CSIRO Australia Telescope National Facility Annual Report 2010

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CSIRO Australia Telescope National Facility
Annual Report 2010

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This is the report of the Steering Committee of the CSIRO Australia Telescope National Facility
for the calendar year 2010

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Cover image: Image of the Milky Way, captured above CSIRO's Australia Telescope
Compact Array in Narrabri, NSW.

Credit: Emil Lenc, CSIRO

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Director's Report

Credit: Wheeler Studios.

'The only constant is change', these famous words from the Greek philosopher Heraclitus, who lived 2500 years ago, are as relevant today as they were in his time. The words reflect the situation in the world at large but are also directly applicable to the subject matter of this report, namely the Australia Telescope National Facility (ATNF), which is a major component of CSIRO Astronomy and Space Science (CASS).

Of the changes throughout 2010, perhaps the most significant (which was highlighted in last year's annual report), was the formation of the new division, CASS. The division is now responsible for the operation of two national facilities, the ATNF and the Canberra Deep Space Communication Complex (CDSCC), which is one of three stations comprising NASA's Deep Space Network. During the year, the details of the CDSCC transition into CASS were ironed out, a new Enterprise Agreement covering the employment of the CDSCC staff was agreed (early in 2011), and the full integration of the new division proceeded. There is still work to be done but I think all staff should be pleased that the disruption was minimal.

A second change is of course reflected in the fact that it is my picture you see near the top of this page. I took over as Chief of CASS and Director of the ATNF in June 2010. It is with a sense of pride therefore that I write the introduction to this annual report, since the organisation that I run is at the top of its game. The credit for this must go to the staff as a whole and to those who came before me, most notably Lewis Ball, who led the organisation through the transition in a highly professional manner. Lewis moved to Chile in September to take up the position of Deputy Director of the Joint ALMA Observatory; he clearly enjoys a challenge!

The Australian Square Kilometre Array Pathfinder (ASKAP) is one of the cornerstones of the Australia - NZ bid to host the next generation of radio telescope, the SKA. ASKAP is one of the largest construction projects that CSIRO has been involved in and it is managed by CASS. When complete in 2013 it will comprise 36 12-m antennas, each equipped with novel, state-of-the-art phased array feed (PAF) receiver systems. With such technology ASKAP will be the world's premier radio survey instrument. As the project transitions from construction to operations, ASKAP will become an integral component of the ATNF. The changes required to incorporate ASKAP into ATNF operations are in the detailed planning stages and will be communicated to the ATNF user community in 2011.

As highlighted elsewhere in this report, engineering work is not confined only to ASKAP. The Compact Array Broadband Backend (CABB) upgrade of the Compact Array at Narrabri entered its commissioning phase, and early science has started to flow. When combined with the now completed upgrade of the L/S receiver systems (the so-called '16cm' band) and the forthcoming Astronomy Australia Ltd funded C/X upgrade, the Compact Array will have superb capabilities similar to that of the EVLA in the USA and e-MERLIN in the UK. I look forward to reading about the new science that the Compact Array will deliver in the coming years.

I return now to Heraclitus, who clearly foreshadowed radio astronomy with one of his less well-known quotes: 'Nature is wont to hide herself'. One of the great advantages of radio astronomy is the ability to peer through the cosmic dust that masks many of the most interesting cosmic phenomena we strive to understand. Five explorations of such phenomena are detailed in this report, reflecting the depth and variety of the science conducted with the ATNF. These are (1) radio pulsar work with Parkes in conjunction with NASA's Fermi satellite; (2) Trans-Tasman VLBI utilising both ASKAP and the new antenna at Warkworth, NZ; (3) the hunt for ultra-high energy neutrinos, also with Parkes; (4) the MALT90 survey using the Mopra telescope; and lastly (5) the new CABB view of planet formation, utilising the new capabilities of the Compact Array.

It is pleasing to see that in this year of change, the rate of publications utilizing ATNF data has maintained its excellent record and that the impact, measured through citations, shows that the ATNF continues to be one of the most productive facilities in the world.

2011 will be a year that sees even more change. The Murchison Radio-astronomy Observatory will see major development efforts as the local infrastructure is constructed, including a state-of-the-art control building, as all 36 of the antennas are built and commissioned and as the first 6 PAFs are installed. On the global SKA front, 2011 will see huge effort committed to delivering the documentation required for the SKA site decision, with a decision expected in early 2012. The planning for ATNF operations as ASKAP comes on line will mature and will be communicated to the astronomical community. I hope also, that we will see spectacular science emerging from the Compact Array as more and more users take advantage of the fantastic new capability.

Philip Diamond

ATNF Director
Chief of CSIRO Astronomy and Space Science

Chairman's Report

Credit: ICRAR.

This is my first Annual Report as the new chair of the Steering Committee and the first Annual Report of the ATNF under its new umbrella division of CSIRO Astronomy and Space Science. Over the last year, it has been a great pleasure to work with and interact with all ATNF staff. I commend everybody for their dedication to radio astronomy and the pursuit of excellence in operations, science and engineering. It's been a particular pleasure to work with Dr Phil Diamond who joined as the new Chief of CASS and ATNF Director in the middle of the year. Dr Diamond joined CASS from his previous post at the University of Manchester after an extensive international search. He arrives with an impressive reputation in running major institutes and radio astronomy programs, and he will serve the ATNF well in dealing with the multiple challenges of delivering ASKAP as well as running the ATNF's existing world-class telescopes. On behalf of the Steering Committee, I welcome Dr Diamond to the ATNF and wish him well for the years ahead.

It's also my great pleasure to thank Dr Lewis Ball for having taken on the role of Acting Director for such an extended period. Dr Ball contributed a great deal of energy in managing the substantial changes in some parts of the organisation. The statistics contained within this report also confirm the continued efficient running of the Facility during this period. Dr Ball's tireless efforts were much appreciated by staff and users. I wish him well in his exciting new role at ALMA.

Whilst much of the focus at ATNF continues to be on the development of ASKAP, the existing facilities of the ATNF continue not only to operate efficiently, but to deliver excellent radio astronomy results to the user community. The continuing world-class nature of the Facility is amply demonstrated by the large, and growing, number of publications (over 100) in international refereed journals, and the fact that half the users on the three facilities (Compact Array, Parkes and Mopra) are overseas investigators.

I'm pleased to see that the Annual Report also records further successes in the implementation of the long-running Compact Array Broadband backend project; a successful 13/20cm receiver upgrade; and a new Parkes 'matrix'. These are significant upgrades, and this continued investment in maintaining and upgrading instrumentation will ensure the ATNF's continuing status as one of the world's highly-ranked radio observatories in the period leading up to the deployment of ASKAP.

Finally, although the delivery of ASKAP is formally outside the remit of the Steering Committee, the entire community is looking forward to the delivery and operation of this exciting SKA precursor and the new capability it will bring to astronomers in Australia and around the world. The impressive suite of surveys that have been proposed will create major shifts in our understanding of the Universe. Challenges on all fronts remain before ASKAP and the SKA become a reality. Members of the Steering Committee will do their utmost best to provide the ATNF with the necessary strategic advice to meet these challenges.

Lister Staveley-Smith

Chair, Australia Telescope Steering Committee

Senior Management

ATNF Director and
Chief CSIRO Astronomy and Space Science
Philip Diamond (from June 2010)

CSIRO SKA Director
Brian Boyle

Deputy Chief, CSIRO Astronomy and Space Science (Acting)
Graeme Carrad

Assistant Director, Astrophysics
Robert Braun

Assistant Director, Operations
Douglas Bock

Assistant Director, Engineering (Acting)
Mark Bowen

Assistant Director, ASKAP

Antony Schinckel (from October 2010)

Research Program Leader

Jessica Chapman

Credit: Wheeler Studios.

I.
The ATNF in Brief

In early 2010, the first of 36 ASKAP antennas was constructed at the Murchison Radio-astronomy Observatory in Western Australia.

Credit: Ant Schinckel, CSIRO.

The ATNF in Brief

CSIRO's radio astronomy observatories are collectively known as the Australia Telescope National Facility (or ATNF). This consists of a set of radio telescopes, provided as a national research facility for use by Australian and international researchers. The telescopes provide for a uniquely powerful view of the southern hemisphere radio spectrum. CSIRO's division of Astronomy and Space Science (CASS), CSIRO's provider of technology and services for radio astronomy, spacecraft tracking and space sciences, has direct responsibility for the successful operation of the ATNF. Located at the CSIRO Radiophysics Laboratory in Sydney, CASS is co-located with the Australian Astronomical Observatory at its Marsfield site. This report covers ATNF-related activities of CASS over the whole calendar year of 2010.

Our Mission

- To operate and develop the Australia Telescope as a national research facility for use by Australian and international researchers;
- To exploit the telescope's unique southern location and technological advantages to maintain its position as a world-class radio astronomy observatory;
- To further the advancement of knowledge.

An Overview of the Facility

The Australia Telescope comprises eight antennas and associated instrumentation located at three geographically separate locations, supported by staff and facilities at the CSIRO Radiophysics Laboratory at Marsfield in Sydney. The three observatories are near the towns of Parkes, Narrabri and Coonabarabran, all in rural NSW.

Parkes Observatory is home to the 64-m Parkes radio telescope, a single, fully steerable antenna equipped with receivers that operate in frequency ranges from 74 MHz to 22 GHz, with bands in the range from 600 MHz to 9 GHz the most commonly used. This telescope has been successfully operated since 1961 and is famous as a national symbol for Australian scientific achievement. Instrumental upgrades, including a 13-beam focal plane array and innovative backend signal processing instrumentation, have maintained the telescope as a state-of-the-art instrument.

Six identical 22-m antennas make up the Australia Telescope Compact Array (ATCA), an earth-rotation synthesis telescope located at the Paul Wild Observatory near Narrabri. The ATCA is equipped with receivers that operate at frequencies between 1.1 and 106 GHz, with use at the highest frequencies restricted primarily to a 'winter season' by atmospheric stability and transparency considerations.

The Mopra Telescope is a single 22-m diameter antenna near Coonabarabran, used primarily for large-scale millimetre-wavelength mapping projects and as part of the Long Baseline Array.

CASS also manages the astronomy use of the CSIRO-administered Canberra Deep Space Communication Complex 70-m and 34-m antennas at Tidbinbilla. NASA/JPL makes approximately 5% of 70-m antenna time available to astronomical research programs.

The eight ATNF radio telescopes can be used together (sometimes in conjunction with antennas operated by the University of Tasmania at Ceduna and Hobart, and the Tidbinbilla 70-m antenna) as a Long Baseline Array (LBA) for a technique known as Very Long Baseline Interferometry (VLBI).

CASS is in the process of developing a next-generation radio telescope, the Australian Square Kilometre Array Pathfinder (ASKAP) which will become part of the National Facility following its commissioning. ASKAP will be a wide field-of-view survey telescope made up of 36 antennas, each 12 metres in diameter. It will be located in a superbly radio-quiet area in the Mid West region of Western Australia and will be a key demonstrator instrument for new technologies for the international Square Kilometre Array (SKA) project.

Technical research and development supporting upgrades of the Facility, as well as for the new ASKAP instrument, are conducted at CASS headquarters in Marsfield.

Governance

The Australia Telescope is operated as a national facility under guidelines originally established by the Australian Science and Technology Council. Until 30 November 2009 the ATNF undertook this activity as a division of CSIRO in its own right. On 1 December 2009, ATNF activity became the responsibility of a new division, CSIRO Astronomy and Space Science (CASS), through which it is responsible via the Executive to the Minister for Innovation, Industry, Science and Research. The Chief of CASS is also the Director of the ATNF.

Divisional policy, strategic planning and operational management are the responsibility of the senior CASS managers, comprising the Chief Philip Diamond, the Acting Deputy Chief Graeme Carrad, Assistant Directors (Douglas Bock, Robert Braun, Antony Schinckel and Mark Bowen [Acting]), CDSCC Director Miriam Baltuck and Research Program Leader, Jessica Chapman.

Divisional plans reflect both CSIRO's 2007–2011 Strategic Plan and the ATNF's vision statement.

ATNF policy is shaped by the Australia Telescope Steering Committee (ATSC), an independent committee appointed by the Minister. The Steering Committee meets at least once a year to advise the Director regarding broad directions of the ATNF's scientific activities and longer term strategies for the development of the Australia Telescope. The Steering Committee appoints the Australia Telescope Users Committee (ATUC) and the Time Assignment Committee (TAC). ATUC represents the interests of the community of astronomy researchers who use the Australia Telescope. The committee provides feedback to the ATNF Director, discussing problems with, and suggesting changes to, ATNF operations. It also discusses and provides advice on the scientific merit of future development projects. ATUC meetings are also a forum for informing telescope users of the current status and planned development of ATNF facilities, and recent scientific results. The TAC reviews proposals and allocates observing time.

The committee members for 2010 are listed in Appendix A.

CASS Management Changes in 2010

In June 2010, Dr Philip Diamond was appointed as Chief of CASS. Dr Diamond joined CASS from the University of Manchester where he was Director of the Jodrell Bank Centre for Astrophysics and coordinator for PrepSKA, the important preparatory phase study for the A$2.5 billion international Square Kilometre Array project.

Dr Lewis Ball, who had been Acting Chief of CASS prior to Philip Diamond's appointment took up the Deputy Chief position. In September 2010, Dr Ball took on a position as Deputy Director of the Joint ALMA Observatory based in Chile.

An international recruitment process took place to fill the Deputy Chief position with Graeme Carrad undertaking the role in an acting capacity. Mark Bowen filled in for Graeme as Research Program Leader for Engineering and Theme Leader for Technologies for Radio Astronomy during this time.

Douglas Bock joined CASS as Assistant Director Operations in January. He arrived from the University of California Berkeley, where he was Assistant Director Operations for the Combined Array for Research in Millimetre-wave Astronomy (CARMA).

David DeBoer, Assistant Director ASKAP left CASS in October and Antony Schinckel, who was Project Manager for ASKAP took up the position vacated by David.

In a structural reorganisation, and following Dr Diamond's appointment, responsibility for the delivery of the Australian SKA Pathfinder (ASKAP) telescope, which sat within the Square Kilometre Array portfolio led by CSIRO SKA Director Brian Boyle, was transferred to the Radio Astronomy portfolio led by Dr Diamond.

Funding

In financial year 2009-2010 CSIRO's total expenditure for radio astronomy activities was A$32.8 million. The total revenue was A$34.0 million, including a direct appropriation of A$33.0 million from CSIRO. A summary of ATNF finances for the year is given in Appendix B.

The Australia Telescope Community

At the end of 2010 the total staff complement of CASS was around 300 people, of which 197 were primarily associated with the ATNF. This was made up of paid staff (research scientists and engineers, technical and administrative support), but excludes casuals, contractors and students. These resources are distributed across five sites within NSW and the ACT, and Geraldton in Western Australia. A list of all staff who worked for CASS on radio astronomy related activities during 2010, including staff from other business units, is given in Appendix C.

Australian and international observers use the Australia Telescope without charge. This is in accordance with general practice of the worldwide radio astronomy community, in which telescope users from different countries gain reciprocal access to facilities on the basis of scientific merit. Such access provides Australian scientists with a diversity of instruments and leads to a rich network of international collaborations.

Observing time on ATNF telescopes is awarded twice a year by the TAC to astronomers on the basis of the merits of their proposed research programs. Approximately 90% of the Australia Telescope's users come from outside CSIRO. Proposals for time on the Compact Array typically exceed the time available by a factor of 2.0–2.5, while Parkes and Mopra proposals typically exceed the time available by a factor of around 1.3. The proposals for Parkes and Mopra are commonly fewer and request more time. In total, approximately 150 proposals are received for the summer semester (October to March) and 200 in the winter semester (April to September) – the difference reflects the high demand for winter millimetre observing using Mopra and the Compact Array.

The ATNF has strong links with its primary user base, the university community, both within Australia and around the world. The 'user–operator' model adopted by the Australia Telescope is unusual, if not unique, in world terms. Members of each observing proposal operate the telescope for their allocated time and the ATNF sites host a constant stream of visiting astronomers from around the world who come for periods of between a few days and a few weeks. This is a significant contributor to the strength of the relationship between CASS and the astronomers that use the ATNF. These relationships are further strengthened by the open, international and collaborative nature of astronomical research: 77% of Australian astronomy papers published in 1998–2002 (the most recent period for which figures are available) had international co-authors, an increase from 55% for the previous five years (Biglia and Butler 2005, *New Horizons: Volume II—A Bibliometric Analysis of Astronomical Sciences Publications*). Although this model will not suit the survey-mode observing of ASKAP, the ATNF intends to retain it for the other facilities.

Research scientists and engineers are heavily involved in the training of postgraduate students, an important contributor to the strength of the interactions between CASS staff and university colleagues. In 2010, CASS staff co-supervised 33 PhD students, most of whom were undertaking degrees at Australian universities. CSIRO provides direct financial support to most of these students, supplementing the support that they receive through their host universities. The majority of current PhD students with CASS have an Australian Postgraduate Research Award.

The Wider Astronomical Community and Other Relationships

Astronomers on the Australia Telescope Steering Committee provide the ATNF Director with strategic advice from the Australian and international research community, and the ATNF provides similar input to other parts of the research community via staff representation on other research community bodies and committees. The Australia Telescope User Committee also provides an effective route for operational feedback and input to CSIRO on future directions from the research community to the ATNF as well as providing communications from ATNF to the user community.

CSIRO is a full member of Astronomy Australia Ltd, an organisation established in early 2007 as a company with the principal objective of managing the National Collaborative Research Infrastructure Strategy (NCRIS) funds for astronomy. CSIRO is also an organisational member of the Astronomical Society of Australia.

CASS also has contracted links with the research and space community, both for the provision of equipment and for provision of research outcomes, data, or aspects of National Facility operations to organisations external to CSIRO. Such contracts are small in number, and in the past have generally concerned the delivery of instrumentation for astronomy, and/or space tracking services. CSIRO has also entered into contracts with Australian university partners for the provision of services that contribute to the operation of the National Facility, and this is now the favoured mode of engagement at CASS. Engagement with university partners is seen as increasingly important and will continue to be actively pursued over coming years by CASS as an effective means of broadening the National Facility resource base, and ensuring the vitality of the Australian astronomy research community as a whole.

CASS links with the Australian and international community are increasing in complexity as the organisation progresses towards the SKA. CAASTRO (the ARC Centre of Excellence for All-sky Astrophysics) was announced in 2010 and will form in 2011 as a partnership and collaboration between several Australian and international universities and research institutions, including CSIRO. ICRAR (the International Centre for Radio Astronomy Research, which comprises Curtin University of Technology and the University of Western Australia) has provided a focus with links to Western Australian universities.

As a component of CSIRO's management of the Murchison Radio-astronomy Observatory, CSIRO has a Collaboration Agreement with the Western Australian Government. A successful bid for funds from the Sustainability Round of the Commonwealth Government Education Investment Fund will enable CASS, in collaboration with CSIRO's Energy Group and several universities, to improve energy efficiency and provide sustainable power for the MRO and for ASKAP's supercomputing requirements at the Pawsey Centre for SKA Science in Perth.

International alliances are also growing, with a small number of 'formal' links underlined by collaborative agreements supplemented by a larger number of informal community collaborations. In 2010 the Auckland University of Technology in New Zealand began joining regular VLBI sessions with its Warkworth 12-m telescope. The formal linkages include those between CSIRO and EU-PrepSKA, NRC-Canada, ASTRON in The Netherlands, the international SKA Program Development Office (SPDO), the Australia – New Zealand SKA Coordination Committee (ANZSCC), and research groups in the USA, New Zealand, India, and China.

Finally, as CASS moves through the design, development and construction phases of the ASKAP project, industry will play a crucial role in the delivery and through-life support of the technologies and infrastructure required. The scale of ASKAP and the consequent requirement to develop commercial applications for many of its components necessitates the engagement of industry at new levels of depth and scale. Relationships with industry continued to develop through 2010 with engagement occurring at the research collaboration level and more strategically through the Australasian SKA Industry Consortium.

Themes

The strategic goals and purpose of CASS by theme (as at the end of 2010) are as follows:

Astrophysics

Theme Goal

To conduct world-class research in astrophysics, retaining astronomy's position as Australia's highest impact science and furthering our understanding of the Universe through innovative use of CSIRO's telescopes.

Theme Purpose

This theme results in world-class science that directly influences international astronomical research and shapes our understanding of the Universe.

The Astrophysics Group undertakes major observational research projects, many of which involve sizable national and international collaborations. The success of these projects is underpinned by a deep understanding and technical knowledge of the telescope systems. In turn, the knowledge gained is used to provide the scientific case and the technical requirements for new generations of telescopes and instrumentation, ensuring that they deliver maximum scientific impact by targeting the highest priority science questions.

Medium-term theme goals (1–5 years) include: (i) powerful new tests of general relativity; (ii) the study of the formation and evolution of distant galaxies; (iii) new surveys for molecules and pulsars in the heart of the Milky Way; (iv) new wide area neutral hydrogen surveys of the disk and halo of the Milky Way; (v) the study of star formation in the Milky Way and external galaxies. Many of these goals are being pursued in the context of Survey Science Proposals being undertaken with ASKAP in which Theme staff play a major role.

Longer-term goals (5–10 years) include: (i) detection of the cosmic background of gravitational radiation; (ii) elucidating the structure and equation-of-state of neutron star interiors; (iii) measuring the gaseous evolution of distant galaxies ($0 < z < 1$); (iv) measurement of the equation of state of dark energy; (v) understanding the evolution of cosmic magnetic fields.

Australia Telescope National Facility Operations

Theme Goal

To continue to operate the most productive radio astronomy facility in the southern hemisphere in order to serve the Australian and international scientific community.

Theme Purpose

This theme operates the National Facility observatories (the Compact Array near Narrabri, the single-dish telescope at Mopra, Parkes, the radio astronomy facilities at the Canberra Deep Space Communication Complex at Tidbinbilla, and the Long Baseline Array) to maximise the scientific value of experiments conducted by Facility users.

The theme is preparing for operation of a new telescope – ASKAP – in Western Australia that is being developed under a sister theme, the Australian SKA Pathfinder. To facilitate this while ensuring the continued world-class operation and scientific impact of the existing facilities at Parkes, Narrabri and Coonabarabran, ATNF's operations are unified across the sites into a Science Operations stream and an Engineering Operations stream. The establishment of a single Science Operations Centre in Marsfield serving all ATNF facilities is planned and activity surrounding planning and engagement of stakeholders involved with this facility has commenced.

The high impact of the ATNF will be sustained by ensuring continuous operation with very high reliability (<5% lost time) and excellent data quality – facilitating astronomical research conducted with our radio telescopes that contributes to the understanding of the Universe.

Technologies for Radio Astronomy

Theme Goal

To develop frontline technology for the advancement of radio astronomy in Australia.

Theme Purpose

To ensure that the ATNF's existing radio telescopes remain at the leading edge of world technology, securing continued demand from the astronomy research community for the ATNF's radio telescopes, with the effect of maximising the science outcomes from astronomy conducted with the Facility.

This directly complements the development of ASKAP being undertaken in the sister theme, the Australian SKA Pathfinder.

These technological developments underpin astronomy's position as the highest impact field of Australian science and its role in shaping our understanding of the Universe.

In addition, this theme supports important spacecraft tracking programs in collaboration with NASA, supplies radio astronomy instrumentation to outside organisations and undertakes strategic collaborations with other radio astronomy institutes. These secondary activities allow a broad range of specialist talent to be maintained and developed within the ATNF, provide significant external revenue for re-investment in the National Facility, and facilitate the international communication necessary to ensure that technological developments at the ATNF continue to be world class.

Spacecraft tracking programs contribute directly to the high profile within the Australian community of CSIRO's involvement in frontline science leading to an improved understanding of our more immediate environment in our Solar System.

The Australian SKA Pathfinder (ASKAP)

Theme Goal

To maximise Australia's participation in the Square Kilometre Array (SKA).

Theme Purpose

This theme's purpose is to maximise Australia's involvement in the SKA via (a) developing the infrastructure for a new remote observatory in Western Australia (the Murchison Radio-astronomy Observatory or MRO); (b) building a world-class radio telescope, ASKAP; and (c) participating in international SKA design efforts.

This development of a new radio telescope complements the technology development for existing radio telescopes undertaken in the sister theme, Technologies for Radio Astronomy.

In low frequency (<3 GHz) survey applications, ASKAP will deliver a roughly 20-fold increase in speed over the existing facilities.

ASKAP will provide considerable impact through: (i) addressing outstanding technology risks along the SKA development path; (ii) delivering a world-class astronomical facility at the world's best site for metre and centimetre radio astronomy; (iii) maximising Australia's participation in the SKA – a billion Euro international facility; (iv) paving the way forward to leverage significant international funds to an SKA sited in Australia and New Zealand.

Most significantly, this theme will exploit Australia's unique combination of global position, technical expertise and radio-quiet environment to deliver another world-leading instrument to study the southern sky and address the biggest questions regarding our knowledge of the Universe.

The Australia Telescope Compact Array

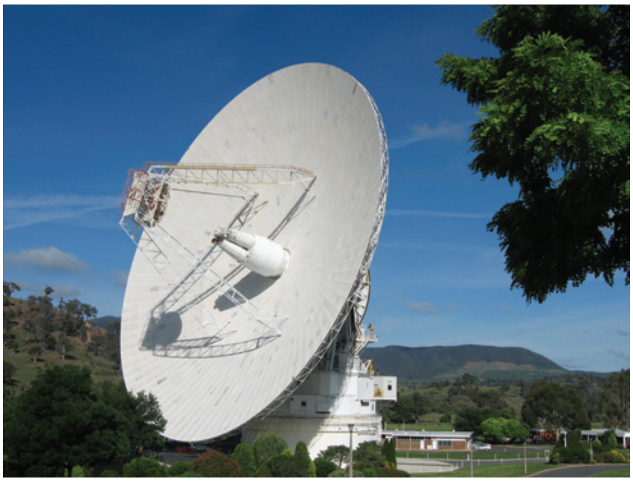
Credit: David Smyth, CSIRO.

The Parkes Radio Telescope

Credit: David McClenaghan, CSIRO.

The Mopra Radio Telescope

Credit: John Masterson, CSIRO.



The Tidbinbilla DSS43 70-m Antenna

Credit: Canberra Deep Space Communication Complex.

The Australian SKA Pathfinder (ASKAP)

Credit: Terrace Photographers Pty Ltd.

2.
Performance Indicators

The Parkes Radio Telescope is the second most cited radio telescope in the world in its class (in terms of citations per paper).

Credit: Tony Crawshaw, CSIRO.

Performance Indicators

1. Scheduled and Successfully Completed Observing Time

For the Compact Array and Parkes Observatory, the ATNF target is that at least 70% of time should be allocated for astronomical observations while the time lost during scheduled observations from equipment failure should be below 5%. For the Compact Array and Parkes, approximately 10% of time is made available as 'Director's time'. This is time that is initially reserved in the published version of the schedule, but which is later made available for approved observing projects.

For most projects, the proposing astronomers are required to be present at the observatory for their scheduled time. For the Compact Array, remote observing is also possible from other sites. In 2010, 32% of Compact Array observations were taken by observers not present at Narrabri. All Mopra observations were taken remotely, with approximately 60% taken from Narrabri and the other 40% from locations including Sydney, North America, Japan, and Europe.

Table 1: Telescope usage in 2010.

	Compact Array	Parkes	Mopra*
Successful astronomy observations	75.5%	75.8%	66%
Maintenance/test time	17.0%	12.1%	5%
Time lost due to equipment failure	4.1%	2.2%	3%
Time lost due to weather	0.6%	2.7%	10%
Idle time	2.8%	7.2%	16%

* Mopra statistics are for dates between 1 May to 24 October, corresponding to the 'millimetre season'.

The telescope usage figures for ATCA and Parkes are similar to those for recent years; Mopra usage dropped back from the all-time-high of 2009, impacted by poor weather particularly toward the end of the season. The period 1 May – 24 October corresponds to the period when observing in the 3 mm band was carried out ('millimetre season'). In recent years, Mopra use has extended, at a somewhat lower level, into the 'shoulder season' preceding the 3 mm season for observations in the 7 mm and 12 mm bands.

2. Response to Recommendations by the User Committee

The Australia Telescope User Committee (ATUC) is an advisory group that meets twice a year to represent the user community in the ATNF decision-making process. After each meeting the committee presents a list of recommendations to the Director. ATUC considers matters raised by the user community, current operations and priorities for future developments.

In most cases ATUC recommendations are accepted and implemented. In 2009, ATUC made 31 recommendations to the ATNF. Of these, 27 were accepted, and 24 of these were completed by May 2010.

The ATUC members are listed in Appendix A.

3. Time Allocation on ATNF Facilities

The allocation of time on Australia Telescope facilities is done on the basis of scientific merit. Two six-month observing semesters are scheduled each year, from October to March (OCTS) and from April to September (APRS). For the period from 1 October 2009 to 30 September 2010 a total of 181 proposals were allocated time on ATNF telescopes (each proposal is counted once only per calendar year although some proposals are submitted twice). Of these, 93 were for the Compact Array, 38 were for the Parkes telescope, 34 were for the Mopra telescope and 16 were for the Long Baseline Array. Observing programs allocated time on ATNF facilities are listed in Appendix D.

Proposals requesting service observations with the Canberra Deep Space Communication Complex DSS-43 (70-m) and DSS-34 (34-m) antennas at Tidbinbilla, which are part of the NASA Deep Space Network, are also accepted.

Figures 1, 2 and 3 show the time allocated to observing teams on the Compact Array, Parkes and Mopra telescopes as a percentage of the total allocated time, determined by affiliation of the team leader.

Figures 4, 5 and 6 show the time allocated to observing teams as a percentage of the total allocated time, determined using the affiliations of all team members. In these plots the time allocated to each proposal has been divided evenly between all authors on the proposal. Including all authors on the proposals, CASS staff were allocated approximately 23% of observing time during the year for the Compact Array, 33% for the Parkes telescopes, and 14% for Mopra. Mopra continued to have a larger involvement by international investigators, who have been allocated about 70% of observing time in recent years.

ATNF telescopes are able to support a broad range of science areas that include Galactic (ISM, pulsar, X-ray binaries, star formation, stellar evolution, magnetic fields), extragalactic (galaxy formation, ISM, Magellanic Clouds, cosmic magnetism) and cosmological science. The research programs involve astronomers from many institutions in Australia and overseas. Typically the proposals allocated ATNF time over one year include at least 400 authors. Of these, approximately 40 authors are from CASS, 80 are from 14 other institutions in Australia, and 280 authors are from around 120 overseas institutions in 20 countries.

Figure 1: Compact Array time allocation by primary investigator, October 2005 – September 2010. For each year the time allocation is for 12 months from October to September.

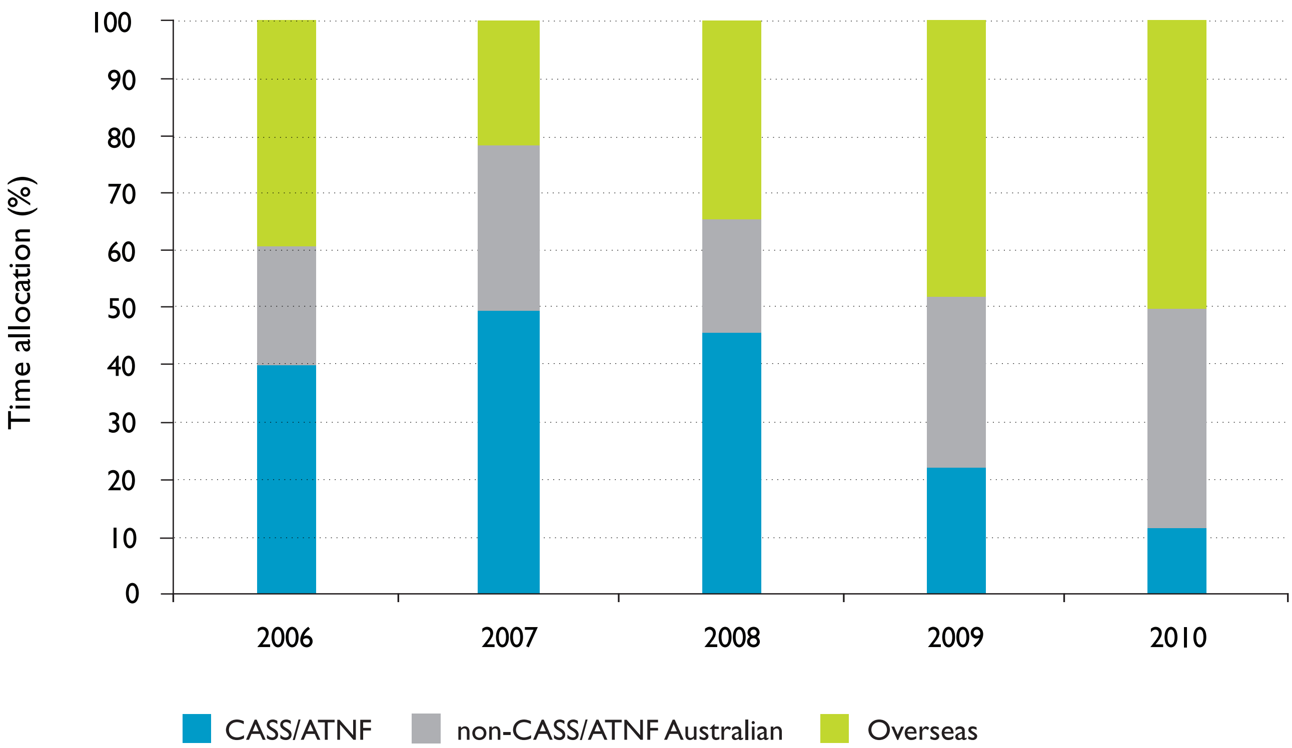


Figure 2: Parkes time allocation by primary investigator, October 2005 – September 2010. For each year the time allocation is for 12 months from October to September.

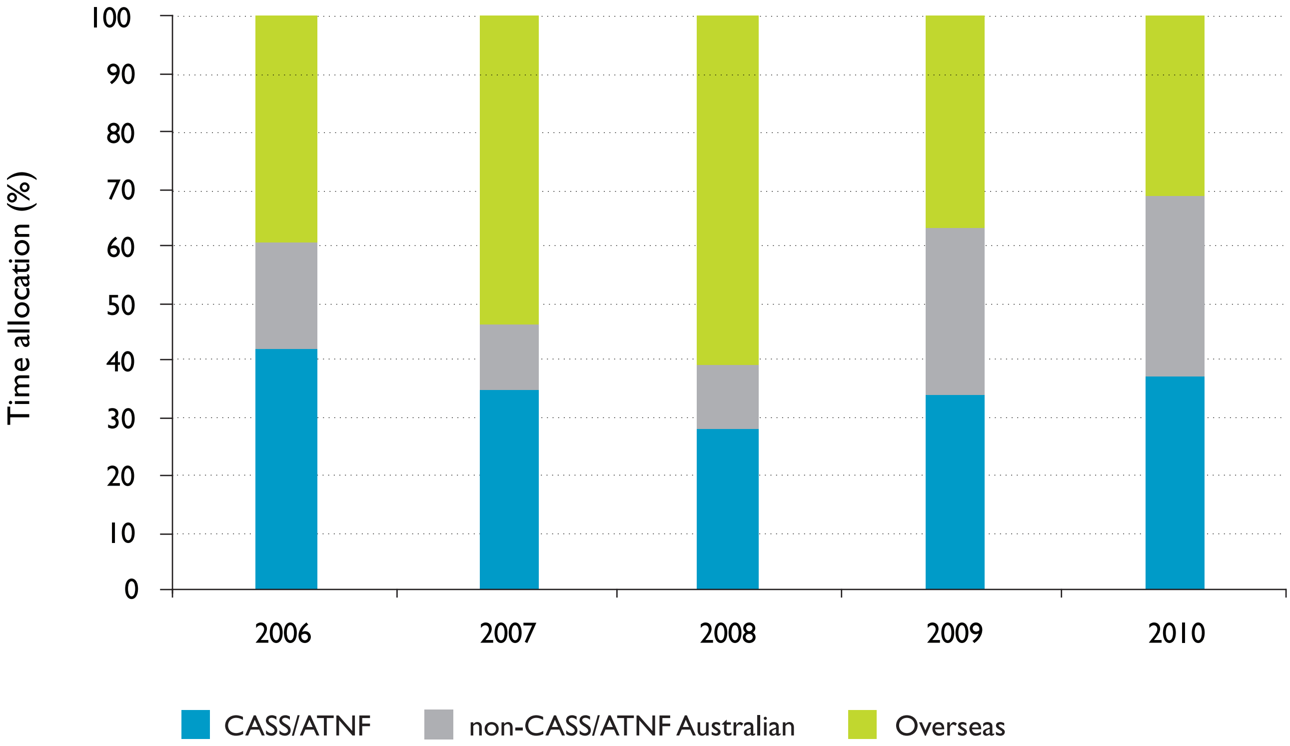


Figure 3: Mopra time allocation by primary investigator, October 2005 – September 2010. For each year the time allocation is for 12 months from October to September.

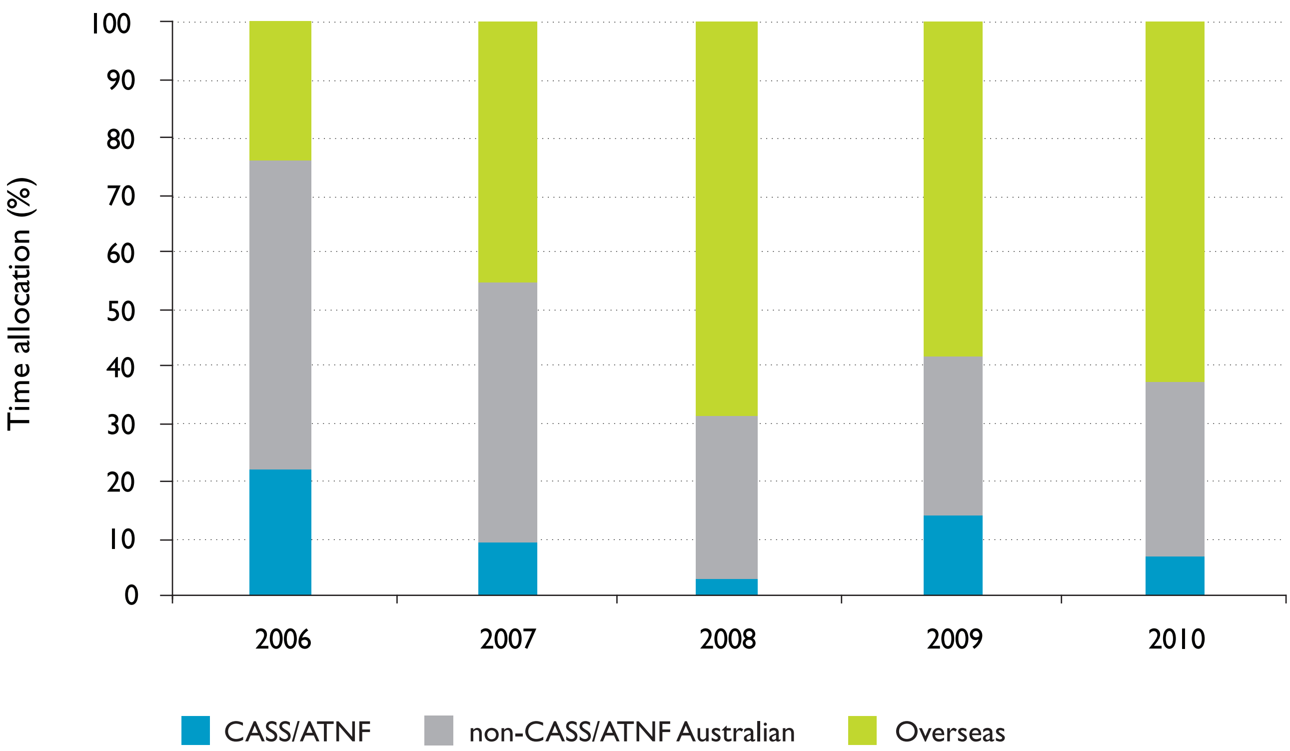


Figure 4: Compact Array time allocation by all investigators.

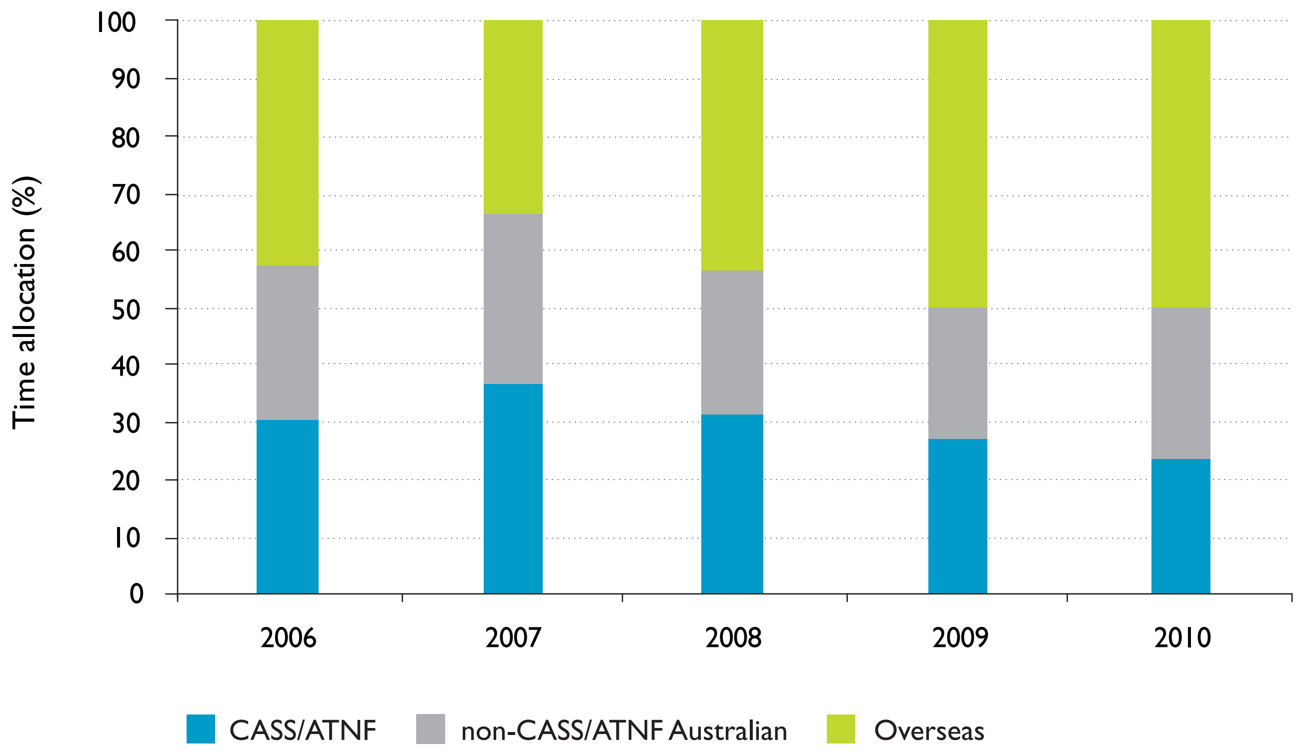


Figure 5: Parkes time allocation by all investigators.

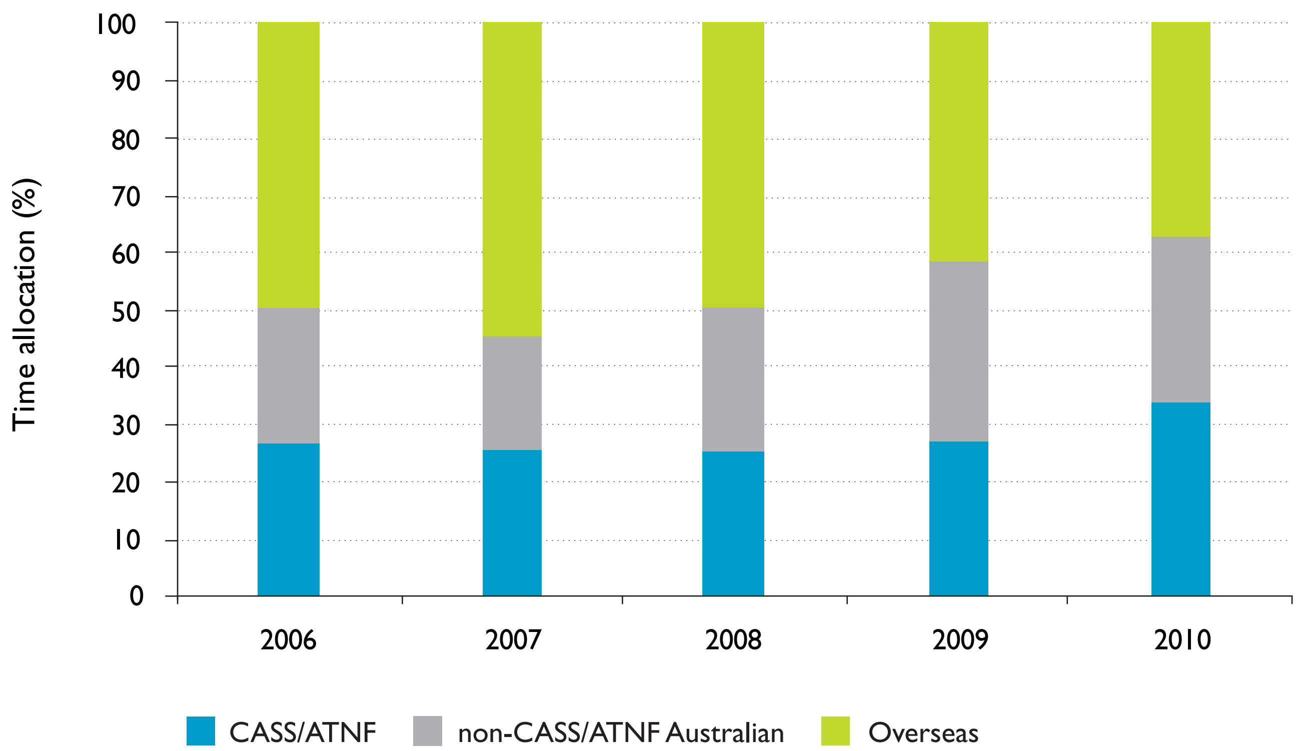
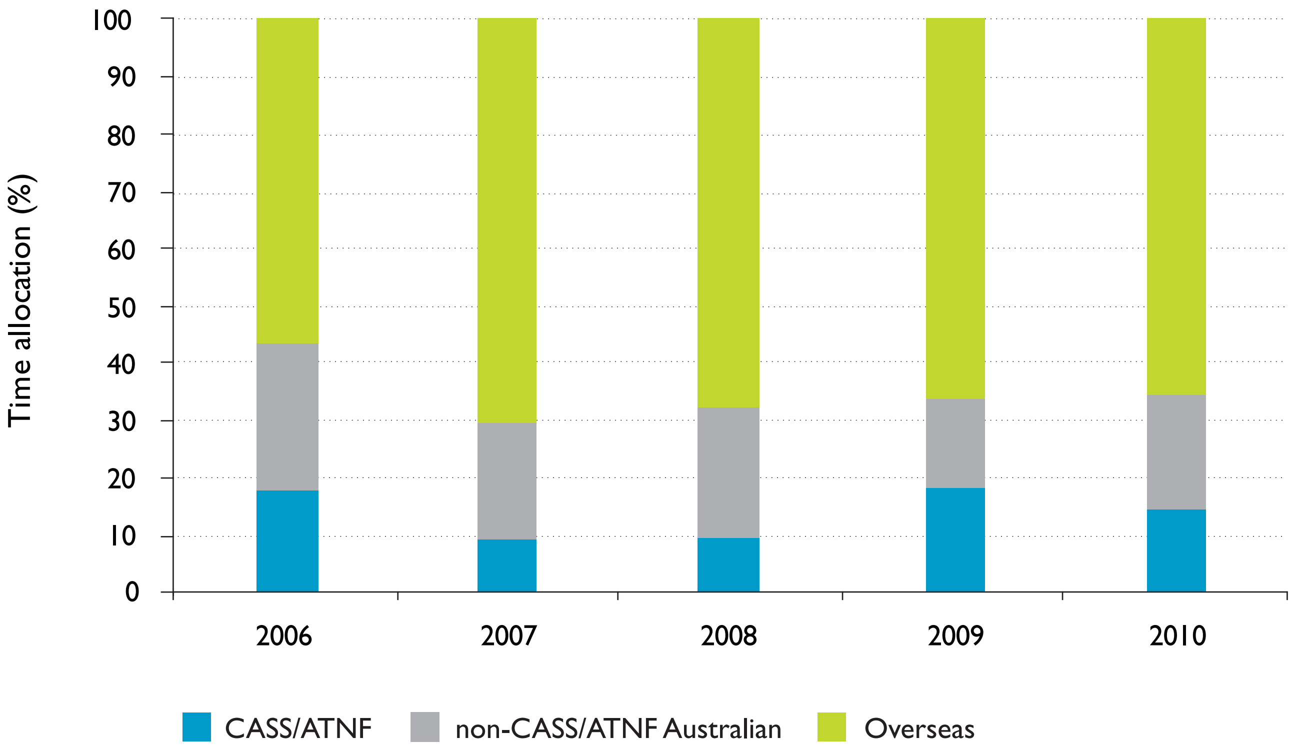


Figure 6: Mopra time allocation by all investigators.



4. Teaching

In December 2010, there were 33 PhD students being co-supervised by CASS staff. Their affiliations and thesis titles are given in Appendix E. Nine students were awarded PhDs during the year and their theses are listed in Appendix F.

Figure 7 shows the numbers of PhD students affiliated with CASS. Figure 8 shows the institutions at which CASS-affiliated students were enrolled in 2009. Most students were enrolled in Australian universities, with the majority of these at the University of Sydney, Swinburne University of Technology, the University of Tasmania and Macquarie University.

Figure 7: Numbers of postgraduate students affiliated with CASS.

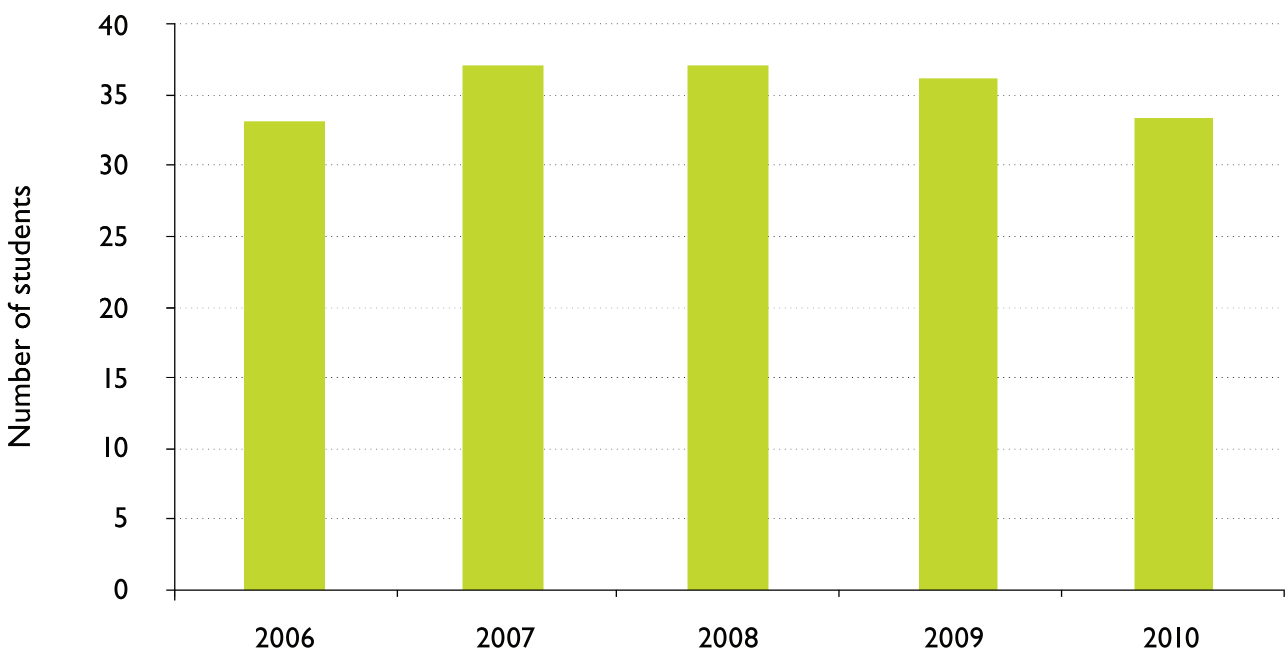
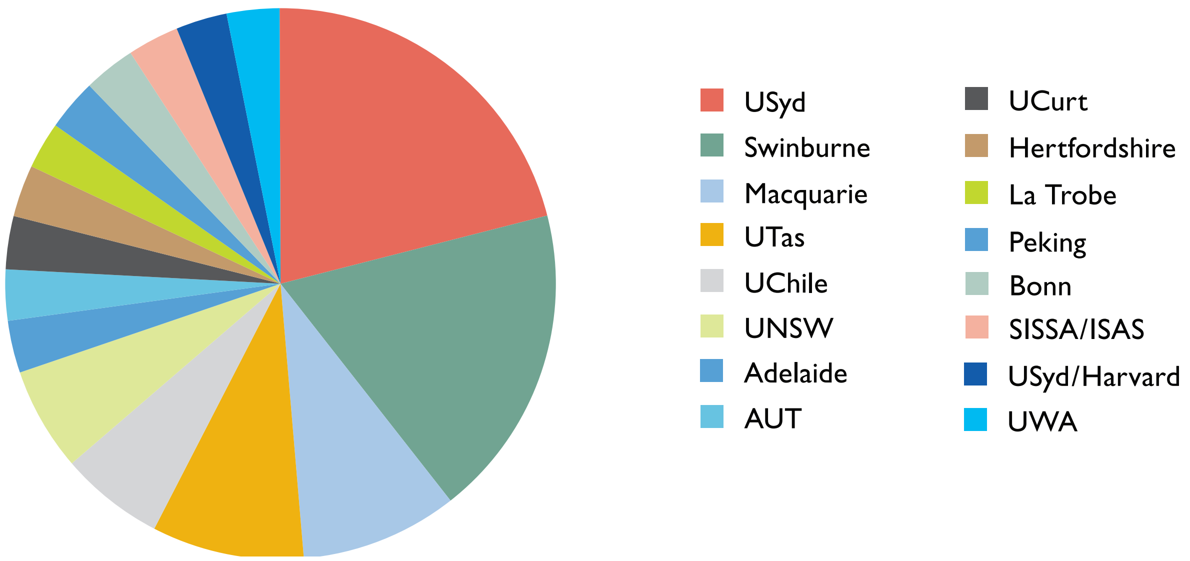


Figure 8: Postgraduate student affiliations 2010.



5. Publications and Citations

Figure 9 shows the number of publications in refereed journals that include data obtained with all Australia Telescope facilities. The publication counts do not include IAU telegrams, abstracts, reports, historical papers, articles for popular magazines, or other papers by CASS authors. In 2010, 107 papers with ATNF data were published in refereed journals. This is the highest number since 2006. These are listed in Appendix G, which also lists 137 other papers (conference papers with ATNF data and other papers by CASS staff).

CASS staff were included as authors on 61% of papers published in refereed journals during the year and as first authors on 21% of papers. If all authors on each paper are treated equally, then CASS authors contributed approximately 20% of all authorship to papers published (for comparison, the total telescope time allocated to CASS staff was around 21% with all authors treated equally on time allocation proposals).

Figure 9: Publications from data obtained with all Australia Telescope facilities (Compact Array, Mopra, Parkes, Tidbinbilla and VLBI), published in refereed journals.

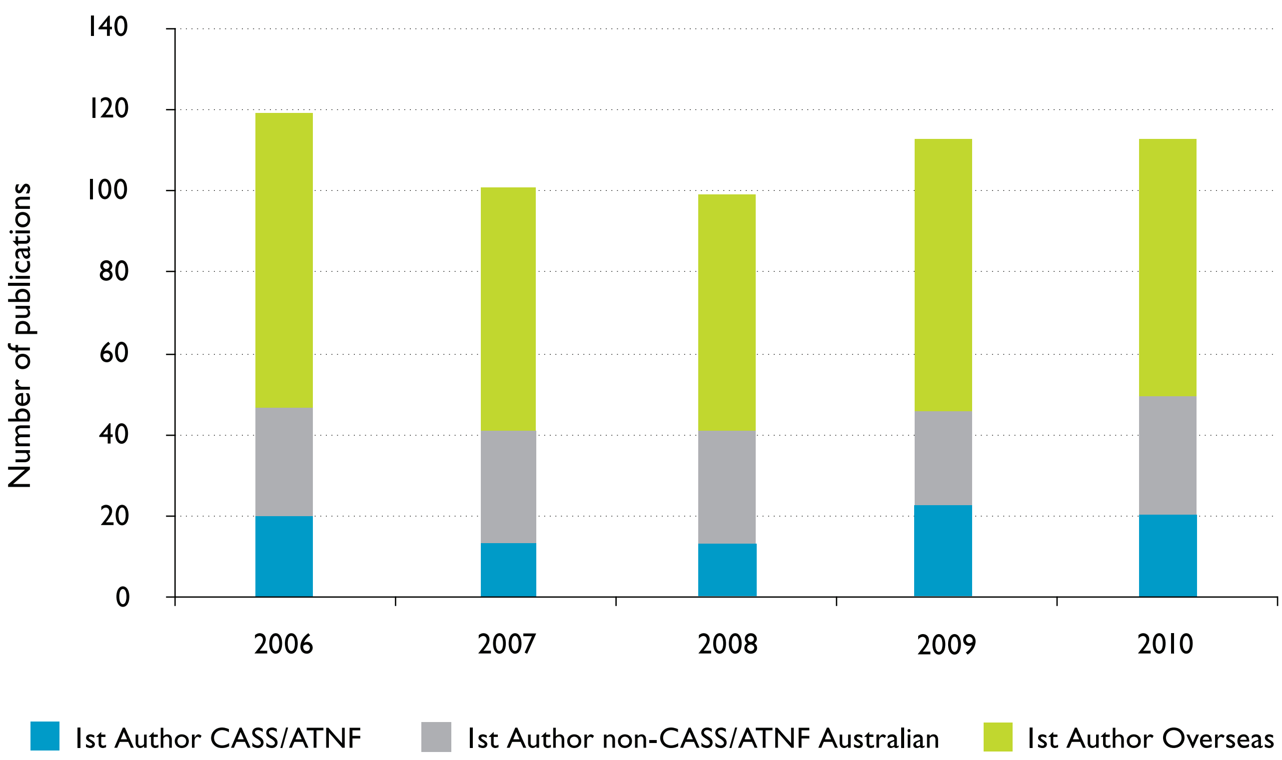
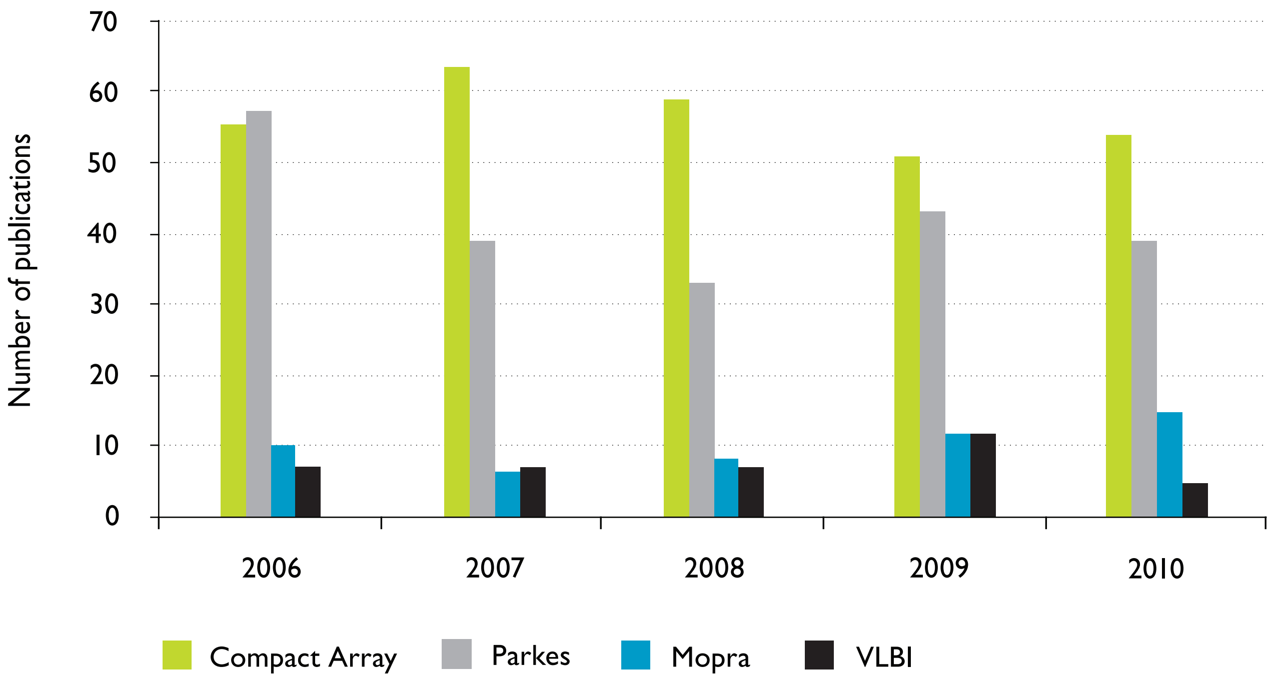


Figure 10 shows publication numbers for papers that include Compact Array, Parkes, Mopra and VLBI data, respectively. A small number of papers with data from more than one facility are counted more than once. For Mopra, the number of refereed publications (15) is the highest ever.

The ATNF is both cost effective and scientifically productive. Overall the ATNF is ranked second in the world behind the NRAO in terms of total number of refereed publications while the Compact Array and Parkes rank second and third respectively in the world in terms of total number of citations to refereed papers (Trimble and Cega 2008, Astron. Nachr. 329(6): 632–647). In terms of citations per paper, Parkes is the second most highly cited radio telescope in the world in its class after Ryle (which has a higher citation/paper ratio but a significantly smaller total number of papers than Parkes).

Astronomy leads Australian science as a discipline of international standing and has a particularly high level of international collaboration. For our current facilities, the ATNF achieves the best science outcomes, in terms of publication and citation counts, when science teams include both Australian and overseas astronomers.

Figure 10: Publications from data obtained with the Compact Array, Parkes, Mopra and VLBI in 2006 – 2010.



6. Public Relations

Figure 11 shows the count of public relations activities for the years 2006–2010. During 2010 CASS issued twelve radio astronomy related media releases (see Appendix H for a full list) and featured in at least 418 print and online articles, and 66 television and radio programs. CASS staff delivered at least 114 public lectures during the year to the general public, education, industry and amateur astronomy audiences.

2009 saw a marked increase in public relations activities compared with previous years, largely due to activities associated with the International Year of Astronomy in 2009, media attention surrounding the 40th anniversary of the Apollo 11 moon landing and the role the Parkes telescope played in this historic event. However, even after the conclusion of these events, public relations activities throughout 2010 remained higher than previous years. In particular, print and online articles more than doubled on the previous year, attributed predominately to growing international interest in continued development of CSIRO's ASKAP radio telescope and the international SKA project. Additionally, despite a slight drop in public talks for the year, 2010 remains higher than years prior to 2009, reflecting the continued involvement of CASS staff in science outreach and education.

The Internet is a major tool for communication with professional astronomers and the public. In 2010 there were 1.26 million 'visits' (46.4 million 'hits') to the central ATNF website (www.atnf.csiro.au). During the year there were also approximately 458,000 visits (10.4 million hits) to the outreach and education website. CASS also contributed to the central CSIRO website at www.csiro.au.

Figure 12 shows the number of visitors to the Parkes and Narrabri Visitors Centres. Visitor numbers at the Parkes Observatory peaked at 136,000 in 2003 following the release of the movie *The Dish*, and the opening of The Dish café.

In 2010 visitor numbers for Parkes Observatory Visitors Discovery Centre dropped to 95 104, the result of a region-wide decline in interstate travellers in the second half of the year due to flooding events across Central NSW, Queensland and Victoria. However, the Centre recorded an increase in visitor satisfaction, increasing its Net Promoter Score by 9%. This significant increase is largely the result of the centre's refurbishment that was completed in late 2010. The new exhibition focuses on the observatory's contribution to radio astronomy, its current operation and research work, and the future of radio astronomy.

The Narrabri Visitors Centre welcomed 14,320 visitors during 2010.

Figure 11: ATNF public relations activities.

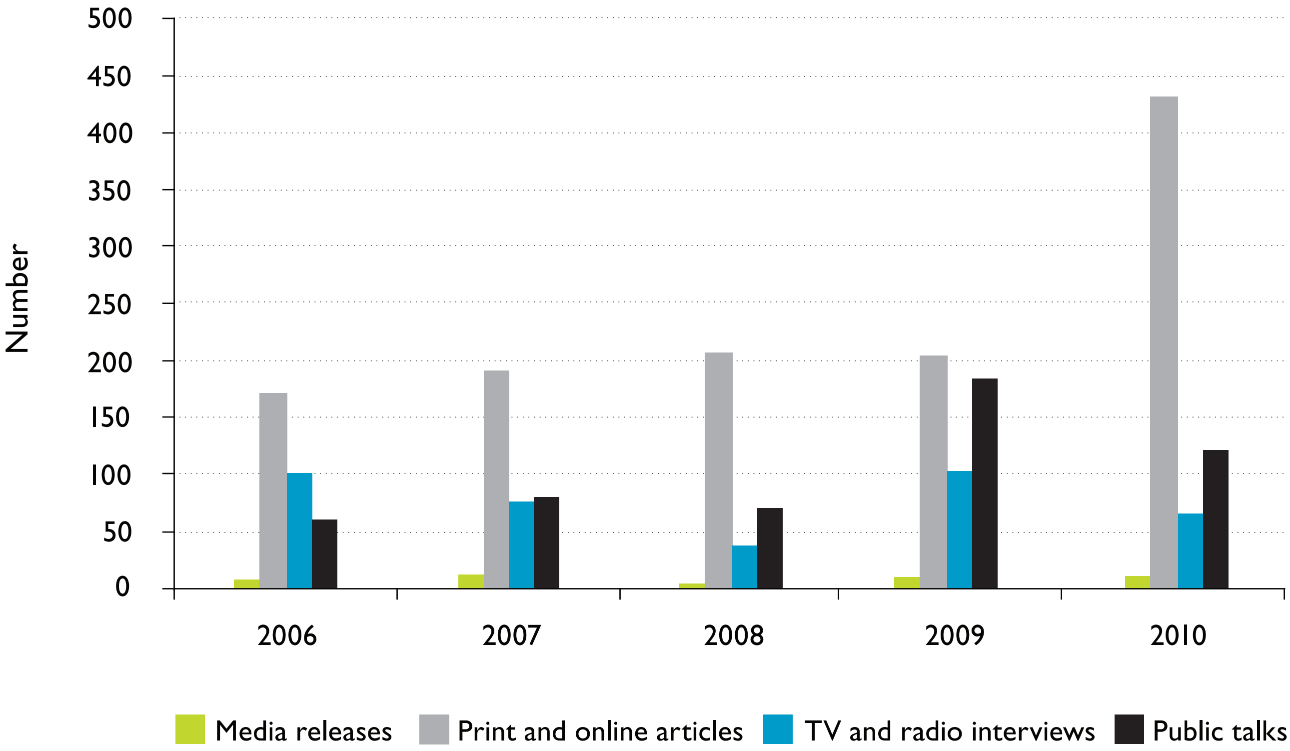
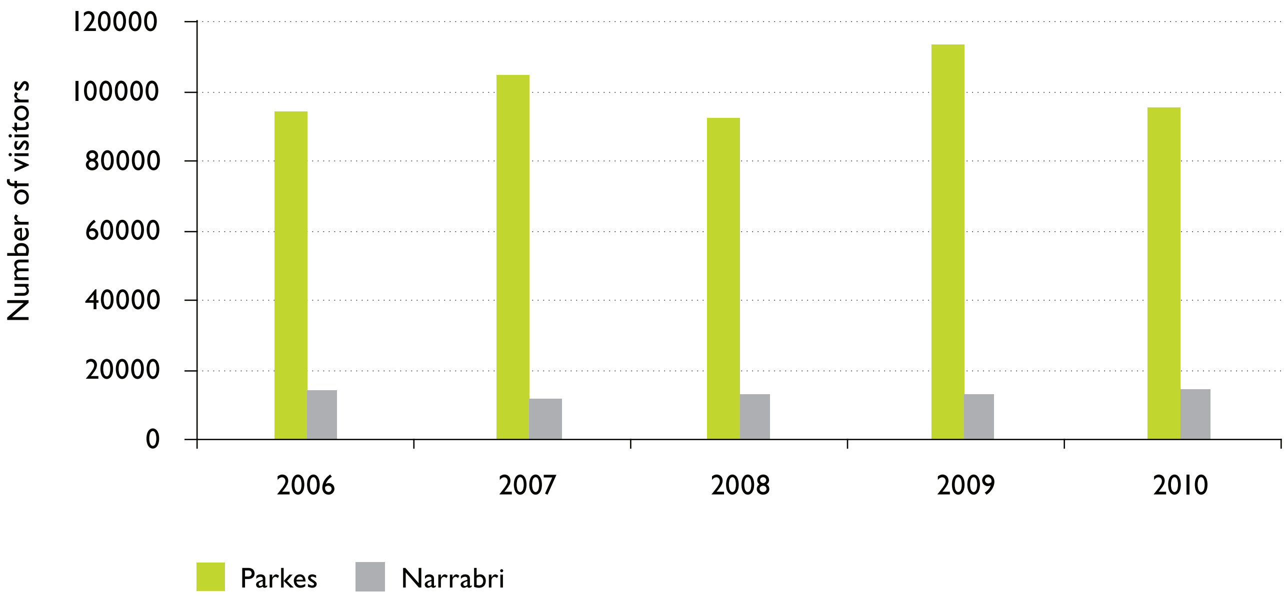


Figure 12: Visitors Centre statistics.



7. User Feedback

Observers at the Parkes, Compact Array and Mopra telescopes are asked to complete a user feedback questionnaire with responses given on a scale of 0 (low) to 10 (high). In 2009 millimetre observing with the Compact Array was absorbed into routine observing and, as a result, feedback for observations with the centimetre and millimetre systems has been combined.

Figures 13 to 15 show the results of user feedback questionnaires from 2008 to 2010 for Parkes, Compact Array and Mopra respectively. Table 2 indicates the average user responses for 2008 to 2010 for all three observatories.

Feedback from observers at the Parkes telescope was lower in most categories in 2009, but has bounced back to previous levels in 2010. There were insufficient responses to provide a statistically meaningful score on the library, which may reflect the fact that most journals are now available on-line.

Figure 14 shows that in 2010 the feedback from observers using the Compact Array was generally consistent with that given in 2009. The scores for the User Guide and Web Information are still lower than is desired, and in part reflect the fact that documentation has lagged behind the developments made with CABB during the year.

Feedback scores for Mopra were generally consistent with previous years with the scores for documentation continuing the improvement in this category seen in 2009.

Figure 13: Parkes user feedback on a scale from 1 (poor) to 10 (excellent).

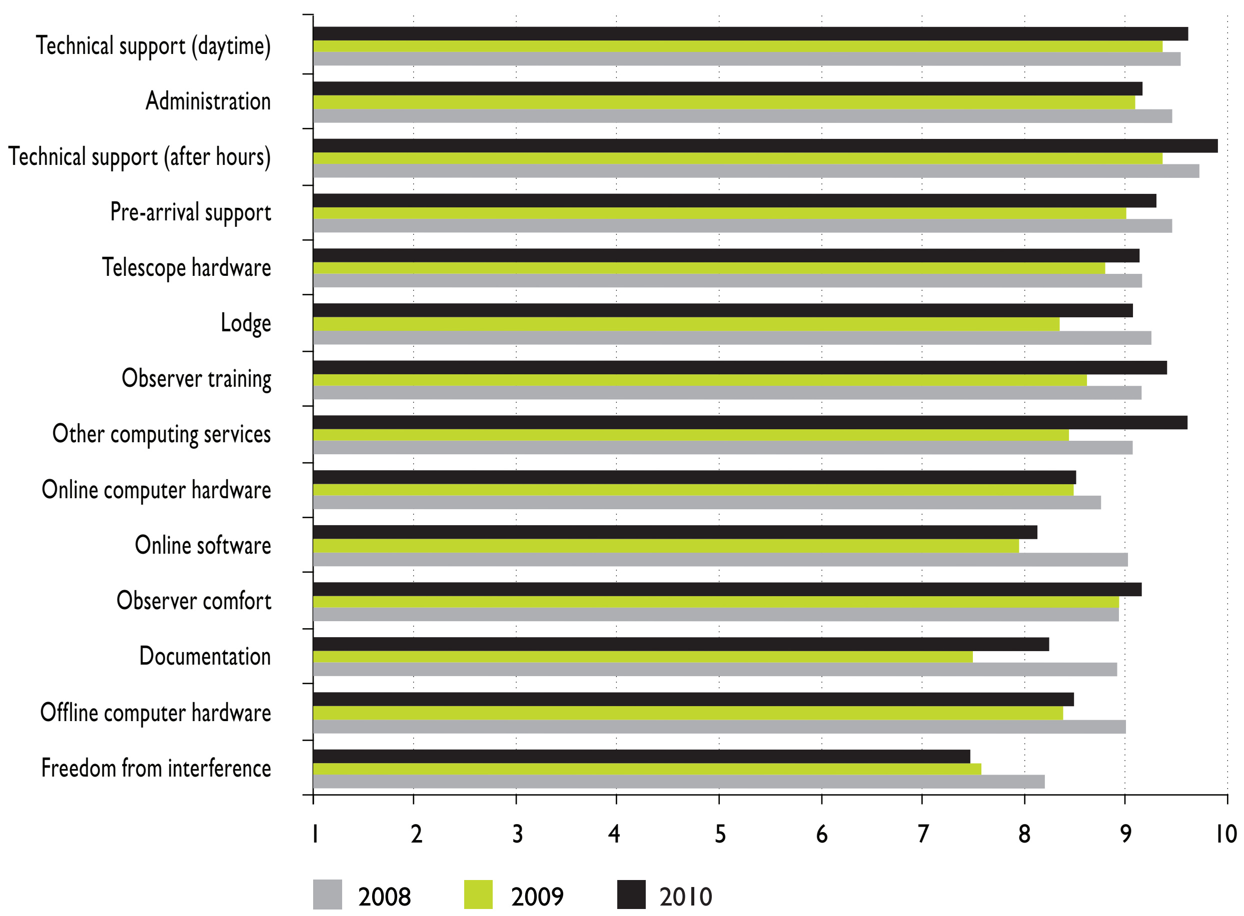


Figure 14: Compact Array user feedback on a scale from 1 (poor) to 10 (excellent). For 2007 and 2008 the figures given are for feedback on centimetre observing only (millimetre observing was reported separately in those years). For 2009, the figures include feedback for both centimetre and millimetre observing.

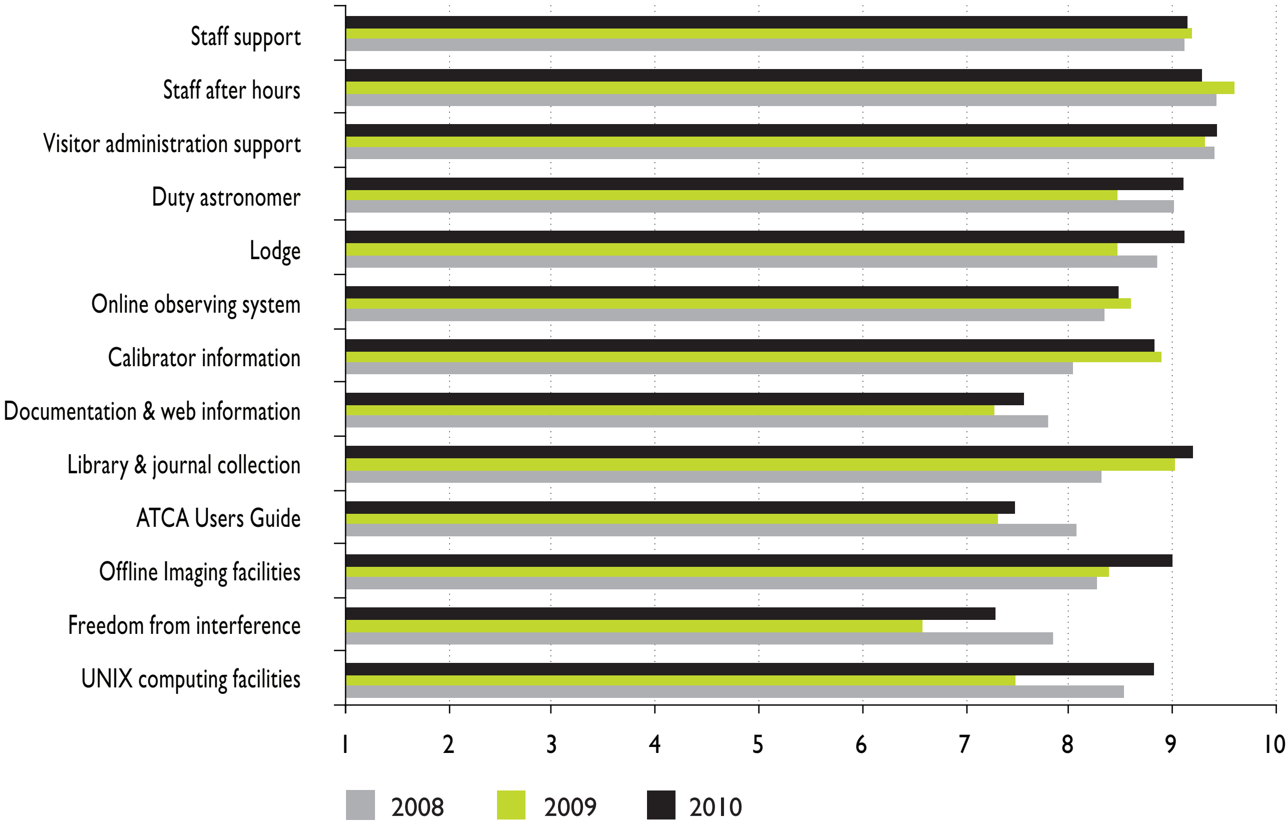


Figure 15: Mopra user feedback on a scale from 1 (poor) to 10 (excellent).

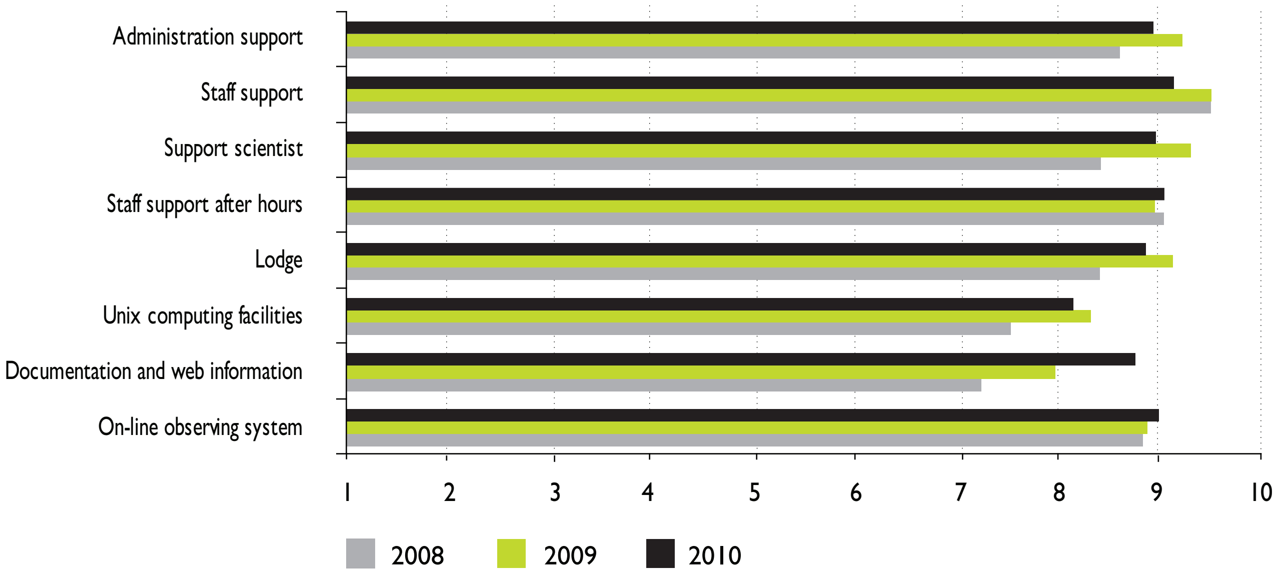


Table 2: Average telescope user feedback questionnaire satisfaction score on a scale from 1 (poor) to 10 (excellent).

Telescope	2008	2009	2010
Parkes	9.1	8.5	8.9
ATCA (cm)	8.5	8.3	8.7
Mopra	8.3	8.9	8.8

3.
Astrophysics

The Parkes Radio Telescope was used in three of the following reports; during pulsar searching and timing, successful VLBI observations (with the first ASKAP antenna), and observations of the Moon's surface rocks and soil to detect ultra-high-energy neutrinos.

Credit: Seth Shostak.

Astrophysics

Overview

The Astrophysics Group undertakes major observational research projects, many of which involve sizable national and international collaborations. The success of these projects is underpinned to a large degree by a deep understanding and technical knowledge of the telescope systems. This knowledge is then used to provide the scientific case and the technical requirements for new generations of telescopes and instrumentation, ensuring that they deliver maximum scientific impact by targeting the highest priority science questions.

As researchers associated with a National Facility, the group is charged with two primary responsibilities:

- To conduct original astrophysical research;
- To provide effective scientific support to ATNF users (both national and international) and to ATNF projects (for example, in the role of project scientist for instrumental upgrades).

While the division between these responsibilities varies by individual, about half of the group effort is expended in each role. In addition to the full members of the Astrophysics Group, there are a substantial number of staff PhD astronomers who have primary responsibilities within other themes of CSIRO Astronomy and Space Science (CASS), but who are still actively engaged (at the 10-50% level) in astrophysics research.

The Astrophysics Group has strong expertise in observational radio astronomy, particularly in the centimetre to metre wavelength range, as well as expertise in other wavelength ranges. The group also has a very broad range of astronomical research interests. This breadth is important for National Facility support, given the diversity of the non-CSIRO user community and the range of projects supported on the facilities. Comparably broad groups are not found anywhere else in Australia. Some of the main areas of astrophysical research that staff were involved in during 2010 were:

- Pulsar research;
- Galaxy interstellar medium and star formation studies;
- Stellar evolution;
- Nearby galaxy research;
- Active galactic nuclei and radio galaxies.

Graduate Student Program

CASS Astrophysics (and some other) staff continue to co-supervise PhD students from (mostly) Australian universities. The program helps strengthen training in radio astronomy science and techniques, and furthers collaboration between CASS and universities. In December 2010 there were 33 PhD students affiliated with CASS (these students are listed in Appendix E). In June 2010 the students organised and held a full-day student symposium where they presented their research to fellow students and staff.

Distinguished Visitors Program

CASS has a distinguished visitors program which provides some financial and other support to facilitate visits from leading researchers for extended periods (from several weeks to a year).

During the year CASS enjoyed visits from many colleagues including:

- Ding Chen (CAS, China);
- Martin Cohen (Univ. Calif. Berkeley, USA);
- William Coles (Univ. Calif. San Diego, USA);
- Marie-Helene Grondin (Bordeaux, France);
- Aris Karastergiou (Oxford, UK);
- Marianne Lemoine (Bordeaux, France);
- Marcella Massardi (SISSA, Italy);
- Thierry Reposeur (Bordeaux, France);
- Jianping Yuan (Urumqi, China);

Special Events

In 2010 CASS staff and collaborators organised several conferences and workshops:

- *Pathways to SKA Science in Australasia,* Auckland, NZ, 16 – 18 February;
- *Stacking Techniques in Wide-field Astronomy,* Sydney, 23 – 24 February;
- *3D Visualisation Challenges for ASKAP,* Sydney, 28 April;
- *Source Finding Challenges for ASKAP,* Sydney, 29 April;
- *ATUC Science Meeting: Future directions for Parkes, Tidbinbilla and LBA,* Sydney, 25 May;
- *Annual ATNF Student Symposium,* Sydney, 28 May;
- *Cosmic Magnetism: From stellar to intergalactic scales,* Kiama, 7 – 11 June;
- *Hyper-Compact HII regions workshop,* Sydney, 8 September;
- *10th Radio Astronomy School, Narrabri,* 27 September – 1 October;
- *ASKAP Survey Science Project Presentations,* Sydney, 1 November;
- *Town Hall Meeting for Decadal Plan mid-term Review,* Sydney, 25 November;
- *WALLABY Science Meeting,* Sydney, 2 – 3 December

Of particular note was the *Cosmic Magnetism* conference, which marked the third instalment of the Southern Cross Astrophysics Conference Series, jointly organised by CASS and the Australian Astronomical Observatory.

The reports on the following pages describe a few of the many projects carried out by CASS staff and National Facility users during the year.

Radio pulsar timing and searching with the Parkes radio telescope in conjunction with the Fermi gamma-ray satellite.

Simon Johnston (CSIRO)

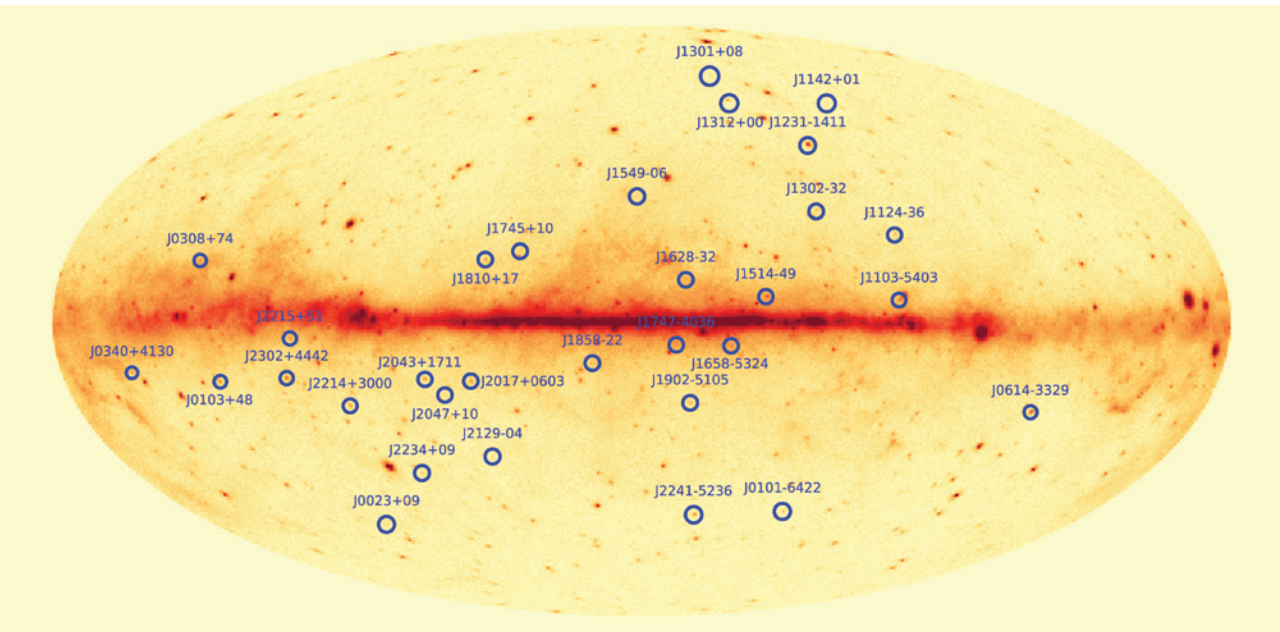
Pulsars are known to emit across the entire electromagnetic spectrum from sub-100 MHz radio waves through to ultra-energetic gamma-rays. Until a few years ago, about 2000 pulsars were known to emit in the radio band whereas only six had pulsed gamma-ray emission. One of these six, the "Geminga" pulsar, does not have detectable radio emission.

One of the key science goals of the Fermi Gamma-Ray Space Telescope, launched in June 2008, is the discovery and study of pulsars. The aims of the project are: (1) to search the known radio pulsars to look for gamma-ray pulsations; (2) to find gamma-ray pulsars directly through blind search techniques; and (3) to find 'unidentified' sources which may turn out to be pulsars after deep radio searches. To succeed in these goals, the Fermi team entered into collaborations with radio astronomers involved in pulsar searching and timing at all the major radio observatories (Parkes Observatory, Jodrell Bank Observatory, Radio Telescope Effelsberg, Nancay Radio Telescope, Green Bank Telescope and Arecibo Observatory).

At Parkes, we are responsible for timing 170 radio pulsars which represents about 70% of the known pulsar population with spin down energies greater than 1034 erg/s, thought to be the lower limit for production of gamma-rays (Smith et al 2008). These highly energetic pulsars are not easy sources to time. They suffer from so-called timing noise which causes jitter in the arrival time of the pulses and also undergo glitches which cause an abrupt change in their spin parameters. In order to maintain phase coherence therefore, we observe the 170 pulsars in a 21 hour observing session every month and have done so since early 2007. Using the observations we construct an accurate ephemeris for each pulsar which predicts the pulse arrival times to better than 1% of the pulse period. These ephemerides are then passed to the Fermi team. A description of the observations and the analysis procedure can be found in Weltevrede et al. (2010).

Fermi has a large field of view and effectively observes the entire sky every few hours. For each of the known pulsars, photons arriving from that position in the sky can be phase-tagged using the radio ephemeris. In this way, a pulse profile in gamma-rays can be built up over the months and years of the mission. Once the profile reaches a certain significance level it is classified as a gamma-ray pulsar. Remarkably, within the first six months of Fermi operations, a total of 46 pulsars had been seen pulsing in gamma-rays; 29 of these were known radio pulsars and 17 were discovered directly from the gamma-rays. This led to a publication of the first catalogue of gamma-ray pulsars in late 2010 (Abdo et al. 2010). Since then, some 20 more pulsars have been detected and are awaiting publication.

Figure 1: Map in galactic coordinates showing the millisecond pulsars discovered by the Fermi-LAT and various readio telescopes including Parkes. The background is the diffuse gamma-ray emission above 500 MeV from the first 2 years of the Fermi mission. Credit: Paul Ray, NRL.



The combination of Fermi and the radio telescopes has also proved to be a magnificent finder of millisecond pulsars. First, Fermi locates gamma-ray sources which appear to be unpulsed and yet have all the spectral and variability characteristics of pulsars. Then, the radio telescopes search for radio pulsations. Once found, it is then possible to go back and fold the gamma-ray photons and produce a gamma-ray pulse profile. Remarkably this technique has found more than 25 millisecond pulsars since the launch of Fermi which represents a 30% increase on the number of field millisecond pulsars discovered over the last 30 years! Many of the millisecond pulsars found in this way are very fast spinning, a substantial fraction of which are in the process of evaporating their companion stars. Papers with initial results from the Parkes and GBT searches are now published (Keith et al. 2011, Ransom et al. 2011).

Overall the future is looking rosy for the study of pulsars across the spectrum. Now that we've obtained a large sample of objects we can start to explore questions like how does the geometry of the star affect the gamma-ray emission, where do the gamma-rays originate and why are so many millisecond pulsars gamma-ray emitters? Furthermore, the Parkes data alone provides a wonderful dataset for exploring the properties of energetic pulsars (Weltevrede et al. 2008a, Weltevrede et al. 2008b, Keith et al. 2010).

This project would not be possible without the hard work and inspiration of the CASS postdocs involved in the project, Mike Keith, Ryan Shannon and Patrick Weltevrede. Thanks are due also to David Smith and Paul Ray who lead the Fermi timing and search teams.

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First science from the ASKAP and Warkworth radio telescopes: Trans-Tasman Very Long Baseline Interferometry blazes path to the SKA

Prof. Steven Tingay, International Centre for Radio Astronomy Research – Curtin University

On behalf of the Australian and New Zealand VLBI teams

One of the ten approved ASKAP Survey Science Projects (SSP) is aimed at establishing CSIRO's ASKAP (Australian Square Kilometre Array Pathfinder) as part of Australian and international very long baseline interferometry (VLBI) arrays, to build a capability for milliarcsecond resolution imaging of compact radio sources in the Southern Hemisphere. The science enabled by such arrays is outlined in Johnston et al. (2007; 2008). An important aspect of this SSP is its connection to the continuing development of VLBI facilities in New Zealand, in particular the new 12 m radio telescope of the Auckland University of Technology, near Warkworth, north of Auckland.

We report here on the first science results to emerge in 2010 from a Trans-Tasman array that includes existing radio telescopes in Australia, the first of the ASKAP antennas at the Murchison Radio-astronomy Observatory (MRO) in Western Australia, and the Warkworth antenna in New Zealand.

Over the course of a three week period in late April and early May 2010, successful VLBI observations were performed using the first ASKAP antenna, along with AUT's Warkworth antenna, CSIRO's radio telescopes in Narrabri (the Australia Telescope Compact Array, or ATCA), Parkes, and Mopra, and the University of Tasmania's Ceduna Radio Observatory in Hobart.

The observations used a custom RF system built by engineers at CASS and a custom digital backend built at the International Centre for Radio Astronomy Research (ICRAR), Curtin University, by PhD candidate Mr Bruce Stansby. Two such identical systems were installed at ASKAP and Warkworth. Regular systems were used at the rest of the Australian telescopes.

The data recorded at each telescope were transferred to ICRAR and correlated using the DiFX software correlator (Deller et al. 2007).

High quality data were obtained for a range of astronomical objects: 3C 273; PKS 1934-638; Centaurus A; and a selection of geodetic calibration sources. The data yielded images with a resolution of approximately 5 mas at 1.4 GHz (dual-polarisation 64 MHz bandwidth). Shown in Figure 2 is the image of Centaurus A.

Another significant result arose from the observations of PKS 1934-638, an archetypal GHz-Peaked spectrum radio galaxy. Because of the high angular resolution obtained at low frequency, these observations have revealed for the first time a frequency-dependant angular separation between the two compact components in this radio galaxy, likely due to synchrotron self-absorption effects. Previously this frequency dependant structure has been incorrectly identified as structural evolution over a 40 year period. The new observations show the way to the correct conclusion that the structure is frequency dependant due to absorption effects and very stable with time, making the source older than previously thought. These results have been presented in detail by Tzioumis et al. (2010).

Finally, the geodetic observations performed as part of this experiment allowed an analysis of the accurate positions of the ASKAP and Warkworth telescopes within the International Terrestrial Reference Frame (ITRF). The results of this analysis have been submitted for publication (Petrov et al. 2011).

The VLBI capability established via this work will be retained and deployed for a range of observations during the remaining ASKAP development, on a best efforts basis as the ASKAP deployment allows, and will transition to the full VLBI system as ASKAP matures. Both ASKAP and Warkworth are now included in the Australian Long Baseline Array (LBA) call for proposals and are thus available to proposers who require higher angular resolution than possible within Australia alone.

The SSP team is also working with Indian colleagues to establish the Giant Metrewave Radio Telescope (GMRT) for VLBI observations, aiming to extend the reach of VLBI in the region, adding to regular VLBI and e-VLBI (electronic VLBI) partners in South Africa, Japan, China and the USA.

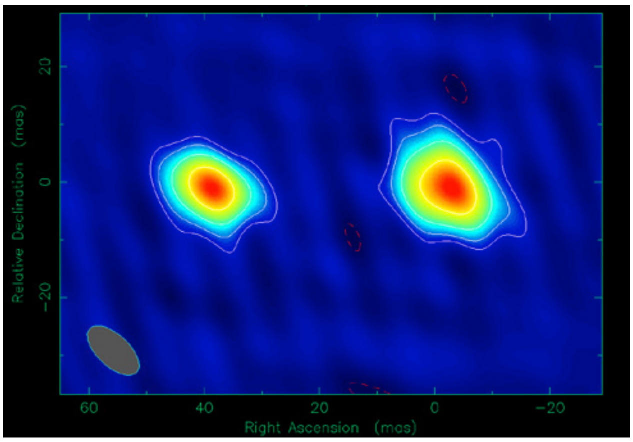

Figure 1: The image of the double component structure of PKS 1934-638 at 1.4 GHz (Tzioumis et al. 2010).

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The Hunt for Ultra-High-Energy Neutrinos

Ron Ekers (CSIRO), Justin Bray (University of Adelaide),
Clancy James (Radboud University), Rebecca McFadden (ASTRON),
Chris Phillips (CSIRO), Ray Protheroe (University of Adelaide),
John Reynolds (CSIRO), Paul Roberts (CSIRO).

In 2010 we used the Parkes telescope to observe the Moon for nanosecond bursts of radio waves created by ultra-high-energy (UHE) neutrinos interacting with the Moon's surface rocks and soil (the regolith). Intriguingly, our preliminary analysis of the data shows an excess number of events that might be a hint of UHE neutrinos, or some unexpected physical phenomenon producing nanosecond-scale pulses on the sky.

Ultra-high-energy cosmic rays are charged particles with energies above 1018 eV. Hitting Earth at the rate of one per square kilometre per year, they are the highest-energy particles in the cosmos. Determining their sources has been frustrated by the fact that cosmic rays, being charged particles, are deflected by cosmic magnetic fields. In addition, UHE cosmic rays lose energy by interacting with CMB (cosmic microwave background) photons and can only be detected on Earth if they originate within a distance of 50 Mpc.

Neutrinos, however, travel in straight lines and do not interact with CMB photons. They are thought to be formed by the same processes that create UHE cosmic rays, and are thus an exciting proxy for them. Neutrinos can be detected through the Askaryan effect: a particle that travels faster than light in a dense dielectric produces a shower of electrons and positrons with a preponderance of the former, resulting in a cone of coherent radio emission, a pulse lasting for about a nanosecond. Large volumes of dielectric are needed, and the major candidates are Antarctic ice and the lunar regolith.

In 1995 Tim Hankins, John O'Sullivan and Ron Ekers made the first attempt to detect radiation from the Moon in this way, using Parkes. This experiment attracted international attention, and a number of similar experiments (conducted with Goldstone, Kalyazin, the WSRT and the VLA) followed. In 2008-09 the present Australian team attacked the problem again, using the Compact Array. In 2010 we returned to using Parkes, observing for a total of 200 hours. In this experiment we changed our strategy, targeting only neutrinos from Centaurus A, because results from the Pierre Auger Observatory (the world's premier UHE cosmic-ray detector) have shown an excess of events traceable to that galaxy.

A broadband coherent pulse from the Moon is dispersed as it passes through the ionosphere, the low-frequency components being delayed with respect to the high-frequency ones. This reduces the peak amplitude of the pulse, and so we need to de-disperse the pulse, in real time. While pulsar experiments routinely do this on millisecond timescales, we need to do it a thousand times faster. In the 2010 Parkes experiment we used a finite impulse response (FIR) filter, implemented in our purpose-built digital backend. The filter can be easily reconfigured to apply a different amount of de-dispersion, so we can adjust it during each observing session to match the prevailing condition of the ionosphere (for which figures are available hourly) and the slant depth of our line of sight to the Moon.

A major consideration with this kind of experiment is how to discriminate between real events and the plethora of terrestrial radio interference pulses occurring on timescales down to nanoseconds, many of which appear to come from motor vehicles. For the Parkes observations we've used four beams of the multibeam system, three positioned to view the limb of the Moon and the fourth off the Moon. A real event will be detected only in one beam pointing at the Moon, while interference coming into the telescope through its sidelobes will appear in all four beams. We apply an anti-coincidence filter to remove such events.

The raw data rate with nanosecond sampling is far too great for recording with current technology, so we use a trigger-and-dump strategy, with only samples exceeding a

Figure 1: The Moon is being used as a detector for ultra-high-energy neutrinos at the Parkes Observatory. Credit: Seth Shostak.

set threshold level (and meeting the appropriate coincidence criteria) being written to disk. The overall sensitivity of the experiment is determined almost entirely by the threshold level so the effectiveness of the real-time processing hardware is crucial.

After post-processing we've been left with more high-sigma pulses a day than the number we'd expect from Gaussian noise. These events must represent a combination of interference that we haven't weeded out and lunar pulses from UHE neutrinos (or some previously unknown phenomenon). A definitive test would be to use a second antenna, a considerable distance from Parkes, so we can use the relative pulse timing to determine if the detected signal really does originate from the Moon. We plan to run such an experiment, using Parkes as the main antenna and the Compact Array as the secondary, in August 2011. Meanwhile, the 2010 Parkes experiment has given us the best lower bound on the flux of UHE neutrinos from lunar detection experiments in our energy range.

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The Millimetre Astronomy Legacy Team 90 GHz (MALT90) Survey

Jill Rathborne, Jessica Chapman, Kate Brooks (CASS) and
Jim Jackson (Boston University)

On behalf of the MALT90 science team and the
Mopra Large Surveys Working Group

Although the basic sequence for high-mass protostellar evolution is generally thought to be the same as for low-mass stars, the exact details remain controversial. Theories suggest that high-mass protostars acquire their mass either locally via 'monolithic collapse' or from a global collapse via 'competitive accretion' (see reviews by Zinnecker et al. 2007 and McKee et al. 2007). Although the exact mechanisms differ, all theories agree that a high-mass star begins its life as a 'pre-stellar' core, which collapses to form an embedded, accreting protostar or 'hot molecular core'. When fusion begins, the star enters the main-sequence and ionizes its surrounding material to form ultra-compact H II regions. Observationally, however, the very earliest stages have remained elusive. Only a handful of candidate high-mass pre-stellar cores have been identified, and it has been difficult to confirm their pre-stellar nature. The earliest well-characterized phase is the "hot core" phase, well after accretion has begun.

The Spitzer Galactic surveys GLIMPSE and MIPSGAL have shown that infrared dark clouds host the massive dense cores, which are making the transition from cold, quiescent pre-stellar cores to active hot cores and H II regions (e.g. Rathborne et al. 2006). Moreover, sub-millimetre surveys such as the APEX Telescope Large Area Survey of the Galaxy (ATLASGAL) are now identifying huge numbers of dense star-forming cores. By combining these surveys, we can begin to study high-mass protostellar evolution by identifying large numbers of objects in each of their evolutionary stages. We aim to capitalize on these advances by conducting a large molecular line survey of massive dense cores with the Mopra telescope: the Millimetre Astronomy Legacy Team 90 GHz (MALT90) survey.

MALT90 will utlize Mopra's unique broad-band capability by mapping cores simultaneously in 16 molecular lines at excellent angular (40") and spectral (0.1 km/s) resolution. The 90 GHz molecular lines are interesting probes because they require high-densities for excitation, thus, the 90GHz emission will arise only from the dense, star-forming cores and not the more diffuse CO-emitting molecular clouds. Moreover, since these lines span a large range of excitation energies and critical densities, they indicate distinct physical conditions and stages of chemical evolution. Thus, because many chemical species are observable, for the first time a large, a systematic survey of core chemistry can be conducted.

Because sub-millimetre emission traces cores in all evolutionary stages, we are using the ATLASGAL catalogue as our basic target list, supplemented by core categorization based on GLIMPSE and MIPSGAL images (Figure 1). We aim to image roughly 1,000 cores each in the pre-stellar, protostellar, and H II region phases. We began MALT90 during June – September 2010, mapping 516 dense cores.

One of our science goals is to determine kinematic distances to each core. MALT90 will have an immediate impact by providing distances to thousands of cores identified in ATLASGAL. Figure 2 shows the HNC velocities measured toward the first-season MALT90 cores, revealing that the

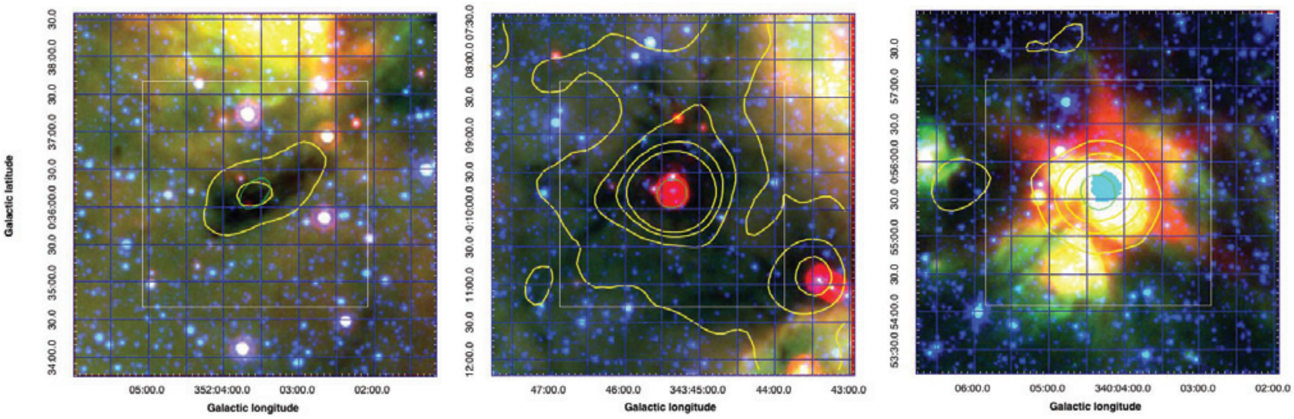

Figure 1: **Spitzer/GLIMPSE and MIPSGAL images toward three examples of high-mass star forming cores (contours are of the ATLASGAL dust continuum emission): Pre-stellar core (left), Protostellar core (middle), and a HII region (right). The white box outlines the region mapped. The primary goal of the MALT90 survey is to characterize star-forming cores and to study their physical and chemical evolution.**

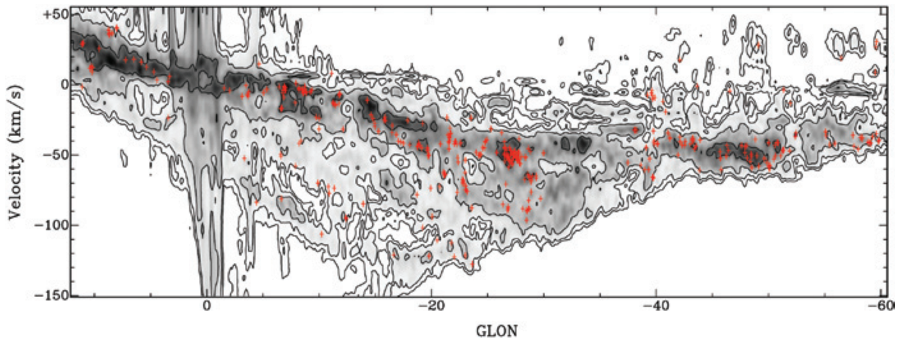

Figure 2: Measured MALT90 HNC velocities (red crosses), overlaid on the longitude-velocity 12CO data from the CfA-Columbia survey (gray contour map; Dame et al. 1987). We find that the dense cores are largely confined to the brightest Galactic CO emission features.

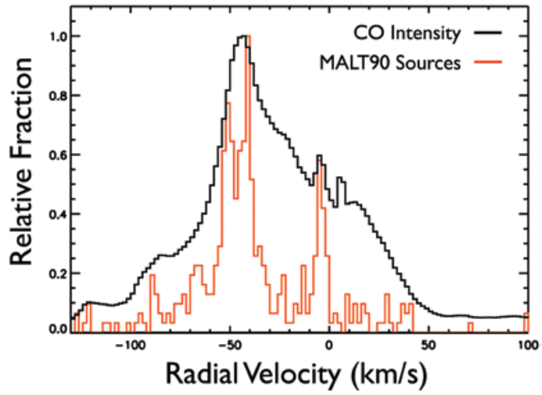

Figure 3: The distribution of MALT90 HNC velocities (red histogram), overlaid on the 12CO spectrum from the CfA-Columbia survey, averaged over the same, sampled region (black). The MALT90 core velocities are much more sharply peaked, compared to the CO, perhaps indicating their confinement to spiral arms.

dense cores are largely confined to the brightest Galactic CO emission features. However, the distribution of dense core velocities differs significantly from the CO spectrum (Figure 3): the dense cores have sharp peaks in their velocity distribution, whereas the CO is much smoother. Although this is preliminary, the simplest interpretation is that the dense cores are confined to spiral arms, but the CO is more widespread throughout the Galactic disk.

A second key goal of MALT90 is to investigate the chemical variation of dense cores as they evolve. Chemical models suggest that the abundances of different molecular species change dramatically with time, and thus, can indicate the core's evolutionary phase. Our data show interesting variations in the N2H+ abundances (Figure 4). For about 12 sources, the HCO+, HCN, and HNC lines are strong, but the N2H+ line is not detected, suggesting that these sources have very low relative abundances of N2H+. However, we also see the opposite abundance pattern: strong N2H+ line emission, with no HCO+, HCN, and HNC detections. Since they are typically rare, these sources probably represent a very short-lived phase in core evolution.

The MALT90 data will be released to the community through the Australia Telescope Online Archive (ATOA) by May 2011. Once complete, MALT90 will be the largest systematic molecular line survey of dense cores ever undertaken. MALT90 will be valuable not only in its own right, but also as an important finding chart to identify key ALMA targets.

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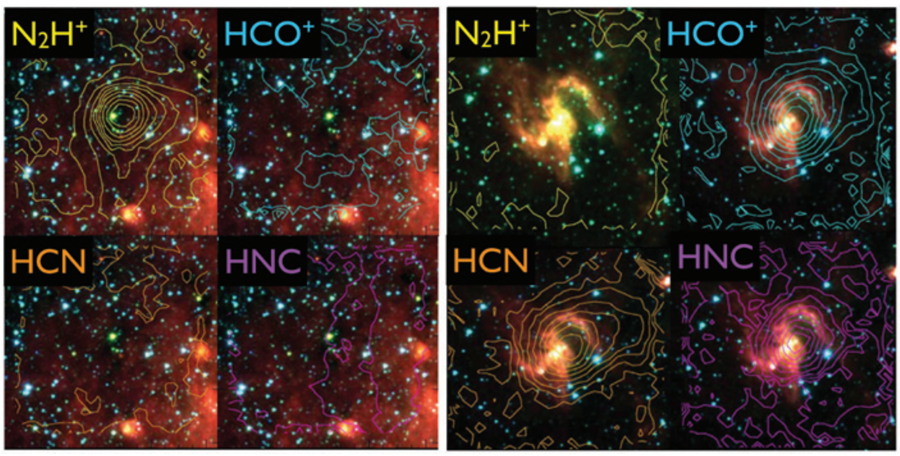

Figure 4: Two cores showing chemical variations (Spitzer GLIMPSE images in colour with contours of the molecular line integrated intensity from MALT90). Left: An "N_2H+ dropout" source, where HCO+, HCN, and HNC are strong but N_2H+ is absent. Right: An "N_2H+ only" source, where HCO+, HCN, and HNC are absent but N_2H+ is strong. These chemical variations likely indicate special phases in the core's chemical evolution.

The new CABB views of planet formation

Sarah Maddison (Swinburne University)

Planets are a natural by-product of the star formation process and form in the dusty disks that surround a young protostar. While the exact details of planet formation remain uncertain, we do know that sub-micron sized grains must clump and coagulate to eventually form objects 1013–1014 times larger. Millimetre (mm) continuum observations of protostellar disks can probe the earliest stages of planet formation as micron-sized grains grow in size to become cm-sized pebbles, which are the building blocks of the planetesimals that will become fully fledged planets (Pollack et al. 1996; Blum & Wurm 2008). Similar observations can also detect the dust in older debris disks, in which the dust content results not from grain growth but from collisional grinding of larger, unseen planetary bodies (Wyatt 2008). The high resolution offered by the ATCA interferometer, and the high sensitivity provided by the new CABB system, allow astronomers to observe the various stages of planet formation occurring in southern star forming regions in unprecedented detail.

Millimetre continuum surveys of protostellar disks allow us to study grain growth, determine disk masses, and probe the disk density distribution. Knowledge of these three quantities is vital if we are to understand the planet formation process. At mm wavelengths, the dust opacity index β (where $\kappa \propto \nu$^β) can be used to estimate grain sizes via $\beta \sim \alpha$–2 (Beckwith et al. 1990), where α is the slope of the spectral energy distribution ($F \propto \nu$^α). An opacity index of $\beta \sim 1$ indicates grain growth up to mm sizes (Draine 2006). This technique has been used to detect mm-sized grains in ~50 disks to date in both the sum-mm and mm (e.g. Natta et al. 2004; Andrews & Williams 2005; Lommen et al. 2007, 2010; Ricci et al. 2010a,b). The mm flux, along with information about the dust opacity, allow dust disk masses to be calculated.

High resolution mm observations also allow the assumed power-law density distribution to be modelled via the visibility data (e.g. Pinte et al. 2008). The density distribution as well as the disk size can both be used to understand dust migration in the disk. Thus mm data from protoplanetary disks provides a wealth of information about the dust content.

The new CABB system has allowed an increase of approximately four fold in the survey speed (or a four fold increase in sensitivity), allowing Ricci et al. (2010b) to detect 3 mm emission from 25 protoplanetary disks in ρ Ophiuchi in 45 hours with a limiting sensitivity of 0.3 mJy/beam, compared to the pre-CABB survey of Lommen et al. (2007), which detected 3 mm emission from ten disks in Chamaeleon and Lupus in 59 hours with a limiting sensitivity of 1.0 mJy/beam. The improved CABB sensitivity has also allowed Ubach et al. (2011) to obtain 3 and 7 mm continuum flux sensitivities (rms) of 0.12 mJy/beam and 0.06 mJy/beam respectively for disks in Chamaeleon and Lupus (see Table 1).

Follow-up targeted mm (and cm) observations of interesting sources that show evidence of pebble-sized grains with ATCA have found some of the largest grains in protostellar disks to date (e.g. TW Hya: Wilner et al. 2005; WW Cha: Lommen et al. 2009; HD100546: Maddison et al. 2010a).

The improved sensitivity of CABB enabled detailed high-resolution observations that were not previously possible with ATCA. In 2009 and 2010, we utilised CABB to observe the enigmatic Herbig Be star HD100546 at 7 mm. There are several lines of evidence which suggest that planet formation may well be underway within the disk of HD100546, including a cleared inner cavity (Grady et al. 2005), spiral structure and dark lanes (Ardila et al. 2007), and similar dust mineralogy as seen in our own solar system (Malfait et al. 1998). At a distance of just 103 pc (van den Ancker et al. 1997) high-resolution observations can probe the inner few 10 AU of the HD100546 disk. After just two hours on-source, the resulting sub-arcsecond resolution image 43 GHz clearly show a deficit of emission at the centre of the disk, in agreement with our pre-CABB 94 GHz images (Maddison et al. 2010b) and infrared observations (e.g. Grady et al. 2005). Combining data from various array configurations from the compact H214 to the extended 6D, we clearly detect the disk emission and resolve the inner clearing, plus some central stellar emission (see Figure 1). For further details, see Maddison et al. (2010b) and Wright et al. (2011). For resolvable sources like HD100546, CABB should be able to determine the grain size as

Table 1: Selection of 3 and 7 mm fluxes and sensitivities (rms) for the recent CABB mm surveys of protoplanetary disks by Ubach et al. (2011) and Ricci et al. (2010b).

Source	F3mm (mJy)	rms (mJy/beam)	F7mm (mJy)	rms (mJy/beam)	Ref.
DI Cha	2.27	0.29	0.91	0.09	Ubach et al.
Glass I	4.44	0.12	0.66	0.07	Ubach et al.
Sz 32	14.35	0.21	1.15	0.02	Ubach et al.
IK Lup	3.4	0.4	0.92	0.06	Ubach et al.
GQ Lup	4.17	0.35	0.97	0.17	Ubach et al.
EX Lup	2.09	0.26	1.4	0.08	Ubach et al.
SR 4	4.4	0.4	..	..	Ricci et al.
EL 20	7.3	0.5	..	..	Ricci et al.
DoAr 24E	8.3	0.4	..	..	Ricci et al.
YLW 16c	6.5	0.4	..	..	Ricci et al.
DoAr 33	3.7	0.3	..	..	Ricci et al.

a function of radius which will allow us to confirm theoretical models of radial (and vertical) size sorting of grains due to settling and radial migrations (e.g. Barrière-Fouchet et al. 2005).

Older debris disks contain several orders of magnitude less dust than their younger counterparts, making them very difficult to detect at long wavelengths without the high sensitivity offered by CABB. The debris disk β Pictoris has been extensively studied since its discovery as an infrared excess star by IRAS (Aumann 1984) and the subsequent imaging by Smith & Terrile (1984), revealing a ~400 AU edge-on disk. The direct detection of an ~8 Jupiter mass planet was recently announced (Lagrange et al. 2009, 2010). At a distance of just 19.3 pc (Crifo et al. 1997), β Pic is an excellent debris disk target for high-resolution imaging. Pre-CABB observations in September 2008 provided a 45 GHz upper limit of < 0.5 mJy (poor weather prevented 3 mm observations). Since the CABB commissioning, we have obtained 8 hours of 3 mm data and 6.5 hours of 7 mm data in September 2009. With CABB we have been able to present the first 3 and 7 mm resolved observations β Pic, the longest wavelength observations of any debris disk (see Figure 2). There is clear evidence of structure within the dust and clearing of dust in the inner disk, in agreement with recent 1.3 mm SMA observations (Wilner et al. 2011). For full details, see Maddison & Wright (2011).

With the successful commissioning of CABB, we can expect a lot of exciting new results on protoplanetary and debris disks and their dust content in the coming years.

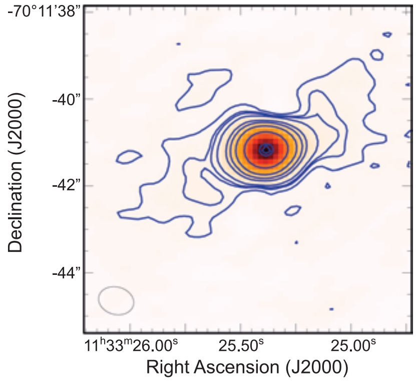

Figure 1a: HD100456 at 44 GHz with arrays H214, 1.5A, 6A and 6D. The image is self-calibrated but mapped without CA06, allowing the disk emission to be mapped. The beam FWHM is 0.82 x 0.63 arcsec (P.A. 74.9 degrees). Contours are at –3, 3, 4, 6, 9, 20, 30, 50, 100, 200 and 220.

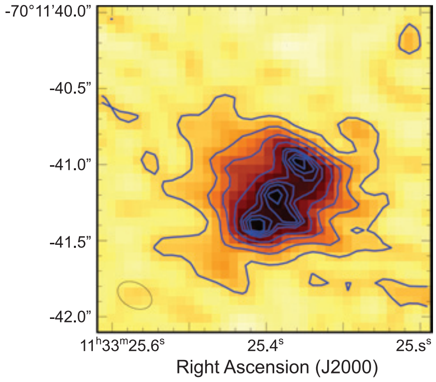

Figure 1b: HD100456 map 44 GHz with arrays H214, 1.5A, 6A and 6D. Here data from CA06 is including, allowing the inner disk to be resolved. There is a deficit of emission in the inner disk, but also 7mm emission from the central star. The beam FWHM is 0.24 x 0.16 arcsec (P.A. 61.8 degrees). Contours are at -3, 3, 6, 9, 12, 15, 16, 17 and 18.

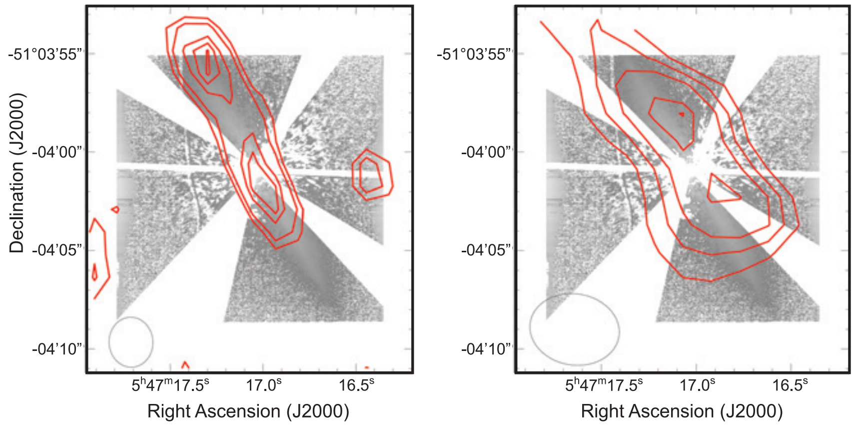

Figure 2: β Pic disk. ATCA continuum emission contours overlaid on ESO/NACO H-band (1.65 μm) image (Boccaletti et al. 2009). Left: 3 mm band (94 GHz) contours at 1.5, 2, 3, 3.5 and 4σ (where σ= 9.5e-5 Jy is the rms noise). The beam is 4.46" x 3.62" with P.A. 80.0 degrees (from Maddison et al. 2011).

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4.
Operations

An Open Day was held at the Australia Telescope Compact Array in July 2010, with recent upgrades such as the Compact Array Broadband Backend (CABB) system showcased throughout the day.

Credit: Tony Crawshaw, CSIRO.

Operations

This year saw Operations begin the detailed planning for the ASKAP era in parallel with the implementation of remote operations upgrades for Parkes and major enhancements to the Australia Telescope Compact Array (ATCA) performance.

Development of maintenance and service models for ASKAP led to a staffing plan for the Murchison Radio-astronomy Observatory Support Facility (MSF) to be located in Geraldton, Western Australia. The facility will primarily serve as a base for Engineering Operations staff. Planning also began for a Science Operations Centre that will support ASKAP users and users of current facilities. In 2010, attention was focussed on developing observing and support models for the Australia Telescope Compact Array (ATCA), Mopra Telescope, and Parkes Observatory. During July–September, a trial pilot project allowed observations for the MALT90 (Millimetre Astronomy Legacy Team 90 GHz) survey project to take place on Mopra, with observers and support astronomers based in Sydney.

Technical developments at Parkes during the year were directed at enabling routine remote operation of the telescope including the ability to drive the telescope and reconfigure the signal path remotely, upgrades to backup power systems, and improved system monitoring. These projects have highlighted the benefits of the new cross-site model in Engineering Operations, with substantial contributions from Narrabri staff to the work.

Also, during the year substantial Parkes historical data was placed in a new archive supported under the Australian National Data Services (ANDS), in a pilot project scheduled for completion in 2011.

At the ATCA, two major upgrades were underway in 2010. The original 20/13 cm receiver package was upgraded to provide complete frequency coverage from 1.1 – 3.1 GHz with substantially improved sensitivity. This receiver system is now known as the '16 cm' system; monitoring upgrades are ongoing. In addition, new configurations of the Compact Array Broadband Backend (CABB) were rolled out during the year, providing fundamentally improved continuum and spectral line capabilities. The major technical upgrades at Parkes and the ATCA were managed through the Technologies for Radio Astronomy Theme.

Science Operations

The Science Operations group consists of four projects: Computing Infrastructure, Scientific Computing and Archives, the Visitors Services Group, and Telescope Operations and Science Services.

Computing Infrastructure

The Computing Infrastructure team provides general account, security and password related computing activities in support of observers.

During 2010, a new high-performance server to host ATOA (the Australia Telescope On-line Archive) and OPAL (On-line Proposal Application and Links) was purchased, significantly improving performance for these applications with plenty of capacity for growth into the future. A new data processing server, with two quad-core Intel Xeon processors and running a 64-bit version of LINUX, allowing the full 16 GB of RAM to be used, was brought into service at Marsfield.

Scientific Computing and Archive

As new modes were rolled out for CABB, the CABB scheduling tool, observing software, and the Miriad data reduction package were further enhanced, tested, and made available. An on-the-fly mosaicing mode was developed for CABB, with the long steady slews providing improved performance over the traditional point-slew-point-slew mode when only short pointings are required, as antenna settling times can become an issue.

The last vestiges of the VMS (Virtual Memory System) operating system were chased out of Parkes with new versions of SHOWTEL and WINDS having been released. Improvements have been made to the Telescope Control System (TCS) and MultibeamVis to better support pulsar and fast binning modes.

MoniCA was initially developed to monitor the performance and conditions of equipment and the environment at the Compact Array, but it was subsequently rolled out at Mopra and Parkes also. A major revision was undertaken during 2010 with the new version enabling control as well as monitoring, and integrating a number of small helper programs developed for individual on-line systems.

The on-line observing proposal system, OPAL, was rewritten to use MySQL, simplifying further maintenance and development in a change that was transparent to users. The Australia Telescope On-line Archive (ATOA) was also further developed and expanded to handle the growing CABB output.

A different approach was established this year to provide an archive of Parkes pulsar observations. CSIRO IM&T and CASS were funded by the Australian National Data Services (ANDS) to establish an archive that initially includes Parkes pulsar observations and can be extended at a later stage to include data from other telescope facilities.

The goals of the ANDS ATNF Data Management Project were to:

- Provide meta-data and data from a subset of Parkes pulsar projects to the astronomy community. For the initial release the archive was restricted to a subset of around five projects that were chosen to be of high scientific importance and/or to represent different observing modes and data formats;
- Establish that the archive software can handle all of the different data formats used for Parkes pulsar data taken since 1990;
- Demonstrate that the archive is extensible. The software was developed in a modular way so that it can later be extended to include other Parkes data and

data from other facilities. In principle, any astronomy data set could be potentially considered;

- Provide an easy-to-use user interface to the archived data. This interface is likely to be similar to the simple form interface in use by the ATOA but with additional fields required for pulsar searches;
- Provide meta-data for a CSIRO registry that will be used with the 'Australian Research Data Commons'.

The archive will be maintained by CASS and will be extended to include data from other Parkes pulsar projects. A significant problem associated with this is, that unlike Mopra and the Compact Array, Parkes pulsar data has not been routinely kept by CASS. However, for many projects, the data is expected to be recoverable on request to the Australian and overseas science teams who took the observations. In 2011 observing teams will be contacted to request transferring data back to CASS for inclusion in the pulsar data archive.

The provision of national data archives is of increasing importance in the 'Super Science' era. For the next generation of major facilities such as ASKAP and the SKA, astronomers will interact with data and data products entirely through such archives. ANDS is funded by the Australian Government's Department of Innovation, Industry, Science and Research (DIISR) to provide resources for research archives of national significance. It also aims to establish an Australian Research Data Commons (ARDC) infrastructure that will be used to provide a cohesive collection of national data archives. Ultimately we envisage an integrated facility that provides access to all ATNF facilities, including ASKAP, and includes data archives from other parts of CSIRO. The ANDS ATNF Data Management Project is an important first step in this direction.

Visitors Services Group

The Visitors Services Group undertook various activities during the year, including workshops on policies and procedures, and a food-handling refresher course.

New appliances and furniture were purchased for Narrabri and the quarters at Parkes. The Marsfield Lodge was again full for months at a time, particularly with CASS and AAO visiting students.

Visitors are now emailed after their stays and asked to complete an online questionnaire form. The return rate has been an impressive 80% to date, with the overall feedback score being very positive.

Telescope Operations and Science Services

Time Assignment Committee

Increasing demand for observing time using ATNF facilities has increased the load on the eight members of the Time Assignment Committee (TAC). The review process was expanded in 2009 with the appointment of a group of 'readers' to support the TAC members. The readers supply grades and comments on a number of proposals within their area of expertise but do not attend meetings or have full access to all proposals. The TAC readers (listed in Appendix A) are astronomers drawn from Australian and international institutions and are appointed by the ATNF Director for a term of three years. During 2010 the review process and means of distributing proposals between TAC readers and members was fine-tuned, and tools added to OPAL to enable the TAC to work more efficiently.

Compact Array Broadband Backend (CABB)

Since observing with CABB commenced in April 2009, a lot of exciting science has been enabled by the new system, as well as gradual improvements in the reliability and user-friendliness of the system. The ATCA User Guide is updated with information on each advance with CABB implementation, and a discussion forum was set up to enable users to share their experiences and discuss matters relating to CABB observing and data reduction.

As a result of some technical challenges encountered by the CABB developers in preparation for the implementation of zoom modes, it was decided not to release the entire 2010APR semester ATCA schedule all at once, and instead release the schedule in stages, to make most effective use of the CABB modes as they became available. The first staged releases comprised only projects that did not require CABB zoom modes, with those projects requiring zooms scheduled in subsequent releases. This ensured that observations could be scheduled in the knowledge that the required CABB mode was available, and that observers could plan their travel confident their observations would not need to be postponed.

However, a necessary result of this approach was that the call for proposals for the 2010OCT semester was made before the schedule for the 2010APR semester had been finalised. All proposers were contacted and advised to resubmit their proposals for 2010OCT, and that those later scheduled for the later part of 2010APR would be removed from consideration for 2010OCT.

An exception was made for 3 mm proposals: as it is only the first three weeks of the October semester in which conditions generally remain suitable for 3 mm observing, proposals submitted for 3 mm observing in the 2010APRS semester did not need to be resubmitted for consideration for scheduling in October, but were considered alongside proposals submitted for 2010OCTS on the basis of their TAC grade.

Further information on CABB is given in Technology chapter on page 51.

ATCA Receiver Upgrade

During 2010 the ATCA coaxially-mounted 20 cm and 13 cm receivers were progressively replaced by an upgraded 16 cm receiver that covered the range 1.1–3.1 GHz, extending the range of the previous receivers and filling the gap between them. The 2 GHz bandwidth is also a perfect match to the CABB input. At the same time, the Ortho-Mode Transducers in the existing receivers were replaced to improve the polarization performance at the higher frequency end of the band. This was carried out for all six receivers on the array and the additional receiver kept available as a 'hot spare'.

The retro-fitting and upgrading was most efficiently completed by working on pairs of receivers at the same time, and so for a six month period the array operated with five of the six antennas available for 20 cm and 13 cm observing. The upgrade was carried out so that, for example, CA06 was not missing its receiver when a 6 km array configuration was scheduled. Proposers were also notified of these plans, and observations were scheduled as much as possible to minimize the impact of the missing antenna.

During the interim period, observations were conducted with a mix of old 20/13 cm receivers and new 16 cm receivers, which added some complexity to scheduling, calibration, and data reduction, but users were appropriately advised by supported staff at the time of their observations. The ATCA User Guide and sensitivity calculator have been upgraded with information on the new 16cm band.

Further information on the receiver upgrade is given in the Technologies Theme report on page 50.

The Science Operations Centre (SOC) Pilot Project

An important part of the planning for future ATNF Operations, that will include the operations of ASKAP, is the establishment of a Science Operations Centre (SOC) in Sydney.

At present, most observations are carried out in a mode where astronomers are present for, and have control over, their own observations at either the Parkes or Narrabri observatory. Additionally, some observing is made remotely by astronomers from other locations. In the future, this 'user-operator' mode will continue to be used for the existing facilities; however, an increasing amount of observing will be carried out from the SOC, particularly for observing teams that require expert support.

The user-operator mode will not be used for ASKAP. Instead, ASKAP observations will be taken remotely from the SOC in a queue-based model, and astronomers will access their data and data products through archive facilities.

The full SOC will be developed using a staged approach. As a first step, in the 2010APR semester, a pilot study was carried out to trial 'SOC-mode' observing where the observers and the astronomers who provide observing support were based in Sydney. The MALT90 survey, a large molecular line survey of dense cores at 90 GHz carried out with Mopra, was used as a demonstration project for this study. The goals of this pilot study were to establish and implement the technical and user requirements for SOC-mode observing, and to trial this observing mode from the ATNF site at Marsfield. Additionally, the ATNF data archives (ATOA) were extended to provide a search facility for, and access to, the processed data cubes resulting from the survey.

The MALT90 project was allocated approximately 860 hours of observing time between mid-July and late September. The science team initially spent three weeks at Narrabri to ensure that their strategies for observing and data reduction were working effectively. Almost all of the observing from early August was then carried out from Sydney. The team made use of the Mopra remote observing facilities in Marsfield, which were enhanced by a high-quality point-point video link installed at Narrabri and Marsfield to facilitate the interactions between staff and observers located at the two sites.

Improvements were also made to the Marsfield Lodge services to provide darker bedrooms and hot meals after hours and at weekends, and a powerful new server and dedicated disk space was provided to allow for fast off-line data processing of the Mopra Large Survey data. As a critical element of SOC observing is the provision of local support to the observers in Marsfield, efforts were made to try and have support astronomers available on site at all times during the scheduled MALT90 observations.

Initial feedback showed that the science team found it straightforward to observe from Sydney, and appreciated the support they received. The observing systems were robust, with very few technical problems, and the video connection helped facilitate working between the two sites. The experiences gained are being incorporated in planning for the next trials of SOC-mode observing.

Long Baseline Array

The Long Baseline Array (LBA) uses the technique of Very Long Baseline Interferometry (VLBI) to image radio sources with milli-arcsecond-scale angular resolution. The LBA includes the Parkes, Mopra, and ATCA observatories, the Hobart and Ceduna antennas of the University of Tasmania, and antennas at the Canberra Deep Space Communication Complex at Tidbinbilla. It also sometimes operates in collaboration with overseas antennas; Hartebeesthoek (South Africa), TIGO (Chile), and O'Higgins (Antarctica) were regular collaborators in recent years.

A milestone was achieved in 2010 with the achievement of 'first fringes' to the first ASKAP antenna in Western Australia and the Warkworth antenna of the Auckland University of Technology. This accomplishment was marked by press releases in Australia and New Zealand, and results from the first observations with this array of PKS 1934-638 were published in the Astronomical Journal.

Hobart and Ceduna VLBI operations continued to be supported under a contract between CASS and the University of Tasmania. Correlation of most LBA observations recorded is performed under contract by Curtin University in Western Australia. Most data is transferred electronically to the correlator with the cooperation of the Australian Research Collaboration Service (ARCS).

Table 1: LBA time allocation.

LBA allocated time	27 days (633 hrs)	
Scheduled proposal time	531hrs	82%
Disk and network tests	~100hrs	15%
Setup and fringe checking	~20hrs	3%
e-VLBI (part of scheduled time)	~65hrs	10%

During 2010 there were four major LBA sessions (March, May, July and October), and shorter sessions in November and December, for a total of 24 days, with an additional 50 hours spread throughout the year for tests and e-VLBI (electronic Very Long Baseline Interferometry) demonstrations. Observations were made in all LBA wavelength bands (20 cm, 13 cm, 6 cm, 3 cm and 1 cm), with the 3 cm band accounting for 55% of the observations in 2010.

In August 2010, the Mopra, Tidbinbilla and Hobart antennas were used to track the IKAROS solar sail of the Japan Aerospace Exploration Agency (JAXA). IKAROS transmits tones in the 8 GHz band and by detecting these with a VLBI array the spacecraft's position in the plane of the sky was accurately determined, complementing the method of timing signals to and from the spacecraft which constrains the position along the line of sight.

Overall the LBA achieved a 96% success rate and most of the telescopes continued with success rates greater than 95%. Lost time at Tidbinbilla was due to a single observation for which no fringes were found. As Tidbinbilla is available for only 10-15% of LBA observations, an isolated failure like this corresponds to a sizeable fraction of its contribution. A summary is given in Table 2.

e-VLBI Developments

Of the LBA time allocation for 2010 given in Table 1, e-VLBI observations made up 10% of the scheduled time. The 16-node quad-processor cluster at Narrabri, provided by Curtin University, is the main correlator for e-VLBI observations. In February 2010, an e-VLBI demonstration at 512 MBps was undertaken using Mopra, ATCA, Kashima (Japan) and Shanghai (China) antennas, as part of the Asia Pacific Advanced Network (APAN) meeting held in Sydney.

The European-led EXPReS e-VLBI project, funded by the European Community during 2006-9, involved development of e-VLBI techniques and processes and was acknowledged as one of the most successful EC projects. CASS is also participating in the follow-on NEXPReS project which commenced in July 2010 to develop the next generation of e-VLBI tools and processes.

CASS staff actively participated in international e-VLBI developments, which culminated in an international e-VLBI workshop held in Perth in October 2010. A small international working group chaired by CSIRO's Chris Phillips will continue to promote the VLBI Data Interchange Format as the standard for e-VLBI observing.

Engineering Operations

In addition to day-to-day operational maintenance, routine receiver changes and the ongoing scheduled maintenance programmes for ATCA, Mopra and Parkes, a number of substantive project stream activities were undertaken (and will continue to be pursued) by Engineering Operations such as:

- Upgrading of the Compact Array, with installation and support of new and improved receiver and signal processing instrumentation developed at Marsfield by staff involved in the 'Technologies for Radio Astronomy' Theme;
- Parkes Remote Operations Projects (refer to page 51 of the Technologies for Radio Astronomy Section), providing for the remote operation of the 64 m radio telescope and new functionality for the control and monitoring of the telescope drive system, receivers, backends and other critical systems needed for safe and efficient remote operation;
- Refurbishment and upgrading of critical electrical power infrastructure, including Uninterruptable Power Supply (UPS) and standby power generation systems at Parkes and Narrabri;
- Installation and development support for 'Guest Instrumentation', including experimental backend signal processors and data recorders;
- Improvements to RFI investigation, analysis and liaison with other spectrum users.

Table 2: ATNF antenna observation time and success rates.

Telescope	Parkes	ATCA	Mopra	Hobart	Ceduna	Tidbinbilla	LBA
Hours observed	501	531	514	503	503	65	531
% success	98	99	99	96	97	86	96

Upgrade of the Compact Array

During the year, Engineering Operations provided close support and assistance to 'Technologies for Radio Astronomy' theme staff in coordinating the planning and installation of a number of substantive upgrades to the Compact Array, including:

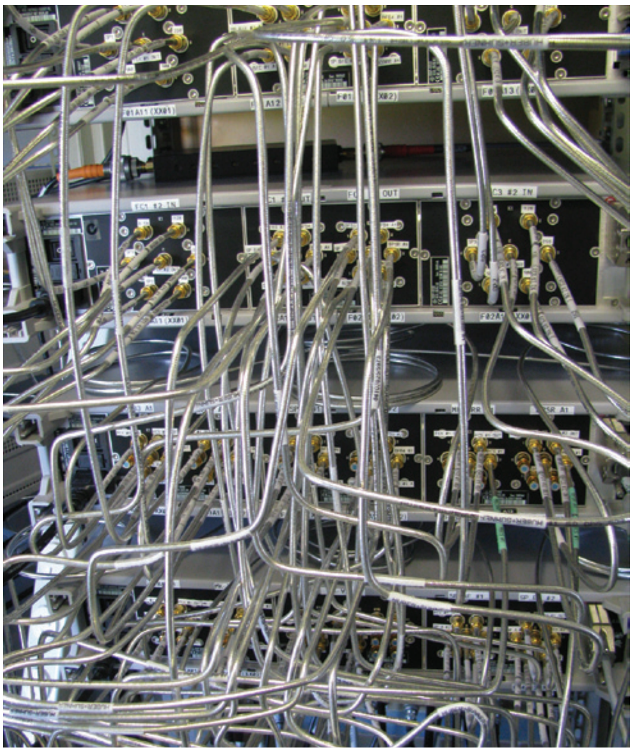
- Centimetre wave receivers;
- Further enhancements to the zoom mode capabilities of the Compact Array Broadband Backend (CABB) system, and
- Water vapour radiometers are now installed on the Compact Array receivers.

These upgrades represent substantial improvements in instrument functionality – for more detail please refer to the 'Technologies for Radio Astronomy' section of this report.

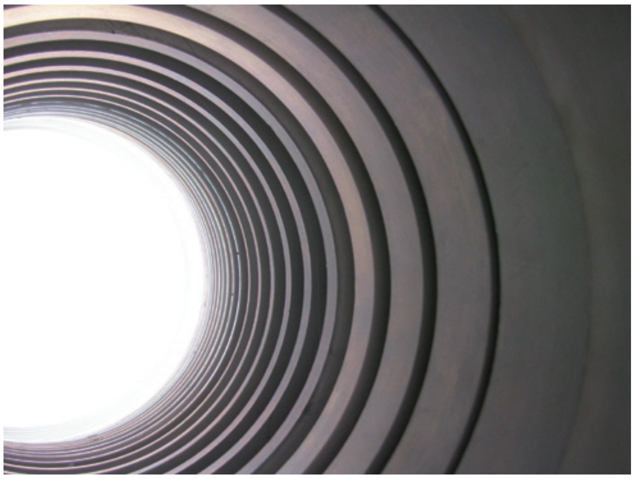
See also page 39 of the Operations chapter, and page 51 of the Technology chapter, for information on CABB.

Parkes Backend Switching Matrix (PBSM)

During the October 2010 Parkes maintenance shutdown, a significant new observing capability for the 64 m telescope was commissioned, as well as the ability to quickly and seamlessly switch the incoming astronomical baseband signal to different signal processing backends, connect multiple backends in parallel (eg. for pulsar timing) and quickly implement new custom configurations. Of all the recently installed observing instrumentation at Parkes, 'The Matrix' (PBSM) arguably has the most immediate everyday impact on observing; besides enabling remote observing, the ability to seamlessly, reliably and quickly alter the instrument configuration is appreciated by both telescope users and maintainers alike.



A rear view of the Parkes Backend Switching Matrix (PBSM). Credit: Erik Lensson, CSIRO.



'Cold Sky View'; the interior of the ATCA CA-04 L-S feedhorn. Credit: Erik Lensson, CSIRO.

The PBSM comprises three suites of custom configured Rohde & Schwarz 'Open Switch & Control Platform' (OSP®) series radio-frequency switching hardware, under the control of a native Linux operating system. The OSP control options include immediate mode addressing of individual RF switches from the front panel, but this manual mode is restricted only to fault finding. Remote connections are enabled via USB and Ethernet.

For normal observing, standard scripts are incorporated directly into applications, such as the Parkes Telescope Control System (TCS). Therefore the task of backend switching is made fully transparent to the user, but full flexibility is retained for custom scripted backend connections as may be needed for special observation modes. Thus the 64/128/256/512 MHz and VHF Parkes Conversion System baseband signals (in both polarisations) are ported through the PBSM to the required selection of eight backend signal processors under software control; currently DFB3, DFB4, MBCORR, BPSR, MK-V VLBI, AFB plus two spare outputs set aside for developmental backends.

Site Electrical Infrastructure

On 25 November, Engineering Operations celebrated an electrical milestone with the commissioning of the new synchroniser connected to the Parkes 250 kVA standby generator, resulting in a successful seamless load transfer between the Country Energy network and the generator. An endemic issue when the generator is running, concerns the dumping of excess heat on hot (peak) summer days. A specific mitigation action is expected to result in a re-orientation or relocation of the generator ahead of the next hot summer.

During the year, Engineering Operations completed the replacement of the uninterruptible power supply (UPS) lead-acid storage batteries at the Compact Array, with a replacement and upgrade planned for Parkes. In March 2011 the Parkes Shutdown, principally scheduled to support the planned telescope drive system (MCP) upgrade, is expected to provide the opportunity to upsize the 64 m Telescope Essential bus UPS capacity from 200 Ah to 450 Ah. Besides the retirement of old secondary batteries, the estimated UPS uptime is expected to increase (from the current 14 minutes) to about one hour.

At Narrabri, the existing ATCA control building generator was identified as unreliable and Engineering Operations are planning the replacement of the existing generator with a refurbished 350kVA Cummins genset with low hours.

Engineering Operations, in liaison with CSIRO Property Services, is also in the midst of a comprehensive review of the site (50 Hz) electrical power infrastructure. At Parkes in particular, some of the site electrical infrastructure remains original and up to 50 years old, though most of the receiver hardware, conversion systems and signal processors have undergone many generations of changes.

Specifically, planning is being conducted for the refurbishment of the site 11 kV high voltage (HV) feed cables, transformer, switchgear and voltage regulator, as well as the low voltage switchboards and cables. For example, some of the electrical switchboards are known to run hot and recently acquired thermal imaging capability within Engineering Operations is being put to good use. The resulting work program takes account of risks and resource priorities, with the expectation that it will run for between two and three years.

Guest Instrumentation

At 12:15 pm on 8 July 2010, the Caltech Parkes Swinburne Recorder (CPSR-2) was switched off for the final time. However, the decommissioning also provided an opportunity for rebirth, through equipment space rationalisation and installation of new RFI screened cabinets with improved cooling.

This paved the way for a new Engineering Operations initiative, through the provision of dedicated developmental 'sandpit' space for experimental guest instruments, such as a new 400 MHz spectrometer and coherent dedisperser using a combination of FPGAs, CPUs and GPUs. This is a collaborative arrangement between ICRAR, Swinburne University of Technology and Oxford University as a potential future replacement for the Parkes Multibeam Correlator (MBCORR).

Consistent with the guidelines discussed at the October 2010 ATUC meeting, such instrumentation may, subject to an acceptance test, be catalogued as part of the suite of national facility instrumentation and therefore available for general use. CSIRO Astronomy and Space Science appreciates the effort and investments made through science collaboration towards new and improved instrumentation.

Engineering Operations will continue to respond flexibly to collaborative proposals; a new 'Guest Instrument Proposal' form was introduced during the year for the purpose of streamlining the coordination and installation of such instrumentation.

ASKAP Support and Operations Planning

Engineering Operations continued to work closely with the ASKAP Project Team staff, in anticipation of, and preparations for, the future operational ASKAP radio telescope. During 2010, the Parkes ASKAP Testbed Facility (PTF) supported ground testing and telescope testing of the proof-of-concept 5x4 Phased Array Feed (PAF), including hot/cold load test installation, telescope control software development and preparations for the arrival of the full prototype PAF.

Collaborative work also continued towards the development of an appropriate maintenance model for the future operational ASKAP, requiring the consideration of a fine balance between telescope performance objectives, equipment reliability, economic consideration, as well as the containment of the site EMC (electromagnetic compatibility) footprint.

Radio Frequency Interference

The increasing demand for commercial wireless communications and government services represents an ongoing challenge for National Facility observatories and radioastronomy facilities worldwide. During the year, in particular at Parkes, observers were at times adversely affected by strong Radio Frequency Interference (RFI). This and related RFI issues were discussed at an RFI Workshop in September 2010. Outcomes from the workshop included:

- The enhancement of RFI reporting within the online ATNF Fault Report System, with improved reporting and tracking of RFI events. That the additional information (onset, duration, spectral characteristics) more fully characterises the RFI source information collected during observation, enabling possible mitigation and (in some cases) potentially eliminating systemic RFI problems. Observers are encouraged to make use of the new functionality. The feedback is useful in addressing RFI issues with other spectrum users, leading to the elimination, or at least minimisation of, RFI impact on observing.
- Planning for improved observatory RFI monitoring, including consolidation of data sources and software based analysis tools, to support staff and observers at existing and new observatories.

Refer also to the 'Spectrum Management' section of this chapter for details of other related developments.

Future Work

The March 2011 Parkes shutdown will afford, inter alia, the opportunity to upgrade the 64 m telescope drive system through the replacement of the existing Manual Control Panel (MCP).

The upgraded MCP will provide the capability to stow the dish under (remote) software control and is one of the key enablers to consistent, reliable and safe remote mode operation for the planned Science Operation Centre (SOC). The new MCP will be fully duplicated, with a 'spare' MCP available as a development platform; for example, allowing for off-line evaluation of SERVO software upgrades. In practice, the timeline to remote operations will be dependent upon the completion of several development projects (refer to the 'Technologies for Radio Astronomy' section) and the establishment of an SOC remote observing operations model, including the development and integration of observing applications software.

Other Activities

Spectrum Management

Spectrum management relating to the protection of radio astronomy has been an important activity for CSIRO since the 1970s. CASS has continued to support such activities and was involved in the following areas in 2010:

- Participation in national spectrum planning and protection activities through the Australian Communications and Media Authority (ACMA). This involved not only national spectrum planning issues, but also participation in ITU (International Telecommunications Union) study groups and preparation for World Radio Conferences (WRC);
- Participation in regional and international meetings under the auspices of the ITU. The primary activity is the regular meetings of ITU Working Party 7D (Radio Astronomy) in Study Group 7 (Science Services). This group is responsible for all technical studies and ITU Recommendations and Reports for the protection of Radio Astronomy; the current chairman is from CSIRO;
- Participation in IUCAF (Scientific Committee on the Allocation of Frequencies for Radio Astronomy and Space Sciences), an inter-union committee of the IAU, URSI and COSPAR. IUCAF has been very active in ITU meetings and has had a significant impact on Study Group and WRC deliberations;
- Participation in the Radio Astronomy Frequency Committee in the Asia Pacific region (RAFCAP), which promotes awareness of radio astronomy and protection of the radio spectrum in the Asia Pacific. RAFCAP works closely with the regional spectrum management group, the Asia Pacific Telecommunity (APT).

The next World Radiocommunications Conference will be held in 2012 (WRC-12); ITU-R studies in 2010 were focussed on Agenda Items for WRC2012 and the production of the Conference Preparatory Meeting (CPM) report. Many WRC Agenda Items impact on radio astronomy but the issue of most concern is Agenda Item 1.6, on 'Spectrum usage by passive services between 275 and 3000 GHZ, and procedures for free-space optical communications links'. CASS has been coordinating this Agenda Item in the Australian processes led by ACMA and also in the APT.

ITU-R Working Party 7D (WP7D) held meetings in June and September 2010. The new ITU-R Report on Radio Quiet Zones (RQZ) progressed well and is expected to be approved by WP7D in 2011.

CASS was a significant participant in RFI mitigation workshops during 2010. At the March RFI2010 workshop held in Groningen, CASS was involved in the SOC and provided three key presentations. CASS also helped to convene an RFI mitigation session at the September AP-RASC'10 regional URSI meeting in Japan and provided two key speakers.

IUCAF and RAFCAP sponsored and helped organise a summer school on 'Spectrum Management in Radio Astronomy' at Mitaka Japan during May – June 2010. This was well attended and CASS provided two lecturers with multiple presentations.

Outreach and Education

2010 was a busy year for outreach and education, building on the increased public awareness and interest created by the International Year of Astronomy in 2009.

The refurbishment of the Parkes Visitor Centre was completed in late 2010, and focuses on the observatory's contribution to radio astronomy, its current operation and research work, and the future of radio astronomy. Credit: Chris Hollingdrake, CSIRO.

Education Activities

CSIRO SKA Director Dr Brian Boyle gave the Stanhope Oration at CONASTA, the National Science Teachers' Conference in Sydney, in July. His talk about the SKA inspired and stimulated science teachers from across Australia. Rob Hollow, Education Officer for CSIRO Astronomy and Space Science, ran workshop sessions on using authentic astronomy data in the classroom and use of other simple classroom activities from the Galileo Teacher Training Program at the event.

Brian and Rob repeated these sessions for Victorian Science teachers at STAVCON (the annual conference of the Science Teachers' Association of Victoria) in November. Rob also gave a series of SKA talks at the Centenary State High School Science Festival and other Queensland schools. Many other outreach talks were given to amateur astronomy groups, school groups and the public by CASS staff during 2010.

The ever-popular CASS teacher workshops were held at Marsfield in March and at Parkes in May. The three-day 'Astronomy from the Ground Up' workshop at Parkes was the largest to date, with 30 teachers from across Australia participating. In April, Rob Hollow also ran a one-day workshop in collaboration with the Victorian Space Science Education Centre and Scienceworks in Melbourne.

In September Rob led a group of eleven Australian science teachers to Hawaii for a science professional development tour. The focus was a workshop on the effective teaching of astronomy, hosted at the Gemini Headquarters in Hilo. The highlight was a tour of the Gemini North telescope followed by some stargazing from the slopes of the majestic Mauna Kea volcano.

The students and staff from Pia Wadjarri Remote Community School toured the Murchison Radio Observatory to inspect the first six dishes of ASKAP in December 2010. This was the first site visit by the students. Work is continuing on an Indigenous Education resource for the Wadjarri Yamatji community in conjunction with the building of ASKAP.

Open Day at the Compact Array

More than 700 people took advantage of the rare opportunity to get a behind-the-scenes look at ATCA during an open day held in July 2010. The open day showcased recent upgrades, including the Compact Array Backend Broadband (CABB) system, and also provided information on the activities of the CSIRO Astronomy and Space Science division.

Attendance at the open day was up twenty percent on the previous open day in 2008. The most popular activities were the antenna tours, control building tours and astronomy and space science presentations.

Shane O'Sullivan and Angela Hein, two of the volunteers that helped out at the ATCA Open Day in July 2010. Credit: Tony Crawshaw, CSIRO.

The four presentations held across the day were also well attended. Dr Jamie Stevens presented 'Under the hood of the Compact Array', Dr Phil Edwards presented 'From the Universe to Culgoora', Glen Nagle from Tidbinbilla presented 'Bootleg postcards: Participatory exploration of distant worlds' and Professor Jim Jackson presented 'Star birth and snaky dark clouds'.

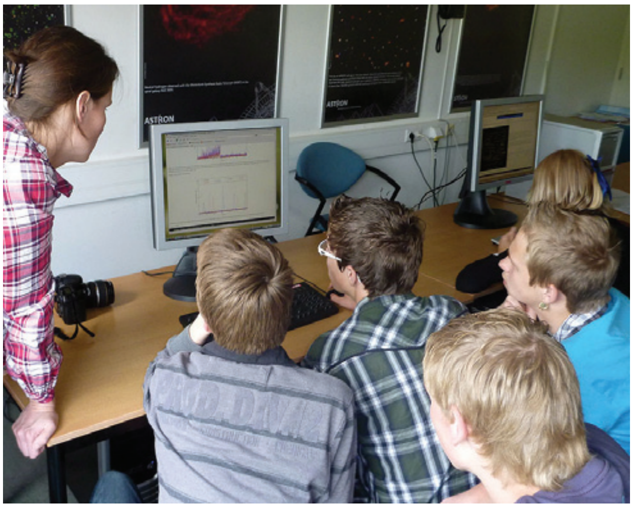
Other activities offered included solar telescope viewing, hands on physics displays from CSIRO Education, a science and astronomy education shop, face painting and a jumping castle. The assortment of quality activities offered to visitors increased the average length of stay.

PULSE@Parkes

The PULSE@Parkes program continued to grow during its third year of operation. During 2010, 185 students from 21 schools were able to control the 64 m Parkes radio telescope to observe pulsars. Whilst most observing sessions were held at CASS Headquarters at Marsfield, two interstate sessions, one at the Victorian Space Science Centre (Melbourne) and one at SPICE (Perth) continued successful partnerships.

Due to high demand for places in observing sessions, an increased number of combined sessions were held in 2010, with schools with small student numbers combining together for an observing run. These sessions allowed students and teachers to mix and share ideas. It was pleasing to see regional schools take part and use the opportunity of a visit to Sydney to expand their students' exposure to science organisations through excursions to other sites. Another positive aspect of the program has been ongoing participation from schools (with new students) that have been involved in program sessions from earlier years.

In other activity, a second international PULSE@Parkes session was held at ASTRON (the Netherlands Institute for Radio Astronomy) in May with students from Emelwerda College. Project members David Champion and Rob Hollow received excellent support and involvement from ASTRON staff. This highly successful session illustrated the possibilities for international collaborations with school students and radio observatories in the future SKA era.



Dutch students and CSIRO Astronomy and Space Science staff linked to the Parkes telescope for an international PULSE@Parkes session. Credit: ASTRON.

CASS Summer Vacation Scholar Alex Mathews worked with the team during the 2010/11 summer break to develop a new module to determine pulse period which should be available online in 2011. The first teacher scholarship for PULSE@Parkes was advertised in late 2010 and the successful teacher, Stephen Broderick from Toowoomba will work at CASS early in 2011 to help develop new teaching resources.

Summer Vacation Program

The 2010/2011 CASS Summer Vacation Scholarship program involved ten undergraduate students who undertake projects in a diverse range of astrophysics and outreach topics. In addition to working on their individual projects, the students visited the Compact Array at Narrabri where each group had a 12 hour slot for an observing program of their choice. They were ably assisted in this by Dr Dominic Schnitzeler from CASS.

At the end of the program, the scholars showcased their work in two symposia; at the joint CASS/AAO/AusGO Student Symposium held at Marsfield as well as the two day 'Big Day In' event at Macquarie University. CASS Chief Dr Philip Diamond was the keynote speaker at this latter event, after which each of the students had a chance to talk about their works in front of other summer vacation scholars from across several CSIRO divisions.

Health, Safety and Environment

CASS continues to Strive for Zero Harm; no injuries, no illnesses and environmental sustainable operations for our staff members, affiliates, contractors and visitors.

CSIRO Corporate Health Safety and Environment (HSE) restructured and implemented a new HSE service delivery model in 2010. This process began in March 2010 and formally 'went-live' in August 2010. A new full time HSE Leader role was created as a result of this activity, responsible for the CASS division including the ASKAP project and the Canberra Deep Space Communication Centre.

The HSE Officer at Marsfield and the HSE Officer (0.2) at Parkes remained the same which ensured good consistency of organisational memory and practice for HSE. However, the restructure process had a significant effect on the Narrabri site, and after much deliberation an HSE Officer (0.4) position was advertised in late December 2010 to support the Narrabri site and another nearby CSIRO site at Myall Vale. Narrabri was supported remotely from Marsfield for the last half of 2010. Additionally, a full-time HSE Officer was employed to support the ASKAP project on a two-year term up to June 2012.

Throughout the change, leadership commitment and engagement with HSE increased throughout 2010, as indicated by Positive Performance Indicators (inductions in the first 24 hours, incidents fully investigated, risk assessments completed and supervisors trained in last three years). All scored in the 'excellent' range achieving 98% compliancy.

The ten CASS summer vacation students visited the CSIRO Astronomy and Space Science Marsfield site. Credit: Rob Hollow, CSIRO.

Incidents and Injuries

CASS (excluding CDSCC staff) had two lost time injuries in 2010, all of which were short term and the staff members returned to their full roles after time awayfrom work. CASS also continued to support one staff member on a graduated return to work program from an incident in late 2009 that was fully resolved by November 2010. In addition to CSIRO staff member injuries, CASS submitted a claim to Comcover following a public liability claim after a visitor fell and injured herself in the car park of one of the Visitors Centres. CASS also supported a return to work program for a CSIRO ICT Centre staff member for six months to facilitate their rehabilitation program.

CASS made one incident notification to Comcare in 2010 for a 'Dangerous Occurrence' following a subcontractor incident at the Murchison Radio-astronomy Observatory site, when one of the contractor's team briefly stepped under a 16 tonne load slung from a crane as they were installing one of the new antennas. Work was stopped immediately; all CSIRO staff, contractors and subcontractors were debriefed, risk assessments were reviewed and the importance of safe work practices was reiterated.

Environmental Awareness Programs

Staff member commitment to HSE in the workplace was once again highlighted by the participation of our staff in programs and events including but not limited to:

- Clean Up Australia Business Day event at the Marsfield site in March, incorporating chemical waste disposal, e-waste, secure document shredding and other general clean-up activities;
- Earth Hour promotion at Marsfield was successful in achieving a 1 KW energy saving;
- Installation of a composting toilet at the Australia Telescope Compact Array site at the Narrabri Visitors Centre.

Coffey Environmental conducted audits at the Parkes and Narrabri sites in late 2009, and in June 2010 provided final audit reports and briefing sessions on possible initiatives to reduce energy and water use and reduce waste on site. Both sites considered their opportunities through discussions with their local HSE Committee.

Health and Wellbeing Programs

Employee Assistance Program (EAP) promotional sessions were held at all CASS sites in February as part of a CSIRO-wide relaunch of the program; sessions were well received by all staff members.

Flu vaccination clinics were held at all CASS sites with excellent attendance, and at the Marsfield site this was combined with a Health and Wellbeing Day that offered mini health checks and a stress management seminar. CASS also continued to promote Ride to Work Day at Marsfield with a healthy morning breakfast for all participants.

Continuous Review and Improvement Initiatives

In January 2010 all radiation and laser sources were reviewed and it was determined that telescopes of the ATNF no longer had any licensable items. As a result the division surrendered its licence to the Australian Radiation Protection and Nuclear Safety Authority (ARPANSA).

An external electrical safety audit of the Parkes and Narrabri sites was conducted against industry best practice and the new corporate HSE Electrical Safety Procedures. The report identified areas of improvement across both sites and reinforced the good electrical safety processes observed.

Work continued on the ASKAP HSE documentation suite, with an ASKAP HSE SharePoint page established as a central location for all relevant information. Contractor specific HSE manuals were produced, the Site Visit Application process and subsequent inductions were strengthened, 4WD training was improved to meet site-specific needs and a new provider for Remote First Aid training was utilised with excellent feedback. The commitment to HSE across the ASKAP project was extensive, and the engagement of a HSE Officer specifically for the project has had proven benefits.

CASS will continue to develop and monitor safety in the workplace and strive for Zero Harm.

Human Resources

CASS staffing levels, (excluding CDSCC) continued to grow throughout 2010 with a total of 30 new staff commencing over the 12 month period. These new staff brought a range of capability to the division with appointments across Engineering (10) Astrophysics (7), Observatory Operations (5), ASKAP Project Specialists (5) and Communications and Outreach (1). There were also two key senior management appointments with Douglas Bock commencing in January as Assistant Director, Operations and Phil Diamond commencing in June as CASS Chief and ATNF Director.

Many of these new staff were engaged to support our ASKAP construction efforts. This included the appointment of Barry Turner who has responsibility for overseeing both the Murchison Radio-astronomy Observatory (MRO) and Murchison Support Facility (MSF). Since April 2010, Barry has grown the Geraldton based support team to five, with plans to further expand over 2011 as activity at the MRO site increases.

Our research capability was enhanced over 2010 with five post-doctoral fellowships filled and the appointment of two research scientists, one of whom worked closely with the national and international astronomy communities to further develop the international Square Kilometre Array (SKA) science case.

The following table shows that staff growth was largely concentrated in several key capability areas. This is very much aligned to the need to deliver to strategic objectives including the completion of the ASKAP project on time and on budget.

Table 3: Staff levels.

LBA allocated time	Total Staff 2009*	Total Staff 2010*
ASKAP/Project Specialists	7	15
Astrophysics	21	25
Communications & Outreach	8	9
Engineering	57	63
Management	9	9
Operations	59	58
Support	4	4
Total	165	183

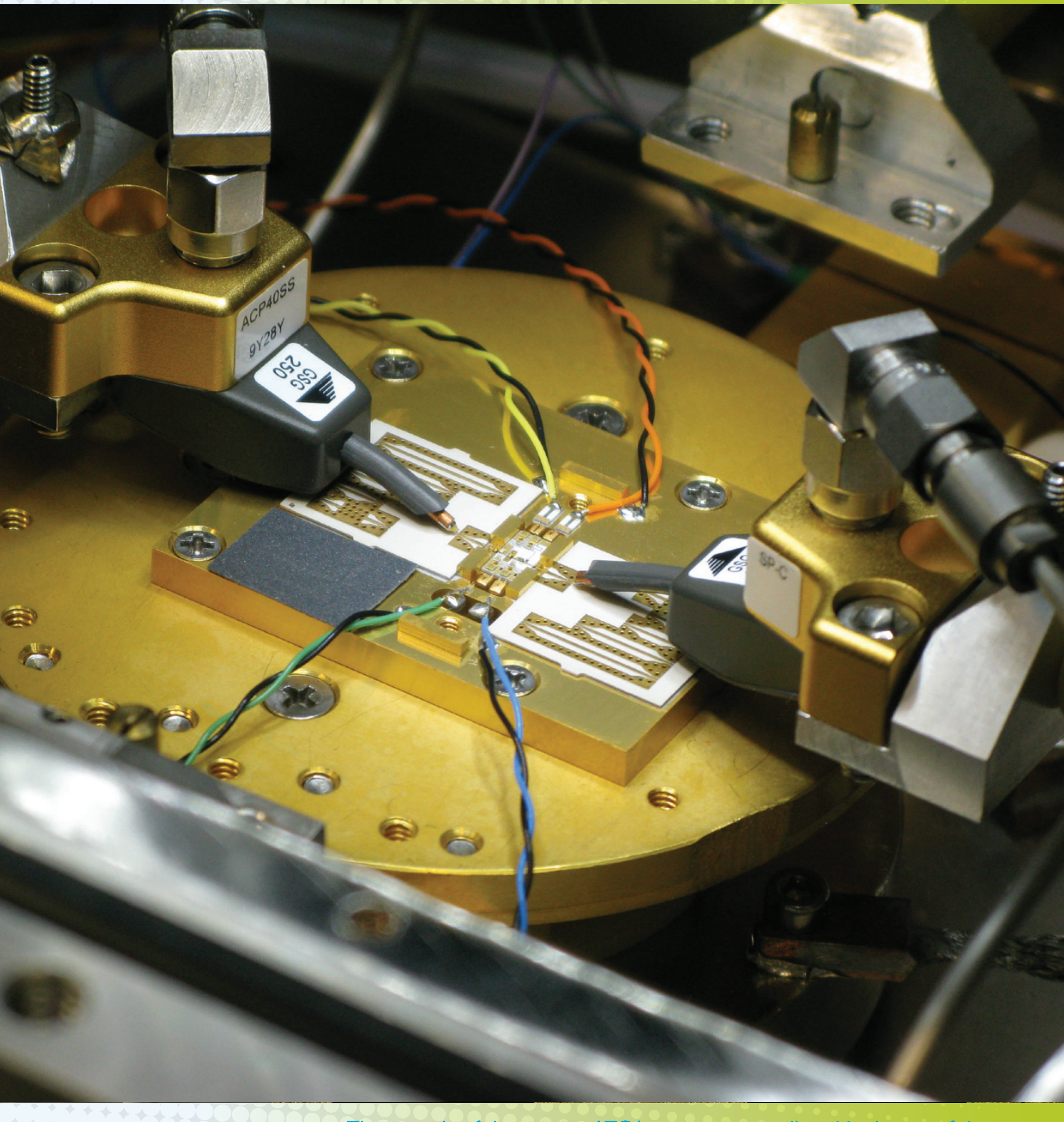
*Excludes casuals, contractors and students.

The total staff numbers shown above exclude the 120 staff from the Canberra Deep Space Communication Complex (CDSCC) in Tidbinbilla that was joined with the ATNF in February 2010 as part of the creation of the CSIRO Astronomy and Space Science (CASS) division. The transition of staff was a major focus for management in the first six months of the year with integration activities continuing throughout 2010.

The expertise of staff was again recognised through a number of awards and scholarships. Within Astrophysics, Ilana Feain and Kate Brooks were successful nominees for the Payne-Scott Award which provides support to researchers returning to work after caring for their children, and Naomi McClure Griffiths and Ray Norris were finalists in the 2010 Eureka Prize for excellence in scientific research. In Engineering, Kjetil Wormnes received a scholarship to the International Space University (ISU) Space Studies Program (SSP) held in Strasbourg, France.

Our continued ability to attract and retain key talent of this calibre is critical to ensuring the future success of CASS.

5. Technology



The upgrade of the existing ATCA cm receivers will enable the use of the full capability of the CABB at cm wavelengths. In this image, the prototype 4–12 GHz low noise amplifier undergoes testing.

Credit: Alex Dunning, CSIRO.

Technology

Technology Developments

A highlight of 'Technologies for Radio Astronomy' theme activity has been the substantive progress made on upgrades to the Compact Array centimetre wave receivers. Further enhancements to the zoom capability of the Compact Array Broadband Backend system (CABB) continued to boost its utility. Telescope Site Development projects made progress toward the goal of remote observations with the Parkes 64-m and water vapour radiometers have been installed on Compact Array antennas. The support of current instrumentation at the ATNF observatories and at other institutions has been a focus of the theme.

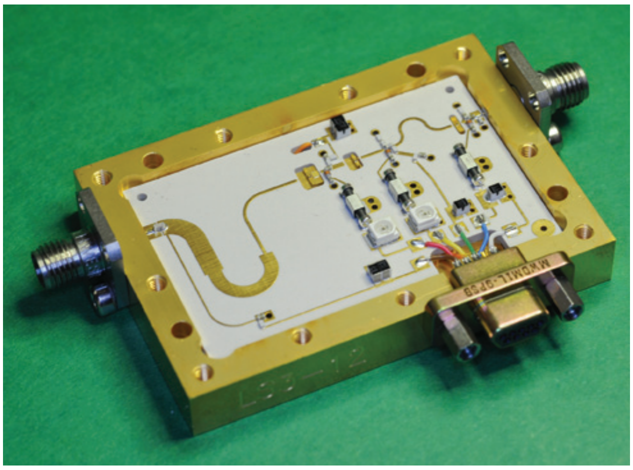
ATCA 20/13 and 6/3 cm Receiver Upgrade

The upgrade of the existing Compact Array centimetre receivers enabled the use of the full capability of the Compact Array Broadband Backend (CABB) at centimetre wavelengths. The upgrade will transform the piecemeal coverage of the 1–12 GHz observing spectrum, delivering almost complete coverage in the 1–3 GHz and 4–12 GHz frequency bands.

A component of the first phase of this cm receiver upgrade project, the retrofitting of the 20/13 cm system's orthomode transducer fins, was completed in 2010. The improved beam shape resulted in much improved polarisation performance at the higher frequency end of the 1–3 GHz band as proven through testing on astronomical sources. The primary beams are symmetrical within 6% over the frequency range 1.1 – 3.1 GHz.

Santiago Castillo installing an upgraded 1.1 – 3 GHz receiver on a Compact Array antenna. Credit: Henry Kanoniuk, CSIRO.

The second phase of the upgrade project, the 20/13 cm upgrade, began in 2009 and required the development of cryogenically coolable 1–3 GHz low noise amplifiers (LNAs), associated broadband RF modules and the hardware and electronics to effect the required modifications to the receiver cryogenic components and control and monitor circuitry. The successful implementation of a 'proof of concept' system in November 2009 paved the way for the production models of the new system to be rolled out in a progressive manner through 2010.



The 1–3 GHz cryogenic, low noise amplifier used in the upgraded 16 cm receiver systems. Credit: Henry Kanoniuk, CSIRO.

The resolution of a low frequency bias oscillation between pairs of Low Noise Amplifiers (LNAs) in some upgraded receivers slightly delayed the installation of the remaining receiver systems; however an installation period during December 2010 saw the last of the suite of six 1–3 GHz receivers installed on the Compact Array antennas. A spare receiver due for delivery in early 2011 will complete the suite. Production versions of the control and monitor electronics are being rolled out with four receivers awaiting the new circuitry and will be completed in the first half of 2011. The upgraded receivers will be designated as 16 cm receiver systems.

As with the proof of concept system, the performance of the production systems was nothing short of excellent. System temperature over the band 1.1 – 3.0 GHz is approximately 20 K, an improvement of between 25–30% over the original ATCA L/S receiver systems. This is a most pleasing result given the expectation that the new systems would at best match the performance of the original receivers. Observers reported that the enhanced performance was obvious and most welcome.

As part of the second phase of the upgrade, development of a suitable design for a 4–12 GHz LNA was planned to prove the feasibility of undertaking the third phase, the 6/3 cm upgrade. Funding for the third phase became available late in 2009 through a grant from Astronomy Australia Limited (AAL). Development of this three stage amplifier followed a more rigorous design path than traditional methodology with each stage being designed, fabricated and tested in the cryogenic environment it will encounter. This contrasts with the more traditional technique of designing all three stages based on device suppliers' performance models. This should result in a performance more tailored to what is needed to replicate the performance improvement achieved with the 1–3 GHz systems. A prototype two-stage 4–12 GHz LNA will be assembled and tested during early 2011, leading to the development of a prototype three stage LNA by mid 2011.

Compact Array Broadband Upgrade

The Compact Array Broadband Upgrade (CABB) project's well deserved reputation as one of the most ambitious CASS projects was borne out by continued challenges to the implementation of zoom modes that seek to enhance its functionality. The continuum mode that has been available since commissioning in 2009 however, has proved its worth and has enabled new science with a number of scientific papers produced in 2010.

The commissioning of the multi-bit digitising system, as opposed to the traditional 1- or 2-bit radio astronomy systems, in March 2009 increased the simultaneous observing bandwidth of the Compact Array sixteen times from 128 MHz to 2 GHz. The complex circuitry and interconnects needed to achieve this has pushed the limits of data transport and inter board communications leading to, amongst other technical difficulties, data corruption that has required significant effort to resolve.

Zoom mode progress was hampered by the issues mentioned above but despite these a number of modes have been implemented which include:

- A 1 MHz mode with the full complement of 16 zooms which became available in December 2010;
- A single 64 MHz mode with one zoom of the planned 16; this configuration, whilst catering for VLBI and NASA spacecraft tracking, was eagerly used for spectral line observing;
- A pulsar binning configuration that can achieve bin times of 120 microseconds was used for successful observations of a number of pulsars including millisecond candidates. It is anticipated that time binning with 20 millisecond time resolution will be available to enable observing programs in January 2011.

The encouraging progress with the zooms for the 1 MHz mode has made feasible the consideration of the next mode to be implemented. This will be the 64 MHz mode and it will be implemented before the 2011 winter observing season. The remaining two modes, 4 MHz and 16 MHz, will benefit from the experience gained with the first two modes.

Warwick Wilson is the founder and a linchpin of CABB, amongst other back end instrumentation, and has intimated that his retirement is imminent. A targeted search for a replacement that can carry on his software role with a systems overview is being conducted and Warwick's desire for continued involvement in a less formal role will be invaluable.

Refer also to page 39 of the Operations chapter for supplementary information on CABB.

Telescope Site Development Projects

Projects seeking to introduce efficiencies into telescope operations in preparation for ASKAP operations were hosted by the Technologies theme but have been primarily managed and undertaken by personnel from National Facilities Operations. Focussing primarily on Parkes, the projects seek to improve the ability for remote observing through improvements in drive control, overall control and monitoring and receiver rationalisation.

The Drive Control project, seeking to deliver a reliable and more serviceable control system for Parkes is on schedule for delivery during a multi-week shutdown in March 2011. An emulation system that replicates the drive characteristics of the Parkes 64-m dish has been developed as part of this project and has allowed offline testing of hardware and software.

The Parkes Equipment Control and Monitor (PECM) project is a conglomeration of smaller projects predominantly utilising staff from Parkes and Narrabri. A significant achievement was the commissioning of a backend switching matrix in October 2010. Software controlled backend switching provides fast, consistent and reliable control over the connections between the conversion system outputs and the suite of Parkes backend systems, including the flexibility to respond to targets of opportunity, parallel operation and new configurations that were previously impractical. Users will notice the nest of cables that used to adorn some racks has diminished considerably. The project is on track to achieve its goals in the latter half of 2011.

Resources to undertake the full scope of the Receiver Rationalisation project were not available during 2010, though the design and fabrication of an improved feed for the H-OH was accomplished in collaboration with BAE Systems. This new feed will achieve the desired increase in bandwidth to make its combination with the existing receiver a viable alternative to the use of the L Band multibeam central pixel. Integration with the existing receiver is scheduled for April 2011.

Refer also to page 42 of the Operations chapter for supplementary information on the Parkes Backend Switching Matrix (PBSM) and Multibeam Correlator (MBCORR) projects.

Water Vapour Radiometers

In November 2010, Water Vapour Radiometers (WVRs) were installed on the millimetre receiver packages of the Compact Array antennas. WVRs are instruments that sample the atmosphere above the antennas to generate corrections that are applied to observational data to improve the integrity of the astronomical signal degraded by the effects of water vapour. Equipping the Compact Array antennas with these devices was primarily funded by UNSW (University of New South Wales) with the units constructed by technology company Astrowave.

The Technologies theme provided components and expertise to Astrowave, and Operations staff supplied the expertise to test and integrate the units into the normal operating system. Characterisation of these units is required prior to their availability for data correction and this is to be undertaken by personnel from both UNSW and Operations.

6. The SKA and the Australian SKA Pathfinder

During September–October 2010, five new ASKAP antennas were assembled at the Murchison Radio-astronomy Observatory. This brought the total number of antennas standing on site to six, following the construction of the first ASKAP antenna in early 2010.

Credit: Terrace Photographers Pty Ltd.

The SKA and the Australian SKA Pathfinder

Development of the Australian Square Kilometre Array Pathfinder (ASKAP) and participation in the international Square Kilometre Array (SKA) program continued to be strategic priorities for CASS during 2010.

2010 marked a breakthrough year for ASKAP, with many significant milestones achieved in all the project domains; highlights include the first six ASKAP antennas constructed and tested at the Murchison Radio-astronomy Observatory (MRO) in Western Australia, successful testing of analog and digital systems which allowed production design to be finalised, the completion of infrastructure design and a construction contract awarded.

The first of 36 identical antennas was constructed and tested in early 2010, and the next five were delivered and assembled as a group during September–October. The antennas are designed, built and tested in China by the 54th Research Institute of China Electronics Technology Group Corporation (CETC54), with the antenna sections then disassembled, shipped to Australia and reassembled onsite at the MRO. The construction of these first six antennas was a major step forward in the development of ASKAP, and the delivery and construction of the next thirty antennas is expected to proceed quickly throughout 2011. The full ASKAP system, including CSIRO-made components such as feeds, receivers and data processing systems, is due to be completed by 2013.

The importance of the ASKAP and SKA projects to both CSIRO and Australia was reinforced in June 2010 when Dr Phil Diamond was appointed as the Chief of CSIRO Astronomy and Space Science. Dr Diamond had previously been involved in coordination of PrepSKA (the European Union's Preparatory Phase Studies for the SKA program) as well as the International SKA Steering Committee. In his new role Dr Diamond works closely with Dr Brian Boyle, SKA Director for Australia – New Zealand, to ensure the delivery of ASKAP by CSIRO and work toward further development and implementation of strategy for the joint Australia – New Zealand bid for the SKA.

From September 2010, Ant Schinckel replaced Dave DeBoer as ASKAP Project Leader, and Dave has taken up a post working at UC Berkeley on the Allen Telescope Array and other projects.

Operations also continued to ramp up at the Geraldton Office, with the employment of MRO Site Manager Barry Turner, and ASKAP Liaison Officer Robin Boddington (on secondment from Curtin University).

The continued progress of the ASKAP project meant that in 2010 approximately 80 staff (60 full-time equivalents, from CASS and CSIRO ICT Centre) spent all or a portion of their time on ASKAP.

Six new ASKAP antennas were constructed at the Murchison Radioastronomy Observatory during 2010. The next thirty antennas are due to arrive in 2011. Credit: Ross Forsyth, CSIRO.

The Australian Candidate SKA Site

Construction of a fibre-optic backbone linking Perth to Geraldton began in May 2010, marked by Senator Stephen Conroy, Minister for Broadband, Communications and the Digital Economy. Later in the year civil works on the installation of the fibre between the MRO and Geraldton also began. The fibre optic cable will form essential data transmission infrastructure connecting the MRO to CSIRO and its research partners both domestically and internationally. Large volumes of scientific data that ASKAP will generate will be transmitted for peta-scale processing at the Pawsey High Performance Computing Centre for SKA Science that will be built in Perth by 2013. The fibre is fully SKA-capable.

Also in 2010, a public discussion paper on regulatory measures to enhance protection for Western Australia's Mid West Radio Quiet Zone (RQZ) was released by the Australian Communications and Media Authority (ACMA). The discussion paper outlined measures being proposed by the ACMA to provide further legislative protection for the Mid West RQZ around the MRO, in order to preserve the radio-quiet environment for the instruments on the MRO.

Australia – New Zealand SKA Coordination Committee (ANZSCC)

CSIRO is an active member of the ANZSCC (Australia – New Zealand SKA Coordination Committee), the intergovernmental body overseeing Australia and NZ SKA strategy and policy. During 2010, CSIRO SKA Director Brian Boyle became the Project Director for the Australia – New Zealand SKA site bid, spending 80% of his time on secondment to the Department of Innovation, Industry, Science and Research.

In June, the 2010 International SKA Forum was held in Assen, in The Netherlands. The Forum brought together astronomers and representatives from governments and funding agencies from around the world, and specialist meetings were also held to discuss the design, construction and science goals of the telescope. A keynote address from Senator the Hon Kim Carr and a presentation by Dr Boyle clearly outlined the scientific merit of the Australia – New Zealand case for siting the SKA, and the non-science benefits that are dependent on the SKA achieving its maximum discovery potential.

Industry Involvement

During 2010, CSIRO's ASKAP and SKA industry engagement activity continued to strengthen through an ongoing program of briefings, publications and tender updates, and early-phase research and development collaborations.

In March 2010, CSIRO attended an annual meeting of the international SKA science and engineering community held in the UK, as well as a workshop in Rome on the non-science benefits that can arise from a mega-science project such as the SKA, hosted by the European Cooperation in Science and Technology (COST) intergovernmental European framework.

In September, CSIRO was represented at an event on SKA governance held in Sydney by the Australian Department of Innovation, Industry, Science and Research in Sydney, and CSIRO also participated in a special workshop held in Tokyo to explore ways in which the Japanese astronomical community might become more involved in the SKA.

The ASKAP team's engagement with industry representatives in Western Australia's Mid West region continued through regular participation in industry events organised by the Mid West Chamber of Commerce and Industry, and the City of Geraldton-Greenough.

CSIRO also continued to be an active member of ASKAIC (Australian SKA Industry Consortium), a self-funded group of companies with a strong interest in ASKAP and the SKA. ASKAIC offers both practical help and excellent guidance in shaping plans for industry involvement.

Four editions of a quarterly publication, *ASKAP Technical Update*, were produced to keep industry and other interested stakeholders informed about the progress being made on technical aspects of ASKAP. Requests for tender were announced via the *ASKAP and SKA News for Australia Industry e-newsletter* and on the AusTender website, including the MRO infrastructure construction, electronic hardware, and installation of the optic fibre cable between the MRO and Geraldton.

A number of strategic collaborations between CSIRO and industry partners also developed during 2010:

- CSIRO and ASTRON (Netherlands) agreed to cooperate on the development and testing of phased array feed (PAF) technology for future radio telescopes to achieve the wide field-of-view capability that will fully exploit the science potential of ASKAP and the SKA;
- CSIRO is working with Direct Energy (Melbourne) on a prototype direct exchange geothermal heat pump system at the site of the first ASKAP antenna, technology which may offer long-term sustainability by improved energy efficiency of ground coupled cooling;
- CSIRO further continued increased engagement with the Murchison Shire Council, participating in regular Council meetings and discussions on topics such as fibre cable installation, and road usage and access;
- CSIRO and Silanna (formerly Sapphicon Semiconductor Pty Ltd) agreed to jointly develop a low-cost, ultra-high bandwidth 'system-on-chip' device to replace tradition receivers currently used in radio astronomy applications;
- Intel Australia generously loaned CSIRO a pre-production supercomputer, along with expertise in performance optimisation, to produce sky simulations for ASKAP and members of the ten ASKAP Survey Science Projects;
- CSIRO continued to work with Horizon Power (Perth) toward the development of a hybrid solar-diesel power generation for the MRO.

SKA Activities

CASS continues its engagement in a number of national and international partnerships with industry, science organisations and governments to support the Australia – New Zealand bid to host the international Square Kilometre Array (SKA) telescope.

Throughout the year CASS staff actively participated in SKA design and development discussions managed by the UK-based SKA Project Development Office (SPDO) as part of the European Union's Preparatory Phase Studies for the SKA (PrepSKA) program. This work ranged from site selection issues (including on site monitoring and developing systems to process the information), system engineering and all aspects of the eventual SKA system design from antenna optics to computing systems.

In support of the development of PAFs for the SKA, CSIRO continues to develop the PAFSKA collaboration. There have been a number of active discussions with all other instititues developing PAFs for radio astronomy, including participating in a PAF-focussed workshop at Brigham Young University in Utah (May 2010) and at the WP2 (Work Package) meeting in Manchester (October 2010).

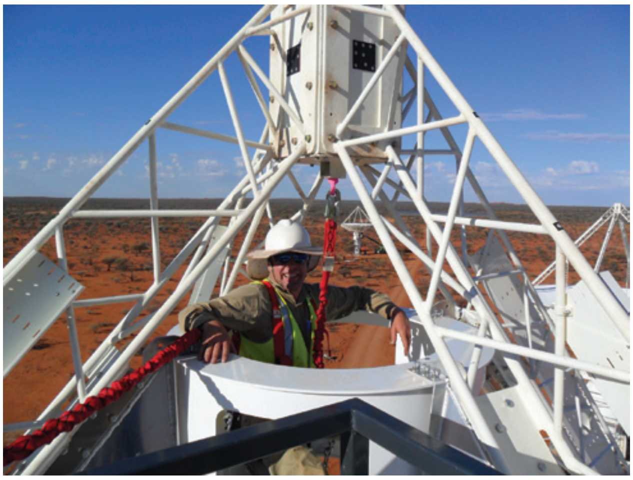
ASKAP Science

Throughout 2010, cooperation continued between CASS and members of the ten large ASKAP Survey Science Projects (SSPs) that were announced during 2009. The Design Studies phase will run until the end of 2012. During the first five years of ASKAP operation, at least 75 per cent of its time will be used by the ten Survey Science Teams (SSTs), each needing more than 1500 hours to complete and designed to make use of the telescope's unique capabilities.

CSIRO's ASKAP team also worked closely with members of the SSTs during the year on the creation of realistic simulated skies in ASKAP's configuration and software tools. Imaging of the simulations and source finding in the output images and data cubes are important aspects of planning for the science that will be conducted with ASKAP; 2010 saw significant progress in this area. For more information on ASKAP Computing, please see page 57.

A formal three-day progress review of the ASKAP SSPs was held in November 2010 at the CASS site in Marsfield. This included a written submission, public science talk and interview with the review committee led by CASS Chief Dr Phil Diamond. The review reflected the positive progress that had been made throughout the year, and the review committee was impressed by the teams' development. The Principal Investigators of each SST will continue to work closely with the CASS ASKAP Project Scientists to keep up-to-date on the progress of ASKAP and the Design Studies.

Three editions of a tri-annual publication, ASKAP Science Update, were produced throughout 2010 to keep the international astronomy community informed about the progress of ASKAP and the Survey Science Projects.



Ross Forsyth stands in the receiver cage, almost 18-m above the ground, of one of the ASKAP antennas at the MRO. Credit: CSIRO.

ASKAP System

Antenna Design and Construction

In late 2009/early 2010, the first ASKAP antenna was assembled at the MRO by the CETC54 (the 54th Research Institute of China Electronics Technology) engineering team, Geraldton based contractors and CSIRO. Following site acceptance testing the ASKAP team commenced the fit-out and integration of the antenna. During September–October, the next five new ASKAP antennas were delivered and installed at the MRO by CETC54 and local subcontractors, and comprehensive site acceptance tests, initial commissioning and internal fit out activities were completed. Some significant retrofits to the first ASKAP antenna were performed to bring it as close to the other production antennas as possible.

Due to the high standard of panel and backup structure manufacturer by CETC54, the surface accuracy actually achieved at the MRO on all six delivered ASKAP dishes was measured using holography as close to 0.5 mm, a factor of two better than the contractual specification, increasing the range of astronomy-capable operation up to 20 GHz. The surface accuracy of the ASKAP antennas is notable because the reflectors are aligned once in the factory, and when reassembled on the backup structure at the MRO they require no further adjustment. This guarantee of in-the-field surface alignment provides a reliable and fast build process for a 'traditional panel' style antenna, and is a positive development for economical SKA antenna deliveries.

Analog Systems and Smart Feeds

During the course of the year the mechanical design of ASKAP's prime focus receiver package was completed, with a dry fit-up of the first two 'chequerboard' Phased Array Feeds (PAF) completed by the end of the year. One PAF will be installed on the Parkes 12-m testbed facility (PTF) and the other on an ASKAP antenna at the MRO.

Prototyping of receiver electronics saw the assembly of main circuit boards, low-noise amplifiers (LNAs), gain cards and conversion cards, and the start of preliminary system integration tests of the prototype boards.

Successful testing of improved 5x4 PAF prototypes allowed the team to model accurate noise models of the LNAs, begin construction of full-size 188 element units and improve understanding of the performance of the chequerboard array.

Alongside the prototypes, preparations were made for the manufacture and testing of sufficient quantities of receiver hardware and electronics for the production of six receiver systems for the first antennas at the MRO (collectively known as 'BETA', the Boolardy Engineering Test Array).

ASKAP team members Aaron Sanders, Paul Cooper and Eliane Hakvoort with the 'dry fit-up' of the Parkes PAF, which was successfully completed in December 2010. Credit: Wheeler Studios.

Digital Systems

The initial design for ASKAP's digital system for the first ASKAP antenna was put into production and completed in early 2010. System integration began with completed boards placed into the prototype cabinets and optical fibre connecting the systems; initial connectivity returned promising results.

The integration of digitisers and beamformers for the PTF was completed at the CSIRO Astronomy and Space Science site at Marsfield in 2010. A total data transport rate of 1.9 Tb/s between the 192- port digitiser and beamformer (via 10 G fibres) was successfully demonstrated.

Prototype boards for the BETA phase of ASKAP were manufactured and tested, and firmware was developed to support the integration effort for the PTF, including data communications, antenna co-variance matrix and a beamformer. By the end of 2010 the production of the first two BETA high performance boards were finalised; these support pedestal system installation on the PTF and the first ASKAP antenna at the MRO.

Computing

Integration of ASKAP's telescope operating system, based on the Experimental Physics and Industrial Control System (EPICS), commenced in early 2010; the digital receiver driver successfully read monitoring points from the digital receiver's control board. A VirtualTOS (VTOS) was developed to provide a simulated Telescope Operating System (TOS) environment for implementing, executing and debugging observations.

An external critical design review was held in March 2010, and significant optimisations were made to the ASKAP imaging code, reducing run time and the memory footprint. The code was also demonstrated on a compute cluster at the National Computation Infrastructure's National Facility, scaling 1024 CPU cores.

Throughout the year realistic sky model simulations were passed through ASKAP imaging software to produce simulated output images for the ASKAP Survey Science Teams to test source-finding algorithms. The creation of realistic simulated skies, imaging of the simulations using ASKAP's configuration, software tools and finding sources in the output images and cubes are important aspects of planning for science that will be conducted with ASKAP.

Data and Signal Transport

Following the 2009 agreement made with telecommunications carrier AARNet (the Australian National Research and Education Network), civil works on the long-haul fibre link between the MRO and Geraldton commenced in mid-2010, with installation of optic fibre along the 390 km route underway by the end of the year. To re-amplify the fibre optic signal every 80-100 km, three repeater huts were installed at Mullewa, Yuin and Murgoo Stations.

By mid-year, the network had taken on a three tier development; the first network specific to MATES (Marsfield ASKAP Test and Engineering Services), the second for the PTF and a third for ASKAP BETA. Prototype assemblies for MATES were developed and in service by a number of ASKAP Integrated Project Teams by December 2010.

System Engineering

The full-scale wooden model of the ASKAP pedestal, mount and hub (known as 'SAPKAP') provided a valuable aid in the development of the MATES testbed system at the Marsfield site. Initial integration of MATES, including electronics and receiver systems, was achieved by the second half of the year with a 'bare bones' analog pedestal system and digital ESI system connected in SAPKAP.

By December a skeletal PAF receiver with partial monitoring and control functions was fitted, which included dummy heat load and temperature monitoring to provide a testbed for the PAF water cooling system, and investigate the possibility of a more efficient and cost-effective option for cooling ASKAP's electronic systems to reduce the telescope's overall demand on power.

Collaborator Projects

Two radio astronomy experiments (other than ASKAP) made use of the superb radio-quiet environment at the MRO in 2010: the Murchison Widefield Array (MWA) and the Experiment to Detect the Global EoR Signature (EDGES).

The MWA is an international collaboration between US, Australian and Indian institutions, including CSIRO, to build a wide-field dipole array concentrating on the low frequency range of the SKA specifications. In 2010 the MWA team passed its first major milestone, completing the 32-antenna prototype array and undergoing an extensive test and verification program between December 2009 and February 2010. Final deployment of the full 512-antenna array is expected to commence in late 2011.

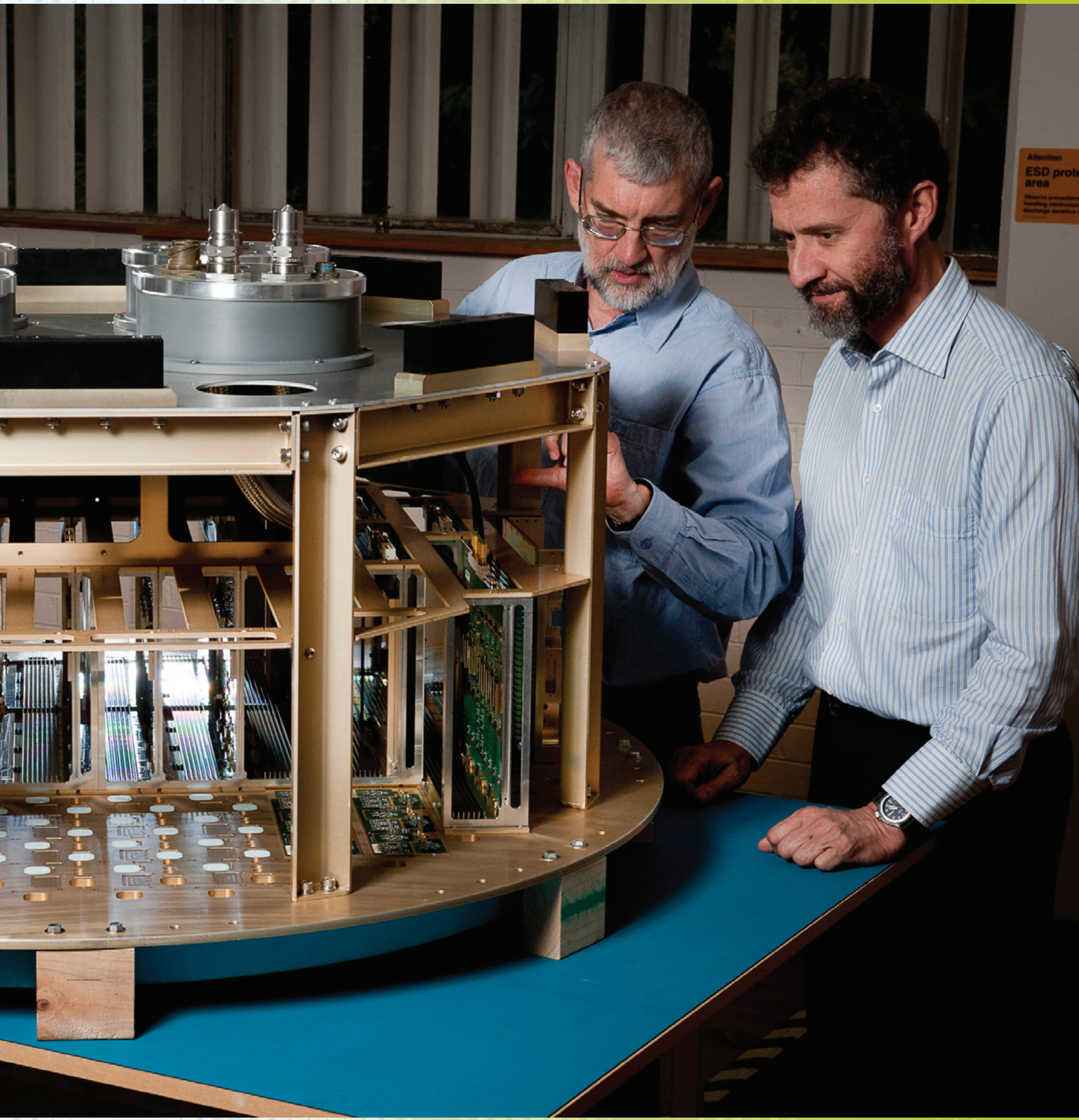
The EDGES project was deployed at the MRO in 2009. A collaboration between Arizona State University and MIT/Haystack Observatory, and funded by the US National Science Foundation, the EDGES project was deployed in 2009. In December 2010, EDGES released the results of a three month experiment designed to measure the all-sky spectrum between 100–200 MHz in order to probe the global evolution of 21-cm emission from neutral hydrogen gas at high redshift.

CSIRO SKA Director Dr Brian Boyle hands over a correlator board to SKAMP Project Leader Prof Anne Green. Credit: Tony Crawshaw, CSIRO.

In 2010 CSIRO staff continued their close collaboration with the University of Sydney on the Square Kilometre Array Molonglo Prototype (SKAMP) project, which aims to test and develop new technology for the SKA by producing a completely new digital signal pathway on the existing mechanical superstructure of the Molonglo Observatory Synthesis Telescope.

During 2010, CSIRO developed and delivered the new signal-processing system to the SKAMP team, as a result improving the telescope's sensitivity by a factor of three, and the data-flow rate by a factor of 10,000. In a synergy with the SKAMP project, CSIRO built a similar correlator for the international MWA consortium. There is strong collaboration between the SKAMP, ASKAP and MWA projects because of the underlying common correlation module, which is the heart of the signal processing system.

7.
Appendices



CSIRO's ASKAP radio telescope will incorporate revolutionary new receiver technology known as Phased Array Feeds (or PAFs). CSIRO ASKAP Receiver Engineer Russell Gough and CSIRO ASKAP Theme Leader and Director Ant Schinckel examine a partially assembled PAF which, when complete, will be installed on an antenna for testing.

Credit: Tim Wheeler, Wheeler Studios.

A: Committee Membership

ATNF Steering Committee in 2010

CHAIR

Professor Lister Staveley-Smith, ICRAR

MEMBERS

Ex-Officio

Dr Matthew Colless, Director, Australian Astronomical Observatory

Dr Alex Zelinsky, Group Executive, CSIRO Information Sciences Group

Dr Ian Oppermann, Director, CSIRO ICT Centre

Astronomers

Professor Rachel Webster, University of Melbourne

Professor Brian Schmidt, Research School of Astronomy & Astrophysics, ANU

International Advisers

Professor Michael Kramer, Director Max-Planck-Institut für Radioastronomie, Germany

Professor Nan Rendong, National Astronomical Observatories, China

Professor Don Backer, Radio Astronomy Laboratory, University of California, USA (deceased)

Broader Community

Mr Alan Brien, Chief Executive Officer, Scitech Discovery Centre

Mr Brett Biddington, Principal, Biddington Research Pty Ltd

Invited

Dr Philip Diamond, Chief CSIRO Astronomy and Space Science; Director, CSIRO Australia Telescope National Facility

Australia Telescope User Committee in 2010

CHAIR

Dr Sarah Maddison, Swinburne University of Technology (May 2009 – October 2011)

SECRETARY

Dr Chris Phillips, CSIRO Astronomy and Space Science (October 2010 – May 2013)

Dr Stacey Mader, CSIRO Astronomy and Space Science (May 2008 – May 2010)

MEMBERS

Dr. Simon Johnston, CSIRO Astronomy and Space Science (October 2010 – May 2013)

Dr Hayley Bignall, Curtin University (October 2008 – May 2011)

Dr Tara Murphy, University of Sydney (October 2008 – May 2011)

Dr Tim Robishaw, University of Sydney (October 2010 – May 2013)

Dr James Urquhart, CSIRO Astronomy and Space Science (October 2008 – May 2011)

Prof John Dickey, University of Tasmania (October 2009 – May 2012)

Dr Chris Springob, Australian Astronomical Observatory (October 2009 – May 2012)

Dr Andrew Walsh, James Cook University (October 2007 – May 2010)

Dr Indra Bains, Swinburne University of Technology (October 2008 – May 2010)

STUDENT MEMBERS

Justin Bray, University of Adelaide (October 2010 – May 2011)

Jacinta Delhaize, University of Western Australia (October 2010 – May 2011)

Aquib Moin, Curtin University (October 2009 – May 2010)

Elizabeth Mahony, University of Sydney (October 2009 – May 2010)

The Australia Telescope Steering Committee appoints members to ATUC. New members usually start their three-year term with the October/November meeting in their first year and finish their term after the May/June meeting in their last year. Students are appointed for one year (two meetings). Dates of first and last meetings are given.

Australia Telescope Time Assignment Committee in 2010

CHAIR

Dr Lisa Harvey-Smith, CSIRO Astronomy and Space Science

MEMBERS

Ex-Officio

Dr Jessica Chapman, CSIRO Astronomy and Space Science

Dr Philip Edwards, CSIRO Astronomy and Space Science

Dr Douglas Bock, CSIRO Astronomy and Space Science

TAC Members

Dr Simon Ellingsen, University of Tasmania

Dr Helen Johnston, University of Sydney

Dr Baerbel Koribalski, CSIRO Astronomy and Space Science

Dr Jean Pierre Macquart, Curtin University of Technology

Dr Martin Meyer, University of Western Australia

Dr Naomi McClure-Griffiths, CSIRO Astronomy and Space Science

Dr Ray Norris, CSIRO Astronomy and Space Science

Dr Willem van Straten, Swinburne University of Technology

TAC Readers

Dr Ettore Carretti, CSIRO Astronomy and Space Science

Dr Maria Cunningham, University of New South Wales

Dr Nichi D'Amico, Cagliari Astronomical Observatory, Italy

Dr Gary Fuller, University of Manchester, UK

Dr Jose Gomez, Instituto de Astrofisica de Andalucia, Spain

Dr Richard Hunstead, University of Sydney

Dr James Jackson, Boston University, USA

Dr Virginia Kilborn, Swinburne University of Technology

Dr Mclaughlin Maura, West Virginia University, US

Dr Enno Middelberg, Ruhr University, Germany

Dr Vincent Minier, University of Paris, CEA Saclay, France

Dr Rafaella Morganti, Netherlands Foundation for Research in Astronomy, the Netherlands

Dr Juergen Ott, National Radio Astronomy Observatory, US

Dr Gavin Rowell, University of Adelaide

Dr Tony Wong, University of Illinois, US

B: Financial Summary

The table below summarises the revenue and expenditure applied to CSIRO's radio astronomy activities, also including related activities resourced from the ICT Centre.

	Year Ending 30 June 2010 (A$'000)	Year Ending 30 June 2009 (A$'000)	Year Ending 30 June 2008 (A$'000)
Revenue			
External	966	1,269	5,252
Appropriation	33,031	31,801	29,741
Total Revenue	33,997	33,070	34,993
Expenses			
Salaries	12,500	12,140	13,959
Travel	976	975	1,123
Other Operating	5,091	4,173	7,756
Overheads*	10,282	12,012	0
Corporate Support Services	0	0	5,131
Depreciation & Amortisation	3,925	3,363	3,452
Doubtful Debt Expense	0	0	0
Total Expenses	32,773	32,663	31,421
Profit/(Loss) on Sale of Assets	0	0	(222)
Operating Result	1,223	407	3,350

Notes

The financial reporting represents matrix reporting for the output side of the matrix, outputs are Portfolios and Themes.

Overheads includes corporate support services and Business Unit support services.

C: Staff List: January to December 2010

MARSFIELD		
Allen	Graham	Engineering
Amy	Shaun	Operations
Axtens	Peter	Engineering
Ball	Lewis	Deputy Director ATNF
Barends	Anne	Executive Secretary to ATNF Director
Barnes	Caroline	Project Support Group
Barry	Samantha	Operations
Bateman	Tim	Engineering
Beresford	Ronald	Engineering
Bock	Douglas	Operations
Bolton	Russell	Engineering
Bonvino	Phillip	Engineering
Bourne	Michael	Engineering
Bowen	Mark	Engineering
Boyle	Brian	Portfolio Leader SKA
Braun	Robert	Assistant Director: Astrophysics
Breen	Shari	Astrophysics
Briggs	Brayden	Health, Safety and Environment
Brooks	Kate	Astrophysics
Brown	Andrew	Engineering
Brown	Shea	Astrophysics
Calabretta	Mark	Software Development
Carrad	Graeme	Assistant Director: Engineering
Castillo	Santiago	Engineering
Caswell	James	Astrophysics
Chapman	Jessica	Operations
Chatterjee	Shami	Astrophysics
Chaudhary	Ankur	Astrophysics
Chekkala	Raja	Engineering
Cheng	Wanxiang	Engineering
Chippendale	Aaron	Engineering
Chung	Yoon	Engineering
Conway-Derley	Flornes	Communications and Outreach
Cook	Geoffrey	Engineering
Cooper	Paul	Engineering
Cornwell	Tim	Research Program Leader: Software Development
Crawshaw	Tony	Communications and Outreach
Crosby	Phil	Business Strategist
Dangi	Binduben	Engineering
Davis	Evan	Engineering
De Souza	Ludovico	Engineering
Death	Michael	Engineering
DeBoer	Dave	Assistant Director: ASKAP
Diamond	Phil	Director ATNF
Dixon	John	Engineering
Doherty	Paul	Engineering
Drazenovic	Victoria	Operations
Dunning	Alexander	Engineering
Edwards	Leanne	Operations
Ekers	Ron	Astrophysics, Federation & CSIRO Fellow

Elton	Troy	Engineering
Emonts	Bjorn	Astrophysics
Feain	Ilana	Astrophysics
Ferris	Richard	Engineering
Forsyth	Ross	Engineering
Fraser	Kylie	Health, Safety and Environment Manager
Fraser	Vicki	Project Support Group
Frost	Gabriella	Project Specialist
Gough	Russell	Engineering
Green	James	Astrophysics
Gupta	Neeraj	Astrophysics
Guzman	Juan-Carlos	Software Development
Hakvoort	Eliane	Engineering
Hampson	Grant	Engineering
Hartmann	Carmel	Assistant to Portfolio Leader SKA
Harvey-Smith	Lisa	Astrophysics
Haskins	Craig	Software Development
Hein	Angela	Health, Safety and Environment
Hobbs	George	Astrophysics
Hollow	Robert	Communications and Outreach
Humphreys	Benjamin	Software Development
Huynh	Minh	Engineering
Jackson	Suzanne	Engineering
Jackson	Carole	Project Specialist
Jeganathan	Kanapathippillai	Engineering
Johnston	Simon	Astrophysics, CSIRO Science Leader
Jurek	Russell	Astrophysics
Kachwalla	Elsa	Operations
Kanoniuk	Henry	Engineering
Keith	Michael	Astrophysics
Kesteven	Michael	Engineering
Khoo	Jonathan	Astrophysics
Kiraly	Dezso	Engineering
Koenig	Ronald	Engineering
Koribalski	Baerbel	Astrophysics
Kosmynin	Arkadi	Operations
Kovac	Jesse	Engineering
Lauter	Benjamin	Engineering
Leach	Mark	Engineering
Lee	Jennifer	Project Support Group
Lenc	Emil	Astrophysics
Lie	Jennifer	Engineering
Londish	Diana	Communications and Outreach
Lopez-Sanchez	Angel	Astrophysics
Mackay	Simon	Engineering
Macleod	Adam	Project Specialists
Maher	Anthony	Software Development
Manchester	Dick	Astrophysics, Federation & CSIRO Fellow
Marquarding	Malte	Software Development
McClure-Griffiths	Naomi	Astrophysics, CSIRO Science Leader
McConnell	David	Assistant Director: Operations
McIntyre	Vincent	Operations
Mickle	Samantha	Engineering
Moncay	Ray	Engineering

Morison	Neale	Software Development
Neuhold	Stephan	Engineering
Ng	Alan	Project Specialist
Ng	Andrew	Engineering
Norris	Ray	Astrophysics
O'Sullivan	John	Engineering
O'Sullivan	Shane	Astrophysics
Phillips	Chris	Operations
Pope	Nathan	Operations
Rathborne	Jill	Astrophysics
Reilly	Leslie	Engineering
Reynolds	John	Operations
Roberts	Paul	Engineering
Roxby	Daniel	Engineering
Russell	Gabby	Communications and Outreach
Sanders	Aaron	Engineering
Schinckel	Antony	Project Specialist
Schnitzler	Dominic	Astrophysics
Shannon	Ryan	Astrophysics
Shields	Matthew	Engineering
Sim	Helen	Communications and Outreach
Smith	David	Management
Spolaor	Sarah	Astrophysics
Storey	Michelle	Policy Strategist
Tesoriero	Julie	Project Support Group
Tuthill	John	Engineering
Tzioumis	Tasso	Operations
Urquhart	James	Astrophysics
Vera	Jeffrey	Engineering
Voronkov	Maxim	Software Development
Weltevrede	Patrick	Astrophysics
Westmeier	Tobias	Astrophysics
Whiting	Matthew	Software Development
Wilson	Warwick	Engineering
Wormnes	Kjetel	Engineering
Wu	Xinyu	Software Development
Xue	Gordon	Project Specialist
MARSFIELD Research Support		
Agnostino	Damiano	CSIRO Finance
Broadhurst	Sue	Reception
Collins	Jim	CSIRO Finance
D'Amico	Andy	Stores
Derwent	Neil	CSIRO Finance
Dwyer	Elissa	CSIRO HR
Hodges	Cheryl	Reception
Joos	Arianna	CSIRO Library
Levers	Helen	CSIRO HR
Lambert	Ken	Stores
Lee	Olivia	CSIRO Finance
Merrick	Sarah	CSIRO Finance
Randell	Sandra	CSIRO Finance
Van der Leeuw	Christine	CSIRO Library
Wilson	Briony	CSIRO Finance
NARRABRI		

Adamson	Belinda	Operations
Bateman	John	Operations
Brem	Christoph	Operations
Brennan	Donna	Operations
Brodrick	David	Operations
Cummins	Cathy	Operations
Dodd	Susan	Operations
Edwards	Philip	Operations
Forbes	Kylee	Operations
Hill	Michael	Operations
Hiscock	Brett	Operations
Hiscock	Jennifer	Operations
Houldsworth	Joanne	Operations
Indermuehle	Balthasar	Operations
Kelly	Pamela	Operations
Kelly	Rosslyn	Operations
Lennon	Brett	Operations
Martin	Heather	Operations
McAllister	Kelly	Operations
McFee	John	Operations
McFee	Margaret	Operations
McKay	Ben	Operations
Mirtschin	Peter	Operations
Munting	Scott	Operations
Rees	Margaret	Operations
Stevens	Jamie	Operations
Sunderland	Graeme	Operations
Tomlinson	Rod	Operations
Tough	Bruce	Operations
Troup	Euan	Operations
Wark	Robin	Operations
Webster	Norman	Operations
Wieringa	Mark	Operations
Wilson	Christine	Operations
Wilson	John	Operations
Wilson	Tim	Operations
NARRABRI Research Support		
Johnson	Brian	CSIRO Property Services
Leven	Clarence	CSIRO Property Services
Wieringa	Jacqui	CSIRO Library
PARKES		
Armstrong	Brett	Operations
Black	Laura	Operations
Carretti	Ettore	Operations
Cole	Janette	Operations
Craig	Daniel	Operations
Crocker	Jonathan	Operations
Dawson	Brett	Operations
Dean	Andrew	Communications and Outreach
Evans	Anne	Operations
Freeman	Geoffrey	Operations
Hockings	Julia	Operations
Hollingdrake	Chris	Communications and Outreach
Hoyle	Simon	Operations

Hunt	Andrew	Operations
Ingram	Shirley	Operations
Laing	Alan	Operations
Laing	Jenny	CPS and Operations
Lees	Tom	Operations
Lensson	Erik	Operations
Mader	Stacy	Operations
McRobert	Ian	Operations
McFarland	Matthew	Operations
Milgate	Lynette	Operations
Preisig	Brett	Operations
Reeves	Ken	Operations
Reeves	Teagan	Communications and Outreach
Ruckley	Timothy	Operations
Sarkissian	John	Operations
Smith	Malcolm	Operations
Spratt	Gina	Operations
Trim	Tricia Lee	Communications and Outreach
Unger	Karin	Communications and Outreach
Veale	Roxanne	Operations/Communications and Outreach
Wilson	Beverley	Communications and Outreach
PARKES Research Support		
Brady	Scott	CSIRO Property Services
GERALDTON WA		
Clayton	Priscilla	Project Specialist
Boddington	Robin	Project Specialist
Puls	Lou	Project Specialist
Turner	Barry	Project Specialist
Whiting	Gemma	Project Specialist

D: Observing Programs

The observations listed are those that were allocated time through the Time Assignment Committee's processes. A small number of 'Target of Opportunity' observations and observations taken during Director's time have been excluded from the list.

Observations made with the Australia Telescope Compact Array

October 2009 to September 2010

Observers	Affiliations	Program	No.
Stevens, Edwards, Wark, Wieringa	CASS, CASS, CASS, CASS	ATCA Calibrators	C007
Staveley-Smith, Zanardo, Potter, Gaensler, Ng, Manchester, Ball, Kesteven, Tzioumis	UWA, UWA, UWA, USyd, USyd, CASS, CASS, CASS, CASS	SNR 1987A	C015
Bauer, Emonts, Koribalski, Dwarkadas, Stockdale, Ryder	UClmba, CASS, CASS, UChig,AAO	Probing Complex CSM in SNe: SN1996cr Monitoring	C184
Hunstead, Broderick, Johnston, Cotter, Morganti	USyd, USouth, USyd, UOx, NFRA	The radio galaxy B1221-423: forming an AGN in a merger?	C956
Brocksopp, Corbel, Fender, Tzioumis	MSSL, UParis, USouth, CASS	Radio Jets in Recurrent and New Black Hole X-ray Transients	C989
Wright, Maddison, Wilner	ADFA, Swinb, CfA	Detailed imaging of the inner gap in the HD100546 protoplanetary disk	C996
Moffett, Johnston, Hughes, Reynoso	UFurman, CASS, URutg, IAFE	An Expansion Study of SN1006	C1114
Coriat, Corbel, Fender, Tzioumis, Kaaret, Tomsick, Orosz	CEA, UParis, USouth, CASS,UCSD, SDSU	Large scale radio/X-ray jets in microquasars	C1199
Lundqvist, Bjornsson, Fransson, Schmidt, Ryder, Perez Torres	StO, StO, StO, ANU, AAO, IAAC	Probing the radio emission from a young Type Ia supernova	C1303
Bains, Chapman, Saikia, Cohen	Swinb, CASS, NCRA, UCB	Revealing the transition from post-AGB stars to planetary nebulae	C1450
Ryder, Stockdale, Amy, Argo, Covarrubias, Van Dyk, Immler, Weiler, Panagia	AAO,CASS, UCurt, AAO, IPAC, GSFC, NRL, STScI	NAPA Observations of Core-Collapse Supernovae	C1473
Lumsden, Urquhart, Maud, Cooper, Hoare	ULeeds, CASS, ULeeds, ULeeds, ULeeds	Ionised winds and jets from massive young stellar objects	C1494
Walsh, Carlstrom, Crawford, Marrone, Mcintyre, Mohr, Stark, Vieira	CfA, UChig, UChig, NRAO, CASS, UII, CfA, UChig	High-Redshift Submillimeter Galaxies and Dark Energy from Clusters	C1563
Mcdonald, Van Loon	UKeele, UKeele	Resolving a shocked high-velocity cloud in the Leading Arm	C1675
Lopez-Sanchez, Hollow, Chapman	CASS, CASS, CASS	CASS Summer Vacation Program 2009/2010	C1726
Koerding, Tzioumis, Fender, Knigge	CEA, CASS, USouth, USouth	Confirmation of radio emission originating from the nova like V3885 Sgr	C1732
Chhetri, Ekers, Ricci	UNSW, CASS, UCal	Search For Gravitational Lenses using the AT20G	C1766
Ubach, Ricci, Maddison, Testi, Wright, Koribalski, Wilner, Brooks	Swinb, ESO, Swinb, ESO, ADFA, CASS, CfA, CASS	A multi-wavelength study of grain growth in protoplanetary disks	C1794

Observers	Affiliations	Program	No.
Moin, Tingay, Phillips, Taylor, Wieringa, Martin	UCurt, UCurt, CASS, UNM, CASS	A Southern Sky survey to detect and monitor radio afterglows associated with recently detected gamma-ray bursts (GRBs)	C1802
Fontani, Beltran, Brand, Burton, Cesaroni, Molinari, Sanchez-Monge	INAF,INAF, UNSW, OAAI,UBARC	Establishing an evolutionary sequence for high-mass star formation	C1804
Delhaize, Staveley-Smith, Meyer, Boyle, Kesteven, Gaensler, Sadler, Subrahmanyan, Driver	UWA, UWA, UWA, CASS, CASS, USyd, USyd, RRI	Galaxy Evolution – A Pathfinder Study	C1805
Britton, Voronkov, Caswell, Ellingsen, Sobolev, Salii	CASS, CASS, CASS, UTas, USU, USU	Class I methanol masers and shocks	C1820
Eckart, Kunneriath, Witzel, Sjouwerman, Straubmeier, Schoedel, Garcia Marin	UKOELN, UKOELN, UKOELN, NRAO, UKOELN, IAAC, UKOELN	Coordinated Observations of SgrA* in 2010	C1825
Harvey-Smith, Gaensler, Kronberg	USyd, USyd	Measuring the Evolution of Magnetic Fields in Galaxies from 0.3 < z < 2	C1853
Voronkov, Goedhart, Caswell, Ellingsen, Sobolev, Gaylard, Ostrovskii	CASS, HartRAO, CASS, UTas, USU, HartRAO, USU	Understanding periodic flares of the methanol masers	C1929
Mahony, Sadler, Croom, Feain, Murphy	USyd, USyd, USyd, CASS, USyd	Deep 20 GHz observations of X-ray selected QSOs	C1964
Hopkins, Norris, Randall, Lenc, Hales, Mao, Middelberg, Huynh	AAO, CASS, CASS, CASS, USyd, UTas, AIR, IPAC	The ATLAS 1.4 GHz survey	C1967
Huynh, Hopkins, Middelberg, Mao, Randall, Norris	IPAC, AAO, AIR, UTas, CASS, CASS	A deep 6cm survey of the extended Chandra Deep Field South	C2028
Walsh, Voronkov, Urquhart, Rowell, Purcell, Peretto, Morgan, Longmore, Loenen, Lo, Jones, Jackson	JCU, CASS, CASS, UAd, UMan, UMan,CfA, KI, UNSW, UNSW, UBos	A 7mm ATCA pilot survey of the southern Galactic plane	C2029
Malu, Subrahmanyan, Wieringa, Narasimha	, RRI, CASS	High resolution Sunyaev Zeldovich 'holes' in the Bullet cluster	C2037
Indebetouw, Chen, Looney, Wong, Seale, Chu, Gruendl	NRAO, UVir, UII, UII, UII, UII, UII	Ultracompact HII Regions in the Magellanic Clouds	C2044
Massardi, Ekers, Partridge, Bonavera, De Zotti, Tornikoski, Rachen, Toffolatti, Sadler	OAPd, CASS, Haverford, SISSA, OAPd,MPIfA,USyd	Almost simultaneous follow-up of extragalactic radio sources observed by ESA's Planck satellite	C2046
Corbel, Edwards, Wieringa, Tingay, Sadler, Thompson, Cameron, Grenier, Chaty, Gehrels, Burrows, Dubus	UParis, CASS, CASS, UCurt, USyd, GSFC, UStan, UParis, UParis, GSFC, PSU, OGR	ATCA follow-up of unidentified flaring Fermi gamma-ray sources	C2051
Emonts, Miley, Norris, Sadler, Mao, Feain, Saikia, Villar-Martin, Ekers, Oosterloo, Tadhunter, Morganti	CASS, LO, CASS, USyd, UTas, CASS, NCRA,CASS, NFRA, USheff, NFRA	CO in high-z radio galaxies: a CABB survey	C2052
Schnitzeler, Dawson, Mcclure-Griffiths	CASS, UNag, CASS	Magnetic support for Galactic supershell walls	C2053
Holwerda, Bouchard, Blyth, Van Der Heyden, De Blok, Allen	UCT, UCT, UCT, UCT, UCT, STScI	Dabbling in the occult: distance and HI mass of an overlapping pair of galaxies	C2060
Fender, Tzioumis, Calvelo, Kawai	USouth, CASS, USouth	Circinus X-1: the most relativistic jet source in the galaxy	C2075

Observers	Affiliations	Program	No.
Ng, Romani, Johnston	USyd,CASS	The Remarkable Wind Bubble Associated with PSR J1015-5719	C2090
Wright, Maddison, Wilner	ADFA, Swinb, CfA	Searching for structure in two southern protoplanetary disks	C2094
Soria, Pakull, Broderick, Corbel, Motch	UCL, StrasbO, USouth, UParis, StrasbO	The newly-discovered radio/optical/X-ray microquasar in NGC 7793	C2096
Kepley, Gaensler	UVir, USyd	Magnetizing the Universe: the Role of Compact Groups	C2103
Voronkov, Britton, Caswell, Green, Ellingsen, Walsh, Fuller, Quinn, Thompson, Urquhart, Hoare, Longmore	CASS, CASS, CASS, CASS, UTas, JCU, UMan, UMan, UHerts, CASS, ULeeds, CfA	Class I maser follow-up of the MMB detections: the outer Galaxy	C2110
Espada, Lopez-Sanchez, Verdes-Montenegro	IAAC, CASS, IAAC	Dense molecular gas tracers in infrared bright southern galaxies	C2116
Alexander, Gulyaev	AUT, AUT	Using ATCA for measuring extremely-weak Stark-broadened RRLs in HII-regions	C2118
Schmalzl, Bourke, Stutz, Launhardt	MPIA, SAO	Tracing infall signatures towards the prestellar core L429	C2119
Chen, Indebetouw, Wong, Ott, Looney, Chu, Gruendl, Seale, Heitsch, Madden, Hony, Galametz	UVir, NRAO, UIl, NRAO, UIl, UIl, UIl, UIl, UMich, CEA, CEA, CEA	Star Formation in the Seemingly Quiet GMC N159-S	C2121
Moin, Frail, Macquart, Tingay	UCurt, NRAO, UCurt, UCurt	Extreme Gamma-ray bursts (GRBs): constraining energetics and probing central engines	C2147
Walsh, Breen, Britton, Brooks, Burton, Cunningham, Harvey-Smith, Hoare, Hindson, Jones, Lo, Longmore	JCU, UTas, CASS, CASS, UNSW, UNSW, USyd, ULeeds, UHerts, UNSW, UNSW, CfA	Accurate water maser positions for HOPS	C2148
Stanway, Levan, Davies	UBr,UBr	Calibrating Optical vs Radio Star Formation Rates in a Baseline Sample of GRB Host Galaxies at $z<0.5$	C2151
Bremer, Tanvir, Stanway, Levan	UBr, ULeic, UBr	A Glimpse at the End of the Dark Ages	C2153
Robishaw, Gaensler	USyd, USyd	Constraining Primordial Magnetic Fields via Faraday Rotation Measure Synthesis in DLAs	C2155
Indebetouw, Cunningham, Townsley, Jones, Dirienzo	NRAO, UNSW, PSU, UNSW, UVir	NGC3576: Triggered formation of a Giant HII Region?	C2156
Quinn, Fuller, Pratap	UMan, UMan, MIT	Class I Methanol Masers: Tracing the Youngest Sources?	C2157
Kong, Lu	NTHU, NTHU	Searching Intermediate-Mass Black Holes in Globular Clusters	C2158
Walsh, Beuther, Longmore, Fallscheer	JCU, MPIA, CfA, MPIA	High mass accretion disks: ATCA's potential for deep impact II	C2164
Ricci, Testi, Mann, Williams, Natta, Brooks	ESO, Acretri, UHawaii, UHawaii, Acretri, CASS	Investigating the first stages of planet formation in the Orion Nebula	C2179

Observers	Affiliations	Program	No.
Ricci, Testi, Belloche, Jorgensen, Brooks, Natta	ESO, Acretri, MPIfR, UBonn, CASS, Acretri	Dust grain growth in Chamaeleon I protoplanetary disks	C2180
Avison, Fuller, Purcell, Caswell, Quinn, Burton, Thompson	UMan, UMan, UMan, CASS, UMan, UNSW, UHerts	Exploratory search for Disks and Outflows around MMB methanol maser sources	C2184
Titmarsh, Ellingsen, Caswell, Brooks, Breen, Walsh, Fuller, Voronkov, Thompson, Burton	UTas, UTas, CASS, CASS, UTas, JCU, UMan, CASS, UHerts, UNSW	Water masers towards 6.7 GHz methanol masers from the Methanol Multi-beam Survey	C2186
Ellingsen, Breen, Voronkov, Caswell, Sobolev	UTas, UTas, CASS, CASS, USU	Rare Class II Methanol Masers: Ideal evolutionary probes for high-mass star formation	C2191
Migliari, Yamaoka, Tzioumis, Uemura, Kinugasa	ESA Villafranca,CASS	Testing the jet origin of the Comptonizing `corona' in X-ray binaries	C2193
Bates, Stappers, Bailes, Johnston, Kramer, Possenti, Burgay, Levin, Van Straten, Bhat, Burke	UMan,Swinb, CASS, MPIfR, CAO, CAO, Swinb, Swinb, Swinb, Swinb	The First Magnetar Discovered in Radio	C2194
Koribalski, Ryder, Lopez-Sanchez, Karachentsev	CASS, AAO, CASS, RAS	Examining the spiral galaxy NGC7531 and its ghost	C2196
Fender, Maccarone, Knigge, Tzioumis	USouth, USouth, USouth, CASS	A possible nearby low-luminosity black hole	C2198
Aravena, Papadopoulos, Feain, Wagg, Bertoldi, Ivison	NRAO, UBonn, CASS, ESO, UBonn, ROE	Testing the ULIRG/QSO transition hypothesis	C2247
Green, Caswell	CASS, CASS	Is there correlated periodicity in CH3OH and OH maser emission in G12.889+0.489?	C2287
Green, Mcclure-Griffiths, Caswell, Harvey-Smith, Robishaw	CASS, CASS, CASS, USyd, USyd	MAGMO: Mapping the Galactic Magnetic field through OH masers	C2291
Bannister, Murphy, Gaensler	USyd, USyd, USyd	Follow-up of Transients and Varaibales from the Molonglo Observatory Synthesis Telescope	C2292
Wong, Hughes, Welty, Xue, Ott, Filipovic, Crawford, Pineda, Muller, Braun, Dickey, Staveley-Smith	UIl, Swinb, UIl, UIl, NRAO, UWS, UWS, JPL, UNag, CASS, UTas, UWA	HI Absorption near High-Brightness Emission in the LMC	C2293
Hobbs, Ravi, Lo, Champion, Norris, Wickramasinghe, Ferrario, Keith, Murphy, Gaensler	CASS, ANU, USyd, CASS, CASS, ANU, ANU, CASS, USyd, USyd	The radio transient sky from minutes to hours: known stellar pulsars	C2303
Stephens, Seale, Looney, Voronkov, Chen, Gruendl, Chu, Ott, Wong, Indebetouw	UIl, UIl, UIl, CASS, UVir, UIl, UIl, NRAO, UIl, NRAO	Evolution of Gas around Massive YSOs in the LMC	C2311
Ravi, Lo, Hobbs, Norris, Gaensler, Murphy, Keith, Champion, Tinney, Melrose, Wickramasinghe, Ferrario	ANU, USyd, CASS, CASS, USyd, USyd, CASS, CASS, UNSW, USyd, ANU, ANU	The radio transient sky from minutes to hours: a volume-limited ultracool dwarf survey	C2313
Beelen, Norris, Lagache, Guelin, Desert, Guilloteau, Puget, Dole, Omont, Caputi, Daddi, Elbaz	IASp, CASS, IASp, IRAM-F, IASp, OBordeaux, IASp, IASp, IAP,CEA, CEA	First Interferometric Deep millimetre Survey	C2317
Sun, Koribalski, Jones, Sarazin, Sivanandam	UVir, CASS, SAO, UVir, UAz	Stripped atomic ISM and intracluster star formation in massive cluster A3627	C2321
Friesen, Bourke, Di Francesco, Caselli, Rushton, Myers	NRAO, SAO, NRCC, ULeeds, ULeeds, SAO	NH3 in Oph A: Studying the small-scale temperature structure in a cluster-forming core	C2322

Observers	Affiliations	Program	No.
Jarrett, Emonts, Tsai, Benford, Blain, Lonsdale, Yan, Eisenhardt, Wright, Cutri, Stanford, Norris	Caltech, CASS, UCLA, GSFC,NRAO, Caltech, JPL, UCLA, Caltech, LLNL, CASS	Radio Continuum Observations of Hyper-Luminous Infrared Galaxies Discovered by the Wide-Field Infrared Survey Explorer	C2328
Curran, Whiting, Webb, Flambaum	UNSW, CASS, UNSW, UNSW	A Pilot Survey for an Unknown Population of High Redshift Galaxies	C2331
Moriarty, Dodson, Rioja, Vlemmings, Ellingsen	UWA, UWA, UWA, UBonn, UTas	Stokes V of Methanol Masers: Measuring B-fields in Star Forming Regions	C2338
Saripalli, Staveley-Smith, Jones, Subrahmanyan	RRI, UWA, ANU, RRI	Large scale structure, the Warm-Hot IGM and giant radio galaxies	C2340
Pantin, Maddison, Menard, Gonzalez, Augereau, Nilsson, Lestrade, Brandecker, Liseau	CEA, Swinb, OGR,OGR, StO, OPM, StO, OSO	Millimetre observations of debris disks	C2342
Titmarsh, Paladini, Noriega-Crespo , Brooks, Carey, Ellingsen	UTas, IPAC, IPAC, CASS, IPAC, UTas	Multiresolution analysis of the radio-FIR correlation within a Galactic HII Region	C2348
Popping, Braun	LADM, CASS	HI detections of the Cosmic Web	C2351
Pestalozzi, Torkelsson, Hobbs, Evangelista	UHerts, CASS, IASF-CNR	The phase-resolved cm radio spectrum of BP Cru	C2353
Vink, Haverkorn, Bamba	UUtrecht, NFRA, ISA	The Nature of the Pulsar Wind Nebula around magnetar 1E 1547.0-5408	C2354
Zeballos, Hughes, Aretxaga, Wilson, Yun	INAOE, INAOE, INAOE, UMass, UMass	Do bright millimeter-galaxies support downsizing?	C2360
Webb, Fender, Corbel, Farrell, Lenc, Heywood, Godet, Barret, Cseh	CESR, USouth, UParis, ULeic, CASS, UOx, CESR, CESR, CEA	Verifying the intermediate mass black hole nature of the ultraluminous X-ray source HLX-1 associated with ESO 243-49	C2361
Brown, Rudnick, Pfrommer, Jones	CASS, UMinn, UTor, UMinn	Unveiling the Synchrotron Cosmic Web: Pilot Study	C2364
Lumsden, Caselli	ULeeds, ULeeds	Are FeLoBAL quasars intrinsically young?	C2365
Troost, Menten, Schuller, Wienen, Walsh, Koribalski, Beuther, Wyrowski	MPIfR, MPIfR, MPIfR, MPIfR, JCU, CASS, MPIA, MPIfR	Looking into the dust – revealing the inner structure and kinematics of ATLASGAL clumps	C2370
Pestalozzi, Torkelsson, Hobbs	UHerts,CASS	The millimetre spectrum of BP Cru	C2373
Suarez, Bendjoya, Niccolini, Domiciano, Gomez	,IAAC	Revealing the circumstellar structure of B[e] stars	C2374
Marrone, Vieira, Carlstrom, Bleem, Crawford, Holzapfel, Stark, Mcintyre	UChig, UChig, UChig,UChig, UCB, CfA, CASS	Molecular Gas in an Obscured Submillimeter Galaxy	C2375
Kraus, Wyrowski, Bergin, Menten, Schilke, Weigelt	UMich, MPIfR, UMich, MPIfR, UKOELN, MPIfR	Zooming in on high-mass star formation with combined VLTI near-infrared interferometry and ATCA millimeter interferometry	C2377

Observations made with the Parkes Telescope

October 2009 to September 2010

Observers	Affiliations	Program	No.
Van Straten, Bailes, Bhat, Oslowski, Manchester, Hobbs, Keith, Johnston, Stappers, Kramer, Possenti, Camilo	Swinb, Swinb, Swinb, Swinb, CASS, CASS, CASS, CASS, MPIfR, CAO, UClmba	Precision Pulsar Timing	P140
Freire, Lorimer, Kramer, Lyne, Manchester, Camilo, D'Amico	MPIfR, JBO, MPIfR, JBO, CASS, UClmba, CAO	Timing and Searching for Pulsars in 47 Tucanae	P282
Bailes, Bhat, Verbiest, Van Straten	Swinb, Swinb, WVU, Swinb	Studies of Relativistic Binary Pulsars	P361
D'Amico, Johnston, Possenti, Lyne, Manchester, Corongiu, Camilo, Burgay, Sarkissian, Bailes, Van Straten, Kramer	CAO, CASS, CAO, JBO, CASS, CAO, UClmba, CAO, CASS, Swinb, Swinb, MPIfR	Timing and searching millisecond pulsars in globular clusters	P427
Burgay, Kramer, Stairs, Manchester, Lorimer, Mclaughlin, Lyne, D'Amico, Possenti, Ferdman, Camilo	CAO, MPIfR, UBC, CASS, JBO, WVU, JBO, CAO, CAO, UBC, UClmba	Timing & geodetic precession in the double pulsar and two relativistic binaries	P455
Manchester, Bailes, Jenet, Hobbs, Sarkissian, Van Straten, Yardley, Burke, Bhat, Oslowski, Hotan, Champion	CASS, Swinb, UTex, CASS, CASS, Swinb, CASS, Swinb, Swinb, Swinb, UCurt, MPIfR	A millisecond pulsar timing array	P456
Titov, Jauncey, Dickey, Tingay, Reynolds, Fey, Ellingsen, Lovell, Hase	, CASS, UTas, UCurt, CASS, USNO, UTas, UTas	Improving the terrestrial and celestial reference frame through Southern Hemisphere Geodetic VLBI Observations	P483
Cersosimo, Mader, Student	UPuert, CASS, UPuert	A 20CM Radio Recombination-Line Survey of the 4th Galactic Quadrant	P486
Eatough, Kramer, Lyne, Manchester, Hobbs, Stairs, Lorimer, Possenti, Burgay, Camilo, Jaroenjittichai, Keith	JBO, MPIfR, JBO, CASS, CASS, UBC, JBO, CAO, CAO, UClmba, UMan, CASS	Timing of binary and millisecond PKSMB/PH pulsars	P501
Ellingsen, Caswell, Breen, Quinn, Green, Fuller, Voronkov	UTas, CASS, UTas, UMan, CASS, UMan, CASS	The MMB Survey: Variable sources and the weakest masers	P502
Mclaughlin, Lyne, Lorimer, Kramer, Manchester, Stairs, Camilo, Keane, Miller, Palliyaguru, Smith	WVU, JBO, JBO, MPIfR, CASS, UBC, UClmba, JBO, WVU, WVU, WVU	Continued Timing Observations of Rotating Radio Transients	P511
Carretti, Staveley-Smith, Haverkorn, Cortiglioni, Gaensler, Kesteven, Bernardi, Poppi	CASS, UWA, NFRA, IASF-CNR, USyd, CASS, KI, CAO	S-band Polarization All Sky Survey (S-PASS)	P560
Possenti, Burgay, Rea, Israel, Perna, Colpi	CAO, CAO, UAm, OARome, JILA, UMILAN	Searching for radio pulsations from the transient AXP in Westerlund 1	P573
Johnston, Weltevrede, Manchester, Keith, Hobbs, Romani, Thompson, Thorsett, Roberts, Possenti	CASS, UMan, CASS, CASS, CASS, GSFC, UCSC, Eureka, CAO	Pulsar timing and the Fermi and AGILE missions	P574
Camilo, Reynolds, Sarkissian, Halpern, Ransom, Johnston	UClmba, CASS, CASS, UClmba, NRAO, CASS	Two radio magnetars	P602
Wolleben, Carretti, Dickey, Fletcher, Gaensler, Han, Haverkorn, Landecker, Leahy, Mcclure-Griffiths, Mcconnell, Reich	DRAO, CASS, UTas, UNT, USyd, NAOBei, NFRA, DRAO, UMan, CASS, CASS, MPIfR	Parkes 300 to 900 MHz Rotation Measure Survey	P617
Haverkorn, Carretti, Gaensler, Heiles, Kesteven, Mcclure-Griffiths, Mcconnell, Wolleben	NFRA, CASS, USyd, UCB, CASS, CASS, CASS, DRAO	The Southern Twenty-centimeter All-sky Polarization Survey (STAPS)	P624

Observers	Affiliations	Program	No.
Breen, Ellingsen, Caswell	UTas, UTas, CASS	12 GHz methanol masers towards Parkes Methanol Multibeam 6.7 GHz maser detections – northerly sources	P625
Burgay, Israel, Possenti, Rea	CAO, OARome, CAO, UAm	Searching for radio pulsations triggered by the X-ray outburst of magnetars	P626
Johnston, DeBoer	CASS, CASS	Testing of focal plane array technologies for ASKAP with 12m and 64m	P628
Spolaor, Bailes, Johnston, Van Straten	Swinb, Swinb, CASS, Swinb	Characterising J0941-39	P630
Keane, Stappers, Lyne, Eatough, Mclaughlin, Van Straten, Karastergiou, Kramer	JBO, JBO, JBO, WVU, Swinb, UOx, MPIfR	The Search for & Confirmation of Nearby RRAT Candidates	P661
Ekers, Alvarez-Muniz, Bray, James, Mcfadden, Phillips, Protheroe, Reynolds, Roberts	CASS, CASS, UAd, UMelb, CASS, UAd, CASS, CASS	A Radio Search for UHE Particles from Centaurus A	P668
Delhaize, Staveley-Smith, Meyer, Boyle, Kesteven, Bailes, Van Straten, Driver	UWA, UWA, UWA, CASS, CASS, Swinb, Swinb	Galaxy Evolution – A Pathfinder Study	P669
Keith, Johnston, Kerr, Ferrara, Van Straten, Camilo, Ray, Ransom, Bailes	CASS, CASS, UWash, GSFC, Swinb, UClmba, NRAO, Swinb	Discovering millisecond pulsars in unidentified Fermi sources	P675
Heesen, Westmeier, Koribalski, Adebahr, Dettmar	UHerts, CASS, CASS, AIR, AIR	Magnetic fields and the cosmic-ray transport in the Magellanic type galaxy NGC55	P694
Williams, Kraan-Korteweg, Woudt	UCT, UCT, UCT	Zone of Avoidance Tully-Fisher Survey	P697
Crawford, Lorimer, Mclaughlin, Kramer, Lyne, Stairs, Camilo, Burgay, Possenti, D'Amico, Freire	Haverford, JBO, WVU, MPIfR, JBO, UBC, UClmba, CAO, CAO, CAO, MPIfR	The Enigmatic Binary PSR J1723-28: A Baby Millisecond Pulsar?	P699
Fuller, Avison, Burton, Thompson, Caswell, Green	UMan, UMan, UNSW, UHerts, CASS, CASS	The Ammonia Properties of A Complete Sample of Methanol Masers	P702
Marka, Schreyer	AIU Jena, AIU Jena	CCS in Bok Globules – A Possible Age Indicator?	P704
Mader, Bourke	CASS, SAO	Chemical and dynamical evolution of cores in R Corona Australis	P706
Mcclure-Griffiths, Robishaw	CASS, USyd	An HI Search for a Magnetic Field in a High-Velocity Cloud	P735
Andersson, Crutcher, Bhat, Vaillancourt	JHU, UIl, Swinb	The Magentic Field in Tapia's Globule 2	P736
Hobbs, Van Straten, Manchester, Keith, Bailes, Carretti, Reynolds, Johnston, Oslowski, Jameson, Sarkissian, Khoo	CASS, Swinb, CASS, CASS, Swinb, CASS, CASS, CASS, Swinb, Swinb, CASS, RP	Commissioning the pulsar backends at Parkes	P737
Spolaor, Johnston, Van Straten, Bailes	Swinb, CASS, Swinb, Swinb	Characterising J0941-39	P739
Hobbs, Ravi, Lo, Norris, Wickramasinghe, Ferrario, Keith, Gaensler, Murphy	CASS, ANU, USyd, CASS, ANU, ANU, CASS, USyd, USyd	High time resolution observations of CU Virginis	P741
Ridley, Mclaughlin, Crawford, Lorimer	WVU, WVU, Haverford, JBO	A high time resolution survey of the Large Magellanic Cloud	P743
Edwards	CASS	Parkes NASA Observations	P746

Observations made with the Mopra Telescope

October 2009 to September 2010

Observers	Affiliations	Program	No.
Muller, Minamidani, Yamamoto, Fukui, Mizuno, Onishi, Kawamura	UNag, UNag, UNag, UNag, UNag, UNag	Characterization of the Magellanic Bridge CO population	M136
Lazendic-Galloway, Dame, Cunningham, Walsh, Slane	Monash, CfA, UNSW, JCU, CfA	Identifying molecular clouds associated with TeV-emitting SNR G347.3-0.5	M137
Barnes, Yonekura, Hernandez, Tan, Caselli, Molinari, Fukui	UFLOR, IBARU, UFLOR, UFLOR, ULeeds, UNag	CHaMP in CO & isotopologues – dynamics & chemistry of clump envelopes	M161
Walsh, Burton, Longmore, Purcell, Lowe, Lo, Breen, Brooks, Phillips, Voronkov, Cunningham, Jones	JCU, UNSW, CfA, UMan, UNSW, CEA, UTas, CASS, CASS, CASS, UNSW, UNSW	HOPS – the H2O southern galactic Plane Survey	M207
Baan, Loenen, Spaans	NFRA, LO, KI	The ISM in nearby galaxies: NGC1365	M250
Hughes, Ott, Wong, Muller, Pineda, Maddison	Swinb, NRAO, UIl, UNag, JPL, Swinb	Mapping the 30 Doradus Molecular Ridge with MOPS	M300
Tothill, Burton, Purcell, Millar, Walsh, Chapman, Wardle	UNSW, UNSW, UMan, QUB, JCU, UMac, UMac	Do the cyanopolyynes provide a chemical clock for hot molecular cores?	M347
Rowell, Burton, Fukui, Nicholas , Maxted, Kawamura, Nakashima	UAd, UNSW, UNag, UAd, UAd, UNag, UNag	Extending a 7mm survey of shocked and dense gas in the W28 SNR field	M390
Cluver, Jarrett, Koribalski, Appleton, Kraan-Korteweg	Caltech, Caltech, CASS, Caltech, UCT	Molecular Gas in HIZOA J0836-43 – How do you fuel an HI-massive starburst?	M394
Dame, Barnes	CfA, UFLOR	Molecular Clouds in the Far 3kpc Arm	M395
Muller, Loenen, Baan, Cunningham, Kawamura, Onishi, Fukui, Lo, Barnes, Walsh, Jackson, Li	UNag, LO, NFRA, UNSW, UNag, UNag, UNag, CEA, UFLOR, JCU, UBos, CfA	Galactic molecular sampler survey, 90-115 GHz	M420
Momose, Muraoka, Tosaki, Kohno, Okumura	UTOKYO NAOJ	12CO(J=1-0) mapping of one of the nearest Luminous Infrared barred spiral Galaxy NGC 1365	M422
Indermuehle, Edwards, Urquhart, Brooks	CASS, CASS, CASS, CASS	Maser and Flux Monitoring at 3mm, 7mm and 12mm	M426
Burton, Storey, Tothill, Hollenbach, Walker, Kulesa, Stutzki, Simon, Martin	UNSW, UNSW, UNSW, SETI, UAz, UAz, UKOELN, UKOELN, Oberlin	The Formation of Molecular Clouds	M446
Burton, Jones, Cunningham, Walsh, Tothill	UNSW, UNSW, UNSW, JCU, UNSW	The Central Molecular Zone at 7 Millimetres	M447
Smith, Eales, Isaak, Davies, Cortese, Auld	UCARDIFF, UCARDIFF, UCARDIFF, UCARDIFF, UCARDIFF, UCardiff	CO Observations of BLAST Nearby Galaxies	M449
Fuller, Avison, Burton, Thompson, Caswell, Green, Lenfestey	UMan, UMan, UNSW, UHerts, CASS, CASS, UMan	Probing The Molecular Environment of A Complete Sample of Methanol Maser Sources	M451
Fuller, Jackson, Peretto, Brooks, Wyrowski, Longmore, Rathborne, Cunningham, Barnes, Walsh, Ellingsen, Muller	UMan, UBos, UMan, CASS, MPIfR, CfA, CfA, UNSW, UFLOR, JCU, UTas, UNag	Complementary 45 GHz Observations of the MALT-90 Pilot Sources	M452

Observers	Affiliations	Program	No.
Cordiner, Charnley, Millar	GSFC, GSFC, QUB	A deep 3 mm survey of IRAS 15194-5115: a search for hydrocarbons, anions and cyanopolyynes	M454
Britton, Voronkov, Ellingsen	CASS, CASS, UTas	A search for class I methanol masers in Lupus	M486
Belloche, Parise	MPIfR, MPIfR	Are we witnessing the end of star formation in Chamaeleon I?	M506
Bourke, Ward-Thompson, Lee, Barnes, Di Francesco, Myers, Tothill, Evans	SAO, UCardiff, UFLOR, NRCC, SAO, UNSW, UTex	The evolution of low-mass dense cores	M510
Testi, Leurini, Zavagno, Deharveng, Cunningham, Molinari	ESO, MPIfR, OMs, UNSW	The bubbling galactic plane: fertilization or sterilization?	M515
Jackson, Brooks, Rathborne, Fuller, Cunningham, Wyrowski, Longmore, Muller, Jones, Mardones, Garay, Bronfman	UBos, CASS, CfA, UMan, UNSW, MPIfR, CfA, UNag, UNSW, UChi, UChi, UChi	Millimetre Astronomy Legacy Team 90 GHz Survey (MALT 90)	M516
Sivanandam, Sun, Koribalski, Rieke, Rieke, Jones, Sarazin	UAz, UVir, CASS, UAz, UAz, SAO, UVir	Stripped cold ISM and intracluster star formation in massive cluster A3627	M517
Chambers, Yusef-Zadeh	NWU, NWU	Characterizing Star Formation in Galactic Center IRDCs	M518
Nicholas, Maxted, Rowell, Burton, Walsh, Fukui, Kawamura	UAd, UAd, UAd, UNSW, JCU, UNag, UNag	Deep 12mm mapping of the molecular gas toward the W28 SNR/cloud interaction region.	M519
Maxted, Nicholas Rowell, Burton, Dawson, Walsh, Fukui, Kawamura	UAd, UAd, UAd, UNSW, UAd, JCU, UNag, UNag	Tracing shocked/disrupted gas towards the TeV gamma-ray supernova remnant CTB 37A	M522
Beuther, Tackenberg, Henning, Linz, Vasyunina, Krause, Nielbock	MPIA, MPIA, MPIA, MPIA, MPIA, MPIA	Kinematics and turbulence of Infrared Dark Clouds: Complementing Herschel far-infrared continuum observations with Mopra gas kinematics	M523
Thompson, Hindson, Urquhart, Clark, Davies	UHerts, UHerts, CASS, Open, ULeeds	Mapping the molecular environment of the G305 Giant HII region	M525
Pirogov, Vasyunina, Zinchenko, Linz, Voronkov	RAS, MPIA, CASS	Kinematic structure of high-mass star-forming regions at different stages of evolution	M526
Duarte Cabral, Fuller, Peretto	UMan, UMan, UMan	Lupus I observed at high resolution: testing models of star formation	M528
Zijlstra, Fuller, Hebden	UMan, UMan, JBO	Carbon and nitrogen isotopes in evolved stars	M530
Fuller, Lenfestey, Peretto	UMan, UMan, UMan	Filaments of IRDCs: The environments of massive cores	M531

VLBI Observations

October 2009 to September 2010

Observers	Affiliations	Program	No.
Deller, Tingay, Bailes	Swinb, UCurt, Swinb	Improving the VLBI astrometry of PSR 0437-4715	V190
Ojha, Lovell, Edwards, Kadler, Monitoringteam, Tingay	USNO, UTas, CASS, GSFC, , UCurt	Physics of Gamma Ray Emitting AGN	V252
Bartel, Bietenholz, Dwarkadas, Bauer, Tzioumis, Tingay, Ellingsen, Horiuchi, Booth	YU, HartRAO, UChig, UClmba, CASS, UCurt, UTas, CDSCC, HartRAO	The structure, deceleration, and distance of supernova 1996cr in Circinus Galaxy	V253
Ellingsen, Caswell, Voronkov, Dodson, Phillips, Green, Dawson, Menten, Shen, Reid, Hachisuka, Goedhart	UTas, CASS, CASS, UWA, CASS, CASS, UNag, MPIfR, SHAO, SAO, MPIfR, HartRAO	Astrometric Observation of Methanol Masers: Determining Galactic Structure and Investigating High-Mass star formation	V255
Moin, Tingay, Phillips, Taylor, Wieringa, Martin	Swinb, UCurt, CASS, UNM, CASS	e-VLBI follow-up of gamma-ray burst radio afterglows detected with the ATCA	V270
Petrov, Murphy, Tzioumis, Phillips, Sadler, Kim, Burke-spolaor, Pogrebenko, Bertarini, Bietenholz, Booth, Fomalont	, USyd, CASS, CASS, USyd, , Swinb, JIVE, MPIfR, HartRAO, HartRAO, NRAO	LBA_Calibrator_Survey-4	V271
Deller, Camilo, Reynolds, Halpern	NRAO, UClmba, CASS, UClmba	Measuring the proper motion of the magnetar PSR J1550-5418 with the LBA	V277
Dodson, Rioja, Surcis, Moriarty, Vlemmings, Ellingsen, Van Langevelde	UWA, UWA, CAO, UWA, UBonn, UTas, JIVE	Polarised VLBI observations of Methanol Masers with the LBA	V288
Tingay, Tzioumis, Moin, Fender	UCurt, CASS, UCurt, USouth	eVLBI observation of Circinus X-1 over two orbits of the binary system: evolution of the quiescent and flaring radio emission	V289
Tingay, Edwards, Phillips, Sadler, Deller, Hancock	UCurt, CASS, CASS, USyd, NRAO, USyd	VLBI observations of a low luminosity GHz-peaked spectrum sample from the AT20G survey	V308
Lenc, Norris, Middelberg, Mao	CASS, CASS, AIR, UTas	A search for AGN activity in Infrared-Faint Radio Sources (IFRS)	V309
Ellingsen, Norris, Lenc, Middelberg	UTas, CASS, CASS, AIR	The 5 GHz Faint Radio Population at VLBI Resolutions	V310
Beasley, Ellingsen	NRAO, UTas	Methanol Maser Proper Motion Measurement of the LMC	V316
Hotan, Reynolds, Hotan	UCurt, UCurt, UCurt	A New Phased-Array LBA Mode for High Precision Pulsar Science	V318
Deller, Loinard, Forbrich	NRAO, UNAM, CfA	The distance to the Coronet Cluster in Corona Australis	V329
Zanardo, Staveley-smith, Tzioumis, Ng, Tingay, Potter	UWA, UWA, CASS, UMcGill, UCurt, UWA	High Resolution Observations of SNR 1987A	V389

Tidbinbilla Observations

October 2009 to September 2010

Observers	Affiliations	Program	No.
Cordiner, Millar, Ni Chuimin, Walsh, Cox	QUB, QUB, UMan, QUB, ESA Villafranca	A search for hydrocarbon anions in Sgr B2	80
Tarchi, Castangia, Horiuchi	INAF, MPIfR, CDSCC	A search for 22 GHz water masers in recently identified INTEGRAL AGNs	100
Breen, Ellingsen, Caswell	UTas, UTas, CASS	Water masers towards 1.2 mm dust clumps – completeness test	101
Bourke, Myers, Caselli, Di Francesco, Jorgensen, Hedden	SAO, SAO, ULeeds, NRCC, CfA, SAO	The Initial Conditions for Star Formation in Clusters	120

E. Postgraduate Students Co-supervised by the CASS in 2010

Name	University	Project Title
Keith Bannister	University of Sydney	Archival and future searches for radio transients
Jay Blanchard	University of Tasmania	Linking the Radio and Gamma-Ray Properties of Blazars
Laura Bonavera	SISSA/ISAS	Planck-ATCA Coeval Observations
Justin Bray	Adelaide University	Ultrahigh energy neutrinos and their detection with the lunar Cherenkov technique
Tui Britton	Macquarie University	Methanol masers in star forming regions
Sarah Burke-Spolaor	Swinburne University of Technology	Supermassive Black Hole Binaries and Transient Radio Events: Studies in Pulsar Astronomy
Rajan Chhetri	University of New South Wales	The study of the large scale mass distribution in the Universe using gravitational lensing
Yanett Contreras	Universidad de Chile	Study of filamentary structures in the southern galactic plane
Andres Guzman	Universidad de Chile, Chile	Ionised jets in massive young star objects as sign of accretion dominated process in their formation
Chris Hales	University of Sydney	Radio polarisation and the origin of galactic and intergalactic magnetic fields
Douglas Hayman	Macquarie University	Densely packed focal plane arrays
Luke Hindson	Hertfordshire University, UK	Wide area molecular imaging of giant HII regions
Annie Hughes	Swinburne University of Technology	Molecular gas in the interstellar medium of the Large Magellanic Cloud
Suzy Jackson	Macquarie University	Integrated systems for next generation telescopes
Lina Levin	Swinburne University of Technology	The high time resolution universe
Kitty Lo	University of Sydney	Exploring the radio transient sky
Vicki Lowe	University of New South Wales	The environments of massive star formation
Elizabeth Mahony	University of Sydney	Understanding the high-frequency radio source population
Minnie Mao	University of Tasmania	Cosmic evolution of radio sources
Sui-Ann Mao	University of Sydney/Harvard University, USA	Magnetic fields in the Milky Way, the Magellanic Clouds and beyond
Deanna Matthews	La Trobe University	High velocity clouds around the Galaxy
Aquib Moin	Curtin University	e-VLBI Science with LBA: Exploring science application for the long baseline component of ASKAP
Vanessa Moss	University of Sydney	Low and intermediate velocity HI clouds in the Milky Way
Stefan Oslowski	Swinburne University of Technology	High precision pulsar timing and the formation and evolution of binary pulsars
Kate Randall	University of Sydney	Discriminating between active galactic nuclei and star forming galaxies in the Australia Telescope Large Area Survey
Anita Titmarsh	University of Tasmania	Investigating the earliest stages of massive star formation
Catarina Ubach	Swinburne University of Technology	Observations of grain growth in protoplanetary disks

Name	University	Project Title
Stuart Weston	Auckland University of Technology	Development and Astrophysical Applications of the High Performance Radio Astronomical Image Processing Pipeline for electronic-Very Long Baseline Interferometry (e-VLBI)
Marion Wienen	Rheinische Friedrich-Wilhelms University, Germany	Multi wavelength follow ups to the APEX telescope large area survey: the galaxy
Kathrin Wolfinger	Swinburne University of Technology	The effect of environment on the evolution of nearby gas-rich spiral galaxies
Daniel Yardley	University of Sydney	Pulsar timing arrays and their applications
Matthew Young	University of Western Australia	An investigation of pulsar dynamics using improved methods of time series analysis
Meng Yu	Peking University, China	Timing for radio pulsars

F: PhD Theses of Students Co-supervised by CASS Staff in 2010

Shari Breen (University of Tasmania, September 2010). "Masers as evolutionary traces of high-mass star formation".

Joanne Dawson (Nagoya University, December 2010). "Supershells as Molecular Cloud Factories in the Evolving ISM: Observations of HI and 12CO in the Galactic Supershells GSH 287+04-17 and GSH 277+00+36".

Alyson Ford (Swinburne University, July 2010). "The HI Cloud Population in the Lower Halo of the Milky Way".

Paul Hancock (University of Sydney, July 2010). "The Australia Telescope 20 GHz Survey and the Search for Young Radio Galaxies"

Emma Kirby (Australian National University, August 2010). "Sharing the Baryons: Stars and Gas in Local Volume Galaxies".

Rebecca McFadden (University of Melbourne, March 2010). "UHE neutrino detection using the Lunar Čerenkov technique".

Atilla Popping (University of Groningen; January 2010). "Diffuse neutral hydrogen in the Local Universe".

Urvashi Rau-Venkata (National Radio Astronomy Observatory, May 2010). ""Parameterized Deconvolution for Wide-Band Radio Synthesis Imaging".

Natasa Vranesevic (University of Sydney, September 2010). "Galactic distribution and evolution of pulsars".

G: Publications

Papers using ATNF data, published in refereed journals

* Indicates publication with CASS staff

C = Compact Array data, M = Mopra data, P = Parkes data, T = Tidbinbilla data, V = VLBI data, S = ASKAP- or SKA-related

*English, J.; Koribalski, B. S.; Bland-Hawthorn, J.; Freeman, K. C.; McCain, C. F. "The Vela Cloud: a giant H I anomaly in the NGC 3256 group". AJ, 139, 102-119 (2010). (C)

Smith, R. G. & Wright, C. M. "A silhouette envelope around GGD30IR detected by Spitzer". MNRAS, 401, 245-251 (2010). (C, M)

*Mao, M.Y.; Sharp, R.; Saikia, D.J.; Norris, R.P.; Johnston-Hollitt, M.; Middelberg, E.; Lovell, J.E.J. "Wide-angle tail galaxies in ATLAS". MNRAS, 406, 2578-2590 (2010). (C)

*Breen, S. L., Ellingsen, S. P., Caswell, J. L.; Lewis, B. E. "12.2-GHz methanol masers towards 1.2-mm dust clumps: quantifying high-mass star formation evolutionary schemes". MNRAS, 401, 2219-2244 (2010). (P)

Friesen, R. K.; Di Francesco, J.; Shimajiri, Y.; Takakuwa, S. "The initial conditions of clustered star formation. II. N2H+ observations of the Ophiuchus B core". ApJ, 708, 1002-1024 (2010). (C)

Barnes, P.J.; Yonekura, Y.; Ryder, S. D.; Hopkins, A.; Miyamoto, Y.; Furukawa, N.; Fukui, Y. "Discovery of large-scale gravitational infall in a massive protostellar cluster". MNRAS, 402, 73-86 (2010). (M)

*Subrahmanyan, R.; Ekers, R. D.; Saripalli, L.; Sadler, E. M. "ATLBS: the Australia Telescope Low-Brightness Survey". MNRAS, 402, 2792-2806 (2010). (C)

*Caswell, J. L.; Kramer, B. Hutawarakorn; Sukom, A.; Reynolds, J. E. "LBA observations of the maser cluster OH 330.953-0.182". MNRAS, 402, 2649-2656 (2010). (V, C)

Keane, E. F.; Ludovici, D. A.; Eatough, R. P.; Kramer, M.; Lyne, A. G.; McLaughlin, M. A.; Stappers, B. W. "Further searches for rotating radio transients in the Parkes Multi-Beam Pulsar Survey". MNRAS, 401, 1057-1068 (2010). (P)

*Huynh, M. T.; Norris, R. P.; Siana, B.; Middelberg, E. "Evidence for infrared-faint radio sources as z > 1 radio-loud active galactic nuclei". ApJ, 710, 698-705 (2010). (C)

Ott, J.; Henkel, C.; Staveley-Smith, L.; Weiss, A. "First detection of ammonia in the Large Magellanic Cloud: the kinetic temperature of dense molecular cores in N 159 W". ApJ, 710, 105-111 (2010). (C)

*Murphy, Tara; Sadler, Elaine M.; Ekers, Ronald D.; Massardi, Marcella; Hancock, Paul J.; Mahony, Elizabeth; Ricci, Roberto; Burke-Spolaor, Sarah; Calabretta, Mark; Chhetri, Rajan; and 14 coauthors "The Australia Telescope 20 GHz Survey: the source catalogue". MNRAS, 402, 2403-2423 (2010). (C)

*Zanardo, G.; Staveley-Smith, L.; Ball, Lewis; Gaensler, B. M.; Kesteven, M. J.; Manchester, R. N.; Ng, C.-Y.; Tzioumis, A. K.; Potter, T. M. "Multifrequency radio measurements of Supernova 1987A over 22 years". ApJ, 710, 1515-1529 (2010). (C)

*Prandoni, I.; de Ruiter, H. R.; Ricci, R.; Parma, P.; Gregorini, L.; Ekers, R. D. "The ATESP 5 GHz radio survey. III. 4.8, 8.6 and 19 GHz follow-up observations of radio galaxies". A&A, 510, A42 (2010). (C)

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H: CASS (ATNF) Media Releases 2010

New leader of CSIRO Astronomy and Space Science Division (20 January)

Following an extensive search and selection process, a senior researcher and university executive, Dr Philip Diamond, has been appointed Chief of CSIRO's Astronomy and Space Science Division.

http://www.csiro.au/news/New-leader-of-CASS.html

First signal received by future telescope (3 March)

An historic milestone was reached recently in Australia's bid to host the Square Kilometre Array telescope – a future international radio telescope that will be the world's largest and most sensitive.

http://www.csiro.au/news/First-signal-received-by-future-telescope.html

Honey, I shrunk the receiver (17 March)

CSIRO and Australian company Sapphicon Semiconductor Pty Ltd have signed an agreement to jointly develop a complete radio receiver on a chip measuring just 5 mm x 5 mm that could eventually be used in mobile phones and other communications technologies.

http://www.csiro.au/news/Honey-I-shrunk-the-receiver.html

Award boost Australia SKA effort (9 April)

CSIRO has been awarded three of the Australian Research Council's new Super Science Fellowships, worth a total of $835,000 over three years, to develop technology for the international Square Kilometre Array (SKA) radio telescope.

http://www.csiro.au/news/Award-boosts-Australian-SKA-effort.html

CSIRO telescope spots mega-star cradle (28 April)

Using a CSIRO radio telescope, an international team of researchers has caught an enormous cloud of cosmic gas and dust in the process of collapsing in on itself – a discovery which could help solve one of astronomy's enduring conundrums: 'How do massive stars form?'

http://www.csiro.au/news/Telescope-spots-mega-star-cradle.html

Aussies and Kiwis forge cosmic connection (26 May)

Using a CSIRO radio telescope, an international team of researchers has caught an enormous cloud of cosmic gas and dust in the process of collapsing in on itself – a discovery which could help solve one of astronomy's enduring conundrums: 'How do massive stars form?'

http://www.csiro.au/news/Telescope-spots-mega-star-cradle.html

Bursting 'bubbles' the origin of Galactic gas clouds (27 May)

Like bubbles bursting on the surface of a glass of champagne, 'bubbles' in our Galaxy burst and leave flecks of material in the form of clouds of hydrogen gas, researchers using CSIRO's Parkes telescope have found.

http://www.csiro.au/news/Bursting-bubbles-the-origin-of-galactic-gas-clouds.html

Natural energy to help power exploration of the Universe (15 June)

The Federal Government has announced today that the CSIRO will receive $47.3 million for the development of solar and geothermal energy technologies to power a radio-astronomy observatory and its supporting computer centre.

http://www.csiro.au/news/natural-energy-to-help-power-exploration-of-the-universe.html

Astronomers find cause of 'dicky tickers' (25 June)

In today's issue of Science, CSIRO astronomer George Hobbs and colleagues in the UK, Germany and Canada report that they have taken a big step towards solving a 30-year-old puzzle: why the 'cosmic clocks' called pulsars aren't perfect.

http://www.csiro.au/news/Astronomers-find-cause-of-dicky-tickers.html

A new way to weigh planets (24 August)

An international CSIRO-led team of astronomers has developed a new way to weigh the planets in our Solar System – using radio signals from the small spinning stars called pulsars.

http://www.csiro.au/news/A-new-way-to-weigh-planets.html

CSIRO 'hot rods' old telescope (13 October)

CSIRO has helped transform the University of Sydney's radio telescope into a world-class instrument, and along the way has learned lessons for its own ASKAP (Australian SKA Pathfinder) telescope.

http://www.csiro.au/news/Hot-rods-old-telescope.html

'Russian doll' galaxy reveals black holes' true power (9 November)

Following a study of what is in effect a miniature galaxy buried inside a normal-sized one – like a Russian doll – astronomers using a CSIRO telescope have concluded that massive black holes are more powerful than we thought.

http://www.csiro.au/news/Russian-doll-galaxy-reveals-black-holes-true-power.html

I: Abbreviations

AAL	Astronomy Australia Ltd
AAO	Australian Astronomical Observatory
AARNet	Australia's Academic and Research Network
ADASS	Astronomical Data and Software Systems
AGN	Active Galactic Nuclei
AIPS	Astronomical Image Processing System
ALFA	Arecibo L-band Feed Array
ALMA	Atacama Large Millimetre Array
ANZSCC	Australia – New Zealand SKA Coordination Committee
APSR	ATNF Parkes Swinburne Pulsar Recorder
ARC	Australian Research Council
ASCC	Australian SKA Coordination Committee
ASDAF	ASKAP Science Data Archive Facility
ASKAIC	Australasian SKA Industry Consortium
ASKAP	Australian Square Kilometre Array Pathfinder
ATCA	Australia Telescope Compact Array
ATLAS	Australia Telescope Large Area Survey
ATNF	Australia Telescope National Facility
ATSC	ATNF Steering Committee
ATUC	Australia Telescope User Committee
BETA	Boolardy Engineering Test Array
CABB	Compact Array Broadband Backend
CALOSIS	Centaurus A Synthesis Imaging Survey
CASS	CSIRO Astronomy and Space Science
CDSCC	Canberra Deep Space Communication Complex
CDF-S	Chandra Deep Field South
CMIS	CSIRO Mathematical and Information Sciences
CSOF	CSIRO Officer
CONRAD	Convergent Radio Astronomy Demonstrator
CoRE	Cosmological Reionization Experiment
COSMOS	Cosmological Evolution Survey
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAS	Data Acquisition Systems
DFB	Digital Filterbank
DIISR	Department of Innovation, Industry, Science and Research
DoIR	Department of Industry and Resources
DSN	Deep Space Network
EIF	Education Investment Fund
ELAIS	European Large Area ISO Survey
e-MERLIN	Extended Multi-Element Radio Linked Interferometer
EPICS	Experimental Physics and Industrial Control System
ESO	European Southern Observatory

EU SKADS	European SKA Design Study
FARADAY	Focal-plane Arrays for Radio Astronomy: Design, Access and Yield
FIR	Far Infrared
FITS	Flexible Image Transport System
FPA	Focal Plane Array
FPGA	Field Programmable Gate Arrays
FTE	Full Time Equivalent
GASS	Galactic All Sky Atomic Hydrogen Survey
GW	Gravitational Wave
HEMT	High Electron Mobility Transistor
HI	Neutral Hydrogen
HIPASS	HI Parkes All Sky Survey
HIZOA	HI Zone of Avoidance
HPC	High Performance Computing
HSE	Health, Safety and Environment
HVC	High Velocity Clouds
IAU	International Astronomical Union
ICIP	Industry Cooperative Innovation Programme
ICRAR	International Centre for Radio Astronomy Research
ICTC	Information and Communications Technology Centre
IEEE	Institute of Electrical and Electronics Engineers
IFRS	Infrared Faint Radio Sources
InP	Indium Phosphide
ISM	Interstellar Medium
ISSC	International SKA Steering Committee
IT	Information Technology
IVS	International VLBI Service
JIVE	Joint Institute for VLBI in Europe
JPL	Jet Propulsion Laboratory
KAT	Karoo Array Telescope
LBA	Long Baseline Array, used for Australian VLBI observations
LFD	Low Frequency Demonstrator
LNA	Low Noise Amplifier
LO	Local Oscillator
LOFAR	Low Frequency Array
LOFAR DMT	Low Frequency Array Dark Matter Telescope
LVHIS	Local Volume HI Survey
MASIV	Micro-Arcsecond Scintillation-Induced Variability
MIRIAD	Multichannel Image Reconstruction Image Analysis and Display
MIT	Massachusetts Institute of Technology
MMBS	Methanol Multibeam Survey
MMIC	Monolithic Microwave Integrated Circuit
MNRAS	Monthly Notices of the Royal Astronomical Society
MNRF	Major National Research Facilities

MOPS	Mopra Spectrometer
MRO	Murchison Radio-astronomy Observatory
MSF	MRO Support Facility
MSP	Millisecond Pulsar
MWA	Murchison Widefield Array
NASA	National Aeronautics and Space Administration
NCRIS	National Collaborative Research Infrastructure Strategy
NRAO	National Radio Astronomy Observatory
NRC-HIA	National Research Council Canada – Herzberg Institute of Astrophysics
NOT	Nordic Optical Telescope, Spain
NSF	National Science Foundation
OCE	CSIRO's Office of the Chief Executive
PAF	Phased Array Feed
PAPER	Precision Array to Probe Epoch of Reionization
PDFB	Pulsar Digital Filterbank
PMPS	Parkes Multibeam Pulsar Survey
PPTA	Parkes Pulsar Timing Array
PTF	Parkes Testbed Facility
RFI	Radio Frequency Interference
RSAA	Research School of Astronomy and Astrophysics
SCG	Southern Compact Group
SEST	Swedish-ESO Submillimetre Telescope, Chile
SINGS	Spitzer Infrared Nearby Galaxies Survey
SKA	Square Kilometre Array
SKAMP	SKA Molonglo Prototype
TAC	Time Assignment Committee
THEA	Thousand Element Array
TIGO	Transportable Integrated Geodetic Observatory
UCSD	University of California, San Diego
UNSW	University of New South Wales
URSI	International Union of Radio Science
USNO	United States Naval Observatory
VLA	Very Large Array
VLBI	Very Long Baseline Interferometry
VO	Virtual Observatory
VSOP	VLBI Space Observatory Program
WDM	Wavelength Division Multiplexed
WLAN	Wireless Local Area Network

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