
ICRAR
International
Centre for
Radio
Astronomy
Research
Volume 1
2009-2010
1

International Centre for
Radio Astronomy Research

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International Centre for Radio Astronomy Research

Curtin University

The University of Western Australia

Government of Western Australia

Contents

ICRAR's vision is to be a collaborative centre that is international in scope, achieving research excellence in astronomical science and engineering, and which, as a coherent and unified part of Australia's national effort, makes a fundamental contribution to the realisation and scientific success of the SKA.

Foreword

1
Dr Bernard Bowen, Chair of the ICRAR Board.
2
Artist's impression of the SKA dishes. *SPDO/TDP/DRAO/ Swinburne Astronomy Productions.*

The International Centre for Radio Astronomy Research, or ICRAR as it is now widely known both nationally and internationally, is an exciting partnership between the Government of Western Australia, Curtin University and The University of Western Australia. This Yearbook offers a glimpse of what can be achieved when people of competence, goodwill and enthusiasm come together in the interests of science and discovery.

The State Government's commitment to science and Australia's bid to host the Square Kilometre Array project was the starting point for ICRAR. With research nodes located at both Curtin University and UWA, Premier Colin Barnett officially launched the centre onto the world stage in September 2009.

Since then ICRAR has gone from strength to strength, growing exponentially and developing signature research themes in science, engineering and information and communication technology. A vibrant and exciting place of work, ICRAR attracts researchers from around the world to lead and support projects that explore and open up new areas of scientific endeavour.

A highlight in the development of ICRAR has been the opportunity for our researchers to reach out and engage the community. Through a plethora of outreach programs and a strong online presence, our researchers connect with the outside world and make it possible for others to share in the wonder and excitement generated by these projects.

Through this inaugural Yearbook, I take the opportunity to thank the Director and all those who have contributed to the development of ICRAR for their professionalism, their attention to detail and their untiring desire to bring the excitement of astronomy and astrophysics to the people of Western Australia and beyond.

Dr Bernard Bowen AM FTSE
Chair of the ICRAR Board

1

1
Artist's impression of mid frequency aperture arrays *SPDO/Swinburne Astronomy Productions.*
2
A visualisation of the layout of SKA antennas. *SPDO/Swinburne Astronomy Productions.*
3
An ASKAP antenna on site at the Murchison Radio-astronomy Observatory. *The WA Department of Commerce.*

The Square Kilometre Array

Is there intelligent life elsewhere in the Universe? What causes black holes? Was Einstein right about relativity? These are just some of the fundamental questions about the Universe that could be answered by the Square Kilometre Array (SKA).

The SKA is a €1.5 billion radio telescope that will provide us with unparalleled insights into physics, cosmology, and the beginnings of time. When built, it will focus on discoveries in five main areas:

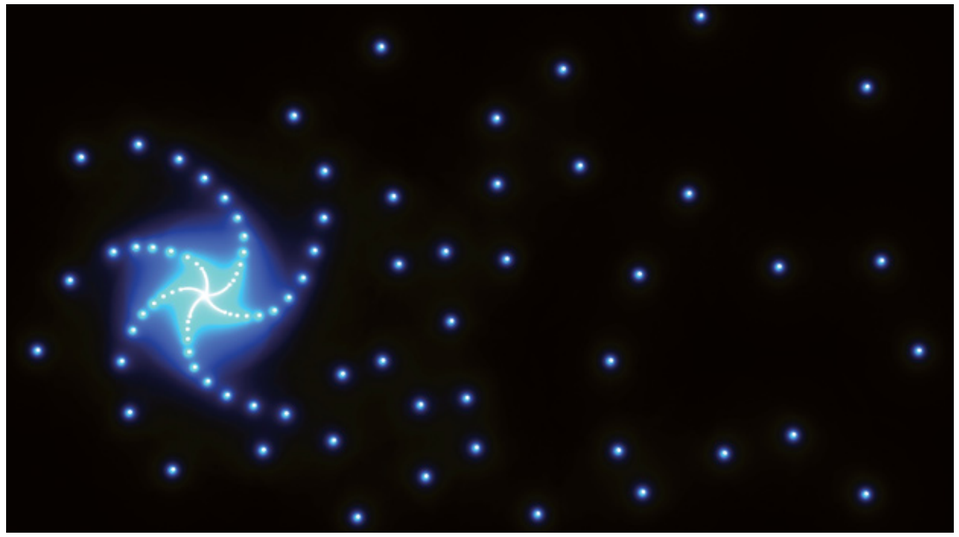
- **The Birth of the Universe**
  The formation of galaxies, dark matter and dark energy
- **The Cradle of Life**
  Searching for life and planets
- **Einstein's Gravity**
  Extreme tests of general relativity
- **The Dark Ages**
  Observing the first sources of light in the Universe
- **Magnetism**
  Investigating the origins & evolution of cosmic magnetism

The SKA is a partnership between 67 organisations in 20 countries, that will build a continent-sized radio telescope in either Australia and New Zealand or southern Africa (a decision on the site is expected in early 2012). It will be unlike any other scientific instrument and will require revolutionary new technology in fields such as high performance computing and manufacturing techniques.

The SKA will be made up of an array of antennas, arranged in clusters, that are spread over thousands of kilometres. These antennas will be linked electronically to form one enormous telescope.

The Australian SKA Pathfinder

The Australian Square Kilometre Pathfinder (ASKAP) is a $150 million radio telescope being constructed in Western Australia by the CSIRO. ASKAP will test new technologies for the SKA and will be a world-class telescope in its own right. When complete, will be the most powerful survey radio astronomy instrument in existence. ASKAP will be made up of an array of 36 dish antennas, each 12 metres in diameter.



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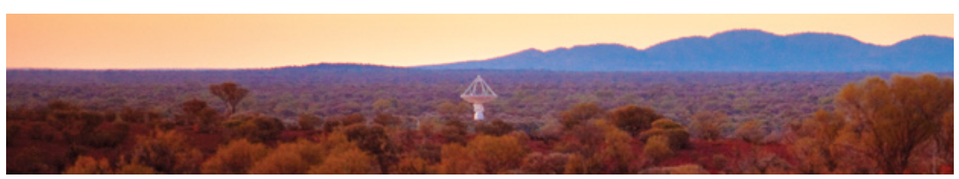

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The Murchison Widefield Array

The Murchison Widefield Array (MWA) is a $30 million low frequency radio telescope under construction at the Murchison Radio-astronomy Observatory. The array, in which ICRAR is a leading participant, is one of only three SKA precursors, or SKA pathfinders on a candidate site, and is an important step in realising the SKA.

A World-class Site

With a combined collecting area of one million square metres, the SKA will give mankind an ability to explore the Universe 10,000 times greater than any existing facility. This enormous leap in capability requires a location that can accommodate thousands of dishes spread over thousands of kilometres. The location also needs to be free of man-made radio noise that would otherwise interfere with the signals from the early Universe in the same way bright city lights drown out the light from distant stars in the night sky.

'In Western Australia, the unique radio quietness of the Mid West region offers one of the best places in the world to observe the Universe.'

In Western Australia, the unique radio quietness of the Mid West region offers one of the best places in the world to observe the Universe. Recognising this potential, the Australian Federal Government, working with the West Australian Government, put forward the Mid West as a home for the core site of the SKA. In making this offer, the two governments recognised the SKA would be the largest ground-based astronomy project of the 21st century and would dominate the national research agenda for the next 50 years.

The SKA represents a significant opportunity to increase Australia's impact in global science. It would expand Western Australia's academic, educational and industrial capabilities, attract world-class researchers and provide spin-off advantages for local communities.

The Federal and State Governments took the first step in preparing for the possibility of hosting the SKA by securing the land to build the Murchison Radio-astronomy Observatory. CSIRO designed and set about constructing ASKAP, an instrument that will showcase the Murchison Radio-astronomy Observatory site, test new technologies for the SKA and deliver world-class radio astronomy in its own right.

The final step was to develop the scientific community and infrastructure in Western Australia essential for conducting world-class research – and so ICRAR was born.

1
The UWA node
of ICRAR.
Dr Bradley Warren.

ICRAR
THE BEGINNING

We're already being noticed on the world stage of astronomy research.

‘Through its national and international partnerships and the energies of its staff and students, ICRAR’s activities are gaining attention around the world.’

1
Deputy Director Professor Lister Staveley-Smith at work with other researchers.
2
Director, Professor Peter Quinn.

1

ICRAR – The Beginning


2

Launched on the 1st of September 2009, the International Centre for Radio Astronomy Research (ICRAR) is a joint venture between Curtin University and The University of Western Australia. The centre’s research focus is the scientific capabilities enabled by the SKA and its pathfinders and the technology necessary to realise these new capabilities.

In ICRAR’s first year, the executive team finalised a comprehensive plan detailing the steps necessary to achieve the centre’s vision. This plan follows two strategic paths:

- **To develop and promote Australian capabilities in research skills, research performance and the creation of intellectual property.**
  This development will be built on the unique scientific opportunities afforded by the Murchison Radio-astronomy Observatory as well as the performance and scientific return of ASKAP and the Murchison Widefield Array. Through demonstrated and quantified capabilities, Australia can make a significant case that it is the best host nation to deliver the SKA to the world.
- **To ensure Australia is an active, effective and collaborative contributor to the advancement of the international effort to design and build the SKA.**
  This path does not specifically seek to promote Australia’s site but rather Australia’s capacity to contribute to the project as a whole.

ICRAR must balance its efforts along both strategic paths in response to evolving national and international opportunities. By doing so, ICRAR positions itself as an organisation with a future beyond its initial five year funding horizon. This long-term future could be in support of an SKA in Australia-New Zealand or an international SKA program in which Australia plays a number of possible leading roles.

Through its national and international partnerships and the energies of its staff and students, ICRAR’s activities are gaining attention around the world. The first year of operations has been one of significant growth:

- **People**
  The number of staff and students has more than doubled to 60 researchers and 30 graduate students. Two prestigious ARC Future Fellowships and five Super Science Fellowships were awarded to ICRAR – more than any other astronomical organisation in Australia.
- **A joint venture between two universities**
  Two young centres of astronomy and engineering research (Curtin Institute for Radio Astronomy and UWA Astronomy and Astrophysics) have grown into two research nodes within one organisation, ICRAR.
- **Resources**
  ICRAR has moved into world-class facilities. In the near future, one of the top 20 supercomputer centres in the world will be on our doorstep.
- **Commitment and achievement**
  ICRAR is now the largest contributing organisation to several work packages within the international PrepSKA program, and has made major contributions to the Australian SKA bid through a new VLBI demonstrator and SKA configuration studies.

The location for the SKA is expected to be decided in the coming year. Whatever the outcome, ICRAR is well positioned to make a significant contribution to the international effort to design and build the SKA and to participate in the fundamental discoveries it will make.

Governance and Management

Governing Board

ICRAR is governed by a competency-based board established under the Joint Venture Agreement and appointed by the State Government. The Board, which meets quarterly, has an independent chair and appointments are made by the Minister for Science and Innovation. Four Board members are appointed as nominees, with one member each nominated by Curtin University, The University of Western Australia, CSIRO and the Department of Commerce.

Dr Bernard Bowen	Chair
Professor Lyn Beazley	Independent member (science education)
Professor Brian Boyle	Independent member (radio astronomy)
Dr Vanessa Guthrie	Independent member (corporate governance & science administration)
Mr Phillip Jenkins	Nominated member (nominated by Department of Commerce)
Professor Linda Kristjanson	Nominated member (nominated by Curtin University)
Mr Graham McHarrie	Independent member (corporate governance)
Professor Alistar Robertson	Nominated member (nominated by The University of Western Australia)
Professor Tom Spurling	Nominated member (nominated by CSIRO)

Science and Technology Advisory Committee

The science and technology advisory committee meets every six months and counsels the Board on science and technology plans. It has an independent chair and seven competency-based members.

Professor Ron Ekers	Chair, CSIRO
Professor Arnold van Ardenne	ASTRON, The Netherlands
Professor Matthew Bailes	Swinburne University of Technology
Professor Erwin de Blok	University of Capetown, South Africa
Professor Geoff Bower	University of California, Berkeley, USA
Professor Peter Dewdney	University of Manchester, UK
Professor Elaine Sadler	University of Sydney
Professor Tom Spurling	ICRAR Board Member

Finance and Audit Committee

The finance and audit committee meets on a quarterly basis.

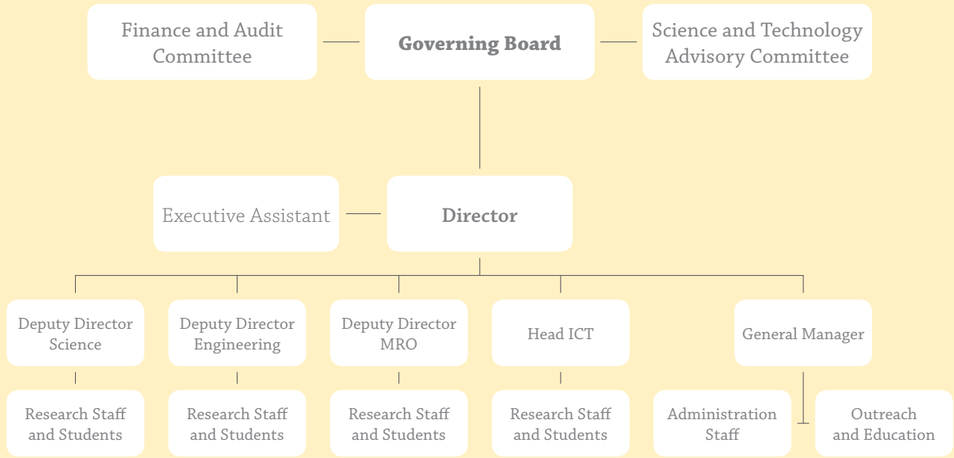
Mr Graham McHarrie	Chair
Dr Vanessa Guthrie	Member
Mr Philip Jenkins	Member
Mr Mark Woffenden	Member

Executive Team

The executive team consists of the director, three deputy directors from the science, engineering and MRO programs and the general manager.

Professor Peter Quinn	Director and CEO
Professor Steven Tingay	Deputy Director for MRO
Professor Lister Staveley-Smith	Deputy Director for Science
Professor Peter Hall	Deputy Director for Engineering
Dr Renu Sharma	General Manager

Organisational Structure



1
General Manager,
Dr Renu Sharma.

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An Inclusive, Innovative and Supportive International Centre

ICRAR aims for international excellence by creating a supportive and friendly environment that nurtures innovation and world-class research. All staff and students are provided with opportunities to develop professionally and interact with peers and mentors from around the world.

Researchers are encouraged to publish in world-class journals, bearing in mind intellectual property considerations. To this end ICRAR has developed a robust intellectual property management plan and offers workshops on intellectual property and commercialisation.

Staff, students and visiting researchers give presentations at well-attended seminars at both nodes of ICRAR several times a month. To encourage academic interaction and facilitate the exchange of ideas, Journal Club is held every Monday at the Curtin node and Astro Morning Tea every Wednesday at UWA.

ICRAR staff from both nodes come together frequently and All Hands meetings are held four times a year to update staff on new developments and progress across the organisation. A range of other special events, often involving work presented by postgraduate or scholarship students, take place throughout the year.

ICRAR aims to allow staff to have a healthy work-life balance, to be a fun place to work and to have an inclusive and supportive culture that nurtures excellence.

The executive delivered version 2.0 of the ICRAR plan to the Minister for Science in June 2010, containing a detailed description of ICRAR's vision and mission, its research and development programs and its 13 individual project plans. This triggered the first major instalment of cash from the West Australian government.

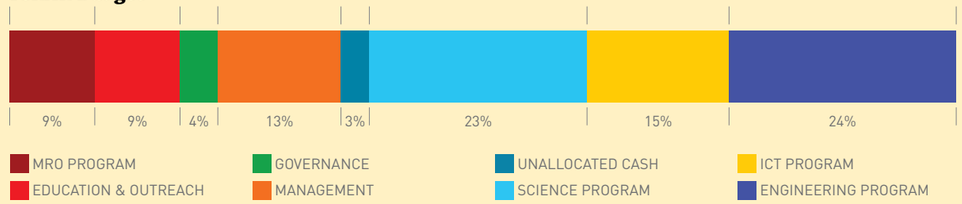
Achievement 2009–2010

Finances

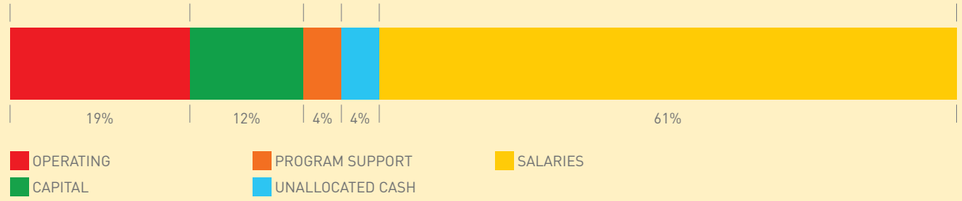
ICRAR is a $103 million centre, with $20 million committed by the State Government of Western Australia and $83 million cash and in-kind support committed by Curtin University and The University of Western Australia. The core cash budget of ICRAR is $32.87 million.

Over 70% of ICRAR's budget is allocated to the four research programs and nearly 10% is spent on education and outreach activities. The budget allocation for different ICRAR programs and expenditure as a percentage is shown below.

ICRAR Budget



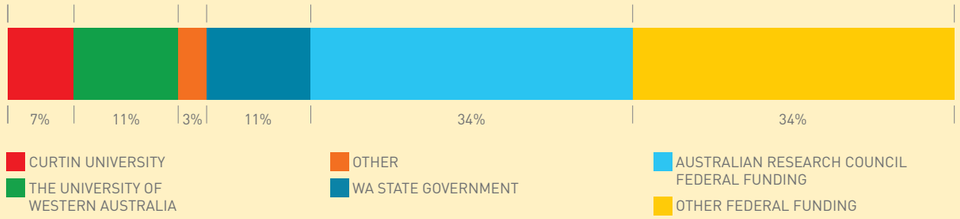
ICRAR Expenditure on Salaries and Operations



Research Grants

ICRAR has been very successful in leveraging its State Government and joint venture funding to win national and international research grants. To date ICRAR has generated an additional $26 million in grants for research projects and activities over the next seven years. ICRAR will continue to seek out new funding opportunities in order to extend the capabilities of the organisation.

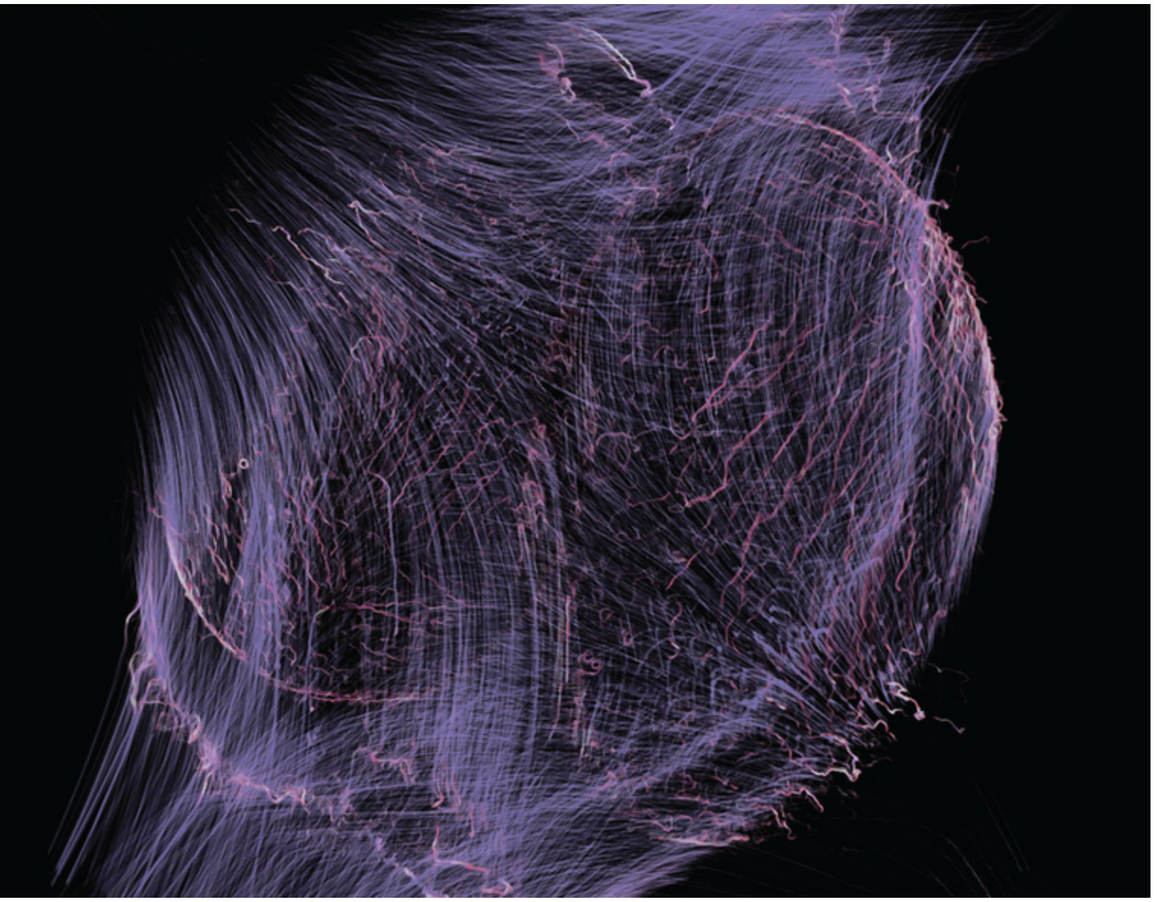
Additional ICRAR Research Grants Total $26 Million



1
Galaxy NGC 2915 at optical & radio wavelengths. Ed Elson/ G. Meurer/ W. J. G. de Blok.

SCIENCE

We're developing ways to get the most out of the world's next generation telescopes, including the Square Kilometre Array.



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1
A streamline rendering of particles at the shockwave from a simulation of Supernova 1987A. *Toby Potter & Derek Gerstmann.*
2
PhD student Jacinta Delhaize helping to set up an antenna at the Chilbolton LOFAR station in the UK.
3
An ASKAP antenna located at the Murchison Radio-astronomy Observatory. *The WA Department of Commerce.*

2

3

Science

ICRAR has three key science themes:

- **Galaxy Assembly and Evolution**
  By studying the properties of gas in the Universe, scientists can learn how galaxies form and evolve. This is done with extensive datasets from telescopes around the world and powerful supercomputing simulations.
- **The Variable Universe**
  The SKA pathfinders will be so sensitive across wide areas of the sky that they will open up new regions of 'observational space'. Technology is being developed to explore these never before studied aspects of the sky and scientists hope new discoveries of highly variable radio sources will allow them to explore extreme physics.
- **The High Angular Resolution Universe**
  Using new technology such as realtime correlation and widefield techniques to explore the Universe through high-resolution images.

ICRAR researchers are responsible for the scientific leadership or co-leadership of several of the ASKAP science survey teams that are currently conducting design studies. In a team effort astronomers, engineers and ICT specialists work together and have access to West Australian supercomputer facilities for rapid analysis of data.

ICRAR scientists also work on the Murchison Widefield Array science themes (Epoch of Reionisation, solar studies, variable sources and galactic/extragalactic science) and trailblazing observations on many of the world's telescope facilities.

To achieve these ambitious research aims, a significant number of tenured staff and fixed term postdoctoral fellows have been hired over the past year. ICRAR also values the growing number of postgraduate students enrolled at the centre. To facilitate national and international collaboration, ICRAR runs a visitor program and regularly hosts scientific workshops in Western Australia and sponsors similar workshops run by partner institutions.

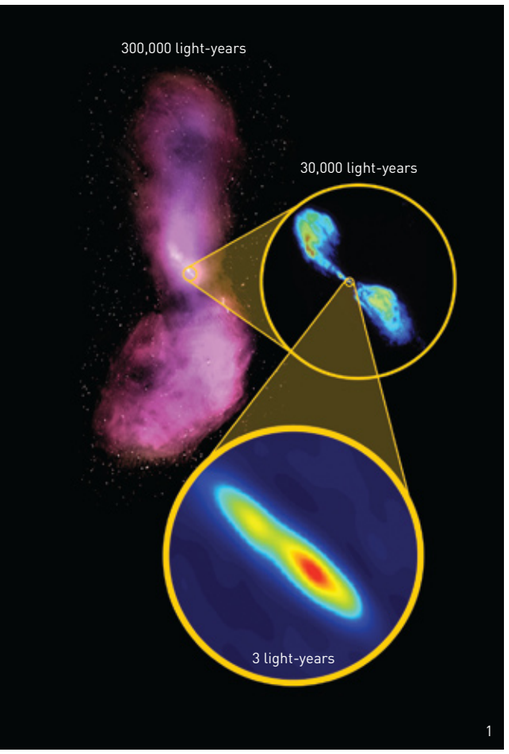
ICRAR was successful in its bid for leadership or co-leadership of four large survey projects using the ASKAP telescope, WALLABY, DINGO, CRAFT and VLBI.

Achievement 2009–2010

ICRAR led the science team for the 'first light' observations from the Murchison Radio-astronomy Observatory using the first dish of the ASKAP array and a similar dish in the North Island of New Zealand, some 5,500 km away.

Achievement 2009–2010

Very Long Baseline Interferometry



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Creating detailed images of galaxies millions of light years away is a huge challenge for radio astronomers. The detail of an image can be increased by using a larger telescope, but significant engineering problems arise as the size of the telescope increases.

There is an innovative solution – to simulate one large antenna with an array of smaller antennas using a technique called interferometry. The further apart the individual antennas are, the larger the simulated telescope and the higher the resolution of the final image. By separating the antennas by thousands of kilometres, the same resolution can be achieved as if using a single antenna thousands of kilometres wide.

Combining signals from antennas with large separations in this way is referred to as Very Long Baseline Interferometry. In Australia, radio telescopes in New South Wales, South Australia, the ACT and Tasmania are routinely connected to provide high resolution observations.

In April and May 2010, ASKAP's first antenna at the Murchison Radio-astronomy Observatory and a new antenna at Warkworth on New Zealand's North Island were included in the system, linking over a distance of 5,500 km for the first time. Observations were conducted of a range of radio sources, including radio galaxy Centaurus A, quasar 3C 273 and compact dual source PKS 1934-638.

The observations of Centaurus A studied the heart of the galaxy, where there is a resident black hole tucked away. The black hole shoots out jets of radio-emitting particles at almost the speed of light, causing its distinctive shape.

ICRAR deputy director Professor Steven Tingay used these observations to image Centaurus A in unprecedented detail at these wavelengths, a task made possible by the long distance separating the ASKAP and Warkworth antennas.

'By separating the antennas by thousands of kilometres, the same resolution can be achieved as if using a single antenna thousands of kilometres wide.'

Zooming in on the black hole at the centre of Centaurus A, 14 million light years away, is no easy feat. The resolution of the image produced is about 5 millarcseconds, which Professor Tingay likens to photographing the head of a pin from 20 km away.

This image of Centaurus A was featured at the International SKA Forum in the Netherlands in June 2010, where it was used to help demonstrate the 'maximum discovery' the Australia/New Zealand SKA candidate site can provide.

Another significant result for the new array arose from the observations of PKS 1934-638, a compact dual source radio galaxy. These high resolution observations revealed a separation between the two compact components in this radio galaxy that changed when observed in different frequencies of radio waves.

1
Zooming in to the heart of galaxy Centaurus A, 14M light-years away.
I. Feain, T. Cornwell & R. Ekers (CSIRO/ATNF); ATCA northern middle lobe pointing courtesy R. Morganti (ASTRON); Parkes data courtesy N. Junkes (MPIfR); Inner radio lobes: NRAO / AUI / NSF; Core: S. Tingay (ICRAR) / ICRAR, CSIRO & AUT.

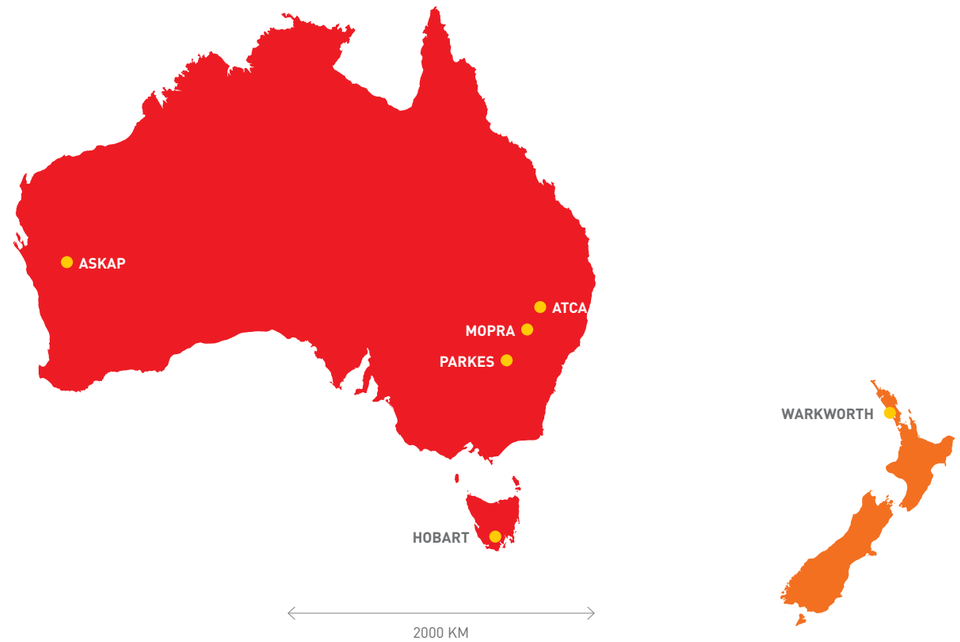
2
Geographic distribution of antennas used for Very Long Baseline Interferometry observations in April/May 2010.

'The resolution of the image produced is about 5 millarcseconds, which Professor Tingay likens to photographing the head of a pin from 20 km away.'

Before this observation, the change in separation was attributed to a change in the structure of the galaxy over time. But these new observations showed the separation is dependent on the frequency the galaxy is observed at, rather than a change in the structure of the galaxy over 40 years of observations. These results, published in The Astronomical Journal (Tzioumis, et al., 2010), mark the first documented science obtained from the new ASKAP and Warkworth antennas.

The high resolution observations used a custom digital backend built by ICRAR PhD candidate Bruce Stansby and installed at both ASKAP and Warkworth, with regular systems in place at the other telescopes. The data recorded at each telescope was transferred to ICRAR and combined using the DiFX software correlator.

As ASKAP is completed, all of its antennas will be included in the Australian Very Long Baseline Interferometry network, increasing the system's sensitivity to fainter objects. Both ASKAP's first antenna and the Warkworth dish are now included in the Australian Long Baseline Array and are available to astronomers from around the world. ICRAR is also working to establish use of the Giant Metrewave Radio Telescope in India for Very Long Baseline Interferometry observations, adding to regular partners in South Africa, Japan, China and the US.



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PROFILE
PROFESSOR GERHARDT MEURER

1

'By comparing the nearest galaxies to the most distant ones detectable, we might be able to see this evolution in a galaxy's structure.'

1
Professor Gerhardt Meurer.
2
Galactic wreckage in Stephan's Quintet. *NASA, ESA and the Hubble SM4 ERO Team.*

Professor Gerhardt Meurer
Research Winthrop Professor,
Extragalactic Star Formation

Professor Gerhardt Meurer's research is improving our understanding of how dark matter is placed within galaxies and how galaxies evolve.

Galaxies are constructed of four key components, stars, dust, gas and dark matter. Stars and dust can be studied using optical and infrared telescopes and the gas is visible to radio telescopes, but dark matter within galaxies cannot be directly observed.

"I am trying to understand the relationship between the distribution of gas in galaxy disks and their dark matter distribution," Professor Meurer said.

"This may allow us to predict how the structure of galaxies changes with time."

Professor Meurer joined ICRAR in January 2010 to take part in ASKAP science surveys and draw on its new capabilities in his galaxy evolution research. When complete in 2013, ASKAP will study very distant galaxies.

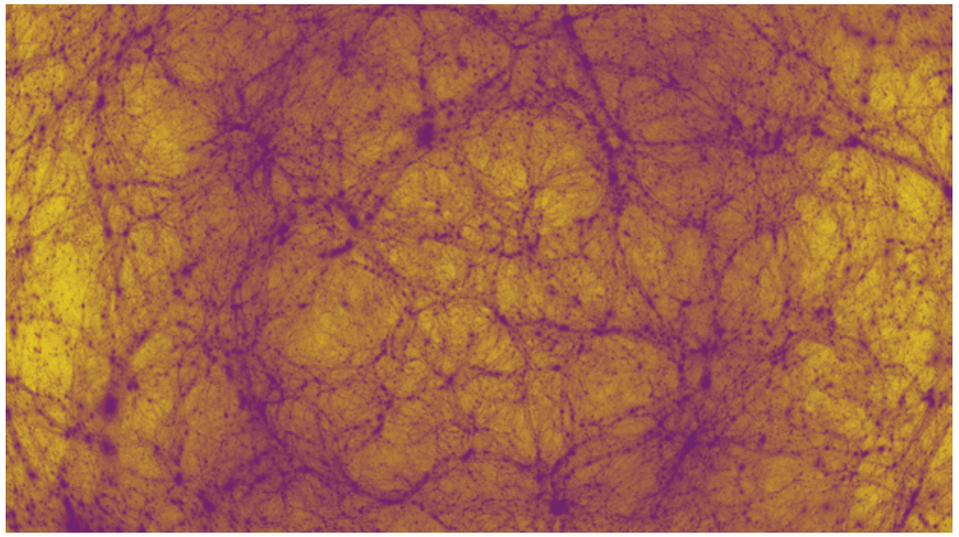
Because it takes significant time for their light to reach us, far away galaxies appear younger than those close by, allowing comparisons between galaxies from different periods in the Universe's history.

"By comparing the nearest galaxies to the most distant ones detectable, we might be able to see this evolution in a galaxy's structure," Professor Meurer said.

Before joining ICRAR, Professor Meurer researched galaxy evolution at The Johns Hopkins University in the United States.

"Above all, my favourite part of my job is still doing research," he said.

2



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The Cosmic Web

1
The dark matter forms filaments that stretch across 500 million lightyears of this simulated Universe; at the intersection of these filaments it accumulates into dense clumps in which galaxies grow.
Dr Alan Duffy (Simulation), Paul Bourke (WASP iVEC) (Visualisation).

The cosmic web is the name given to the gas that lies along immense filaments of dark matter stretching across the Universe. Galaxies are dispersed along these filaments like morning dew on a spider's web. The distribution of gas and filaments has been well defined theoretically using large simulations, but the cosmic web has never been directly observed. If we were able to directly detect the web, this combined with the theoretical models and simulations would uncover a wealth of information about the Universe and how structures such as our own galaxy were formed.

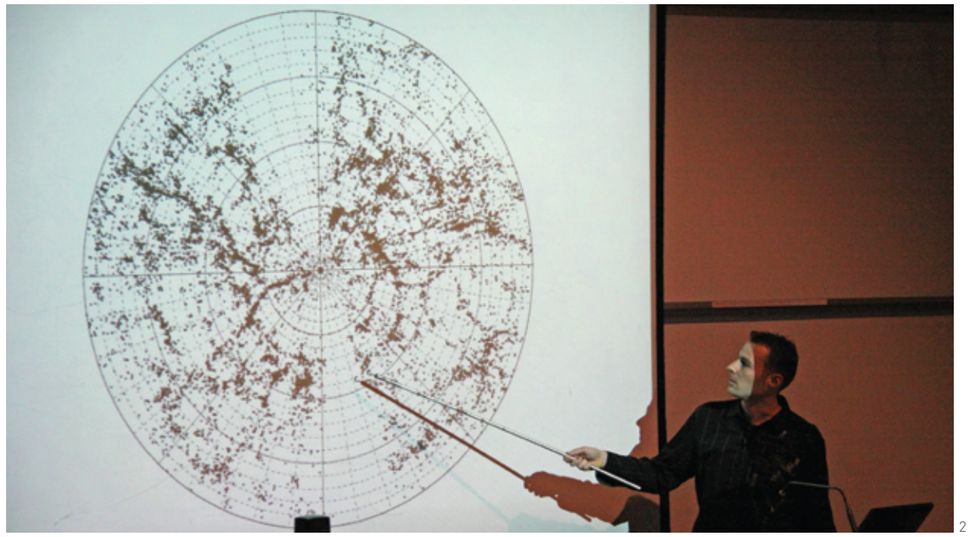
'This is a rapidly developing field bringing together observers, theorists and programmers - each of whom must push the boundaries of their respective disciplines.'

But realising this goal is a challenge on both theoretical and observational grounds. To be successful, we must simulate and survey an enormous region of the Universe, detecting extremely weak signals with exquisite sensitivity.

Only a next generation facility such as ASKAP or the SKA would be able to detect the weak signals at the level of sensitivity required, and even the SKA could not directly image the web in a single observation. Instead, we need to make observations of specific regions and add together, or 'stack', these measurements to improve sensitivity and reinforce the signal.

For this reason simulations are an invaluable tool. They can tell us about the relationship between galaxies (which we can observe) and the underlying web along which they lie. Armed with this simulated information we can develop algorithms and play a cosmic game of 'join the dots', before comparing predictions of where the web should be found with actual observations taken with an instrument such as ASKAP.

This is a rapidly developing field bringing together observers, theorists and programmers - each of whom must push the boundaries of their respective disciplines. It is only at ICRAR that all three are under the same roof and have the resources to realise this exciting goal of making the first detections of the cosmic web.



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All-Sky Astronomy with CAASTRO

2
PhD student Florian Beutler presenting his work at the Astronomical Society of Australia, Hobart Tasmania.
John Goldsmith.

The ARC Centre of Excellence for All-sky Astrophysics (CAASTRO) is the latest hub of astronomical research in Australia. The decades ahead will see radio astronomers, optical astronomers, theoretical astrophysicists, high performance computing specialists and engineers working together at the centre to answer some of the most fundamental questions of our time.

The three science themes of CAASTRO are:

- **The Evolving Universe**
  When did the first galaxies form, and how have they evolved?
- **The Dynamic Universe**
  What is the high-energy physics that drives change in the Universe?
- **The Dark Universe**
  What are the dark energy and dark matter that dominate the cosmos?

Australia has invested more than $400 million in the development of widefield astronomy instrumentation such as ASKAP, MWA, the AAT and SkyMapper and the associated infrastructure and high performance computing facilities.

'ICRAR will be the largest recipient of ARC funding in the consortium, receiving $5.4 million.'

CAASTRO was awarded $20.6 million in the most recent round of ARC funding and is scheduled to begin operations in April 2011. ICRAR will be the largest recipient of ARC funding in the consortium, receiving $5.4 million.

With links to institutions around the world, CAASTRO is administered by the University of Sydney under the direction of Professor Bryan Gaensler and driven by a group of Australian institutions including the Australian National University, the University of Melbourne, Swinburne University and ICRAR. ICRAR's Professor Lister Staveley-Smith is the centre's deputy director while Professor Steven Tingay is a member of the executive team. In 2011 ICRAR and CAASTRO will develop a major project relating to the Epoch of Reionisation (see page 57).

More information about CAASTRO can be found at *www.caastro.org.au*

1

PROFILE
DR MINH HUYNH

'I joined ICRAR because it is growing so rapidly, with many leading researchers in radio astronomy coming from around the world.'

1
Dr Minh Huynh.
2
A diagram showing an Earth based telescope observing a compact source through the moving interstellar medium.
3
PhD student Kevin Koay.

Dr Minh Huynh
Research Associate Professor and Deputy International SKA Project Scientist

Dr Minh Huynh spends her days observing distant super-massive black holes called active galactic nuclei.

Dr Huynh is currently making an image of an area slightly bigger than a full Moon in a part of the sky called the Chandra Deep Field South. This part of sky has been well studied by telescopes such as the Hubble Space Telescope, Spitzer Space Telescope and Chandra X-Ray Observatory.

Dr Huynh is also the deputy international SKA project scientist. Working with project scientist Joe Lazio and astronomers around the world, her role is to ensure that the goals of astronomers are met by the technical design of the SKA.

"I am essentially the interface between astronomers and engineers for the SKA project," Dr Huynh said.

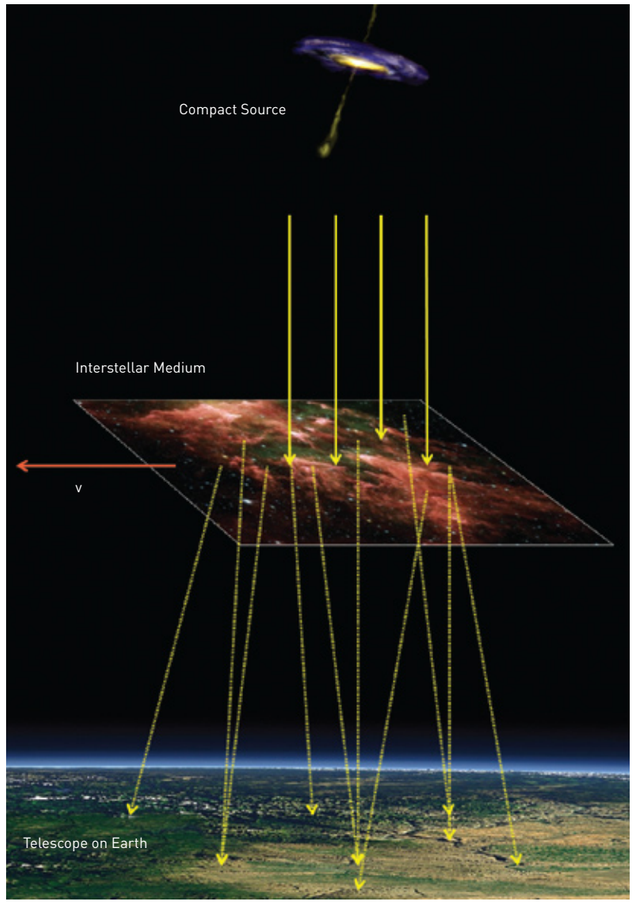
"We are continually refining and updating the science case of the SKA to derive more specific technical requirements for the engineers.

"I have been interested in the SKA project for years and the chance to play a key role in its development was very attractive."

Before arriving at ICRAR, Dr Huynh studied distant galaxies with NASA's Spitzer Space Telescope. She also developed a compact source catalogue of objects both in and beyond the Milky Way using Planck, a European Space Agency satellite.

"I joined ICRAR because it is growing so rapidly, with many leading researchers in radio astronomy coming from around the world," she said.

"I like that I am challenged every day."



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3

Studying the Universe with the Interstellar Telescope

Most people know that when they look at the night sky the stars seem to twinkle but planets do not. This is because the Earth's atmosphere acts like a small telescope. The light from stars is refracted by the random fluctuations in the atmosphere, causing them to twinkle. But the images of our neighbours in the Solar System are large enough that the random twinkling from one edge of the planet's image is different from the random twinkling at the other edge; combine these patterns and they cancel out.

Twinkling occurs at radio wavelengths too, but in this case it is caused by the atmosphere of our own Milky Way galaxy. While atmospheric twinkling is a nuisance to optical astronomers, radio twinkling is generated at interstellar distances, and the resolving power of the resulting 'interstellar radio telescope' is enormous. In effect, the telescope has a diameter of about one hundred million kilometres, enabling us to study the images of quasars, the bright regions around supermassive black holes at the centres of distant galaxies, with a resolution better than a hundred millionth of a degree.

A group of researchers including ICRAR's Jean-Pierre Macquart and Hayley Bignall, have uncovered the curious result that quasars at very large distances twinkle less than their nearby counterparts, indicating that the apparent images of quasars at high redshift are larger. Why is this?

ICRAR PhD student Kevin Koay is leading an international team of researchers in a project to harness the Interstellar Telescope to find out. One enticing explanation is that the apparent size increase with redshift is caused by the Intergalactic Medium, the elusive, tenuous matter that exists between galaxies, with a density of only one particle every ten cubic metres. Detecting this medium is important because over 80% of the ordinary matter in the Universe - the stuff that people, planets and stars are made of - is thought to reside there.

But, whatever the explanation, this high-resolution glimpse into the distant Universe is sure to reveal some astonishing insights.

1
The inner workings of an MWA receiver.

ENGINEERING

Our engineers are tackling frontier experiments requiring innovation in astrophysics and instrumentation.

1

Engineering

1
The first receiver for the Murchison Widefield Array low frequency radio telescope.
2
David Emrich, MWA Commissioning Engineer.
3
Artist's impression of mid frequency aperture arrays. *SPDO/Swinburne Astronomy Productions.*
4
Professor Peter Hall in an anechoic testing chamber. *Curtin University.*

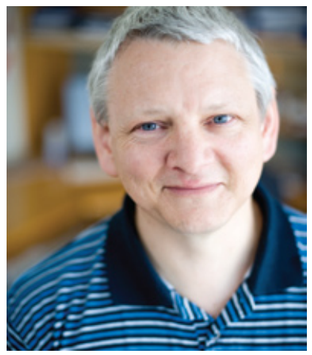
ICRAR is one of few international astronomy institutes to have an embedded engineering capability. Under the direction of Professor Peter Hall, our engineers are directly involved in critical parts of the SKA design, including areas related to the SKA's low frequency antennas. ICRAR's engineering projects fall into the following broad areas:

- Establishment of a leading-edge radio astronomy engineering laboratory with antenna, radio frequency and digital systems capabilities.
- Design, development and characterisation of new generation sparse aperture arrays for the SKA, folding in experience from the Murchison Widefield Array and other instruments.
- Delivery of new hardware and software instrumentation to support the integration of ASKAP into the Australian Very Long Baseline Interferometry network.
- Delivery of hardware and software instruments, deployable on ASKAP and elsewhere, for exploring the high time resolution (fast transient) Universe.
- Development of new instruments to support ICRAR astronomers in their search for the global spectral signature associated with the Epoch of Reionisation in the early Universe.
- Implementation of strategic and operational electromagnetic compatibility activities to ensure the continuing radio quietness of the Murchison Radio-astronomy Observatory.

The high impact, practical, nature of ICRAR's engineering projects provides cross-disciplinary training for the system specialists who will design and construct the SKA.

The prototype 32-antenna Murchison Widefield Array passed a full test and verification process and is now operational and collecting substantial amounts of engineering and science data.

Achievement 2009–2010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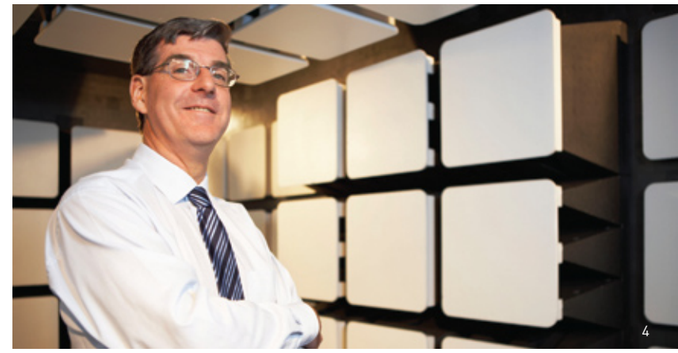
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The Aperture Array Verification Program

'In conceptual terms, aperture arrays replace the familiar parabolic dish.'

Together with researchers from nine European Union nations, ICRAR's engineers and scientists are making a significant contribution to the SKA Aperture Array Verification Program. This program addresses the design and prototyping of all-electronic 'aperture array' receptors for the detection of cosmic radio waves in the 70MHz to 1400MHz range. Through the development of large collectors composed of many small, low cost antenna elements, the program is pivotal to the design and scientific application of the SKA.

In conceptual terms, aperture arrays replace the familiar parabolic dish (which can be thought of as a beam-former based on optics and steel) with an all-electronic equivalent. Within the aperture array, many small antennas collect incoming radio waves and the beam-forming is done electronically, typically using time-delay and add operations.

The electronic beam-forming can be replicated many times to give beams in many different directions simultaneously, resulting in a very wide total field-of-view on the sky. Other advantages flowing from the lack of moving parts include essentially instantaneous beam position switching and the potential for higher operational reliability.

Aperture arrays are frequently divided into two categories depending on the distance (in wavelengths) between the small antennas. If the separation is more than a half-wavelength the array is 'sparse'. Sparse arrays have the useful property of allowing the aperture array effective collecting area to grow rapidly as the operating frequency decreases, partly counteracting the increasing galactic noise and tending to preserve the sensitivity of the radio telescope.

The merits of sparse aperture arrays at low SKA frequencies (<300 MHz) has been clear for some time, but with new antenna, receiver and signal processing technologies, the sparse approach may offer a cost-effective solution to beyond 450 MHz. After this point dishes or dense phased arrays become progressively more attractive.

The Aperture Array Verification Program defines a number of stages of research, development and demonstration in order to deliver deployable systems for the SKA by 2016. ICRAR has system design, technology development, prototyping and array characterisation roles within the program.

The centre has a well defined five-year aperture array project through which it will contribute about $7 million in cash and in kind support to the Aperture Array Verification Program. It is the only non-European contributing participant, and much of the required sparse array prototyping will be done at the Murchison Radio-astronomy Observatory in conjunction with WA-based companies.

Over the next year, ICRAR's contribution to the Aperture Array Verification Program will be directed to four main areas.

- Examination of the merits of conical spiral elements for the low frequency component of the SKA.
- Development of new radio frequency systems suitable for a variety of sparse array elements.
- Investigation of low-power, low-cost fibre-optic data links. These links are an enabling technology for very wide field-of-view systems within the SKA.
- Assessment of the merits of solar power for individual array elements. A solar solution could reduce SKA capital and operating costs and, used with fibre-optic links, would provide important electrical isolation.

In September 2011, ICRAR will host an international workshop addressing the science and engineering aspects of SKA-low, the section of the telescope covering the band 70-450 MHz.

1

PROFILE
DR NATHAN CLARKE

'I found the magnitude of the SKA inspiring and was excited by the prospect of all this happening here in WA.'

1
Dr Nathan Clarke.
2
Exposed circuitry of an MWA receiver being worked on in the ICRAR lab.
3
The ICRAR lab at Curtin University.
4
MWA dipole antennas located in the Murchison Radio-astronomy Observatory.

Dr Nathan Clarke
Research Engineer

Dr Nathan Clarke has every kid's dream job - he works with engineers at NASA's Jet Propulsion Laboratory. Together they are developing ways to detect a type of fast-changing radio signal called a fast transient.

Fast transient radio signals from astronomical sources are typically associated with highly energetic and bright cosmic events, all on extreme scales. Studying them can offer clues to the physical nature of the Universe.

"Due to their short timescales, these signals are often invisible to conventional radio telescopes," Dr Clarke said.

"Tomorrow's instruments, such as ASKAP and the SKA, need to be outfitted with new real-time signal processing systems in order to search for them."

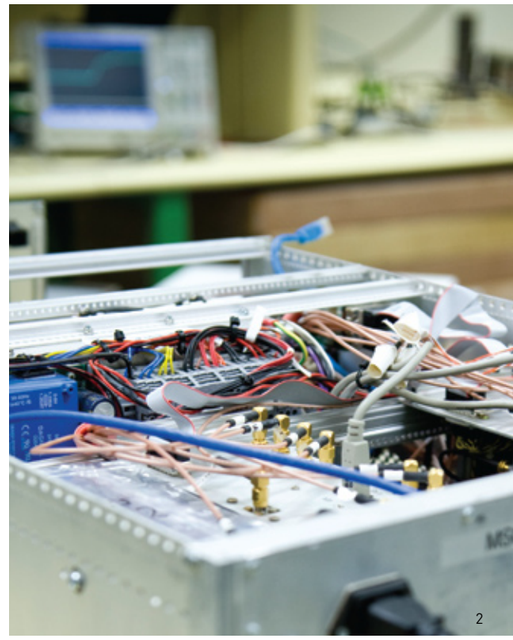
Dr Clarke has extensive experience in designing electronics for telecommunications, wireless LAN and mobile phones, but a passion for solving interesting engineering problems led him to join ICRAR in early 2010.

"I found the magnitude of the SKA inspiring and was excited by the prospect of all this happening here in WA," he said.

"I wanted to be a part of it."

Dr Clarke now manages the High Time Resolution engineering project at ICRAR. His work is intended to guide the design for ASKAP's fast transient detection system, a project that has great potential given ASKAP's ability to survey large sections of the sky very quickly.

He also assists the group defining system requirements for detecting fast transient radio signals with the SKA.



2

The Engineering Lab

ICRAR is establishing a $2.4 million cutting-edge engineering laboratory to support research in technical astronomy and the Murchison Radio-astronomy Observatory program. Located at the Curtin node, the lab provides space, equipment and supplies to enable researchers to turn their ideas into reality.

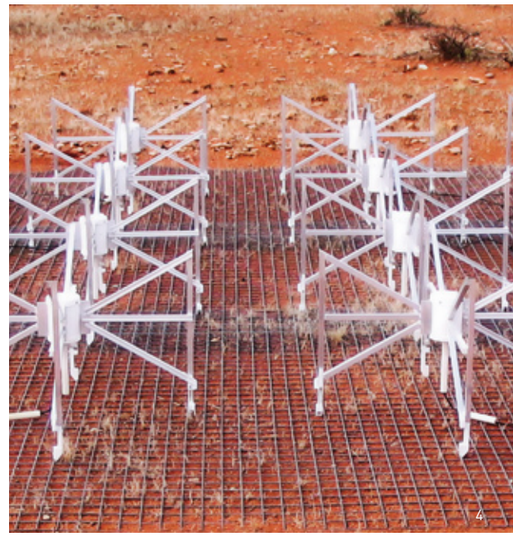
The lab also provides the expertise to support design, construction and testing of prototype electronic circuits. Through relationships with local industry partners, these can then be refined into mass-producible systems that can be deployed as technology demonstrators at sites including the Murchison Radio-astronomy Observatory.

Over the past year, the laboratory has been fitted out with purpose-built workbenches, storage systems, a radio frequency screened test chamber and essential test and measurement equipment. More advanced measurement instruments will be acquired in the future, including a state-of-the-art vector network analyser for characterising low-noise radio frequency amplifiers and antennas. There are also plans to develop an outdoor facility for the construction and testing of larger antenna systems.

Present users of the laboratory include engineers testing the radio telescope receiver and signal processing hardware for the Murchison Widefield Array, two PhD students building electronics and antenna prototypes and faculty researchers working on antenna simulations and prototype receiver hardware. In the future, it is expected the laboratory will be occupied by researchers working on the development of high-speed signal processing systems for transient signal detection, novel active antenna designs for the SKA Aperture Array Verification Program and other Murchison Radio-astronomy Observatory projects.

The laboratory underlines ICRAR's commitment to novel engineering and technology in support of the Murchison Radio-astronomy Observatory and SKA development activities.

3



4

RADIO ASTRONOMY IS THE YOUNGEST CHILD OF THE OLDEST OF SCIENCES

Joseph ‘Joe’ Lade Pawsey, 1957

Conical Spiral Antennas

1
PhD student Aziz Jiwani testing a prototype conical antenna design in an anechoic chamber.
2
Tony Costa (left), Managing Director of Lateral Sands Solutions, discussing industry interaction with Senior Research Engineer Mark Waterson.

As part of its involvement with the Aperture Array Verification Program (AAVP), ICRAR has undertaken the design and prototype development of a sparse aperture array antenna element that will operate over the broad frequency band of 70-450 MHz.

The element, based on a conical spiral design, is one of several being evaluated by the Aperture Array Verification Program consortium. The spiral is an attractive antenna in many respects, having terminal and radiation characteristics which remain fairly constant with frequency.

The design features constant beam patterns, high front-to-back ratio, consistent impedance behaviour, low pattern ellipticity (enabling good polarisation purity) and relatively low mutual coupling in an array configuration. The spiral antenna belongs to the travelling wave antenna category, where the radiation due to the current distribution along the surface takes place during the travelling wave process in a smooth and continuous manner. This gives the antenna its stable characteristics over a wide frequency band.

To better understand the behaviour of conical spiral antennas, various designs have been studied using electromagnetic tools involving solvers such as Finite Element Method and Method of Moments.

Despite its advantages, the spiral is a single polarisation antenna (either left or right-hand circular) in its basic form. It is also more complex to fabricate than its dipole competitors. ICRAR is working to produce a dual-polarisation 'counter-wound' spiral which can be printed onto an easily-deployed dielectric sheet.

Other AAVP contributors are studying the pros and cons of several other elements. However, element performance is only one aspect of a complex system optimisation for AAVP and, regardless of the final choice, ICRAR engineers will be central to the development and characterisation of the next-generation test arrays to be deployed at the Murchison Radio-astronomy Observatory.

1

Engineering Briefing Day

2

In July 2010, ICRAR invited about 65 guests from industry, academia and government to hear about some of the centre's engineering projects, including those involving ASKAP and the SKA. Professor Peter Hall set the scene with an overview of the SKA, its current status, recent developments and ICRAR's contribution to the global engineering development effort.

Senior members of the engineering team spoke about topics such as next generation antenna prototyping, the Murchison Widefield Array rollout, the benefits of sparse aperture arrays for the SKA and 'trailblazer' transient radio source detection systems for ASKAP.

The day's discussions focused on exciting new areas of SKA science and engineering, and the resulting opportunities for local collaborators to participate in high impact programs with ICRAR. The guests showed particular interest in the electromagnetic compatibility project, which focuses on developing the best methods for testing equipment and protecting the radio quietness of the Murchison Radio-astronomy Observatory.

While the briefing went well beyond the 'cup of tea' originally envisioned, the overwhelmingly positive feedback made it clear ICRAR's collaborators and sponsors appreciated an informal, conversational approach to hearing about the centre's plans and aspirations. A frank discussion of the challenges in realising the SKA was also very useful, with industry appreciating the level of innovation being pursued and the SKA community listening to the wisdom of industry representatives in areas such as remote facility development. Given the success of the day, more briefings covering engineering and other ICRAR programs are likely to be held in 2011.

1 A view inside the 6500 slot robotic tape library operated by iVEC. The StorageTek SL8500 library is currently being updated with higher capacity tape drives which will allow for storage of up to 32.5 PB of uncompressed data. *Prof. Andreas Wicenec.*

INFORMATION AND COMMUNICATIONS TECHNOLOGY

We're working on some of the greatest computing challenges in the world today.

Information and Communications Technology

The data volumes, data flow rates and processing requirements of the SKA and its pathfinders pose huge challenges for information and communications technologies. Radio astronomy projects are already attracting the attention of industrial leaders such as IBM, Cisco, Intel, Google and Microsoft.

ICRAR's proximity to the Murchison Radio-astronomy Observatory, the experience of its staff in designing and operating data intensive facilities and the capabilities of the new Pawsey High Performance Computing Centre for SKA Science provide a unique opportunity for the centre to take a leading role in radio astronomy ICT research internationally.

ICRAR is developing a signature capability in the area of data intensive research. The centre's ICT team, led by Professor Andreas Wicenec, will have seven full time staff by the middle of 2011. The team will focus on two main development projects, building a data intensive research pathfinder for ASKAP and Murchison Widefield Array data and the development of the SKA science data system design. A third ICT project will involve the application of high performance computing technologies to a range of other ICRAR signature capabilities.

The ICT program also has a robust educational focus, supervising several PhD and internship students and working with universities in Perth to establish computer science courses with an emphasis on supercomputing and the SKA.

A conceptual layout of the overall process and control system for end-to-end science operations of the SKA was developed by ICRAR and incorporated into a plan developed by the international SKA Program Development Office.

Achievement 2009–2010

The SKA - an ICT Radio Telescope

'New Scientist recently estimated the global internet data traffic for 2010 to be around 22 billion gigabytes per month. The SKA will manage at least this in a single day.'

"Space is big, really big. You just won't believe how vastly hugely mind-bogglingly big it is." Douglas Adams, author, The Hitchhiker's Guide to the Galaxy

Observing the entire Universe through space and time, from now to the very first stars and galaxies to exist over 10 billion years ago, is an unparalleled feat of human scientific endeavour. New Scientist recently estimated the global internet data traffic for 2010 to be around 22 billion gigabytes per month. The SKA will manage at least this in a single day, requiring the world's most sophisticated supercomputers.

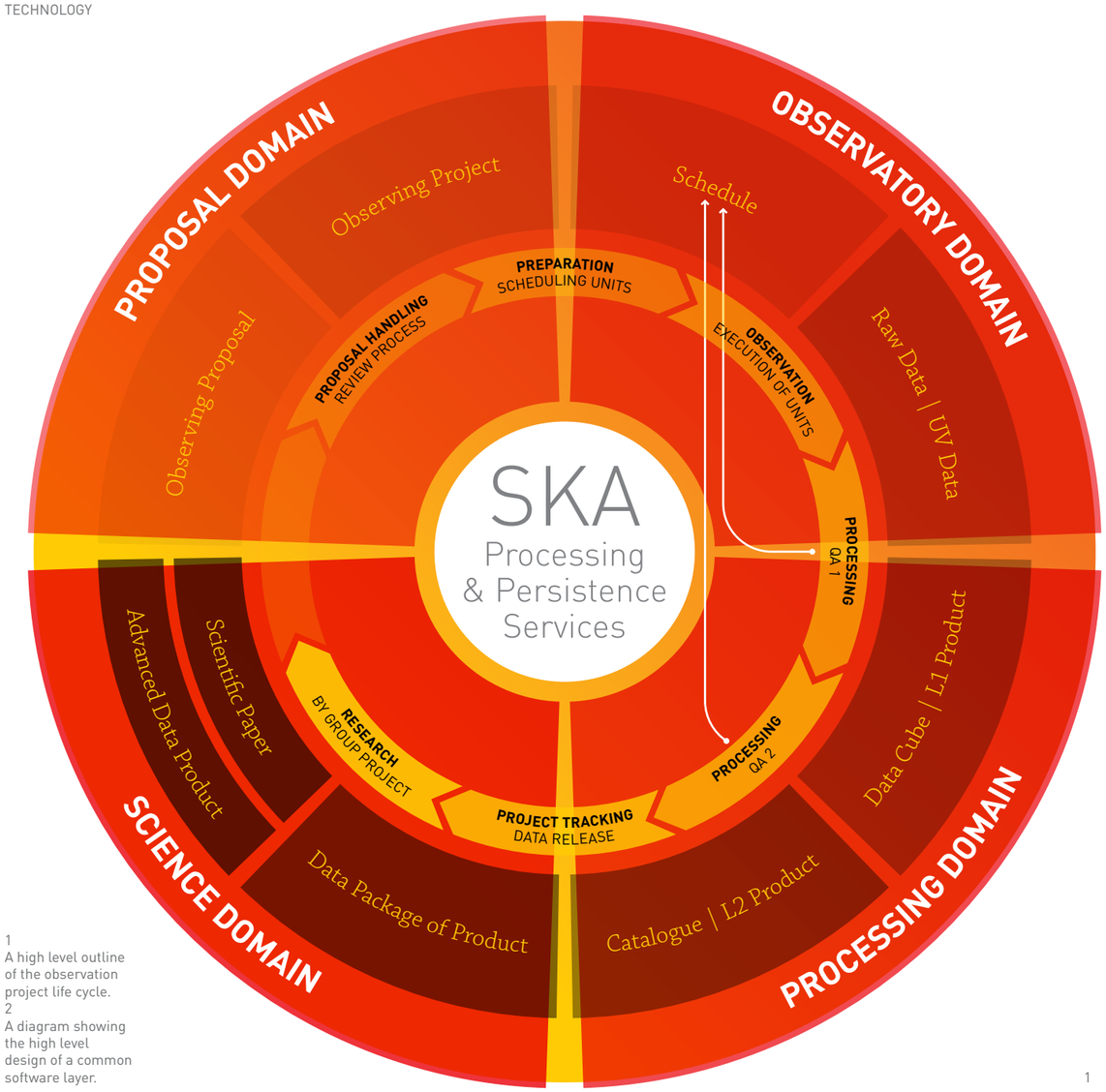
At its heart, the SKA will be an ICT telescope, with data flowing from thousands of antennas to a central computing hub at speeds between two and five million gigabytes per second. With these unimaginable volumes of data to transfer, store, analyse and extract science from, building the SKA starts with designing data management solutions for a range of problems, including algorithm design and optimisation, networking, processing and power efficiency.

ICRAR is creating a conceptual systems design for the SKA, a project headed up by astronomer and ICT specialist Professor Andreas Wicenec. In designing a system capable of dealing with the data generated by the SKA, it is important to identify what can be solved by adapting design patterns and technologies created for other global facilities. It is a task Professor Wicenec is well equipped to take on, with his expertise in the science data flow and archives of some of the world's largest observatories, including the Atacama Large Millimeter/submillimeter Array (ALMA).

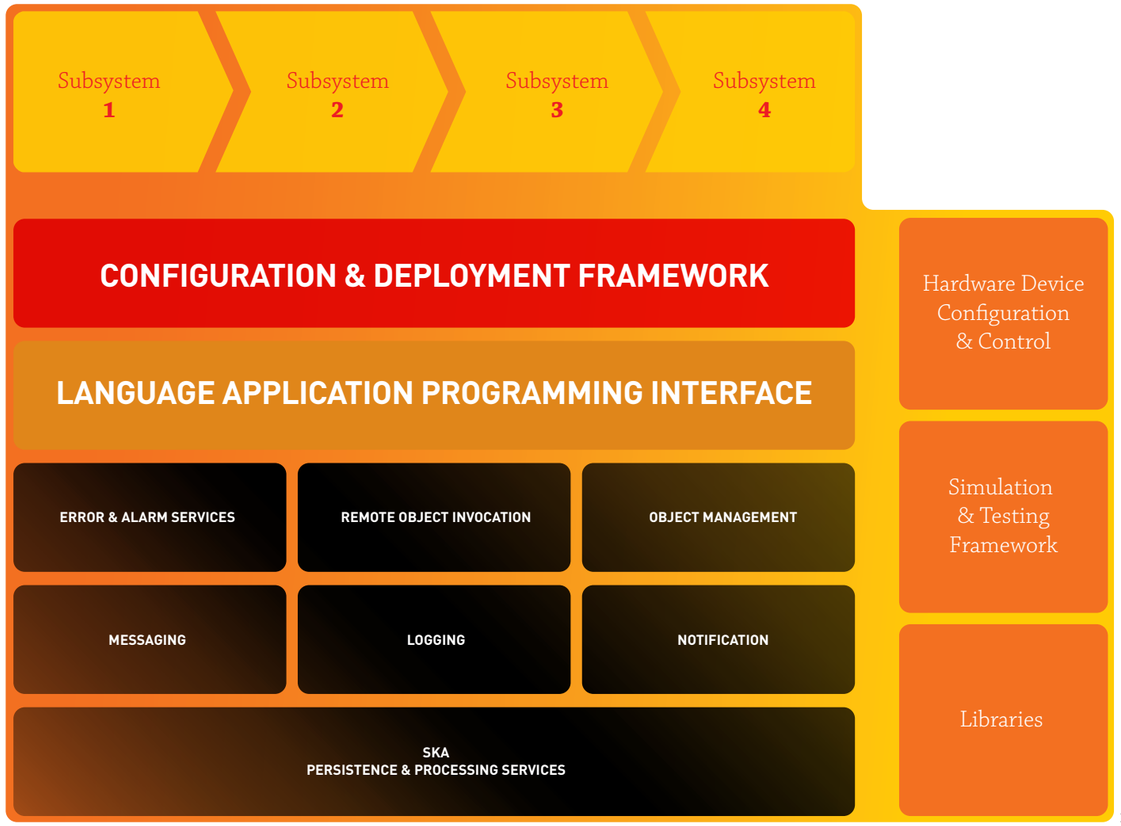
The term 'archive' in the ALMA data flow does not correctly reflect the functionality of that layer of the enormous software package driving the observatory. A more suitable name would be the 'observatory persistence layer'. This persistence layer provides the short, mid and long term 'memory' of the observatory. It contains not just the scientific data but all relevant data and information to execute observations and keep track of the observatory environment.

For the SKA, this means storing and managing device sensor data from thousands of individual antenna stations, distributed over several thousand kilometres. This is novel terrain for astronomy, but fairly common in national power grids, for instance.

Based on experience with ALMA, the proposed SKA project life cycle is a three dimensional, layered model with the 'processing & persistence services', or 'archive', at the very bottom. The observing project life cycle is used to bind all the required software services together into a single high level view. The life cycle is divided into four domains - proposal, observatory, processing and science.



1
A high level outline of the observation project life cycle.



2
A diagram showing the high level design of a common software layer.

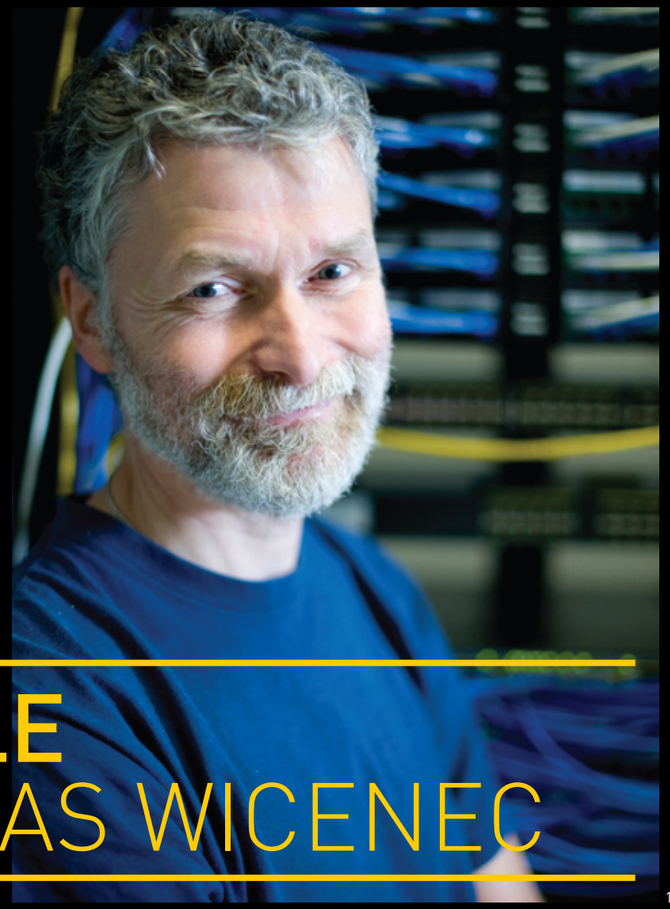
1

The proposal domain encapsulates all the services and data needed for scientists to propose new observing projects. Once accepted by selection committees, the 'observing proposal' is turned into an 'observing project' containing a detailed technical description of how the observations are to be carried out by the observatory.

In the observatory domain, observatory information is collected in the proposal domain to prepare long, mid and short-term schedules before executing the highest priority observation in the queue. In the processing domain 'raw data' from the observation is turned into data cubes and catalogues at speeds approaching real-time. Both the collection of the raw data and the processing into data cubes require dedicated, very high performance computing capabilities.

Once all observations for a particular project have been obtained we enter the science domain, where project scientists receive a package of the collected data. For SKA observations, the size of this data package might be of the order of petabytes, requiring the development of new distribution techniques. Ideally the data will not be widely distributed but released to associated high performance computing where scientific evaluation can be carried out. The resulting 'advanced data products' and 'scientific papers' will be fed back into the SKA archive where they can potentially be used to define new 'observing proposals'.

Based on experience with the development of the ALMA software system ICRAR is designing a layer of common software packages and tools. This will allow development teams to focus on the implementation of the required functionalities of their respective subsystems, while relying on a broad basis of commonly required services and tools, like logging, monitoring and messaging.



PROFILE
ANDREAS WICENEC

1

‘I like working with this mixture of astronomy and IT, and being able to contribute to the SKA is really exciting.’

1
Prof. Andreas Wicenec.
2
The back-side of the EPIC cluster unveils a truly impressive amount of cables for power, networking and intercommunication
Prof. Andreas Wicenec.

Professor Andreas Wicenec
Winthrop Research Professor,
Data Intensive Research

As the head of ICRAR’s ICT program, Professor Andreas Wicenec’s work ensures scientists will be able to analyse the huge amounts of data generated by next generation radio telescopes.

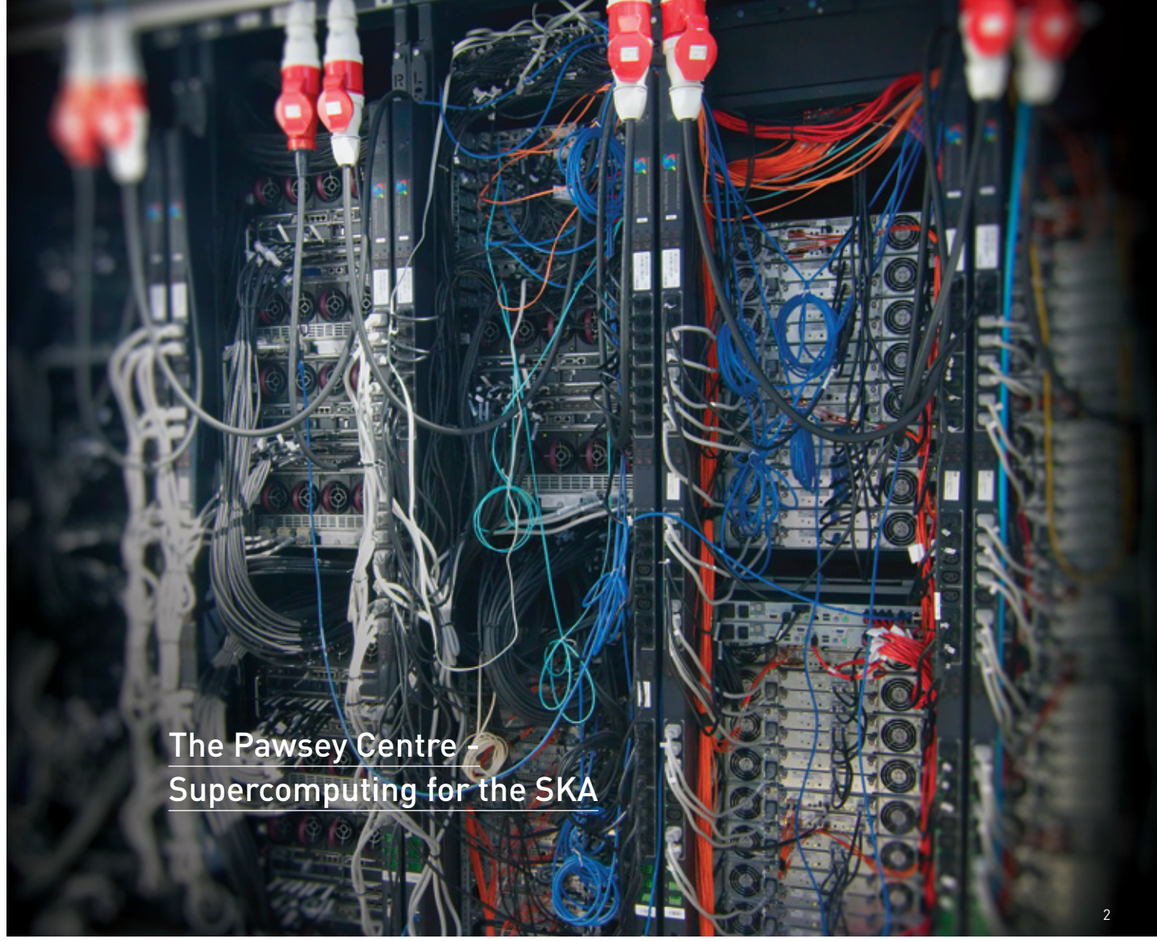
“ASKAP and the SKA are amazing astrophysical instruments that pose enormous challenges for data flow, data management and processing,” he said.

“I like working with this mixture of astronomy and ICT, and being able to contribute to the SKA is really exciting.”

Before joining ICRAR in August 2010, Professor Wicenec spent over a decade designing and implementing science archival systems for the European Organisation for Astronomical Research in the Southern Hemisphere (ESO).

He also led the archive development team for ALMA, a radio telescope under construction in Northern Chile.

Professor Wicenec and his team work with researchers around the world to develop innovative solutions for database management, data storage and high performance computing.



The Pawsey Centre – Supercomputing for the SKA

2

The computational elements of the SKA will need to process up to an exabyte, or one billion gigabytes, of data every day. To process and interpret this much scientific information will take computers faster, larger and more energy efficient than anything currently available.

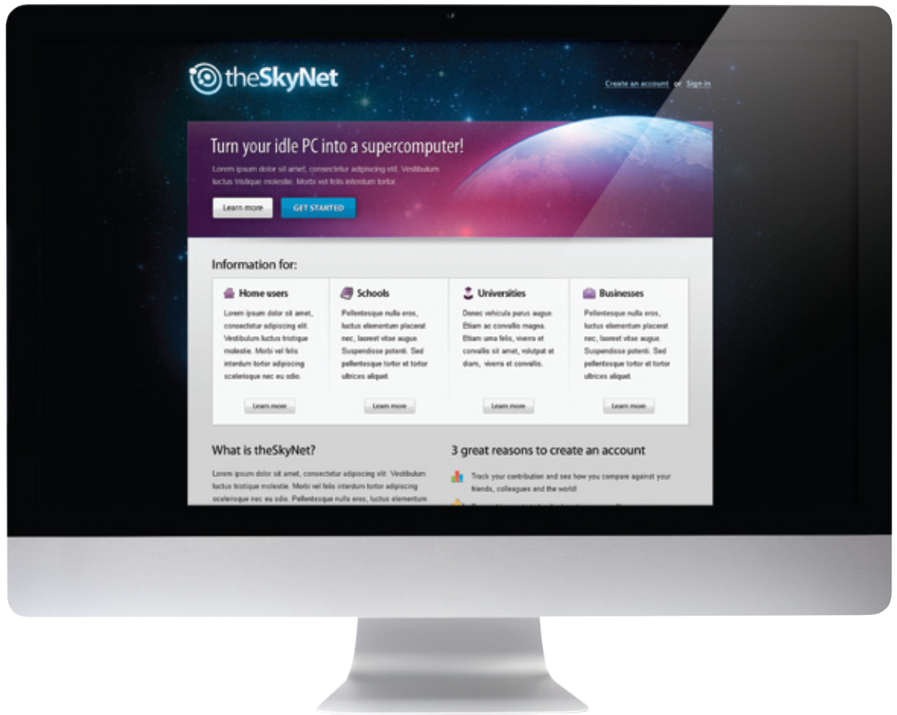
‘The POD is the second most powerful supercomputer in Australia, and ranked number 87 in the world.’

The Pawsey High-Performance Computing Centre for SKA Science (Pawsey Centre) is an $80 million centre funded by the Australian Government’s Super Science Initiative in 2009. The Pawsey centre will be designed, built and operated by iVEC, a consortium of CSIRO and four universities in Perth (Curtin, Edith Cowan, Murdoch and UWA) and will be fully operational by the end of 2013. The Pawsey Centre will provide an extremely powerful supercomputing facility in WA, ready for use by ASKAP and the Murchison Widefield Array as well as in the fields of nanotechnology, life science and geoscience. ICRAR staff are advising iVEC, who are designing the Pawsey Centre’s systems, on the specialist requirements for radio astronomy projects.

The Pawsey Centre supercomputers will be used by ICRAR to carry out large-scale astrophysical simulations and the reduction of data from ASKAP and Murchison Widefield Array surveys. This will involve the application of sophisticated source finding algorithms and processing petabytes of data.

The Pawsey Centre has already achieved a significant milestone with the installation of a performance optimised data centre (POD) at iVEC’s Murdoch University location. The POD houses ‘EPIC’, the second most powerful supercomputer in Australia, and ranked number 87 in the world. The next stage will be a system optimised especially for data intensive research, even more powerful than the existing supercomputer. The centre is expected to deliver a petaflop class computing facility by 2013.

More information about the Pawsey Centre can be found at *www.ivec.org/super-computing/pawsey-hpc-centre.*



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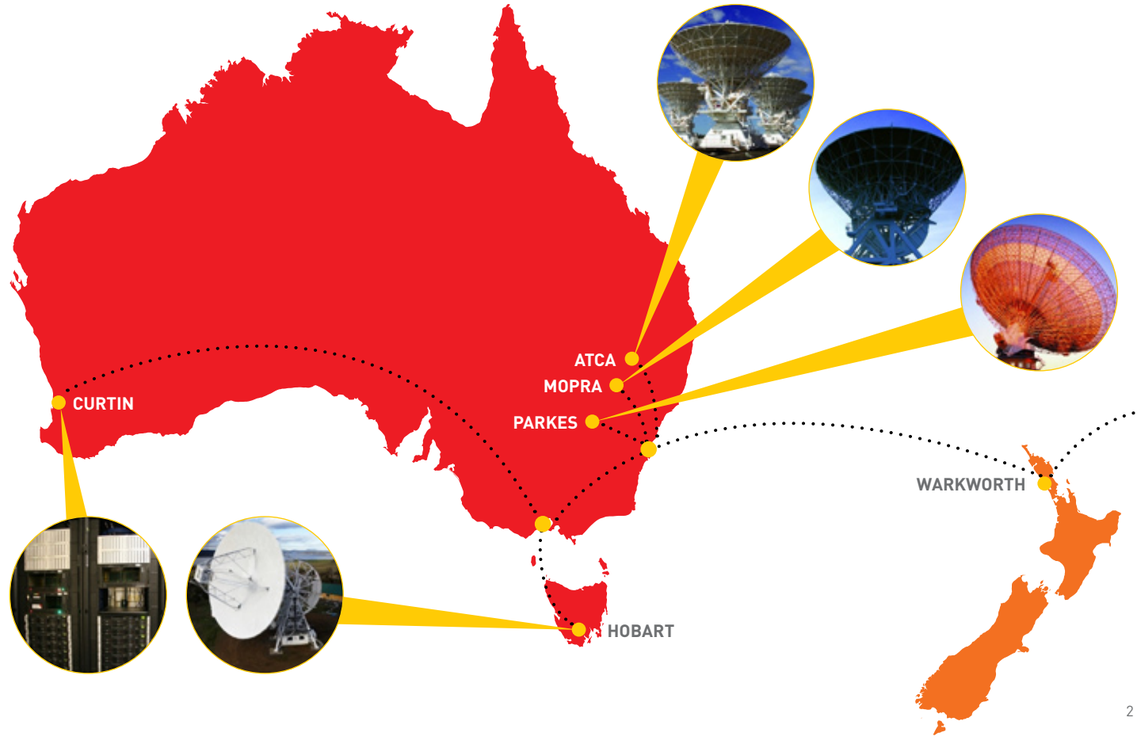


2

1
Proposed site design for theSkyNet homepage.
2
Data collected by radio telescopes throughout Australia and New Zealand is transferred over high speed internet and processed at Curtin University.

theSkyNet - Computing with Clouds

Computers throughout the world have 'spare' computing power available most of the time. By drawing on this untapped resource, it is possible to simulate a single powerful machine capable of doing real and relevant scientific research.

'People who donate computing power will contribute to genuine scientific research.'

Launching in September 2011, theSkyNet is a citizen science initiative designed to raise awareness of the SKA and radio astronomy. It will allow people to donate spare computing power to process data collected by ICRAR researchers and help advance our understanding of the Universe.

The initiative is inspired by a raft of similar projects that have sprung up in recent years, including SETI@ home, Galaxy Zoo and Solar Storm Watch. By making science accessible to people with an interest in science, these sites have benefited from resources that would have been impossible to fund using conventional mechanisms.

People who donate computing power will contribute to genuine scientific research and will be offered digital rewards for sustained participation in the project. The site will also host SKA-related news and links to other sites. After the initial roll out of theSkyNet, a second phase will incorporate educational aspects to help teach students computer programming skills. Students will be able to tackle real high performance computing problems and program scripts that process real data in the most efficient way.

Drawing upon the cloud infrastructure of Curtin University theSkyNet is an ICRAR project in collaboration with UK-based eMedia Track, Oxford University, Western Australia's Department of Commerce and Perth IT company Systemic.

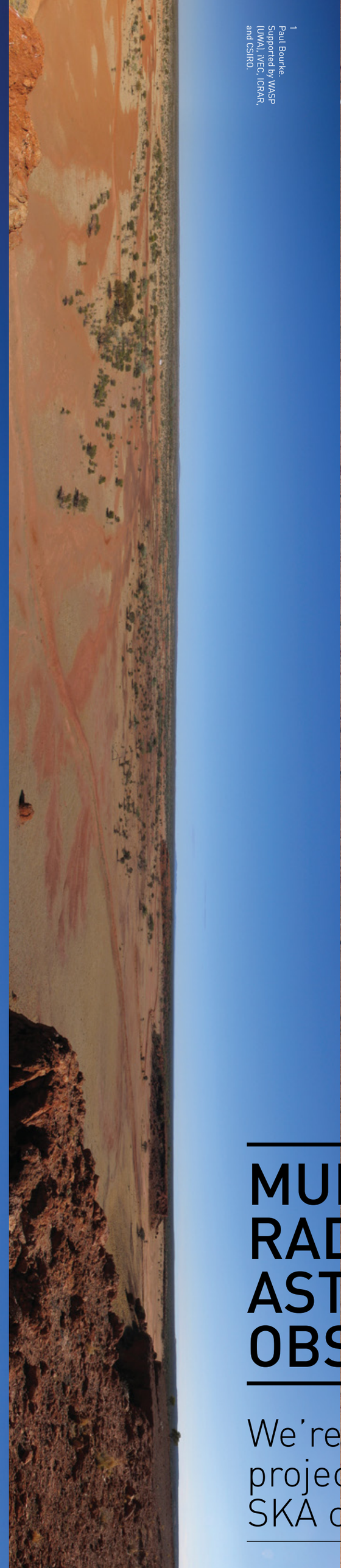
Electronic Very Long Baseline Interferometry

'In 2010, CUPPA processed about 300 terabytes of raw data from 40 separate astronomical projects.'

The Australian Long Baseline Array telescope group produces over 50 terabytes of raw data in one week of observing. Traditionally, this data was recorded to disks which were freighted interstate at significant expense and logistical complexity.

Assisted by staff at ARCS and iVEC, the data is now transferred over high speed internet from the telescopes in New South Wales, Tasmania, the ACT, South Africa and New Zealand to a petascale data store at iVEC. The data is stored here until it can be processed on CUPPA, a data processor based at Curtin University. CUPPA has been the primary data processor, or correlator, for the Australian Long Baseline Array since it was acquired by ICRAR in 2008.

In 2010, CUPPA processed about 300 terabytes of raw data from 40 separate astronomical projects, the busiest year yet. These included the first astronomical observations from the ASKAP antenna installed at the Murchison Radio-astronomy Observatory and the new telescope in Warkworth, New Zealand. The correlation process is now almost completely remotely operable, making the Australian Long Baseline Array unique among international very long baseline interferometry arrays.



1 Paul Bourke. Supported by WASP (UWA), iVEC, ICRAR, and CSIRO.

MURCHISON RADIO-ASTRONOMY OBSERVATORY

We're already delivering projects at the Australian SKA candidate site.

Murchison Radio-astronomy Observatory

One of the advantages ICRAR has is close proximity to one of the two proposed SKA sites, the Murchison Radio-astronomy Observatory. There are two major projects currently under construction at the observatory site, the Murchison Widefield Array and ASKAP. There are also some smaller projects such as EDGES, an experiment to detect signals from a period of time known as the Epoch of Reionisation.

ICRAR contributes to fieldwork for the Murchison Widefield Array, a $30 million SKA precursor being built by an international consortium. The centre is also involved in Very Long Baseline Interferometry tests with ASKAP and will support trailblazing experiments using the telescope to detect fast transients. The Aboriginal liaison officer for ASKAP, Robin Boddington, is hosted by ICRAR on behalf of CSIRO.

ICRAR has expertise in electromagnetic compatibility to ensure equipment sent to the site does not interfere with the radio-quiet environment. The centre also organises regular events in communities close to the Murchison Radio-astronomy Observatory and the nearby city of Geraldton as part of its outreach and education programs.

A full project plan was completed for the Murchison Widefield Array. The plan passed formal reviews by funding agencies Astronomy Australia Limited and the US National Science Foundation.

Achievement 2009–2010

The Murchison Widefield Array

The Murchison Widefield Array is a $30 million low frequency radio telescope under construction at the Murchison Radio-astronomy Observatory. The array is one of only three SKA precursors, or SKA pathfinders on a candidate site, and is an important step in realising the SKA.

ICRAR is making a leading contribution to the project through engineering and science programs, on-site logistical support and project management. The Murchison Widefield Array is also supported by a large number of partner institutions in Australia, India and the United States.

The Murchison Radio-astronomy Observatory was chosen as the site for the project because its pristine radio-quiet environment will allow science investigations to be conducted at the low end of the radio frequency spectrum. The primary science goals of the Murchison Widefield Array are:

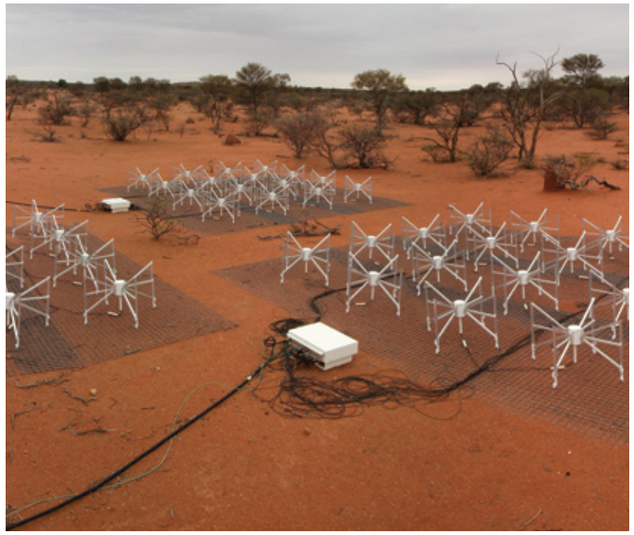
- Investigations of the Epoch of Reionisation
- Solar, Heliospheric and Ionospheric phenomena
- Transient radio sources
- Galactic and Extragalactic phenomena

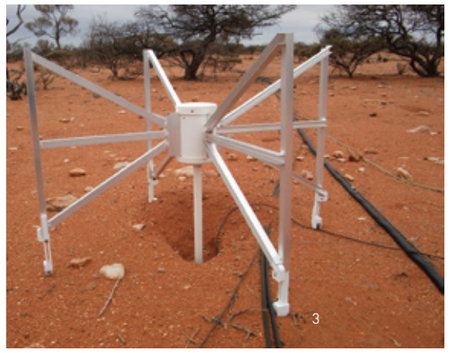
Currently, the Murchison Widefield Array consists of a 32-tile prototype system, with each tile having 16 dipole antennas in a four-by-four grid. The final system is intended to be 512 tiles, with over 8,000 dipole antennas. Each tile is combined into a single antenna by a 'beam-former', a component that merges the individual signals from each of the 16 dipole antennas. The beam-former also steers the antenna towards the required section of sky. The signal from each tile is then fed into a network of receivers, which initially process the signal and output digital data to the correlator system. Finally the correlator completes a data reduction process to produce the final data output.

'A test and verification program for the 32-tile prototype system has been completed and construction is underway on the full 512-tile array.'

A test and verification program for the 32-tile prototype system has been completed and construction is underway on the full 512-tile array.


1


2


3


4


5

1
A close-up of MWA dipole antennas
David Herne.
2
Several MWA tiles on the ground at the MRO.
Paul Bourke and Jonathan Knispel. Supported by WASP (UWA), iVEC, ICRAR, and CSIRO.
3
A close-up of an MWA dipole antenna.
Paul Bourke and Jonathan Knispel. Supported by WASP (UWA), iVEC, ICRAR, and CSIRO.
4
Sunset as clouds roll across the Murchison Radio-astronomy observatory.
Dr Sascha Schediwy.
5
The Sun sets over the MRO silhouetting an ASKAP antenna.
The WA Department of Commerce.

Other progress involves local industry partner Poseidon Scientific Instruments, who have completed the first field-ready receiver enclosure, due for testing on site in early 2011. Full manufacture of the enclosure is expected in late 2011 after testing is complete.

During the test and verification program for the prototype 32-tile system, a wealth of useful data was collected which the science team are continuing to analyse and explore. For instance, data collected from the prototype system has been used to create an image of the full sky showing the bright radio galaxy Pictor A. This image demonstrates that the overall Murchison Widefield Array performs well and reproduces the radio sky accurately at this level.

The first science observations of the Sun using the array also showed interesting activity that will be further investigated as the Sun reaches the peak of activity in its 11 year cycle. These results, and others, give the team confidence that the hardware and software employed in the 32-tile configuration are a good basis on which to extend the system to 512 tiles.

More information about the Murchison Widefield Array can be found at ***www.mwatelescope.org***

PROFILE
DR FRANZ SCHLAGENHAUFER

'Working on such cutting-edge research comes with its share of challenges.'

1
Dr Franz Schlagenhaufer.
2
Electromagnetic Compatibility Testing in an anechoic chamber.
Dr Franz Schlagenhaufer.

Dr Franz Schlagenhaufer
Research Engineer

Dr Franz Schlagenhaufer is ICRAR's electromagnetic compatibility specialist.

His job is to make sure the radio astronomers' own equipment does not disturb the radio-quiet environment of the Murchison Radio-astronomy Observatory and ensure the success of telescopes constructed at the site.

Dr Schlagenhaufer manages all of ICRAR's electromagnetic compatibility needs, including the development of measurement procedures, the set up of a specialised laboratory and ongoing training and education.

"The basic measurement techniques for electromagnetic compatibility are known, but they often need to be tailored for requirements particular to radio astronomy," Dr Schlagenhaufer said.

Since joining ICRAR from the Western Australian Telecommunications Research Institute in March 2010, Dr Schlagenhaufer has been instrumental in obtaining accreditation for ICRAR as an inspection service for electromagnetic compatibility and electromagnetic modelling.

He has also brought the Electromagnetic Compatibility Society of Australia's annual symposium to Perth in November 2011.

Working on such cutting-edge research comes with its share of challenges.

For instance, the emission requirements for some equipment on the Murchison Radio-astronomy Observatory site are beyond the sensitivity capabilities of an electromagnetic compatibility lab.

In these cases, Dr Schlagenhaufer must ensure the shielding performance of enclosures after the electronic devices are installed without being able to conduct final tests.

"I particularly enjoy the mix between theoretical work and practical measurements," he said.

"It is exciting to work on a high-profile project such as ASKAP or the SKA, and the electromagnetic compatibility aspects are a rewarding challenge for an engineer."

Electromagnetic Compatibility Testing

Ensuring electronic equipment doesn't produce interference for radio telescopes is a challenge faced by every radio observatory. To maintain the pristine radio-quiet environment of the Murchison Radio-astronomy Observatory, all equipment on site must pass rigorous electromagnetic compatibility testing and assessment.

ICRAR has gained accreditation from the National Association of Testing Authorities as an inspection body for electromagnetic compatibility. During the accreditation process, the association ensures organisations have access to adequate tools, the experience to use them and procedures in place for conducting assessment. ICRAR's accreditation covers two main areas, the assessment of electrical and electronic products against relevant standards and electromagnetic field modelling.

The modelling of electromagnetic fields is based on known antenna characteristics, taking into account the effects of the surrounding environment on the field. This is applicable where structures near the emitter change the radiation pattern and for unintentional emission, such as some components of ASKAP, the Murchison Widefield Array and the SKA.

Going Bush

Situated over 200km inland from the West Australian coast and about 300km from the remote coastal city of Geraldton, the Murchison Radio-astronomy Observatory is one of the most remote observatory sites in Australia. ICRAR staff regularly visit the site, which is still very much in development. It makes for an interesting field trip compared to the mature operational telescope sites usually visited by astronomers!

ICRAR contributes to both major projects under construction at the observatory, the Murchison Widefield Array and ASKAP. ICRAR engineer David Emrich coordinates the activities of the Murchison Widefield Array project at the site and, together with Aboriginal liaison officer Robin Boddington and CSIRO, ensures trips to the observatory run smoothly.

Trips to the observatory site are vital to the Murchison Widefield Array project because they provide early science results from the instrument. These results can be used to attract further funding for the project and to check the validity of the various parts of the system. There are also some aspects of the Murchison Widefield Array system that can not be tested in a lab environment, because it is too radio noisy compared to the site.

1
The Murchison Radio-astronomy Observatory in Western Australia. *Paul Bourke and Jonathan Knispel. Supported by WASP (UWA), iVEC, ICRAR, and CSIRO.*

The Epoch of Reionisation

The Epoch of Reionisation refers to the period in the history of the Universe when the neutral intergalactic medium was ionised by the emergence of the first luminous sources. In 2011, a new collaborative project between ICRAR and CAASTRO will take off aimed at detecting signals from this time in the early Universe.

The goal of this project is to measure the faint signals from neutral hydrogen gas during the Epoch of Reionisation. These signals are swamped by a much brighter unwanted noise from our galaxy and other extragalactic radio sources but can be detected, in principle, by a simple system with a single antenna.

‘The project aims to build a portable system, likened to a radio telescope in a trailer, which is completely self-contained.’

Although this project is science driven, it is technically challenging and requires new antenna and receiver designs that are extremely stable and well calibrated. The project is being led by ICRAR with involvement from CAASTRO and international collaborators.

In the first half of 2011, receiver and spectrometer hardware will be designed and tested. Building a precision, calibrated receiver is the first major challenge and the project will engage industry partners to design and manufacture a prototype receiver. Ongoing evaluation of a prototype antenna, based on a conical log spiral broadband design, has been undertaken by staff and students at the Curtin node of ICRAR. In the second half of 2011, regular field trips to the site will begin to test the hardware and gather data.

The project aims to build a portable system, likened to a radio telescope in a trailer, which is completely self-contained. This portable system, which will include a power source, could then be taken to a radio-quiet location such as the Murchison Radio-astronomy Observatory.

REACHING OUT

Our research is too exciting not to share.

1 NASA Astronaut Dr Andy Thomas speaks to over 700 high school students during a visit to Perth and ICRAR. *Paul Ricketts, Centre for Learning Technology, UWA.*

Reaching Out

1
Tuning In exhibition pictured at a physics student day at Adventure World theme park.

As a hub of radio astronomy research, part of ICRAR's role is to raise community awareness about this area of science and allow the public to participate in the lead up to large scale science projects such as the SKA. The centre uses neighbourhood observing events, public lectures, seminars, school visits, eNewsletters and a strong online presence to actively reach out to the community of Western Australia and beyond. ICRAR also plays an important role in supporting teachers and students with astronomy-related learning materials, resources and activities.

'In 2010, ICRAR saw over 4500 school students and 2500 members of the general public through more than 100 successful events.'

In 2010, ICRAR saw over 4500 school students and 2500 members of the general public through more than 100 successful events. The ICRAR website, Facebook and Twitter accounts received over 20,000 hits from more than 10,000 unique visitors. ICRAR works to engage a full spectrum of audiences, with recent highlights including a visit by an Australian astronaut, a travelling hands-on exhibition during National Science Week, an indigenous art exhibition and an international forum in the Netherlands.

Together with Scitech and Astronomy WA, ICRAR organised a large community event called Astrofest to mark the end of the 2009 International Year of Astronomy. Astrofest was attended by more than 4000 people and featured talks, displays, astrophotography, competitions, heaps of telescopes and a lecture by Professor Fred Watson from the Australian Astronomical Observatory.

Achievement
2009–2010

Tuning In for National Science Week

In August 2010, ICRAR astronomers and science communicators surprised thousands of people at busy shopping centres, city high streets and public parks with a travelling science exhibition called Tuning In. Rather than promoting an event for individuals to attend, Tuning In brought telescopes and activities to where people already were. The exhibition featured three 10" optical telescopes fitted with solar filters and two working radio telescopes, a dipole antenna (part of the MWA) and a tiny radio telescope with a more familiar dish design.

ICRAR staff hit the road to help the public of Western Australia 'Tune In' to the SKA, bringing the exhibition to Geraldton, New Norcia, Badgingarra, Joondalup and Forrest Place in central Perth over five days. More than 2,500 people stopped and took a few minutes to observe the Sun through a solar telescope, read about the SKA and learn how a radio telescope works.

The outreach team spent months designing innovative, eye-catching displays to attract passers by to the exhibition. It was designed to take people from the familiar territory of optical astronomy (through the use of solar scopes) to the less familiar domain of radio astronomy. The working equipment of Tuning In allowed people to learn about radio astronomy projects in a hands-on way.

The questions, the smiles, the average dwell time and the number of sustained interactions proved the travelling exhibition to be a great success. Tuning In will continue to engage passers by at locations around the country in 2011.

Students with SPIRIT

Professional astronomers and astrophysicists aren't the only people who can make worthwhile scientific discoveries thanks to a new internet telescope. The SPIRIT (SPICE-Physics-ICRAR Remote Internet Telescope) allows West Australian high school and university students to conduct their own surveys and find new objects millions of light years away. Accessed remotely through the internet, this research grade telescope allows students to observe the Universe, gather data and conduct real science.

'Any school in Western Australia can access SPIRIT – all they need is a computer with an internet connection.'

SPIRIT's primary mirror has a diameter of 35cm - perfect for viewing objects hundreds of millions of light years away. It is housed in a 3.5m dome observatory on the roof of The University of Western Australia's physics building.

Any school in Western Australia can access SPIRIT – all they need is a computer with an internet connection. SPIRIT is also used by tertiary students studying astronomy and astrophysics at the university. The interface allows students to control the telescope with nothing more than an internet browser. Students can 'drive' the telescope and get images of celestial objects in real time.

They can also schedule images to be acquired while they sleep, which are taken unattended and made available for download the following morning.

During the pilot phase of this project, students from Shenton College and Mount Lawley Senior High School successfully achieved a Minor Planet Center observatory code for the telescope. This allows future observations and discoveries to be submitted to, and recognised by, the international scientific community.

Using remotely controlled photometric filters, students can take precise measurements of galaxies and star clusters to determine how old they are and the colours they emit. These accurate observations enable them to study physical characteristics of distant stars.

Astronomer and project developer Paul Luckas, from the Centre for Learning Technology at UWA, used commercially available components to fast track the deployment of the telescope.

1

2

1
Hon. Dr Elizabeth Constable, WA education minister and Paul Luckas at SPIRIT's launch.
Paul Ricketts, Centre for Learning Technology, UWA.
2
SPIRIT on its robotic mount, allowing it to be remotely controlled via the internet.
Paul Ricketts, Centre for Learning Technology, UWA.
3
Artwork from the Ilgarijiri exhibition.
John Goldsmith.
4
Deputy Director Professor Steven Tingay with Indigeneous Australian Tedo Ryan during the Ilgarijiri trip to the Murchison.
Dr Megan Argo.

3

4

Ilgarijiri – Things Belonging to the Sky

In 2009, Australian Indigenous artists from Yamaji Art in Geraldton and astrophysicists from ICRAR came together to explore different understandings of the night sky and the Universe. The result was Ilgarijiri - Things Belonging to the Sky, an art exhibition connecting the ancient with the modern.

Artists and astronomers participated in a series of group activities, including a visit to the Murchison Radio-astronomy Observatory and the Murchison Widefield Array. They shared stories about the landscape and the artists painted interpretations of their experiences. Over 100 paintings were produced, typically in the "dot art" style.

Ilgarijiri - Things Belonging to the Sky aimed to promote reconciliation between Indigenous and non-Indigenous people in Australia through the night sky, a sight shared by all people on Earth. The exhibition toured Australia and South Africa in 2009 and 2010, and is due to visit New Zealand and Washington DC in 2011.

The project generated wide acclaim and provided opportunities for the artists to gain exposure for their work. Well over half of the paintings have been sold to buyers around Australia and the world and the artists continue to be inspired by their experiences in the Murchison.

Astronaut Lands in Perth

1
Dr Andy Thomas during his visit the ICRAR's Curtin University node *Curtin University.*
2
Dr Thomas answered questions from WA students after presenting on his time in space. *Paul Ricketts, Centre for Learning Technology, UWA.*
3
Astronomer Dr Leith Godfrey giving a close up look of the sky to a local school student in Laverton. *Natasha Moore.*

'Dr Thomas's wife, fellow astronaut Dr Shannon Walker, took questions from several students in the audience as she orbited the planet at more than 27,000 km/h.'

Many people might claim to be off the planet or out of this world, but Dr Andy Thomas can back up the statement with solid proof. The Australian-born astronaut has strapped into a NASA Space Shuttle or Russian Soyuz rocket on no less than four occasions.

Dr Thomas visited Perth in September 2010 and gave a talk for 700 students from more than 50 schools across Western Australia. He described what it is like to blast off from Earth at thousands of kilometres an hour, live in orbit and even take a space walk. Dr Thomas encouraged students to think about what they need to do now in order to achieve their potential in the future. Speaking of his own career path Dr Thomas described his passion for engineering and science, which ultimately led him to him becoming an astronaut.

Dr Thomas also spoke to about 300 people as part of an evening for the general public that included a live linkup to the International Space Station. During the event Dr Thomas's wife, fellow astronaut Dr Shannon Walker, took questions from several students in the audience as she orbited the planet at more than 27,000 km/h.

Born and raised in Adelaide, Dr Thomas earned his degree and then PhD in Engineering at the University of Adelaide. He flew his first mission in space on Space Shuttle Endeavour in May 1996 and completed his fourth space flight on STS-114, logging over 177 days in space. He is currently working for the Exploration Branch of the Astronaut Office.

Dr Thomas' Perth visit was made possible thanks to the work of the Fogarty Foundation, Scitech and ICRAR, and the events were hosted by The University of Western Australia and Curtin University.

Reaching Beyond

ICRAR works closely with people and organisations around the world to prepare for the SKA and showcase the strength of the proposed site in Australia and New Zealand. Outreach and education manager Pete Wheeler is a member of the International SKA Outreach Committee and works with Questacon, the Department of Innovation, Industry, Science and Research and CSIRO to raise awareness and understanding of the SKA at a national and international level.

In June 2010, the annual International SKA Forum in the Netherlands brought together scientists, politicians and government agencies from around the world. ICRAR contributed to the delivery of a strong Australia/New Zealand presence at the forum.

3

ICRAR in the Media

DECEMBER 2010

'Imaging the Interstellar Medium'
Astronomy Only

'Imaging our 'clumpy' galaxy'
Astronomy WA

'Researchers tune into the Universe's oldest radio signal'
Merredin Wheatbelt Mercury

NOVEMBER 2010

'Tasman link boosts 'superscope' bid'
SpaceInfo.com.au

'Karen connects Aussie and NZ astronomy teams over 5500km'
The National Business Review, New Zealand

'Outback race for the Square Kilometre Array telescope'
Science Illustrated

'Detecting big bangs'
Stories of Australian Astronomy

'Teen meets star Aussie astronaut'
Manjimup-Bridgetown Times

'Aussie telescope spots cosmic cataclysm'
SpaceInfo.com.au

'Robotic telescope swings into action for cosmic explosion'
Campus Daily

OCTOBER 2010

'Globular clusters more than one-off event'
ABC Science

'Globular clusters contain at least two separate populations of stars: Australian scientists'
Xinhuanet

'Massive globular clusters'
Scientific Computing

'ICRAR gets globular with new insight'
Astronomy WA

'School holiday fun at Gingin Observatory'
Central Midlands & Coastal Advocate

'ASKAP Survey Science Projects'
ASKAP Science Update (CSIRO)

'Western Australia strengthens radio astronomy links with China'
State of the Future (Department of Commerce)

'Kenji sheds light on how distant galaxies grow'
Science Matters

'Australia's astronaut inspires students to follow their dreams'
Science Matters

'Science Week at UWA – 2010'
Science Matters

'New astronomy centre will boost ICRAR staff'
Science Matters (The University of Western Australia)

'New telescope helps high schools aim for the stars'
Norseman Today

SEPTEMBER 2010

'Giant dish project hinges on quiet'
The West Australian

'Australian NASA astronaut wows Perth'
Science Network WA

'Dreamtime astronomy at Wolfe Creek'
Astronomy WA

'Aussie Astronaut to speak in Perth'
SpaceInfo.com.au

'The brightest and the best'
Science Illustrated

'Seeing Farther than Ever Before – The Square Kilometre Array'
The Naked Scientists, Interviews

AUGUST 2010

'Tuning In exhibition to visit New Norcia'
Central Midlands & Coastal Advocate

'Following dreams at UWA science camp'
South Western Times

'Chance to tune in to astronomy'
Midwest Times

'Astronomers align for stellar meeting'
Astronomy WA

JULY 2010

'ICRAR Astronomer has star quality'
Astronomy WA

'Star discovery for Perth astronomer'
WA Today

'Bidding for Big Ear'
The Age Education Resource Centre

JUNE 2010

'No moving parts – a new kind of radio telescope'
Stories of Australian Astronomy

'Boost for SKA bid'
Astronomy Way

'Link-up creates radio telescope'
North East Technology Park, UK

MAY 2010

'Aussies and Kiwis forge a cosmic connection'
Phys Org News

'Trans-Tasman Antennas Successfully Linked'
Square Kilometre Array Australia-New Zealand

'Space junk trackers'
SpaceInfo.com.au

'WA Governor empowers students with science'
Science Network WA

'SKA expert talks'
Subiaco POST

APRIL 2010

'Forum sparks passion for science'
Bairnsdale Advertiser

'Guide to the Universe'
Albany & Great Southern Weekender

JANUARY 2010

'Leading discoverers put WA on the cutting edge'
The West Australian

'AARNet and the lords of the dark fibre'
The Australian

DECEMBER 2009

''Seeing' 20c at 3.7 Million Paces'
Australasian Science

'Stellar Display of Aboriginal art'
Canberra Weekly Magazine

NOVEMBER 2009

'Local scientists give array of inspiration'
Bullsbrook Ellenbrook Advocate

'All eyes on the sky for Year of Astronomy'
Canning Times

'Star watching for amateur astronomers'
Canning Examiner

'The bid's on track'
Australian R&D Review

OCTOBER 2009

'UWA researchers are top contenders'
Subiaco POST

'UWA and Curtin launch State further towards global SKA'
WA Business News

'WA a hub of international astronomy research'
Southern Gazette

'$100m radio astronomy centre boosts SKA bid'
Science Matters (The University of Western Australia)

SEPTEMBER 2009

'Art flips Western universe'
The West Australian

'Four aces make our SKA bid twinkle'
The West Australian

'$100m boost for eye on space'
The West Australian

'Exhibition running for award; Reach for stars'
Geraldton Guardian

'Ancient and modern wisdom blend'
Canning Times

'Opening the skies to the past and the future'
UWA News

'IBM on board'
Geraldton Guardian

'Radio astronomy's centre of gravity shifts west'
The Australian

'Boost for space race'
Western Suburbs Weekly

'Tapping the universe'
Canning Times

'Go West, young person'
The Age

'Rubbing shoulders with top scientists'
Geraldton Guardian

'Four aces make our SKA bid twinkle'
The West Australian

'New centre next step towards SKA'
WA Business News

'$100m boost for SKA bid'
Geraldton Guardian

SEPTEMBER 2009 CONTINUED

'WA seeks largest telescope'
Ballarat Courier

'WA widens scope of research'
Townsville Bulletin

'Astronomy centre opens'
Herald Sun

'$100m boost for eye on space'
The West Australian

'Govt has high hopes for future of $80m radio astronomy centre'
Canning Times

'Centres for Square Kilometre Array telescope launched'
Engineers Australia

'Stellar dimensions'
Australian R&D Review

'Aiming for the sky: launch of International Centre for Radio Astronomy'
Government of Western Australia, European Office

'World-class radio astronomy research centre launched'

'Australia to directly assist international SKA project'
State of the Future (Department of Commerce)

AUGUST 2009

'$100m star wars'
The Sunday Times

'Big Bang within sight'

'Astronomy project strengthens quest'
Illawarra Mercury

JULY 2009

'Forum focus on astronomy'
Midwest Times

'Flexibility in science career'
Geraldton Guardian

JUNE 2009

'$80m SKA space science centre'
The Mining Chronicle

MAY 2009

'Event heightens stellar interest'
Geraldton Guardian

'Students shoot for the stars'
Merredin Wheatbelt Mercury

'Making space for astronomy study'
Comment News

'Students zoom in on telescope'
Western Suburbs Weekly

WORKING TOGETHER

We're working with organisations around the world to produce the best possible research.

1 An artists impression of radio astronomy data streaming from Western Australia. *Curtin University, as appeared in R&D Now Summer 2010.*

Industry Engagement

1
Poseidon Scientific Instruments hand over the completed MWA receiver to ICRAR. From left to right: Professor Steven Tingay, Jesse H Searls (PSI), Derek Carroll (PSI) and Mark Waterson.

Mega-science projects such as the SKA require a very high level of industry engagement. This involvement spans all project stages, from research and development through to construction and operation.

Currently, most links between industry and the SKA are related to regional pathfinders such as ASKAP and the Murchison Widefield Array. There is a well-developed Australasian SKA Industry Consortium, of which ICRAR is a full member, with substantial WA participation.

'ICRAR offers even modest-scale West Australian ventures international visibility in high-impact SKA research and development. '

While ICRAR is primarily a research and development centre, it has a particular mission to demonstrate the availability and capacity of local industry to support the SKA endeavour. In the first year of ICRAR operations, many links with industry have been formed around the engineering and technology programs, particularly relating to aperture arrays and ICT. ICRAR is, or will be, active in showcasing and expanding local capabilities via a range of activities including:

- Procurement, commissioning and operation of a high performance computing facility.
- Development, prototyping and deployment of digital receivers for the Murchison Widefield Array.
- Prototyping and characterisation of next generation sparse aperture array antennas, and associated radio frequency and signal transport systems.
- Design and production of specialised digital processing engines for cosmic transient and Very Long Baseline Interferometry science and technology programs.
- Design and delivery of remote infrastructure solutions, including power, for Murchison Radio-astronomy Observatory instruments.
- Establishment and operation of an electromagnetic compatibility facility.
- Exchange of selected personnel between radio astronomy and industry to build a greater understanding of SKA requirements in key industry sectors.
- Growth of radio astronomy options in education at various levels to provide industry with suitable graduates.
- Interaction with the Australian SKA Industry Consortium to ensure more WA businesses, including small and medium enterprises, participate in national industry initiatives.

ICRAR offers even modest-scale West Australian ventures international visibility in high-impact SKA research and development. While there is no guarantee that this will lead directly to contracts downstream, it enhances WA's reputation as a site for the SKA. There is also potential for the creation of technology with spin-off applications and beneficial international licensing arrangements.

ICRAR became the leading international contributor of manpower to two major PrepSKA work packages, aperture arrays and data flow systems.

Achievement 2009–2010

1

Poseidon Scientific Instruments

Poseidon Scientific Instruments is a West Australian company with a global reputation for their high performance frequency standards. As part of a joint initiative with ICRAR, the company has taken on the job of integrating and packaging the digital receivers needed for the Murchison Widefield Array.

This job involves taking prototype hardware, completing the design process and integrating the systems in a physical package suitable for the harsh Murchison environment. An added constraint was the need for extreme radio quietness, necessitating a rigorous approach to electromagnetic compatibility. With the first packaged receivers being shipped to site soon, the company is in a good position to bid for the rollout of systems for the full 512-tile MWA when international funding for the instrument is finalised.

Poseidon Scientific Instruments is also working with ICRAR engineers to design next generation low frequency antenna elements for the SKA. The company sees great value in understanding the astronomy requirements of such an instrument and the project will give them excellent visibility in the international SKA design process.

National Collaborations

ICRAR's activities span the national and international stages. Locally, we are working with universities, educators and industries to prepare the State for the excitement, opportunities and challenges of the SKA and its pathfinders. Internationally, we are part of the SKA project and are contributing to the global effort to design and perfect SKA technologies and science case. On the Australian national stage, ICRAR has formed strong collaborations with established and emerging research and engineering communities.

The most important of these collaborations is ICRAR's strong partnership with CSIRO and the research teams based at the CSIRO Centre for Space Science (CASS) in Sydney. Working with CSIRO engineers and scientists, ICRAR is contributing to the development of ASKAP capabilities and the design of the astronomical survey projects that will have a significant impact on forefront research problems in modern astronomy and astrophysics. ICRAR Director, Professor Peter Quinn, also works closely with Professor Brian Boyle and Professor Phil Diamond from CASS as part of the Australian/New Zealand SKA Coordination Committee (ANZSCC). This committee joins together the New Zealand and Australian Federal and State governments to coordinate the Australia/New Zealand effort host the SKA project.

The ARC Centre of Excellence for All-sky Astrophysics (CAASTRO) embodies the strong national research bridges ICRAR wants to form to advance Australian astronomy. As the largest member of the CAASTRO collaborating organisations (University of Sydney, Melbourne University, Australian National University and Swinburne University), ICRAR will participate in all three major research themes of CAASTRO and will employ 15 of the 42 positions funded through CAASTRO. ICRAR sees CAASTRO as an ideal mechanism to join optical and radio communities in Australia and for Australia to prepare to take on leading roles in astronomical survey science which will dominate the international research agenda for the next 10-20 years.

International Collaborations

ICRAR works with organisations around the world on fundamental research relevant to SKA science and the development of SKA designs and technologies. These collaborations include:

- **Murchison Widefield Array project**
  This $30 million SKA precursor is ICRAR's largest collaborative project. The project consortium consists of seven Australian universities, CSIRO, two divisions of MIT, Harvard University and the Raman Research Institute in India, plus a range of secondary academic and industry partners. The Curtin node of ICRAR raised over $10 million last year to kick-start the final stages of construction.
- **PrepSKA**
  ICRAR is one of the largest contributors to the PrepSKA program, with substantial inputs to work on aperture array receptors, system design and costing and ICT architectures. ICRAR staff chair or serve on a number of review and consultative committees and working groups.
- **SKA Program Development Office**
  ICRAR's Dr Minh Huynh is the deputy international SKA project scientist, and spends half her time in Perth and half at the SKA Program Development Office in Manchester
- **Aperture Array Verification Program**
  ICRAR is the only external partner and plays a leading role in this new 11-member, European-led consortium, being responsible for a major work package to deliver new generation sparse aperture arrays for the SKA.
- **SKA Technology Demonstrator Program**
  ICRAR assists in the technology development program review committee and also acts as an advisor to this Cornell-led program.
- **Pathfinders HI Survey Coordination Committee**
  As chair of this committee, ICRAR has co-organised three international meetings involving science teams from the University of Cape Town, ASTRON, the University of Groningen and CSIRO. These meetings have resulted in proposed coordinated HI surveys for the major pathfinder telescopes.

ICRAR also collaborates with a number of individual organisations:

- **Cambridge University (United Kingdom)**
  ICRAR works closely with colleagues at the Cavendish Laboratory to develop next generation SKA performance and cost estimation tools, facilitating detailed design of the initial phases of the SKA. PhD student Tim Colegate has made extended visits to Cambridge and the SKA Program Development Office to progress this development.
- **Oxford University (United Kingdom)**
  A fruitful PhD student exchange and co-supervision program has commenced with the Department of Astrophysics. Students Jacinta Delhaize (ICRAR) and Danny Price (Oxford) have undertaken reverse visits. ICRAR has also funded a joint study, with iVEC and Oxford, on the application of cloud computing to the processing and data management challenges of the SKA.
- **Max Planck Institute for Nuclear Physics (Germany)**
  Under a Go8/DAAD scheme, researchers from ICRAR and the Max Planck Institute have received funding for a two year program of exchange visits. These visits will improve understanding of the generation of radio emission from expanding supernova shock fronts.
- **NASA Jet Propulsion Laboratory (United States)**
  ICRAR and the NASA Jet Propulsion Laboratory in California are developing new hardware and software to search for fast radio transients. This will initially be used with existing telescopes around the world, but it is hoped the technology will eventually be deployed on ASKAP and inform the SKA project.
- **IBM**
  ICRAR and IBM have signed a letter of intent outlining a broad collaborative program of research into the data intensive technologies required for the SKA. Several workshops have been held with IBM and ICRAR staff and an overall agreement will be developed that leads to design studies for the SKA data system.
- **Large Synoptic Survey Telescope (Chile)**
  The Large Synoptic Survey Telescope is the highest priority optical astronomy project for the US community this decade. It will survey the entire sky every three nights and produce a catalogue of stars and galaxies containing over one billion objects. ICRAR and the Large Synoptic Survey Telescope have signed an agreement to fund a shared research position to investigate database technologies relevant to both the Large Synoptic Survey Telescope and the SKA. This will lay the basis for optical and radio research using the SKA precursors and large optical surveys.

1
ICRAR's Curtin University node, the Brodie-Hall Building of the Curtin Institute of Radio Astronomy.

STAFF AND STUDENTS

Our energetic and passionate staff have gathered from across the globe to work on the SKA.

Applications to the Federal Government and the Science and Industry Endowment Fund resulted in two Future Fellows, five Super Science Fellows and one John Stocker Fellow (valued at about $3 million) – more than any other astronomical organisation in Australia.

Achievement
2009–2010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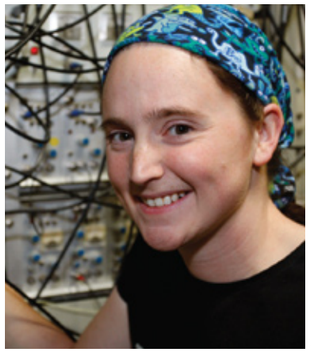
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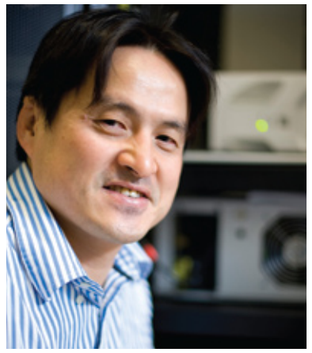
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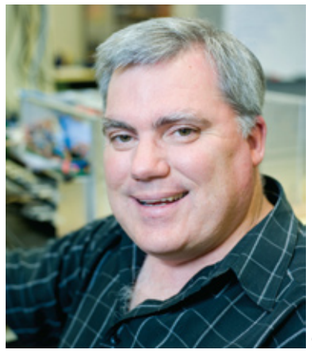
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1
Wayne Arcus
MWA Project Manager, 1-Sept-09
Project Management.

2
Dr Megan Argo
Postdoctoral Fellow, 1-Sep-09
Starburst galaxies, supernovae and masers.

I use radio telescopes to study the gas content and compact components in normal and starburst galaxies. I also coordinate the outreach activities of the Curtin node of ICRAR.

3
Professor Kenji Bekki
Professor, 11-Jan-10
Galaxy formation and evolution, globular clusters and Magellanic Clouds.

Using numerical simulations, I am now trying to understand how stars, open and globular clusters, and galaxies have been formed throughout cosmic time. I am also interested in comparing my simulation results with observational ones derived by radio and optical astronomers.

4
Florian Beutler
PhD, 1-Sep-09
Cosmology with the 6dF Galaxy Survey.

5
Dr Hayley Bignall
Postdoctoral Fellow, 1-Sep-09
VLBI, AGN and Interstellar scattering.

I run the data processor for the Australian Long Baseline Array, and also do research in high angular resolution radio astronomy - looking at transient and variable radio sources, jets in active galactic nuclei, and using interstellar scintillation as a probe of small-scale structure.

6
Dr Jan Geralt Bij de Vaate
Senior Research Fellow, 1-Sep-10
Aperture Arrays.

I assist with design of the low frequency Aperture Array of the SKA with a research focus on active antennas.

7
Dr Tony Blackett
HAR/VLBI Software, 12-Apr-10
Software Development.

Developing web-based software applications for ATNF and CIRA. This includes a revised and improved VLBI recorder monitoring application for use in ATNF's VLBI observations.

8
Robin Boddington
Aboriginal Liaison Officer, 19-Oct-09
Liaison.

Robin is seconded to CSIRO and based in Geraldton.

9
Dr Nathan Clarke
Research Engineer, 7-Apr-10
High Time Resolution Radio Astronomy.

I design digital systems for detecting high time resolution transient signals. I am the project engineer for ICRAR's High Time Resolution project and for ASKAP's CRAFT Survey Science Project. I am also involved with specifying SKA system requirements for detecting fast transient signals.

10
Tim Colegate
PhD, 1-Sep-09
Science and engineering trade-offs for the Square Kilometre Array.

11
Phil Crosby
PhD, 1-Sep-09
Improved success in mega-science projects.

12
Shinkee Chung
Research Assistant, 1-Sep-09
GPU Programming.

I am a casual research assistant for ICRAR, assisting the science team.


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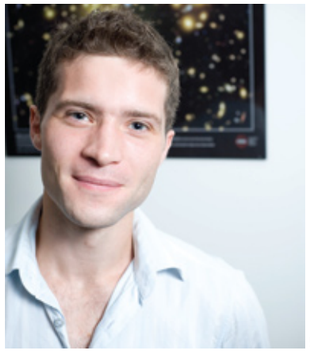
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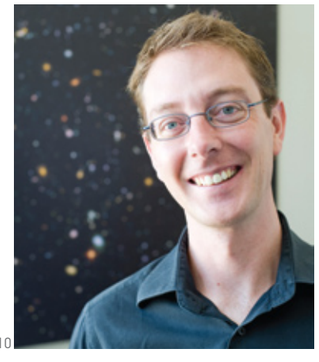
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1
Kathryn Daniels
Administration Assistant, 1-Sep-09
Administration.

I provide admin support for the Curtin node of ICRAR and work with the Administrative Coordinator.

2
Jacinta Delhaize
PhD, 1-Sep-09
Galaxy Evolution and the 21cm Neutral Hydrogen Line.

3
Jonathan Diaz
Masters, 15-Feb-10
Simulations of the Magellanic Stream.

4
Dr Richard Dodson
Research Fellow, 1-Sep-09
Astronomical techniques.

I have specialised in the observations of stars; specifically MSFR & Pulsars/AGB stars. I also now work on fast transient sources, which are a mystery as to their origins. To do these observations I developed new instruments and techniques, some using GPUs. I am also an nVIDIA Academic Partner.

5
Dr Alan Duffy
Research Associate, 1-Sep-09
Galaxy Formation, Cosmology.

As part of an international collaboration I create hydrodynamic (SPH) simulations of galaxies forming, all within the current cosmological standard model of Dark Energy and Dark Matter. These in turn are compared with observations of observed systems to test the underlying physics and cosmology.

6
Dr Ed Elson
Super Science Fellow, 17-Dec-10
Multi-wavelength galaxy studies, including star formation, dark matter studies, and gas dynamics.

I am the WALLABY Super Science Fellow, meaning that I'll play a significant role in the development, testing and implementation of the WALLABY science plans and goals. I will also be focusing on star formation studies, work that will be carried out with Professor Gerhardt Meurer.

7
David Emrich
MWA Commissioning Engineer, 1-Sep-09
MWA Site activities, commissioning and integration.

I am almost entirely dedicated to supporting the building, installing, commissioning and testing of the 512-antenna Murchison Widefield Array radio telescope, being built in the Murchison Radio-astronomy Observatory, which is also the Australian candidate site for the Square Kilometre Array.

8
Tammy Geddes
Executive Assistant, 1-Sep-09
Executive Assistant to the Director.

9
Derek Gerstmann
PhD, 8-Jun-10
Ultra-scale Visualisation with Adaptive Resource Management for Data Intensive Scientific Research.

10
Mark Glossop
IT Projects Officer, 1-Sep-09
MWA ICT Systems Engineer, 20-Sep-10

I'm part of the engineering team working to build and commission the Murchison Widefield Array radiotelescope. As an "IT generalist", I'm involved in both software development and system operations.

11
Dr Leith Godfrey
Post-Doctoral Research Fellow, 4-May-10
Multi-wavelength studies of AGN jets.

Apart from continuing my own research on AGN jets, part of my job at ICRAR has involved putting together a compilation and discussion of the science case for the high angular resolution component of the SKA. This is important for Australia's bid to host the SKA.

12
John Goldsmith
PhD, 1-Sep-09
Cosmos, culture and landscape.

Documenting, learning and sharing Indigenous astronomical and sky knowledge in contemporary society.


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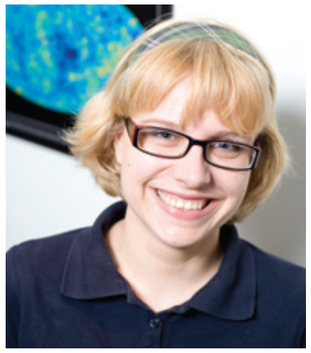
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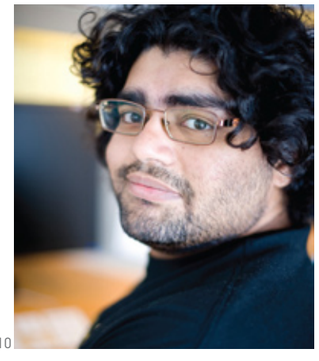
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1
Leanne Goodsell
Administrative Assistant Purchasing Officer, 29-Nov-10
Reception, office systems and administrative requirements.

I deal with purchasing activities, travel arrangements, meet and greet visitors to ICRAR, support the Senior Administrative Officer, staff and students in order to achieve individual and team goals.

2
Kirsten Gottschalk
Outreach and Education Officer, 13-Jan-10
Science Communication.

I am involved in communicating ICRAR's work to everyone else, this includes being ICRAR's media contact, updating the website, organising events for students and the community and helping our staff present their research.

3
Professor Peter Hall
Deputy Director (Engineering), 1-Sep-09
Radio astronomy engineering.

I am responsible for the strategic and operational aspects of ICRAR's engineering program. My personal research includes new technologies for the SKA, as well as international SKA system design activities. I am also heavily involved with industry engagement initiatives for the SKA.

4
Dr Christopher Harris
Research Associate, 1-Sep-09
Parallel Signal and Image Processing.

I lead ICRAR's HPC for Radio Astronomy project. In this role, I work with ICRAR scientists and students to develop hardware-matched scientific algorithms to support their research. I also teach courses in Computer Architecture and GPU Programming.

5
David Herne
PhD, 1-Sep-09
High-Fidelity Mapping and Calibration of the Ionosphere to Low-Frequency Radio Waves.

6
Shaun Hooper
PhD, 1-Sep-09
Low-Latency Detection and Localisation of Gravitational Waves from Compact Binary Coalescence.

7
Laura Hoppmann
PhD, 1-Aug-10
Area of Research: Evolution of the Gas Content of the Universe.

8
Dr Aidan Hotan
Lecturer, 1-Sep-09
Radio Pulsars & Magnetars.

9
Claire Hotan
Masters, 1-Sep-09
Testing a potential new site for an optical telescope in Australia.

10
Dr Minh Huynh
Research Associate Professor, 1-Oct-10
High redshift galaxies and AGN, formation and evolution of galaxies and multiwavelength surveys.

I am an astronomer studying galaxy formation and evolution through deep multiwavelength surveys. I am also the Deputy International SKA Project Scientist, and in that position I am helping the SKA project develop its science case, and am the link between the SKA engineers and astronomers.

11
Aziz Jiwani
PhD, 1-Sep-09
Active Antenna Arrays.

12
Harleen Kaur
Administrative Assistant, 12-Jul-10
Administration.


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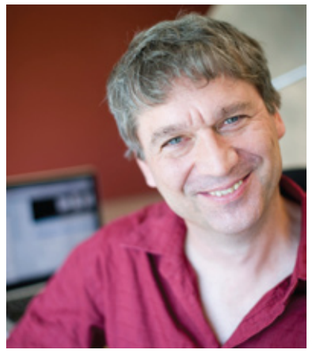
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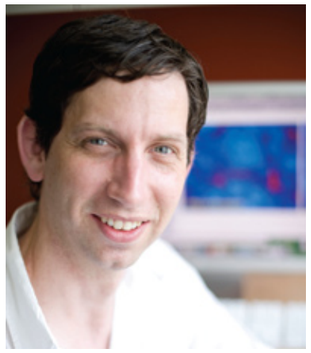
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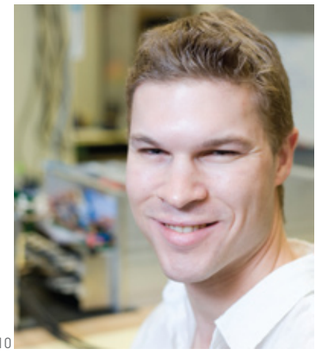
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1
Jun Yi (Kevin) Koay
PhD, 1-Sep-09
Detecting Radio Transients at Cosmological Distances and Probing the Ionized Intergalactic Medium.

2
Kathy Kok
Administration Officer, 6-Jan-10
Finances.

I handle financial reporting requirements and administration procedures.

3
Dr Nadia Kudryavtseva
Super Science Fellow Transients, 1-Dec-10
Research.

I am working on commissioning science with the MWA. My main topics of research are active galactic nuclei, x-ray binaries, supernovae, search for super-massive binary black holes and possible gravitational waves from them and magnetic fields in the Universe.

4
Sarah McNamara
Administrative Assistant, 6-Jan-10
Administration.

5
Dr Myrtille Laas-Bourez
Postdoctoral research fellow, 22-Mar-10
Robotic telescopes, image processing, astrometry and space debris observation.

I am the co-director of the 1-metre zadko telescope. I am in charge of the finalisation of the robotisation of the telescope and the science project implementation (GRB optical observation, coincidence observation with LIGO/VIRGO, SN survey, asteroids survey, ground follow of GAIA mission etc.

6
Leona Lim
Executive Assistant, 3-May-10
Executive Assistant to the Director.

7
Christopher Lord
MPhil, 1-Sep-09
A Low Frequency Array of Simple Radio Telescopes for the Detection of Solar X-Ray and Radio Flares, and the Study of the Ionosphere.

8
Dr Jean-Pierre Macquart
Teaching and Research Fellow, 1-Sep-09
Theoretical Astrophysics.

I work on a broad range of topics encompassing Active Galactic Nuclei, pulsars, interstellar and intergalactic propagation effects and radio transients.

9
Professor Gerhardt Meurer
Research Winthrop Professor, 18-Jan-10
Extragalactic star formation.

I am working on extragalactic surveys related to the HI surveys (WALLABY and DINGO) that will be performed by ASKAP. These include huge optical surveys like Pan-STARRS and smaller surveys that target HI selected galaxies and look at their star formation properties.

10
Associate Professor Martin Meyer
Research Associate Professor, 1-Sep-09

I study galaxy formation and evolution as part of the research staff at ICRAR, and am particularly interested in understanding the role played by neutral hydrogen gas. I am the PI of DINGO, a deep HI survey planned for ASKAP.

11
Dr James Miller-Jones
Curtin Research Fellow, 15-Jul-10
VLBI, X-ray binaries and transients.

I work mainly on VLBI observations of X-ray binaries, attempting to understand the jet-disc coupling in these systems. I also have an interest in slow transients, being involved in transients key science projects with several of the SKA pathfinder instruments.

12
Aquib Moin
PhD, 1-Sep-09
Observational study of transients associated with GRBs and XRBs using e-VLBI/VLBI.


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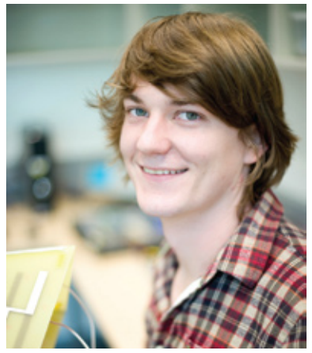
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1
Dr John Morgan
Research Fellow, VLBI, 4-May-10
VLBI.

I work in research on wide-field VLBI. VLBI is the highest-resolution imaging technique in Astronomy. Widefield VLBI combines this with a large field of view, producing images of small patches of sky up to a terapixel in size.

2
Dr Shantanu Padhi
Research Engineer, 7-Jun-10
RF, Microwave, Antenna and Antenna array.

I am working on the Aperture Array project. The primary aim of this project is to design and develop new generation aperture array systems for SKA.

3
Dr Sabyasachi Pal
Research Associate, 1-Sep-09
Transients, multi-wavelength astronomy, microquasars and radio astronomy.

I do research to search for and understand transient sources in the sky.

4
Dr Attila Popping
Super Science Fellow, 22-Nov-10
HI observations and Diffuse neutral hydrogen.

I am interested in doing observations and developing methods to detect very faint and deep emission of neutral hydrogen. My main role at ICRAR is to work on the science commissioning and preparation of DINGO, an ASKAP project to investigate very deep HI emission.

5
Toby Potter
PhD, 1-Sep-09
Simulating the remnant of SN 1987A.

6
Danny Price
PhD, 1-Sep-09
Sparse Aperture Arrays for the SKA.

7
Professor Peter Quinn
Director, 1-Sep-09

My aim is to guide ICRAR to become a leading international research centre in astronomical sciences and technology and a major contributor to, and user of, new facilities like the SKA. My research interests focus on computational and theoretical studies of the formation and evolution of galaxies and the nature of dark matter, as well as technologies for data intensive research.

8
Hayden Rampadarath
PhD, 11-Oct-10
Wide-Field VLBI.

9
Dr Cormac Reynolds
Teaching and Research Fellow, 1-Sep-09
VLBI studies of AGN.

I study Active Galactic Nuclei, principally by means of high angular resolution radio astronomy. I'm responsible for the installation and maintenance of our VLBI correlation facility. I also teach undergraduate courses on radio astronomy.

10
Dr Maria Rioja
Research Fellow, 1-Sep-09
VLBI technique, the use and development of new strategies.

I work on the application of VLBI technique to studies of very different objects (i.e. AGNs, star formation regions and evolved stars), in a wide range of frequencies, to produce high angular resolution maps and high precision astrometry. The former enables proper motion, and distance-parallax measurements.

11
Tina Sallis
Finance Officer, 1-Jan-10
Finance.

I'm responsible for monitoring and reporting on ICRAR finances at the Curtin node.

12
Dr Franz Schlagenhaufer
Research Engineer, 1-Mar-10
Electromagnetic Compatibility (EMC).

I specify EMC requirements and develop measurement procedures for radio astronomy. I'm also setting up a laboratory for EMC tests on equipment and for on-site tests as well as contributing to EMC training and education.


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1
Morag Scrimgeour
PhD, 1-Sep-09
Measuring Cosmology with Motion in the Universe.

2
Dr Renu Sharma
General Manager, 1-Sep-09
Management and governance.

I am a member of the ICRAR Executive and am responsible for the management of ICRAR

3
Bruce Stansby
PhD, 1-Sept-09
An Economical Survey Telescope to Study the Rate of Radio Astronomical Transient Events.

4
Professor Lister Staveley-Smith
Deputy Director (Science), 1-Sep-09
Radio astronomy science.

I lead research programs related to observations and simulations of the galaxies including their structure and evolution, and the variable Universe. All these programs utilise state-of-the-art facilities and will soon include a suite of next-generation radio telescopes, such as ASKAP, and supercomputing facilities, such as the Pawsey Centre.

5
Jennifer Talbot
Administrative Coordinator, 1-Sep-09
Administration.

6
Jonathan Tickner
Senior Technical Officer, 1-Mar-10
MWA Support and Lab Manager.

I am a Safety and Health representative and assist in the physical fabrication of equipment used in ICRAR Activities

7
Professor Steven Tingay
Deputy Director (MRO & Geraldton), 1-Sep-09
Very Long Baseline Interferometry and technology for radio astronomy.

I'm a Deputy Director of ICRAR and develop and lead several of the ICRAR projects. I contribute to these projects in terms of science and technical astronomy. I have particular interests in using commercial off-the-shelf technology for radio astronomy, a wide range of science, and outreach.

8
Michael Todd
PhD, 1-Mar-10
Transient Astronomy using the 1.0-metre Zadko Telescope.

9
Associate Professor Kevin Vinsen
Research Associate Professor, 1-Sep-09
Large Databases.

I'm part of the ICRAR ICT team working on the data challenges large astronomy projects involve.

10
Dr Bradley Warren
Research Assistant Professor, 1-Sep-09
Interstellar Medium in Nearby Galaxies.

I study the interstellar medium (atomic and molecular gas, dust) in galaxies close enough to resolve structure. I am particularly interested in gas dominated dwarf galaxies, where only a small portion of the atomic gas reserves have been converted to stars.

11
Mark Waterson
Sr. Research Engineer, 9-Nov-09
RF systems design.

Managing the Radio Astronomy Engineering Lab is my primary responsibility; I provide advice and design input to other ICRAR engineering projects including the MWA receiver development.

12
Dr Randall Wayth
Postdoctoral Research Fellow, 1-Sep-09
Fast and slow transients, low frequency radio astronomy, the EoR, high performance computing, real-time data processing, MWA and VLBI.

I am involved with several projects at ICRAR including the V-FASTR fast transients trailblazer, MWA commissioning and RTS support, development for VLBI with the GMRT and am leading a new EoR global signal experiment.


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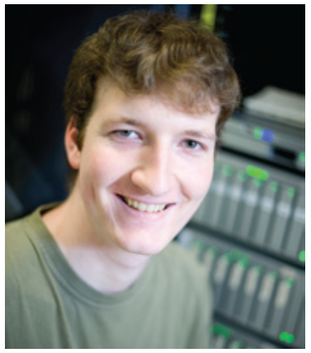
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Research Assoc. Professor Linqing Wen
Res. A/Prof, 1-Sep-09
Gravitational Wave Astronomy.

I am interested in gravitational wave astronomy especially in synergies of gravitational waves with electromagnetic radiation.

2

Stefan Westerlund
PhD, 22-Mar-10
A Parallel Source Finder For Searching Radio Astronomy Images using High Performance Computing.

3

Dr Tobias Westmeier
Research Assistant Professor, 1-Oct-10
HI studies of galaxies, high-velocity clouds and the Magellanic stream.

My research interests are related to the study of neutral hydrogen in and around nearby galaxy with the aim to study their structure and evolution. As a member of the WALLABY and DINGO projects I am working on the problems of source finding and source parametrisation in large, blind HI surveys.

4

Pete Wheeler
Manager, Outreach and Education, 1-Sep-09
Science Communication.

Our team provides an interface between ICRAR and the outside world. We coordinate ICRAR's online presence, interact with media, deliver events for schools and communities and work collaboratively with other groups to raise the profile of radio astronomy, science, ICRAR's work and the SKA.

5

Winthrop Professor Andreas Wicenec
ICT Program Head, 2-Aug-10
Data Flow & Storage Design and HPC Integration.

I am leading the ICT program of ICRAR and as such my team and I are involved in the design and planning of ICRAR's HPC resources, in particular of the Pawsey centre. In addition we are working on the conceptual design for the SKA data system and on HPC algorithms and database integration.

6

Matthew Young
PhD, 1-Sep-09
Pulsar Astrophysics.

7

Giovanna Zanardo
PhD, 15-Sep-09
Radio Evolution of SNR 1987a.

1
ICRAR is part of the major survey teams that plan to use ASKAP when its 36 antennas are complete in 2013. *Courtesy of the WA Department of Commerce.*

ON THE HORIZON

We think the best is yet to come.

‘During this momentous time, ICRAR will become fully staffed and all 13 project plans will be active and delivering results.’

On the horizon

The coming year is a very exciting one for the international SKA community. By the end of 2011, the site selection process for the SKA will have run its course and a recommendation on the preferred site will have been formulated by the SKA site selection group.

A new international organisation will be formed to facilitate the construction of the SKA. The governing council of this new organisation will receive the site recommendation and is expected to make a final decision in early 2012. The council will also be responsible for the funds invested in the SKA preconstruction program and will decide on the location of the new SKA Project Office and appoint a new SKA director.

During this momentous time, ICRAR will become fully staffed and all 13 project plans will be active and delivering results. The centre’s programs will work towards the dual goals of supporting the Australasian SKA bid and ensuring the health and expansion of the international SKA project.

It is hoped ICRAR’s domestic and international collaborations will place it in the best position to lead, and contribute to, SKA preconstruction work in the areas of science, engineering and ICT. The preconstruction work program covering the four years from the beginning of 2012 to the end of 2015 has been mapped out in a document called the SKA preconstruction execution plan. The total value of this work, plus the funds needed to set up a new SKA Project Office, is estimated to be about €90 million.

The work contained in the plan covers the further development of SKA precursor technologies, the detailed design of SKA systems and infrastructure and the documentation to tender contracts for the start of construction in 2016. In the early part of 2012, this work will be allocated to organisations and industries around the world.

1
Spiral galaxy M74. NASA, ESA and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration.

ALL TRUTHS ARE EASY TO UNDERSTAND ONCE THEY ARE DISCOVERED; THE POINT IS TO DISCOVER THEM

Galileo

2009-2010