DETAILED PROJECT ACTIVITY	127
APPENDIX B7: MMIC DEVELOPMENT - ANNUAL REPORT FOR FY2002-2003	132
EXECUTIVE SUMMARY	132
1. OVERVIEW OF PROGRESS IN 2002-3	132
2. MILESTONES	132
3. PROMOTION OF THE FACILITY	133
4. FINANCIAL REPORTING	134
APPENDIX B8: SQUARE KILOMETRE ARRAY MOLONGLO PROTOTYPE (SKAMP) - PROJECT ANNUAL REPORT FOR FY2002-2003	137
EXECUTIVE SUMMARY	137
1. MILESTONES	137
2. OTHER ESTABLISHMENT ISSUES	138
3. RESEARCH, ACCESS & COLLABORATION	138
4. PROMOTION OF THE FACILITY	139
5. COMMERCIALISATION	139
6. FINANCIAL REPORTING	140
APPENDIX B9: SKA SITE STUDIES - PROJECT REPORT FOR FY2002-2003	141
1. MILESTONES	141
2. OTHER ESTABLISHMENT ISSUES	142
3. COLLABORATION AND LINKAGES	142
4. MARKETING	143
5. PROMOTION	143
6. FINANCE	143
APPENDIX B10: SKA SUPERCOMPUTER SIMULATIONS AND BASEBAND PROCESSING (SKASS) - PROJECT REPORT FOR FY2002-3	144
EXECUTIVE SUMMARY:	144
1. MILESTONES	144
2. OTHER ESTABLISHMENT ISSUES	150
3. RESEARCH ACCESS AND COLLABORATION	151
4. MARKETING AND PROMOTION OF THE FACILITY	153
5. COMMERCIALISATION	154
6. FINANCIAL REPORTING	154
7. DETAILED PROJECT REPORTS AND RESEARCH HIGHLIGHTS	155
APPENDIX C: COMPOSITION OF INTERIM AABOM	164
APPENDIX D: COMPOSITION OF CURRENT AABOM AS AT NOVEMBER 2003	164
APPENDIX E: GLOSSARY	165
APPENDIX F: CERTIFICATIONS	168

APPENDIX G: FINANCIAL TABLES	176
G1 DIFFERENCES IN SPREADSHEETS FROM THOSE SUPPLIED BY DEST.....	176

1. Background

In 2001, the ATNF led a proposal, on behalf of the Australian astronomical community, to the Federal Government’s “Major National Research Facilities” (MNRF) program. The proposal was awarded \$23.5m over 5 years, and also attracted \$28.5m of matching funding from participants and their sponsors.

The broad goal of the Australian Astronomy MNRF is to maintain the pre-eminent position of Australian astronomy by investing in the two main areas of radio and optical/infrared astronomy, represented by the SKA and Gemini respectively, and adopting a unified approach under the Facility.

The specific objectives of the Facility are to:

- increase Australia’s share of premier optical/infrared telescopes such as the Gemini 8-metre twin telescopes;
- develop enabling technologies for Australia to play a key role in, and host, the Square Kilometre Array, the centimetre-wave radiotelescope of the future; and
- use this position to develop the Australian astronomical instrumentation industry.

The MNRF includes 12 participants, listed in Table 1, each of whom have agreed to provide matching funding either as cash or as in-kind support.

	Institution	Total matching contribution (\$m)
1	CSIRO ATNF	8.2
2	Sydney Uni	2.9
3	AAO	2.6
4	ANU	2.4
5	Swinburne Uni	1.2
6	UNSW	1.1
7	WA	0.8
8	CTIP	0.8
9	U. Melbourne	0.3
10	APT	0.1
11	CEA	0.1
12	Dell	0.1
	ARC*	0

**Note that the ARC declined to be a formal participant, but is a major stakeholder and ultimately provides much of the matching funding for Gemini.*

The ARC also has a role in the MNRF in so far as it has the responsibility for negotiating Australia’s bid for an increase in Gemini observing time, and providing the Australian Gemini Steering Committee (AGSC) to advise the MNRF.

We are pleased to report that, since this MNRFP Program started, we have been joined by a number of other participants, including:

- Cisco Systems (Australia)
- Connell Wagner
- CSIRO Manufacturing and Industry Technology
- CSIRO Molecular Science
- Macquarie University Centre for Electromagnetic and Antenna Engineering

These new participants, while contributing significantly to the Program, have no formal obligation to the MNRFP Program and so their very important contributions are not listed in the financial tables.

2. Detailed Description

2.1 Projects

The MNRFP consists of ten separate projects, listed in Table 1. Detailed project descriptions are given in Appendices A1-A10.

Project #	Project name	Main participants	Description	MNRFP funding (A\$m)	Matching contribution (A\$m)	Total project Size (A\$m)
1.	MNRFP project office	ATNF	Organisation and administration of the MNRFP	0.848	0.25	1.098
2.	Gemini (increased share)	RSAA UNSW SydU ATNF UMelb Swinburne	Purchase an increased share in the Gemini consortium	14.527	16.568	31.095
3.	Gemini (RSAA instrumentation)	RSAA	Contribute matching funding through construction of instrumentation for Gemini	0	1.213	1.213
4.	Gemini (AAO instrumentation)	AAO	Contribute matching funding through construction of instrumentation for Gemini	0	2.6	2.6
5.	CABB	ATNF	Develop correlator technology to upgrade the ATCA Array to 2 GHz bandwidth	2.375	2.9	5.275

6.	NTD	ATNF CTIP CEA APT	Develop multi-beaming antenna technology and advanced optical signal transport and signal processing schemes, by constructing new technology demonstrator antennas and developing interference mitigation techniques.	2.535	4.05	6.585
7.	MMIC	ATNF	Development of integrated RF systems on MMIC chips	1.45	1.8	3.25
8.	SKAMP	Sydney Uni	Develop broadband, high-speed signal processing technology, multi-beaming and wide field of view techniques, and low-cost cylindrical antenna technology, upgrading the Molonglo telescope as an SKA demonstrator.	0.739	0.995	1.734
9.	Siting	WA ATNF	Evaluate potential sites for suitability for the SKA	0	0.8	0.8
10.	SKASS	Swinburne Dell	Supercomputing simulations of SKA design and development of baseband recording and software correlation techniques.	1.026	1.15	2.176
	TOTAL			23.5	28.513	52.013

2.2 Governance

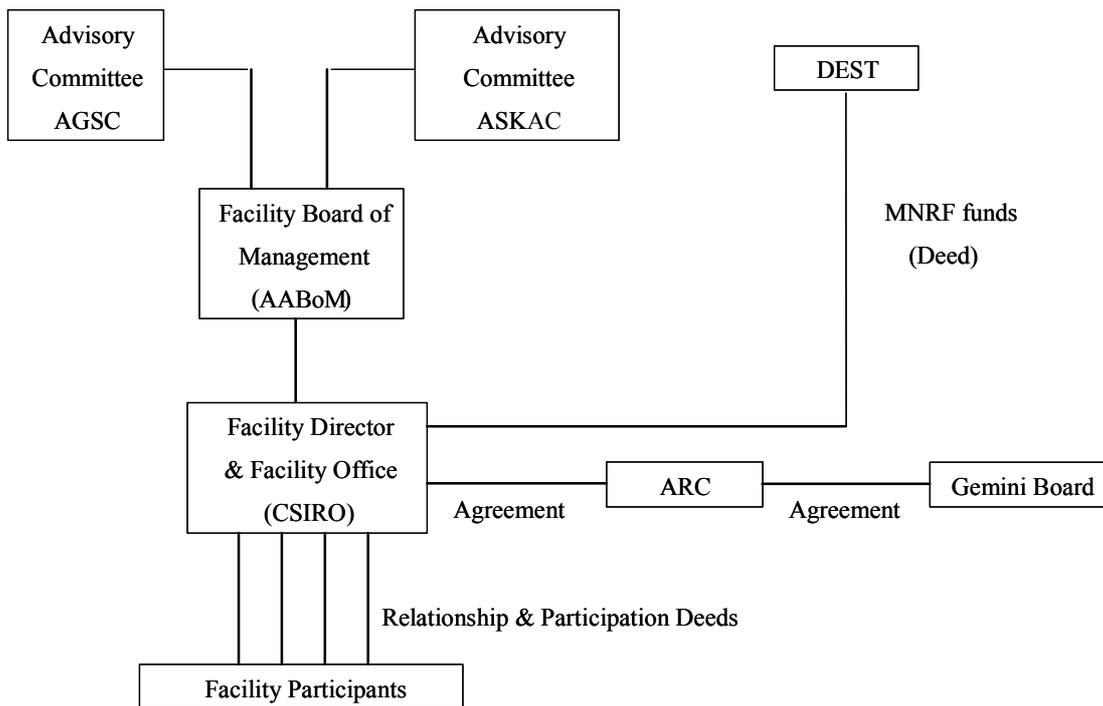


Figure 1: Relationships within the MNRF

Figure 1 shows the relationships within the MNRF. The MNRF is operated by the Facility Director, who manages a Facility Office hosted by CSIRO ATNF. The Director reports to the Board (AABoM, for Australian Astronomy Board of Management). AABoM are advised by the Australian Gemini Steering Committee (AGSC) and the Australian SKA Consortium (ASKAC).

Funding is provided to the Facility Office by DEST, who in return are provided with annual reports, performance indicators, etc.

Funding to participants is provided by the Facility Office. This funding is contingent on receipt of satisfactory progress reports detailing performance against agreed milestones.

The Australian Research Council (ARC) manages the relationship with the Gemini consortium, including negotiating additional Australian membership. Payment for additional time is made by the Facility Office to the Gemini consortium on request from the ARC.

At the time of signing the MNRF Deed with DEST (4 November 2002), the participants were unable to find a composition of the Board that satisfied all their requirements. Therefore, that Deed stated that the initial board (see Appendix C) would last for six months and would then produce recommendations on the future composition of the board. At the AABoM meeting of 7 March 2003, a possible composition was discussed and agreed on, resulting in a position paper and a subsequent email discussion by AABoM members and MNRF participants. That discussion reached a broad consensus for a board of eight members as follows:

- 2 members nominated by ASKACC
- 2 members nominated by AGSC
- 1 member nominated by CSIRO
- 1 member nominated by the NCA
- 1 member nominated by the ARC
- The Facility Director (non-voting)

All MNRF participants other than the ARC and CSIRO have the opportunity to nominate and to vote on the AGSC and ASKACC members. This new board structure was voted on by participants, and the result declared on 29 May 2003. It was subsequently approved by DEST and by CSIRO. The current composition of the Board is listed in Appendix D.

3. Progress and Issues 2002-3

3.1 Overview

This section gives an overview of the progress of each project, together with highlights and significant milestones achieved in 2002-3. Further project-specific milestones are listed against the project plans in appendices B1-B10. While some projects are forging ahead on schedule, start-up on some has been slightly slower than envisaged. However, we do not see any significant obstacles in any of the projects of the MNRF.

3.2 Project Status Summaries

Detailed project Reports, including performance against milestones, are given in Appendices B1-B10 for each project. Here we give a short summary of the status for each Project.

3.2.1 The MNRF Office

The MNRF Office was set up to administer the Australian Astronomy MNRF. In this start-up phase, progress has been good, and most milestones were achieved. Hurdles included the complexity imposed by the conflicting requirements of DEST, CSIRO, and ARC, and the extensive reporting requirements which some participants found difficult to manage. At the start of the MNRF, it was not possible to devise a satisfactory Board structure, and so an interim board structure was set up. A new board structure has now been set up within the period specified in the start-up deeds, and the MNRF program is now on a sound footing. The project finances are roughly on track, and the MNRF Office has underspent by 8% compared to its projected budget in this reporting period.

3.2.2 The Gemini Project



The Gemini-South telescope at Sunset

The primary goal of this project is to purchase an increased Australian share in the Gemini Partnership. This has been successful, and an additional 1.43% share of Gemini has been purchased. Because of delays in the international negotiations, the initial payments were not made in the 2002/3 reporting period, resulting in a large balance carried forward of \$2.051m. Most of this was used to make an initial Gemini payment in October 2003.

3.2.3 RSAA Gemini Instrumentation



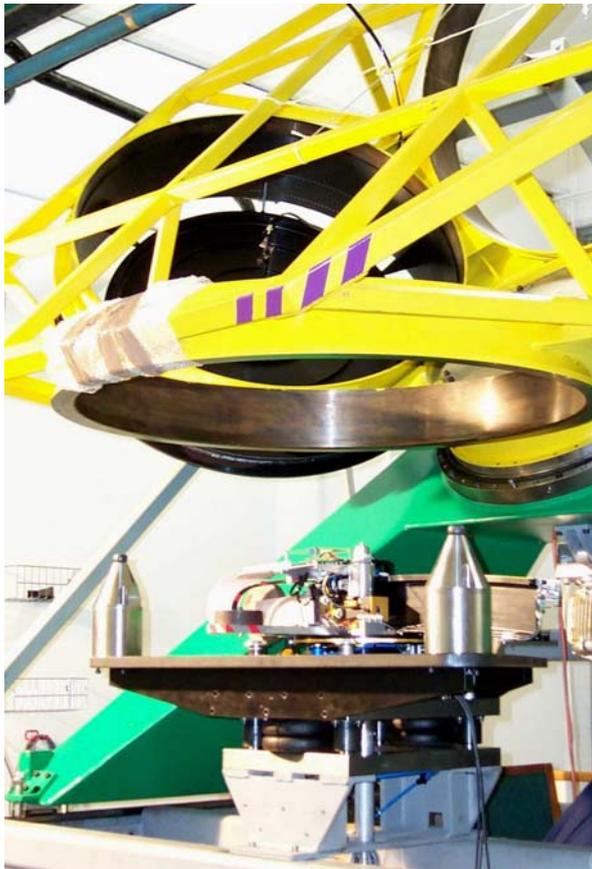
Adjustment of the NIFS instrument at RSAA in October 2002, shortly before it was destroyed by fire

The Research School of Astronomy and Astrophysics (RSAA) Of the Australian National University (ANU) offered to make an in-kind contribution to the Gemini project by contributing the unreimbursed labour associated with constructing Gemini instrumentation. Since making that commitment, RSAA were hit by tragedy in the Canberra bush fires in January 2003. However, RSAA were also in the fortunate position of

- making excellent progress on the construction of the Near-infrared Integral Field Spectrograph (NIFS) for Gemini. Although the NIFS instrument was destroyed by the bushfires as it neared completion, all the plans and designs were saved, and a new NIFS instrument is now being constructed by Auspace Pty Ltd under contract to RSAA.
- being awarded a contract from Gemini to build the Gemini South Adaptive Optics Imager (GSAOI).

As a result, RSAA are making an in-kind contribution of \$420k to the MNRF in this reporting period, compared with the \$243k to which they were committed in the Business Plan.

3.2.4 AAO Instrumentation



The robot being installed in the OzPoz spectrograph at the AAO

The AAO proposes to enhance the Australian astronomy community's engagement with 8m and larger telescopes, while providing an in-kind contribution to this MNRF. It will do this by

- providing resources to support the 'back office' functions for the allocation of observing time on Australia's share of the International Gemini Observatory,

- developing and implementing new instrumentation technologies, which enhance the scientific interests of Australian astronomers in their use of Gemini and other telescopes of 8m class and larger.
- developing a prototype of the Kilo-Aperture Optical Spectrograph (KAOS) for Gemini.

3.2.5 Australia Telescope Compact Array Broadband backend Upgrade (CABB)



The Australia Telescope Compact Array

This program will deliver a new broadband backend system for the Australia Telescope Compact Array (ATCA) at Narrabri which will

- improve the continuum sensitivity of the ATCA by at least a factor of four and provide a greatly enhanced spectral line performance,
- provide for connections to additional antennas, such as might be constructed as part of the NTD project, or for special reference antennas required for interference mitigation,
- develop new correlator technology and signal processing components for the SKA

In this reporting period, good progress has been made in several areas, but there were unexpected problems with the complex Field Programmable Gate Array design software, which have pushed the project behind the schedule envisaged in the business plan. Such problems are not surprising when working at the cutting edge of technology. This delay has been compounded by a lack of available staff, caused by unrelated factors. As a result, the project is significantly behind the schedule

described in the business plan, and resulted in a significant underspend. We present a revised project plan in Appendix A5. Despite this slow start-up, it is expected that this lost ground will be made up in subsequent years, particularly because of the experience gained in some of the areas that caused the delays. The final completion date for this project remains unchanged.

3.2.6 SKA New Technology Demonstrator (NTD)



The Konkur Luneburg lens with prototype feed translator arms

The goal of the NTD project is to develop a wideband, multi-beam technology demonstrator comprising a “mini-station” of a next-generation radio telescope, incorporating the core technologies of:

- wide field-of-view microwave lenses (“Luneburg lenses”) or phased-array antennas;
- optical signal transport; and
- digital signal processing techniques such as achromatic beam-forming and wide-field imaging.

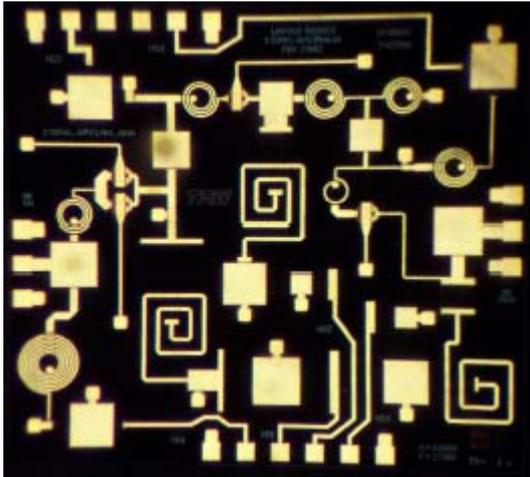
The Luneburg Lens prototyping work is progressing well, and a new feed translator system for the Lens has been designed and manufactured. A new artificial dielectric material has been developed, and the manufacturing process for this has been patented.

There has been some slippage in the lens project milestones due to the challenges involved in developing the new manufacturing process. Delivery of a prototype 0.9 m Luneburg Lens constructed from the new dielectric material is now expected by

December 2003 instead of July 2003. It is still expected that the choice of demonstrator concept will be made by 30 June 2004, as proposed in the MNRF Business Plan. Further work is required to determine whether the Luneburg Lens concept is appropriate for the SKA context or whether its use will be confined to commercial development only.

This project is significantly overspent, partly because of a willingness by participants to invest even more heavily in this area of technology development than was originally envisaged. The project plan will be revised accordingly in 2003/4.

3.2.7 MMIC Development



An early prototype integrated receiver chip, developed as part of this MNRF

The MMIC Development Program will deliver Monolithic Microwave Integrated Circuits (MMICs) for inclusion in the various SKA demonstrators including the Australia Telescope Compact Array Broadband Backend (CABB), the SKA Molonglo Prototype (SKAMP) and other enhancements of ATNF telescopes. These components will include high-speed digital devices for data sampling and transmission, broadband low noise microwave amplifiers and integrated receiver and beam-forming systems. This project will also develop generic technology and expertise for eventual use in the SKA and other next-generation radio-telescopes.

As the design of these other projects proceeded, the MMIC requirements became clearer and the specific goals of the MMIC project have been adjusted to meet these requirements. The first year of the project has been successful, not only in beginning the planned first MMIC fabrication run on time but also in laying the foundation for future activities. The major achievement in this period was the completion of a number of InP MMIC designs and their submission for a fabrication run in March 2003. Designs included a range of broadband low noise microwave amplifiers covering the 1 to 12 GHz band and a 40GHz data amplifier aimed at multi-Gbit data transfer systems.

This project has successfully ramped up, and during this reporting period marginally overspent as described in Appendix B7.

3.2.8 SKA Molonglo Prototype (SKAMP)



The Molonglo Telescope

This project is a joint venture between the University of Sydney and CSIRO. Its overall goal is to upgrade the Molonglo telescope to be a world-class spectral line instrument, at the same time developing technologies of relevance to SKA.

The project has been very successful during this reporting period, and all milestones have been completed on schedule. Highlights include the completed design for the 96 station continuum correlator, and the scoping of the wideband feed project. The project has marginally underspent as described in Appendix B8.

3.2.9 SKA Siting project



Mileura station, WA, which is a prime candidate site for the central cores of both LOFAR and SKA, being viewed by Colin Lonsdale (MIT) and Ray Norris (ATNF).

This project has the goal of determining requirements and characteristics for Australian siting for the SKA telescope. The project will respond to requests from the international radio astronomy community for general information regarding Australian siting for next-generation radio telescopes. The WA Government is a formal MNRF participant in this project and is contributing its own resources to site studies for future radio telescopes in its State. As a result, this project includes WA-specific outcomes. Studies specific to States other than Western Australia are also being conducted, but are outside the scope of this MNRF.

The project has been very successful thus far, and has received a boost from our WA candidate site at Mileura being ranked (on the basis of scientific and technical criteria) by the Low Frequency Array (LOFAR) site evaluation committee as the best site in the world for LOFAR. This occurred as a direct result of the interference measurements and other site studies that had been done for the SKA. As a result of this choice of candidate site for LOFAR, suitable regions of the Mid West region of WA have been excluded from mining exploration, and these regions have been carefully characterized. Much of this site characterisation work is common to both LOFAR and SKA, and in this and many other respects, LOFAR may be viewed as Phase 1 of SKA. LOFAR is also being used as a test case for future radio telescope siting to enable Australia to be in the best competitive position when detailed SKA siting requirements become known.

During this reporting period, the WA Government have committed \$142k compared to the \$200k commitment in the Business Plan. The Western Australian Government, through the Department of Premier and Cabinet, has elected to internally absorb some of the salary costs of contributing to the MNRF and not allocate them to the project. This will enable funds to be carried forward into 2004 in anticipation that those funds will be allocated to a comprehensive field testing program.

3.2.10 SKA Supercomputer Simulations and Baseband Processing (SKASS)



The supercomputer installed at Swinburne as part of this MNRF

This SKA-related program at Swinburne University of Technology (SUT) is investigating the ways in which supercomputers can be used to assess and improve the potential capabilities of the SKA, through simulations of sources of radio emission and through the collection and analysis of real radio astronomy data. As a consequence of these activities, tools and hardware will be developed that will significantly enhance the capabilities of existing radio astronomy facilities at the Parkes Observatory and the Australia Telescope Compact Array (ATCA).

The first year of this project has been a success. All stated research goals for the first year of the project have been met. Operational supercomputers have been established, verified, and benchmarked at the Hawthorn campus of the University and at the Parkes Observatory. These machines are now operational and available for use by the MNRF consortium as well as by outside users, both domestic and international, providing increased opportunities for scientific research and development to Australian scientists, and potential commercial opportunities for SUT. These machines have been used to complete the first year research milestones for the project. This has been achieved despite a slight underspend described in Appendix B10. This is attributed to start-up delays and is not expected to continue.

A boost to this project has come from Australia's involvement with LOFAR, since simulation software written at Massachusetts Institute of Technology (MIT) for LOFAR has been ported to the Swinburne supercomputer and is now being used for

SKA simulations. This underlines the degree of similarity and potential cross-fertilisation between SKA and LOFAR.

3.3 Issues

3.3.1 Gemini

As noted in Appendix A2, we have not yet secured the level of access to Gemini that was envisaged in the MNRF proposal. This, together with the strengthening Australian dollar (see Fig. 1) leaves a predicted balance of \$5.253m (assuming an exchange rate of 0.60). This sum offers the opportunity for further Australian access to large telescopes such as Gemini, in order to complete the goals of the MNRF.

The rate of 0.60 is used as it is the approximate two-year average exchange rate, and so is the most appropriate rate to use when making long term budget plans. At the current exchange rate (0.67) the total Gemini balance will be \$6.223m, and if the Australian dollar reaches US\$0.70 the balance will be \$6.579m.

This balance may be used to take advantage of any of all of the following potential opportunities:

1. Purchase a greater share of Gemini, should it become available
2. Purchase “additional nights” on Gemini from other members
3. Cover fluctuations in exchange rate, should the Australian dollar fall
4. Commence design studies or detailed negotiations, or build instrumentation, to secure a strategic advantage for Australia in Gemini or other world-class or next-generation telescopes.

Options 1-3 are within the scope of the MNRF proposal and business plan. While Option 4 is within the spirit of the MNRF proposal, it may fall beyond the specific goals set out in the Deeds and Business Plan. A number of opportunities have been identified, and they will be pursued with full community consultation within the broad goals of the MNRF.

3.3.2 SKA and LOFAR

SKA clearly remains the primary long-term strategic goal for Australian radio-astronomy. However, because of MNRF-related activities, an opportunity has arisen to participate in the design and construction of a “Phase 1” SKA in the shape of the international Low Frequency Array (LOFAR) project. By participating in LOFAR, the strategic outcomes of the MNRF are likely to be significantly enhanced. Furthermore, the LOFAR construction timescale is very similar to that of the MNRF.

LOFAR is conceptually a very similar instrument to SKA, and shares many technologies, but it is less ambitious and construction could start in 2004-5. Several overseas commentators have noted that if LOFAR is built in Australia, then there is a high probability that SKA will also be built in Australia. Thus, LOFAR is an attractive stepping-stone towards SKA, for the following reasons:

- LOFAR increases the probability that SKA will be built in Australia,
- LOFAR demonstrates to our international partners the feasibility of building and operating such an array in Australia,
- LOFAR serves as a prototype for many of the technologies that we are developing for SKA,

- LOFAR maintains the momentum, providing a useful stepping-stone between now and the start of construction of SKA in 2010.

At present, none of the objectives of any of the MNRF projects have been altered in response to this new opportunity, and SKA work is proceeding as planned. While LOFAR represents an exciting opportunity to advance our SKA goals, and thus is within the spirit of the MNRF proposal, it may fall beyond the specific goals set out in the Deeds and Business Plan. We intend to set up a community consultation process to establish the optimum strategy for integrating LOFAR and SKA.

Although no funds from this MNRF have been expended on LOFAR, LOFAR technology (which is very similar to SKA technology) is already being used to further the goals of the SKA project. For example, an extensive suite of LOFAR simulation software developed at Massachusetts Institute of Technology (MIT) has been shared with Swinburne, as a potential LOFAR partner, at no cost, and has been installed on the Swinburne supercomputer and used for SKA simulations.

3.3.3 CSIRO ICT Centre

One participant, CTIP (CSIRO Telecommunications and Industrial Physics), has undergone restructuring since the MNRF came into being, and the parts of CTIP which were involved in this MNRF have moved into a new CSIRO Division – CICTC (CSIRO Information and Communications Technologies Centre). Although the previous details of the new arrangements are not yet clear, as a Director for the CICTC has not yet been appointed, it is expected that CICTC will take over the role of CTIP in this MNRF.

3.3.4 New Defence Headquarters near MOST

In late 2002 it was announced that a new Operational Headquarters of the Defence Department was to be constructed only a few kilometres from the Molonglo telescope, which is being upgraded under the SKAMP project of this MNRF. Radio signals from this new building have the potential to interfere with the operation of the upgraded telescope, and could be a potential threat to this MNRF. The Defence Department are working with Sydney University to explore options to remove or mitigate the effects of the interference. Options include setting up a joint research project to develop radio frequency interference mitigation techniques over the period 2004-2006.

3.4 Variations to Business Plan

3.4.1 Overview

There have been no significant changes to the business plan. All goals and overall budgets remain substantially as stated in the original business plan drawn up in November 2002. However, there are a number of changes in detail, particularly regarding the detailed funding profile of individual projects. During FY2003/4, a new business plan will be drawn up incorporating these changes, and forwarded to DEST for approval.

3.4.2 Variation to Board Composition

The composition of the Board (AABoM) has been changed from the initial composition as foreseen in the original Business Plan. This change, and the resulting

membership, has been approved by both DEST and CSIRO, and agreed to by all participants and members of the initial board.

3.4.3 Variation to AAO Schedule of matching contributions

Section 3.3.3(i) of the business plan outlines the contribution to be made by the Anglo-Australian Telescope Board (the entity which is responsible for the Anglo-Australian Observatory). The contributions outlined in the business plan are tentative in nature and remain so. Instrumentation opportunities which are expected to arise in 2003/4 are likely to result in a firmer schedule in the 2003/4 annual report. The value of in-kind contributions from instrument development for 2003/4 was \$52k compared to the tentative schedule value of \$100k, so the schedule of in-kind contributions has been adjusted (see appendix A3) to reflect this while keeping the total commitment over the lifetime of the MNRF unchanged.

3.4.4 Variation to RSAA Schedule of matching contributions

As shown in Appendix A4, the profile of the in-kind contribution of RSAA has changed slightly to accommodate the changing circumstances resulting from the Stromlo fires and the new instrument contracts. The total in-kind contribution over the period of the MNRF is unchanged, and the profile of the cash contribution is unchanged.

3.4.5 Variation to SKASS Schedule of matching contributions

The cash contribution from Dell has been moved from 2002/3 to 2003/4.

3.4.6 Variation to CABB plan

As described in detail in Appendix A5, the budget profile for CABB has been revised from the business plan, but the total amounts, goals, and timescales for completion are identical. The descriptions of deliverables have been finalised.

3.4.7 Variation to MMIC plan

As described in detail in Appendix A7, the profile of the MMIC project has been refined since writing the business plan, resulting in a revised profile of funding and project goals, but maintaining the same overall plan and funding totals.

3.5 Facility's Access regime

Gemini

Access to the additional share of the Gemini telescopes that has been purchased through this MNRF is available to all Australian astronomers, free of charge, through a peer-review process described in Appendix A1.

ATCA

As part of the development of SKA technologies by projects CABB and MMIC, the Australia Telescope Compact Array (ATCA) will be upgraded, and access to this upgraded ATCA will be available to all Australian astronomers, free of charge, through a peer-review process described in Appendix A5.

SKAMP

The SKAMP project will upgrade the Molonglo telescope. On completion of the SKAMP project, it is planned that proposals for observations will be submitted to the

Australia Telescope Time Assignment Committee (TAC) for peer review. Observing time will be allocated based on the TAC ranking, with some time set aside for maintenance, development, and Director's discretionary time.

SKASS

The supercomputers funded by this project are available to all astronomers upon request, as described in Appendix A10.

3.6 Progress with Establishment

The Australian Astronomy MNRF is up and running, and delivering against milestones. Significant establishment milestones include:

- The signing of the MNRF deed and relationship deed in November 2002
- The appointment of an MNRF Director (R.P.Norris) in November 2002
- The appointment of an interim Board in November 2002
- The appointment of a newly constituted Board in July 2003.

3.7 Governance

Details of governance are given in Section 2 above, and the initial and final board compositions are given in Appendices C and D.

3.8 Milestones

Detailed tables of performance against milestones for the individual projects are given in Appendices B1-B10.

3.9 Collaboration and Linkages

A key goal of this MNRF is to foster and enhance strategic collaborations at both the national and international level.

3.9.1 Strategic Partnerships: international

Gemini and the SKA are major international collaborations. This MNRF enhances Australia's role in the strategic planning and implementation of both programs.

Gemini

The Gemini partnership includes the following countries: USA, UK, Canada, Brazil, Argentina, Chile, and Australia. The enhanced role provided by this MNRF has allowed greater Australian engagement with these strategic partners, who play a major role in setting the future directions of world astronomy. This occurs at all levels:

- Scientific – through increased telescope access and collaboration with international astronomers
- Technological – through increased participation and influence in the Gemini instrumentation program.
- Strategic – through an enhanced role in key Gemini advisory positions, including Gemini Board, Gemini Advisory Committees, Gemini New Initiatives Office.

A specific example of Australian international scientific leadership was the Second Gemini Future Instrumentation Workshop held in Aspen, Colorado, in June 2003, where the Gemini Partnership came together to determine its scientific aspirations and new instrumentation needs. One of the primary goals of the Gemini MNRF project is

to increase Australian engagement in the Gemini instrumentation program, and so a series of workshops and meetings at all the major astronomical centres were held over the nine months prior to Aspen. The resulting Australian “Science Cases” document was presented by Australia’s seven representatives at the Aspen meeting. The outcomes of the Aspen process overlapped considerably with Australia’s interests, and, as a result, there is likely to be significant Australian participation in the design study and procurement process.

SKA

The International SKA Consortium includes the UK, USA, Canada, China, the Netherlands, India, Italy, Chile, South Africa, and Australia. It is coordinated by the International Steering Committee, a body formed under a Memorandum of Understanding between these partners. This MNRFC cements Australia’s leading role in this high-profile international endeavour in the following key areas:

- Scientific – engaging with the international community by developing the science case for the SKA.
- Technological – working with our international partners to evaluate competing leading-edge technologies for the SKA.
- Strategic – providing a strong scientific and technical framework to the international community for locating the SKA in Australia, and of Australia to play a lead role in its design and construction.

Australia has a strong leadership role in the International SKA Program, and for most of this reporting period Prof. Ron Ekers of ATNF has chaired the International SKA Steering Committee (ISSC). Ron Ekers and Wim Brouw, both of ATNF, have attended ISSC meetings in August 2002 (in The Netherlands) and January 2003 (in Puerto Rico). Other Australians (Carole Jackson, Elaine Sadler, Peter Hall) have attended other international SKA meetings concerned with science cases and engineering.

A significant International SKA meeting took place in Groningen, The Netherlands, in August 2002, and was attended by many Australian SKA representatives. Several meetings of specialist groups were organised by Australian SKA members, who were instrumental in driving the agenda.

An additional significant international SKA meeting took place in Geraldton, WA, on 29 July -1 August 2003. This included an SKA conference, a meeting of the ISSC, and several meetings of specialist SKA groups. While formally outside the scope of this report, much of the preparation for this meeting took place within the FY2002/3 reporting period. A full report of this meeting will be included in the MNRFC annual report for 2003/4.

IAU General Assembly

The General Assembly of the International Astronomical Union (IAU) took place in Sydney, Australia, in July 2003. While formally outside the scope of this annual report, nearly all the preparation of the meeting was conducted in FY 2002/3 by participants in this MNRFC. As well as the many scientific symposia and meetings associated with the General Assembly, of particular note were

- The IAU Industry Day, at which members of the optical and radio astronomy instrumentation communities discussed collaborative opportunities with representatives of Australian industry,

- An exhibition open to the public, at which there were several displays of optical and radio astronomical technology, including specific SKA and Gemini displays.

3.9.2 Strategic partnerships: national

The process of developing this MNRF has brought together a number of key partnerships at the national level. A strategic goal of the MNRF is to develop these partnerships into an integrated framework for access to, and development of, Australian astronomical facilities.

Key national partnerships include:

- The National Committee for Astronomy (NCA). This committee of the Australian Academy of Science provides overarching strategic directions for Australian astronomy. This committee was instrumental in framing the bid for the Gemini-SKA MNRF.
- Engineers Australia (EA) – promoting industry participation. This is a key strategic relationship, and has resulted in linkages, advocacy, key presentations, and sponsorship. The AABoM chair, Dr. Martin Cole, is a past national president of EA, and a member of PMSEIC and other high-profile bodies.
- The ATNF Steering Committee – responsible for framing policy for the Australia Telescope National Facility.
- The Australian Research Council (ARC).
- The Australian Gemini Steering Committee (AGSC) – responsible for framing policy for Australian Gemini involvement.
- The Australian SKA Consortium (ASKAC) – coordinating Australian research programs for the SKA.
- The Australian Time Assignment Committee, responsible for allocating the Australian time on the Anglo-Australian and Gemini telescopes,
- The Australia Telescope Time Assignment Committee, responsible for allocating the time on existing radiotelescopes, including those to be upgraded by the MNRF.

The MNRF complements and builds on these national structures. Specifically, it will use these linkages to achieve its goals in the following key areas:

- Framing national scientific directions and collaborations through advice from AGSC and ASKAC.
- Fostering a coordinated approach to national facility access.
- Providing a national focus for instrumentation research and development in astronomy.
- Enhancing and developing links with Australian industry partners

A one-day MNRF symposium is planned in 2004, including a joint meeting of AABoM, AGSC, and ASKACC, in which all these elements will be drawn together.

The individual project reports (Appendices B1-B10) report on the specifics of how these collaborations have been achieved and maintained. Here we simply note that all projects of the MNRF have been very successful in engendering and maintaining such collaborations.

3.10 Facility's Contribution to Research and Training

A number of PhD students (described in detail in Appendix B) are associated with the development projects of this MNRF. A large number of additional PhDs will use the upgraded facilities, but as these upgrades are still in progress, it is not yet possible to measure the number of PhDs associated with them.

In addition, the MNRF has enabled the hiring of a number of new positions in the technology development areas. These are mainly young people who will receive training as part of their skills development.

3.11 Commercialisation, and contribution to Australian industry

Within this MNRF, participants play the lead role in positioning their work for commercialisation and in dealing with customers. The Facility Office takes a coordinating role, where appropriate and in consultation with the Participants, so that a “critical mass” of combined facility-generated IP may be reached, focused on opportunities and possibly commercialised through a business structure complementary to the Facility's scientific aims.

Because this MNRF interacts with a number of different international organisations, each of whom have their own IP policies and practices, the management of IP differs from project to project to optimise the opportunities for development of IP. IP management policies are therefore discussed in individual projects.

The technology development projects in this MNRF, both in the SKA and in the Gemini arenas, have involved Australian companies who are working with us to develop new technologies, developing industry expertise in those technologies, and then applying that expertise to other industry challenges. The international linkages developed through working with the MNRF also enable these companies to open up new international markets for their products and services. Examples include (but are not confined to):

- Auspace, who are working with RSAA to build the new NIFS instrument for Gemini
- Connell-Wagner, who are working with ATNF to explore siting issues for SKA and LOFAR
- CEA, who are working with ATNF and CTIP to develop phased-array antenna technology
- APT, who are working with ATNF, CTIP, and other CSIRO Divisions to develop new artificial dielectric materials for advanced antenna systems.
- Argus Technologies, who are working with Sydney University on the SKAMP upgrade to Molonglo.

3.12 Marketing and Promotion

Our marketing strategy ensures that at each stage of the commercialisation strategy, there is “positioning” through personal contact, publicity, exhibition displays, published papers and conferences that convey the capabilities being generated by the Facility. Participants have the primary responsibility for this marketing, while whenever appropriate, the Facility Office will undertake a coordinating role.

Communications about the scientific aims and progress of the Facility will address both the scientific community and the public.

The scientific community will be informed through existing and well-developed methods, including:

- Participant's web pages.
- Publications by Participants and users of the facility.
- Scientific conferences relating to facility development.
- Visits by and interactions with overseas astronomers and engineers.
- Through the General Assembly of the International Astronomical Union (IAU) that held in Sydney in 2003.

Of particular interest was the "Industry Day" held at the IAU General Assembly on 23 July. While this very successful event, bringing astronomers together with industry representatives, lies outside this reporting period, much of the work and planning for this lies within the reporting period. It was accompanied by many outstanding displays by several of the participants of this MNRF.

The wider community is informed through:

- Press releases and articles of general scientific interest in newspapers, magazines, radio, and TV. Some 63 articles have appeared in the press on the SKA during this reporting period, largely in newspapers such as the Australian, the Sydney Morning Herald, the Age, the Canberra Times, the Financial Review, the Weekend Australian, and the West Australian.
- Brochures on the SKA. These have been prepared to address interest in the SKA from the scientific, business, educational communities and the general public.
- SEARFE – a spectrum monitoring awareness project for high school students across the country. The aim of this project is to measure signal levels in the SKA radio spectrum and gain an appreciation of the value of the spectrum and practical experience in radio science. This project is a collaborative venture between ATNF, the University of Sydney, the UNSW, and a number of high schools spread over four States and territories of the Commonwealth. Data collected by the students will be useful in the site selection process. Financial support for this project has been obtained from industry, university, science and engineering institutions.
- Science "Outreach" programs run by some Participants.

Further details may be found in the individual project reports. In addition, there is a great deal of material available on the web which may be accessed via

<http://www.atnf.csiro.au/projects/ska/>

and

<http://www.ausgo.unsw.edu.au/>

3.13 Compliance with Biological & Radiation Safeguards and Environmental Issues

The Facility engages purely in astronomical research and associated technological developments, none of which are considered contentious in terms of science ethics, environmental risks, or danger to participants or others.

The Gemini Observatories, with which this Facility is associated, have fulfilled all environmental requirements for their operation, as have the facilities of the Australia Telescope. Any expansion of ATNF activities beyond the existing sites will be subject to an Environmental Impact Study.

Site selection studies for the SKA in Western Australia are in collaboration with the Office of Science and Innovation, the WA Department of Conservation and Land Management, and local leaders of the Aboriginal community.

4. Financial Report

Detailed financial reports in the format required by DEST are given in the spreadsheets in Appendix G. Here are presented overviews of income and expenditure by project, together with some explanatory notes. Note that all tables are in thousands of dollars except where otherwise stated. Tables 1 and 2 of Appendix G show the actual and budgeted matching contributions by participants.

4.1 General Explanatory Notes

4.1.1 Overall MNRF Facility funding profile

The MNRF business plan proposed a total expenditure of MNRF funds of \$3.874m in 2001/3. However, the DEST funding profile allowed an MNRF appropriation of only \$2.0514m in 2001/3. It was expected that the shortfall would be met by borrowing from MNRF corporate funds. This borrowing has not yet been necessary because:

- The project plans for the CABB and MMIC projects were revised after the business plan was drawn up, with a revised funding profile which reduced their call on MNRF funds in 2002/3.
- Delays in signing the Gemini contracts meant that the anticipated Gemini payment for 2002/3 was not made until FY 2003/4.

It should be noted that the funding profile is expected to return to be close to the originally planned spending profile in 2003/4.

4.1.2 Overheads

To calculate overheads for all projects, AABoM decided that all participants should use a standard overhead rate of 2.0 on base salary, which means that overheads are calculated as being equal to base salary (i.e. without on-costs). This is stated in Section 3.1 of the business plan and so has been agreed to by all parties, including DEST. However, the DEST tables ask for on-costs (which typically amount to about 25% of base salary) to be included in "salaries". Therefore salary and on-costs are included in the tables as requested, and then in "other costs" are included the remaining overheads of (base salary minus on-costs), which will typically be about 75% of base salary.

For CSIRO expenses, overheads have been calculated as 67% of the sum of salaries and on-costs. This figure of 67% has been calculated as the appropriate mean rate for staff working on this MNRF to give the overall overheads multiplier of 2.0.

4.1.3 Expenditure in 2001/2

It was agreed by DEST, and included in the business plan, that expenditure in the MNRF in 2001/2 could be included as part of the MNRF. However, the DEST tables used in Appendix G do not include a column for 2001/2. Therefore, in all cases where there was expenditure in 2001/2, this has been included in the first column of the spreadsheet, which therefore shows expenditure over two financial years.

4.2 Overview

Table 4.1: Budget vs. Expenditure for 2001/3 by project						
Project	Budgeted Contrib'n From MNRF funds	Budgeted Matching Participant Cash Contrib'n	Budgeted Matching Participant In-kind Contrib'n	Total Budget	Total Expenditure	Variance
1. MNRF project office	432	0	50	482	446	36
2. Gemini (increased share)	2051	2251	0	4302	2469	1833
3. Gemini (RSAA instrumentation)	0	245	173	418	420	-2
4. Gemini (AAO instrumentation)	0	0	112	112	135	-23
5. CABB	500	250	400	1150	358	792
6. NTD	185	250	460	895	1621	-726
7. MMIC	500	300	300	1100	300	800
8. SKAMP	0	90	128	218	134	84
9. Siting	0	0	200	200	117	83
10. SKASS	205	85	588	805	688	117
TOTAL	3873	3471	2411	9682	6688	2994

Notes:

- Columns 3 and 4 of this table, and Tables 1-6 in Appendix G, show budget figures given in the (earlier) business plan, as requested by DEST. Financial tables in the project reports (Appendices B1-B10) show budget figures taken from the (later) project plans in Appendices A1-A10, which is more useful for project tracking. In some cases, project plans have been revised since the original business plan was drafted and contain revised spending profiles, and hence budget figures in any one year will differ between the business plan and the project plans. Actual expenditure is, of course, the same in all tables.

Appendix A – Project Plans

For each of the ten MNRF projects, a project plan was drawn up at the start of the project, and in many cases was incorporated as an Annexe to a Participation Deed between the MNRF and the Participant.

These Project Plans are included here for reference. The Annual reports of each Project against these Project Plans are included in Appendix B.

Appendix A1: MNRF Office Project Plan

Project Leader: Ray Norris, CSIRO ATNF
Participating Organisations: CSIRO ATNF

Summary

The MNRF Office is set up to administer the Australian Astronomy MNRF. This project plan is brief, as most of the functions of the MNRF are embedded within the nine other projects of the MNRF and are described in their respective annual reports.

1. Overview and Goals

The Facility Director, through the Facility Office, will be responsible for:

- Oversight of the operational management of the Facility,
- Financial management and reporting,
- Reporting to DEST in accordance with the Deed,
- Project review and liaison with Participants,
- Reporting Facility performance indicators to the Facility Board of Management,
- Managing business development and collaboration between Participants and other parties,
- Agreements between CSIRO and the Participants,
- Meeting Key Performance Indicators determined for the Facility,
- Environmental issues, and
- Other duties as directed by the Facility Board of Management.

The primary goal of the Project Office is to ensure the successful operation of all aspects of the MNRF. The MNRF consists of a number of self-contained projects, and so the role of the Project Office has been largely to oversee these projects, ensure that all the agreements and project plans are in place, and conduct the operation of the Facility Board (the Australian Astronomy Board of Management, or AABoM). A major issue was that the initial board was an interim one, with a composition that was deemed to be unsatisfactory, and so a major task of the MNRF Office was to propose a new board composition that was acceptable to all stakeholders, and then implement that new board structure.

2. Major milestones and Performance Indicators

2.1 Milestones

- MNRF Deed (between CSIRO and DEST) to be signed by 31 December 2002
- MNRF Relationship Deed (between all MNRF participants to be signed by 31 December 2002
- Project Plans to be in place, and MNRF Participation Deeds (one each between CSIRO, on behalf of the MNRF office, and each participant) to be signed by 31 December 2002
- New board composition to be agreed by 4 June 2003
- Annual report to be provided to DEST within three months of the end of each financial year.

- AABoM to meet at least four times per year

2.2 Board Composition

The Australian Astronomy MNRF has a board named AABoM (Australian Astronomy Board of Management), but its initial composition was an interim one, as the MNRF participants were unable to find a composition that satisfied all requirements within the limited time available prior to the signing of the MNRF Deed. That deed stated that the initial board would last for a period of six months from the date of signing the Deed (4 November 2002), and within one month of the end of that period would produce recommendations on the future composition of the board. The participants would then vote on that recommendation. So it is necessary to agree on a recommendation, in consultation with participants and other stakeholders, by 4 June 2003, and then set up this new board.

3. Budget

Table 1 shows the income to be used for the MNRF Office. The large expenditure in 2001-2003 is partly for legal fees for establishing the MNRF.

Table 1: Funding for MNRF office.					
Note that \$50k p.a. is provided as an in-kind contribution by the host institution, CSIRO ATNF					
Year	Deliverables	Milestone	Contribution In-kind \$m	Contribution Cash \$m	Facility Contribution \$m
01/02			0.00	0.00	0.2755
02/03	Facility management services in Agreement.	30.6.03	0.05	0.00	0.1565
03/04	As above	30.6.04	0.05	0.00	0.104
04/05	As above	30.6.05	0.05	0.00	0.104
05/06	As above	30.6.06	0.05	0.00	0.104
06/07	As above	30.6.07	0.05	0.00	0.104
			Total: 0.25	0.00	Total: 0.848

4. Key personnel

The MNRF Director is Prof. Ray Norris of CSIRO ATNF. Business Manager for the MNRF during the period of setting up all the contracts was Kieran Greene of CSIRO TIP. Membership of both the initial Board composition (up to 4 May 2003) and the current board are given in Appendices C and D.

Appendix A2: Increased Share of Gemini - Project Plan

Project Leader: Ray Norris, CSIRO ATNF

Participating Organisations:

- *CSIRO ATNF*
- *ARC*
- *ANU RSAA*
- *Sydney University*
- *UNSW*
- *University of Melbourne*
- *Swinburne University of Technology*

Summary

The Gemini Partnership is an alliance of seven countries, including Australia, which operates two of the world's largest optical/infrared telescopes: the Gemini telescopes located in Hawaii and Chile. A significant fraction of the Australian Astronomy MNRF funding is allocated to buying an increased Australian share in the Gemini Partnership. This would result in

- more telescope nights for Australian astronomers
- an increased potential for Gemini instrumentation contracts to Australian institutions
- a higher Australian profile on the international stage, resulting in a greater degree of Australian influence on global science

In addition, there is a longer-term strategic goal to increase Australian access to next-generation optical telescopes.

This workplan covers only the payments for access to Gemini and does not include any instrument construction which is described in separate workplans.

1. Overview

1.1 Extract from the Business Plan

The primary aim of the Gemini Program of the MNRF is to increase access for Australian astronomers to the telescopes of the Gemini Observatory. Australia currently has a 4.76% share in Gemini and the intention is to increase access, primarily through acquiring a larger share using the funds available from the MNRF and matching funds.

An additional aim is to develop existing optical/infrared instrumentation expertise at AAO, RSAA and collaborators by increasing the Australian participation in Gemini instrumentation contracts.

The primary aim of purchasing Gemini share with the MNRF funds may be affected by a number of factors including: the amount of share relinquished by other Gemini partners, competition for share by other partners and exchange rate variations. As these factors are not under the control of the Facility there is a possibility that Facility

funds available will exceed the cost of the share available for purchase. In this case, the Board of Management will, in consultation with DEST, the ARC and Participants consider options that best serve the interests of Australian astronomers and the broader community. Options that may be considered include (1) buying observing “nights” on Gemini from other Gemini partners to supplement time available through share or (2) contributing to Gemini instrumentation projects that which may, in turn, be used as offsets to gain extra Gemini share or observing nights. Implementation of any option other than the direct purchase of a larger Gemini share, as envisaged in the MNRF Proposal, is contingent on the approval of DEST and other parties acting for the Facility in negotiations with Gemini.

1.2 Overview of Gemini negotiations

At the time of writing the MNRF proposal, Australia owned a 4.76% share of the Gemini telescopes. It was known that Chile was relinquishing its 4.76% share, and it was hoped Australia would be able to purchase the entire Chilean share, doubling the Australian share of Gemini to nearly 10%. This proposal had a buy-in cost of US\$9.6m (for the capital payments) plus a planned annual operating cost of US\$1.165m. The total cost over 5 years would be A\$25.7m, assuming an exchange rate of 0.60. We planned to increase the benefit to Australia by making some of the buy-in payment in the form of in-kind instrumentation rather than cash, and had been assured informally that this was likely to be possible.

This strategy has so far been partially successful. The full strategy has not been able to be realised for the following reasons:

- The MNRF was funded for \$23.5m rather than the requested \$27.85m.
- Other Gemini partners also made bids for the Chilean share
- Our proposal to contribute in-kind instrumentation as well as cash was declined by the Gemini Partnership.

After extended negotiations with the other partners seeking to acquire part of the Chilean share, Australia agreed to take up 30% of Chile’s 4.76% share, i.e. an increase of 1.43%. As a result, at the November 2002 Gemini Board meeting the Gemini partners finally settled the distribution of the 4.76% Chile share amongst the four bidding partners (US, Australia, Canada, Brazil) as follows:

Country	Fraction of Chilean share	Resulting additional share of Gemini
USA	52.5%	2.499%
Australia	30.0%	1.428%
Canada	15.0%	0.714%
Brazil	2.5%	0.119%

The overall shares of the Partnership then became:

USA	50.12%
UK	23.81%
Canada	15.00%
Australia	6.19%
Brazil	2.50%
Argentina	2.38%

As we purchased 1.43% of Gemini rather than 4.76% as budgeted for, there remains a balance of funds in the Gemini MNRF program. As envisaged in the MNRF business plan, the balance of the Gemini MNRF program funding is available to gain further access to Gemini and other major telescopes.

2 Goals

The primary goal of this element of the MNRF is to increase Australian access to Gemini, resulting in

- more telescope nights for Australian astronomers
- an increased potential for Gemini instrumentation contracts to Australian institutions
- an higher Australian profile on the international stage, resulting in a greater degree of Australian influence on global science

The additional telescope nights will be made available to all Australian astronomers through the peer-review process already used for the existing Gemini telescope nights and the Anglo-Australian Telescope (AAT). Specifically, the process is conducted by the Australian Time Allocation Committee (ATAC) which is operated by the Anglo-Australian Observatory (AAO).

Construction Contracts for Gemini Instrumentation are awarded by the Gemini Partnership in an open competitive tender process. Australian expertise gained by use of Gemini facilities will increase the innovative character of Australian instrumentation, increasing the likelihood that an Australian instrument will be selected.

3 Major milestones and Performance Indicators

3.1 Milestones

- The agreement with Gemini will be signed by ARC, on behalf of the Commonwealth Government, by November 2003.
- Australian astronomers will have access to an increased number of nights on Gemini by January 2003
- A decision will be made on the strategic use of the balance of the MNRF Gemini funding by mid 2004

3.2 Key Performance Indicators

Key performance Indicators will be

- The number of nights on Gemini used by Australian scientists
- The number of papers produced from these Gemini observations
- The number of Australian graduate students having access to the Gemini telescopes
- The number, value, and performance of Australian instruments built for Gemini

4 Budget

4.1 MNRF Income for Gemini

Table 1 shows the income from MNRF funding to be used for the purchase of the additional Gemini share.

2002-3	2003-4	2004-5	2005-6	2006-7	TOTAL
2.051	3.436	3.677	3.885	1.476	14.527

4.2 Matching contributions in cash

Part of the matching contributions consists of cash payments made towards the existing (4.76%) share of Gemini, as shown below. Each institution shown makes an annual payment into a trust fund set up at Sydney University, which is then paid directly to the US National Science Foundation (NSF) who administer the Gemini Partnership. In addition, an annual component is paid from an ARC linkage infrastructure grant, and there is a \$1.5m reserve (accumulated from previous Gemini payments, and held as a reserve against possible exchange rate fluctuations) in the Sydney University trust account which has been committed as matching funding.

	2002-3	2003-4	2004-5	2005-6	2006-7	TOTAL
(1) Institutional subscriptions:						
CSIRO ATNF	32	32	32	32	32	160
ANU RSAA	245	245	245	245	245	1225
Sydney Uni	65	65	65	65	65	325
UNSW	210	210	210	210	210	1050
Uni. Melbourne	52	52	52	52	52	260
Swinburne	10	10	10	10	10	50
(2) ARC linkage grant	1637	1637	1637	1637	1637	8185
(3) Sydney Uni trust fund	0	0	0	0	1500	1500
TOTAL	2251	2251	2251	2251	3751	12755

Note that the University of Southern Queensland also currently makes an annual payment of \$5k, but were unable to make a formal commitment of this for future years, and therefore declined to be named as partners in the MNRF proposal.

4.3 In-kind matching contributions

The Anglo-Australian Observatory (AAO) and the Research School of Astronomy and Astrophysics (RSAA) of the Australian National University have committed \$2.6m and \$1.213m respectively in in-kind matching contributions. These amounts will be used for the design and construction of instrumentation that enhances Australia's engagement in Gemini and other large telescope projects... These are detailed separately in a workplan prepared by each of these institutions. There is likely to be a proposal to revise the RSAA contribution because of the Mt. Stromlo fires.

4.4 MNRF Expenditure on Gemini

The negotiations with the Gemini Partnership, described in Section 1 of this workplan, started in 2002, concluding in 2003, and Australian astronomers had access to the additional 1.428% of Gemini time from 1 February 2003. Gemini subscriptions are paid in US\$, and so are subject to exchange rate variations.

The payment for the additional share of Gemini consists of five parts, all of which are to be paid to the NSF as Executive Agency for the Gemini Project, and all of which provide Australian astronomers with increased observing time:

1. Operating payments

Regular payments are made to cover the additional operations costs associated with purchase of 30% of the Chile share. A payment of 50% of the annual operating cost is due on 1 March of each year and 50% on 1 July of each year. The amounts payable in each calendar year for the additional share are determined by the immediately prior Gemini Board meeting. For planning purposes, the payment schedule is expected to be:

2003 US\$ 364,280
2004 US\$ 382,188
2005 US\$ 401,434
2006 US\$ 421,362
2007 US\$ 442,430

The amounts shown for 2006 and 2007 are indicative, as the Gemini planning budget beyond the end of 2005 is not yet finalised. The figures given assume the continuation of the current 5% annual increase.

2. Back payments for Chilean operating expenses.

As part of the negotiated agreement, Australia agreed to pay 30% of Chile's (unpaid) 2001 and 2002 operations costs, resulting in the following payments by Australia, which are due as soon as the agreement is signed.

2001 US\$ 265,547
2002 US\$ 349,992

3. Back payments for UK nights.

As part of the negotiated agreement, Australia agreed to pay for "UK nights" on Gemini-S that were relinquished as part of the agreement that (finally) settled the Chile share purchase deal. There are to be two payments, each of US\$52,843. One should be paid with the 2003 operating payment, and the other in 2004.

4. Capital repayment to Chile

For Australia's purchase of the additional 1.43% share, a payment for Chile's previous capital investment in Gemini is required. The total amount of US\$2,810,047 is to be paid by 30 November 2005. This will be paid in three equal payments of US\$936,682 due on 1 Nov 2003, 1 Nov 2004 and 1 Nov 2005.

5. Payment for Argentina.

Argentina failed to pay its 2002 operations contribution of US\$672,954. The Gemini Board agreed that the other partners will pay Argentina's 2002 operations costs in

proportion to the new overall shares and assume Argentina's 2003 telescope time in the same proportions. The payment of this amount for the existing 4.76% will be met by the ARC, and the payment for the new 1.43% will be from the MNRF. Thus an amount of $1.43/(100-2.38) * US\$672,954 = US\9815 is payable by the MNRF in 2003. Similarly, if Argentina fails to pay its share of 2003 costs, US\$11125 will be payable by the MNRF in 2004.

A detailed payment schedule, including all of these parts, is shown in Table 5 (at the end of this workplan). The total amounts payable, grouped by financial year, are summarised as follows:

Date	2002-3	2003-4	2004-5	2005-6	2006-7	TOTAL
Amount (US\$)	510345	1723876	1328493	1348080	653111	5563905
Amount (A\$)	850575	2873127	2214155	2246800	1088518	9273175
Amount in A\$ is calculated assuming an exchange rate of 0.60						

4.5 Balance of Gemini part of MNRF funding



Figure 1: Australian dollar exchange rate

The reduced cost of access to Gemini, compared to our original plans, together with the strengthening Australian dollar (see Fig. 1) leaves a predicted balance of \$5.253m (assuming an exchange rate of 0.60). This sum offers the opportunity for further Australian access to large telescopes.

Year	2002-3	2003-4	2004-5	2005-6	2006-7	TOTAL
Income	2.051	3.436	3.677	3.885	1.476	14.527
Expenditure	-0.851	-2.873	-2.214	-2.247	-1.089	-9.274
Balance	1.2	0.563	1.463	1.638	0.387	5.253

The rate of 0.60 is used as it is the approximate two-year average exchange rate, and so is the most appropriate rate to use when making long term budget plans. At the

current exchange rate (0.67) the total Gemini balance will be \$6.223m, and if the Australian dollar reaches US\$0.70 the balance will be \$6.579m.

This balance may be used to address any of all of the following potential opportunities:

1. Purchase a greater share of Gemini, should it become available
2. Purchase “additional nights” on Gemini from other members
3. Cover fluctuations in exchange rate, should the Australian dollar fall
4. Commence design studies or detailed negotiations, or build instrumentation, to secure a strategic advantage for Australia in Gemini or other world-class or next-generation telescopes.

Options 1-3 are within the scope of the MNRF proposal and business plan. While Option 4 is within the spirit of the MNRF proposal, it may fall beyond the specific goals set out in the Deeds and Business Plan. A number of opportunities have been identified, and they will be pursued with full community consultation within the broad goals of the MNRF.

5 Key personnel

The Australian Gemini Scientist is Prof. Warrick Couch of UNSW, and the Australian International Gemini Project Board Member is Dr. Gary Da Costa of RSAA. The positions are appointed by the Australian Gemini Steering Committee.

6 Issues

- Exchange rate fluctuations. As our income from DEST is in A\$, but our payments to Gemini are in US\$, exchange rate fluctuations were considered to be a potential hazard for long-term viability of this project. Hedging was considered as an option. Fortunately, in view of the strengthening Australian dollar, no funds were hedged. This remains an option if the Australian dollar shows signs of weakening.
- Unspent Gemini funding. A decision must be made on whether to explore further opportunities for access to Gemini, or whether changing circumstances make it more attractive to explore, subject to DEST approval, alternative ways of gaining Australian access to other large telescopes.
- Ability of Australian scientists to produce world-class science from the use of Gemini. This project buys Australia a larger share of the Gemini telescopes. The ability of Australian scientists to make effective use of this share will depend on both (a) the provision of first-class instrumentation on the Gemini telescopes, and (b) the ability of scientists to mount first-class projects on these instruments. While Australian astronomers have an enviable track record of performing world-class science, the instrumentation on Gemini has been delayed for a variety of reasons (including the Mt Stromlo fires). The capabilities of the Gemini telescopes have been slower in ramping up than envisaged by the user community in all partner countries. This has been reflected in a relatively slow start-up in usage of the Gemini telescopes by Australian scientists. As the capabilities of the telescopes increase, we are confident that Australian scientists will take their accustomed place at the front of the global field.

7 Project Plan

As this project is concerned only with funding the additional subscription to Gemini, the project plan is encapsulated in Section 4 of this workplan. The project plan may acquire further elements once the issues discussed in Section 6 are resolved.

The outcomes of this project will be scientific results, as indicated by scientific papers published in refereed journals, training, as indicated by the number of Australian graduate students having access to the Gemini telescopes, and the number, value, and performance of Australian instruments built for Gemini

8 Intellectual Property and Commercialisation

No commercial IP will be generated by the activities in this workplan. Scientific discoveries will result from observations funded by this program, and these will be placed in the public domain through publication in international refereed scientific journals.

9 Education and Outreach

We expect many graduate students to be trained in astronomy as the result of the additional access to Gemini funded by this program, and this will be one of the key performance indicators of this program.

		2002-3	2003-4	2004-5	2005-6	2006-7	TOTAL
(1) Institutional subscriptions:							
	CSIRO ATNF	32	32	32	32	32	160
	ANU RSAA	245	245	245	245	245	1225
	Sydney Uni	65	65	65	65	65	325
	UNSW	210	210	210	210	210	1050
	Uni. Melbourne	52	52	52	52	52	260
	Swinburne	10	10	10	10	10	50
(2) ARC linkage grant		1637	1637	1637	1637	1637	8185
(3) Sydney Uni trust fund		0	0	0	0	1500	1500
TOTAL		2251	2251	2251	2251	2251	12755

Date	2002-3	2003-4	2004-5	2005-6	2006-7	TOTAL
Amount (US\$)	510345	1723876	1328493	1348080	653111	5563905
Amount (A\$)	850575	2873127	2214155	2246800	1088518	9273175
Amount in A\$ is calculated assuming an exchange rate of					0.6	

Date	Mar-03	Jul-03	Nov-03	Mar-04	Jul-04	Nov-04	Mar-05	Jul-05	Nov-05	Mar-06	Jul-06	Mar-07	Jul-07	TOTAL
Operating	182140	182140		191094	191094		200717	200717		210681	210681	221215	221215	2011694
Chile back-payments	265547	349992												615539
UK nights	52843	52843												105686
Chile capital			936682			936682			936682					2810046
Argentina	9815			11125										20940
TOTAL	510345	584975	936682	202219	191094	936682	200717	200717	936682	210681	210681	221215	221215	5563905

Appendix A3: RSAA Gemini Instrumentation - Project Plan

Project Leader: Prof. Penny Sackett, ANU RSAA

Participating Organisations: ANU RSAA

1. Overview

The Research School of Astronomy and Astrophysics (RSAA) Of the Australian National University (ANU) will participate in the Australian Astronomy MNRF through four major areas:

1. Support for the operating costs of the Australian share of Gemini Telescopes throughout the period of the MNRF in the amount of \$245k per year through the period of the MNRF (this is covered primarily by Project Plan A2 and is not considered further here).
2. In-kind contributions of unreimbursed costs and overheads associated with the construction of the Near-infrared Integral Field Spectrograph (NIFS) for the Gemini North 8m telescope, from July 2002 through completion of NIFS or the end of the MNRF, whichever comes first.
3. Contingent upon the award of a new instrument contract (e.g. GSAOI) to the RSAA by the Gemini consortium, in-kind contributions of unreimbursed costs associated with the construction of that instrument for Gemini, through completion of the instrument or the end of the MNRF, whichever comes first.
4. Contingent upon the award of a new instrument contract (as in c) above) of suitable size to the RSAA, and the exchange rate of AUD/USD remaining at or below that assumed in the instrument contract, RSAA will also make a cash contribution of \$70k per year over the five-year lifetime of the MNRF. Should these contingency conditions be met, this cash contribution from the RSAA is only to be used for increased Australian access to the Gemini telescopes.

2. Goals

The goals of the participation of the RSAA in the Australian Astronomy MNRF are:

- increased Australian access to the Gemini telescopes,
- improved scientific productivity of the Gemini telescopes through improved and expanded instrumentation built by RSAA, and
- increased development of technical and engineering expertise at the RSAA through the design and construction of state-of-the-art astronomical instruments for the benefit of Australia.

The original list of milestones for the instrumentation plan is shown below. These have been modified (*italics*) due to the destruction of NIFS I in the 18 January 2003 bushfires of Canberra, and the successful award of a second Gemini instrument, the Gemini South Adaptive Optics Imager (GSAOI) to RSAA. The NIFS instrument is being rebuilt, with the aid of subcontractor Auspace, Ltd. The delivery of NIFS II will thus be delayed with respect to that expected for NIFS I, while the second Gemini instrument built by RSAA is ahead of the originally-planned schedule.

Major Milestones	Milestone	Date
1.	Complete each of the remaining milestones for the completion of NIFS. I. <i>Complete each of the remaining milestones for the completion of NIFS II.</i>	July 2003 <i>December 2004</i>
2.	Deliver NIFS I to Gemini. <i>Deliver NIFS II to Gemini.</i>	September 2003 <i>February 2005</i>
3.	Successfully commission NIFS I on Gemini North. <i>Successfully commission NIFS II on Gemini North.</i>	March 2004 <i>June 2005</i>
4.	Award of a new instrument contract from Gemini. <i>GSAOI contract awarded to RSAA.</i>	July 2004 <i>November 2002</i>
5.	Contingent on 4.) above, complete each of the milestones associated with the design and construction of said instrument.	January 2007 <i>September 2005</i>
6.	Contingent on 4.) above, deliver said instrument.	March 2007 <i>November 2005</i>
7.	Contingent of 4.) above, successfully commission said instrument.	September 2007 <i>May 2006</i>

3. Timelines and Budget

RSAA's Gemini Instrument Project Plan is shown in brief below. In addition, RSAA contributes to Project 2, Increased Access to Gemini, through a cash contribution of 0.245\$m per year to support Australia's share of Gemini operating costs, which is not shown in the budget table below. In-kind expected for NIFS I and GSAOI estimated at the beginning of the MNRf are shown, and will be reported against annually.

Year	Project Goals	Milestone	Contribution In-kind \$m	Contribution Cash \$m
01/02			0.00	0.00
02/03	Gemini subscription Cash contrib. (caveats) NIFS development: Stage 1 Second Instrument Development: Stage 1	30.6.03	0.2030 0.0914	0.245 0.07
03/04	Gemini subscription Cash contrib. (caveats) NIFS development: Stage 2 Second Instrument Development: Stage 2	30.6.04	0.2030 0.0914	0.245 0.07
04/05	Gemini subscription Cash contrib. (caveats) NIFS development complete Second Instrument Development: Stage 3.	30.6.05	nil 0.0914	0.245 0.07
05/06	Gemini subscription Cash contrib. (caveats) NIFS development complete Second Instrument Development: Stage 4	30.6.06	nil 0.0914	0.245 0.07
06/07	Gemini subscription Cash contrib. (caveats) NIFS development complete Second Instrument Development: Stage 5	30.6.07	nil 0.0914	0.245 0.07
			Total: 0.863	Total: 1.575

The \$863k of in-kind contribution consists of two parts:

- Unreimbursed \$406k in-kind associated with second instrument (eg, GSAOI construction/delivery).
- Unreimbursed \$457k in-kind (after 1 July 2002) associated with NIFS construction/delivery

4. Key Personnel

Project Leader:	Professor Penny D. Sackett
NIFS Instrument Scientist:	Dr. Peter McGregor
NIFS Instrument Engineer:	Mr. John Hart
NIFS Instrument Manager:	Mr. Jan van Harmelen

5. Issues

As indicated in the original Business Plan, if a second Gemini instrument contract (eg, GSAOI) were not awarded to the RSAA during the period of the MNRF, the RSAA would not be able to meet its contributions c) and d) above, as explained in the contingency clause. If a contract is made, but it is not of sufficient size or the exchange rate is not at or below that assumed in the instrument contract, RSAA will not be in a position to make the cash contribution listed in d) above, as explained in the contingency clause. The primary risks for completion of instrument contracts are: loss of key personnel and unfavourable exchange rates.

6. Project Plan

Detailed project plans for NIFS and any other Gemini instruments built at RSAA will be available on request. Substantial documentation is publicly available electronically via the homepage of RSAA at <http://www.mso.anu.edu.au> .

7. Intellectual Property and Commercialisation

Intellectual property will remain with the RSAA and the Gemini consortium. Opportunities will be taken where possible to work with Australian industry and thereby encourage two-way transfer of technological expertise to and from industry and academia, while protecting ANU's ownership of IP.

8. Education and Outreach

The public is interested in astronomical instrument development at the RSAA; tours of the workshops and descriptions of the instrumentation and their uses prove to be popular at Open Days and in public talks. The instruments will be used as examples in the PhD level course given in Astronomical Observing and Instrumentation at the ANU. Where possible, PhD projects will be offered associated with instrumentation construction, to train a next generation of Australian instrument builders.

Appendix A4: AAO Instrumentation - Project Plan

Project Leader: Chris Tinney, AAO

Participating Organisations: AAO

Executive summary

The AAO proposes to enhance the Australian astronomy community's engagement with 8m and larger telescopes. It will do this by providing resources to support the 'back office' functions for the allocation of observing time on Australia's share of the International Gemini Observatory, and investing in instrumentation technologies for 8m and larger telescopes. A number of opportunities are currently arising and so the longer-term goals have deliberately been left open to enable flexibility in our negotiations on future instrumentation contracts.

1 Overview

The Anglo-Australian Observatory's (AAO) work plan has the general aim of providing increased engagement with 8m and larger telescopes to Australian astronomers. It does this by

- (a) directly facilitating increased access to observing time with the International Gemini Observatory's facilities for Australian astronomers, and
- (b) facilitating the development and implementation of new instrumentation and instrumentation technologies, which align with, and enhance, the scientific interests of Australian astronomers in their use of the facilities of the International Gemini Observatory and other telescopes of 8m class and larger.

The work plan does this via the following specific activities, totalling AAO commitments of at least A\$2.6m over the years 2002-2007.

Activity Number	Description
1.	AAO support of the 'back office' functions for Australian applications for telescope time on the International Gemini Observatory (A\$12K per annum)
2.	Gemini wide-field Multi-Object Spectrograph ("KAOS") pre-concept study (A\$52K).
3.	Other instrumentation development (TBD)

In addition, AAO will acquire five nights guaranteed time with the OzPoz facility of the European Southern Observatory (ESO) Very Large Telescope (VLT) and will explore contributing this to the Australian astronomical community in 2005 as an in-kind contribution valued at A\$320k.

2 Major milestones

Activity Number	Milestone	Date
1.	Smoothly receive and process Australian Gemini proposals.	30 March and 30 September each year from 2002-2007
2.	Publication of KAOS "Purple Book".	June 30, 2003.
3.	Other instrumentation milestones TBD.	

3 Timelines and budget

Year	1.Gemini Proposal Back Office	Contrib. In-kind (\$m)	Contrib. Cash (\$m)	MNRF Contrib. (\$m)
01/02		0.012		
02/03		0.012		
03/04		0.012		
04/05		0.012		
05/06		0.012		
06/07		0.012		
Total		0.06		

Year	2. KAOS Pre-concept Study	Contrib. In-kind (\$m)	Contrib. Cash (\$m)	MNRF Contrib. (\$m)
01/02	-			
02/03		0.052		
03/04	-			
04/05	-			
05/06	-			
06/07	-			
Total		0.052		

Year	4.Other instrumentation contracts (TBD)	Contrib. In-kind (\$m)	Contrib. Cash (\$m)	MNRF Contrib. (\$m)
01/02	-			
02/03	-			
03/04	Preliminary estimate	0.288		
04/05	Preliminary estimate	0.4		
05/06	Preliminary estimate	0.8		
06/07	Preliminary estimate	1.0		
Total		2.488		

4 Key personnel

Brian Boyle (AAO Director 2001-July 2003)

Chris Tinney (AAO Acting Director, July 2003-December 2003)

Matthew Colless (AAO Director, January 2004 onwards)

Stuart Ryder (AAO)

Joss Hawthorn (Head of Instrument Science, AAO)

Sam Barden (Head of Instrumentation, AAO)

5 Issues

Activity 1 is an on-going activity with no risks or contingencies.

Activity 2 is a low-risk science/design activities in which the AAO has an extensive track record.

Activity 3 has deliberately been left open to enable flexibility in our negotiations on future instrumentation contracts, as there are some excellent opportunities emerging on a short timescale, and so it would be premature to be too specific at this stage. The chances of success of obtaining a major contract are believed to be extremely high.

6 Project Plan

Project plans for activities 1 and 2 are already sufficiently covered above. Project plans for activity 3 will be drawn up once instrument contracts are finalised.

7 Intellectual Property and Commercialisation

There are no specific arrangements yet in place to manage IP and to produce commercial outcomes. The AAO does not have a register of background IP. The MNRF will discuss with the AAO how the IP can best be managed within the terms and spirit of the MNRF once the plans for activity 3 become clearer.

8 Education and Outreach

Outreach and education has not been built into the plan. The AAO is not a university and does not have PhD or honours students working on the projects.

9 Key Performance Indicators

The key performance indicators for these activities will be successful delivery of the milestones summarized in section 2.

Appendix A5: Australia Telescope Compact Array Broadband Backend (CABB) - Project Plan

Project Leader: Warwick Wilson, CSIRO ATNF

Participating Organisations: CSIRO ATNF

Executive Summary

This program will deliver, by mid-2006, a new broadband backend system for the Australia Telescope Compact Array (ATCA) at Narrabri. The maximum bandwidth of the instrument will be increased from the current 128MHz to 2GHz, a factor of 16 improvement. This will improve the continuum sensitivity of the ATCA by at least a factor of four as well as providing a greatly enhanced spectral line performance, particularly at the higher observing frequencies.

The system will not only cater for the existing six antennas of the ATCA but will also provide for connections to additional antennas. This will allow the integration into the array of possible future antennas, such as might be constructed as part of the SKA New Technology Demonstrator (NTD) project, or for special reference antennas required for interference mitigation.

An implicit but essential part of this project is the development of technology for the SKA. The correlator and associated signal processing components of the SKA could not be built using existing technology, and this project is effectively using the upgrade of the ATCA as a development path for this technology.

1. Overview

The major components of the upgrade are:

1. A new conversion and local oscillator system which together will act as the interface between the existing receivers and the digitisers. All current and projected receiver systems will be accommodated in the new design. A novel feature of this system will be that all local oscillators will be fixed in frequency. The required fringe rotation of the signals will be carried out in the downstream signal processing section of the backend.
2. New wideband digitisers which will sample the full 2 GHz bandwidth with multi-bit accuracy. The resulting high dynamic range will mean that the instrument will tolerate high levels of radio frequency interference and allow mitigation techniques to be implemented in the downstream signal processing section of the backend.
3. A wideband transmission system for transporting the data from the antennas to the central site. This system will make use of the single mode optical fibre network which was recently installed at the ATCA as part of a previous MNRF upgrade.
4. A bulk delay compensation system to correct for the varying time delays experienced by the received signals. This system will provide coarse digital delay correction. Fine delay tracking will be implemented in the downstream signal processing section of the backend.

5. A new digital signal processing system based on a novel Polyphase Digital Filter Bank (DFB) structure that has been developed recently at ATNF and CTIP. In its baseline mode of operation, the DFB will provide high frequency resolution across the entire 2 GHz band, with up to 4096 frequency channels. An inherent property of the DFB structure is its excellent isolation between channels, which is important for interference cancellation. The DFB will be a highly versatile programmable filter system that will provide multiple sub-bands at selectable bandwidths, resolutions and centre frequencies within the 2GHz band.
6. A new broadband tied array adder system for the ATCA. This will allow the instrument to be operated at full bandwidth in real time phased array mode.

The project plan includes the development and construction of the following two prototype instruments.

1. A proof of concept DFB spectrometer, which will be used to investigate and demonstrate the capabilities of the new structure in an operational environment. The bandwidth of this device will be initially around 300MHz. It is likely that this demonstrator instrument will be installed for limited periods at other ATNF facilities, such as the single dish millimetre wave system at the ATNF Mopra observatory. It will have the potential to significantly enhance their performance.
2. A set of full bandwidth (2GHz) DFBs which, when combined other hardware, will provide an 8GHz bandwidth spectrometer for the ATNF Mopra observatory. The design and development of the 2GHz DFB is an objective of the CABB project. Resources for the development of the full spectrometer system will come from other sources.

2 Goal

The goal of the program is to develop new signal processing techniques for future use in the SKA. The viability of these techniques will be demonstrated through their application to the construction of a new broadband backend system for the Australia Telescope Compact Array (ATCA) at Narrabri. This involves the replacement of all electronic systems involved in the data path from the output of the receivers to the on-line correlator. The maximum bandwidth of the instrument will be increased from the current 128MHz to 2GHz, a factor of 16 improvement. Apart from the resultant increase in sensitivity at all observing frequencies, the wider bandwidth is an important factor in making the ATCA a more effective instrument at the new millimetre wave observing bands.

3. Milestones

Date	Milestone
January 2002	Commencement of project – Conceptual Design
April 2003	Completion of DFB Demonstrator spectrometer
February 2004	Testing of prototype photonic data transmission system
July 2005	Commencement of installation at Narrabri
January 2006	Current six antenna ATCA operational with new backend
July 2006	Completion of integration of NTD into ATCA system
July 2007	Broadband ATCA tied array operational

4 Timelines and budget

The following budget profile is taken from the business plan. The deliverables are unchanged in overall scope but their descriptions have been refined.

Year	Project Summary, Goals and Deliverables	Contrib. In-kind (\$k)	Contrib. Cash (\$k)	MNRF Contrib . (\$k)
01/02	Conceptual design studies	100	0	0
02/03	Conceptual design continues Develop DFB demonstrator	300	250	500
03/04	Develop prototypes of final system	350	400	725
04/05	Move from prototyping to full production	350	700	750
05/06	Production and installation	100	150	200
06/07	Tied array installation	100	100	200
Total		1300	1600	2375

To calculate the fractions of these future budgets that will be used on salaries, capital, and other, it has been assumed that salaries account for 41%, capital for 32%, and other for 27%. These figures are based on experience to date with this project.

5 Key personnel

Project Leader: Dr. Warwick Wilson

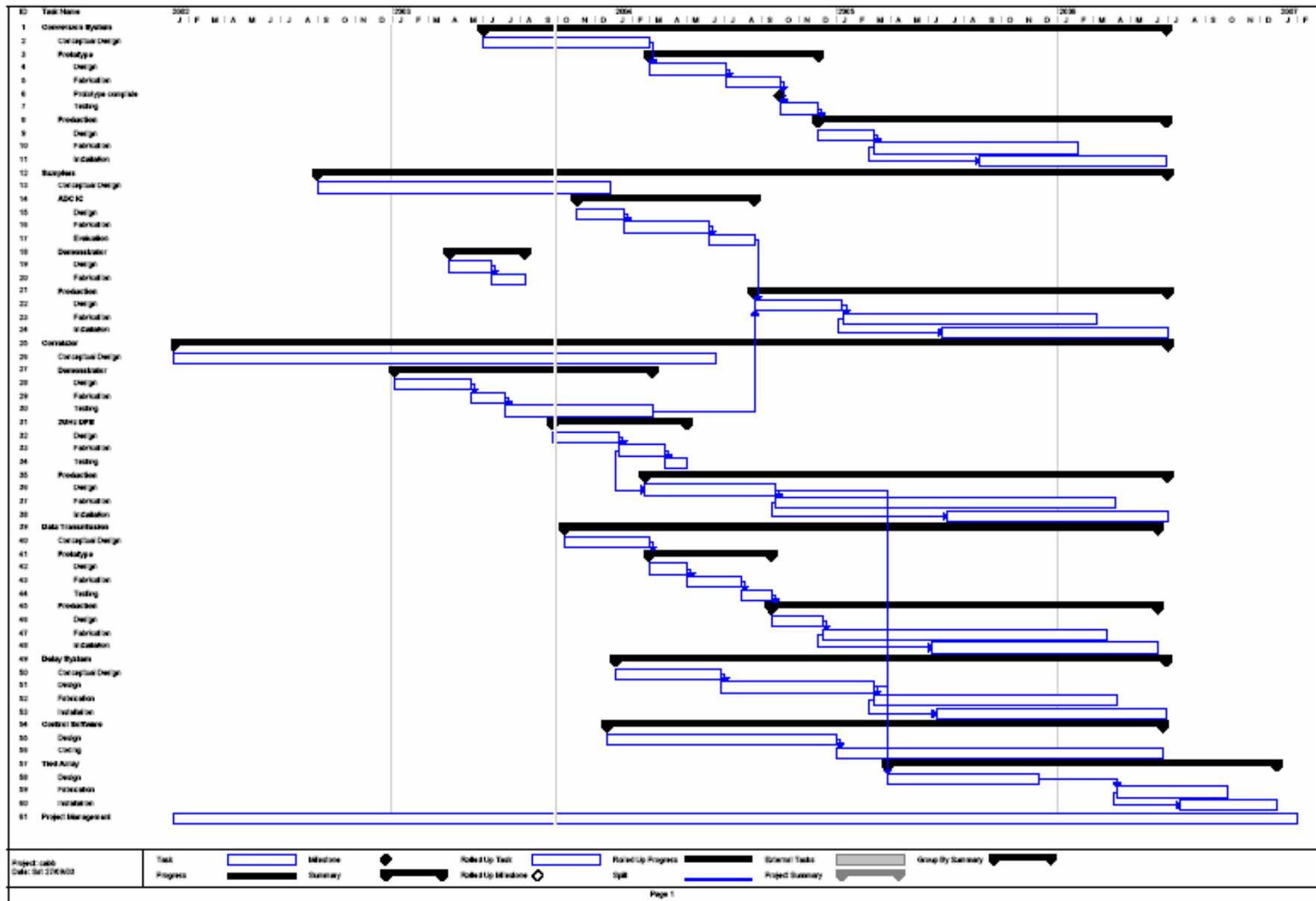
Senior design engineers: Mr. Dick Ferris, Mr. Evan Davis, Mr. Mark Leach, Dr. Paul Roberts

Design Engineers: Mr. Scott Saunders

Science Liaison: Dr. Chris Phillips.

6 Project Plan

See attached Gantt chart



Appendix A6: New Technology Demonstrator - Project Plan

Project Leader: Peter Hall, ATNF(2001-3), John Kot, CICTC(2003-)

Participating Organisations:

- *CSIRO ATNF,*
- *CSIRO ICT Centre (CICTC),*
- *CSIRO TIP (CTIP)*
- *CSIRO Manufacturing and Industrial Technology (CMIT)*
- *Macquarie University*
- *CISCO Systems (Australia)*
- *CEA Pty Ltd.*
- *APT Pty. Ltd.*

Executive summary

A multi-beam radio telescope generates many independent beams on the sky, all using the same physical collecting area. This is a key technology for next-generation radio telescopes such as LOFAR and the SKA. It leads to a number of major benefits:

- A significant part of the telescope infrastructure is available simultaneously to multiple users, leading to more efficient use of the instrument.
- Upgrading the telescope to add extra beams or higher bandwidth is achieved principally through upgrading the processing power available, and this can be done as the cost of the processing power falls with time.
- The flexibility to form shaped beams allows dynamic RFI mitigation through pointing nulls in the antenna beam pattern at the interfering source. The global nature of radio communications means that this capability will be vital for future radio telescopes, especially since key science drivers such as observations of the early Universe at high red-shift will involve observing outside reserved frequency bands.
- The flexibility of the instrument will lead to new science capabilities through the development of new observing modes.
- The goal of the NTD project is to develop a wideband, multi-beam technology demonstrator comprising a “mini-station” of a next-generation radio telescope, incorporating the core technologies of:
 - wide field-of-view microwave lenses or phased-array antennas;
 - optical signal transport; and
 - digital signal processing techniques such as achromatic beam-forming and wide-field imaging.

The target date for completion of the NTD is 2007.

1. Overview

The NTD will be a representative “mini-station” of a next-generation radio telescope such as LOFAR or the SKA. The NTD itself can be broken into a number of principle sub-systems. The NTD project will comprise:

- a) Engineering development of the principle sub-systems, and

b) System engineering to integrate the sub-systems; to understand how design decisions in one sub-system impact on the overall system; to understand how the NTD will be incorporated into an overall telescope such as the SKA.

The principle sub-systems of the NTD are:

Either:

An optional wide field-of-view (FOV) quasi-optical antenna ahead of the receiving antenna array, to increase the collecting area for operation at cm wavelengths (e.g. Luneburg Lens)

or

A wideband receiving antenna array, incorporating highly-integrated RF receivers
Optical signal transport to carry the information from the receiving array to the backend processor

A backend processor for beam forming and correlation

These sub-systems, the principle technological challenges, and our approach to each are described in more detail below. The decision between options (a) and (b) above will depend on the results of initial testing of prototypes.

1.1 The wide FOV quasi-optical antenna

To achieve a given collecting area using phased arrays of small antennas, the number of antennas required increases as the square of the upper frequency of operation. To achieve the equivalent collecting area of a moderate-sized dish becomes very expensive at cm wavelengths. To increase the collecting area, a quasi-optical antenna system consisting of lenses or reflectors may be placed ahead of the receiving array. To maintain the benefits of multi-beaming, the quasi-optical antenna must have a large FOV.

Spherical lenses (the “Luneburg Lens”) are a unique class of optical antenna that can place beams without restriction upon the entire sky. The practical collecting area that can be achieved by this type of lens is limited by the overall weight and loss. The key to increasing this limit is new composite dielectric materials offering much lower density and loss. The requirements for loss, density, isotropy, uniformity and dispersion required for a telescope such as the SKA present a major challenge. This challenge is being tackled through cross-divisional interactions within CSIRO, bringing together expertise in relevant areas: theory and measurement of the electromagnetic properties of materials (CICTC); polymer foam technology (CMS); and materials science and manufacturing technology (CMIT). For analysis and design of spherical lenses and integrated feed systems, there is a PhD project undertaken by Nasiha Nikolic, jointly supervised between CSIRO and Macquarie University.

1.2 The receiving array

A receiving array may be used either

- As an **aperture array**, in which the array is to be the main receiving antenna, as in the Netherlands SKA prototype or the LOFAR antenna
- At the focus of a Luneburg lens
- At the focus of a reflector, which might either be a parabolic dish (like Parkes) or a cylinder (like Molonglo), or a hybrid wide-field shaped reflector.

The antenna elements forming the receiving array must be capable of sufficient packing density to fully-sample the electromagnetic field at the maximum operating frequency. They must be capable of wideband performance, over at least a 3:1 bandwidth and preferably higher. The receiving array must have good polarization performance. For an aperture array, this performance must be maintained while the beam is scanned off axis to at least 45° and ideally considerably greater than 60° for VLBI operation.

This part of the project is based principally upon a PhD project supervised jointly between CSIRO and Macquarie University, commencing in 2003-04. This work builds strongly on existing links with ASTRON, and it is intended also to further develop links with our MNRF industry partners CEA P/L.

1.3 Integrated receivers

The sheer number of receivers in a large array dictates a solution with the maximum degree of integration possible; otherwise the cost of interconnections between sub-systems would be enormous.

This part of the project is being carried out under the MNRF MMIC development project (project 7 of this MNRF Program), and builds upon CSIRO's partnership with Cisco and Macquarie University in the field of wireless networks that followed on from the development of CSIRO's patented IEEE 802.11a WLAN technology. It is based upon a PhD project being undertaken by ATNF engineer Suzy Jackson, co-supervised by ATNF and Macquarie University, and aims to develop an integrated receiver (LNA to ADC) using an RF CMOS process.

As well as university/industry links, the work on antenna arrays and integrated receivers links closely with work being done jointly with ASTRON and under the EU FP6 program, as well as the MNRF SKAMP project.

1.4 Signal transport

Even a modest-sized receiving array can generate a very large data flow. For example, using a 100-element dual-polarized array and sampling a 32MHz band at 8-bit resolution generates around 100 Gbps of data, which must be transported to the receiver backend for processing. Ultimately, in a large telescope, there will be similar data transport issues across a number of scales: within a single antenna tile, at the station level, and a WAN linking stations. Optical fibre technology is the obvious choice to realize this kind of capacity at reasonable cost.

CSIRO already has significant expertise in high-bandwidth optical fibre networks, through the ATNF and CENTIE, and the expertise across these two areas is to a large extent complementary. The aim is a cross-divisional interaction to explore different approaches to different parts of the network, to arrive at an optimum solution.

1.5 Signal processing

The DSP technology at the backend of the multi-beam array has much in common with the MNRF CABB project. Typical functions performed by the backend are filtering into sub-bands using polyphase filter banks, forming auto- and cross-correlation products within each sub-band, and weighted linear summation within each sub-band to form beams, and these functions are largely common to both

projects. However, there are a number of different strategies for achromatic beam forming, and research will explore optimum approaches to different levels of beam forming. For example, wideband time-delay beam forming may be appropriate at the antenna tile level, but impractical at the station level.

The other key technology is RFI mitigation using adaptive and deterministic beam forming, to suppress unwanted interfering radio signals. The NTD will be an ideal test bed for RFI mitigation algorithms, as well as studying the effect of adaptive beam forming on array calibration.

2. Goals

Primary goals:

- To develop a multi-beam radio-telescope demonstrator and to add impetus to the Australian bid for significant involvement in the development of next-generation radio telescopes such as LOFAR and the SKA;
- To develop expertise in a key technology for next-generation radio science instrumentation;
- To generate opportunities for commercial spin-off technology;
- To develop a test bed for new RFI mitigation techniques.
- Secondary goals:
 - To enhance existing linkages and to develop new ones across CSIRO (for example, in the area of materials science), with Australian universities (for example through PhD programs linked to this project), and with industry partners (such as CEA P/L and Cisco).
 - To support postgraduate research and education related to advanced technology for next-generation radio telescopes.

3. Major milestones

Year	Project goal	Milestone
2002-03	Construction of first prototype spherical lens	30:06:2003
2003-04	Demonstrate direct digital receiver concept for digital phased array Choice of NTD concept	30:06:2004
2004-05	NTD PDR	30:06:2005
2005-06	NTD CDR	30:06:2006
2006-07	Complete construction of NTD	30:06:2007

4. Timelines

Year	Date	Project summary, goals, and deliverables	Contrib. in-kind (\$m)	Contrib. cash (\$m)	MNRF Contrib. (\$m)
01-02	Dec 2001	<p>Establish cross-divisional collaboration (CTIP, CMIT, CMS, ATNF) to investigate possible low loss, low density composite dielectric materials.</p> <p>Develop analysis and design software for spherical lenses</p>	0.10	0.00	0.00
02-03		<p>Demonstrate low-loss dielectric with values suitable for spherical lens.</p> <p>Complete design of prototype spherical lens and wideband feed.</p> <p>Test hybrid array / lens system using FARADAY phased array</p> <p>Develop signal transport model based on LOFAR and SKA specifications.</p> <p>Develop wideband beam-former concept using direct digital sampling.</p> <p>Complete construction of prototype spherical lens and wideband feed.</p>	0.36	0.25	0.185
03-04		<p>Complete EM testing on prototype lens. Evaluate test results.</p> <p>Develop business plan for possible commercialization of dielectric / lens technology</p> <p>Decision point on further development work on spherical lenses.</p> <p>Demonstrate high-speed direct digital sampling and polyphase filter bank technology.</p> <p>Decide choice of NTD concept (lens; lens + array; phased array)</p> <p>Develop complete EM analysis of lens plus integrated feed.</p>	0.61	0.40	0.70

04-05	Stage 1: NTD design and development of proof-of-concept prototypes. NTD PDR Stage 2: NTD design & development	0.71	0.70	0.95
05-06	NTD CDR Stage 3: NTD development & construction	0.41	0.15	0.45
06-07	Complete NTD construction	0.26	0.10	0.25
Total		2.45	1.60	2.535

The total income and expenditure is therefore \$6.585m.

The expected schedule of income and expenditure is as follows:

Income:

	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
ATNF Cash	0	250	400	700	150	100	1600
ATNF in-kind	100	200	400	500	200	50	1450
CTIP in-kind	0	160	160	160	160	160	800
CEA in-kind	0	0	25	25	25	25	100
APT in-kind	0	0	25	25	25	25	100
MNRF	0	185	700	950	450	250	2535
TOTAL	100	795	1710	2360	1010	610	6585

The expected schedule of future expenditure is as follows, and is based on an assumed ratio of cash expenditure on salaries/capital/other of 40:30:30.

	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
Salaries	0	174	440	660	240	140	
Capital	0	130.5	330	495	180	105	
Other	0	130.5	330	495	180	105	
In-kind	100	360	610	710	410	260	
Total	100	795	1710	2360	1010	610	6585

5. Key personnel

Trevor Bird, CICTC
John Bunton, CICTC
Richard Donelson, CMIT
Karu Esselle, Macquarie University
Dick Ferris, ATNF
Peter Hall, ATNF
Jeffrey Harrison, Macquarie University
Douglas Hayman, CICTC / ATNF
Suzy Jackson, ATNF
Graeme James, CICTC
John Kot, CICTC
Nasiha Nikolic, CICTC
Ray Norris, ATNF

6. Issues

Microwave lenses – high risk technology: To build lenses of the size required for the SKA requires dielectrics of extraordinarily low loss and density, and extraordinarily high isotropy and uniformity. Material science and structural issues may mean that we are not able to achieve these goals. However, initial results suggest that, even if we do not achieve a material of sufficiently low density to meet the SKA target, there will still be major scientific and commercial applications for this technology, and we are pursuing these options in parallel with the developments for the SKA.

7. Project Plan

Year 2001-02

- Establish a cross-divisional CSIRO project to investigate potential low-loss, low-density dielectric materials, bringing together the expertise from CTIP / CICIC (theory of the electromagnetic properties of dielectric mixtures and artificial dielectrics; microwave measurement of dielectric samples), CMS (polymer technology), and CMIT (materials science and manufacturing technology).
- Develop analysis and optimization software for the design of spherical dielectric lenses at microwave frequencies.
- Develop refracting concentrator multi-beam SKA whitepaper.

Year 2002-03

- Demonstrate low loss dielectric suitable for spherical lens
- Complete design of prototype spherical lens
- Complete design of wideband feed for prototype lens
- In conjunction with FARADAY project, test lens + phased array feed system, using FARADAY array and Konkur Luneburg lens.
- Complete construction of prototype spherical lens

Year 2003-04

- Complete electromagnetic testing of prototype dielectric lens to determine viability of the technology in terms of loss, isotropy, and uniformity.
- Continue material development, and make a decision about moving to a 2nd stage prototype.
- Develop business plan for dielectric material technology.
- Commence PhD project on integrated receiving antenna arrays: complete initial design study.
- Complete hybrid SKA submissions.
- Complete Australian SKA demonstrator plans.
- Demonstrate high-speed direct digital sampling and filter bank technology
- Decision point for NTD concept

Year 2004-05

- NTD Stage 1: Develop NTD design and proof-of-concept prototypes
- Complete NTD PDR
- NTD Stage 2: Commence stage 2 NTD design & development

Year 2005-06

- Complete NTD CDR
- NTD Stage 3: Commence NTD development and construction

Year 2006-07

- Complete NTD construction + commissioning

8. Intellectual Property and Commercialization

We will seek opportunities to commercialise the technology developed as part of this project. This will be facilitated by our strong links with our several industry partners.

9. Education and Outreach

The NTD project has a significant education component, supporting 2 PhD students. There are significant links both within CSIRO across divisions, with local universities, and with industry partners such as CEA P/L and CISCO.

As the capabilities of the technologies become clearer, there will also be a significant effort, via the ATNF, to engage to Australian radio astronomical community to refine and to explore the requirements and capabilities of the NTD.

10. Key Performance Indicators

- NTD design successfully pass PDR
- NTD design successfully passes CDR
- Successful commissioning of NTD instrument.
- Successful completion of PhD programs; publications by PhD students.
- Degree of Australian participation in international radio telescope projects LOFAR & SKA
- Patents and other evidence of commercialisation.

Appendix A7: MMIC Development - Project Plan

Project Leader: Warwick Wilson, ATNF

Participating Organisation: CSIRO ATNF,

Executive Summary

This program will deliver components for inclusion in the various SKA demonstrators including the Australia Telescope Compact Array Broadband Backend (CABB), the SKA Molonglo Prototype (SKAMP) and other enhancements of ATNF telescopes. These components will include high-speed digital devices for data sampling and transmission, broadband low noise microwave amplifiers and integrated receiver and beam-forming systems. This project will also develop generic technology and expertise for eventual use in the SKA and other next-generation radio-telescopes.

1 Overview

The major part of the program consists of three Microwave/Millimetre-wave Integrated Circuit (MMIC) fabrication runs, using technologies such as Gallium Arsenide, Indium Phosphide and Silicon Germanium. These are the processes which are currently seen as those most likely to contribute significantly to the development of the SKA. ATNF has built up considerable expertise in MMIC design using these state of the art processes over the past few years. This program will provide the means for this expertise to develop further so that Australian engineers can maintain their position at the forefront of SKA technology development.

As the design of the various demonstrators proceeds, the requirements for specific MMICs will become clear and the MMIC Development program will be tailored to meet these requirements. Some examples of areas which will rely on, or are likely to benefit from, the inclusion of special purpose MMICs are:

- Integrated receiver systems for the NTD program, aimed at producing highly compact complete receiver systems, as will be required for the SKA.
- Very broadband low noise microwave amplifiers, where the challenge is to achieve the wide bandwidths which are planned for the SKA.
- Microwave beamforming networks.
- Very high speed, high precision samplers and digitisers which will be required for the NTD and CABB programs.
- Photonic devices for use in the data transfer systems of the NTD and CABB.

2 Goals

- To develop MMIC components for SKA related applications.
- To maintain and develop the considerable expertise in MMIC design, using state of the art processes. This expertise has been built up over the past few years in Australia.

3 Major milestones

Date	Milestone
March 2003	Submit designs for first fabrication run
April 2004	Submit designs for second fabrication run
December 2004	First devices available for integration into demonstrators
January 2005	Submit designs for third fabrication run
December 2005	Final devices available for integration into demonstrators
December 2006	Completion of integration into demonstrators

4 Timelines and budget

The funding profile taken from the business plan is as follows:

Year	Project Goals	Milestone	Contrib. In-kind \$m	Contrib. Cash \$m	Facility Contrib. \$m
01/02	Stage 1: Preliminary design		0.10	0.00	0.00
02/03	Stage 2: MMIC fabrication	1.10.02	0.20	0.30	0.50
03/04	Stage 3: MMIC fabrication	1.1.04	0.30	0.20	0.40
04/05	Stage 4: MMIC integration in Demonstrators	1.1.05	0.20	0.10	0.30
05/06	Stage 5: MMIC final fabrication	1.7.05	0.10	0.10	0.15
06/07	Stage 6: MMIC Integration in Demonstrators.	1.7.07	0.10	0.10	0.10
			Total: 1.00	Total: 0.80	Total: 1.45

Since writing the business plan, we have been able to refine this profile, resulting in a slightly different profile of funding and project goals, but maintaining the same overall plan and funding totals:

Year	Project Summary, Goals and Deliverables	Contrib. In-kind (\$m)	Contrib. Cash (\$m)	MNRF Contrib. (\$m)
01/02	Preliminary investigations, purchase design tools	0.03	0.06	
02/03	First MMIC fabrication run	0.05	0.02	0.13
03/04	Second MMIC fabrication run	0.2	0.2	0.32
04/05	Third MMIC fabrication run	0.32	0.22	0.4
05/06	Integration into demonstrators	0.3	0.2	0.45
06/07	Integration into demonstrators	0.1	0.1	0.15
Total		1.0	0.8	1.45

We forecast the following cash flow (k\$) within this funding profile.

MNRF Funded	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
Labour	0	50	50	50	50	20	220
Capital	0	30	220	300	350	100	1000
Operating	0	50	50	50	50	30	230
Total	0	130	320	400	450	150	1450
ATNF Funded							
Labour	30	50	200	320	300	100	1000
Capital	60	20	200	220	200	100	800
Total	90	70	400	540	500	200	1800

5 Key personnel

Project leader: Dr. Warwick Wilson

Senior design engineers: Mr. Russell Gough, Dr. Paul Roberts

Design engineers: Ms. Suzy Jackson, Mr. Peter Axtens

6 Issues

At present, all our Indium Phosphide devices have been fabricated at the TRW (Northrop-Grumman) plant in California. Export licences for these devices have become more difficult since September 11. Even though we have designed these devices ourselves, it is necessary to obtain export licences to ship them back to Australia. We are therefore exploring alternative European suppliers, via the EU FP6 Pharos program, in which we are participants.

7 Project Plan

A Gant chart is attached.

8 Intellectual Property and Commercialisation

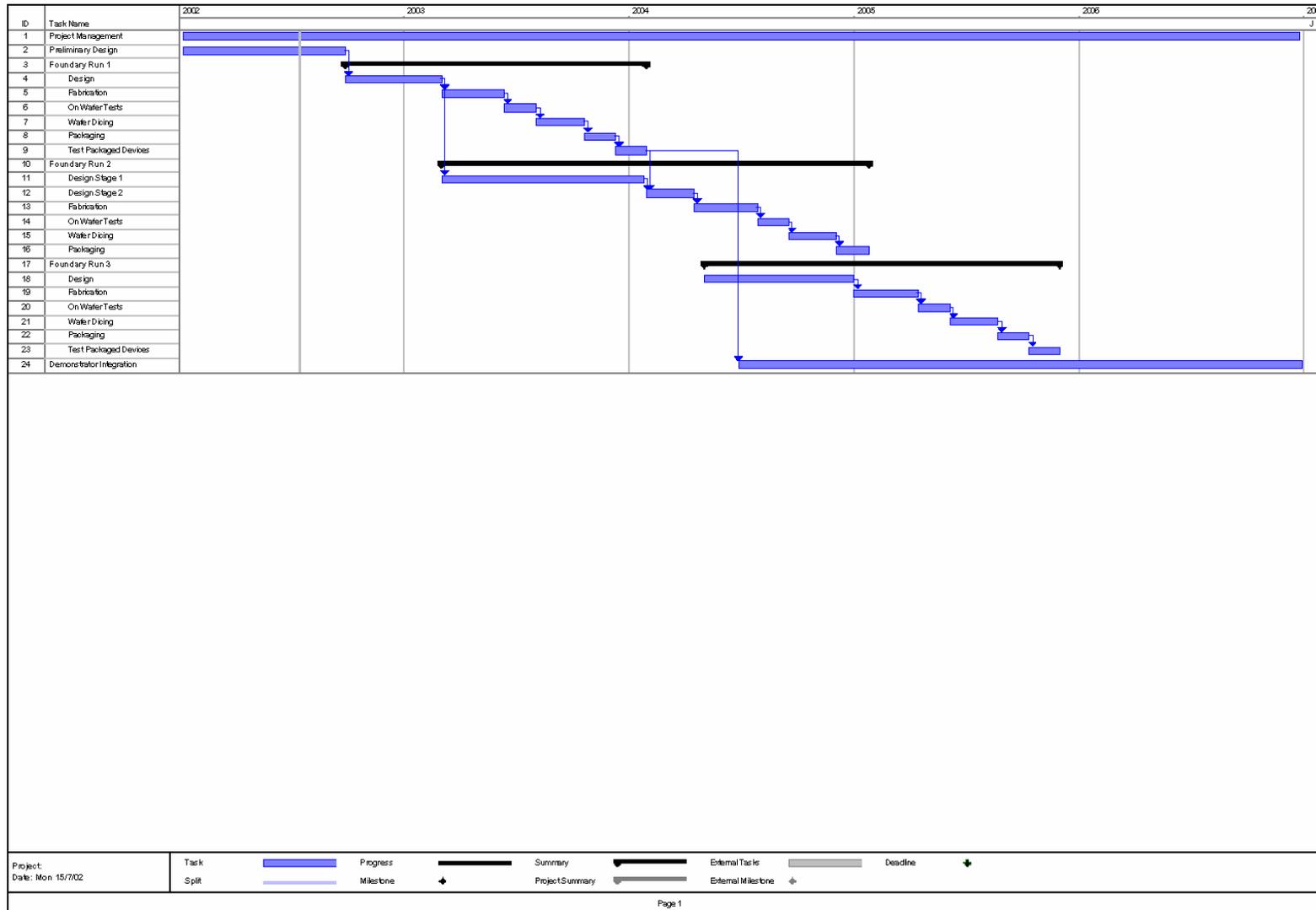
This project is self-contained so there is no need for an IP register. We plan to invite CSIRO Business Development and Commercialisation unit to explore potential commercialisation outcomes from this work.

9 Education and Outreach

We will seek opportunities to engage one or more PhD students in this project.

10 Key Performance Indicators

Key performance indicators are the achievement of major milestones, on time and within budget.



Appendix A8: SKAMP (SKA Molonglo Prototype) Project Plan

Project Leader: Anne Green, Sydney University

Participating Organisation:

- *Sydney University*
- *CSIRO ATNF*
- *CSIRO ICT*

Executive summary

In line with the priorities identified in the 2001 mid-Term Review of Australian Astronomy, to develop enabling technologies to strengthen Australia's case to host the SKA, this project is a joint venture between the University of Sydney and CSIRO, entitled the SKA Molonglo Prototype (SKAMP) project. Its overall goal is to upgrade the Molonglo telescope to be a world-class spectral line instrument, at the same time developing technologies of relevance to SKA. It has the following specific aims:

1. Demonstrate SKA-relevant technologies, particularly relating to ultra-wideband line feeds for cylindrical geometry antennas, wide field-of-view imaging and high-speed digital signal processing.
2. Provide a new low frequency spectral-line facility in the southern hemisphere, building on the existing Molonglo Observatory Synthesis Telescope (MOST), which is owned and operated by the University of Sydney.
3. Undertake supervision and training of postgraduate students as an essential contribution to producing scientists and engineers to design and use the next generation telescopes.

Not all of the SKAMP project is included in this MNRF project.

1 Overview

1.1 Context and Significance

Both the location and the technology for the next-generation Square Kilometre Array (SKA) telescope are still to be decided. Australia has an excellent case for being selected as the site of the SKA. To help capture a share of the \$2b SKA program for Australian industry, we need to use the current MNRF program to demonstrate a credible concept for the technology of the SKA itself. The SKAMP project provides the opportunity to test and evaluate the cylindrical reflector concept for the SKA, and to lead into the next stage of advanced prototypes, which will be an excellent strategic pathway to gaining funding for a full SKA in 2010-12. A second major outcome for the SKAMP project will be the commissioning of a powerful new low-frequency facility for radio astronomy in Australia.

Funding received from the ARC Research Networks, the RFI mitigation project and the development with industry of an ultra-wideband feed system for a cylindrical antenna are all external to the MNRF program. However, the research objectives and outcomes are all well-aligned with no duplication of resourcing. In addition, ARC funding has been received for 2004 – 2006 to support the operation of MOST with the science goals of studying the properties and history of star formation in the Milky Way Galaxy. This project will run in parallel with the SKAMP development and will

complement the project by providing simultaneous images for close comparison and verification of positions and flux densities.

2 Scope of the SKAMP Project

The outcome from the SKAMP project will be a sensitive telescope equipped with a 2048 channel spectrometer, operating continuously over the frequency range 300—1400 MHz, with an instantaneous operating bandwidth of about 50MHz. The potential angular resolution of the telescope will range from 26 to 126 arcsec (provided that the entire length of the telescope is fitted with the new feed structure), with a sensitivity of between 0.02 and 1 mJy/beam. The field of view will be several square degrees. The new technologies to be demonstrated are:

- Implementation of a wideband feed operating over the whole frequency range (this is the biggest technical challenge)
- Two stage beam-forming to give extremely wide fields of view
- Digital filter-banks operating at speeds above 100 M samples/sec
- The correlation of a large number of antenna stations providing high fidelity imaging and polarization capabilities
- Control, monitoring and data handling of approximately 100 antennas as a step towards LOFAR and the SKA

To achieve these outcomes, the project has been divided into five stages, which can proceed largely in parallel.

Stage I – a continuum correlator (partially included in this MNRF project)

The first stage of the project is the construction and installation of a 96 station continuum correlator, with 3 MHz of bandwidth centred at 843 MHz (the current operating frequency of the MOST). This system will be used with the existing front-end feeds and signal pathway of the MOST. The goal is to prove high dynamic range imaging with correlation processing, in parallel with the existing data acquisition systems. Simultaneous observations will allow precise verification of the new signal pathway and continuation of the current science programs, the Sydney University Molonglo Sky Survey (SUMSS) and the Galactic Plane Survey. All of Stage I is included in the MNRF project with the exception of the hardware and software design of the correlator, which will be funded from a University of Sydney Sesqui R&D grant.

Stage II – a spectral-line correlator (included in this MNRF project)

The second stage of the project is the development and construction of a 2048 channel spectral-line correlator, centred on 843 MHz. This stage will use the existing ring antennas (which determine the 30 MHz bandwidth for this stage of the project) with a new local oscillator, timing, signal distribution, and full optic fibre feeds to each of the 88 independent bays of the telescope. It is planned to digitise the signal at the telescope focal plane using an integrated circuit for the mixers, RF filters and

samplers. A new 2048 channel polyphase filterbank will input to the correlator, which is a scaled-up version of the Stage I correlator. The entire 1.6 km of the cylindrical reflector will be fitted with new mixers and samplers for one low-noise amplifier (LNA) per independent bay. The present restriction to one hand of circular polarization will remain for this stage. For operation of the MOST under its previous configuration, 4 LNAs are added together for the illumination of a bay. The configuration for Stage II will reduce the effective collecting area of the telescope. However, the consequent reduction in sensitivity is largely offset by the ten-fold increase in instantaneous bandwidth.

Stage III - increase the tuning range (included in this MNRF project, with the exception of the line feed design)

The third stage of the project will produce a 300—1400 MHz continuous spectral line capability, although the instantaneous bandwidth will be limited to about 50 MHz (by the bandwidth associated with the signal processing). This will not compromise the proof of concept for the SKA demonstration, as a new contiguous broadband line feed will be developed and installed on a section of the array as the key new technology (this feed development is funded by the ARC and is not part of this MNRF). What fraction of the 1.6 km is converted is still to be decided. The feeds will be combined in 8-element sections, with two new low cost LNAs for every element, for full polarisation capability, to minimize the system noise. It is proposed that the beam-forming, low cost LNAs and digitization circuits will be combined into a sandwich structure, located behind the line feeds, up on the telescope structure. Detailed designs for this stage are under development and may be changed to capitalize on new technologies released to the commercial market. There is also close collaboration with the element combination developments being undertaken at CSIRO.

Stage IV – develop new solutions for transferring broadband digital data (not included in this MNRF project)

SKAMP will trial high-speed, fibre-linked data acquisition as a testbed for both the advanced SKA prototype and for the planned LOw Frequency ARray (LOFAR). To expedite the linkages and promote the advancement of skills across countries and disciplines, we have submitted an application for seed funding under the new ARC Research Networks initiative. The fibres themselves will have already been installed under phase II of the project, and what is being developed in this project is novel digitisation, optoelectronics, and broadband data transfer techniques.

Stage V – RFI mitigation (not included in this MNRF project)

For a telescope as sensitive as the SKA, the growing levels of radio frequency interference (RFI) across much of the radio spectrum have to be tackled. Smart solutions in RFI mitigation are required, and the challenge for the SKAMP project of the planned siting of the operational Headquarters of the Defence Department only a few kilometres from the telescope has provided the impetus for a joint research project. The success of this RFI mitigation project will be an important test for astronomers to manage the interface with Australia's national interests. We will seek funding from Defence and elsewhere to establish a small research group to develop mitigation tools over the period 2004-2006.

2 Goals

The goal of the SKAMP project is to build a new low frequency spectral-line facility onto the existing MOST. This will be achieved from the design and construction of a 2048 channel spectrometer, polyphase filter-banks and dual-stage beam-forming systems, and a wideband line feed, to enable observation of the sky continuously over the frequency range 300 – 1400 MHz.

The project will also train young engineers for next generation radio telescopes.

3 Major milestones

The goals and milestones are listed under Section 4 in the Table showing timelines and budgets.

4 Timelines and budget

Each section in this Table represents the achievements anticipated for each year of the project. Each row within a section details particular goals and milestones. The last three columns show respectively the in-kind contribution and the cash contribution from the University of Sydney, and the cash that the SKAMP project will use from the MNRF program.

Milestones associated with the ARC Discovery Grant to develop a wideband feed, and the relevant associated funds, are not given in the following Table as they are not directly part of the MNRF program. The funds for this and a related University of Sydney Sesqui R&D Grant (2002) are listed in the Annual Financial reporting under “Other Sources”.

Year	Date	Stage	Milestones & Goals	Contrib. In-kind (\$'000s)	Contrib. Cash (\$'000s)	MNRF Contrib. (\$m)
02/03	Jul 2002	I	Appoint SKAMP Site Manager	140	0	0
	Sep 2002	I	Design concept for continuum correlator			
	Jan 2003	III	Specify wideband feed project			
	Mar 2003	II	Build infrastructure & isolate signal pathway			
	Jun 2003		Update SKA scope of project document			
03/04	Dec 2003	I	Test continuum correlator design	140	90	172
	Mar 2004	I	Appoint RF Engineer			
	May 2004	II	Design concept for spectral-line correlator			
	Jun 2004	I	Fringes from 96-station continuum correlator			
	Jun 2004		Update SKAMP scope of project document			
04/05	Sep 2004	II	Complete design for spectral line correlator	140	90	272
	Dec 2004	II	Design for polyphase filterbank complete			
	Mar 2005	II	Design concept for LO/IF & samplers			
	May 2005	II	Filters and correlator boards manufactured			
	Jun 2005	II	Optic fibre installation implemented			
	Jun 2005		Update SKAMP scope of project document			
05/06	Sep 2005	III	Design concept for beam-formers	140	180	226.7
	Oct 2005	II	Digital signal to central control room			
	Dec 2005	II	Commission spectral line correlator			
	Jun 2006	III	Prototype feed & front end designed, tested			
	Jun 2006		Update SKAMP scope of project document			
06/07	Sep 2006	III	Build prototype feed	140	90	68
	Dec 2006	V	Document on RFI strategies complete			
	Apr 2007	III	Production & installation of feed systems			
	Jun 2007	III	Commissioning tests on full system			
	Jun 2007		Update SKAMP scope of project document			

5 Key personnel

Key personnel for the SKAMP project are as follows:

Dr Anne Green, Director of Molonglo Observatory and Senior Lecturer in the School of Physics at the University of Sydney. Dr Green is the leader of the SKAMP project with overall responsibility for management and direction. Time allocation 0.25 FTE

Dr Michael Kesteven, Senior Research Scientist at CSIRO, Australia Telescope National Facility. Dr Kesteven is the Senior Project Manager and has been co-ordinating overall system design and implementation. Time allocation 0.1 FTE.

Mr Duncan Campbell-Wilson, Site Project Manager and Officer-in-Charge at the Molonglo Observatory. Mr Campbell-Wilson is responsible for telescope operation and maintenance and for integration of the new signal pathway into and parallel with the present telescope system. He will also oversee sections of the project and the time allocation is 1.0 FTE. The technical officers at the MOST are funded by an ARC Discovery Grant to operate and maintain the facility. They will also contribute to the building and maintenance of SKAMP.

Dr John Bunton, Senior Engineer at CSIRO, Telecommunications & Industrial Physics. Dr Bunton is an Advisor and System Specialist who has played a major role in the design of the correlator and the beamforming electronics. It is anticipated that his role will increase. He will co-supervise the work of Mr Tim Adams. Time allocation 0.1 FTE.

Dr Andrew Parfitt, Leader of the Space & Satellite Communications Systems, CSIRO Telecommunications & Industrial Physics. Dr Parfitt is an antenna expert who is co-supervising the PhD student Mr Martin Leung. He will also have a supervisory role with the Research Associate appointment on the feed development project as he is a co-PI on the Grant. Time allocation 0.1 FTE.

Dr Bevan Jones, Managing Director of Argus Technologies Australia P/L. Dr Jones is the industry partner on the ARC Linkage grant and will be responsible for feed prototype building and testing and some co-supervision of the PhD student. Cylindrical antennas are core business for Argus Technologies. Time allocation 0.1 FTE.

There is a contribution on an informal basis from School of Physics staff, principally on scientific issues: *Prof Richard Hunstead*, *Dr Simon Johnston*, *Dr Elaine Sadler* From the CSIRO, Australia Telescope National Facility, there will be additional input from members of the ATNF SKA team, including *Prof Ron Ekers*, *Dr Frank Briggs* (located in Canberra) and *Dr Peter Hall*. Some external scientific and technical advice will be sought from other members of the SKA consortium, *Prof John Dickey* (U. Minnesota), the Dutch phased array team.

The project has a training capacity and student projects include:

- *Martin Leung* PhD student (wideband feed development)
- *Aaron Chippendale* PhD student (high dynamic-range imaging and configuration simulations)
- *Tim Adams* future PhD student & now Research Assistant (correlator & polyphase filterbank design and construction)

There will also be additional research and technical appointments made for the project:

- Research Associate funded by the ARC Linkage grant (*Dr Sergey Vynogradov*) to study the theoretical options for an ultra-wideband low frequency feed system.

- RF Engineer, funded by the MNRF program and located at the Molonglo Observatory, to design and build the beam-forming sections of the front-end and to implement the signal transport system.
- Project engineer and system software co-ordination, based in Sydney and working closely with Dr Kesteven. Funding for this position (externally to the MNRF) is being negotiated.

6 Issues

Technical risk

Much of the MNRF program funding for this project is for production and implementation of complex systems from components designed in separately funded sub-projects or commercially available at competitive costs. Cost effectiveness is a crucial aspect of the success of the SKAMP project. The most high-risk part of the project arises from the sub-project to develop an ultra wideband feed for a cylindrical antenna. The success of the SKAMP project will not be compromised if the full technical specifications are not achieved in a single feed element. The goals of the project may still be achieved if the feed system is constructed in several contiguous elements (each of modest bandwidth) or if somewhat less than the entire 1.6 km of the existing telescope is fitted with a new low frequency feed.

Defence Department Headquarters

In late 2002 it was announced that a new Operational Headquarters of the Defence Department was to be constructed only a few kilometres from the Molonglo telescope. Radio signals from this new building have the potential to interfere with the operation of the upgraded telescope, and could be a potential threat to this MNRF project. The Defence Department are working with Sydney University to explore options to remove or mitigate the effects of the interference. Options include funding a joint research project to develop radio frequency interference mitigation techniques over the period 2004-2006.

7 Project Plan

Year 2002-2003

The first year of the project will be spent on conceptual design of the 96 station continuum correlator, Stage 1 of the SKAMP project. Since the correlator design is based on programmable chips, there is a conjunction of hardware and software design. Tools used are Protel and Xilinx.

The company now producing Protel (Altium) are interested in offering technical support for the project, which is at the limit of the capability of their products. Another part of the initialisation of the project is the construction of essential infrastructure at the MOST site. A parallel signal pathway is designed to enable ongoing science programs to proceed without interruption and to provide essential calibration and verification of the new system. The appointment of the Site Project Manager (Mr Duncan Campbell-Wilson) has occurred. This is a 5 year appointment. He has supervised the infrastructure changes and has designed and built part of the signal pathway (delay boards and fringe rotators). Other personnel are listed in Section 5. Design costs for correlator and feed project are externally funded.

From Table 5:

Item 1: Site Project Manager 1.0 FTE overheads costed at 2.0	\$140,000
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Year 2003-2004

The second year of the project will see the completion of the narrowband continuum correlator board, comprising 21 Field Programmable Gate Arrays (FPGAs), to preserve maximum flexibility in the design. Salary costs of correlator designer (Mr Timothy Adams) will be borne externally. The board will be manufactured externally and tested in Sydney. Control software and data acquisition software will be tested. The design concept for the spectral-line correlator will be completed. It is the expectation that a scaled up version of the first board will be the foundation of the new design. Commissioning test on the continuum correlator will be carried out. An RF engineer, to work at the MOST site, will be appointed to build and manage the front end architecture. This appointment is ongoing for 4 years. PhD student Aaron Chippendale will conduct imaging and simulation experiments as part of his thesis project.

From Table 5:

Item 1: Site Project Manager 1.0 FTE overheads costed at 2.0	\$140,000
Item 2: RF Engineer at Molonglo 1.0 FTE overheads costed at 2.0	\$108,000
Item 3: Correlator hardware and software development	\$154,000

Year 2004-2005

The third year of the project will be spent in designing the 2048 channel polyphase filterbank and completion of the spectral-line correlator. The modification needed to provide the 30 MHz bandwidth front end will be designed by the RF engineer. It is expected that the digitisation will occur out on the telescope. This will simplify the transport of signals via optic fibre to the control centre. Implementation of a full fibre-fed network to all 1.6 km of the telescope will be undertaken during the year.

From Table 5:

Item 1: Site Project Manager 1.0 FTE overheads costed at 2.0	\$140,000
Item 2: RF Engineer at Molonglo 1.0 FTE overheads costed at 2.0	\$108,000
Item 3: Correlator testing and software development	\$54,000
Item 4: Implementation of optic fibre network to feeds	\$100,000
Item 5: Production of polyphase filterbank	\$100,000

Year 2005-2006

The fourth year of the project will see the commissioning of the spectral-line correlator backend and the completion of the design for the two stages of beam-forming. Evaluation of the spectral imaging capability and the dynamic range achieved will be conducted by Aaron Chippendale as part of his PhD thesis. His project also includes an experiment on the Epoch of Reionisation, carried out at the Australia Telescope National Facility. The prototype of the ultra-wideband feed will be built, and the integrated system of LNAs, mixers and potentially samplers, will be completed. The major tasks will be to prepare the telescope feed structures and build the front end receivers, packaging commercial LNAs and mixers with digitisers.

The final feed design and development will be funded by an ARC Linkage Project, and the construction of the final production feeds funded by the MNRF. The cost of this, as is appropriate for an experimental, cutting-edge design, is uncertain. We expect that 500m of line feed will be installed in the telescope, but an unexpectedly

high production cost may mean that a smaller section will be installed. While this will not compromise the ability of SKAMP to be a prototype demonstrator, it may constrain some scientific programs which require the highest sensitivity available with full area coverage, and so in that case additional funding will be sought from other sources.

From Table 5:

Item 1: Site Project Manager 1.0 FTE overheads costed at 2.0	\$140,000
Item 2: RF Engineer at Molonglo 1.0 FTE overheads costed at 2.0	\$108,000
Item 3: Construction of feed, production of beam-formers & receivers	\$298,700

Year 2006-2007

The final year of the project will focus on building and commissioning the chosen prototype feed. The PhD student Martin Leung will complete his thesis this year. The selected feed and integrated amplifier/mixer/sampler will be built and installed at the telescope. The full signal pathway will be connected. Commissioning test will be undertaken on the 50 MHz instantaneous bandwidth system, operating over a wide range of frequencies.

From Table 5:

Item 1: Site Project Manager 1.0 FTE overheads costed at 2.0	\$140,000
Item 2: RF Engineer at Molonglo 1.0 FTE overheads costed at 2.0	\$108,000
Item 3: Final installation of feeds and front end systems	\$50,000

All salaries for appointments under the project are costed with a factor of 2.0 for overheads.

8 Intellectual Property and Commercialisation

Relationship agreements exist for all the MNRF participants. It is expected that the collaborators in the SKAMP project will develop significant IP connected with wide field of view imaging, high speed digital correlation of signals and techniques associated with a cylindrical reflector array. The IP generated is to be freely shared by all partners in the collaboration for the purposes of the research. In addition, IP agreements exist for the project to develop a wideband dual polarisation feed system, between the University of Sydney, CSIRO and Argus Technologies. Agreements will be negotiated for follow-on projects such as the advanced SKA prototypes

Foreground IP will be reviewed regularly to check for patentable material and commercialisation opportunities. Participants will be free to publish and present material, with the appropriate acknowledgements, in relevant research forums, in accordance with University stipulations.

9 Education and Outreach

The SKAMP project has substantial training opportunities. Postgraduate degree projects already underway or planned include:

- PhD to develop ultra wideband feed (Martin Leung),
- PhD to study RFI mitigation (Daniel Mitchell)
- PhD to study high dynamic range imaging and configuration simulations (Aaron Chippendale),

- PhD or traineeship to design polyphase filterbank (potentially Tim Adams),
- PhD and Honours projects to exploit the science goals investigating the neutral hydrogen structures and galaxy populations at redshifts equivalent to the hydrogen line at a radio frequency near 843 MHz.

10 Key Performance Indicators

The key performance indicators for this project are:

- the milestones achieved on time and on budget,
- the successful completion of the PhD programs associated with this project
- the number of scientific publications reporting the results from the operation of the SKAMP facility.

Appendix A9: SKA Siting Project Plan

Project Leader: M. Storey

Participating Organisations: WA State Govt., CSIRO ATNF

1 Overview

This project has the goal of determining requirements and characteristics for Australian siting for the SKA telescope. The project will respond to requests from the international radio astronomy community for general information regarding Australian siting for next-generation radio telescopes.

These studies will

- define the characteristics which are desirable for an SKA site,
- study physical characteristics of potential WA sites,
- perform radio-frequency background level and possible tropospheric stability monitoring in WA as appropriate and as practicable,
- study requirements and implementation strategies for a radio-quiet reserve,
- commence negotiations with State Governments, landowners, and other stakeholders.

The WA Government is a formal MNRF participant in this project and is contributing its own resources to site studies for future radio telescopes in its State. As a result, this project includes WA-specific outcomes. Studies specific to States other than Western Australia are also being conducted, but are outside the scope of this MNRF.

2 Goals

The purpose of this project of the MNRF Program is to reinforce Australia's bid as the prime location for the SKA through site studies, providing a strong scientific and technical framework to the international community for locating the SKA in Australia. Australia needs to take the initiative in site studies if it is to position itself as a leading contender to host the SKA in the next decade.

2.1 Deliverables:

- Site-testing results/reports indicating the radio frequency interference environment of selected potential WA sites
- Reports, or input to reports for the international radio astronomy community regarding hosting next-generation telescopes in WA.
- Studies to determine the "radio quietness" of areas selected as possible sites for the SKA in WA. ATNF will provide guidance on site survey requirements while the Government of Western Australia will sponsor measurement programs. Results of the survey will also be reviewed by ATNF.
- Advice to the International SKA Consortium on the best methodologies and techniques for conducting site studies.
- A process to choose the best site in Australia for the SKA, and a decision on where this best site is located.

2.2 Objectives:

- Compile sufficient information on the potential SKA sites in WA to be able to provide required information to the international SKA community to aid in their site selection procedures.
- Respond as appropriate to requests from the international radio astronomy community for information regarding WA potential sites for future radio telescopes.
- Position Australian siting favourably as viewed by the international SKA community. This will include identifying complementary projects that would give the potential Australian SKA sites a competitive advantage for attracting the SKA.
- Work with the international bodies of any complementary projects to identify site selection criteria and establish if there are any suitable Australian sites for these projects.

3 Milestones, Timelines and budget

No funding for this project is being supplied by the MNRF, and all funding is “matching” SKA funding, from two sources:

1. The Department of the Premier and Cabinet of the Western Australian State Government has committed \$200k p.a. for four years as an in-kind contribution.
2. CSIRO ATNF have made no formal commitment within the scope of this MNRF plan to contribute to this project, as the extent of the site work was unclear at the start of the MNRF. However, significant in-kind resources are in fact expected to be committed by CSIRO ATNF, at or greater than a level of about \$200k p.a.

The WA Government are providing in-kind support in terms of manpower and by financing the required procedures. CSIRO ATNF is providing manpower support and some equipment and facilities as required. An informal collaboration between the WA Government and ATNF will ensure that appropriate work is done at the appropriate times, recognizing the common and compatible aims of the two bodies.

The Project Plan taken from the MNRF business plan is given in the following Table. At the time when the business plan was drawn up, the exact nature of the siting project was unclear, and this is reflected in this table.

Year	Project Goals	Milestone	WA In-kind Contribution \$m	Contribution Cash \$m
01/02			0.00	0.00
02/03	Stage 1: Survey	30.6.03	0.20	0.00
03/04	Stage 2: Survey	30.6.04	0.20	0.00
04/05	Stage 3: Survey	30.6.05	0.20	0.00
05/06	Stage 4: Survey	30.6.06	0.20	0.00
06/07			0.00	0.00
			Total 0.80	Total 0.00

We are now in a position to refine the project, resulting in the following table of project goals and milestones. Detailed plans beyond 2004-5 are unclear, as they are contingent on the results of the earlier site testing.

Year	Activity	Milestone/KPI
2002-3	Establish clear contact points between OSI (WA Office of Science and Innovation) and CSIRO ATNF	Good contact and working relationship established between OSI and ATNF by 30 June 2003
	Characterize the Mileura Station site with detailed information on landform, vegetation, geology etc	Produce CDROM by 30 June 2003 with detailed information on the land for the central core at Mileura.
	Investigate issues of native title, planning permission, EIA etc in relation to the Mileura site.	Contact made with relevant bodies and discussions held by 30 June 2003
	Identify further international concerns and priorities for SKA sites in the Mid West region. Use LOFAR site studies to further illuminate these studies.	Produce Australian Initial Site Analysis Document for submission to ISSC.
	Work to identify a science support base in WA capable of supporting SKA.	Met with key science groups in WA in order to investigate sources of support and collaboration
2002-4	Organise international SKA Meeting in Geraldton, 27 July - 2 Aug 03, including ISSC visits to Mileura site	Successful meeting
2003-4	Respond to ISSC feedback on Initial Site Analysis Document, to characterize sites better.	Produce report
	Establish a process for selecting the best SKA site within Australia.	Process finalised and initiated by 30 Dec 2003.
	Choose one "reference site" for further evaluation.	Reference site chosen by 31 October 2003
	Give input into RFI testing procedure for SKA sites, to ensure an adequate RFI testing procedure	International RFI protocol produced with adequate Australian input
	Stage 2: Initiate extended RFI tests to be conducted remotely over a full year, at a reference site for Australian site selection.	Remote testing commenced by 30 Jun 04
2004-5	Prepare final submissions for SKA siting if required	Final submission completed

	Respond to ISSC on site submission if required	Response produced and distributed to ISSC
	Continue extended RFI tests to be conducted over a period of one year	Remote testing finished by 30 Jun 05 Tests completed and report produced
2005-6	Interact with ISSC as appropriate regarding SKA siting, so that Australian site is selected as SKA site	Australian site is chosen as SKA site
	Evaluate siting project, and identify improvements	Evaluation completed

4 Key personnel

Rob Gates, Acting Manager, International Science Infrastructure, Office of Science and Innovation, Department of Premier and Cabinet, Government of Western Australia is the principal contact in WA.

Dr Michelle Storey is the principal contact for this project in CSIRO ATNF.

Dr. Don Sinnott, chair of the Siting Working Group subcommittee of ASKAC.

5 Issues

This project is principally concerned with responding to requests as they arise from the International SKA Steering Committee. These requests change over time and so the project must be sufficiently flexible to respond to changing requirements. Until the ISSC formulates its detailed requirements, it is an issue to progress the project sensibly based on likely international requirements. For siting issues, LOFAR has been used as a test case for future radio telescope siting to enable us to be in the best competitive position when detailed SKA siting requirements become known.

6 Project Plan

The project plan is encapsulated in the Table in section 3 above.

7 Intellectual Property and Commercialisation

IP arrangements are per international agreement with SKA project. We do not expect commercial outcomes from this project.

8 Education and Outreach

We will conduct extensive outreach briefings with local communities and produce background documents and presentations as required, and will conduct media interviews. We will also use the SEARFE project as a means of publicising the site studies and the SKA.

One publication has been produced:

- Thomas, B. MacA. "Progress towards establishing a radio-quiet reserve in Western Australia". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).

Appendix A10: SKA Supercomputer Simulations and Baseband Processing (SKASS) - Project Plan

Project Leader: Steven Tingay, Swinburne University of Technology

Participating Organisations:

- *Swinburne University*
- *CSIRO ATNF*

Version: 4 December 2003

Executive summary

This SKA program at Swinburne University of Technology (SUT) will investigate the ways in which supercomputers can be used to assess and improve the potential capabilities of the SKA, through simulations of sources of radio emission and through the collection and analysis of real radio astronomy data. As a consequence of these activities, tools and hardware will be developed that will significantly enhance the capabilities of existing radio astronomy facilities at the Parkes Observatory and the Australia Telescope Compact Array (ATCA).

Broadly, the SUT SKA group will aim to:

1. Demonstrate baseband recording technologies that can be used as prototypes for baseband processing machines as part of the SKA, including possible applications in beam forming, precision pulsar timing, spectroscopy, and software correlation, as well as other applications;
2. Develop within the Facility resources that will be integrated into the existing radio astronomy national facilities, to significantly enhance these facilities for existing and future users;
3. Produce and support simulations of different aspects of SKA performance, including array configuration work and the effects of RFI, both internally to the SUT SKA group but also via strong collaborations with national and international partners.

The activities of the SUT SKA group will revolve around the major resources at its disposal: a supercomputer to be installed at the Hawthorn campus of SUT; an SUT-owned supercomputer to be installed at the Parkes Observatory; and an SUT-owned workstation cluster that will be installed at the ATCA. These supercomputing resources are substantial, in terms of global supercomputing capabilities, and especially within the fields of astronomy and astrophysics within Australia. A goal of the SUT SKA program is to make 30% of the supercomputer at the SUT Hawthorn campus available to the Australian and global SKA communities, and encourage guest investigators to use this resource as part of their SKA studies.

Due to the rapidly evolving nature of the SKA project, the strong emphasis on national and international collaborations, and the long term timeframe of the work (5 years), it is possible that the details of the SUT work plan may be renegotiated periodically, to ensure that the direction of the project maintains goals that will deliver the best outcome for Australian radio astronomy. Any negotiations in this respect will be made between the SUT and the other MNRF partners.

In section 1 below, a summary of the SUT 5-year MNRFF work plan is given in tabular form. In section 2, the details of the SUT 5-year MNRFF work plan activities and deliverables are given, along with detailed information regarding the SUT MNRFF financial arrangements and budget, a description of commitments of key personnel, a description of background IP, and an assessment of risks to the SUT MNRFF project.

1) Summary Statement of Work, Deliverables & Payment Table

The Square Kilometre Array (SKA) Supercomputing Simulations and Baseband Processing Project

Date	Milestone	Summary Statement of Work	Deliverables	MNRFF Payment (AUD millions)
30.06.03	SUT SKA workforce established	New hires will be made to undertake the specific work plan as outlined in this annexure	New hires equivalent to 2.5 FTEs to manage and implement the work plan as outlined in this annexure	0.2052
	SUT and Parkes supercomputers operational.	A supercomputer will be installed at the SUT, Hawthorn campus, as a major resource for SKA studies.	An operational supercomputer at the SUT, verified, benchmarked, and 30% of which is available for SKA studies.	
	Initial simulations of baseband data including RFI	A supercomputer will be installed at the Parkes Observatory, which will be used to record baseband data. The SUT supercomputer will be used to simulate the sampled voltage output of a radio telescope, including the effects of simple sources of RFI	An operational supercomputer at the Parkes Observatory, verified for data collection. An analysis and verification of the simulated data, in preparation for more advanced simulations, as input for a software correlator.	

	<p>Completion of a two-station software correlator running on the SUT supercomputer</p> <p>Investigation of new ATNF digital filter bank</p> <p>A meeting of Australian groups undertaking SKA simulations</p> <p>Participation in global coordination of SKA simulation activities</p>	<p>A prototype software correlator will be implemented on the SUT supercomputer and used to correlate recorded VLBI data</p> <p>A study of the plans for the new ATNF wide bandwidth digital filter bank will be undertaken</p> <p>The Australian groups involved in SKA simulation work will be brought together to promote collaborations</p> <p>An effort will be made to represent the SUT at a high level within the global SKA simulation field.</p>	<p>Verification of the software correlator output, in comparison to the ATNF LBA correlator and an initial scientific analysis of the correlated data, in preparation for a large-scale software correlator in later years</p> <p>A document evaluating the suitability of the new ATNF digital filter bank as a component of a next generation baseband recorder.</p> <p>Documentation describing the outcomes of this meeting and evidence of collaborative projects underway</p> <p>High level representation in the SKA Simulation Working Group</p>	
30.06.04	Software correlator operational	The two-station software correlator will be generalised to N stations, for use in simulating the response of the SKA to radio frequency interference and for use in correlating real radio astronomy data	<p>A software correlator capable of correlating real and simulated data from both single-dish telescopes and N-element interferometers</p> <p>A completed Masters thesis, based on the initial software correlator work.</p>	0.2052

	<p>Workstation cluster to Narrabri</p> <p>A baseband recording system that can be deployed at any Australian radio telescope</p> <p>A meeting of international groups undertaking SKA simulations</p> <p>Establish the LOFAR simulation software package as the standard SKA simulation package</p>	<p>A set of computers will be removed from the SUT and installed at the ATCA to provide a significant computing resource at that Observatory, for use as a baseband recorder similar to that installed at Parkes.</p> <p>Approximately 2.5 terabytes of disk space will be installed at each of two Australian radio telescopes, for use in baseband recording applications, in conjunction with associated hardware.</p> <p>An international meeting of SKA simulation workers will be organised, in conjunction with the 2003 SKA Workshop in Geraldton, Western Australia, to follow on from the Australian meeting and to plan an efficient work program for the global SKA simulation community</p> <p>Collaborate with the MIT LOFAR simulation group to install the LOFAR package on the SUT supercomputer, verify the operation of the package, and develop the software in order for it to fill the role of standard simulation</p>	<p>A set of computers removed from the SUT and installed at the ATCA, operational and verified for data collection</p> <p>Mass storage installed and verified for data collection at two Australian telescopes. These systems will be portable and usable as a baseband recorder at any Australian radio telescope.</p> <p>Documentation describing the outcomes of this meeting</p> <p>MIT LOFAR package installed on the SUT supercomputer, verified for operation by the MIT group, and available to national and international users as an SKA simulation resource.</p>	
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		package for SKA studies	A plan for the development of the LOFAR software to specifically address the needs of SKA simulations.	
30.06.05	Complete development of the LOFAR package as the standard simulation package for SKA RFI mitigation studies at Parkes and the ATCA Software correlator integrated with array configuration studies	The LOFAR simulation package will be developed into the standard SKA simulation package according to the plan produced in year 2 Using the supercomputers at the Parkes Observatory and the ATCA, RFI surveys will be undertaken at these sites. Simulated RFI will be correlated on the SUT software correlator and integrated with array configuration studies of the SKA	A software package which supports the simulation of SKA technical concepts, available for the international SKA community Characterisation of RFI at both the Parkes Observatory and the ATCA and availability of tools for observers to monitor RFI levels Simulated datasets that combine the effects of RFI with other environmental and astronomical effects.	0.2052
30.06.06	Demonstrate RFI mitigation in simulated and real data	RFI mitigation strategies that can operate in real-time at the Parkes Observatory and the ATCA will be developed RFI mitigation strategies will be developed as part of the SKA simulations that integrate the SUT software correlator and array configuration studies	A demonstration of RFI mitigation at both the Parkes Observatory and the ATCA A demonstration of RFI mitigation as part of the SKA simulations	0.2052
30.06.07	Real and simulated spectral line observations with RFI mitigation	RFI mitigation techniques will be applied to spectral line observations at the Parkes Observatory and the ATCA.	An evaluation of the utility of RFI mitigation for spectral line observations at the Parkes Observatory	0.2052

		Spectral line SKA observations will be simulated, using the RFI mitigation algorithms developed to minimise the effects of simulated RFI.	and the ATCA An evaluation of the utility of RFI mitigation for spectral line observations using the SKA	
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Table 1: Summary Statement of Work, Deliverables & Payment Table

2) Project Plan

A. Details of financial contributions to the Swinburne University of Technology Gemini and SKA Programme and approximate programme budget

The SUT is a participating organisation in the MNRF program. Therefore, as per the Facility Business Plan, the SUT will provide \$1.15m of in-kind funding to the Facility, in addition to a \$50k cash contribution (over the 5 years of the program). Dell Computer Pty Ltd will make a one-off \$85k cash contribution to the Facility to support the SUT program. As Dell Computer Pty Ltd will be making a cash contribution to the Facility and will provide expert technical advice when required and requested, it is inappropriate to assign Dell Computer Pty Ltd a specific work plan as a partner in the MNRF.

To match these in-kind contributions to the Facility, the SUT will receive \$1.026m of MNRF funds over the 5 years of the program, \$205.2k per year. In addition, although not a participating organisation in the MNRF, contingent upon participation of the SUT in the MNRF program, the State Government of Victoria has committed \$262.5k over an 18 month period in 2003/2004, in three-monthly instalments of \$43.75k, to support the Victorian Node of the Gemini and Square Kilometre Array program at the SUT.

The SUT in-kind contribution to the Facility will take the form primarily of the supercomputer resources at the Hawthorn campus of the SUT, the Parkes Observatory, and the ATCA. In particular, 30% of monies spent by the SUT on the supercomputer based on the SUT campus in Hawthorn will be considered as an in-kind contribution to the Facility, in proportion to the percentage of the supercomputer available for SKA work. Currently approximately \$600k per year is budgeted by the Centre for Astrophysics and Supercomputing for maintenance and upgrades of the supercomputing facilities. The in-kind contribution over 5 years simply due to this component of spending will almost cover the SUT commitment to the Facility. Other components of in-kind contribution include 100% of other monies spent on the supercomputing resources at the Parkes Observatory and the ATCA, as well as any salaries relevant to supercomputer maintenance and administration over the 5-year period.

Table 2 contains an approximate schedule for SUT in-kind contributions to the Facility. This schedule includes a large initial outlay on establishing supercomputer facilities at SUT Hawthorn and at Parkes in the first year, a large outlay in the second year on establishing a workstation cluster at the ATCA, ongoing upgrades of the facilities at SUT Hawthorn, annual cash contributions to the Facility, and on-going support salary costs. It should be noted that the schedule in table 2 the in-kind contributions total significantly more than is strictly required of the SUT. Further, the SUT may contribute significantly more in in-kind contributions to the Facility, depending on future developments in the project work plan.

YEAR	SUT Hawthorn supercomputer upgrades (\$k)	Parkes/ATCA supercomputer upgrades (\$k)	Cash contribution (\$k)	Salaries (\$k)
1	300	200	10	100
2	100	100	10	15
3	100	0	10	15
4	100	0	10	15
5	100	0	10	15

Table 2: Approximate SUT in-kind budget

The MNRF monies received by the SUT, and those received from Dell Computer Pty Ltd, will be used to support salaries and ancillary costs for staff hired to undertake the work program detailed in this Annexure. An approximate anticipated budget for the MNRF monies is shown in table 3 below and described in the accompanying text. The budget is dominated by base salary costs and associated university overheads on base salary. Travel costs associated with travel to telescopes and other facilities for extended periods to install, test, and operate equipment, as well as attendance at national consortium meetings and the annual International SKA Workshop meetings, is the next largest item of expenditure. Since the SUT group aim to publish the results of their MNRF work, expected publication costs have been included.

Any minor infrastructure and equipment expenditure deemed necessary to meet our goals will be made from either MNRF monies (approximately \$10k per year budgeted for computing related costs), Victorian State government monies, or as an in-kind contribution from the SUT. The SUT group will adopt strict accounting procedures to maintain up-to-date records of all expenditure under three separate headings: Federal government MNRF contribution; Victorian State government contribution; or SUT in-kind contribution.

YEAR	Base Salary (\$k)	University on-costs (\$k)	Income (\$k)	Staff Relocation (\$k)	Computing (\$k)	Travel (\$k)	Publications (\$k)
1	134	52	205.2	20	10	15	5
2	137	53	205.2 + 85 (MNRF + Dell)	0	10	15	5
3	140	55	205.2	0	10	15	5
4	146	57	205.2	0	10	15	5
5	120 - 150	47 - 59	205.2	0	10	15	5
Totals	677 - 707	217 - 229	1111	20	50	75	25

Total income (\$k)	1111
Total expenditure (\$k)	1064 - 1008

Table 3: Approximate anticipated SUT MNRF 5-year budget

The base salaries in table 3 are estimated by taking into account 1 FTE initially at SUT classification A7, 1 FTE initially at SUT classification B1, and 0.5 FTE initially at SUT classification B6. Normal progress through the SUT salary scale is assumed. The range in estimated salary cost shown in year 5 reflects an uncertainty in the level of resources available in that year at the 0.5 FTE level, the availability of funds in this year being dependant on the requirements of the program and the program expenditure in previous years.

The difference between the base salary expenditure in each year and the \$205.2k of MNRF money available to the SUT in any given year is budgeted towards ancillary costs and overheads. A large fraction of the overhead costs will be the 10% university overhead on all grant money coming into the SUT and the 29% on-cost for base salaries. Remaining monies, approximately \$100k to \$150k in total over the 5 year period will support the activities of the SUT SKA team, including relocation expenses for postdoctoral workers arriving from overseas, computing resources, travel budgets, publication charges etc as discussed above. It is expenditure on these ancillary items in the first three years that will determine if 2.0 or 2.5 FTE salaries are available to the SUT SKA program in year 5.

It should be noted that the above budget is approximate only and may be impacted by future enterprise bargaining agreements, cost of living salary increases etc that are beyond the control of the SUT SKA group. The contracts of the SUT SKA group members are being managed appropriately with these uncertainties in mind, with the option to reduce or increase salary costs in the last two years of the 5-year project.

Where appropriate, the SUT SKA group will aim to fund expansion of its research program through various grant opportunities, outside the structure of the MNRF. For example, an ARC Discovery proposal which aims to use supercomputers to form high-resolution, wide-field images from the largest and most complex VLBI datasets

ever recorded is pending. This proposal will test data storage and image processing algorithms that have direct relevance to the operation of the SKA. Also, an ARC Linkage – International proposal is pending which aims to bring a leading figure from the Korean VLBI Network (currently being constructed) to the SUT, to explore the possibilities of software correlators as an operational component of real VLBI arrays. This work has a direct link to the SUT SKA program. A proposal to the Innovation Access Programme – International Science and Technology – to support some aspects of SKA research is currently being planned.

B. Description of activities and deliverables to be provided by the Swinburne University of Technology

Year 1 (ends 30 June, 2003)

The activities of the SUT SKA group in the first year concentrate on obtaining, setting up, and verifying the resources required for the work program of latter years, and providing them to external workers as well as workers in the SUT group. Included in these activities will be the setting of detailed strategies and the identification of collaborative ventures with other Australian and international groups working on the SKA.

This collaborative aspect of the work of the SUT SKA group is particularly important in the context of the SKA as a national and international project. Currently the SKA is driven at the highest levels by a global consortium - the SKA is the first major radio astronomy resource to be born as a global enterprise. However, the bulk of technical progress towards the SKA is being driven by a number of national consortia, of which the Australian consortium is particularly strong and well organised. As a consequence of the national and international activity in SKA studies, a great many groups and individuals around the world are working on various aspects of the SKA.

A number of considerations make it vital that the SUT group work closely with both our national and international colleagues. Firstly, the Australian consortium is already a coherent unit which provides a framework for the efficient use of MNRF resources, since the work programs of the individual consortium members are highly complementary and aimed toward certain common goals. In the case of the SUT SKA program, we will work especially closely with staff of the ATNF and the ANU to achieve meaningful simulations of the projected performance of the SKA, given a range of design parameters and scientific goals.

Secondly, simulating the SKA is a vast task. With limited resources, the Australian SKA community will have to work as efficiently as possible to achieve this task. The same is true of the international community. The SUT SKA effort will therefore aim to be aware of global developments in the field of SKA simulations and will attempt to take a leading role in the organisation of the international SKA simulation effort.

The resources and facilities to be established as part of the SUT SKA project in the first year of operation will be:

1. The SUT SKA workforce, personnel hired specifically to contribute to the SUT SKA work plan, as described here. The SUT SKA work plan will support 2.5 FTEs over the 5 year period. These hires will specifically be:
 - a. **An SKA Project manager at a 0.5 FTE level to manage the direction of the project, the budget, required reporting, and contribute to the scientific output of the project;**
 - b. **Postdoctoral workers at the 2.0 FTE level to implement the bulk of the work plan.**

2. An operational supercomputer at the Hawthorn campus of the SUT that will be benchmarked against the top 500 machines around the world, and 30% of which will be available to both national and international collaborators for SKA simulation studies. This supercomputer will be capable of supporting the types of software applications and tools that are outlined in detail below. Specific steps toward this milestone are:
 - a. **Purchasing of the machines and components for the supercomputer. The supercomputer will consist of up to 106 dual processor machines, based on Pentium 3 and 4 processors;**
 - b. **Installation of the supercomputer at the SUT, including operational software and hardware;**
 - c. **Verification of supercomputer operations by performing standard benchmark tests on the supercomputer;**
 - d. **Comparison of the supercomputer to the list of the top 500 global supercomputers. The aim for the machine is a top 200 place in the top 500 list;**
 - e. **30% of the final supercomputer resource at SUT to be made available for SKA-related studies to both internal and external (national and international) users.**

3. An operational supercomputer at the Parkes Observatory, for use as a baseband recorder in pulsar and RFI studies, as a prototype for baseband recorders that may be used as part of the SKA. Specific steps toward this milestone are:
 - a. **Purchasing of the machines and components for the supercomputer. The supercomputer will consist of up to 30 dual processor machines, based on Pentium 4 processors;**
 - b. **Integration of the supercomputer into the Parkes radio telescope;**
 - c. **Verification of supercomputer operations through collection of pulsar timing data;**
 - d. **Initial documented scientific analysis of baseband data recorded and processed using the supercomputer.**

Based on the experience gained installing the supercomputers at SUT and at Parkes, the supercomputers will be used to perform initial simulations that will be relevant for later years of the SUT SKA program and also develop software tools that will be relevant for later years. In particular, these activities will be:

4. Initial simulations of the sampled voltage output of a radio telescope with arbitrary system temperature and gain characteristics, including the effects of simple RFI signals. Specific steps toward this milestone are:

- a. **Production of an efficient algorithm to generate random Gaussian noise as a model for the sampled voltage output of a radio telescope and implementation of this algorithm in software;**
 - b. **Production of power spectra from the simulated data with an arbitrary temporal and frequency sampling;**
 - c. **Verification that the power spectra give the correct signal to noise ratios when added coherently;**
 - d. **Insertion of frequency structure into the simulated voltage data by adding simple sources of RFI to the data simulation algorithm.**
5. Implementation of a prototype two station software correlator on the SUT supercomputer. In later years this software correlator will be generalised to N baselines and used to correlate real astronomy data, as a technology demonstration for the SKA, but also as a correlator for simulated baseband measurements of RFI that will be incorporated into array configuration studies of later years. Specific steps toward this milestone will be:
- a. **Development of software that will correlate data initially recorded using the S2 VLBI system, on the SUT supercomputer. This software will account for all geometric effects usually considered in VLBI and will return fringe-rotated complex visibilities as a function of time with arbitrary temporal and frequency sampling, on a single baseline;**
 - b. **Verification of the software via comparison with the correlation results for the same recorded data from the ATNF LBA correlator at ATNF headquarters in Sydney.**
6. A study of the new digital filter bank at the Parkes Observatory, to assess its suitability as part of a next generation baseband recorder, will be undertaken. A document describing the suitability of the digital filter bank will be produced.

In addition, the steps the SUT group will take to encourage collaboration within the Australian and international SKA simulation communities will be:

- 7. Host a meeting of all Australian researchers involved in SKA simulation studies at the SUT and make the results widely available to both the Australian SKA Consortium and international SKA study groups. A document recording the outcomes of this meeting will be produced. These outcomes may be reflected in revisions of the detailed SUT SKA work plan, from time to time;
- 8. Develop SKA simulation strategies with collaborative partners that will make efficient use of MNRF resources. A document will be produced that will describe the nature of these collaborations. The outcomes of these initial collaborative consultations may be reflected in revisions of the detailed SUT SKA work plan, from time to time.
- 9. Gain high-level representation on the SKA Simulation Working Group, a working group constituted by the International SKA Steering Committee, and contribute to the direction of the international SKA simulation effort, enhancing Australia's and SUT's exposure in the international project;

Year 2 (ends 30 June 2004)

In the second year of operation the SUT SKA group will use the computational capabilities built up during the first year of operation to develop those tools that will be used in simulations of the SKA, and further explore prototype hardware that may eventually be used as part of the SKA. The SUT SKA program will also continue to build further resources and facilities. In particular:

1. The prototype single-baseline software correlator developed during year 1 will be extended into a generalised N baseline correlator during year 2. This correlator will be capable of correlating both simulated data and real data collected from arrays of radio telescopes. In later years of the SUT SKA program, the software correlator will be used to correlate simulated SKA data, in particular estimating the response of the SKA to RFI, and will demonstrate the correlation of real-time data from the ATCA or the Australian VLBI array. It will be possible to project forward to the SKA era and determine if software correlation, in some form, could be a useful technique for the SKA itself. Specific steps to this milestone will be:
 - a. **Taking the single baseline correlator and devising an efficient algorithm for replicating it across the entire SUT supercomputer, maximising data transfer rates across supercomputer nodes;**
 - b. **Verification that the correlator output is correct by correlation of a multi-baseline VLBI experiment and comparison to the output of the ATNF LBA correlator which correlates the same recorded data;**
 - c. **Demonstration that the software correlator can correlate simulated sampled voltages, including simulated data that involves the effects of RFI;**
 - d. **A completed Masters thesis based on some aspects of the software correlator development, including scientific results of relevance to the SKA.**

2. A sub-cluster of the SUT supercomputer will be removed from the SUT Hawthorn campus and installed at the ATCA, in Narrabri. This cluster of machines will be used to develop a baseband recording capability at the ATCA, similar to that developed at Parkes during the first year of the SUT program. In later years the Narrabri baseband recorder will be used to investigate baseband recording using a phased array, rather than a single dish, again as a prototype recorder for SKA configurations that use phased arrays of elements. In later years both the baseband recorders at Parkes and Narrabri will be used to characterise the RFI environments at those sites. Specific steps to this milestone will be:
 - a. **Removal of a sub-cluster of machines from the SUT cluster and relocation at the Narrabri Observatory;**
 - b. **Installation of the machines and integration into the Observatory infrastructure in order that the machines can be used as a baseband recorder for data from the tied ATCA;**
 - c. **Verification of the machines as a baseband recorder via collection and analysis of data from the tied ATCA, probably as part of a VLBI observation used to test the software correlator.**

3. Approximately 2.5 Terabytes of disk storage will be installed at each of two Australian radio telescopes, in order to store large volumes of radio astronomy data at baseband. This facility could be used for the RFI survey activities of later years or for use in collecting VLBI data for use with the software correlator. It is envisaged that 2.5 Terabytes of disk storage will go to the Parkes Observatory. The other 2.5 Terabytes of disk storage could go to either the DSN Tidbinbilla installation or the ATCA, depending on feasibility and utility at the site. A study will be completed to determine if Tidbinbilla or the ATCA is the best location for the disk storage. By using hardware sourced from Finland that interfaces to the current VLBI data acquisition system, these disks will be configured as portable baseband recorders that can be used at any of the Australian radio telescopes. Specific steps toward this milestone will be:
 - a. **Developing specifications for the disk-based baseband recording system, including the Finnish hardware, the mass storage devices, and the PCs required to drive the hardware;**
 - b. **Purchasing the required hardware;**
 - c. **Testing the portable baseband recorder at the Parkes radio telescope and verifying that the system performs as expected by collecting and analysing baseband data i.e. conducting a spectral line observation using the system and comparing the results to the results from the Parkes correlator;**
 - d. **Performing a two-station VLBI experiment using the two baseband recorders and analysing the recorded data using the software correlator on the SUT supercomputer.**

In order to meaningfully follow on from the meeting of Australian researchers working in SKA simulation studies, to build on the representation of the SUT SKA project within the international SKA project, and to further promote broad collaborations within the international SKA community:

4. An international meeting of the SKA simulation research community will be organised. At this meeting a plan by which the international SKA simulation workforce can efficiently collaborate towards coordinated outcomes will be discussed. This meeting will promote the SKA in general and specific collaborations between international groups in particular.
5. Establish the LOFAR software simulation package as the standard software package for SKA simulations. The LOFAR package is being developed specifically for the LOFAR consortium by the LOFAR group at the MIT and the SUT group, in collaboration with the MIT group, propose to develop and support the LOFAR simulator to a level at which it will be able to simulate all of the various proposed SKA concepts. The SUT group aim to make this resource available to all national and international SKA groups as an aide to their SKA design studies. Specific steps toward this milestone will be:
 - a. **Installation of all secondary software required by the LOFAR simulation package;**
 - b. **Host a visit to SUT by a member of the MIT LOFAR group, in order to have the LOFAR simulation package installed on the SUT**

- supercomputer and for the SUT SKA group to obtain training in the use of the package;**
- c. Make the LOFAR simulator on the SUT supercomputer available to the global SKA community, to aid in global SKA design studies;**
 - d. Development of a plan, in collaboration with the MIT LOFAR group, to further develop and support SKA capability in the LOFAR simulator.**

Year 3 (ends 30 June 2005)

In year 3 the software tools developed on the various supercomputers that were installed and developed over years 1 and 2 at the SUT, the Parkes Observatory, and the ATCA will be put to work to analyse simulated SKA data, to begin an evaluation of the realistic performance of the SKA, and also to analyse real radio astronomy data, as prototype analysis tools for the SKA itself. These activities will include:

1. The LOFAR simulation package will be fully developed into the standard simulation package for the SKA, according to the plan developed in year 2.
2. The characterisation of the RFI environment at the Parkes Observatory and the ATCA. This work will entail an RFI survey as a function of frequency and time, identifying the sources of RFI and providing a mechanism by which observers at these Observatories can monitor the RFI environment at the time of their observations;
3. The integration of the software correlator developed during years 1 and 2 with array configuration simulations of the SKA to provide simulated SKA datasets that contain realistic representations of environmental effects (atmospheric and ionospheric effects, radio frequency interference, geography, etc) as well as astronomical effects (source strengths, positions, sizes, spectra, etc). The integration of the software correlator and the array configuration simulations will require the generation and combination of separate uv datasets containing 1) the response of the SKA to RFI and 2) the response of the SKA to the radio astronomy signal plus corrupting effects. It is hoped that by combining the correlation of simulated RFI with datasets simulated from array configuration studies, it will be possible to learn in detail the effect of RFI on deep images of the radio sky made by the SKA. This work will be done in close collaboration with staff of the ATNF. By integrating the array configuration simulations and the software correlator simulations, it should be possible to produce SKA images with and without the corrupting effects of RFI, to estimate the conditions under which the images become seriously degraded by RFI. From this analysis, it should be possible to learn which approaches to RFI mitigation are likely to be most successful and useful to the SKA.

Year 4 (ends 30 June, 2006)

Once RFI surveys have taken place at the Parkes Observatory and the ATCA, the SUT SKA group will have built a library of recorded RFI signals on which to test RFI mitigation schemes and algorithms. Due to the experience and ongoing work in this field at the ATNF, the SUT group will work closely with ATNF staff on:

1. Implementing RFI mitigation tools for use with the baseband recorders based at the Parkes Observatory and the ATCA and software correlators, for real-time single dish, phased array, and perhaps interferometric observations. These RFI mitigation tools, running on the baseband recorders will be prototypes for similar tools to be potentially used on the SKA;
2. Implementing similar RFI mitigation tools on the SUT software correlator, for use in the SKA simulations, to determine how well RFI can be removed from SKA datasets and to evaluate the improvement in image quality provided by various RFI mitigation schemes, using controlled tests.

Year 5 (ends 30 June 2007)

After demonstrating the RFI mitigation tools at the Parkes Observatory and the ATCA, and as part of SKA simulations, as tests of mitigation schemes, we will:

1. Implement real-time RFI mitigation and correlation of data at the ATCA and Parkes for spectral line observations, evaluating the effects in the final datasets and images;
2. Implement RFI mitigation as part of the integrated software correlator and array configuration SKA simulations of spectral line observations with the SKA, applying RFI mitigation on the simulated RFI input, to evaluate the effects in the final SKA datasets and spectral line images.

C. Key personnel and commitments

Key personnel for the SUT SKA project are as follows:

- Prof Matthew Bailes, Director of the Centre for Astrophysics and Supercomputing and member of the Australian SKA Consortium (ASKAC). Prof Bailes has overall responsibility for the activities within the Centre for Astrophysics and Supercomputing and will spend approximately 5% of his time in SKA related activities, primarily as a member of the ASKAC.
- Dr Steven Tingay, SUT SKA Project Leader. Dr Tingay has day-to-day responsibility for the activities of the SUT SKA group, including supervising students and postdoctoral workers in the group, developing and coordinating the group's work program, allocating the group's budget, and providing reports to the State and Federal governments. Dr Tingay will spend 50% of his time managing the SUT SKA project.
- Dr Richard Ogley, Postdoctoral Fellow, SKA research and development.
- Dr Shinji Horiuchi, Postdoctoral Fellow, SKA research and development (appointment pending).
- Drs Ogley and Horiuchi will spend 100% of their time on SKA related research and development, implementing the bulk of the work plan as it appears in this annexure; they will be tenured initially on 3 year appointments with a further 2 year renewal of contract possible, depending on budgetary and project progress considerations.

As well as the key personnel listed above, several others members of the SUT Centre for Astrophysics and Supercomputing will contribute indirectly to the success of the SKA project. These staff members will generally provide computing and system administration support and general administrative support to the project.

D. Background IP and assessment of project risks

The SUT SKA group intend developing significant intellectual property, building on its experience in baseband recording in radio astronomy. In particular, the development of a large-scale software correlator running on a supercomputer is potentially useful as an operational element in small to medium scale interferometric arrays, in particular VLBI arrays, with possible commercial opportunities. The SUT SKA group will protect their IP in this area, and other areas, in a way which is consistent with the IP policy of the MNRF “Gemini and SKA National Facility”.

Since the basic approach of the work of the SUT SKA group will be collaborative, adding value to the work of collaborators and deriving value for our own work, a potential risk to our work will be external factors. For example, it is possible that installing SUT-owned equipment into Observatory situations may be delayed for unforeseen technical reasons or changes in the Observatories operations or equipment with time.

Also, since the SUT SKA group’s work relies heavily on cutting-edge computational power, the availability of various components to upgrade and maintain the supercomputers at the SUT and the Observatories could potentially limit or delay the types or scales of SKA simulations which may be possible over the lifetime of the project. Attempting to predict the types of hardware that will be available 3 years into the project is difficult and if great improvements in data storage or processor speed take place, these improvements may prompt us to change our strategy and work plans to best take advantage of technology developments.

APPENDIX B: INDIVIDUAL PROJECT REPORTS

Each of the ten MNRF projects were asked to provide an annual report. These ten separate reports have been summarised in the body of the overall MNRF report. In addition, each of the ten reports are appended here to give a greater level of detail than is contained in the overall MNRF report.

Appendix B1: MNRF OFFICE - PROJECT REPORT FOR FY2002-2003

Project Leader: Ray Norris, CSIRO ATNF
Participating Organisations: CSIRO ATNF

Executive Summary

The MNRF Office is set up to administer the Australian Astronomy MNRF. This report is brief and describes only administrative functions, as most of the functions of the MNRF are embedded within the nine other projects of the MNRF and are described in their respective annual reports. As expenditure on the MNRF Office started in FY2001-2, when the MNRF was being set up, this report covers both 2001-2 and 2002-3.

1. Milestones

Progress against milestones is shown in Table 1.

Milestone	Progress in FY2002-3
MNRF Deed (between CSIRO and DEST) to be signed by 31 December 2002	Deed signed on 4 November 2002.
MNRF Relationship Deed (between all MNRF participants to be signed by 31 December 2002	Deed signed between participants in late October to early November 2002.
Project Plans to be in place, and MNRF Participation Deeds (one each between CSIRO, on behalf of the MNRF office, and each participant) to be signed by 31 December 2002	Al though the Participation Deeds were ready for signing on schedule, it proved difficult to extract Project Plans (which need to be attached to the Deed as a Schedule) from participants. Participation Deeds are being signed in November-December 2003.
New board composition to be agreed by 4 June 2003	Composition agreed by a vote of all participants completed on 29 May 2003.
Annual report to be provided to DEST within three months of the end of each financial year.	Annual Report has been delayed this year by difficulty found by participants in providing required information.
AABoM to meet at least four times per year	Much of AABoM's business has been conducted by email, necessitating only infrequent face-to-face meetings. In 2001/2 AABoM exchanged 250 emails and had 5 face-to-face meetings. In 2002/3 AABoM exchanged 331 emails and had only one face-to-face meeting.

2. Other establishment issues

There are two significant establishment issues:

- Difficulty of setting up collaborations between government bodies. DEST, CSIRO, and ARC each have their own procedures and expectations, and are relatively inflexible in dealing with other organisations. This made setting up an agreement involving these three bodies to be much harder than was expected. Happily, these challenges are now resolved, but remain as a lesson for other similar programs that may be set up in the future. No similar problems were encountered in dealing with any of the other participants (universities and industry) in this MNRF.
- Difference between DEST expectations and participant expectations. Some participants have found it difficult to provide the level of detailed reporting required by DEST, resulting in this annual report being delayed. It is expected that after the learning experience this year, subsequent years will run much more smoothly, resulting in annual reports being delivered on schedule.
- The Australian Astronomy MNRF has a board named AABoM (Australian Astronomy Board of Management), but its initial composition was an interim one, as the MNRF participants were unable to find a composition that satisfied all requirements within the limited time available prior to the signing of the MNRF Deed. That deed stated that the initial board would last for a period of six months from the date of signing the Deed (4 November 2002), and within one month of the end of that period would produce recommendations on the future composition of the board. The participants would then vote on that recommendation. So it was necessary to agree on a recommendation, in consultation with participants and other stakeholders, by 4 June 2003, and then set up this new board.

At the AABoM meeting of 7 March 2003, the MNRF Director proposed a possible composition which was discussed and agreed on, resulting in a position paper and a subsequent email discussion by AABoM members. That discussion reached a broad consensus resulting in a further position paper which was voted on by all MNRF participants, resulting in support by 11 of the 12 participants, with one abstention. After approval by DEST, this was used as the basis of the formation of a new AABoM, which has now been appointed.

3. Collaboration and Linkages

This MNRF has strong links to the national peak bodies in its areas of influence (Gemini: Australia Gemini Steering Committee; SKA: Australia SKA Consortium Committee) through their nomination of members to AABoM, and through other informal linkages. In addition, the MNRF Director was active in promoting links between the MNRFs, and co-organised a successful meeting of all MNRF Directors at the Australian Academy of Science to explore potential sharing of expertise between MNRFs.

4. Financial Reporting

Tables 1-6 provide details of the MNRF expenditure and in-kind contributions, and may be summarised as follows:

According to Section 3.2.3 of the MNRF Business Plan, outline planned expenditure for 2001-3 is as follows:

Year	Deliverables	Milestone	Contribution In-kind \$m	Contribution Cash \$m	MNRF Contribution \$m
01/02			0.00	0.00	0.2755
02/03	Facility management services in Agreement.	30.6.03	0.05	0.00	0.1565

The \$50k in-kind contribution is entirely from the ATNF, and was expected to consist of \$34k in salaries and \$16k in other expenditure.

Actual expenditure, taken from the PSS (Project Support System), is as follows:

	2001/2	2002/3	Total
Salaries	117.6	43.3	160.9
Capital	0	0	0.0
Other	90.4	52.1	142.5
Totals			303.4

CSIRO ATNF uses effort logging to record salaries in its PSS. Because of an error, no salary for the MNRF Director was costed against this project in 2002/03. It is estimated that the facility director spent 15% of his time on MNRF in 2002/3, resulting in an additional salary cost (including on-costs) to the MNRF of \$20.8k, resulting in the following cash expenditure:

	2001/2	2002/3	Total
Salaries	117.6	64.1	181.7
Capital	0	0	0.0
Other	90.4	52.1	142.5
Totals			324.2

This amount is charged as cash expenditure and entered in table 3a of the financial tables.

To this should be added the overheads, calculated as 0.67 of salary, as described in Section 4.1 of the main annual report, as follows:

	2001/2	2002/3	Total
Overheads	78.8	42.9	121.7

This amount is charged as in-kind expenditure and entered in table 1a of the financial tables.

Overall income and expenditure may then be summarised as follows:

Year	Budgeted matching contribution from ATNF \$m	MNRF funding \$m	Total Budget \$m	Actual Expenditure \$m	Variance %
01/02	0.00	0.2755	0.2755	0.2868	4
02/03	0.05	0.1565	0.2065	0.1591	2
TOTAL	0.05	0.4320	0.4820	0.4459	3

Notes on finances:

- Variance = (expenditure-income)/(income)
- Of the expenditure on this project, \$19,437 in 2001/2 and \$45,716 in 2002/3 was spent on legal fees.

Appendix B2: INCREASED SHARE OF GEMINI - PROJECT REPORT FOR FY2002-2003

Project Leader: Ray Norris, CSIRO ATNF

Participating Organisations:

- *CSIRO ATNF*
- *ARC*
- *ANU RSAA*
- *Sydney University*
- *UNSW*
- *University of Melbourne*
- *Swinburne University of Technology*

Executive Summary

The Gemini Partnership is an alliance of seven countries, including Australia, which operates two of the world's largest optical/infrared telescopes: the 8m Gemini telescopes located in Hawaii and Chile. The primary goal of the Gemini Project within the MNRF is to increase Australian access to Gemini, resulting in: more telescope nights for Australian astronomers; an increased potential for Gemini instrumentation contracts to Australian institutions; a higher Australian profile on the international stage, resulting in a greater degree of Australian influence on global science.

In addition, there is a longer-term strategic goal to increase Australian access to next-generation optical/infrared telescopes.

The additional telescope nights will be made available to all Australian astronomers through the peer-review process already used for the existing Gemini telescope nights and the Anglo-Australian Telescope (AAT). Specifically, the process is conducted by the "Australian Time Allocation Committee" (ATAC) which is supported by the Australian Gemini Office (AusGO) and the Anglo-Australian Observatory (AAO).

Construction contracts for Gemini instrumentation are awarded by the Gemini Partnership in an open, competitive tender process. Australian expertise gained by use of Gemini facilities will increase the innovative character of Australian instrumentation, increasing the likelihood that an Australian instrument will be selected.

The primary achievement of the MNRF Gemini Project in FY2002-3 was the purchase of an additional 1.43% share in the Gemini Partnership, resulting in additional nights on the Gemini telescopes being available to Australian astronomers.

Other achievements which are just as important in their own right, and impact significantly upon this project, although they are not strictly part of it, include:

- The near completion of the Near-infrared Integral Field Spectrograph (NIFS) instrument for Gemini by ANU RSAA. Sadly, this was destroyed by the Mount Stromlo fires. Happily, RSAA have retained the contract and the

designs were preserved, so that a new NIFS is now under construction, and is likely to be delivered to Gemini in early 2005.

- The award of a US\$3.27m contract to RSAA to design and build the Gemini-South Adaptive Optics Imager for Gemini.
- Significant design work and exploration of enabling technologies by the AAO for next generation telescopes. In particular, the AAO completed a contract for a wide-field multi-object spectrograph ("MOMFOS") valued at US\$20k for the Gemini New Initiatives Office in 2002/2003, has European Union support valued at €70k for the exploration of self-propelled focal plane robots ("starbugs") in 2003/2004, and is proposing additional EU funds to support exploration of large telescope spectrograph concepts in 2003/2004.

This report covers only the payments for access to Gemini, and does not include the instrument construction which is described in separate workplans from the AAO and RSAA. As the additional Gemini time that has been purchased under this MNRF program is used indistinguishably from the Gemini time that had already been purchased by Australia, results in this report refer to results from Australian Gemini usage as a whole.

1. Milestones

Progress against milestones is shown in Table 1. We note in particular the significant primary goal of this Project of the MNRF, which was to increase Australian access to the Gemini telescopes. This has been successful in the first year of the MNRF program, resulting in a 1.43% increase in the Australian share of Gemini from 4.76% to 6.19%.

Milestone	Progress in FY2002-3
The agreement with Gemini for increased access to Gemini will be signed by ARC, on behalf of the Commonwealth Government, by November 2003.	A 1.43% increase in Australian share of Gemini has been successfully negotiated, contracts signed, and payments made, by October 2003.
Australian astronomers will have access to an increased number of nights on Gemini by January 2003	Increased access to nights, resulting from the increased share, started on 1 February 2003.
A decision will be made on the strategic use of the balance of the MNRF Gemini funding by mid 2004	Discussions are starting.

2. Other establishment issues

There are four significant establishment issues:

- Exchange rate fluctuations. As our income from DEST is in A\$, but our payments to Gemini are in US\$, exchange rate fluctuations were considered to be a potential hazard for long-term viability of this project. Hedging was considered as an option. Fortunately, in view of the strengthening Australian dollar, no funds were hedged. This remains an option if the Australian dollar shows signs of weakening.
- Unspent Gemini funding. For reasons detailed in the Project Plan, the amount of additional Australian share of Gemini that we have so far been able to

negotiate is less than expected in the MNRF proposal, resulting in a balance of cash carried forward. A decision must be made on whether to use this balance to explore further opportunities for access to Gemini, or whether changing circumstances make it more attractive to explore, subject to DEST approval, alternative ways of gaining Australian access to other large telescopes. AABoM will consider this question in 2003/4.

- Ability of Australian scientists to produce world-class science from the use of Gemini. This project buys Australia a larger share of the Gemini telescopes. The ability of Australian scientists to make effective use of this share will depend on both (a) the provision of first-class instrumentation on the Gemini telescopes, and (b) the ability of scientists to mount first-class projects on these instruments. While Australian astronomers have an enviable track record of performing world-class science, the instrumentation on Gemini has been delayed for a variety of reasons (including the Mt Stromlo fires). The capabilities of the Gemini telescopes have been slower in ramping up than envisaged by the user community in all partner countries. This has been reflected in a relatively slow start-up in usage of the Gemini telescopes by Australian scientists. As the capabilities of the telescopes increase, we are confident that Australian scientists will take their accustomed place at the front of the global field.
- Entry of the UK into the European Southern Observatory (ESO). The UK is a 25% (approx.) partner in Gemini and thus plays a significant role in its destiny. Recently the UK astronomy community was successful in a bid for major additional funding to allow the UK to become a full partner in ESO, which operates the Very Large Telescope (VLT), a cluster of 4 8-meter optical/IR telescopes in Chile that are directly competitive with Gemini-South. The UK has indicated to the Gemini Board its firm commitment to Gemini. This may generate opportunities for Australia in a number of ways. The long-standing bi-national Anglo-Australian Telescope Agreement provides an important complementary venue for the two countries to pursue common objectives in Gemini and beyond.

3. Facility's Access regime

Access to Australian Gemini time, including the additional Australian Gemini time purchased under this MNRF project, is allocated by an open peer review system, operated by the Australian Gemini Office, with additional administrative support provided by the Anglo-Australian Observatory, as described in the MNRF Business Plan. Proposals for the use of the telescope time are invited from all Australian scientists two times each year, and these proposals are assessed and ranked by the Australian Time Allocation Committee (ATAC). As is established practice in astronomy, no charge is made to users for access to the facility.

Evidence that this access has been well exploited by Australian astronomers is provided via statistics on the demand for and use of time on the Gemini telescopes over the last 5 semesters (covering 2001, 2002, and the first half of 2003). During that time, a total of 64 proposals were submitted to the ATAC for observing time on the Gemini telescopes. This involved a total of 38 Australian researchers from 10 different institutions; the distribution of those astronomers (in academic, research scientist and postdoctoral positions) and the number of proposals they submitted across these institutions is as follows:

Institution	No. of researchers	No. of proposals	% of proposals
ANU	13.5	25.5	40
UNSW	6	12	19
Swinburne	5	7	10
AAO	4	4	6
USyd	3	4	6
UMelb	2.5	9	14
Macquarie	2	1	2
Monash	1	0	0
UQld	0.5	1	2
ATNF	0.5	0.5	1
Total	38	64	100

Of these 64 proposals, 45 were for time on Gemini North, requesting a total of 356 hours. With ATAC having a total of 184 hours to allocate, time on this telescope was therefore oversubscribed by a factor of 1.93. Similarly, the 19 proposals for Gemini South requested a total of 131 hours, oversubscribing the 92 hrs that ATAC had to allocate by a factor of 1.43. Overall, both telescopes were oversubscribed by a factor of 1.76. The number of proposals ATAC awarded time to and were subsequently approved by the Gemini Director (on the basis of the recommendations made by the Gemini International Time Assignment Committee – ITAC) totalled 46, of which 29 were on Gemini North and 17 on Gemini South.

The imbalance in the number of proposals for the northern and southern telescopes is because the latter was unavailable for the first 6 months of the period covered here, and had a more limited choice of instruments. Also with both telescopes being in a commissioning phase over the period analysed, the amount of time made available for scientific observations was only at the 40-50% level for Gemini North, and 35-45% level for Gemini South. From semester 2003B onwards, both telescopes will allocate a minimum of 70% of their time to science.

Despite these limitations to their operation, the Gemini telescopes have nonetheless been used to pursue an extensive range of astrophysical programs.

4. Collaboration and Linkages

In addition to the enhanced links Australia has developed with the other partner countries through its membership in Gemini, there is strong evidence that the science programs being pursued by Australian researchers on the Gemini telescopes involve a high level of international collaboration. Two-thirds (43/64) of the proposals that were submitted in the 2001-2003 period involved collaborations with researchers outside Australia. The following table gives a profile of what countries these collaborators were from, and the number of institutions and researchers involved.

Country	Number of institutions	Number of researchers
USA	22	41
UK	8	21
Canada	4	5
Germany	3	6
France	2	2
Chile	1	7
Gemini Obs	1	2
Italy	1	1
Belgium	1	1
Netherlands	1	1
Japan	1	1
Argentina	1	1

Collaborations involving astronomers in countries which belong to the Gemini Partnership have the opportunity of getting multiple allocations of time for their project through being able to apply to the individual time assignment committees in each of the partner countries. Australian astronomers have been effective users of this “joint proposal” mechanism, with more than a third (23/64) of Australian proposals being in this category, and the majority of cases being successful in winning sizeable allocations of time (up to 5.5 nights).

5. Facility’s Contribution to Research and Training

The Gemini telescopes are playing an important role in the training of Australian postgraduate students. Of the 64 proposals submitted, 24 (38%) involved observations that were part of a student’s thesis project. The following table lists the number of such students according to institution; it can be seen that there has been particularly strong postgraduate involvement in Gemini at the Universities of Melbourne and NSW.

Institution	Number of postgrad students	%
University of Melbourne	8	41
UNSW	5	26
ANU	4	21
University of Sydney	1	6
Monash	1	6
Total	19	100

Postdoctoral researchers supported on Gemini-related ARC grants (mostly in the Discovery Program) will number nine by mid-2003, at ANU, Swinburne, U Melb, UNSW and U Qld.

6. Contribution to Australian industry

The aspect of Gemini operations covered by this report does not impact directly on Australian industry. Instead the strong linkages built up with Australian industry through the Gemini instrumentation programs is listed in the separate AAO and RSAA reports.

7. Promotion of the Facility

The world-leading position of Australia in global astronomy has the capacity to inspire young Australians and contribute to the development of a Science, Engineering and Technology focused society. The Australian astronomical community has capitalized on this and regularly uses results from its telescopes in press releases and in programs such as the ABC's "Catalyst" and the Science Show.

One example was the dedication of the Gemini South telescope, attracting coverage on ABC TV's main evening news. The Australian Gemini Scientist (AGS), Prof. W. Couch, was also interviewed on Channel 9's "Today" show about the first major scientific results to be obtained with the Gemini telescopes, highlighting Australian involvement.

There have also been considerable efforts to raise awareness of Gemini and its significance to Australian astronomy amongst the public, within government, and throughout the professional and amateur astronomy communities. The AGS has given a number of public talks at a variety of venues which include the Australia Museum, primary schools, and amateur astronomy societies. The AusGO (Australian Gemini Office) also packaged up a number of stories based on scientific results that Australian astronomers had obtained through their use of Gemini, for the CEO of the ARC to present to the Prime Minister. The International Astronomical Union's General Assembly, which was held in Sydney in July 2003, was also used as an opportunity to promote Gemini, with the AusGO having a stand prominently located within the exhibition area, which was visited by hundreds of visiting astronomers as also members of the public.

The AusGO continues to promote the Gemini telescopes and their facility instruments to Australian astronomers through special workshops and its website (<http://www.ausgo.unsw.edu.au>). In the 2002/2003 year, the AGS ran a Gemini 'users' workshop at the University of Queensland, attended by all interested astronomers within that state. He also initiated a nation-wide response and planning process for The Second Gemini Future Instrumentation Workshop held in Aspen in June 2003. Here the Gemini Partnership came together to determine what its scientific aspirations are for the latter half of this decade and beyond, and hence what new instrumentation needs to be acquired for the Gemini telescopes. Given Australia's desire to increase its engagement in the Gemini instrumentation program (one of the primary goals of the Gemini MNRF project), it was essential that it participate vigorously and effectively in this workshop. This was achieved by a 9 month long planning process, which involved a series of workshops and meetings at all the major astronomical centres within Australia, where scientific visions were pooled and instrument concepts formulated. This culminated in the production of an Australian "Science Cases" document, the contents of which were presented by Australia's seven representatives at the Aspen meeting. As it turns out, the outcomes of the Aspen process overlap considerably with Australia's desires and interests in new Gemini instrumentation, and we can look forward to having strong involvement in the design study and procurement process.

8. Commercialisation and Information Transfer

Gemini instrument construction will lead to commercialisable Intellectual Property and this is listed in the separate AAO and RSAA reports.

Intellectual property generated by this Project of the Facility is in the form of astronomical discoveries which are placed in the public domain. As Gemini is only now being fully equipped with world-class instrumentation, publications are only just starting to appear in the international refereed literature and are listed below.

Published

Davidge, Da Costa, Jorgensen and Allington-Smith. 'The M31 dwarf spheroidal companion And V: g', r' and I' imaging with GMOS on Gemini North' *Astron. J.* 124, 886, 2002 (GMOS imaging from GMOS-North system verification, taken before formal GMOS Time Assignment commenced)

Papers submitted or in preparation

Bridges et al. 'Photometry and Spectroscopy of Globular Clusters in M60'

Bridges et al. 'Spectroscopy of Globular Clusters in NGC 524'

Bridges et al. 'Spectroscopy of Globular Clusters in NGC 3379'

Croom et al. 'Gemini imaging of QSO host galaxies at $z=2$ '

Drinkwater et al. 'Stellar populations of ultra-compact dwarf galaxies'

Francis, Webster, Drinkwater 'High redshift galaxies with flat radio spectra'

Harris, Schmidt et al. 'The Hawaii deep survey'

Melatos et al. 'Milli-hertz variability in sub-arcsecond wisps and knots in the Crab Nebula'

Tonry, Schmidt et al. 'High-z supernova search: Fall 1999 results'

Wood, van de Steene, Weldrake 'Infrared emission lines in the PAGB star candidate IRAS 16115-5044'

Technical publications related to Gemini involvement

Hart, McGregor and Bloxham 'NIFS concentric integral field unit' *Proc. SPIE* 4841, 34, 2002.

McGregor, Conroy, Bloxham and van Harmelan 'Near-infrared integral field spectrograph (NIFS): an instrument proposed for Gemini' *Publ. Astron. Soc. Aust.* 16, 273, 1999.

McGregor, Dopita, Wood and Burton 'Science with NIFS, Australia's first Gemini instrument' *Publ. Astron. Soc. Aust.* 18, 41, 2001.

McGregor, Hart, Conroy, Pfitzer, Bloxham, Jones, Downing, Dawson, Young, Jarnyk and van Harmelan, 'Gemini near-infrared integral field spectrograph (NIFS)' *Proc SPIE* 4841, 178, 2002.

9. Financial Reporting

Tables 1-6 provide details of the MNRF expenditure and in-kind contributions.

Explanatory notes to the payments may be found in the MNRF Gemini Project statement of Work. Income and expenditure for this project may be summarised in FY2002-3 as follows:

MNRF GEMINI PROJECT BUDGET 2002-3	
(1) Institutional subscriptions:	\$k
CSIRO ATNF	32
ANU RSAA	245
Sydney Uni	65
UNSW	210
Uni. Melbourne	52
Swinburne	10
(2) ARC linkage grant	1637
(3) MNRF funding	2051
TOTAL BUDGET	4302

MNRF GEMINI PROJECT EXPENDITURE 2002-3	
	\$k
(1) Matching funding paid into Sydney University trust fund for payment of existing \$4.76% Gemini subscription. This consists of the \$1855k ARC grant (shown in Table 2 of Appendix G, and audit document 7) plus \$614k total institutional subscriptions shown in Table 2 of Appendix A2, and audit document 6)	2469
(2) Cash payment to NSF for the additional 1.43% share	0
TOTAL EXPENDITURE	2469

Payment to NSF for FY2002-3 was held up by contractual delays (in the USA), and so payment for FY2002-3 was not made until October 2003, and will be formally reported in the MNRF annual report for FY2003-4. Thus, formally, expenditure of MNRF funds on this project in FY2002-3 is zero. Thus the MNRF income of \$2051 shown above has all been carried forward to next financial year. For information, the amount paid to Gemini from the MNRF in October 2003 was US\$1,095,320.00

A letter certifying payment of all the institutional contributions is appended to this report in Appendix F, and a note from Sydney University confirming payment of the ARC Linkage grant is on file and can be supplied on request.

Expenditure profile for the following years is still uncertain because of the uncertain spending profile associated with remaining Gemini funds, and has therefore been left unchanged from the business plan.

Appendix B3: RSAA GEMINI INSTRUMENTATION - PROJECT REPORT FOR FY2002-2003

Project Leader: Prof. P. D. Sackett, ANU RSAA

Participating Organisations: ANU RSAA

EXECUTIVE SUMMARY

The RSAA (Research School of Astronomy and Astrophysics) of the Australian National University (ANU) participates in the Australian Astronomy MNRF through:

- support for the operating costs of the Gemini Telescopes through the period of the MNRF,
- in-kind contributions associated with the construction of the Gemini South Adaptive Optics Imager (GSAOI) for the Gemini South 8m telescope, and
- the completion of the Near-infrared Integral Field Spectrograph (NIFS) for the Gemini North 8m telescope.

ANU and the National Optical Astronomy Observatory (NOAO) of the USA presented competing designs for GSAOI at the Conceptual Design Review held in Hawaii in August 2002. ANU was chosen in November 2002 to develop the detailed design and construct the instrument. The Preliminary Design Review was held in May 2003. The construction contract between ANU and the Gemini Observatory was signed in September 2003. The Critical Design Review was held in October 2003, after which the Gemini Observatory gave its approval for construction to proceed. GSAOI is currently on track for an on-time delivery in late 2005.

NIFS was undergoing final alignment tests when it was destroyed in the Canberra bushfires of Jan 2003, just six months before shipment was scheduled. The Gemini Observatory has since signalled its confidence in ANU by agreeing to have NIFS rebuilt by the Canberra-based aerospace company, Auspace, in collaboration with ANU. The bushfires were a major setback for the NIFS project. However, it is now expected that NIFS-II will be shipped to Hawaii as soon as December 2004.

1. MILESTONES

	Milestone	Milestone Date	Outcome
	Complete each of the remaining milestones for the completion of NIFS.	NIFS-I: July 2003 NIFS-II: December 2004	The NIFS contract with the Gemini Observatory was amended as a result of the Canberra bushfires.
	Deliver NIFS to Gemini.	February 2005	Delivery of NIFS-II to ANU is now scheduled for 13 September 2004. Auspace are on track to meet this milestone. Delivery of NIFS-II to Gemini is expected 5 months later.

	Successfully commission NIFS on Gemini North.	June 2005	
	Award of a new instrument contract from Gemini.	Before July 2004	GSAOI contract awarded in November 2002
	Contingent on 4.) above, complete each of the milestones associated with the design and construction of said instrument.	September 2005	GSAOI completed its Critical Design Review on 27-28 October 2003, before the scheduled date of 5 December 2003.
	Contingent on 4.) above, deliver said instrument.	November 2005	
	Contingent of 4.) above, successfully commission said instrument.	May 2006	

2. OTHER ESTABLISHMENT ISSUES

The RSAA Technical Projects Manager, Liam Waldron, has taken over as GSAOI Project Manager so that Jan van Harmelen can act as Project Engineer for GSAOI and continue to be the Project Manager for the NIFS rebuild.

A mechanical engineer, Glen Jones, has been hired to oversee procurement of out-sourced cryostat components for GSAOI and NIFS-II.

An instrumental astronomer position has been advertised to assist the GSAOI/NIFS Project Scientist, Peter McGregor, in these tasks that must now be performed in parallel as a result of the destruction of NIFS-I. Advertisements for the position closed on 31 October 2003.

3. RESEARCH, ACCESS & COLLABORATION

3.1 Facilities Access Regime

This is not presently applicable. RSAA is constructing two instruments for Gemini telescopes. Access to the Gemini telescopes is detailed in Project 2.

3.2 Collaboration and Linkages

Auspace Pty Ltd is rebuilding NIFS under subcontract from ANU.

3.3 Facility's Contribution to Research and Training

On-time acceptance of GSAOI by the Gemini Observatory will generate 20 nights of guaranteed time using the instrument on the Gemini South telescope. This guaranteed time decreases by one night for every 2 weeks acceptance is over-schedule to a minimum of 8 guaranteed nights.

Acceptance of NIFS will generate 12 guaranteed nights using the instrument on Gemini North. These nights are available for use by the Australian instrument teams of GSAOI and NIFS, respectively.

Sixteen RSAA engineers and technicians are working on the GSAOI and NIFS projects. Involvement in these projects exposes these technologists to design tools, components, procedures, and international collaborative discussions to which they would not have access if it was not for these projects.

The recent GSAOI Critical Design Review is one example where instrument scientists and engineers from USA, Canada, and Chile visited ANU to review the design and exchange information.

3.4 Contribution to Australian industry

NIFS is being rebuilt by Auspace Pty Ltd, which is a small enterprise based on advanced space technology with an international focus. Auspace recognizes that astronomical instrumentation demands similar technological skills to space instrumentation, and that it commands a significant international market with over US\$10 billion set to be invested internationally in astronomical hardware over the next decade.

The rebuild of NIFS has resulted in technology transfer from ANU to Auspace that has strengthened Auspace's market position.

4. PROMOTION OF THE FACILITY

4.1 Marketing

This is not currently directly applicable to RSAA.

4.2 Promotion

Two papers promoting NIFS to an international audience of technologists were presented at the August 2002 SPIE meeting in Hawaii:

- *McGregor et al, 2002, SPIE 4841, 1581-1591, "Gemini Near-Infrared Integral Field Spectrograph (NIFS)"*
- *Hart et al, 2002, SPIE, 4841, 319-329, "NIFS Concentric Integral Field Unit"*

NIFS won the ACT Government New Technology and Innovation Award and a Highly Commended Award at the 2003 Engineering Excellence Awards, Canberra Division.

ANU made a national press release ("ANU wins competition to build \$6.3m sharp-eyed imager") upon the award of the GSAOI construction contract in December 2002.

ANU's success in winning the GSAOI construction contract in competition with the premier optical astronomy observatory in the USA promoted Australia's science and technology to the entire Gemini partnership of USA, UK, Canada, Australia, Chile, Argentina, and Brazil.

The early, thorough, and successful completion of the GSAOI Critical Design Review by ANU has set new standards for instrumentation achievement within the Gemini partnership and further promoted Australian scientific and technological capability.

ANU participated in the Industry Day associated with the International Astronomical Union General Assembly in Sydney in July 2003 where the NIFS and GSAOI projects were promoted to Australian industry.

5. COMMERCIALISATION

This is not applicable to RSAA in the report period.

6. FINANCIAL REPORTING

Subject to the caveats listed below, RSAA agreed to provide the following contributions to the Australian Astronomy MNRF in FY2002/3 as part of the RSAA Gemini Instrument Building (Project 3). Note that RSAA also paid an institutional subscription of \$245k to Gemini, which is included in Project 2 (and listed in Table 2 of the overall financial tables).

#	Item	Commitment (from Project plan) (\$k)	Outcome (\$k)
1	GSAOI cash contribution	70 (subject to caveats)	0 (see note 1)
2	In-kind contributions from unreimbursed contributions to NIFS, GSAOI, and others instruments.	294.4	420.384 (see note 2)

Note 1: Item 2 was contingent upon RSAA winning a new bid to supply instrumentation to Gemini and on the AUD/USD exchange rate remaining at or below the rate assumed in the instrument contract (see the MNRF Business Plan). RSAA won a contract to provide GSAOI for Gemini South, with an assumed exchange rate of 1AUD = 0.63USD. During the report period, the AUD strengthened; at October 2003 it stood at 0.70USD, and by late November is even higher. On the contract price of some US\$3.2m, this fluctuation represents at least A\$508k, or A\$102k p.a. over 5 years, which must be absorbed by RSAA. Given the contingency in the conditions under which this cash contribution would be made, RSAA is not in a position to make this contribution.

Note 2: In-kind salary contributions amount to \$420k, which contains a) unclaimed NIFS overhead from July 2002 to June 2003 calculated from hours work and base salary of all staff working on the project, b) donated NIFS labour of Project Scientist, and c) donated GSAOI labour of Project Scientist and Project Manager. This amount is entered in Table 1 of the overall financial tables.

In summary, RSAA have committed \$420k of in-kind contributions to this project within this financial period, compared to the \$243k committed in the business plan, or

the \$294k committed in the Project Plan. Due to exchange rate fluctuations, RSAA was not able to make the \$70k cash contribution associated with the GSAOI contract.

These in-kind contributions may be summarised as follows:

	2002/3
Salaries	420
Capital	0
Other	0
Totals	420

There is no cash expenditure in this project.

Because of the nature of this project, expenditure is equal to income.

Appendix B4: AAO Instrumentation - PROJECT REPORT FOR FY2002-2003

Project Leader: Chris Tinney, AAO

Participating Organisation: AAO

Executive Summary

The Anglo-Australian Observatory has participated in the Australian Astronomy MNRF through its support for the 'back office' functions for Australian applications for telescope time on the International Gemini Observatory, and the Gemini wide-field multi-object spectrograph (KAOS) pre-concept study. During FY2002-3, its principal contribution has been in responding to scientific input requirements to the pre-concept study and contributing to the KAOS *Purple Book*.

1. Milestones

	Milestone	Milestone Date	Outcome
1.	Provide 'back office' support	Continuing activity	Support provided at the agreed level
2.	Pre-concept study for the Gemini wide-field multi-object spectrograph, KAOS.	30 June 2003.	Pre-concept study documentation delivered on time.

2. Other establishment issues

The key AAO personnel involved with MNRF activities during the reporting year were:

Brian Boyle, Director

Chris Tinney, Head of Astronomy

Joss Hawthorn, Head of Instrument Science

Roger Haynes, Acting Head of Instrumentation

Anna Moore

Stuart Ryder

No new appointments were made during the year specifically as a result of MNRF activities. If the AAO is successful in the new instrumentation contracts referred to in the Project Plan, there may be new appointments made during FY2003-4.

3. Research, access and collaboration

Facility's access regime

AAO provides 'back office' support consisting of (1) operating the Australian Gemini time-application web server, and (2) providing technical assessments, phase 2 proposal support and secretarial services.

Collaborations and linkages

AAO has fostered a linkage with NOAO in preparing the KAOS pre-concept study.

Facility's contribution to research and training

No activity in the reporting year.

Contribution to Australian industry

No activity in the reporting year.

4. Promotion of the facility

Marketing

The AAO is pursuing an aggressive regime in marketing its instrumentation work, based on personal contacts with institutions like the UKATC, University of Cambridge and University of Oxford.

Promotion

The AAO stand at the IAU Astro Expo in July 2003 attracted much interest, as did the brochure *Novel solutions for your astronomy*, published to outline AAO's capabilities in instrument-building and design. AAO also participated in the Industry Day at the IAU General Assembly.

The KAOS *Purple Book*, embodying the results of the pre-concept study, has been widely circulated.

Some instrumental advances related to the pre-concept study are being prepared for presentation at the SPIE Instrumentation Symposium in June 2004.

5. Commercialisation

Not applicable, except inasmuch as has been referred to already (e.g. in transfer of information to users).

6. Financial reporting

The contributions for 2002/3 consist only of in-kind contributions, for (a) Gemini "back-office" support, and (b) a pre-concept study for the Gemini wide-field multi-object spectrograph, KAOS.. These matching contribution consist of salaries plus overheads (calculated as in Section 4.1 of the main report).

#	Item	Commitment (from Project plan) (\$k)	Base salary (\$k)	Oncosts (\$k)	Other costs (\$k)	Total (\$k)
1	Provide 'back office' support for 2002/3 (S. Ryder, C. Tinney, H. Woods)	12.0	13.2	3.4	9.7	26.3
2	Pre-concept study for the Gemini wide-field multi-object spectrograph, KAOS. (J. Brzeski, J Hawthorn, A McGrath, A. Moore)	52.0	41.6	10.8	30.8	83.2
3	30-metre telescope development (C. Evans, J. Hawthorn, R. Haynes)	0	12.7	3.3	9.4	25.4
	TOTAL	64.0	67.5	17.5	49.9	134.9

These in-kind contributions may be summarised as follows:

	2001/2	2002/3	Total
Salaries (including on-costs)	0	85.0	85.0
Capital	0	0	0.0
Other	0	49.9	49.9
Totals			134.9

There is no cash expenditure in this project.

Appendix B5: Australia Telescope Compact Array Broadband Backend (CABB) - Annual Report for FY2002-2003

*Project Leader: Warwick Wilson, CSIRO ATNF
Participating Organisations: CSIRO ATNF*

1. Overview

The major milestone for 2002/3, the completion of the digital filter bank demonstrator, has not been achieved. Good progress has been made towards this goal but unexpected problems with the complex Field Programmable Gate Array design software have caused delays. Although ATNF has considerable experience and expertise in the design of FPGAs, the much-increased level of complexity of the DFB FPGA circuits called for a new approach to the design process. New design tools were purchased and installed and considerable effort was expended on learning the new system. Although this has resulted in significant delays to the early stages of the project, the experience gained should pay dividends as the project progresses, particularly due to the widespread application of FPGAs in many areas.

Delays have also occurred in other areas due to a lack of ATNF funded manpower arising from over-runs in other unrelated projects. There have, however, been cases where work on other projects has been directly applicable to the CABB project. An example is the successful installation of very wide-band analogue data links over fibre optic cables on the Compact Array. The experience gained with these links will provide invaluable input to the decision, yet to be finalised, on the means of transporting the data in the CABB project.

A revised Gantt chart, which takes account of these delays, is attached. The final completion date remains unchanged.

2. Milestones

Progress against milestones is shown in Table 1, with estimated revised dates for these milestones.

Milestone	Date shown in Project Plan	Outcome	Revised date
Commencement of project – conceptual design	January 2002	Commenced on schedule	January 2002
Demonstration of DFB demonstrator spectrometer	April 2003	Delayed by learning process on new FPGA design tools	October 2003
Completion of 2GHz DFB (digital filterbank)			April 2004
Testing of prototype photonic data transmission system	February 2004	Delayed by over-runs in unrelated areas	August 2004
Testing of prototype conversion system	April 2004	Delayed by over-runs in unrelated areas	October 2004
Commencement of installation at Narrabri	July 2005		July 2005
Six antenna ATCA operational with new backend	January 2006		July 2006
Broadband ATCA tied array operational	July 2007		January 2007

3. Other establishment issues

None encountered.

4. Collaboration and Linkages

The development work for this MNRF enabled a prototype digital polyphase filterbank spectrometer to be developed. Building on this, UNSW have successfully applied for ARC funding to construct a full production filterbank spectrometer for the Mopra telescope. Thus, as a spin-off from this project, the Mopra telescope will be upgraded to be the most versatile millimetre single-dish telescope in the world.

5. Financial Reporting

Financial projections from the project plan are as follows:

Year	Contribution In-kind \$k	Contribution Cash \$k	MNRF Funding \$k
01/02	100	0	0
02/03	300	250	500
TOTAL	400	250	500

Thus the total income for the project was \$1150k. The cash and in-kind contributions are entirely from the ATNF.

Actual expenditure, taken from the PSS (Project Support System), is as follows:

	2001/2	2002/3	Total
Salaries	0	146.5	146.5
Capital	37.0	76.3	113.3
Other	0	0	0
Totals			259.8

This amount is charged as cash expenditure and entered in table 3a of the financial tables.

To this should be added the overheads, calculated as 0.67 of salary, as described in Section 4.1 of the main annual report, as follows:

	2001/2	2002/3	Total
Overheads	0	98.2	98.2

This amount is charged as in-kind expenditure and entered in table 1a of the financial tables.

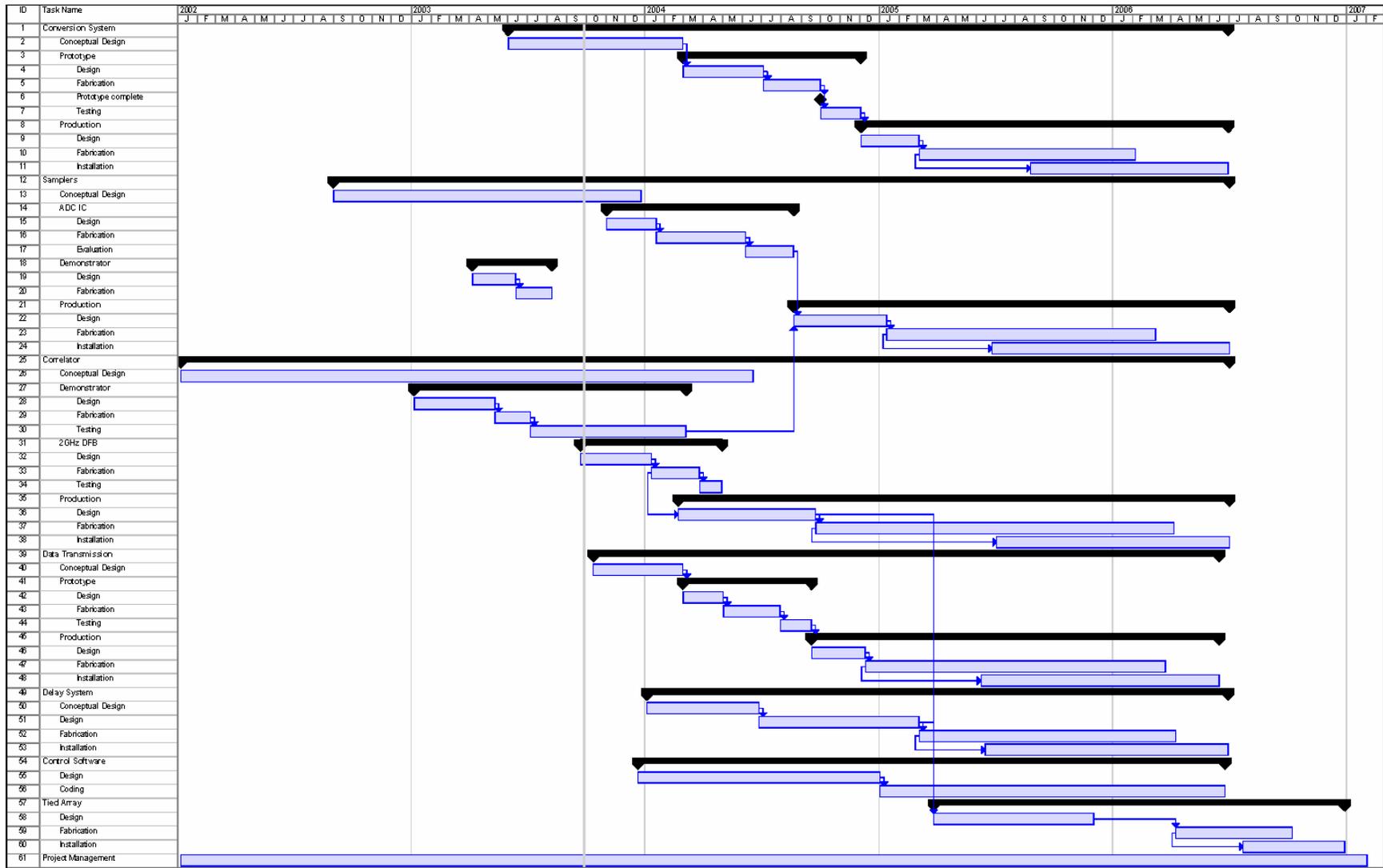
Overall income and expenditure may then be summarised as follows:

Year	Budgeted Matching ATNF funding \$k	Budgeted MNRFFunding \$k	Total Budget \$k	Actual Expenditure \$k
01/02	100	0	100	37
02/03	550	500	1050	321
TOTAL	650	500	1150	358

This project therefore shows a significant underspend, the causes of which are discussed above in Section 1 of this Appendix. As a result of this slow start-up, we have revised the budget profile as follows. The funding profile has been revised from the business plan, but the total amounts, goals, and timescales for completion are identical. The descriptions of deliverables have been finalised.

Year	Project Summary, Goals and Deliverables	Contrib. In-kind (\$k)	Contrib. Cash (\$k)	MNRFFContrib. (\$k)
01/02	Conceptual design studies	40	0	0
02/03	Conceptual design continues Develop DFB demonstrator	115	40	190
03/04	Develop prototypes of final system	295	260	535
04/05	Move from prototyping to full production	350	600	750
05/06	Production and installation	450	600	750
06/07	Tied array installation	50	100	150
Total		1300	1600	2375

To calculate the fractions of these future budgets that will be used on salaries, capital, and other, it has been assumed that salaries account for 41%, capital for 32%, and other for 27%. These figures are based on experience to date with this project.



Project: cabbb
Date: Sat 27/09/03

Task		Milestone		Rolled Up Task		Rolled Up Progress		External Tasks		Group By Summary	
Progress		Summary		Rolled Up Milestone		Split		Project Summary			

Appendix B6: New Technology Demonstrator - Project Report for FY2002-3

Project Leader: Peter Hall, ATNF

Participating Organisations:

- *CSIRO ATNF,*
- *CSIRO ICT Centre (CICTC),*
- *CSIRO TIP (CTIP)*
- *CSIRO Manufacturing and Industrial Technology (CMIT)*
- *Macquarie University*
- *CISCO Systems (Australia)*
- *CEA Pty Ltd.*
- *APT Pty. Ltd.*

Executive summary

The Luneburg Lens prototyping work is progressing well. A new artificial dielectric material has been developed, and the manufacturing process for this has been patented. There has been some slippage in the lens project milestones due to the challenges involved in developing the new manufacturing process. Delivery of a prototype 0.9 m Luneburg Lens constructed from the new dielectric material is now anticipated by December 2003 instead of July 2003. It is still expected that the choice of demonstrator concept will be made by 30 June 2004, as proposed in the MNRF Business Plan. Further work is required to determine whether the Luneburg Lens concept is appropriate for the SKA context or whether its use will be confined to commercial development only.

A new feed translator system for the Lens has been designed and manufactured. Software to control the feed translator has been written.

Two Australian SKA Concept description whitepapers have been written. The “Eyes on the Sky” whitepaper is based on Luneburg Lens antennas as a method for exploring a multi-fielding SKA concept.

1. Milestones

Progress against the project goals and milestone dates for the NTD Project for financial years 2001–2 and 2002–3 are listed in the following tables.

Milestone/goals	Target date	Outcome
Establish cross-divisional collaboration (CTIP, CMIT, CMS, ATNF) to investigate possible low loss, low density composite dielectric materials.	December 2001	Collaboration set up and flourishing
Develop analysis and design software for spherical lenses	30 June 2002	Software constructed on target (see Section 9 below).
Demonstrate low-loss dielectric with values suitable	30 June 2003	New dielectric developed with very low loss. (see Section 9

for spherical lens.		below).
Construct first prototype spherical lens	30 June 2003	Prototype constructed November 2003
Test hybrid array / lens system using FARADAY phased array.	30 June 2003	Tests conducted using Konkur lens in February 2003
Develop signal transport model based on LOFAR and SKA specifications.	30 June 2003	Development of this model is in progress
Develop wideband beam-former concept using direct digital sampling.	30 June 2003	This development is behind schedule.

2. Other establishment issues

- The focus of this project so far has been the development of the Luneburg Lens. It is not yet clear whether this will in fact be a suitable technology for the SKA, although we note that this development has already produced a patent and which we expect to be commercialised. A decision point will be reached in 2003/4 whether to continue work on the Luneburg lens, or whether to concentrate instead of phased array technology.
- The phased array work in this area is complementary to the European Union Faraday and Pharos programs, and to the LOFAR program. ATNF and CICTC are participants in all these programs, thus developing a high degree of synergy and cross-fertilisation.

3. Research, Access & Collaboration

3.1 Facility's Access regime

The NTD prototype will be available for other engineering science developments. If it is suitable for astronomical use, it will be incorporated into the ATNF telescopes and will be open for use by all astronomers using the National Facility.

3.2 Collaboration and Linkages

This project has been joined by new collaborators who were not part of the initial MNRF proposal: Cisco Systems, Macquarie University Centre for Electromagnetic and Antenna Engineering, and Connell-Wagner, who have made a \$500k donation of their billable time.

Discussions were held between CSIRO, CEA and Dutch collaborators on achromatic phased array design in early 2003, while Arnold van Ardenne, an ATNF Distinguished Visitor from ASTRON in the Netherlands was visiting ATNF. A digital array prototype was defined and areas for potential further work were identified.

APT has supplied Al₂O₃ nanoparticle powder for testing purposes. Currently APT is unable to supply the TiO₂ nanoparticle powder required for testing the current materials but may be able to supply this in future. This will be pursued after further research and tests with TiO₂ macro structures produced with new CMS manufacturing process.

4. Facility's Contribution to Research and Training

This project has contributed to the training of young engineers through the following programs:

- Two PhD students (Suzy Jackson & Doug Hayman)
- Two vacation students (Paul Conner & Simon Nawrot)
- One industry experience program student (Adam Deller)

5. Promotion of the Facility

There have been many promotional activities, including:

- Presentation of material at the "IAU industry day" at the IAU General Assembly, Darling Harbour
- Outreach to high-school students through the SEARFE project (see <http://www.searfe.atnf.csiro.au/>)
- TV programs such as the ABC "Catalyst" program
- Publication of popular articles in national newspapers and magazines such as the Australian, the Sydney Morning Herald, the Age, the Canberra Times, the Financial Review, the Weekend Australian, and the West Australian. Some 63 articles have appeared in the press on the SKA during this reporting period.
- Publications in specialist journals and international magazines. These include
 - Cole, M., "Engineering the Square Kilometre Array" in EA magazine, January 2003.
 - Hall, P. J. : The Square Kilometre Array - An Australian Perspective, ITEES (Aust) Monitor, 26(3), 2001, pp. 18 - 20.
 - Hall, P. J. : Square-Kilometre Array Radio Telescope May Come to Australia, What's New in Radio Communications, April/May 2001, pp. 35-38.
 - Brouw, W. "Australian research effort for the SKA". Astrophys. Space Sci., 278, 205-208 (2001).
 - Ekers, R.D. "Square Kilometre Array". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).
 - Ferris, R.H., Bunton, J.D. & Stuber, B. "A 2GHz digital filterbank correlator". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).
 - Hall, P.J. "Australian SKA: progress and directions". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).
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 - Hall, P.J., Kutuzov, S. & Dagkesamanskii, R. "A prototype Luneburg lens antenna". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).
 - Roberts, P. "Impulse sampling and photonic A/D conversion in the SKA". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).
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 - Hall, P.J. "The Square Kilometre Array - Australian directions". In: Workshop on Applications of Radio Science (WARS 2002), Leura, 20-22 February, 2002, (2002).
 - Mitchell, D.A., Sault, R.J. & Kesteven, M.J. "Post correlation versus real-time adaptive RFI cancellation". In: URSI XXVIIth General Assembly, Maastricht, 17-24 August, 2002, p0115.(2002).
 - HALL, P. J. "Square Kilometer Array (SKA) prototyping in Australia - an overview". In: URSI XXVIIth General Assembly, Maastricht, 17-24 August, 2002, p1326.pdf (2002). (S)
 - Reports to the International SKA Consortium or other bodies, including:
 - Hall, P. J. (Ed.): The SKA — Initial Australian Site Analysis, May 2003. (<http://www.skatelescope.org/documents/swp.shtml>)
 - Chippendale, A. P., Storey, M. C. and Hall, P. J. : Low Frequency Array — RFI Site Test Report Mileura Station WA, Report to the LOFAR International Steering Committee, March 2003. (http://web.haystack.mit.edu/lofar/siting_docs/AUS_RFI.pdf)
 - Hall, P. J. (Ed.): Eyes on the Sky — A Refracting Concentrator Approach to the SKA, Submission to International SKA Steering Committee, July 2002. (<http://www.skatelescope.org/documents/dewp.shtml>)

6. Commercialisation

We are working with our industry partners to commercialise the patented new material that we have developed for the Luneburg lens.

7. Financial Reporting

The financial projection for income for this reporting period, taken from the project plan, is as follows:

Year	ATNF Contrib'n In-kind \$k	ATNF Contrib'n Cash \$k	CTIP Contrib'n In-kind \$k	MNRF Funding \$k
01/02	100	0	0	0
02/03	200	250	160	185
Total	300	250	160	185
Total Income: \$895k				

Note that CEA and APT were not expected to make a contribution in this reporting period.

Actual ATNF expenditure, taken from the PSS (covered by costcodes FN58 and FN59) is as follows:

	2001/2	2002/3	Total
Salaries	0	406.2	406.2
Capital	0	7.5	7.5
Other	0	356.6	356.6
Totals	0	770.3	770.3

This amount is charged as cash expenditure and entered in table 3a of the financial tables.

To this should be added the ATNF overheads, calculated as 0.67 of salary, as described in Section 4.1 of the main annual report, as follows:

	2001/2	2002/3	Total
Overheads	0	272.1	272.1

This amount is charged as in-kind expenditure and entered in table 1a of the financial tables.

CTIP made an in-kind contribution (costcode DS48) as follows:

	2001/2	2002/3
Salaries	0	156.9
Capital	0	0
Other	0	421.8
Totals	0	578.7

Total expenditure is therefore as follows:

Cash

	Total
Salaries	406.2
Capital	7.5
Other	356.6
Totals	770.3

In-kind

	Total
Salaries	156.9
Capital	0
Other	693.9
Totals	850.8

Overall income and expenditure may then be summarised as follows:

Year	Budgeted ATNF matching contrib'n \$k	Budgeted CTIP matching contrib'n \$k	Budgeted MNRF funding \$k	Total Budget \$k	Expenditure \$k
01/02	100	0	0	100	0
02/03	770.3	160	185	795	1621.1
TOTAL	550	160	185	895	1621.1

8. Detailed Project Activity

Dielectric lens materials and manufacture

<i>Activity / planned activity</i>	<i>Outcomes / Status as at 30 Jun 2003</i>	<i>Year</i>
Investigate possible composite dielectric materials with isotropy, low loss and low density over a wide bandwidth.	Two candidate materials identified: cubic crystalline lattices of short metal wires, and random mixtures of high aspect-ratio dielectric particles in low density polymer foam	2001-2002
Manufacture small samples and test in waveguide cavities.	Wire crystals and Al ₂ O ₃ platelets both give promising results for loss and density, but dielectric constant is low. Isotropy and high dielectric constant hard to achieve simultaneously. Dielectric mixtures look better at present, so proceed with this type of material, using TiO ₂ to achieve higher dielectric constant.	2001-2002
Continue with waveguide testing of TiO ₂ samples	Initial results with TiO ₂ in extruded PP foam do not show increase in dielectric constant. More careful analysis reveals relationship between dielectric contrast and aspect ratio, showing that 10:1 is OK for Al ₂ O ₃ , but TiO ₂ needs >30:1	2001-2002
Continue with waveguide testing of TiO ₂ samples of larger aspect ratio	Some increase in dielectric constant, but not sufficient. Investigation of samples shows that the large aspect ratio platelets are being broken up by the extrusion process. Trials arranged with different extrusion equipment.	2001-2002
Continue with waveguide testing of TiO ₂ samples of larger aspect ratio	Samples produced using twin-screw extruder show sufficiently high dielectric constant to proceed to design of prototype lens, using the range of dielectric constants 1.1 to 1.55	2002-2003
QC testing of material using waveguide cavities	New material passed lab tests (see Donaldson SKA2003 paper): Repeatable, isotropic, very low loss materials ($\tan \delta \leq 10^{-4}$) with required dielectric permittivity ($\epsilon_r = 1.1$ to 1.69) fabricated from artificial dielectric but currently with density too high ($\rho = 0.45$) for SKA use (too heavy to make even 4 m diameter lens). The material is too expensive for SKA use as its cost is proportional to its density. More fundamental work is required to achieve lower density materials. Medium density material able to be extruded and construction of 0.9 m diameter lens in progress. Design complete for layered tessellated construction process using extruded diamond shaped tiles. Expected delivery of 0.9 m diameter lens in December 2003. Low loss fibreglass shell identified as suitable for protective covering.	2002-2003

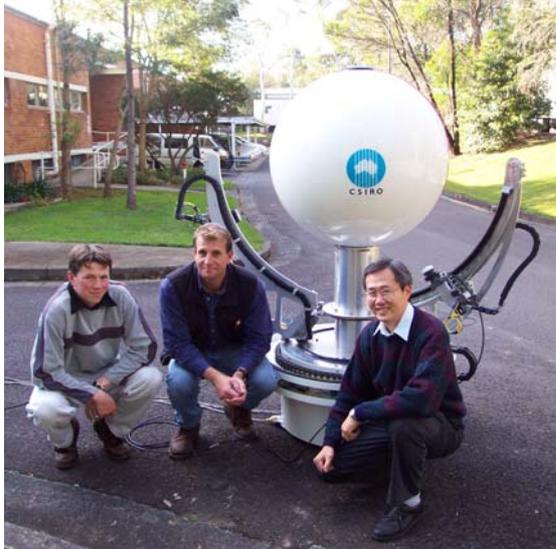


Dielectric lens antenna analysis and design

<i>Activity / planned activity</i>	<i>Outcomes / Status as at 30 Jun 2003</i>	<i>Year</i>
Develop software for analysis & design of layered spherical lens with simple feed	Analysis software for full EM analysis of a spherical lens with multiple, lossy shells + simple feed models completed. Includes optimization	2001-2002
Develop simple ray-tracing analysis of layered spherical lens for verification	Developed ray-tracing code & confirmed agreement with full EM model	2002-2003

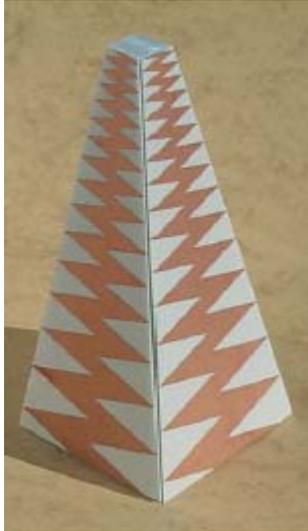
Prototype Luneburg Lens Feed Translator

A prototype feed translator system with two independent feeds for the 0.9 m Luneburg Lens has been designed and manufactured. Software to control the feed translator has been written and tested in operation with the translator.



Prototype Feed translator system

Control software for prototype feed translator system



Prototype zig-zag antenna

Phased array development

<i>Activity / planned activity</i>	<i>Outcomes / Status as at 30 Jun 2003</i>	<i>Year</i>
Develop wideband optical signal transport concepts for phased array	Signal transport models developed for LOFAR and for SKA whitepapers	2002-2003
Develop digital signal processing and beam forming concepts for phased array	Wideband beam-former concept based on direct digital sampling developed for SKA, and presented at international SKA meeting in Groningen (??)	2002-2003
Test ASTRON phased array in conjunction with Luneburg lens in CTIP NFATR	Test report	2002-2003



SKA Design Concept Whitepapers

- Eyes on the Sky: A Refracting Concentrator Approach to the SKA, Chippendale *et. al.*
- Contribution to Cylindrical Reflector SKA, Bunton *et. al.*

Remote area power

Remote area power provision has been identified as a crucial design factor for SKA and LOFAR, particularly for the proposed Australian sites and also for remote areas in the other proposed SKA sites. Australia is a world leader in remote area power provision and it is expected that the NTD will demonstrate advanced remote area power provision compatible with the extreme radio requirements of the next generation radio telescopes. Further work in this area is planned, including a workshop bringing together Australian research and industry experts to address this topic scheduled for early September 2003.

Appendix B7: MMIC Development - Annual Report for FY2002-2003

*Project Leader: Warwick Wilson, ATNF
Participating Organisation: CSIRO ATNF,*

Executive summary

The major goal of this project is to provide MMIC devices for the various MNRF technology demonstrators, whilst maintaining and developing the ATNF expertise in MMIC design. As the design of the demonstrators proceeds, the MMIC requirements become clearer and the specific goals of the MMIC project have been adjusted to meet these requirements. The first year of the project has been successful, not only in beginning the planned first MMIC fabrication run on time but also in laying the foundation for future activities.

1. Overview of Progress in 2002-3

The major achievement in this period was the completion of a number of InP MMIC designs and their submission for a fabrication run in March 2003. Designs included a range of broadband low noise microwave amplifiers covering the 1 to 12 GHz band and a 40GHz data amplifier aimed at multi-Gbit data transfer systems. Wafers from this run are due to be returned for testing in September 2003.

A number of purchases were made to improve and diversify the ATNF's MMIC design software resources. Negotiations were also completed with a number of MMIC fabrication houses aimed at obtaining propriety design information. This data is used in the design operation to facilitate the selection of the optimum process for each design.

We were successful in attracting a new PhD student (Suzy Jackson) to this project.

2. Milestones

This project is on schedule and has met this year's milestone. As the design of the demonstrators proceeds, the MMIC requirements become clearer and the specific goals of the MMIC project have been modified to meet these requirements, as follows:

Date in project plan	Original Milestone	Outcome/ revised milestone	Revised milestone date
March 2003	Submit designs for first fabrication run	Designs for the first InP fabrication run were submitted in March 2003. The fabricated wafers are due for delivery in September 2003.	completed
April 2004	Submit designs for second fabrication run.	Submit designs for sample and hold circuit. (Devices in second fabrication run now specified)	January 2004
(new milestone)		Submit designs for integrated receiver prototypes	April 2004
(new milestone)		Submit designs for integrated receiver assemblies	November 2004
December 2004	First devices available for integration into demonstrators	On schedule	December 2004
January 2005	Submit designs for stage 2 InP fabrication run	On schedule	January 2005
(new milestone)		Begin production fabrication of integrated receivers	January 2005
December 2005	Final devices available for integration into demonstrators	Samplers available for integration into demonstrators	November 2005
December 2006	Completion of integration into demonstrators	Complete final integration of devices into demonstrators	January 2007

3. Promotion of the Facility

Several publications have been produced, including:

- Chippendale, A.P. "SiGe LNA noise temperature projections for the Square Kilometre Array". In: URSI XXVIIth General Assembly, Maastricht, 17-24 August, 2002, (2002).
- Chippendale, A.P. "Technology issues for SKA receiver design". In: Workshop on Applications of Radio Science (WARS 2002), Leura, 20-22 February, 2002, (2002).

4. Financial reporting

The projected budget for this project for this reporting period, taken from the project plan (Appendix A7), is as follows. Note that the spending profile for this project differs significantly from that shown in the business plan, as described in Appendix A7, although the total expenditure over the lifetime of the MNRF remains unchanged.

Year	Project Summary, Goals and Deliverables	Contrib. In-kind	Contrib. Cash	MNRF Contrib.
01/02	Preliminary investigations, purchase design tools	30	60	0
02/03	First MMIC fabrication run	50	20	130
TOTAL		80	80	130

Actual expenditure, taken from the PSS (Project Support System), is as follows:

	2001/2	2002/3	Total
Salaries	23.5	63.5	87.0
Capital	10.6	0	10.6
Other	50.2	94.3	144.5
Totals	84.3	157.8	242.0

This amount is charged as cash expenditure and entered in table 3a of the financial tables.

To this should be added the overheads, calculated as 0.67 of salary, as described in Section 4.1 of the main annual report, as follows:

	2001/2	2002/3	Total
Overheads	15.8	42.5	58.3

This amount is charged as in-kind expenditure and entered in table 1a of the financial tables.

Overall budget and expenditure may then be summarised as follows:

Year	Budgeted ATNF contrib'n \$k	MNRF contrib'n \$k	Total Budget \$k	Actual Expenditure \$k
01/02	30	70	100	100
02/03	145	95	240	200
TOTAL 2001-3	175	165	340	300

The revised cash flow, showing actual expenditure to June 2003 and projected expenditure for the remainder of the project is:

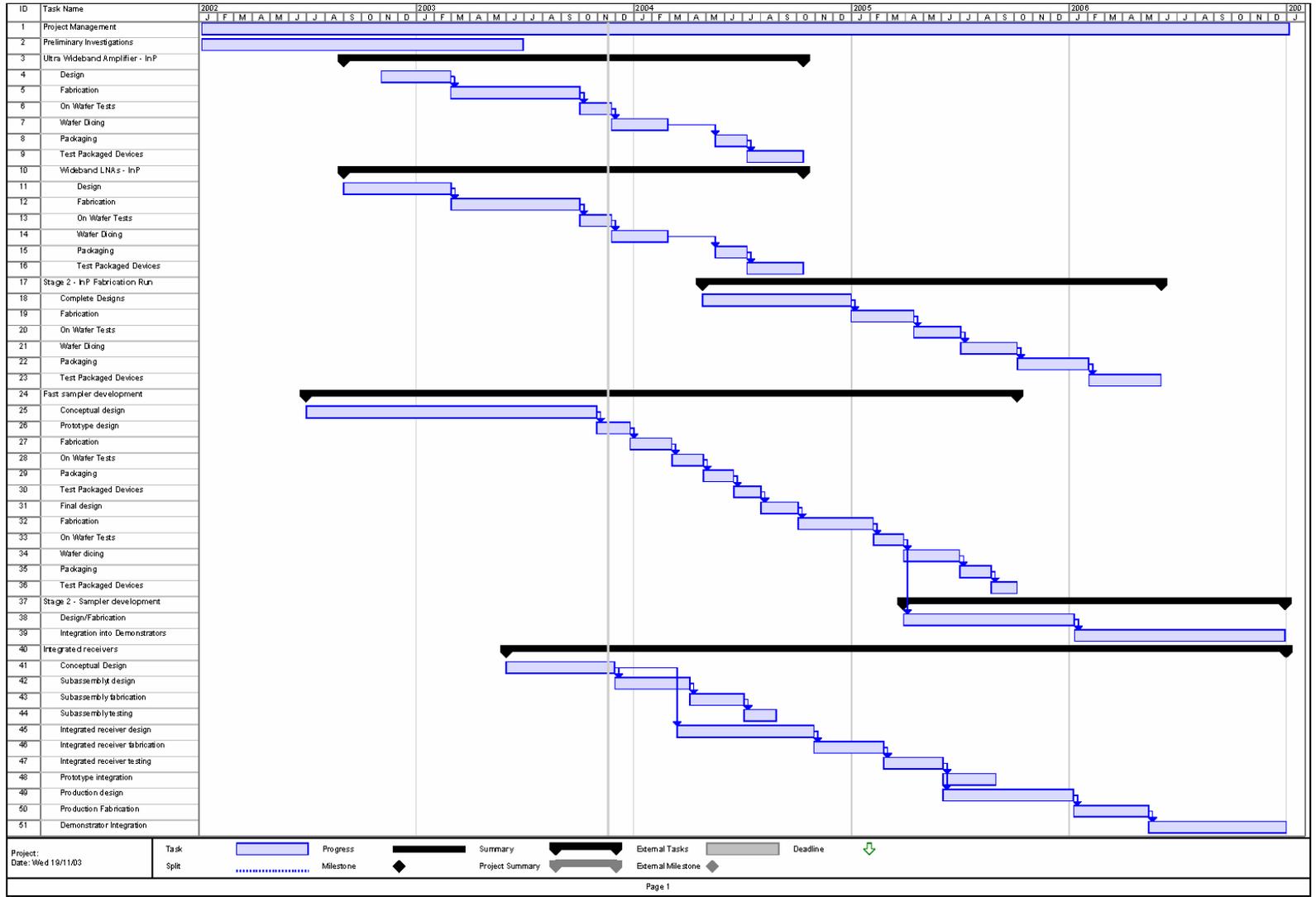
Annual Cash Flow (k\$)

<i>MNRF Funded</i>	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
Salaries	40	0	70	70	60	30	270
Capital	30	45	285	300	300	80	1040
Operating			40	40	40	20	140
Total	70	95	375	390	390	130	1450

ATNF Funded							
Labour		100	200	300	300	100	1000
Capital	30	45	200	225	200	100	800

This results in the following revised schedule of future ATNF contributions

Cash	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
Salaries		100	200	300	300	100	1000
Capital	30	45	200	225	200	100	800
Other			0	0	0	0	0
Total	30	145	400	525	500	200	1800
In-kind							
Overheads		67	134	200	200	67	668



Appendix B8: SQUARE Kilometre Array Molonglo Prototype (SKAMP) - Project Annual Report for FY2002-2003

Project Leader: Dr. Anne Green, Sydney University

Participating Organisation:

- *Sydney University*
- *CSIRO ATNF,*
- *CSIRO ICT*

Executive summary

The SKAMP Project is divided into five stages, which can proceed largely in parallel. A substantial part of the first year has been spent in initialling and defining the scope of the project.

Stage 1 is a 96 station continuum correlator, with a 3MHz bandwidth centred at 843 MHz. This system will be used with the existing front-end feeds and signal pathway of the Molonglo Observatory Synthesis Telescope (MOST). This year we have essentially completed the infrastructure, specified and designed the subsystems, and completed the correlator design. The isolation of an independent signal pathway has been achieved, to allow ongoing observations with the present technology to proceed. We have made decisions on the data format and analysis packages. The hardware and software design of the correlator was funded from a University of Sydney Sesqui R&D grant, and is not part of this MNRF.

Stage 2 will be a 30 MHz bandwidth spectral-line correlator, centred on 843 MHz. Existing ring antennas will be used, with a new intermediate frequency distribution system. Specification of this stage is well-advanced.

Stage 3 will implement a wide bandwidth capability and frequency agility in the range 300 – 1400 MHz, with an instantaneous bandwidth of 50 MHz and a wide field-of-view imaging capability. Concept designs for this part are in progress. Feed development for a dual polarisation line feed is proceeding, funded by an ARC Linkage Project Grant.

Stage 4 (not included in this MNRF project) will trial high-speed, fibre-linked data acquisition as a testbed for both the advanced SKA prototype and for the planned Low Frequency ARray (LOFAR).

Stage 5 (not included in this MNRF project) is to develop sophisticated solutions to the growing problem of radio frequency interference (RFI). A small research group will be established to develop mitigation tools over the period 2004-2006.

1. Milestones

Milestones for the Year 2002 – 2003 have been completed on schedule:

- Appointment of SKAMP Site Manager, Mr. Duncan Campbell-Wilson
- Complete design of 96 station continuum correlator

- Specify wideband feed project
- Build infrastructure and isolate a second signal pathway
- Update of SKAMP scope of project document to include design modifications

2. Other establishment issues

The appointment of SKAMP Site Project Manager (Mr. Duncan Campbell-Wilson) has been accomplished. It is planned to advertise a position for an RF engineer, based at the Molonglo Observatory. This appointment is to design and implement the two stages of beam-forming and carry out the fibre-feeding of the new front end. ARC funding (through a Discovery Grant) has been awarded for the operation of the telescope for the period 2004 to 2005 inclusive, to undertake a scientific program to observe the southern sky. Observations at the present stage of the SKAMP project will not impede its progress. On the contrary, maintenance of a working instrument is essential for intermediate testing of SKAMP sub-systems. Staff supported by this ARC grant are Mr. John Barry and Mr. Greg Kingston. Additional funding is being sought for a software engineer. There are currently three young engineers working and training in the project (Aaron Chippendale, Martin Leung, Timothy Adams).

3. Research, Access & Collaboration

3.1 Facility's Access regime

The MOST is owned and operated by the University of Sydney as a research and educational facility. Adequate access for testing of developments for the SKAMP project has been organized via the establishment of a parallel signal pathway. This will allow current science programs to proceed while the SKAMP project continues.

While MOST is not itself a National Facility, it is made available to all astronomers on an informal basis. When SKAMP is complete, it is important that all Australian astronomers are able to access it, and a plan will be drawn up during the course of SKAMP construction to achieve this.

On completion of the SKAMP project, it is planned that proposals for observations will be submitted to the Australia Telescope Time Assignment Committee (TAC) for peer review. Observing time will be allocated based on the TAC ranking, with some time set aside for maintenance, development, and Director's discretionary time.

3.2 Collaboration and Linkages

The SKAMP project is an essential part of Australia's contribution to the SKA development plan. Hence, it is linked to a major international consortium at several levels – through both scientific and technical working groups. The wideband feed project is a three-way collaboration between the University of Sydney, CSIRO and Argus Technologies Australia.

3.3 Facility's Contribution to Research and Training

The MNRF Programme objective of access for Australian astronomers to a world-class low frequency imaging spectral-line radio-telescope will be achieved at completion of the SKAMP project. In the year FY2002-2003 the opportunity for R&D has come with the planning and progress in implementation of a 10-layer high-speed continuum correlator. The wideband feed development is a joint industry project,

sharing technology expertise in antenna design with CSIRO and the University of Sydney. Both these projects are training young engineers. Future appointments at MOST of RF and software engineers will increase the technology skills base in regional NSW.

In addition, two PhD students (Aaron Chippendale and Martin Leung) are already engaged in SKAMP as part of their thesis studies.

3.4 Contribution to Australian industry

The wideband feed project will benefit the Australian SME Argus Technologies P/L in providing a cost effective line feed for a cylindrical antenna, operational over a 5:1 wavelength range. It is also training a potential new employee and will provide the company with the opportunity to tender for relevant projects associated with the SKA and LOFAR projects.

Fruitful discussions were held with the software tools company Altium (previously Protel). Their Marketing and Technical executives are interested in providing advanced support and software to enable faster progress in the logical routing of signals in the correlator.

4. Promotion Of The Facility

The SKAMP website has been linked to the international SKA website and the project was presented at the international SKA conference held in July, 2003 in Geraldton, W.A. The project was also displayed at the Technology Day and during the International Astronomical Union General Assembly, held in Sydney in July 2003. Papers were also presented at the meeting "SKA: Defining the Future" held in Berkeley, California, on 9-12 July 2001. A full list of papers is available on <http://www.physics.usyd.edu.au/astrop/ska/>.

One refereed paper has been published based on the MNRF work:

- Warr, G.B., Bunton, J.D., Campbell-Wilson, D., Cram, L.E., Davison, R.G., Green, A.J., Hunstead, R.W., Mitchell, D.A., Parfitt, A.J. & SADLER, E.M. "Prototyping SKA technologies at the Molonglo radio telescope". In: Workshop on Applications of Radio Science (WARS 2002), Leura, 20-22 February, 2002, (2002).

The following additional publications have also been produced:

- Warr, G.B., Bunton, J.D., Campbell-Wilson, D., Davison, R.G., Hunstead, R.W., Mitchell, D.A. & Parfitt, A.J. "Prototype SKA technologies at Molonglo. 2. Antenna and front end". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).
- Green, A.J., Bunton, J.D., Campbell-Wilson, D., Cram, L.E., Davison, R.G., Hunstead, R.W., Mitchell, D., Parfitt, A.J., Sadler, E.M. & Warr, G.B. "Prototype SKA technologies at Molonglo. 1. Overview". In: SKA: Defining the Future, Univ. of California, Berkeley, 9-12 July 2001, (2001).

5. Commercialisation

The commercialization strategy of SKAMP is described in Section 3.4 (above).

6. Financial Reporting

For the FY 2002-2003, no funds were expended from the MNRF contribution. The appointment of the Site Project Manager (Mr. Duncan Campbell-Wilson) was covered by the University of Sydney contribution .

Hardware and software design for Stage 1 continuum correlator was funded from the University of Sydney Sesqui R&D grant, external to the MNRF grant (and not listed in Table 5).

The budget projection for this reporting period, taken from the project plan, is as follows.

Year	Matching Contrib'n In-kind \$k	Matching Contrib'n Cash \$k	Facility Contrib. \$k
01/02	0	0	0
02/03	127.5	90	0
TOTAL	127.5	90	0

Actual expenditure for 2001-3 on SKAMP is as follows.

Year	Contrib. In-kind \$k	Contrib. Cash \$k	Facility Contrib. \$k
01/02	0	0	0
02/03	134	0	0
TOTAL	134	0	0

Actual expenditure is as follows:

Cash – no expenditure

In-kind

	2001/2	2002/3	Total
Salaries	0	67	67
Capital	0	0	0
Other	0	67	67
Totals			134

Appendix B9: SKA SITE STUDIES - PROJECT REPORT FOR FY2002-2003

Project Leader: Dr Michelle Storey

Participating Organisations: CSIRO ATNF, Government of Western Australia

Executive summary

The project has been very successful thus far, and has received a boost from our WA candidate site being chosen as a potential site for LOFAR. As a result of this, suitable regions of the Mid West region of WA have been excluded from mining exploration, and these regions have been carefully characterized, using LOFAR siting as a test case for SKA siting, as LOFAR can be viewed as a phase 1 SKA telescope. The LOFAR International Steering Committee recently ranked the WA site as the best site in the world on science and technical grounds for the LOFAR radio telescope.

As a result, this site is now being carefully characterised, and this process may serve as a model of best practice when characterising other potential SKA sites. LOFAR has also had the effect of publicising the siting issue, and we are happy to report that local communities strongly support future radio telescope siting in the area.

An Initial Site Analysis Document was prepared and submitted to the International SKA Steering Committee including significant material from WA, and was very well received.

1. Milestones

Year	Activity	Milestone/KPI
2002-3	Establish clear contact points between OSI (WA Office of Science and Innovation) and CSIRO ATNF	Good contact and working relationship established between OSI and ATNF
	Characterize the Mileura Station site with detailed information on landform, vegetation, geology etc	CDROM produced with much detailed information on the land of the central core for SKA on Mileura Station.
	Investigate issues of native title, planning permission, EIA etc in relation to the Mileura site.	Contact made with relevant bodies and discussions held.
	Identify further international concerns and priorities for SKA sites in the Mid West region. Use LOFAR site studies to further illuminate these studies.	An Australian Initial Site Analysis Document was submitted to the ISSC. A White Paper and Final Siting Proposal was prepared for LOFAR siting, further characterizing the SKA site on Mileura Station, including an RFI report on Mileura Station. Much information was collected from local and Government sources in the preparation of these reports. A visit by a delegation from the LOFAR

		Consortium was hosted in February 2003, in order to receive feedback on Mileura Station and WA as a site for next-generation radio telescopes. Input was provided as requested for the Australian Initial Site Analysis Document.
	Work to identify a science support base in WA capable of supporting SKA.	OSI have hosted visits by Dr Michelle Storey and organized meetings with key science groups in WA in order to investigate sources of support and collaboration and to collect information to outline the relevant support base in WA for SKA siting.
	Prepare Initial Site Analysis Document for International SKA Steering Committee	Document prepared and submitted on time
2002-4	Organise international SKA Meeting in Geraldton, 27 July -2 Aug 03, including ISSC visits to Mileura site	SKA2003 successfully organized, sponsored and run in Geraldton WA. ISSC visit to Mileura arranged and paid for by OSI and CSIRO.

2. Other establishment issues

Contributions and Personnel:

An informal collaboration between the WA Government and ATNF will ensure that appropriate work is done at the appropriate times, recognizing the common and compatible aims of the two bodies. The collaboration has been productive and constructive thus far, and has involved assistance from the Mid West Development Commission based in Geraldton.

The principal stakeholders are the WA Govt, CSIRO, the International SKA Steering Committee and the Australian SKA Consortium Committee, especially the Siting Working Group subcommittee of ASKAC.

3. Collaboration and Linkages

The project involves a close collaboration between CSIRO ATNF and the Government of Western Australia. It has also involved assistance from the Mid West Development Commission. In addition, several industry sponsors were involved in the planning and preparation for the 2003 international SKA conference held in Geraldton, including Cray Australia, Stott and Hoare, Connell Wagner, SGI Australia, Telstra Countrywide and the WA branch of the Institute of Engineers.

The project involved working closely with the International Steering Committees of the SKA and LOFAR radio telescope projects, as the purpose of the project is to respond to the requirements of these bodies in characterizing and presenting information on potential future radio astronomy sites in WA.

4. Marketing

In a collaboration with the Government of WA, CSIRO ATNF planned and ran the 2003 international SKA conference in Geraldton, WA. The conference was very successful and showcased regional Australia as a site for future radio astronomy facilities.

5. Promotion

We have conducted briefings for local Councils and the local indigenous community on radio telescope siting issues, as well as radio interviews and newspaper interviews.

We ran the SEARFE project in a school in Geraldton in order to raise awareness of radio-quietness and its importance to radio astronomy.

6. Finance

The only formal financial commitment is the in-kind matching funding from WA State Government, and this is listed in the table below. In addition, an in-kind contribution was made by CSIRO ATNF, but has not been accounted separately in this financial year from the NTD project (project 6 of this MNRF) and so is included in those financial tables. In future years this will be accounted separately.

During this reporting period, the WA Government have committed \$117k compared to the \$200k commitment in the Business Plan. The Western Australian Government, through the Department of Premier and Cabinet, has elected to internally absorb some of the salary costs of contributing to the MNRF and not allocate them to the project. This will enable funds to be carried forward into 2004 in anticipation that those funds will be allocated to a comprehensive field testing program.

Actual expenditure is as follows:

In-kind

	2001/2	2002/3	Total
Salaries	0	73.30	73.30
Capital	0	0	0
Other	0	43.55	43.55
Totals			116.85

Appendix B10: SKA Supercomputer Simulations and Baseband Processing (SKASS)

- Project Report for FY2002-3

Project Leader: Dr Steven Tingay

Participating Organisations:

- *Swinburne University of Technology*
- *Dell Computer Pty/Ltd*
- *State of Victoria*
- *CSIRO ATNF*

Executive Summary:

The first year of the Major National Research Facilities (MNRF) Square Kilometre Array (SKA) project at the Swinburne University of Technology (SUT) has been a success. All stated research goals for the first year of the project have been met. Operational supercomputers have been established, verified, and benchmarked at the Hawthorn campus of the University and at the Parkes Observatory. These machines are now operational and available for use by the MNRF consortium as well as outside users, both domestic and international, providing increased opportunities for scientific research and development to Australian scientists, and potential commercial opportunities for SUT. These machines have been used to complete the first year research milestones for the project, which will be expanded in subsequent years, as detailed below and in the SUT MNRF Participation Deed. Up to date information on results from the SUT SKA project are available from <http://astronomy.swin.edu.au/SKA>.

1. Milestones

The numbering below corresponds to the statement of milestones in the Swinburne Participation Deed.

Milestones 2, 3, 4, 5, 6, 7, 8, and 9 have been fully addressed and completed. Milestone 1, relating to the establishment of the SUT SKA workforce, is 2/3 complete and expected to be fully completed by 20 October, 2003.

- The SUT SKA workforce has largely been established, specifically to carry out the work plan described in the SUT MNRF Participation Deed. The work plan will support 2.5 FTEs over the 5 year period of the project. Staff hire activity in the first year of the project has included:
- Appointment of an SKA Project Manager at a 0.5 FTE level, to manage the direction of the SUT SKA project, administer the project budget, produce required reports to Federal and State governments, and contribute to the scientific output of the project. Dr Steven Tingay was appointed to this position and commenced duties on January 6, 2003, under a 5 year contract.

- Appointment of one postdoctoral worker, to implement the bulk of the detailed work plan. Dr Richard Ogley was appointed to this position on April 1, 2003, under an initial 3 year contract.
- Another postdoctoral worker was offered a position, to implement the bulk of the detailed work plan, but was unable to commence duties before the end of the 2002-03 financial year, due to delays in obtaining visas for himself and his family. Dr Shinji Horiuchi has been appointed to this position and will commence duties on October 20, 2003, under an initial 3 year contract.

An operational supercomputer has been established at the Hawthorn campus of the SUT and benchmarked against the top 500 machines around the world. Thirty percent of the capacity of this supercomputer has been made available for use by both Australian and international groups involved in SKA research and development.

Specific steps resulted in the completion of this milestone:

- Machines and components that make a major contribution to the capacity of the supercomputer cluster were purchased, primarily 60 dual processor Pentium 4 server class machines. Thirty percent of the purchase cost of this equipment has been counted as an in-kind contribution to the MNRF project and is accounted for in the accompanying financial tables. The full supercomputing cluster at the Hawthorn campus comprises 106 dual processor 3 and 4 server class machines.
- The supercomputer was installed at the Hawthorn campus of SUT, including full installation of operational software and hardware. Figure 1 shows part of the installed supercomputer.
- Verification of supercomputer operations was achieved by performing standard benchmarking tests and running various types of existing parallel codes. For example, in the quarter following installation of the supercomputer, the machine hosted a total of 35 separate users, 51% of which were staff and students of the Centre for Astrophysics and Supercomputing (including the SKA research group), 26% of which were external to the Centre for Astrophysics and Supercomputing but staff or students of SUT, and 23% of which were users external to SUT, including users from 3 foreign institutes. The supercomputer therefore came online quickly and was utilised for a variety of studies, including SKA work.
- The supercomputer was benchmarked against the top 500 supercomputers around the world, achieving a ranking of #180 in this list, as of November 2002 (<http://www.top500.org/lists/2002>), at this time the 2nd fastest supercomputer in Australia. This result achieved the goal of a top 200 position for the SUT supercomputer. The supercomputer is only one of two machines in the top 500 list dedicated to astrophysical studies. The SUT supercomputer was officially opened by Craig Barrett, the CEO of the world's largest manufacturer of processor chips, Intel, on September 3, 2002.

Following installation and verification procedures, 30% of the capacity of the supercomputer was made available as part of the MNRF to Australian and overseas groups involved in SKA-related research and development. The availability of this supercomputing resource was advertised widely to the Australian community at an SKA simulation meeting held at SUT in May 2003 (see item 7 below) and internationally through the SKA Simulation Working Group (SSWG; see item 9

below). Several collaborations have been initiated between Swinburne and external groups due to this resource being made available, creating new opportunities for Australian researchers and attracting overseas researchers to the National Facility (see item 8 below).

An operational supercomputer has been established at the Parkes Observatory, for use as a baseband recorder in pulsar and RFI studies, as a prototype for baseband recorders that may be used as part of the SKA. Specific steps resulted in the completion of this milestone:

Machines and components that make a major contribution to the capacity of the supercomputer cluster were purchased, primarily 30 dual processor Pentium 4 server class machines. 100% of the purchase cost of this equipment has been counted as an in-kind contribution to the MNRFP Programme and is accounted for in the accompanying financial tables.

The supercomputer was installed at the Parkes Observatory and integrated into the Observatory's observing system. Figure 2 shows the installed supercomputer at the Observatory, known as the Caltech Parkes Swinburne Recorder II (CPSR-II), the second generation baseband recorder produced through a collaboration between the Caltech Institute of Technology, SUT, and the ATNF. CPSR-II is a baseband recorder, meaning that it samples the raw voltages produced by the telescope receiver and down-conversion system at the Nyquist rate, allowing complete reconstruction of all the information (both amplitudes and phases) present in the signal. This generates a huge amount of data (128 Megabytes per second in the present configuration), the recording and analysis of which requires a small supercomputer.

The operation of CPSR-II was verified by the collection and processing of pulsar timing data using software developed at SUT, yielding the first scientific results from CPSR-II. CPSR-II is now producing the most precise pulsar timing observations in the world.

The supercomputer baseband processing system has been used as part of a number of scientific investigations of pulsars, including the Ph.D. thesis work of two students, Mr Haydon Knight, and Mr Aidan Hotan, and the postdoctoral work of Dr Stephen Ord. For example, Figure 3 shows the signature of Shapiro delay in the newly discovered binary system J1909-3744. This figure shows the extra delay imparted to the pulses radiated from the pulsar as they travel through the deformed space-time surrounding the companion star. The shape and height of the Shapiro delay provides information about the inclination of the binary system and the mass of the companion. Results like this can be combined with other relativistic observables to perform precise tests of Einstein's General Theory of Relativity.

New observations made with CPSR-II have also revealed giant pulses in J1824-2452. Giant pulses have only been observed in two millisecond pulsars. They are difficult to observe because they are very localised in time, requiring extremely high time resolution observations. CPSR-II has the precision to observe this phenomena, and has done so with considerable success. Figure 4 shows a profile of the millisecond pulsar J1824-2452. Superimposed upon the profile is an observation of a giant pulse from this object. The giant pulse shown in the figure has been resolved with CPSR-II and shown to be 2 microseconds wide. A considerable portion of this width may be actually be due to scatter broadening of the giant pulse during its propagation through the interstellar medium, its intrinsic which may well be much narrower.

The SUT supercomputer at the Hawthorn campus has been used in initial simulations of baseband data (sampled voltage output) from a single radio telescope with arbitrary system temperature and gain characteristics. These simulations have included simulating the effects of radio frequency interference (RFI) on single antenna observations. The single antenna simulations will be expanded in later years to include the simulation of baseband data for antenna arrays. These simulations will produce baseband data that will be processed on a software correlator running on the SUT supercomputer (item 5), to investigate the likely effects that RFI will have upon the correlator output of the SKA. In later years, methods that can be used to mitigate the effects of RFI will also be explored. RFI is likely to be one of the potential limiting factors for operation of the SKA and a great deal of international effort is being expended on studies of how the effects of RFI can be avoided and mitigated.

Specific steps were made toward this milestone of the SUT SKA project:

An efficient algorithm for the generation of random Gaussian noise (simulating the sampled voltage output of a radio telescope) was implemented on the SUT supercomputer. In order to simulate baseband data, the simulated voltage output of a radio telescope must be produced at the Nyquist frequency for the bandwidth being considered. For example, to simulate a single polarisation bandwidth of 1 GHz, voltages must be sampled at the Nyquist rate of 2 GHz, which is equivalent to a 0.5 ns period between samples. If we wish to simulate 2000 spectral channels across the full 1 GHz bandwidth from a single antenna output, then 4000 data samples must be created in order to form the autocorrelation function. Therefore the total required time period for the simulated data is 2 micro-seconds. A single supercomputer node produces the simulated data slower than real-time, by a relatively large factor (10 to 1000, depending on the node and the load on the node). The generation of simulated data corresponding to a realistic SKA observation will therefore push the SUT supercomputer to the limit of its capacity.

Simulated baseband data, as described above, have been used to form single antenna power spectra, as a precursor to forming cross power spectra on interferometer baselines. These power spectra have been generated in software and have simulated:

- 1) a continuum radio source plus antenna system noise;
 - 2) a continuum radio source plus a source of RFI plus antenna system noise (see below Figure 5);
 - 3) an astronomical spectral line radio source plus antenna system noise (Figure 6).
- These power spectra can be produced using arbitrary temporal and frequency sampling.

The single antenna baseband data simulations have been verified by simulating a known radio telescope, the Parkes radio telescope. Values of the Parkes system temperature and gain were used in a simulation run, along with a continuum radio source of a known power. Power spectra were produced from these simulated data and averaged over a series of integration times, allowing a study of the measured mean signal amplitude, the RMS deviation around the measured mean amplitude, and the signal to noise ratio for the amplitude. It was found that the signal to noise ratio varied in proportion to the inverse square root of the integration time, as theoretically expected. Also, calculated values of the noise and signal to noise ratio match extremely well to the corresponding theoretically determined quantities for the empirically determined Parkes radio telescope system parameters (Figure 7). These

results show that the approach taken to simulate baseband data is correct and can now be extended to simulating baseband data for arrays of antennas.

As mentioned in b above, baseband data have been simulated that represent a continuum source in the presence of RFI and system noise. These simulations are performed by adding random Gaussian noise (sampled voltages representing a continuum radio source plus system noise) to a sampled pure sinusoid that represents a source of radio frequency interference at a single frequency. Complex RFI can be approximated as a linear combination of pure sinusoids. These simulations will be extended in the second year of the SUT SKA project to a study of how RFI appears on interferometer baselines typical of the SKA baselines.

A prototype two-station software correlator has been implemented on the SUT supercomputer. In later years this software correlator will be generalised to N-baseline operation, for use in cross correlating real radio astronomy data recorded at radio telescopes using baseband recording technology, as well as correlating simulated baseband data of the type discussed above in item 4. Specific steps toward this milestone were made:

- Software was developed which can capture data recorded using the S2 VLBI recording system onto hard disk, ready for correlation on the SUT supercomputer. Software was then developed on the supercomputer that implements a full geometric delay correction model for any two given radio telescopes on Earth over any given period of time and for any given celestial coordinates, applies the delay corrections to the recorded baseband data, forms cross correlation functions for an arbitrary frequency channelisation and arbitrary correlator integration time, and finally forms fully corrected and calibrated complex cross power spectra (amplitude and phase over the recorded bandpass). This software forms the basis of the two station software correlator. Figure 8 shows an initial result from the software correlator work, the amplitude and phase as a function of time for the strong quasar PKS B0826-373 on the Parkes to Tidbinbilla baseline at a centre frequency of 2290 MHz and a 16 MHz bandwidth..
- The software correlator output (amplitude and phase as functions of frequency and time) were compared to the output of the LBA correlator at ATNF headquarters in Sydney, for the same recorded data. Correlation of test data for the Vela pulsar and the quasar PKS B0826-373 show that the LBA correlator output and the SUT software correlator output agree extremely well with each other and with theoretical expectations for noise and signal to noise as a function of coherent integration time (Figure 9). The development of the software correlator forms part of the Masters thesis of Mr Craig West.

As part of the first year of operation of CPSR-II at the Parkes Observatory (item 3), consideration was given to the suitability of the planned polyphase filter bank at Parkes as part of a next generation pulsar timing machine. The polyphase filter bank will capture the raw sampled data from the telescope front end and perform a hardware FFT in order to channelise the bandpass. Given the signal corruption caused by aliasing, a simple direct FFT is not a suitable mechanism to channelise the bandpass for pulsar observations. Notwithstanding, there is considerable interest in the application of polyphase filterbanks to astronomical observations [1]. These

instruments would be effective for pulsar observations only if sufficient oversampling is performed so as to minimise aliasing [2].

References:

[1] Ferris, R. H., Bunton, J.D., Stuber, B.,
<http://www.atnf.csiro.au/SKA/techdocs/DFCHandout.pdf>

[2] John Bunton ALMA memo 447
<http://www.alma.nrao.edu/memos/html-memos/abstracts/abs447.html>

A meeting of Australian individuals and groups involved in SKA-related simulation studies was held on May 23, 2003, at SUT. The meeting consisted of eight presentations on SKA and LOFAR simulations followed by an open discussion of how the various Australian SKA simulation efforts can benefit from collaborations, identify areas of common interest, and avoid significant duplications of effort. An outcome of the meeting was the initiation of a significant collaboration between SUT and the ATNF (see item 8 below) and a set of presentations that are now available to the global SKA community via the world wide web. Information on the meetings and online versions of most of the meeting presentations are available from <http://astronomy.swin.edu.au/SKASSWG/SSWG.html>. The guest of honour at the meeting was Prof. Richard Schilizzi, International Director of the SKA project, who gave a colloquium presenting an overview of the International SKA project. These meeting will continue on a six monthly basis over the course of the MNRF.

A consequence of the close communication between different groups in Australia involved in SKA simulation work, fostered by the meetings initiated by the SUT SKA group (item 7 above), is that collaborative work is now being undertaken between these groups. A major collaboration between the SKA simulation group of the ATNF and the SUT group aims to marry efforts in order to produce realistic simulations of SKA observations that include the effects of RFI. The ATNF group concentrates on array configuration simulations for the SKA, using computers to place SKA elements into an optimal configuration for the SKA science goals. These simulations generate “fake” visibility data that can be imaged and analysed in order to assess the performance of different array configurations. The SUT group is concentrating on lower level simulations of baseband data that include RFI and measure the effects on visibility data produced in correlators. Thus, it is feasible to combine the ATNF array configuration visibility data with the RFI-affected visibility data output by the SUT software correlator into a single dataset that will simulate the realistic astronomical performance of the SKA in the presence of a hostile RFI environment. The array configuration work of the ATNF group is highly computationally intensive and they are making substantial use of the SUT supercomputer in order to carry out this work, under the supercomputer time dedicated to the MNRF. Regular visits of ATNF staff to Swinburne are planned for the next 12 months. This collaborative effort makes the best use of MNRF resources and draws upon outside resources, in order to address important work in SKA simulations.

In 2003 the International SKA Steering Committee (ISSC) constituted an advisory working group dedicated to performing SKA simulations, the SKA Simulations Working Group (SSWG). This working group brings together groups and individuals

from all partner countries in the SKA international project in order to assist with the SKA design and definition process, by way of performing SKA simulations which will illuminate advantages and disadvantages of the different SKA concepts that have been proposed. In May 2003 Dr Steven Tingay, the SUT SKA project leader, was appointed as the first Chair of the SSWG, fulfilling a goal of achieving high level representation for Australia on the SSWG. Dr Tingay expects to be able to make a significant contribution to the direction of the international SKA project as Chair of the SSWG, enhancing Australia's and SUT's exposure within the international project.

2. Other establishment issues

The main administrative target to be reported on, the appointment of staff, is covered as item 1 of the preceding section. As stated in that item, two staff appointments were made in the first year of the Swinburne MNRF project, compared to the three that were expected to be made. The third appointment was delayed beyond the end of the first financial year due to delays in visa issue. This third appointment has been completed and the new staff member will commence duties on 20 October, 2003.

The following staff members have contributed, are currently contributing, or will contribute in the future to the Swinburne MNRF program operations.

MNRF funded staff

Dr Steven Tingay (Swinburne SKA project leader)

Dr Richard Ogley (Postdoctoral fellow, SKA research and development)

Dr Shinji Horiuchi (Postdoctoral fellow, SKA research and development – to commence in October 2003)

Drs Ogley and Horiuchi have been attracted to Australia from England and Japan, respectively, to participate in the Swinburne MNRF project.

Centre funded staff

Prof. Matthew Bailes (Centre Director, ASKAC member)

Dr Stephen Ord (Postdoctoral fellow, pulsar astrophysics)

Dr James Murray (Supercomputer manager)

Ms Michelle Jolley (General administrative support)

Mr Andrew Jameson (Supercomputer support)

Mr Craig West (Supercomputer support)

Affiliated students

Mr Haydon Knight (Ph.D. student, pulsar astrophysics)

Mr Aidan Hotan (Ph.D. student, pulsar astrophysics)

Mr Craig West (Masters student, software correlator studies)

Dr Willem van Stratten (Ph.D. student, pulsar astrophysics – since graduated)

3. Research access and collaboration

3.1 Facility's access regime

The main physical resource utilised by the SUT MNRF project are the supercomputers at the Hawthorn campus and the Parkes Observatory. The supercomputer on campus is used by many different groups in different capacities, ranging from undergraduate teaching and training, through ARC funded research projects, and for commercial activities. The 30% of the supercomputer capacity that is reserved for MNRF use is available, free-of-charge, to any individual or group anywhere in the world who wishes to undertake SKA-related research and development. In practice this access would involve some level of at least initial collaboration with Centre staff. Time is allocated to users depending on the nature of the project they wish to undertake and any deadline that exists on the work. The supercomputer is highly flexible and many projects can be run in parallel (this is generally how the supercomputer is used) or the entire machine can be dedicated to a particular project if required. No formal time allocation procedure is imposed on users, however consultation with the supercomputer manager and support staff is required before very large projects are started. This very open access policy to the supercomputing facilities is in accordance with the Facility Business Plan and allows users to utilise the supercomputer for their greatest benefit and convenience.

3.2 Collaboration and linkages

The SUT MNRF project contributes to the scientific, technological, and strategic goals as part of the national and international SKA projects, as set out in the Facility Business Plan, in the following ways:

- Scientific – The SUT MNRF project is focused on providing resources to extend the capabilities of Australia's existing radio astronomy community, particularly in those areas of study that are relevant to the science case for the SKA. An example of this focus is in the use of the SUT supercomputer to undertake cosmological and galaxy formation simulations that can be used to predict what the SKA will be required to observe. This research aids in refining the scientific case for the SKA and provides scientific direction for technical design efforts. This work is part of a broad effort, involving all international partners, to define the physical characteristics of the SKA and the scientific questions that the SKA will address.
- Technological – The SUT MNRF project is focused on evaluating the technical limitations of the proposed SKA concepts, also as part of a broad international effort. Through SKA simulations that will be undertaken on the SUT supercomputer in collaboration with national partners such as the ATNF and international partners such as groups in Europe and at MIT, we will gain an understanding of how the SKA will operate and the factors that will limit its performance. The SUT SKA group is also focused on real, rather than abstract, technological aspects of the SKA, developing new baseband

recording and processing instruments that will be used to demonstrate technologies of relevance to the SKA. These demonstrators will be deployed on existing Australian radio telescopes, to the advantage of existing users and will provide commercial opportunities for SUT. The prime example of this in the first year of the SUT MNRF project is the CPSR-II machine at the Parkes Observatory.

- Strategic – Through the scientific and technological aspects of the SUT SKA project, the SUT group is contributing to a strong SKA framework in Australia that demonstrates to the international community Australia's excellent capability as potential host to the SKA, and Australia's ability to play a lead role in the design and construction of the SKA. Further, the SUT SKA project has gained strategic high level representation within the international project, through the Chairmanship of the SSWG by Dr Steven Tingay. Dr Tingay's appointment to this position by the International SKA Steering Committee enhances and strengthens Australia's visibility within the international project.

3.3 Facility's contribution to research and training

The research milestones listed in section 1 contribute directly to the stated goal of the MNRF, to demonstrate enabling technologies for the SKA, to provide increased observing capacity for existing Australian facilities, and resources for Australian astronomers, and to promote Australia as a leading candidate to host the SKA. The relevant research undertaken is described in detail in section 1 above. For example, the development and deployment of CPSR-II at the Parkes Observatory has both demonstrated technologies that could be used for highly advanced pulsar studies with the SKA and also currently contributes to the capability of existing Australian facilities, as evidenced by the early research output of the instrument. In future years of the SUT MNRF project, similar baseband recording technologies will be demonstrated for very long baseline interferometry, pulsar timing, spectroscopy, and RFI mitigation. Also, the open access policy for the SUT supercomputer allows Australian scientists access to a unique facility with which to investigate aspects of SKA science and technology, as evidenced by galaxy formation simulations being made by SUT researchers, or the array configuration work being undertaken by partners at the ATNF. As pointed out in subsection b above, the best way to promote Australia as eventual host of the SKA is to contribute strong national research programs to the international SKA effort, which is what the SUT SKA project has successfully initiated in the first year of the MNRF.

The facilities provided by Swinburne under the MNRF are contributing to two Ph.D. theses (Aidan Hotan and Haydon Knight) and one Masters thesis at SUT (Craig West), as indicated in section 2 above. This is a significant degree of skills training at the highest level, within the context of Australian radio astronomy.

3.4 Contribution to Australian industry

Not applicable in the case of the SUT SKA project. We have no direct contact with local technology companies, deliver no services to particular industry sectors, or foster the development of small and medium sized enterprises.

4. Marketing and promotion of the Facility

At SUT a high importance is placed on promotion and outreach activities. While no opportunities for commercial marketing have arisen during the first year of the MNRF, we have actively promoted the goals and results of the SUT SKA project, as well as the national and international SKA projects, to both professional and public audiences.

4.1 Professional activities

A set of web pages have been produced, describing the SUT SKA project, as well as aspects of the international project. This web site is updated regularly with research results, as well as announcements for future meetings. The URL is <http://astronomy.swin.edu.au/SKA>.

SUT hosted a meeting of Australian SKA simulators on May 23, 2003. Presentations were given on the range of SKA simulation programs in Australia and the meeting closed with an open discussion session which concentrated on possible collaborations that could be initiated between Australian groups. Information on the meeting is available from the URL above. Three presentations at this meeting were made by SUT staff members.

SUT hosted an invited colloquium on the international SKA project by the Director of the international project, Prof. Richard Schilizzi, on May 23, 2003.

SUT hosted an invited colloquium on the SKA project by the Secretary of the International SKA Steering Committee, Prof. Russ Taylor, on 26 July, 2002.

4.2 Public outreach

Herald Sun newspaper, Tuesday October 29, 2002, "Galaxy quest: travel beyond the solar system".

The Age newspaper, Thursday September 12, 2003, "Australia looks to the ultimate in telescopes".

The Australian newspaper, Wednesday September 11, 2002, "Supercomputer sets its sights on the stars".

Swinburne campus review, 2002/03, "Supercomputer is unveiled at Swinburne"
ABC TV, Catalyst, Dr Tingay interviewed as part of SKA feature for episode 22, series 4, to go to air in August 2003.

Dr Tingay interviewed by Guardian and New Scientist journalists, June 2003.

5. Commercialisation

The baseband recorder SUT have developed in conjunction with the California Institute of Technology, which is installed at the Parkes Observatory, is the major new product developed under the SUT SKA project in 2002/03. Commercial opportunities exist to provide similar instruments to parties outside the MNRF Programme. In particular, interest has been registered from Observatories in China, India, and the USA for baseband recorders and processors of this type and commercial discussions will be initiated in the 2003/04 financial year.

6. Financial reporting

The commitment for this reporting period listed in the Project Plan is as follows:

Year	Contrib. In-kind (\$k)	Contrib. Cash (\$k)	Facility Contrib. (\$k)
01/02	0	0	0
02/03	600	0	205.2
Total	600	0	205.2

In-kind contributions from Swinburne are as follows:

	Budget 2002/2003	Actual 2002/2003
Salaries	100	150.6
Capital	500	309.5
Other	0	1.7
Total	600	461.8

Cash expenditure is as follows:

	Budget 2002/3	Actual 2002/2003
Salaries	186	0
Capital	10	226.5
Other	40	0
Totals	236	226.5

A summary of budgeted and actual expenditure for 2002/3 is as follows:

Budget	
MNRF	205.2
In-kind commitment	600
Totals	805.2
Expenditure	
In-kind	461.8
Cash	226.5
Total	688.3

In addition, a grant of \$131.25k was received from the Victorian State Government, but that is not yet built into the business plan.

7. Detailed Project Reports and Research Highlights



Figure 1: Part of the SUT supercomputer installed at the Hawthorn campus, 30% of which is dedicated for use as part of the M NRF.

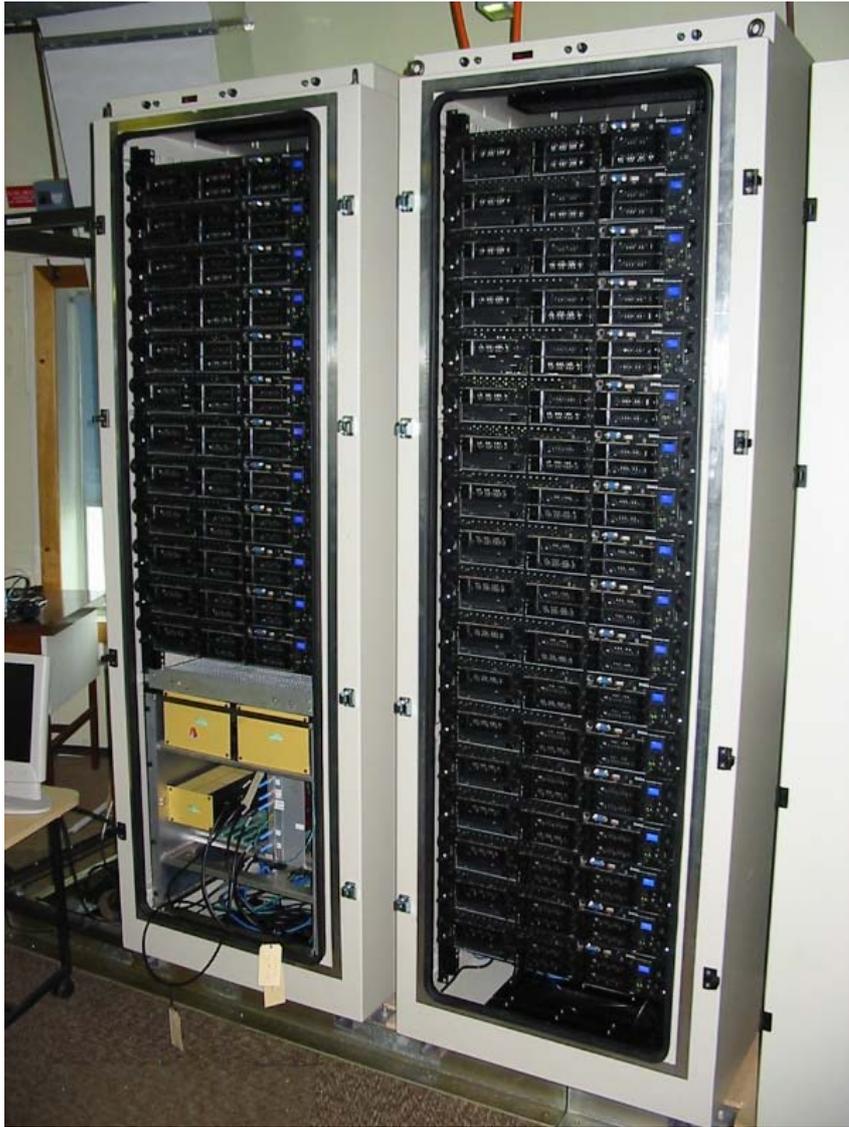


Figure 2: The installed CPSR-II at the Parkes Observatory. The leftmost rack contains the actual digital sampler that is connected to the observatory down-conversion system, fed by the receivers in the focus cabin. This sampler board was built by collaborators at Caltech in the US. It accepts two independent 64 MHz bands with dual polarisations for each band. Full polarimetry is therefore possible. The other rack slots contain the supercomputer, a 30 node cluster of dual CPU Dell 2650 rack-mount servers, running at a clock speed of 2.2 GHz. The two machines on the top of these racks have 3 GB of RAM and act as "primary nodes". They are responsible for distributing data to the rest of the cluster by means of high speed gigabit Ethernet. In all the cluster has over four terabytes of disk storage space, and enough processing power to coherently de-disperse the data from most low dispersion measure pulsars in real time. Data gets from the sampler to the supercomputer by means of direct memory access cards (EDT 60's) installed in both primary nodes.

Shapiro Delay in PSR 1909–3744

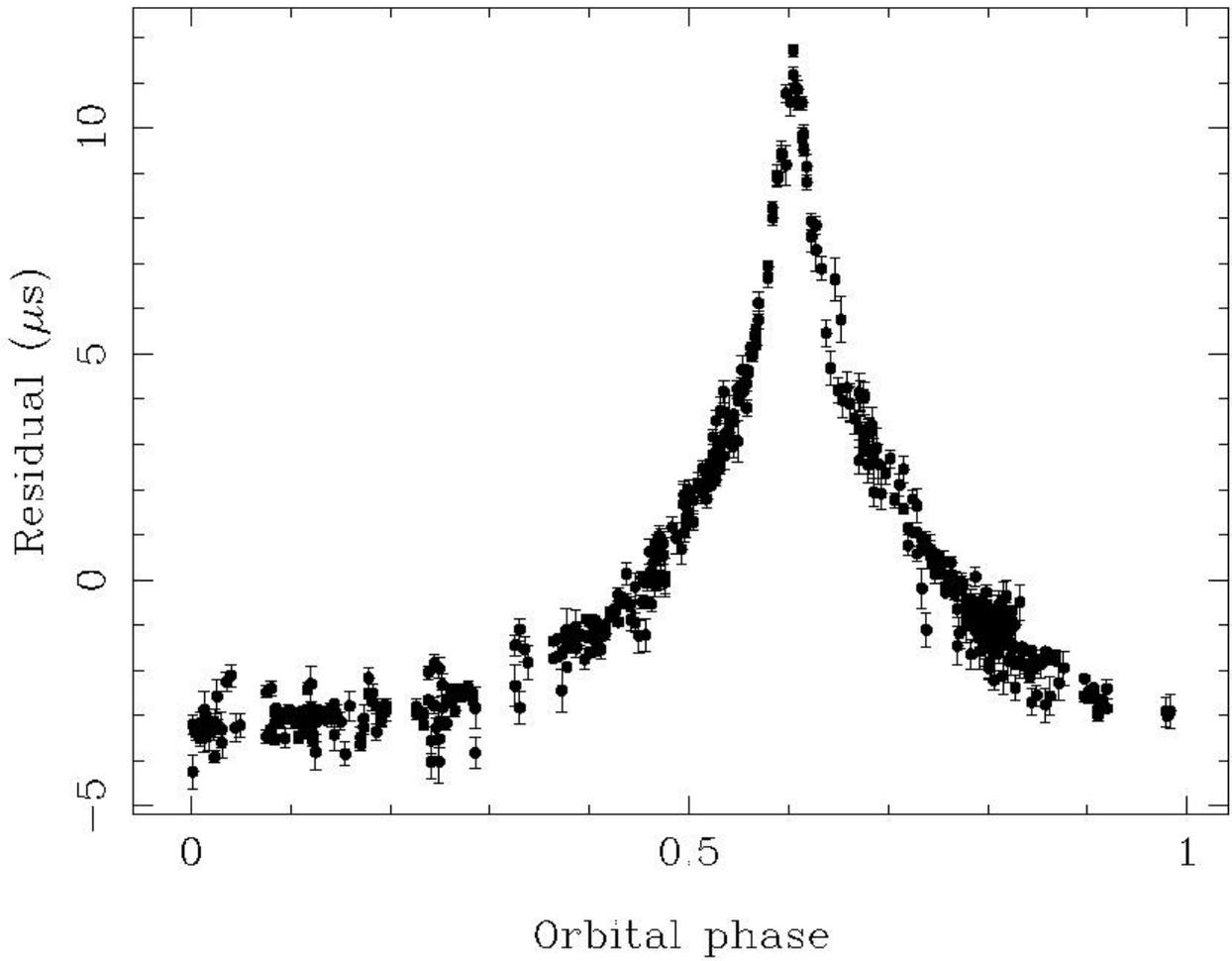


Figure 3: The signature of Shapiro delay in the binary pulsar J1909-3744. As the individual pulsars travel through the distorted space-time surrounding the companion they are delayed. This delay is detected as an excursion from the predicted time of arrival as a function of orbital phase.

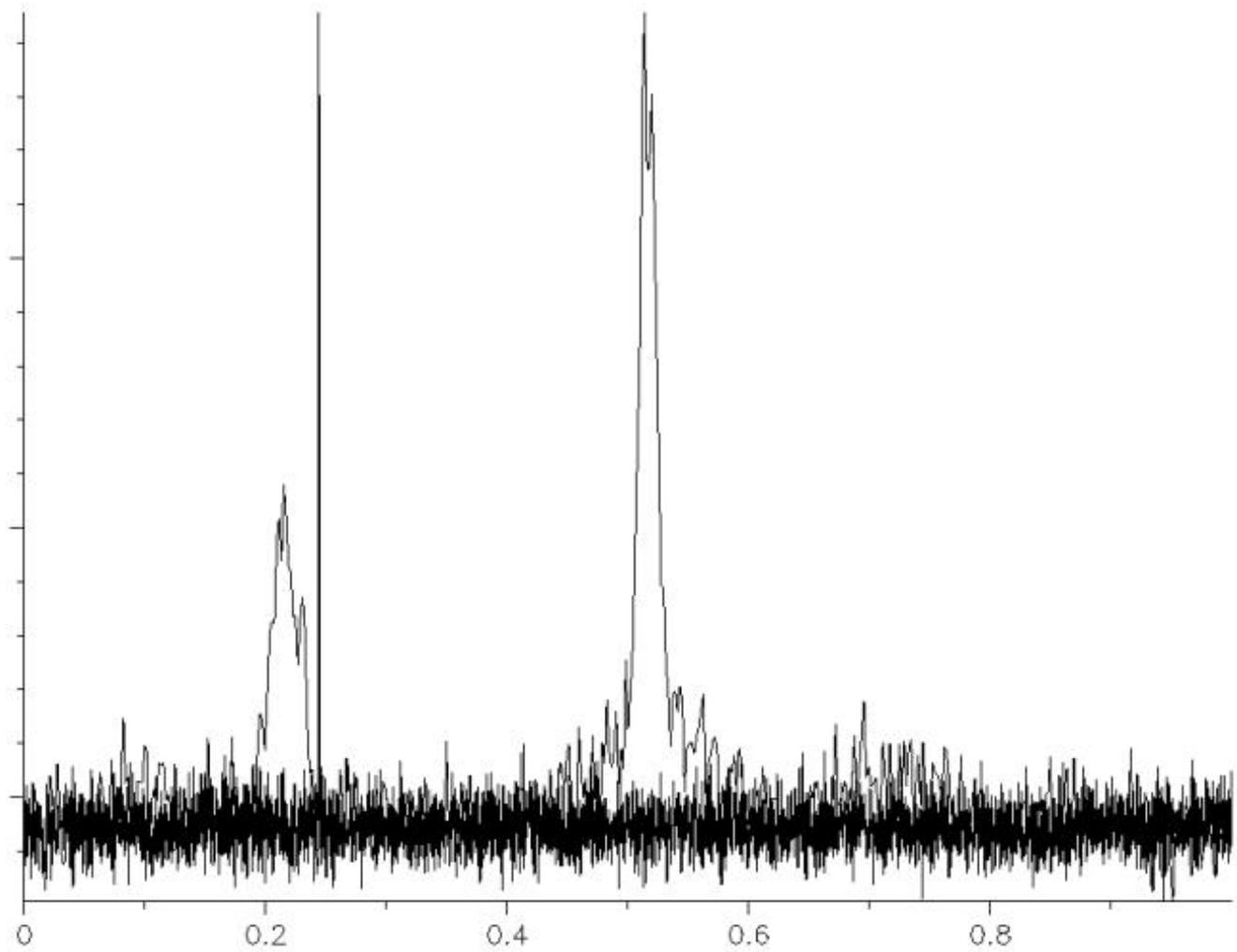


Figure 4. An observation of the millisecond pulsar J1824-2452. Horizontal axis is pulsar phase and vertical axis is uncalibrated power. Superimposed on this plot is an observation of a giant individual pulse from this object. The giant pulse has been resolved with the CPSR-II instrument and found to be 2 microseconds wide.

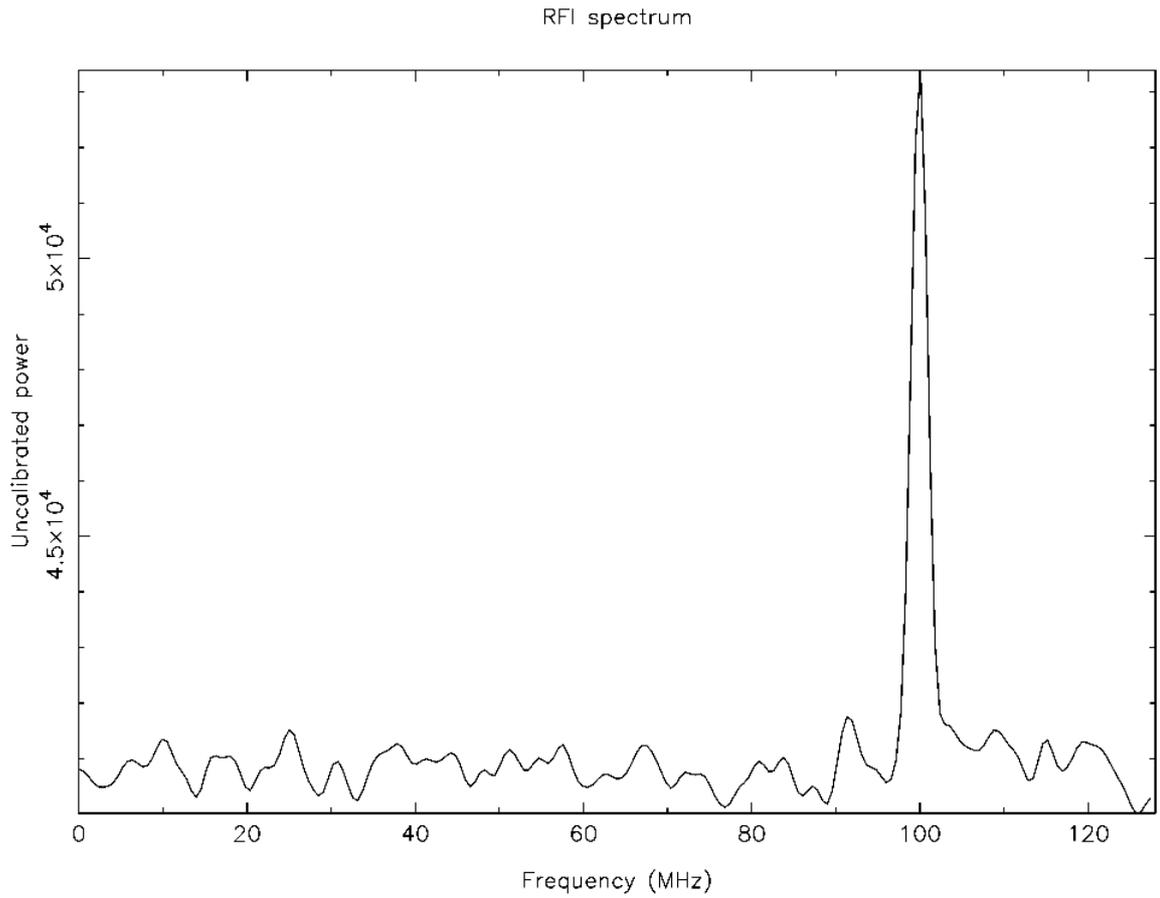


Figure 5: the single antenna power spectrum for a bandwidth of 128 MHz, produced from simulated baseband data that includes contributions from radio telescope system noise, a constant strength astronomical continuum radio source, and a source of RFI. The interference is the strong spike 100 MHz from the lower edge of the bandpass.

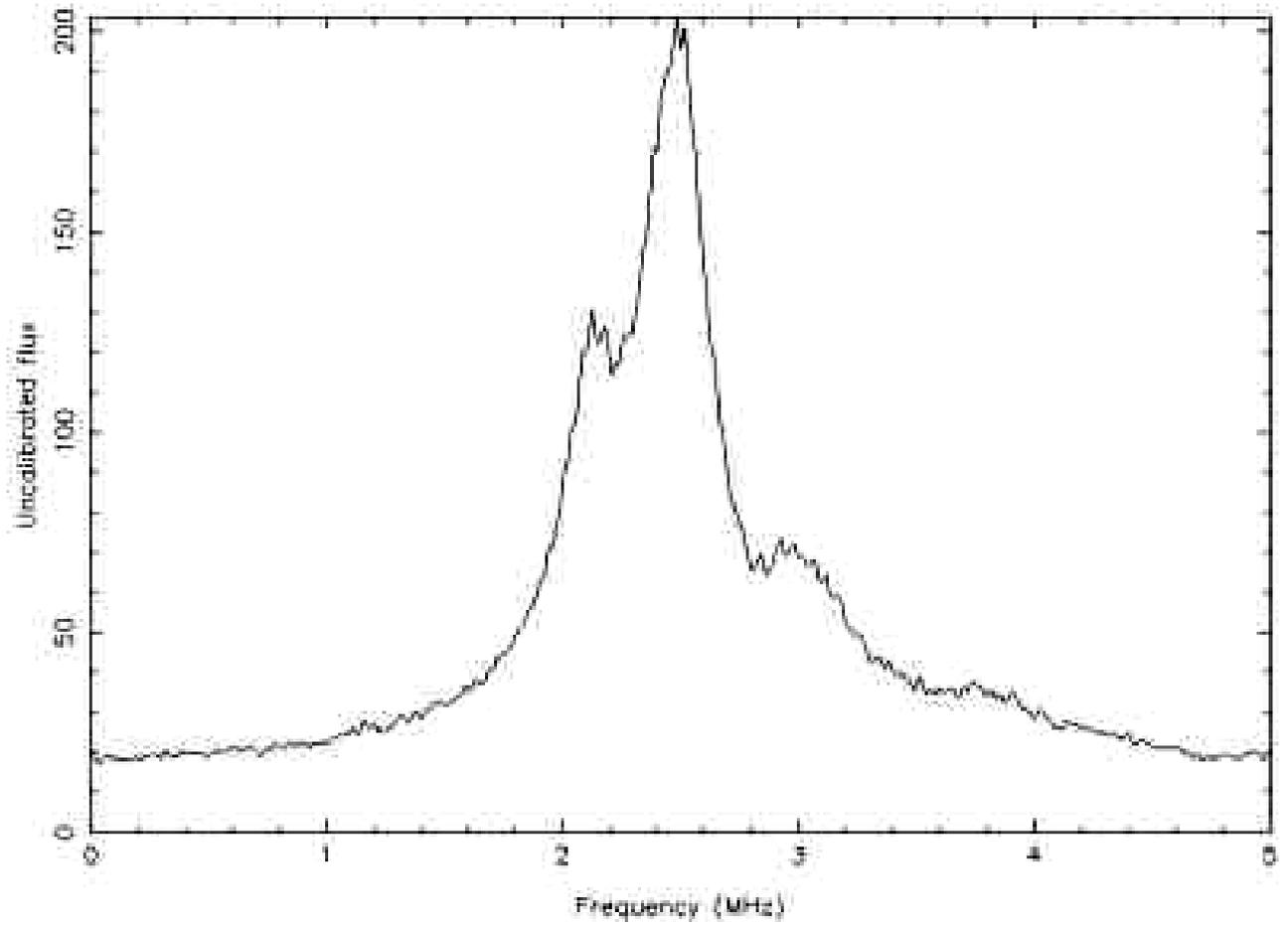


Figure 6: the single antenna power spectrum over a 5 MHz bandwidth produced from simulated baseband data that includes contributions from radio telescope system noise and an astronomical spectral line radio source with a complicated frequency structure.

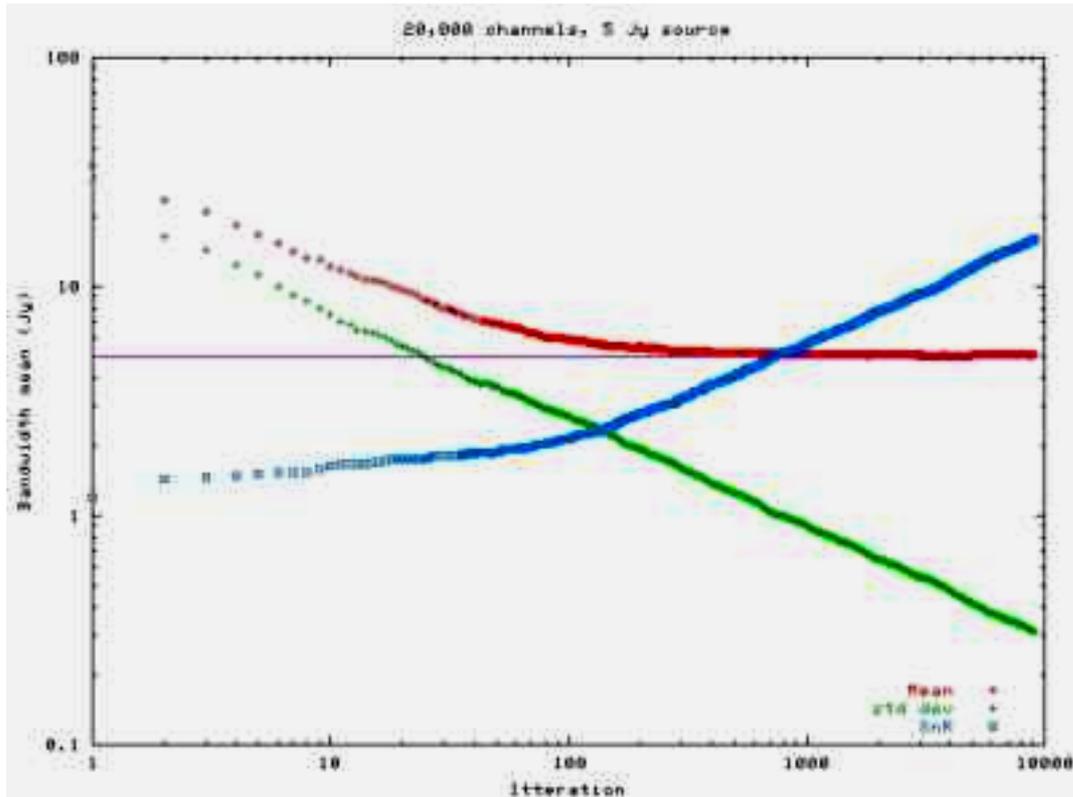


Figure 7: an analysis of the noise and signal to noise ratio on the amplitude measured for simulated baseband data from a single radio telescope, as a function of integration time. The horizontal axis is integration time in milliseconds. The vertical axis is in Jy (RMS noise level, source strength). The red points show the measured amplitude, converging to 5 Jy at long integration times (the strength of the continuum source used in the simulation). The green points show the RMS noise around the mean amplitude, decreasing as the square root of the integration time, as expected. The blue points show the signal to noise ratio for the amplitude measurement, increasing as the square root of the integration time, as expected.

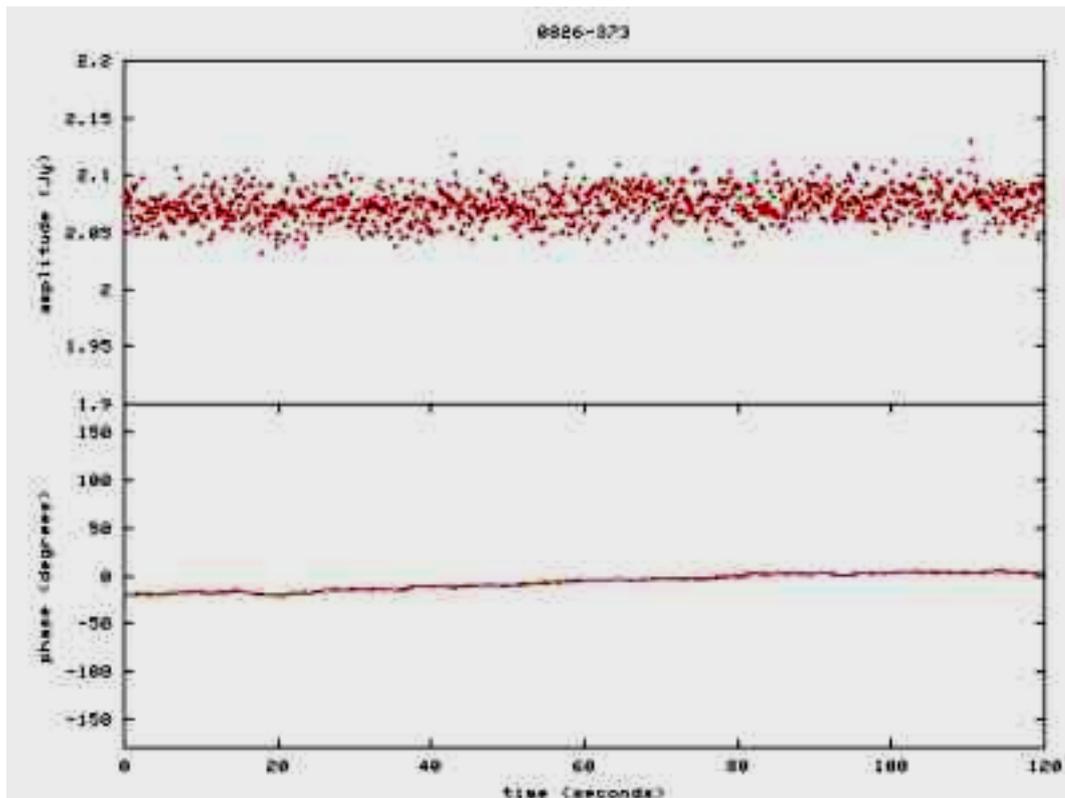


Figure 8: The amplitude and phase output of the SUT software correlator (coherent average over the 16 MHz bandwidth of the observation and a 0.1 second integration time) as a function time over a 2 minute period for the quasar PKS B0826-373, on the Parkes to Tidbinbilla baseline at 2290 MHz. The amplitudes are fully calibrated.

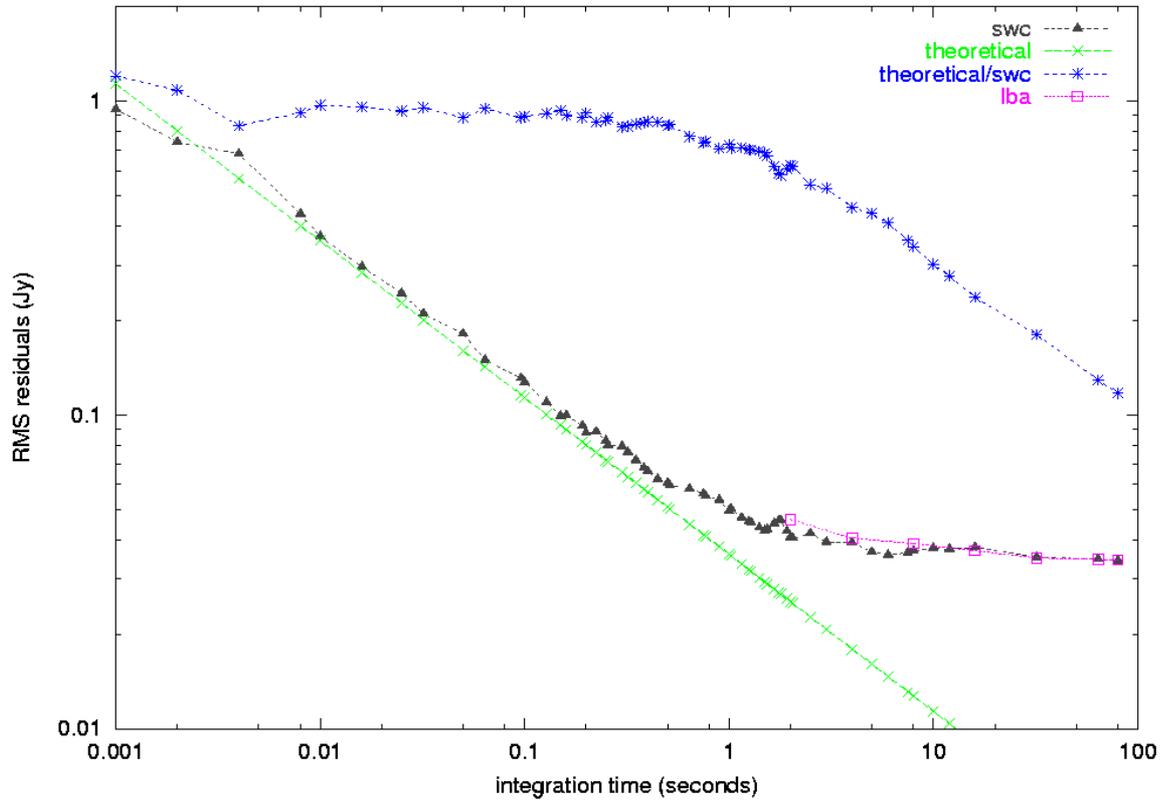


Figure 9: An analysis of the SUT software correlator. Each point on the plot represents the RMS residual (in Jy) on the amplitude (coherently averaged across the full 16 MHz bandwidth and coherently averaged over the indicated integration time) derived from an observation of PKS B0826-373, on the Parkes to Tidbinbilla baseline at 2290 MHz. The green points are theoretically determined values using nominal values for the Parkes system temperature and gain at this frequency and bandwidth. The black points are the measured values from the software correlator, using the nominal Parkes system parameters to calibrate the data. The pink points are the measured values for the same data, but processed on the ATNF LBA correlator in Sydney, again using the nominal Parkes system parameters to calibrate the data. Both the software correlator and LBA correlator values deviate from the theoretically expected values at long integration times due to the presence of unmodelled variations in the individual instrumental bandpasses. The blue points are the ratios of the theoretical to software correlator RMS residuals.

APPENDIX C: COMPOSITION OF INTERIM AABOM

Prof Brian Boyle	Anglo-Australian Observatory
Dr Martin Cole	(independent)
Dr Warrick Couch	University of New South Wales
Prof Lawrence Cram	Australian Research Council
Dr Gary Da Costa	ANU RSAA
Prof Ron Ekers	CSIRO Australia Telescope National Facility
Dr Bob Frater	(independent)
Prof Penny Sackett	ANU RSAA
Prof Ray Norris	CSIRO Australia Telescope National Facility
Dr Elaine Sadler	University of Sydney
Dr Rachel Webster, chair	University of Melbourne (NCA nominee)

APPENDIX D: COMPOSITION OF CURRENT AABOM

as at November 2003

Name	Institution	Nominated by
Brian Boyle	CSIRO	CSIRO
Ray Norris (MNRF Director)	CSIRO	CSIRO
Matthew Colless	AAO	NCA
Lawrence Cram	ARC	ARC
Penny Sackett	ANU	AGSC
Roger Franzen	Auspace Pty Ltd	AGSC
Ron Ekers	CSIRO	ASKAC
Martin Cole (chair)	Cole Innovations Pty Ltd	ASKAC

APPENDIX E: GLOSSARY

AABoM	The Australian Astronomy Board of Management, which is the Board of this MNRF. See http://www.atnf.csiro.au/projects/mnrf2001/
ADC	Analogue to Digital Converter
AGSC	Australian Gemini Steering Committee, a body set up to coordinate and maximise the effectiveness of Australian interactions with the Gemini partnership, and Australian usage of the Gemini telescopes. See www.ausgo.unsw.edu.au
ANU	Australian National University, the host institution of the Research School of Astronomy and Astrophysics (RSAA). See www.anu.edu.au
ARC	Australian Research Council, which is not itself a participant in this MNRF but is a significant stakeholder and the ultimate provider of much of the matching funding. See www.arc.gov.au
ASKAC	Australian SKA Consortium, a body set up to coordinate Australian SKA (and LOFAR) activities. See http://askac.atnf.csiro.au/
ATCA	Australia Telescope Compact Array, the flagship radio-telescope of the Australia Telescope National Facility. See http://www.narrabri.atnf.csiro.au/
ATNF	Australia Telescope National Facility, which is a Division of CSIRO and the operator of Australia largest radio-telescopes at Parkes and Narrabri. See www.atnf.csiro.au
CDR	Critical Design Review, the stage of a project immediately preceding the start of construction.
CICTC	CSIRO ICT Centre. A new CSIRO Division formed from parts of CMIS and CTIP (q.v.) See http://ict.csiro.au/ . CICTC are a participant in this MNRF, having taken over those parts of CTIP which were initially participating in the MNRF.
CMIS	CSIRO Maths and Information Sciences. See http://www.cmis.csiro.au/
CMIT	CSIRO Division of Manufacturing and Infrastructure Technology. CMIT have been primarily responsible for the manufacturing process for the Lunenburg lens. See http://www.cmit.csiro.au/
CMOS	Complementary Metal Oxide Semiconductor, a type of technology used to fabricate chips.
CMS	CSIRO Division of Molecular Science. A Division of CSIRO who have been working on the material used to make the Lunenburg Lens. See http://www.csiro.au/index.asp?type=division&id=Molecular%20Science
CSIRO	Commonwealth Scientific and Industrial research Organisation, Australia's largest research organisation. See www.csiro.au
CTIP	CSIRO Telecommunication and Industrial Physics. A Division of CSIRO which was initially a participant in this MNRF, but whose functional areas involved in this MNRF have now been transferred to CICTC. See http://www.tip.csiro.au/
DSN	The NASA Deep Space Network, used to track NASA's spacecraft. One of the three major DSN stations worldwide is located at Tidbinbilla, Australia. See http://deepspace.jpl.nasa.gov/dsn/
FOV	Field Of View of a telescope – the angular extent of the sky which can

	be simultaneously viewed by the telescope.
GaAs	Gallium Arsenide – a material used to make very fast, very low-noise chips and devices
Gbps	Giga bits-per-second – used to express the bandwidth of a transmission medium.
InP	Indium Phosphide – a material used to make very fast, very low-noise chips and devices
ISSC	International SKA Steering Committee, which is effectively the Board of the International SKA Project. See http://www.skatelescope.org/ska_committees.shtml
LBA	Long Baseline Array – a name given to Australia’s network of VLBI antennas. See http://www.atnf.csiro.au/vlbi/
LNA	A Low Noise Amplifier, the sensitive “front-end” of a radio telescope. The LNA design is a critical factor in the overall sensitivity of the telescope.
LOFAR	Low Frequency Array. A next-generation internationally-funded telescope which is a precursor to SKA and which Australia is making a bid to host, partly because hosting LOFAR significantly increases the probability that the SKA will be located in Australia. Construction is planned to start in 2005 at a cost of A\$200m, and it is hoped that it will be located in Western Australia. LOFAR is currently outside the scope of this MNRF. See http://www.atnf.csiro.au/projects/ska/general/lofar.html
MIT	Massachusetts Institute of Technology, one of the world’s premier Universities and a participant in the LOFAR and SKA projects. See http://www.mit.edu/
MMIC	Monolithic Microwave Integrated Circuit. A state-of-art chip which, unlike the low-frequency silicon chips used in computers, is designed to handle the high frequency microwave signals used in radio-astronomy and other commercial applications.
MOST	Molonglo Observatory Synthesis Telescope, an instrument owned and operated by Sydney University, and being upgraded under the SAMP project of this MNRF. See http://www.physics.usyd.edu.au/astrop/most/
NCA	National Committee for Astronomy, a subcommittee of the Australian Academy of Science. It is responsible for coordinating Australian astronomy activities. See http://astro.ph.unimelb.edu.au/~rwebster/nca/index.html
NTD	New Technology Demonstrator. Project 6 of this MNRF.
PDR	Preliminary Design Review. The stage of a project at which preliminary designs are reviewed, prior to make a final detailed design.
RF	Radio Frequency – an electromagnetic signal in the frequency range 100 kHz to 1000 GHz
RFI	Radio Frequency Interference, which might come from mobile phones, taxis, TV stations, satellites, aircraft, or any number of other transmitters. RFI can potentially destroy the performance of a radio-telescope, and we avoid this by (a) siting the telescope away from sources of RFI, such as in inland Australia, and (b) by using sophisticated RFI mitigation techniques to remove it. In practice, a combination of these techniques will be needed for next-generation

	radio-telescopes such as LOFAR and SKA.
RSAA	Research School of Astronomy and Astrophysics, which is a Research School of the ANU (Australian National University) and which is headquartered at Mt. Stromlo. See www.mso.anu.edu.au
SKA	Square Kilometre Array. A next-generation internationally-funded radio-telescope. Construction is planned to start in 2010 at a cost of A\$2b, and it is hoped that it will be located in Australia. See www.atnf.csiro.au/projects/ska
SKAMP	Square Kilometre Array Molonglo Prototype. One of the projects of this MNRF, in which the Molonglo telescope (MOST) will be upgraded as a prototype for SKA.
SUT	Swinburne University of Technology, one of the participants in this MNRF. See http://www.swin.edu.au/
VLBI	Very Long Baseline Interferometry, in which signals from radiotelescopes hundreds or thousands of kilometres apart are combined to synthesise a telescope capable of very high spatial resolution. See http://www.atnf.csiro.au/vlbi/

APPENDIX F: CERTIFICATIONS & AUDITS

These certifications are to confirm some of the figures shown elsewhere in this document. Original documents are available upon request.

08/10 '03 13:43 FAX 61 2 9385 6060

SCHOOL OF PHYSICS UNSW

002



Prof. Warrick Couch
Australian Gemini Scientist

8 October, 2003

As Australian Gemini Scientist and manager of the Australian Gemini Office, I hereby certify that the institutional cash contributions to the Australian Research Council Linkage-Infrastructure Equipment & Facilities (LIEF) Grant "Australian Membership of the International Gemini Partnership", which pays for Australia's share of the annual operations costs of the Gemini Observatory, were as follows in 2003:

The Australian National University	\$245,000
The University of New South Wales	\$210,000
The University of Sydney	\$65,000
The University of Melbourne	\$52,000
Australia Telescope National Facility	\$32,000
Swinburne University of Technology	\$10,000
University of Southern Queensland	<u>\$5,000</u>

Total = \$619,000

Warrick Couch



INDEPENDENT AUDIT REPORT

To the Department of Education, Science and Training

Scope

I have audited the attached Statement of Income and Expenditure, being a special purpose financial report for income and expenditure, of the Anglo-Australian Observatory's participation in the Major National Research Facilities Program for the period ended 30 June 2003. The Statement of Income and Expenditure was prepared at the request of the Anglo-Australian Observatory for the use of the Department of Education, Science and Training.

The Anglo-Australian Observatory is responsible for the preparation and presentation of the Statement of Income and Expenditure and has determined that the accounting policies used are appropriate to the needs of the Department of Education, Science and Training. I have conducted an independent audit of the Statement of Income and Expenditure in order to express an opinion on it to you.

The Statement of Income and Expenditure has been prepared solely for the Anglo-Australian Observatory and the Department of Education, Science and Training for the purpose of fulfilling the financial reporting requirements agreed between the two parties. I disclaim any assumption of responsibility for any reliance on this report or on the Statement of Income and Expenditure to which it relates to any persons other than the Anglo-Australia Observatory and the Department of Education, Science and Training, or for any purpose other than that for which it was prepared.

The audit has been conducted in accordance with Australian National Audit Office Auditing Standards, which incorporate the Australian Auditing Standards, to provide reasonable assurance as to whether the Statement of Income and Expenditure is free of material misstatement. Audit procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the statement, and the evaluation of accounting policies. These procedures have been undertaken to form an opinion as to whether, in all material respects, the Statement of Income and Expenditure is presented fairly so as to present a view, which is consistent with my understanding of the results of operations under the Agreement. The Statement of Income and Expenditure specified does not require the application of all Accounting Standards and Urgent Issues Group Consensus Views.

The audit opinion expressed in this report has been formed on the above basis.



Auditor's report to the Australian National University in relation to the Major National Research Facility ('MNRF') titled the Gemini and Square Kilometre Array - Australia's Astronomy Future (the 'facility')

Scope

We have audited the 'Outcome' Financial Information ("financial information") contained in section 6 of the 'Project Report for FY 2002-2003'. The Australian National University ("ANU") is responsible for the preparation and presentation of this information. The ANU has determined that the accounting policies used are appropriate to meet the requirements of the MNRF Participation Deed between the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the ANU ("the Agreement"). We have conducted an independent audit of the financial information in order to express an opinion on it to the ANU.

The financial information has been prepared by the ANU for the purposes of fulfilling their annual reporting obligations under clause 10(a) of the Agreement. We disclaim any assumption of responsibility for any reliance on this report to which it relates to any person other than those mentioned above, or for any purpose other than that for which it was prepared.

Our audit has been conducted in accordance with Australian Auditing Standard 802 - "The Audit Report on Financial Information Other than General Purpose Financial Report" to provide reasonable assurance as to whether the financial information is free of material misstatement. Our procedures include examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial information. These procedures have been undertaken to form an opinion as to whether in all material respects, the financial information presents fairly the contribution the Australian National University has made to the MNRF.

Given the nature of in-kind contributions, testing has been limited to:

- 1 Verifying the mathematical accuracy of the calculation of the in-kind contributions, based on salary rates and hours used by the ANU in the calculation.
- 2 On a sample basis, comparing hours in the in-kind calculation to those used recorded on time sheets.
- 3 On a sample basis, comparing rates used in the in-kind calculation to the rates prescribed in the ANU Enterprise Agreement for the employees particular level.
- 4 On a sample basis, confirming that the employees were employees of the ANU.

We are unable to verify the accuracy of time recorded on timesheets as relating to the MNRF.

The audit opinion expressed in this report has been formed on the above basis.

Audit opinion

In our opinion, the financial information presented in the section 6 of the 'Project Report for FY 2002-2003' presents fairly the contribution the Australian Nation University has made to the MNRF.

KAMB

KPMG

Don Cross

Partner

Canberra



KPMG, an Australian partnership, is a member of KPMG International, a Swiss non-profit association.

4 May 2004



**Chartered Accountants
& Advisers**

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AUDITORS REPORT TO THE DEPARTMENT OF EDUCATION, SCIENCE AND TRAINING REPRESENTING THE COMMONWEALTH IN RESPECT OF THE MAJOR NATIONAL RESEARCH FACILITY – CSIRO AUSTRALIA TELESCOPE NATIONAL FACILITY

FINANCIAL INFORMATION FOR THE PERIOD ENDED 30 JUNE 2003

Scope

We have audited the financial information, which is stamped for identification purposes, of the CSIRO Australia Telescope National Facility's ("ATNF") participation in the Major National Research Facilities Program ("MNRF") for the period ended 30 June 2003, as required by clause 13.3 of the Commonwealth Deed. The ATNF is responsible for the preparation and presentation of the financial information. We have conducted an independent audit of the financial information in order to express an opinion on it to the Commonwealth.

Our audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial information is free from material misstatement. Our procedures include examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial information, and the evaluation of accounting policies and significant accounting estimates. These procedures have been undertaken to form an opinion as to whether in all material respects, the financial information is presented fairly in accordance with Australian accounting concepts and standards and requirements of the Commonwealth Deed so as to present a view of the income and expenditure of ATNF which is consistent with our understanding of its financial activities during the year.

Audit opinion

In our opinion, the financial information presents fairly the income and expenditure in respect of the grant for the period to 30 June 2003.

1. The Grant has been expended solely upon the establishment, enhancement and/or operation of MNRF in accordance with relevant Australian Accounting Concepts and applicable Australian Accounting Standards.
2. ATNF's reporting of all allocations of the budgetary resources between Heads of Expenditure has a sound and reasonable basis.
3. Assets acquired by ATNF from the Grant are vested as provided in the Commonwealth Deed (Clause 20).
4. The value of ATNF's contributions (both cash and in-kind) towards the establishment and operation of the MNRF have a sound and reasonable basis.

Other

The MNRF's budget, as contained in the Business Plan and Deed, has been completed on a total project basis and not in relation to each participant. As a result, we are unable to compare ATNF's income and expenditure to the budget.

BDO

BDO
Chartered Accountants

Kevin R Reid
Partner

Sydney, this 12th day of February, 2004



Liability limited by the Accountants
Scheme, approved under the
Professional Standards Act 1994 (NSW)
BDO is a national association of separate
partnership and entities



**Chartered Accountants
& Advisers**

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**AUDITORS REPORT TO THE DEPARTMENT OF EDUCATION, SCIENCE AND TRAINING REPRESENTING
THE COMMONWEALTH IN RESPECT OF THE MAJOR NATIONAL RESEARCH FACILITY – CSIRO
TELECOMMUNICATIONS AND INDUSTRIAL PHYSICS DIVISION**

FINANCIAL INFORMATION FOR THE YEAR ENDED 30 JUNE 2003

Scope

We have audited the financial information, which is stamped for identification purposes, of the CSIRO Telecommunication and Industrial Physics Division ("CTIP") participation in the Major National Research Facilities Program ("MNRF") for the year ended 30 June 2003, as required by clause 13.3 of the Commonwealth Deed ("the Deed"). CTIP is responsible for the preparation and presentation of the financial information. We have conducted an independent audit of the financial information in order to express an opinion on it to the Commonwealth.

Our audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial information is free from material misstatement. Our procedures include examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial information, and the evaluation of accounting policies and significant accounting estimates. These procedures have been undertaken to form an opinion as to whether in all material respects, the financial information is presented fairly in accordance with Australian accounting concepts and standards and requirements of the Deed so as to present a view of the income and expenditure of CTIP which is consistent with our understanding of its financial activities during the year.

Audit Opinion in respect of Salaries, Travel and Operating Expenses

In our opinion, the financial information presents fairly the income and expenditure in respect of the Deed for the year ended 30 June 2003.

1. Expenditure has been incurred solely for the establishment, enhancement and/or operation of MNRF in accordance with relevant Australian Accounting Concepts and applicable Australian Accounting Standards.
2. CTIP's reporting of all allocations of the budgetary resources between Heads of Expenditure has a sound and reasonable basis.

Qualification in respect of Direct Overheads and Indirect Costs

CSIRO management have represented that direct overheads and indirect costs have been allocated to the project in accordance with CSIRO methodologies and calculations. We are unable to form an opinion on the reasonableness of the expenditure allocated to CTIP's participation in the MNRF project without undertaking an audit of total expenditure and the complex calculations underlying the basis of allocation of expenditure to this project. We note that we have been provided with supporting analysis for the overheads charged to the project.

BDO

BDO
Chartered Accountants

Kevin R Reid
Partner

Sydney, this 20th day of April, 2004



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Professional Standards Act 1994 (NSW)
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partnership and entities

4 A
PROCESSED

Sent to T Montague
7.11.03



6 November 2003

Schedule One
Audit Opinion

TO: The Minister for Innovation
Department of Innovation, Industry and Regional Development
13th Floor, 55 Collins Street
Melbourne 3000

**GEMINI AND SQUARE KILOMETRE ARRAY FACILITY, SWINBURNE
UNIVERSITY OF TECHNOLOGY**

This audit opinion is prepared for the purposes of the Grant Agreement dated 24 December 2002 between the Department of Innovation, Industry and Regional Development and Swinburne University of Technology.

Scope

We have conducted an independent audit in accordance with Australian Auditing Standards of the attached Financial Statement for the year ended 30 June 2003 in order to express an opinion on it for the purposes of the Agreement.

Our audit involved an examination of evidence supporting the amount of expenditure incurred, including all Victorian Grant funds and the amount of income contributions (both cash and in kind) received. This included an examination of the University's financial records and receipts, and an evaluation of the policies and procedures used to calculate the expenditure on the Victorian Project Contributions. These procedures have been undertaken to form an opinion as to whether the methodology used to calculate the expenditure and contributions is in accordance with the Agreement, and that the figures are true and fair.

The audit opinion expressed in this report has been formed on the above basis.

Audit Opinion

I confirm that in my opinion in accordance with the terms of the Agreement:

- Swinburne University of Technology has incurred \$688,386 expenditure on the Victorian Project (including in kind contributions).
- The contributions of Swinburne and each of the Consortium Members to the Victorian Project are correctly set out in the attached financial statement.

Alan Hunter, CPA
Senior Internal Auditor

Date: 6 November 2003

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Innovative Research

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Internal Audit & Review

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MNRF Program Director
Professor Ray Norris
CSIRO
Epping NSW 2220

16 March 2004

Dear Professor Norris

CERTIFICATION OF EXPENDITURE
CSIRO Australia Telescope National Facility

As requested, I certify that during the period 1 July 2002 and 30 June 2003 the University of Sydney's in-kind contribution to the SKA Molongolo Prototype (SKAMP) project was an in-kind contribution of \$133,932.80. This contribution consisted of the payment of salary for Duncan Campbell-Wilson. The contribution was calculated as follows:

Base Salary	\$66,966.40
+ 100% (oncost & overhead)	\$66,966.40
Total	\$133,932.80

The attached spreadsheets, which have been agreed to the University's General ledger, provides details of the payments to Mr Campbell-Wilson. Also attached is a statement by A/Professor Brian James, which details the duties undertaken by Mr Campbell-Wilson. These duties appear to be consistent with the terms of the MNRF Participation Deed

Please contact me if you have any questions.


Craig Prosser CPA



STANTON PARTNERS

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**INDEPENDENT AUDIT REPORT
TO THE COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH
ORGANISATION ("CSIRO") REPRESENTED BY THE AUSTRALIAN
TELESCOPE NATIONAL FACILITY ("Division")**

Scope

We have audited the attached Payments Statement ("Statement") for the Department of Education, Science and Training: Major National Research Facilities ("MNRF") Gemini and Square Kilometre Array 2002/2003 ("GSKA") program run through the Office of Science and Innovation ("OSI") of the Department of Premier and Cabinet pursuant to an agreement between the OSI and the CSIRO Division. The OSI is responsible for the information contained in the Statement and has determined that the Statement meets the needs of the acquittal requirements of the CSIRO Division.

We have independently audited the Statement in order to express an opinion.

The attached Statement has been prepared, pursuant to the MNRF Participation Deed, for the purpose of reporting to the CSIRO Division. We disclaim any assumption of responsibility for any reliance on this report or on the Statement to which it relates to any person other than the purpose for which it was prepared.

Our audit has been conducted in accordance with Australian Accounting Standards. Our procedures included examination, on a test basis, of evidence supporting the amounts in the Statement and verification of the existence of a separate accounting facility in relation to expenditure incurred on the MNRF GSKA program. These procedures have been undertaken to form an opinion as to whether, in all material respects, the Statement is presented fairly in accordance with applicable generally accepted accounting standards.

The audit opinion expressed in this report has been formed on the above basis.

APPENDIX G: FINANCIAL TABLES

The following notes should be read in conjunction with the spreadsheets.

G1 Differences in spreadsheets from those supplied by DEST

As far as possible, we have retained the format of the template spreadsheets supplied by DEST. However, this was not completely possible for the following reasons:

- The spreadsheets supplied by DEST contained some errors (e.g. some of the cells containing “Totals” had typos in them) and these have been corrected.
- The spreadsheets supplied by DEST do not contain a column for 2001/2, although this is in fact covered within the MNRF (see Section 4.1.3 of this report), and in our business plan and project plans, and so we are required to report against it. We were not sure how to deal best with this, as to handle it properly means changing all spreadsheets, and DEST have asked us not to do this. Therefore, we have folded all 2001/2 figures into 2002/3 figures and reported on the total.

Table 1

In-Kind Contributions from Participating Parties (\$'000s)

Participating Party	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Contributions (Total to Date - Actual)	Cumulative Contributions (Total to Date - Agreement)	Projected Grand Total 5 Years	Agreement 5 Years	Difference over 5 Years
CSIRO ATNF												
Salaries	0.0	760.0		830.0	830.0	340.0	230.0	0.0	760.0	2990.0	2990.0	0.0
Capital	0.0							0.0	0.0	0.0	0.0	0.0
Other	550.3	250.0		280.0	280.0	120.0	80.0	550.3	250.0	1010.0	1010.0	0.0
Total	550.3	1010.0	-459.7	1110.0	1110.0	460.0	310.0	550.3	1010.0	4000.0	4000.0	0.0
CSIRO TIP												
Salaries	156.9	96.0		96.0	96.0	96.0	96.0	156.9	96.0	480.0	480.0	0.0
Capital	0.0	64.0		64.0	64.0	64.0	64.0	0.0	64.0	320.0	320.0	0.0
Other	421.8							421.8	0.0	0.0	0.0	0.0
Total	578.7	160.0	418.7	160.0	738.7	160.0	160.0	578.7	160.0	800.0	800.0	0.0
AAO												
Salaries	67.5	50.7		200.0	274.7	541.3	674.7	67.5	50.7	1741.4	1741.4	0.0
Capital	0							0.0	0.0	0.0	0.0	0.0
Other	67.5	25.3		100.0	137.3	270.7	337.3	67.5	25.3	870.6	870.6	0.0
Total	135.0	76.0	59.0	300.0	412.0	812.0	1012.0	135.0	76.0	2612.0	2612.0	0.0
UNI OF SYDNEY												
Salaries	67.0	128.0		131.0	135.0	135.0	67.0	67.0	128.0	596.0	596.0	0.0
Capital								0.0	0.0	0.0	0.0	0.0
Other	67.0							67.0	0.0	0.0	0.0	0.0
Total	134.0	128.0	6.0	131.0	135.0	135.0	67.0	134.0	128.0	596.0	596.0	0.0
ANU												
Salaries	420.0	173.0		173.0	173.0	173.0	173.0	420.0	173.0	865.0	865.0	0.0
Capital								0.0	0.0	0.0	0.0	0.0
Other	0.0							0.0	0.0	0.0	0.0	0.0
Total	420.0	173.0	247.0	173.0	173.0	173.0	173.0	420.0	173.0	865.0	865.0	0.0
SWINBURNE												
Salaries	150.6	98.0		101.0	106.0	29.0		150.6	98.0	334.0	334.0	0.0
Capital	309.5	491.0		327.0				309.5	491.0	818.0	818.0	0.0
Other	1.7							1.7	0.0	0.0	0.0	0.0
Total	461.8	589.0	-127.2	428.0	106.0	29.0	0.0	461.8	589.0	1152.0	1152.0	0.0
APT												
Salaries		15.0		15.0	15.0	15.0	15.0	0.0	15.0	75.0	75.0	0.0
Capital								0.0	0.0	0.0	0.0	0.0
Other		5.0		5.0	5.0	5.0	5.0	0.0	5.0	25.0	25.0	0.0
Total	0.0	20.0	-20.0	20.0	20.0	20.0	20.0	0.0	20.0	100.0	100.0	0.0
CEA												
Salaries		15.0		15.0	15.0	15.0	15.0	0.0	15.0	75.0	75.0	0.0
Capital								0.0	0.0	0.0	0.0	0.0
Other		5.0		5.0	5.0	5.0	5.0	0.0	5.0	25.0	25.0	0.0
Total	0.0	20.0	-20.0	20.0	20.0	20.0	20.0	0.0	20.0	100.0	100.0	0.0
W.A. STATE DEPT												
Salaries	73.3	100.0		100.0	100.0	100.0		73.3	100.0	400.0	400.0	0.0
Capital		75.0		75.0	75.0	75.0		0.0	75.0	300.0	300.0	0.0
Other	43.6	25.0		25.0	25.0	25.0		43.6	25.0	100.0	100.0	0.0
Total	116.9	200.0	-83.1	200.0	200.0	200.0	0.0	116.9	200.0	800.0	800.0	0.0
Grand Total In-kind												
Salaries	935.3	1435.7	-500.4	1661.0	1744.7	1444.3	1270.7	935.3	1435.7	7556.4	7556.4	0.0
Capital	309.5	630.0	-320.5	466.0	139.0	139.0	64.0	309.5	630.0	1438.0	1438.0	0.0
Other	1151.9	310.3	841.6	415.0	452.3	425.7	427.3	1151.9	310.3	2030.6	2030.6	0.0
Total	2396.7	2376.0	20.7	2542.0	2336.0	2009.0	1762.0	2396.7	2376.0	11025.0	11025.0	0.0

Table 2

Cash Contributions From Participating Parties (\$'000s)

Participating Party	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Total to Date - Actual	Cumulative Total to Date - Agreement	Projected Grand Total 5 Years	Agreement 5 Years	Difference 5 Years
CSIRO ATNF	1032.0	832.0	200.0	1032.0	1532.0	432.0	332.0	1032.0	832.0	4160.0	4160.0	0.0
ANU	245.0	315.0	-70.0	315.0	315.0	315.0	315.0	245.0	315.0	1575.0	1575.0	0.0
UNI OF SYD	65.0	155.0	-90.0	155.0	155.0	155.0	1655.0	65.0	155.0	2275.0	2275.0	0.0
UNSW	210.0	210.0	0.0	210.0	210.0	210.0	210.0	210.0	210.0	1050.0	1050.0	0.0
SWINBURNE	10.0	10.0	0.0	10.0	10.0	10.0	10.0	10.0	10.0	50.0	50.0	0.0
UNI OF MELB	52.0	52.0	0.0	52.0	52.0	52.0	52.0	52.0	52.0	260.0	260.0	0.0
DELL COMP.		85.0	-85.0					0.0	85.0	85.0	85.0	0.0
Total	1614.0	1659.0	-45.0	1774.0	2274.0	1174.0	2574.0	1562.0	1659.0	9455.0	9455.0	0.0

Other Sources	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Total to Date - Actual	Cumulative Total to Date - Agreement	Projected Grand Total 5 Years	Agreement 5 Years	Difference 5 Years
ARC LINKAGE	1855.1	1637.0	218.1	1637.0	1637.0	1637.0	1637.0	1855.1	1637.0	8185.0	8185.0	0.0
Victorian govt.	131.3		131.3					131.3	0.0	131.3	0.0	131.3
SU Sesqui R&D	0.0		0.0					0.0	0.0	0.0	0.0	0.0
Uni of Southern Qld	5.0		5.0					5.0	0.0	5.0	0.0	5.0
insert additional Other Items above this line												
Total	1991.4	1637.0	354.4	1637.0	1637.0	1637.0	1637.0	1991.4	1637.0	8185.0	8185.0	0.0

	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Total to Date - Actual	Cumulative Total to Date - Agreement	Projected Grand Total 5 Years	Agreement 5 Years	Difference 5 Years
MNRF Grant	2340.0	2340.0	0.0	4760.0	8000.0	7500.0	900.0	2340.0	2340.0	23500.0	23500.0	0.0

Grand Total of Cash Contributions	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Total to Date - Actual	Cumulative Total to Date - Agreement	Projected Grand Total 5 Years	Agreement 5 Years	Difference 5 Years
	5945.4	5636.0	309.4	8171.0	11911.0	10311.0	5111.0	6322.8	5636.0	41140.0	41140.0	0.0

Table 3**Cash Heads of Expenditure (\$'000s)**

Total of Heads of Expenditure	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Total to Date - Actual	Cumulative Total to Date - Agreement	Projected Grand Total 5 Years	Agreement 5 Years	Difference 5 Years
Salaries	821.4	483.0	338.4	155.0	155.0	155.0	155.0	821.4	483.0	1441.4	1103.0	338.4
Capital	357.9	560.0	-202.1	1760.0	1760.0	1759.0	1809.0	357.9	560.0	7445.9	7648.0	-202.1
Other	3112.6	5323.0	-2210.4	6708.0	6949.0	7157.0	6248.0	3112.6	5323.0	30174.6	32385.0	-2210.4
Totals	4291.9	6366.0	-2074.1	8623.0	8864.0	9071.0	8212.0	4291.9	6366.0	39061.9	41136.0	-2074.1

Table 4

Summary of Resources Applied to Activities of MNRF (\$'000s)

	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Total to Date Actual	Cumulative Total to Date Agreement	Projected Grand Total 5 Years	Agreement 5 Years	Difference 5 Years
Grand Ttl 5 Yrs Inkind from Tble 1	2396.7	2376.0	20.7	2542.0	2336.0	2009.0	1762.0	2396.7	2376.0	11045.7	11025.0	20.7
Grand Ttl 5 Yrs Cash Expd from Tble 2	5945.4	5636.0	309.4	8171.0	11911.0	10311.0	5111.0	5945.4	5636.0	41449.4	41140.0	309.4
Ttl Resources Cash & Inkind Income	8342.1	8012.0	330.1	10713.0	14247.0	12320.0	6873.0	8342.1	8012.0	52495.1	52165.0	330.1

Allocation of Total Resources Applied to Activities of MNRF Between Heads of Expenditure (\$)

	Actual 2001/2003	Agreement 2001/2003	Variance	Agreement 2003/2004	Agreement 2004/2005	Agreement 2005/2006	Agreement 2006/2007	Cumulative Total to Date Actual	Cumulative Total to Date Agreement	Projected Grand Total 5 Years	Agreement 5 Years	Difference 5 Years
Total Salaries Cash & Inkind	1756.7	1918.7	-162.0	1816.0	1899.7	1599.3	1425.7	1756.7	1918.7	8497.4	8659.4	-162.0
Total Capital Cash & Inkind	667.4	1190.0	-522.6	2226.0	1899.0	1898.0	1873.0	667.4	1190.0	8563.4	9086.0	-522.6
Total Other Cash & Inkind	4264.5	5633.3	-1368.8	7123.0	7401.3	7582.7	6675.3	4264.5	5633.3	33046.8	34415.6	-1368.8
Grand Total (Cash & Inkind)	6688.6	8742.0	-2053.4	11165.0	11200.0	11080.0	9974.0	6688.6	8742.0	50107.6	52161.0	-2053.4

Table 6

Cash Cost (net of GST) of Purchased Capital Equipment (\$'000s)

Fin Years	Description	Location	Quantity	Value (\$)	Total (\$)
2001/03	List items separately > \$50K				
	Supercomputer & IF, Parkes	Swinburne/ATNF	1.0	536.0	536.0
	Molonglo filterbank/correlator	Molonglo	1.0		0.0
	SKA demonstrator	ATNF	1.0		0.0
	Test equipment	ATNF	1.0		0.0
	Software	ATNF	1.0		0.0
	W'band correlator	ATNF	1.0	259.8	259.8
	Group items < \$50K				
		ATNF	6.0	25.2	25.2
	In-kind capital items	CSIRO TIP			0.0
	W.A. DPC			0.0	
Total					821.1
2003/04	List items separately > \$50K				
	Supercomputer ATCA	Swinburne/ATNF	1.0		0.0
	Molonglo filterbank/b'former	Molonglo	1.0		0.0
	Semiconductor fabrication	ATNF	1.0		0.0
	SKA demonstrator	ATNF	1.0		0.0
	Test equipment	ATNF	1.0		0.0
	Software	ATNF	1.0		0.0
	W'band correlator	ATNF	1.0		0.0
	Group items < \$50K				
	In-kind capital items	CSIRO TIP			0.0
	W.A. DPC			0.0	
Total					0.0
2004/05	List items separately > \$50K				
	Molonglo filterbank/b'former	Molonglo	1.0		0.0
	SKA demonstrator	ATNF	1.0		0.0
	W'band correlator	ATNF	1.0		0.0
	Semiconductor fabrication	ATNF	1.0		0.0
	Group items < \$50K				
In-kind capital items	CSIRO TIP			0.0	
	W.A. DPC			0.0	
Total					0.0
2005/06	List items separately > \$50K				
	Molonglo filterbank/b'former	Molonglo	1.0		0.0
	Molonglo feeds & LNAs	Molonglo	1.0		0.0
	Semiconductor fabrication	ATNF	1.0		0.0
	SKA demonstrator	ATNF	1.0		0.0
	W'band correlator	ATNF	1.0		0.0
	Group items < \$50K				
In-kind capital items	CSIRO TIP			0.0	
	W.A. DPC			0.0	
Total					0.0
2006/07	List items separately > \$50K				
	Molonglo feeds & LNAs	Molonglo	1.0		0.0
	W'band correlator	ATNF	1.0		0.0
	Group items < \$50K				
In-kind capital items	CSIRO TIP			0.0	
	W.A. DPC			0.0	
Total					0.0
Grand Total					821.1

Table 5: Summary of Planning/Construction/Upgrade/Operating Expenditure (\$'000s)

		Actual 2001/2003	Agreement 2001/2003	Variance 2002/2003	Agreement 2003/2004	2004/2005 Agreement	2005/2006 Agreement	2006/2007 Agreement	Total to Date Actual	Total to Date Agreement	Variance To Date	Projected Grand Total 5 Years	Agreement 5 Years
SKA Planning Phase	<i>NTD</i>	1621.0	895.0	726.0	1710.0	2360.0	1010.0	610.0	1621.0	895.0	726.0	7311.0	6585.0
	<i>MMIC</i>	300.0	1100.0	-800.0	900.0	600.0	350.0	300.0	300.0	1100.0	-800.0	2450.0	3250.0
	<i>Siting</i>	117.0	200.0	-83.0	200.0	200.0	200.0	0.0	117.0	200.0	-83.0	717.0	800.0
	<i>SKASS</i>	688.0	877.9	-189.9	633.8	311.6	234.2	205.2	688.0	877.9	-189.9	2072.8	2262.7
				0.0					0.0	0.0	0.0	0.0	0.0
SKA Construction/ Upgrade Phase	<i>CABB</i>	358.0	1150.0	-792.0	1475.0	1800.0	450.0	400.0	358.0	1150.0	-792.0	4483.0	5275.0
	<i>SKAMP</i>	134.0	217.5	-83.5	441.0	434.5	523.2	167.0	134.0	217.5	-83.5	1699.7	1783.2
				0.0					0.0	0.0	0.0	0.0	0.0
				0.0					0.0	0.0	0.0	0.0	0.0
				0.0					0.0	0.0	0.0	0.0	0.0
SKA Total Planning & Construction		3218.0	4440.4	-1222.4	5359.8	5706.1	2767.4	1682.2	3218.0	4440.4	-1222.4	18733.5	19955.9
Operating Phase	<i>Office</i>	446.0	482.0	-36.0	154.0	154.0	154.0	154.0	446.0	482.0	-36.0	1062.0	1098.0
	<i>SKA</i>											0.0	0.0
	<i>Gemini (total)</i>	3024.0	4657.0	-1633.0	6182.0	6583.0	7191.0	6482.0	3024.0	4657.0	-1633.0	29462.0	31095.0
Total Operating Phase		3470.0	5139.0	-1669.0	6336.0	6737.0	7345.0	6636.0	3470.0	5139.0	-1669.0	30524.0	32193.0
Grand Total Expenditure		6688.0	9579.4	-2891.4	11695.8	12443.1	10112.4	8318.2	6688.0	9579.4	-2891.4	49257.5	52148.9