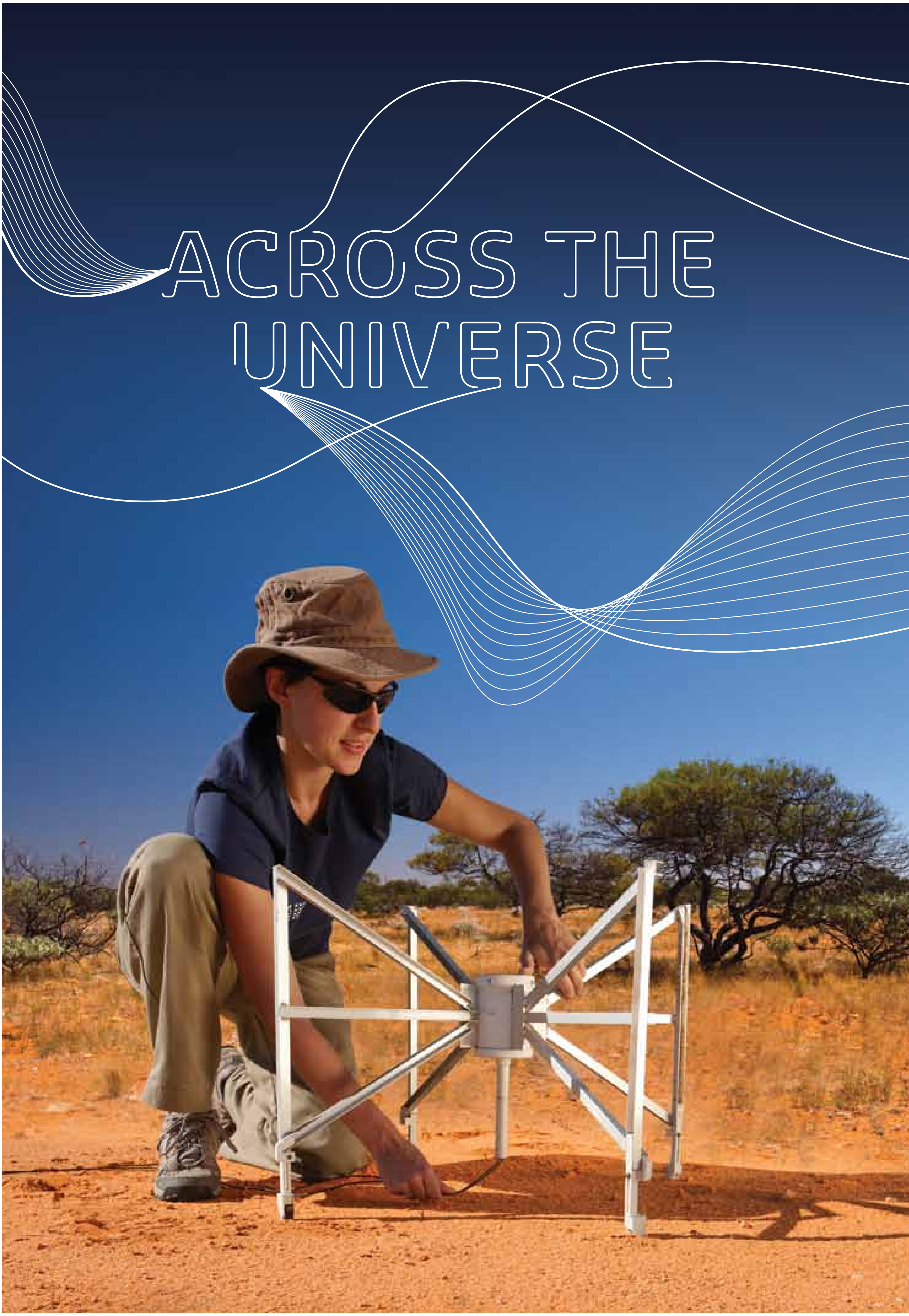
ACROSS THE UNIVERSE



The Square Kilometre Array, a global megascience project to develop the world's largest and most sensitive radio telescope, is a step closer to reality as it moves into pre-construction. And it really is closer than you think – it's in Perth's backyard.

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IT has been a long time coming. The Square Kilometre Array (SKA) started as a concept in 1991, with an international working group formed in 1994. Australia has been involved since the earliest days, and this paid off in May 2012 when it was finally announced that Australia–New Zealand and South Africa would share the hosting of the colossal project to build the largest and most sensitive radio telescope in the world.

The SKA will essentially be a network of linked antennas, with a total signal-collecting area of one square kilometre. But the project itself will be much, much bigger: after all, 67 organisations across 20 countries are currently involved in the development and construction of this telescope. Its scope is truly global.

Australia will host two key components of the telescope: a group of dishes equipped with radio cameras to survey the sky at high radio frequencies, and a low-frequency 'aperture array' of fixed antennas. The low-frequency SKA (SKA-low) will be able to capture images of large sections of the sky very quickly, and will be able to detect variable and transient events by comparing repeated measurements over time. South Africa will host a complementary group of dishes designed to study smaller sections of the sky in much more detail.

As one communicating instrument spanning the globe and made up of literally thousands of antennas, the SKA will be able to probe the depths of the Universe in greater detail than ever before. It will provide fundamental information on the genesis and history of our Universe, including the birth and evolution of galaxies, stars and individual planets. It will also improve our understanding of high-energy physics, challenge the theory of general relativity, and investigate the nature of dark matter and dark energy. If extraterrestrials are sending us signals, it will detect them.

It's hard to grasp just how big a step forward this telescope technology is. It will be the most sensitive radio telescope ever built – able to detect an airport radar on a planet 50 light years away. It will generate enough raw data to fill 15 million 64 GB iPods every day, and its central computer will have the processing power of about 100,000,000 personal computers. The technology required just to build it didn't exist five years ago, and some of it is still extremely experimental today. Being able to manage and interpret the masses of data it will generate is another enormous challenge.

The SKA is demanding and is driving advances in high-performance computing, signal processing, radio-frequency systems and high-speed communications – all of which will also benefit down-to-earth applications such as personal computing, telecommunications and wireless technologies over the next few years.

ALTHOUGH the SKA is only now moving into pre-construction, there are already advanced radio telescopes in Australia looking at the night sky. As part of the technology development push towards the SKA, Curtin University scientists and engineers have designed, developed and built a low-frequency aperture array telescope at the Murchison Radio-astronomy Observatory (MRO), 200 km inland from the Western Australian coast and approximately 300 km from Geraldton. The Murchison Widefield Array (MWA) is an international collaborative project, led by the Curtin Institute of Radio Astronomy (CIRA) and made up of 13 institutions across Australia, India, New Zealand and the United States.

Professor Steven Tingay, Co-Director (Science and Operations) of CIRA and Director of the MWA explains: "The MWA


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STOCKTREK IMAGES / THINKSTOCK

Left: The Murchison Widefield Array low-frequency precursor telescope for the SKA

is a technology and science precursor for the SKA. It is one of only three precursors worldwide developing the cutting-edge science and technology needed for the SKA, and is the only one investigating the low radio-frequency requirements. Our success with the MWA is a significant factor in Australia being named as the host site for SKA-low, which will now also be built at the MRO."

Professor Peter Hall, Co-Director (Engineering and Industry) of CIRA, highlights the significance of having SKA-low hosted in Australia: "It shows international recognition of Australia's strength in radio astronomy. CIRA has been a strong advocate for SKA-low, and has backed this up with leading-edge projects such as the MWA. These projects have demonstrated beyond doubt our commitment to the SKA, the effort we put into our collaborative relationships, and our science and engineering capacity."

THE MWA has already explored engineering solutions for low-cost, high-performance antennas, and addressed some of the computing challenges produced by very high data rates and volumes. Algorithm development occurring from interpreting MWA data will also be directly relevant to the eventual processing of data from SKA-low. The MWA itself has just finished construction and is now looking at the night sky for calibration and testing. It will begin its research program in early 2013.

The MWA provides an indication of what SKA-low will look like and how it will operate. It is made up of 128 aperture array 'tiles', made up of 4,096 fixed antennas. The majority of the tiles are placed in a core region, 1.5 km across, with the remainder placed more widely, giving a maximum baseline of 3 km. Each antenna signal must be collected, processed and correlated with all of the other signals to allow for real-time imaging of the sky. The resulting data and images are then transmitted on a dedicated optical fibre data link to Perth, where they will be stored at the Pawsey High Performance Computing Centre for SKA Science. As Tingay wryly notes: "It is an instrument that starts in the Murchison and finishes more than 700 km away in Perth. The scientists who use it will probably never even see the antennas."

SKA-low will take the idea of a megascience instrument to a whole new level. It will have 50 to 100 stations of low-frequency aperture array antennas, with 5,000 to 10,000 antennas per station. And that's just phase one. Phase two will extend the array to 250 low-frequency stations in Australia (spread up to 200 km from the core at the MRO). This enormous instrument will be a game changer in 21st-century astronomy, just on its own. In a complementary phase two development, the aperture array technology will be extended to higher frequencies, with this installation envisaged to be in South Africa, co-located with an extended high-frequency dish array.

If you want to study something as large as the Universe, you need an instrument as big as a planet. **C**