The Australian SKA Pathfinder

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CSIRO Astronomy and Space Science
Arniston, 3 May 2010
What is ASKAP?

- **Australian Square Kilometre Array Pathfinder**

- Located near Boolardy, Western Australia
- Precursor telescope of the Square Kilometre Array (SKA)
- Demonstrator for new receiver technologies

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Where will ASKAP be located?

- Perth
- Darwin
- Sydney
- Brisbane
- Alice Springs
- Melbourne
- Adelaide
- Hobart
- Canberra

WESTERN AUSTRALIA

NORTHERN TERRITORY

SOUTH AUSTRALIA

QUEENSLAND

NEW SOUTH WALES

VICTORIA

TASMANIA

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MRO Support Facility – Geraldton

- Maintenance
- Operations
- Outreach

420 km

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Shire of Murchison:
- 50,000 km²
- 0 gazetted towns
- 29 sheep/cattle stations
- 160 population

The Netherlands:
- 41,500 km²
- 431 municipalities
- 16,493,156 pop.
Radio Frequency Interference

Light Pollution

131 MHz (FORTE)
Radio Frequency Interference
Radio Frequency Interference
Radio Frequency Interference

Sydney
Population: $4 \times 10^6$

Narrabri
Population: $9 \times 10^3$

Boolardy
Population: a few
Proposed Location for the SKA

- Australia ideal for the SKA
  - Low RFI environment
  - Plenty of space
  - Good infrastructure
  - Commitment of OZ and NZ governments
Proposed Location for the SKA

5500 km
## ASKAP Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2009</td>
<td>Antenna 1 deployed</td>
</tr>
<tr>
<td>Nov 2010</td>
<td>Fibre link installed</td>
</tr>
<tr>
<td>Nov/Dec 2010</td>
<td>Delivery of antennas 2 – 6</td>
</tr>
<tr>
<td>Feb – Sep 2011</td>
<td>BETA installation and commissioning tests</td>
</tr>
<tr>
<td>May 2011</td>
<td>Mid-term review of Survey Science Projects</td>
</tr>
<tr>
<td>June 2011</td>
<td>BETA early science</td>
</tr>
<tr>
<td>Dec 2011</td>
<td>All 36 antennas delivered</td>
</tr>
<tr>
<td>Mid 2012</td>
<td>Final review of Survey Science Projects</td>
</tr>
<tr>
<td>Q4 2012</td>
<td>ASKAP complete</td>
</tr>
<tr>
<td>Early 2013</td>
<td>Beginning of science operations</td>
</tr>
</tbody>
</table>

*First antenna deployed in 2010, all 36 antennas delivered in Dec 2011.*

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*CSIRO. ASKAP Simulations*  
*Wednesday, 5 May 2010*
ASKAP Design Goals

- High dynamic range, wide-field imaging
  - Number of antennas 36 (630 baselines)
  - Antenna diameter 12 m
  - Maximum baseline 6 km (30 antennas inside 2 km)
  - Angular resolution 10 arcsec
  - Sensitivity 65 m²/K
  - Frequency range 700 – 1800 MHz
  - Focal plane phased array 192 elements
  - Field of view 30 deg²
  - Processed bandwidth 300 MHz
  - Number of channels 16 384
  - Integration time 5 s
ASKAP Design Goals

- High dynamic range, wide-field imaging
  - Number of antennas: 36 (630 baselines)
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First ASKAP Antenna Deployed

- First ASKAP antenna shipped to Australia and installed on site in December 2009.
First ASKAP Antenna Deployed

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Antenna Design

- Antennas built by 54th Research Institute of China Electronics Technology Group Corporation (CETC54).
- Azimuth / elevation mount with elevation range of +15° to +89°.
- Third (polarisation) axis: dish can rotate by ±180° to keep orientation fixed w.r.t. the sky.
- Slender support legs to minimise aperture obstruction.
Antenna Design

△ Installation of the receiver housing

◆ The polarisation axis in action
First VLBI Fringes

- First VLBI fringes on 22 April between ASKAP and Mopra!
- First trans-Tasman fringes (ASKAP–Warkworth) on 23 April!

More to come soon!

CSIRO. ASKAP Simulations

Wednesday, 5 May 2010
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ASKAP Array Configuration

- Initial array configuration
  - Spectral line:
    - Inner 30 antennas only, max. baseline 2 km.
    - Resolution: 30 arcsec at 1.4 GHz.
  - Continuum:
    - 36 antennas in 6 km array.
    - Resolution: 10 arcsec at 1.4 GHz.

Gupta, Johnston, Feain & Cornwell (2008)
Beam size of full array at natural weighting.

<table>
<thead>
<tr>
<th>Declination (deg)</th>
<th>Snapshot beam (arcsec x arcsec)</th>
<th>10 hr beam (arcsec x arcsec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-50</td>
<td>19.1 x 15.4</td>
<td>19.4 x 15.9</td>
</tr>
<tr>
<td>-30</td>
<td>17.6 x 15.2</td>
<td>18.9 x 17.5</td>
</tr>
<tr>
<td>-10</td>
<td>17.9 x 15.3</td>
<td>19.6 x 18.2</td>
</tr>
<tr>
<td>0</td>
<td>18.4 x 15.3</td>
<td>19.5 x 19.3</td>
</tr>
<tr>
<td>+10</td>
<td>21.5 x 15.1</td>
<td>20.1 x 19.2</td>
</tr>
</tbody>
</table>
Synthesised Beam at 1.4 GHz and $\delta = -30^\circ$

**Uniform weighting**

- FWHM: 18.9 arcsec
- Sidelobes: $-5.5\%$...+$3.1\%$

**Natural weighting**

- FWHM: 27.5 arcsec
- Sidelobes: $-2.4\%$...+$4.9\%$
### ASKAP Design Goals

**High dynamic range, wide-field imaging**

- Number of antennas: 36 \((630\, \text{baselines})\)
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Phased Array Feed

PAF prototype installed on the 12-m Parkes testbed antenna

John O’Sullivan with the PAF prototype
Final FoV and sensitivity will depend on details of beam-forming.
30 deg^2 Field of View

Virgo Cluster

M90
M89
M87
M86
M84
M59
M58
M60

Wednesday, 5 May 2010
30 deg² Field of View

Virgo Cluster

M90, M89, M87, M86, M84, M80, M59, M58, M60

VLA 1.4 GHz

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Survey Science Projects

• 30 deg² field of view → ASKAP will be a survey machine.
• Over the first 5 years of operation
  • 75% will be devoted to large survey science projects (SSPs).
  • 25% will be given to smaller guest science proposals.
• Survey science projects are large projects with > 1500 h.
• Open, international, competitive process set up for submission of expressions of interest and proposals.
• SSP proposals were evaluated by committee of international experts with a broad range of proficiencies.
• A total of 10 SSPs were invited to work with ATNF through the design study phase.
• Origin of SSP team members:
  • 30% Australia, 30% Europe, 30% North America, 10% other.
SSPs “A Group”

• **WALLABY** *(Pls: B. Koribalski, L. Staveley-Smith)*
  - Widefield ASKAP L-band Legacy All-sky Blind Survey
  - Extragalactic neutral hydrogen survey
  - 75% of the entire sky
  - Up to 500,000 galaxies out to a redshift of 0.26
  - **Aims:** H I properties and large-scale distribution of galaxies, galaxy formation, missing satellites problem, evolution and star formation, mergers and galaxy interactions, H I mass function, distribution and evolution of cool gas, cosmological parameters, nature of the cosmic web

• **EMU** *(Pl: R. Norris)*
  - Evolutionary Map of the Universe
  - Deep radio continuum survey (10 µJy/beam rms)
  - 75% of the entire sky
  - **Aims:** probing star forming galaxies to redshift 1, powerful starbursts to even greater redshifts, AGN to the edge of the universe, discovering new classes of rare objects, trace the evolution of star forming galaxies and massive black holes throughout the history of the universe, explore large-scale structure
SSPs “A- Group”

- **GASKAP** *(PIs: J. Dickey, N. McClure-Griffiths)*
  - Galactic ASKAP Spectral Line Survey
  - H I and OH in Milky Way and Magellanic System
  - 10 × improvement in brightness sensitivity and angular resolution
  - **Aims:** OH masers from evolved stars and star formation regions, diffuse emission from molecular and atomic clouds, H I absorption towards background continuum sources and the structures in the gas that trace the effects of stellar winds and supernova explosions, stunning images of the ISM

- **DINGO** *(PI: M. Meyer)*
  - Deep Investigation of Neutral Gas Origins
  - Evolution of H I from the current epoch to $z \approx 0.5$
  - Legacy dataset spanning cosmologically representative volumes
  - **Aims:** key cosmological distributions, including $\Omega_{\text{HI}}$, H I mass function and halo occupation distribution function, combined with optical data to enable study of co-evolution of stellar, baryonic and dark matter content of galaxies
SSPs “A- Group”

• **FLASH** *(Pl: E. Sadler)*
  - The First Large Absorption Survey in H I
  - Blind H I absorption-line survey of background radio continuum sources
  - **Aims**: neutral gas content of galaxies, cosmic H I mass density in the redshift range $0.5 < z < 1.0$, $100 \times$ increase in total number of absorption line systems

• **POSSUM** *(Pls: B. Gaenser, T. Landecker, R. Taylor)*
  - Polarisation Sky Survey of the Universe’s Magnetism
  - Radio source polarisation, RM synthesis
  - Wide-field survey for RM grid across the sky
  - **Aims**: ordered components of the Milky Way’s magnetic field, test dynamo and other models of magnetic field generation in galaxies and clusters, carry out comprehensive census of magnetic fields as a function of redshift in galaxies, AGN, galaxy clusters and the IGM
SSPs “A– Group”

• **VAST** *(Pls: T. Murphy, S. Chatterjee)*
  - ASKAP Survey for Variables and Slow Transients
  - Search for transients with timescales > 5 s
  - **Aims:** study of flare stars, intermittent pulsars, X-ray binaries, magnetars, extreme scattering events, intra-day variables, radio supernovae and orphan afterglows of $\gamma$-ray bursts

• **CRAFT** *(Pl: P. Hall)*
  - Commensal Real-time ASKAP Fast Transients Survey
  - Survey for transient sources with timescales < 5 s
  - **Aims:** study the most energetic and brightest single events in the universe, high brightness temperature objects, extreme states of matter, physics of strong gravitational fields, sensitive probe on the huge reservoir of baryons in the IGM
SSPs “Strategic Priorities Group”

- **VLBI** (PI: S. Tingay)
  - The High-resolution Components of ASKAP: Meeting the Long Baseline Specifications for the SKA
  - ASKAP + Australian Long Baseline Array, high-speed data recording equipment, software correlation facilities and high speed data transport networks
  - **Aims:** proper motion and parallax of pulsars, high-resolution imaging of AGN, follow-up of transient radio sources, distances and proper motions of OH masers

- **COAST** (PI: I. Stairs)
  - Compact Objects with ASKAP: Surveys and Timing
  - Pulsar timing aimed at high-profile issues in astrophysics
  - **Aims:** gravitational waves, tests of General Relativity and other theories of strong gravity, studies of binary stellar evolution, blind searches for pulsars, Galactic neutron star population, pulsar emission mechanism, structure and magnetic field of the Galaxy
Survey Science Project Management

- Interaction between SSPs and ASKAP through
  - 5 technical working groups
  - Coordination and Management group

- Coordination and Management group
  - SSP PIs meet with ASKAP staff on a bi-monthly basis

- Technical working groups
  - Meetings between SSP WG chairs and ASKAP staff as needed
• Sky simulation based on
  • SKADS S3-SAX sky (Obreschkow et al. 2009) for spectral line
  • SKADS S3-SEX sky (Wilman et al. 2008) for continuum
• 30 antennas in the 2 km core configuration
• 32 idealised beams on a 1° grid
• Total integration time of 8 h
• Continuum simulations have been deconvolved using multi-scale CLEAN
ASKAP Continuum Simulations
ASKAP Simulations

- New simulations released on 16 April.
  - Fully-sampled beams for homogeneous noise levels.
  - Correction of flux error in previous continuum simulations.
  - Spectral cube with lower noise for source finding tests.
- Next release due end of May, focussing on
  - Transient sources
  - Polarisation
- ASKAP simulations are publicly available:
Commitment of Australian Government

- Super Science Initiative of the Australian Government

Super Science Fellowships

Key Points
- The Government will provide $27.2 million over four years to run two rounds of three-year early-career fellowships, to ensure our most promising young researchers continue to have opportunities to work in areas of national significance during the global recession.
- Fellowships will be offered in three areas of existing research strength:
  1. Space science and astronomy;
  2. Marine and climate science; and
  3. Future industries research – biotechnology and nanotechnology.

Facts and Figures
- The scheme will offer 100 fellowships in total (50 fellowships per round), each worth up to $72,500 per annum.
- The first round of fellowships to commence funding in 2010, with applications called in the second half of 2009.
Commitment of Australian Government

**Outcome**

- Announced by the Minister for Innovation, Industry, Science and Research, Senator Kim Carr, during a ceremony held at ATNF on 8 April 2010.
- 1\textsuperscript{st} round commencing in 2010

<table>
<thead>
<tr>
<th>Targeted Discipline Area</th>
<th>No. of requested fellowships</th>
<th>No. of approved fellowships</th>
<th>Success Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space science and astronomy</td>
<td>36</td>
<td>17</td>
<td>47.2%</td>
</tr>
<tr>
<td>Marine and climate science</td>
<td>53</td>
<td>17</td>
<td>32.1%</td>
</tr>
<tr>
<td>Future industries</td>
<td>60</td>
<td>16</td>
<td>26.7%</td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

- 2\textsuperscript{nd} round commencing in 2011

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<th>No. of requested fellowships</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Space science and astronomy</td>
<td>38</td>
<td>16</td>
<td>42.1%</td>
</tr>
<tr>
<td>Marine and climate science</td>
<td>43</td>
<td>17</td>
<td>39.5%</td>
</tr>
<tr>
<td>Future industries</td>
<td>43</td>
<td>17</td>
<td>39.5%</td>
</tr>
<tr>
<td>Total</td>
<td>124</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>
Job Opportunities

• Total of **33 Super Science Fellowships** in Astronomy and Space Science all across Australia over the next 4 years.
• About **10** of these will be directly related to **ASKAP**.
• Positions will be advertised in May for commencement in mid/late 2010.
• Great opportunity for early-career researchers within 3 years of a PhD.
For more Information...

- **Public ASKAP website:**

- **ASKAP Science/Technical Updates:**

- **ASKAP Project Scientists:**
  - Simon Johnston
  - Ilana Feain (acting: Tobias Westmeier)
  - atnf-askap-ps@csiro.au

- **anzSKA websites:**
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