ASKAP Update

December 2012

The ASKAP Update is a regular series dedicated to conveying the latest news about the Australian SKA Pathfinder (ASKAP) project to international science and engineering communities. It is available online at www.atnf.csiro.au/projects/askap.

Years of work validated with phase closure

System verification tests on three ASKAP antennas at the MRO installed with CSIRO's innovative new phased array feed (PAF) technology successfully demonstrated phase closure in August 2012.

The phase closure tests are an important step in calibrating the antennas in preparation for interferometry with ASKAP. Furthermore, these tests demonstrate the proper functioning of the antennas and their electronic systems.

Following phase closure, further commissioning tests saw steady progress through the BETA Engineering Commissioning Plan lead to the production of the first preliminary images using the ASKAP antennas.

Though the images are not yet representative of the true capabilities of the full system, they do represent an important first step in the use of multiple PAFs together as an interferometer.

The team took observational data of a pair of compact sources with a single boresight beam and another positioned at a chosen angular separation. The source field was centred on the bright radio galaxy PKS 1934-638.

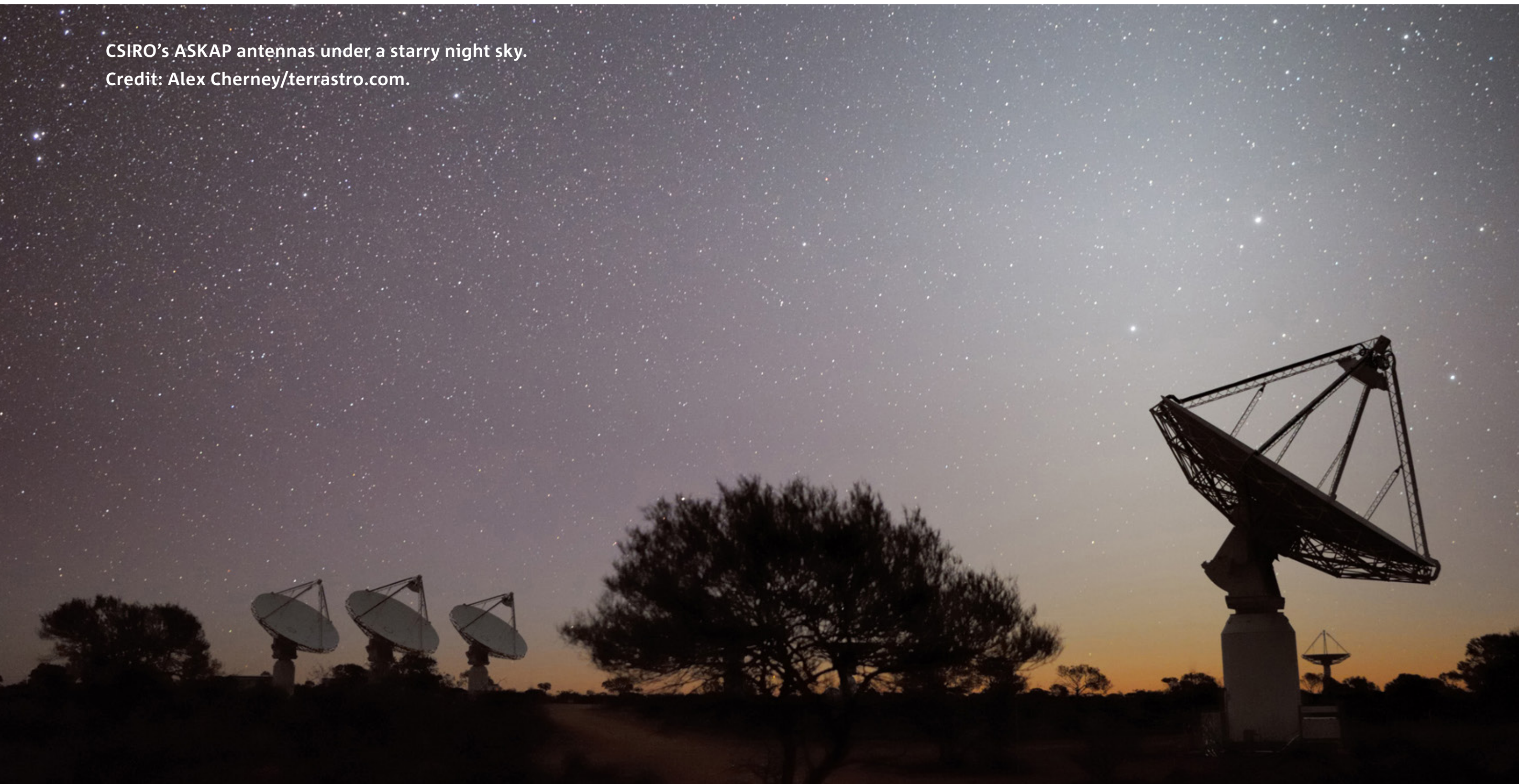
The beamformer subsystem captured 16 single 1 MHz channels, the raw data were then correlated in software to form visibilities which were imaged and cleaned manually using ASKAPsoft.

According to the commissioning team, the formed beams exhibited good phase stability over the duration of the observation – an encouraging result that shows ASKAP is ready to make full use of the hardware correlator when it arrives in the coming year.

"Obtaining phase closure on a three-baseline system is an early confirmation that our phased array feed systems work as expected in end-to-end tests with a high degree of precision', says Ant Schinckel, ASKAP Project Director.

"The team then took hours of observational data using multiple beams looking at galaxies a degree apart and produced these preliminary images. Though we have more work to do, this is an impressive result that confirms it can be done with our antennas using phased array feeds."

The next step for the ASKAP team will be commissioning another three antennas installed with PAFs to make up the Boolardy Engineering Test Array – an important six-antenna engineering test array – and commissioning of the hardware correlator.



CSIRO's ASKAP antennas under a starry night sky.
Credit: Alex Cherney/terrastro.com.

ADE PAFs 'generations ahead'

Enhancements to ASKAP's Phased Array Feed (PAF) receiver design have progressed under a work package known as the ASKAP Design Enhancements (ADE) project.

As highlighted in the August edition of the ASKAP Update, the redesign intends to improve efficiency and performance of the receivers across the ASKAP band, while leading to reductions in overall cost and build time.

Such improvements will be achieved by a number of upgrades, including improvement of the chequerboard geometry of the PAF, upgrading to signal transmission using RF-over-Fibre (RFoF) technology, direct sampling of the RF signal at the MRO Control Building, and new digital signal processing (DSP) hardware that uses the latest in FPGA devices.

Pivotal to the new receiver design is analogue-only signal processing at each ASKAP antenna, and full relocation of all digital system processing to MRO Control Building, up to 7 km away.

According to ASKAP Project Manager Adam Macleod, the new DSP card set is remarkable, thanks to the latest developments in FPGA technology.

"These cards are one-and-a-half generations ahead of what is commercially available," says Adam, "This is a bold step forward for systems of this size and scale in radio astronomy. The architecture will set new benchmarks in both antenna simplicity and radio quietness."

The 'Dragonfly' 16-channel digital receiver card supports direct sampling of RF signals output by the PAF receiver. Analog to Digital Converters sample each input channel sampled at 1536 MSPS (megasamples per second) with 12-bit resolution.

The card features 4 Kintex-7 FPGAs for pre-processing; high-speed interfaces facilitate up to 30Gbps of communications between each FPGA pair. While standard Ethernet supports configuration, control and monitoring, there are also 24 x 10 Gbps optical ports for data output.

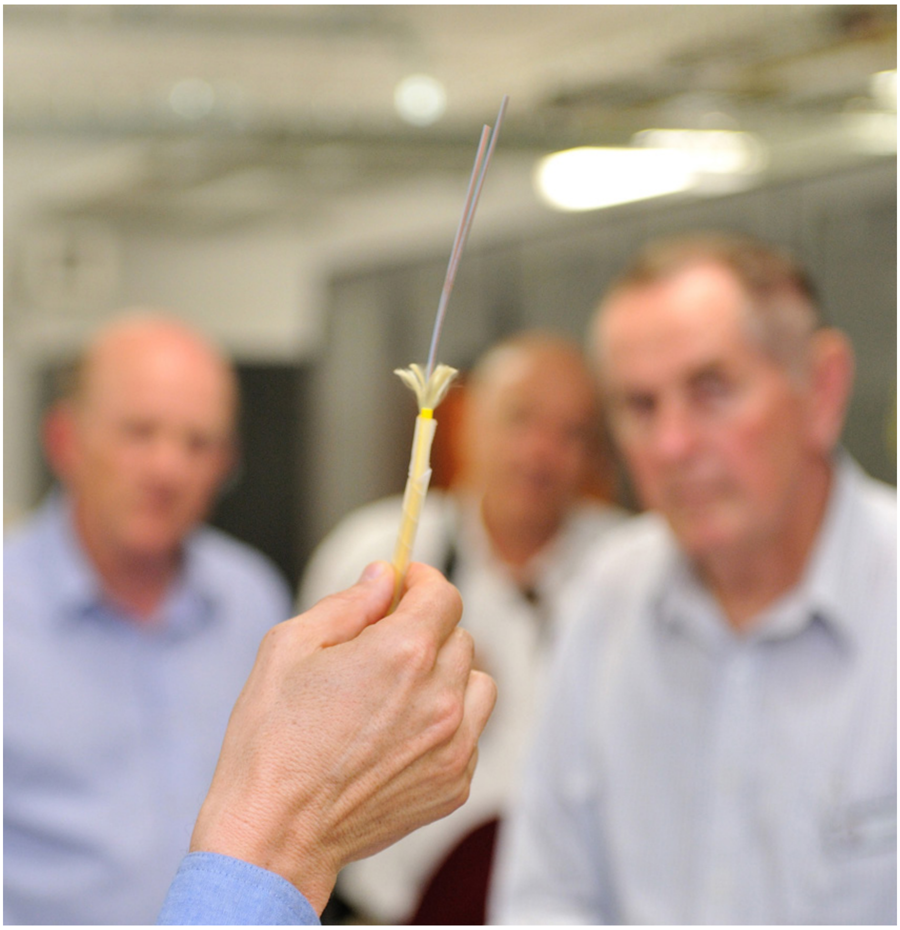
The highly flexible 'Redback' DSP card supports implementation of beamformer or correlator functionality, featuring six Kintex-7 FPGAs for signal progressing, each with 8GB of DRAM connected.

Additionally, each FPGA also has high-speed interfaces which facilitate more than 20 Gbps communications with every other FPGA, and for external interfaces the card features 30 x 10 Gbps optical inputs and 12 x 10 Gbps optical outputs.

Both the Dragonfly and Redback cards are built into 1U rack-mountable chassis, keeping the designs modular and portable. Initial revisions of both cards are fully functional, and importantly, have been used in the evaluation of other ADE hardware.

Since the Critical Design Review (CDR) in mid-2012, the ADE team has since been engaged in manufacture and assembly of the first-of-type MkII system.

ADE prototyping activities indicate that the performance specifications and cost targets will be achieved. Successful completion of integration testing in the coming months will allow for manufacture of the next set of ASKAP receiver systems.



During relocation of the 'BETA Box' into the Control Building, hundreds of underground fibres were carefully spliced and connected to the optic fibre terminations within the correlator room.

Michael Reay and Scott Munting study fibre optical fibre patching, during relocation of BETA Box electronics.

ASKAP 'moves in' to the MRO Control Building

Earlier this year, construction of the MRO Control Building was completed and, following successful testing of the facility, the building was officially handed over to CSIRO for occupation. The Control Building is a unique facility, specifically designed to overcome the challenges of its remote location and stringent radio quiet requirements of the Murchison Radio-astronomy Observatory.

The building houses power distribution, networking and communications equipment, telescope control computers, and also the complex digital processing, beamforming and correlator equipment to be used by ASKAP and other major instruments under development at the MRO, such as the Murchison Widefield Array (MWA).

During design and construction of the 800m^2 building, particular attention was paid to operating requirements and efficient energy management.

The wide temperatures range experienced in the Mid West region of Western Australia necessitates distinctive design solutions – such as painting the outer surfaces white to reflect radiant energy from the sun, incorporating highly insulated cladding materials for the outer structure to minimise energy requirements during summer, and raising the building above the ground to optimise air flow for cooling during the winter months and at night.

Additionally, heat generated by the complex electronic and computing equipment in the building is removed via an innovative ground-coupled cooling system. Bores have been drilled for the geo-exchange cooling system, which 'sinks' waste heat from the building's chiller plant directly into the ground via a fully sealed closed loop water pipe system

To maintain the specific radio-quiet standards of the MRO, two layers of welded steel shielding form Faraday cages that encase the electrical and electronic equipment within the building and prevent emissions generated by this equipment from interfering with telescope operations. An inner steel shield surrounds the digital processing and correlator systems and a second outer skin surrounds the entire building to provide a total of 200 dB of attenuation – equivalent to a reduction in RFI emissions by a factor of 100 million million million.

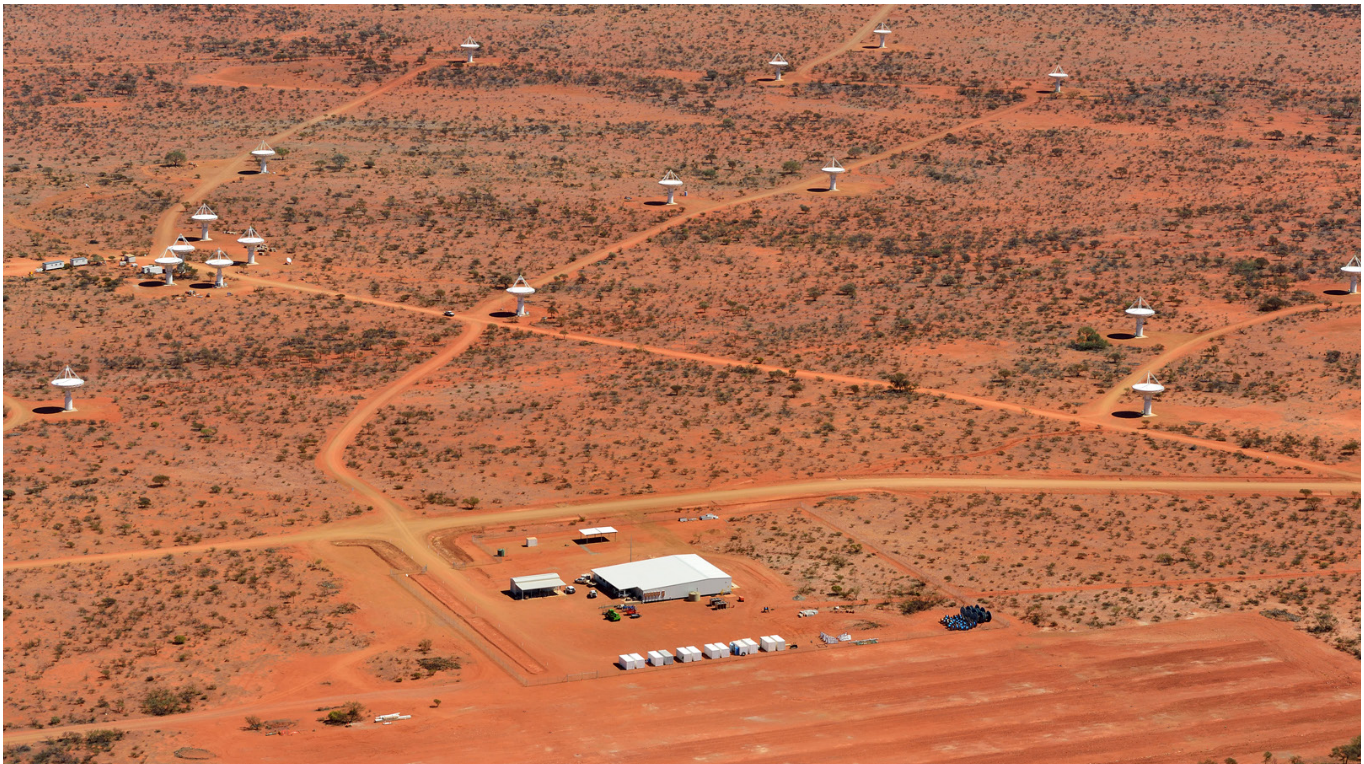
More recently, following the fitting out of the building interior with furniture and storage facilities, occupation and commissioning activities have focussed on the relocation of the temporary 'BETA Box' – the temporary housing of the correlator, beamformer and networking equipment for the first part of ASKAP. This equipment was previously housed in a modified 20' shipping container located adjacent to the first three ASKAP antennas installed with phased array feed receiver systems.

The successful decommissioning of the BETA Box and the recommissioning of data transport links from the digital receivers to the beamformers in the Control Building now paves the way for commissioning of more ASKAP antennas. With another three PAFs installed at the MRO, the six-antenna engineering test array, BETA, will be used to prepare the team for commissioning of the full 36 antenna ASKAP radio telescope.

The numbers:

- **1.9Tb/s:** data carried by the 216-fibre link from each ASKAP antenna to the correlator room
- **5:** windows in the 'breakout' room – a space to provide a break from the window-less environment of the main building (designed to prevent RFI leakage)
- **13:** trucks carried the Control Building in separate pre-fabricated hi-tech steel 'modules' from South Australia that were assembled onsite at the MRO
- **130m:** the depth of bore holes drilled in the ground to support geothermal cooling solutions
- **7776:** total number of fibres that connect the ASKAP antennas with the MRO Control Building
- **100 billion billion:** the reduction factor that dual shielded Faraday Cages reduce RFI generated inside the Control Building to protect the astronomical signals received at the antennas from contamination.

An aerial view of the MRO Control Building surrounded by ASKAP antennas at the Murchison Radio-astronomy Observatory.



ASKAP celebrates Opening in October

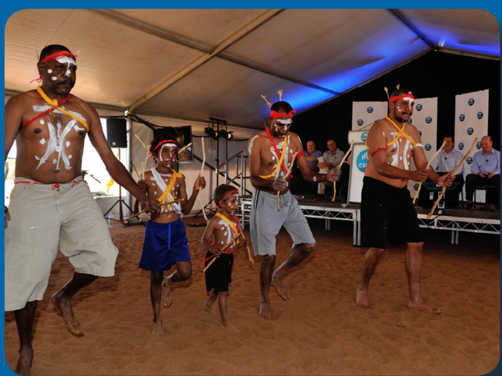
CSIRO's newest radio telescope, the Australian SKA Pathfinder (ASKAP), was officially opened in October 2012 by Australian Science and Research Minister, Senator Chris Evans during a ceremony at the Murchison Radio-astronomy Observatory (MRO) in Western Australia.

Guests and dignitaries transported to the ASKAP site for the day included board members of the SKA Organisation, senior government representatives, ambassadors and high commissioners of SKA member countries, government, science and industry organisations, neighbouring pastoralists and traditional landowners, the Wajarri Yamatji.

Addresses were given by Dr Megan Clark (CSIRO Chief Executive), Simon Broad (Murchison Shire President), the Hon. John Day (Western Australian Minister for Science and Innovation), Godfrey Simpson (Wajarri Yamatji) and Minister Evans.

Local events were also held at each of the CSIRO Astronomy and Space Science sites around Australia to celebrate the special event. The ceremony also signifies the transition of the project from construction phase, as the team now turns their focus onto engineering and scientific commissioning activities.

The ceremony, held close to the core of the ASKAP antenna array under a bright blue sky, included traditional dancing by members of the Wajarri Yamatji and an official naming ceremony during which traditional Wajarri names were bestowed upon each of the antennas.



Representatives of the Wajarri Yamatji perform traditional dances.

Murchison Shire President Simon Broad (far left) and the Hon. John Day, WA Minister for Science and Innovation (far right) watch on as CSIRO Chief Executive Megan Clark and Australia Science and Research Minister Senator the Hon. Chris Evans declare ASKAP and the MRO open.

ASKAP team members celebrate after the ceremony.

Guests walk through the antennas on their way to the ceremony location.

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