



NEWSLETTER

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FROM THE INTERNATIONAL SKA PROJECT OFFICE

Representatives from Funding Agencies or Science Ministries of 14 countries, the European Commission, and the European Southern Observatory met on 6 February in the Hague to discuss the science goals, management, and timeline of the SKA project, and to exchange information on national and regional activities in support of the SKA. There were two major outcomes from the meeting. With respect to SKA site selection, the meeting requested that the International SKA Steering Committee supply them with a non-prioritized short-list of acceptable sites instead of a ranked list. Secondly, the meeting decided to form a Working Group, the Funding Agencies Working Group (FAWG), to discuss a number of issues – final site selection, governance, and funding - and report back to the main group in time for its next meeting in September. The ISSC chair and ISPO Director are ex-officio members of the FAWG.

The International SKA Steering Committee met for the 15th time at NRAO in Socorro, New Mexico in March. The main items of discussion were the site selection process, the ISPO budget, possible future governance structures for the project, and input to be provided to the FAWG. It was also agreed that generating a preliminary cost estimate for the SKA was a high priority for the ISPO.

In preparation for the evaluation of the candidate site proposals by the International SKA Site Evaluation Committee (ISSAC) in June and July, and the site short-listing by the ISSC in late August at its meeting in Dresden, the ISPO Working Groups and Task Forces have evaluated a number of aspects of the site submissions and generated expert reports for the ISSAC and ISSC. Yervant Terzian's report in this Newsletter gives the details of the work done. I would like to use this forum to thank all the

individuals involved in the WGs, TFs and in external review panels for the time and considerable effort put into this essential part of the site selection process.

One of those people is Steven Tingay who chaired the Simulations Working Group and the Task Force on Configurations Simulations which did the assessment of the configurations proposed by the candidate sites. Steven is stepping down as SimWG chair after three years and I want to thank him for his substantial contributions to the work of the international project during that time. I'm sure we'll be calling on his expertise and enthusiasm again in the future.

The Engineering and Science WGs have both made considerable progress in their various spheres of activity in the last six months, as you will see as you read further. The Outreach Committee is devoting its energy towards mounting a successful campaign at the IAU General Assembly in Prague in August, while the Operations WG is in the process of completing its initial White Paper on SKA Operations. The EWG, SWG and OWG will come together in Paris in early September for a continuation of the very successful face-to-face discussions last November in Pune. The results of the Paris meeting will be reported in our next Newsletter.

In the news from consortia and institutes, we have reports from Australia and New Zealand, Canada, China, Europe, South Africa, and the USA. The sum total of the global engineering and pathfinder development effort is truly impressive, and is contributing in a major way to the system design activity for the international project.

Richard Schilizzi
Director

NEWS FROM THE WORKING GROUPS

ENGINEERING

The EWG has recently undergone some membership changes with Ron Beresford, Frank Briggs and Colin Jacka rotating off the Group. At the same time, Kjeld van der Schaaf (ASTRON) and John O'Sullivan (ATNF) have joined us. Welcome to Kjeld and John, and thanks to Ron, Frank and Colin for their contributions – we're hoping that all three will remain closely associated with EWG task forces. Recognizing the growing importance of computing matters, a new task force dealing with calibration and imaging has been formed. Tim Cornwell will lead the C&I Task Force, while Kjeld van der Schaaf will chair the existing Computing Task Force. In other changes, Sandy Weinreb and Larry D'Addario are stepping down as RF Systems and Signal Processing chairs; Bruce Veidt will take over from Sandy, while the signal processing chair is currently vacant. Thanks to both Sandy and Larry for their leadership over the last few years. Fortunately, both expect to remain involved with the task forces at some level.

The EWG task force white papers, dealing with aspects of the SKA system design, are now available (via the EWG web page) as exposure drafts. Some are still incomplete but work by the ISPO on completing and editing the documents, and production of a composite volume, is proceeding. This compendium will be available as discussion material for forthcoming international meetings, as input to an SKA cost-performance study, and as background material to reviewers of SKA technology proposals formulated over the next 18 months.

The major SKA public meetings in 2006 will be working forums to be held in Paris, in the period 4-8 September. The two-day EWG task force sessions will be held immediately after a European SKADS engineering day, and prior to a two-day joint meeting with the Science Working Group and the Operations Working Group. This year the EWG meetings will focus on the Reference Design; demonstrations of key SKA technology; recent cost trends for major systems; and realistic cost, performance and timescale projections. All EWG and task force members are strongly encouraged to attend, as are members of the other working groups. Further details, including registration information, are available via the SKA website; please ensure you register before July 31. Watch the web site for updates to the program and logistical arrangements. In planning the meetings, we are grateful for the hospitality of the Institut d'Astrophysique de Paris and the sponsorship of the Observatoire de Paris.

At its March meeting in Socorro the ISSC approved a "Term Sheet" setting out provisions for R&D collaboration between SKA partners and IBM. A call for expressions of interest from SKA institutes interested in collaboration has now closed and the ISPO has begun the process of briefing IBM and facilitating agreements with SKA partners. Note that this is a non-exclusive collaboration, and that it applies only to R&D, not to commercial dealings. The ISPO has also been heavily involved in supporting the SKA site assessment process in many ways, including co-ordination of specialist

reporting groups, and examination of infrastructure and related projections.

The Socorro ISSC meeting approved the ISPO request for more system engineering support to continue development of SKA cost and performance estimation tools. A call for expressions of interest closed recently, with the result that the ATNF will supply an input of 0.5 FTE over the 12-month period beginning Quarter-4,

2006. A short-term goal of the project is a better cost estimate of a representative SKA Reference Design; longer term aims involve development of a more sophisticated modelling environment, allowing optimization of Reference Design components.

*Peter Hall
International Project Engineer, and
Chair EWG.*

OUTREACH

The main activities of the Outreach committee concentrated on preparations for the exhibition at the IAU General Assembly at Prague in August. These include an update of the main conference posterboard but also the production of a new flyer which will be available in addition to the SKA brochure. Following the establishment of a reference design for the telescope, the Outreach committee is now preparing a number of illustrations of what the telescope may look like. Firstly, a physical model of the core of the SKA Reference Design is being built at ASTRON under contract to the ISPO. This model will be a centre piece of the exhibition at Prague. In addition, a

group of Italian designers has been contracted to produce a computer animation showing the reference design. Still images will feature in a number of articles that are being written for popular astronomy magazines in the Europe, Australia and the USA. Finally, the Outreach committee would like to thank Stephanie Voegelé for all her valuable help in the past three years, and wish her well in her new job in France.

*Michael Kramer
Chair Outreach Committee*

SITE EVALUATION

At the end of 2005, the ISPO received four proposals to site the SKA, one each from Argentina/Brazil, Australia, China and South Africa. Copies of the proposals were forwarded to the ISSC, the Site Evaluation Working Group, and to other relevant groups for analysis and evaluation. The RFI monitoring sections of the proposals were submitted on March 17, 2006. In addition, on the same date, the ASTRON independent RFI survey results, of all four sites, were also submitted to the ISPO. All the RFI reports were transmitted to the SEWG Task Force on RFI, Chaired by Professor Steve Ellingson, for analysis and evaluation. The proposals were also sent to the SEWG Task Force on Regulatory Issues to analyze the radio spectrum allocation policies and procedures for the SKA sites. The Simulations Working Group Task Force on Array Configurations also received the proposals for analysis.

The ISSC has appointed an independent International Site Selection Advisory Committee (ISSAC) to evaluate the proposals for candidate sites and advise the ISSC on the ranking of the sites.

The ISSAC is being provided with the analysis reports as mentioned above, in addition to copies of the Request for Proposals, the submitted Proposals,

clarifications to the RFP issued by the ISPO, and responses by the proposers to questions submitted to them by the ISPO after the proposals were received.

The ISSAC will meet in Cambridge, UK, early in July, with representatives of the proposing countries to discuss the proposals and to clarify any additional questions. The ISSAC will then review all the information according to the 'Principles of Siting Evaluation' and the 'Evaluation Criteria' as specified in the Request for Proposals for siting the SKA. It is anticipated that the ISSAC will provide a report on their findings to the ISSC by July 31, 2006.

The ISSC is scheduled to meet in Dresden, Germany, at the end of August, 2006 and decide on a short list of acceptable sites for the SKA. This list will be provided to the funding agencies of the different countries participating in the SKA project. It is anticipated that the funding agencies will decide on a process to make the final site selection in the next two or so years.

*Yervant Terzian
Chair SEWG*

SIMULATIONS

Since the last SKA newsletter the SimWG and the CSTF (Configuration Simulations Task Force: a subset of the SimWG) have concentrated on working through the SKA site proposals that were submitted to the ISPO at the end of 2005. These proposals came from Argentina/Brazil, Australia, China, and South Africa.

Part of these proposals outlined the expected performance and characteristics of the proposed sites, from the point of view of array configurations. The proposers were provided guidance on the basic format of the array configuration, following from constraints laid down in the ISSC's Request for Proposals from 2004, by the CSTF. In addition, the proposers were given a comprehensive set of figures-of-merit that were going to be used to estimate the array performance in a number of different observing situations that will be used to fulfill the SKA science goals. This was supported by software written by the CSTF to assist proposers.

After the proposals were submitted, the CSTF prepared a report on the array configurations proposed by the different teams. This report contains no comparative analysis of the different sites, and makes no judgement on which site is "best", but

presents a factual and quantitative analysis of each site individually.

This report has now been submitted to the ISPO, to be handed to the ISSC and the ISSAC (International SKA Site Advisory Committee), as reference material for the site evaluation process.

I'd like to take this opportunity to thank all of the CSTF and SimWG members who assisted me in compiling this report.

This will be my last contribution to the SKA newsletter as Chair of the SimWG and Chair of the CSTF, as I have resigned from these positions. The last 3 years as SimWG Chair have been interesting, exciting, and hard work. I've enjoyed it and hope that the SimWG can continue its useful work in the next period of development of the SKA, as the siting and technology planning gets underway in earnest.

*Steven Tingay
Former Chair SimWG*

SCIENCE

As reported in the last newsletter, members of the SWG have spent much of the last year holding a series of conferences to promote and develop the SKA Key Science Projects (KSPs). All of these meetings have now been held, and were highly successful. Some final comments on these events are below.

Strong Field Tests of Gravity

Interaction with the gravitational wave community is crucial for promoting and understanding this project. To this end, a workshop entitled "Gravitational Waves, Radio Pulsars, and Astrometry: Testing Gravity in the Next Decade" was held in Birmingham, UK, on 2006 March 30–31. The aim of the workshop was to bring together the communities involved in the major experiments testing theories of gravity over the next decade, to develop experimental strategies, to foster enhanced communication, and to exchange techniques and ideas between the different disciplines related to gravity science. Organised by Michael Kramer (representing SKA), Alberto Vecchio (representing LISA), Graham Woan (representing LIGO/VIRGO) and Sergei Klioner (representing GAIA), the workshop was attended by 47 participants, representing the SKA, LISA, GAIA, and LIGO/VIRGO communities around the world.

Both LIGO and LISA will detect gravitational waves directly. The SKA will probe gravity using techniques based on pulsar timing. Pulsar timing has the ability to probe both near field gravitational effects as well as the far field gravitational wave effects. Near field effects can be tested by observing a pulsar in a close orbit around another star. The precise evolution of the orbit can be used to place strong limits on the validity of

Einstein's theory. Observations of a set of pulsars can be used to infer the presence of a gravitational wave background. GAIA will also be able to detect the presence of very low frequency gravitational waves by searching for minute fluctuations in star positions that would be correlated in widely separated regions on the sky.

The workshop was organised in sessions, consisting of a small number of invited talks that were meant to inspire discussion on the key issues, followed by contributed talks. All talks can be downloaded from the meeting's website

(<http://www.jb.man.ac.uk/ska/gravmeeting06>). The workshop concluded with an open discussion on how to achieve advances in gravitational physics, the milestones of discoveries that could be used as measures for such advances and the potential synergies between the different instruments and approaches. The discussion started with a (unranked) list of previous and possible future discoveries and continued with the discussion of possible synergies between the different experiments and how they can be outlined and presented in an obvious form. It was concluded that there is indeed large number of synergies and complementarities existing between the experiments. Ways were discussed how to visualise the parameter/theory space that is probed by the different experiments. Possible choices include the mass range of studied black holes or the parameter space of the Parameterised-Post-Newtonian (PPN) formalism. Work on these areas has been started. Finally, it was agreed that the workshop was highly useful and that it should be repeated on a regular timescale of the order of one year.

In addition, a larger KSP conference on pulsars is being planned in Thailand at the end of March 2007.

Cosmic Magnetism

The proceedings of a very stimulating 2005 conference on "The Origin and Evolution of Cosmic Magnetism," organised by the SWG magnetism team, have now been published as a special issue of *Astronomische Nachrichten*. We pass on huge thanks to Rainer Beck, Gianfranco Brunetti, and Luigina Feretti for editing this 255-page volume, which we hope will act as a definitive review of current understanding and future prospects.

Astrobiology: The Cradle of Life

SWG members organized a special session on the importance of radio astronomy for astrobiology at the Astrobiology Science Convention 2006 in March, held in Washington, DC. "AbSciCon" is a conference designed to bring together the astrobiology community, and specifically the NASA-supported segment of it. Occurring every 2 years since 2000, the most recent conference attracted roughly 1000 participants. The motivation behind the radio astronomy symposium was to increase the exposure and inform the astrobiology community about the relevant questions that can be pursued with the existing and planned tools of radio astronomy (particularly the SKA). The decision to focus on radio astronomy more broadly rather than the SKA specifically was deliberate and reflects the general invisibility of radio astronomy observations within typical astrobiological discussions. As an example, there was an entire session on proto-planetary disks in which even millimeter and sub-millimeter observations were barely mentioned.

The symposium consisted of 5 invited talks, one contributed talk, and several posters. Of the talks, four were presented by people with some connection to the SKA, including two

from the SWG. Consequently, the SKA was mentioned in most of the talks, and there was a poster specifically on the SKA. (In addition, the U.S. SKA Consortium exhibit booth, along with SKA brochures, was displayed and many of the brochures were taken.)

The result of the symposium can probably be described as mixed. The talks were uniformly interesting, reasonably well attended, and there was enthusiastic discussion after the symposium by a number of people who had been in attendance. However, there were also aspects of AbSciCon that did not lend themselves well to the original goal. For instance, AbSciCon is so large that there are multiple parallel symposia; some of those scheduled concurrently with the radio astronomy symposium had clear overlaps.

Future Large Ground-based Telescopes

This meeting was a special session at the joint American Astronomical Society-Canadian Astronomical Society meeting in Calgary on June 8. The focus was on both the SKA and future large optical telescopes (with apertures of 25 meters or more) and the scientific and technical aspects that the radio and optical instruments share. The session consisted of four invited talks. Providing overviews of the projects and highlighting key technical aspects of them, Raymond Carlberg described the TMT (Thirty-Meter Telescope) and James Cordes described the SKA. Two scientific goals for both telescopes were then highlighted, as Amy Barger spoke on "The High-Redshift Universe" and Ralph Pudritz spoke on "Planet Formation and Migration."

SKA Phase I

Now that the organization of these meetings is completed, much of the focus for the SWG is on developing a detailed science case for a Phase I SKA, with 10% of the full SKA collecting area and maximum

baselines of approximately 50 km, but otherwise with specifications as laid out in the Reference Design. After a great deal of polling and discussion, the SWG has converged on three key topics for the Phase I SKA:

- First Light: The Epoch of Reionisation
- Building Galaxies: Hydrogen and Magnetism
- Pulsars and the Transient Sky

These represent a sampling of the five KSPs for the full SKA, but also include some discovery science for which the Phase I SKA can carve an exciting niche in its own right. The SWG has also identified a dozen other secondary experiments for the Phase I SKA, including weak lensing, the intercluster medium, and spacecraft tracking.

The task at hand is now to produce a science case document for the Phase I SKA. This work has begun, with the goal being to have documents describing the case for the three key topics available by 2006 August—in time for dissemination at the IAU

General Assembly—with the full document completed by 2006 December.

The other major activity currently being undertaken by the SWG is the writing of a memo on “complementarity,” which discusses the context of SKA science with respect to other current and future large projects. This will be submitted to the consortium of national and multi-national funding agencies in 2006 July.

Several SWG members will attend the inter-working group meeting in Paris in 2006 September, where we will work with the EWG and OWG to refine the science requirements and instrument specifications. A short SWG-only meeting will be convened that week also.

Bryan Gaensler
Chair SWG

MEETINGS

> SKA conference in Oxford

The conference "Cosmology, Galaxy Formation and Astroparticle Physics on the pathway to the SKA" was held on Monday - Wednesday 10-12 April 2006 in the Department of Physics in the University of Oxford.

Each day began with reviews of current knowledge and throughout the day contributed talks from people working across the wavebands highlighting where the SKA could contribute in solving the important questions of the future.

105 participants took part in the conference on astro-particle physics (day 1), on Cosmology and large-scale structure and other aspects of cosmology (day 2), and epoch of reionization and galaxy formation (day3).

Conference proceedings will be produced and will be available via the LoSKA homepage

(<http://www.astro.physics.ox.ac.uk/LOSKA/CONFERENCE/>) in the near future.

> SKA Working Groups meeting in Paris

04 - 08 September / 2006 Paris

NEWS FROM THE CONSORTIA AND INSTITUTES

AUSTRALIA

New Technology Demonstrator (NTD) and Extended New Technology Demonstrator (xNTD)

The main tasks of the NTD project are now to further understand the behaviour of Vivaldi feeds and develop a better Focal Plane Array design to meet the requirements of the xNTD and SKA for high dynamic range, frequency coverage and sensitivity to polarisation. It appears that the needs of the xNTD could be better met using a feed based on a periodically loaded linear connected array. This approach would need the design of the LNA to be closely integrated with the feed design. The NTD project team will develop a 5-element x 5-element prototype tile that will be further developed for the xNTD.

First fringes were recently obtained from the two-element interferometer in Sydney. However, the THEA tile has not yet been mounted on the antenna because lab testing showed that interference from a local analogue TV signal at 527 MHz - greater than expected - would create intermodulation problems in the passband above 1 GHz. As a result, the team have had to modify the front-end circuits of the THEA by including filters and replacing a buffer amplifier and they expect to install the THEA tile in July. Meanwhile, investigations of other feed and LNA designs are progressing well.

Recruiting for the xNTD project has begun in order to engage a second Project Manager, four software engineers, and three engineers for the digital, receiver and data transmission projects.

The xNTD project covers the commissioning of the instrument and its early science. In developing plans for commissioning the xNTD team will draw on experience gained in the commissioning of other instruments, such as the Australia Telescope Compact Array.

Over the past few months there has been considerable interaction with the South African and Canadian SKA teams. Tim Cornwell visited South Africa and has identified common work packages in the software development of the xNTD with the South African KAT project. Three of the Canadian SKA team spent a week here in May, during which a number of areas were identified where the two teams could collaborate.

A draft paper on Science with the xNTD has recently been made available at <http://www.atnf.csiro.au/projects/ska/Memoseries.html>

Radio Frequency Environment of Australia's Candidate Site, Mileura WA

Monitoring of radio interference during 2005-2006 has confirmed the results of previous sensitive RF-monitoring measurements taken at Mileura in 2001, and has established the stable nature of the radio-frequency environment over time. This radio-frequency environment is now being protected by the Australian Communications and Media Authority (ACMA) who have introduced a spectrum embargo for the area around the proposed SKA core site. The ACMA are now proceeding to develop a radio-quiet zone over the site.

The RFI monitoring results show that spectral occupancy is extremely low, even in the region of spectrum below 1600 MHz, which is internationally the most crowded. In addition, recent astronomical measurements taken with several arrays of crossed dipoles by the Low Frequency Demonstrator project (see following article), located some 30 km from the proposed Australian SKA core site, have shown that astronomical observations can be made at Mileura with exceptionally low levels of radio-frequency interference.

The radio-quietness of the Mileura site results from the area's very low population density over large distances from the site. Monitoring has also been conducted at several proposed remote array-station locations: again, results indicate that these sites are also extremely radio-quiet.

In March 2006 the Government of Western Australia announced the creation of a Radio Astronomy Park on Mileura Station in order to develop Western Australia as the world's pre-eminent location for radio astronomy research.

LFD Early Deployment Array established at Mileura in Western Australia

During 2005 the Early Deployment Array of the Low Frequency Demonstrator (LFD) came to life on Mileura Station in Western Australia, thanks to the efforts of astronomers from the University of Melbourne, ANU, ATNF, MIT and Curtin University (WA). This three-station interferometer – an international project led by members of MIT's Haystack Observatory - became a functioning radio telescope, making a few basic astronomical observations and sampling the radio environment at 80–300 MHz. Further details of the project can be found at <http://www.haystack.mit.edu.au/ast/array/mwa/LFD>

The array was set up in the Ejar Paddock, located about 14 km west-south-west of the Mileura homestead and about 30 km northwest of the ATNF site-testing equipment measuring RFI for the SKA. The FM band was studied intensively because of the project's ultimate goal of probing the epoch of reionization in the 21-cm line of neutral hydrogen; even at this frequency there were almost no signals, just occasional strong bursts (probably caused by reflections from meteor trails). Results from the LFD Early Deployment have been recently presented in newsletter 6 from the Australian SKA Planning Office (www.atnf.csiro.au/news/aspo-newsletter/ASPOnewsletter6.pdf).



Prototype dipole antennas of the Mileura Wide-field Array Low Frequency Demonstrator

Acknowledgements

Many individuals and institutions have contributed to the Early Deployment effort. Contributing institutions include Haystack Observatory, MIT, the University of Melbourne, The Australian National University, Curtin University, CSIRO Australia Telescope National Facility, the Mileura Cattle Company, the Government of Western Australia, the Australian Partnership for Advanced Computing National Facility, and the Australian Research Council.

Report on SKA Simulations and eVLBI at Swinburne

Swinburne University, in collaboration with the ATNF, the University of Tasmania and the University of Western Australia, has begun real-

time 1-Gbps eVLBI testing. This work builds on new fibre links to the CSIRO telescopes, the provision of high-speed fibre connections to the University of Western Australia and Swinburne, the development of disk-based 1-Gbps recorders for VLBI and Swinburne's development of a software VLBI correlator running on a Beowulf supercomputer and machines at the University of Western Australia. Issues of data transmission, on-the-fly monitoring and correction of delays and phases, and real-time correlation will be investigated using the Australian eVLBI array; lessons learnt will carry over into the SKA arena.

On the SKA simulations front, the EU-funded SKADS project is now in full swing. Swinburne is a full partner in SKADS and heavily involved in the science and technical simulations (the DS2 and TI work packages). The next step following meetings in Brussels and Bonn in November 2005 and February 2006 respectively is for Swinburne to host European researchers to start developing the code for various SKA simulations on its supercomputer. This work will get under way in earnest over the coming year.

SKA Molonglo Prototype (SKAMP)



The Molonglo Synthesis Telescope at sunset; mature, but still going strong!

SKAMP 1 (96-station continuum correlator): the hardware and firmware have been debugged to a high level of confidence.

SKAMP 2: Design of the SKAMP spectral-line correlator has been taken over by two digital-design engineers associated with the University of Tasmania, and work on it is now well underway. Schematics for the boards are nearly complete. Data rates per board will be about 0.2 Gb/s. Racks have been installed for fibre patch panels, polyphase filterbanks and the correlator.

Work on the Rapid Prototyping Telescope (RPT) has continued and it is ready to receive the first eight-element line feed module. Double meshing has been installed to improve the system temperature and crimping added to reduce surface distortions.

Analogue beam-forming prototypes have been designed; for stage 1 this combines the 8 elements of the module, for stage 2 it combines 6 modules giving 4 outputs per bay. Planning for data acquisition software and analysis algorithms is underway – expected data rates of 0.5 GByte/sec mean that some real-time analysis is essential. Integration of the dual polarisation feed module and RPT has been planned.



AMP 2 – spectral-line correlator

SK



Racks installed for panels, filterbanks, and correlator

SKA News from New Zealand

The Australasian SKA Consortium has proposed the placement of remote array-stations in New Zealand as part of its submission to host the SKA. The inclusion of such stations will provide a scientifically very valuable long east-west baseline of over 5500 km from the core location. New Zealand has the capacity to support array-stations and the astronomy community is strongly backing this proposal. Significant funding has already been allocated to support SKA activities in New Zealand.

Following the successful Trans-Tasman (New Zealand-Australia) VLBI tests in July and November last year (made possible by funding from the Ministry for Economic Development), New Zealand radio astronomers have recently conducted a VLBI test with Japan. This test was conducted in the framework of collaboration between

Auckland University of Technology's Centre for Radiophysics and Space Research, and Kashima Space Research Centre, where the project is led by Dr Yasuhiro Koyama. Australia provided support, with Australian radio telescopes (the Australia Telescope Compact Array) observing a 10 Jy radio source PKS1921-293 simultaneously with New Zealand and Japan.

Swinburne University's Centre for Astrophysics and Supercomputing provided fringe-test and software correlation software. Data are currently processing in the New Zealand Supercomputer – the one where computer graphics for “The Lord of the Rings” – the movie directed by the Oscar winner New Zealander Peter Jackson was made.

The Council of the Royal Society of New Zealand has approved Affiliated Membership for The New Zealand Committee for the Square Kilometre Array (SKANZ). SKANZ comprises representatives from universities, Crown Research Institutes, government agencies and the private sector.

*Michelle Storey & Helen Sim
Australian SKA Consortium*

Further news from Australasia can be found in the ASPO Newsletters at <http://www.atnf.csiro.au/news/aspo-newsletter/>

CANADA

Over the past six months the on-going SKA project R&D in Canada by the NRC Herzberg Institute for Astrophysics and university groups across the country has focussed on two important areas of research for the – phased-array feeds and cost-effective reflector designs.

Phased-Array Feeds.

Work continues on the Phased-Array Feed Demonstrator (PHAD) at a steady pace. PHAD is an engineering demonstrator that will explore the capabilities and design problems with densely-packed arrays at the focus of reflector antennas. Prototypes of all the major components have now been fabricated and are undergoing testing.

Our spherical near-field antenna test range is operating and under heavy use. We have been capturing the full 4-pi steradian radiation patterns of elements at various locations in a large finite array. This data will be critical for the design of beam forming networks. Figure 1 shows the array in the anechoic chamber and Fig. 2 shows a 3-D representation of a typical element pattern. This pattern shows the main co-polarized pattern enveloping the 4-lobed cross-polarized pattern. The peaks of the cross-polarized lobes are about 10-dB below the peak of the co-polarized lobe.

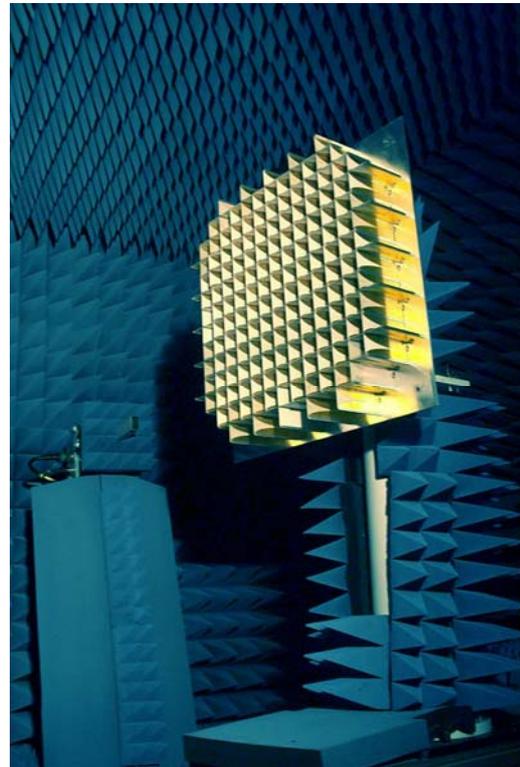


Figure 1 A vivaldi array in the near-field scanner test range

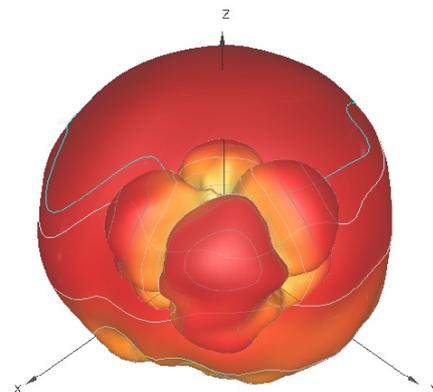


Figure 2 3-D representation of a typical vivaldi element pattern. The main co-polarized lobe envelops the 4-lobed cross-polarization pattern.

A new element design has been finalised and uses a simple matching network to cover the range 1--2 GHz. The output is fed to a receiver board (Fig. 3), where the signal is amplified,

frequency shifted in a single-chip receiver, and the analogue output transmitted down twisted-pair line to the digital-signal processor. The PHAD receiver module prototype contains four receiver channels, each consisting of an SMA input connector, bias tee for supplying power to antenna mounted electronics, a 1 dB noise figure LNA stage and a 1 to 2 GHz DBS receiver IC (Maxim 2116). The receiver outputs are buffered by differential line drivers to drive transformer isolated RJ-45 Gigabit Ethernet jacks, here used for 4 MHz bandwidth analog signal transmission over moderate distances (50-100 m) to the remote digitizing racks using inexpensive CAT5e shielded cable. An I2C serial backplane is used for receiver control and monitoring. 50 such modules will be required for a 200-element PHAD array.

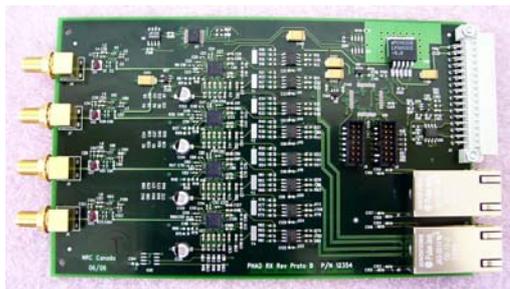


Figure 3 The 4-channel receiver board for PHAD. The LNAs are just right of the SMA connectors, with the receiver chips are left of centre. The RJ-45 jacks are in the lower right.

LNA Development

At the University of Calgary, a CMOS LNA optimization technique has been developed that simultaneously optimizes the noise contribution of the LNA transistors and the noise contribution of the gate inductor (to appear in the July issue of the IEEE Transactions on Circuits and Systems, 2006). Three 0.18um CMOS LNAs have been fabricated to confirm the optimization procedure. A novel wide-band LNA topology that was introduced IEEE ISCAS, 2006, was fabricated in 90nm. Initial tests show noise temperatures below 40K over the 700-1400 MHz frequency range. Equipment to enable very precise measurements of the LNA noise figures has been purchased.

Reflector Research.

NRC has initiated a project to examine the use of composite materials for the construction of cost-effective reflectors. To date, we have engineering designs for reflectors in the 10 to 15-m diameter range and have now begun testing the RF properties of various composite. Tests are at a preliminary stage, but first results are promising.

*Sean Dougherty
Canadian SKA Consortium*

CHINA

News from China by June 15, 2006

It has been a great time for the FAST project during the last 6 months: The project was approved by the Chinese Academy of Sciences (CAS) in November 2005. An International Review meeting on FAST was held successfully in Beijing in March 2006. And a detailed site exploration of FAST has been performed smoothly since March 2006. The funding proposal for FAST construction has been refined with CAS policy makers, and will be submitted to the National Development and Reformation Commission

1 CAS approval of FAST in Nov.2005

In the board meeting of the CAS on Nov. 4, 2005, hosted by President LU Yongxiang, the candidate national science project FAST (Five-hundred-meter Aperture Spherical Telescope) was finally approved by the CAS leadership. The project has now entered a phase of software development, engineering, demonstration, as well as establishing the appropriate organization. The CAS awarded 15 new positions and 1 M€ for further preparatory work on FAST construction for the year 2006.

2 International Review meeting on FAST in March 2006

To assess the feasibility of the FAST Project, the CAS & CAE appointed a Review Panel to address the following questions:

- 1). Science requirements of the FAST Project.
- 2). Technical specifications to meet the science requirements.
- 3). Technical plans to achieve the specifications.
- 4). Project management and staffing.
- 5). Cost and schedule of the Project.
- 6). Operations planning after the completion of the FAST telescope.



Fig.1. International Review meeting on FAST held at Friendship hotel in Beijing, Mar. 2006

The panel consisted of 11 foreign and 7 domestic experts who come from Australia, Canada, Germany, Japan, the Netherlands, UK, USA and China. The panel was greatly impressed by the overall technical design of the FAST telescope, including its active main reflector, focus cabin support, and the measurement and control involved to achieve proper pointing and tracking.

As a result of an intensive discussion during the two-day meeting on May 30-31 in Beijing (Fig.1), and a visit to the 30 m Miyun FAST model on April 1, 2006, and further communication exchanges after the meeting, the review panel strongly suggested that FAST project should move to the next phase of detailed design and construction.

3 Siting SKA and FAST in China

The proposal for siting SKA in China, and the summary Report on RFI monitoring have been submitted to the ISPO on Dec.31 2005 and March. 10 2006, respectively. Meanwhile, FAST site investigation has gone into a more detailed phase with drilling exploration, as shown in Fig.2, which is to be further evaluated by the end of June 2006.



Fig.2. Siting FAST at Dawodang in Guizhou

4 Progress on the Miyun FAST model

Here we present the most recent progress on the Miyun FAST model.

Receiver

A complete L-band receiver has been built for the FAST demonstrator. This includes feed, LNA, Mixer, IF cables and a digital backend, etc. This is an ambient temperature receiver, whose main specs are: working frequency range: 1370-1470MHz, system temperature: ~100K, a backend able to process a continuous 10MHz bandwidth data tunable within the frequency range mentioned above. We will test this receiver on the demonstrator in late June, and carry out HI and pulsar observations. A 610MHz receiver is under construction at the moment.

Feed support

A new Stewart platform has been built, as shown in Fig.3. It weighs about 160kg. After some indoor tests, it will be attached mid-year to the cable car in order to stabilize the position of the receivers.



Fig.3. the new Stewart platform used for the Miyun FAST model

Reflector

By the end of 2005, the adaptive cable-mesh reflector, the feed suspension, the measurement and control system of the Miyun FAST Model have been built. On-site experiments were carried out since the beginning of 2006.

The aperture of the adaptive cable-mesh reflector is 30 meters. The cable-mesh consists of 472 sections of main cables, 145 control cables and 145 nodes. The main reflector consists of 252 panels. A detailed close-up of a typical node is shown in Fig. 4.

After being installed, the cable-mesh was pre-tensioned following 5 steps. After each step, the shape of the reflector was assessed and fine adjustment was made to the finite element model of the cable-mesh. After 5-step pre-tension, the main reflector has reached the desired neutral spherical shape, with a r.m.s error of about 1mm. In the next step, we will deform the adaptive cable-mesh reflector from a spherical surface to paraboloid.

We plan to carry out astronomical observations with Miyun FAST Model around July in 2006.



Fig.4. Structure of cable-mesh Reflector

FAST Laboratory in NAOC,
China

EUROPE

SKADS

The European SKA Design Study project is in full operation since its kickoff last November 2005. The next milestone is our first annual report which must be submitted to the EC on August 10th. This will be quickly followed by our first SKADS Workshop to be held September 4th in Paris. The SKADS Workshop is the first day of a whole week of SKA activities in Paris, organised by the ISPO. For more information, and to register, please visit the International SKA website at http://www.skatelescope.org/SKAmeeeting_Paris/. All are welcome to attend the SKADS workshop!

SKADS Recruitment

The SKADS Management Team is now complete with the recruitment of André van Es in the role of Project Manager for SKADS. André joined ASTRON in August 2000 as the head of the Process Support Group, a group that is in charge of planning and control of all ASTRON projects. André has been involved in several projects at ASTRON including VISIR, LOFAR PDR, MIDI and THEA. With his extensive experience in radio astronomy engineering and management, we are very fortunate to have André on-board!

Recruitment continues apace within the rest of the SKADS project. At Cardiff University, interviews are currently underway to select a postdoctoral research associate to work on the SKA network simulator within Design Study 3 of SKADS.

We're looking forward to welcoming Shanmugha Sundaram who will join JIVE to work with Cormac Reynolds on astronomical data simulations as part of Design Study 2, Task 2.

Shanmugha is currently a research scientist at the Indian Institute of Astrophysics, in Bangalore, India, and we expect him at JIVE this summer.

With the recent success of the UK PPARC proposal, Oxford University has made two appointments for work in SKADS. Matt Jarvis is the manager for the Science Simulations task of Design Study 2 which is under the leadership of Steve Rawlings. Matt's research is focused on observational cosmology with particular emphasis on the coevolution of galaxies and black holes over the history of the Universe. He is managing the ambitious science simulations task whose aim is to simulate the sky across the whole range of the Key Science projects in order to define the SKA that can carry out the most science in an optimal way. Matt began in SKADS with the organisation of an excellent workshop in Oxford on June 7th which brought together all the partners in Europe working on science simulations.

Hans-Rainer Klöckner also joins the SKADS project to work on the more practical side of the simulations. Task-2 of Design Study 2 is investigating the radio sky as seen through the telescope, and Hans will be particularly involved in calibration issues.

The Max Planck Institute for Radio Astronomy in Bonn is expecting the imminent arrival of Dharamvir Lal, most recently from the Academia Sinica Institute of Astronomy and Astrophysics in Taipei. He has worked on calibration issues for low frequency arrays in presence of ionospheric seeing disc, and his knowledge and experience in this area will be invaluable to the scientific simulations

undertaken within Task-2 of Design Study 2.

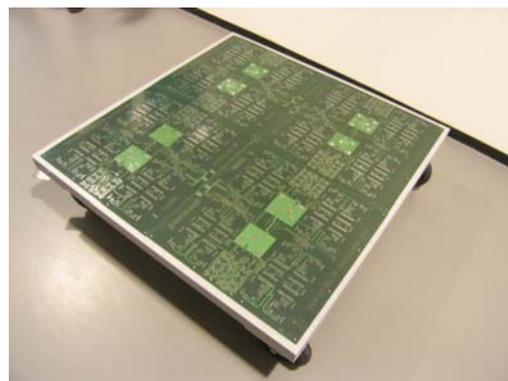
In France, in collaboration with the Horizon Project, there is a concentrated effort in the area of sky simulations related to the Epoch of Reionisation (EoR). Paola di Matteo will take up a SKADS postdoctoral position at the Observatoire de Paris in September, working full time on simulations of the EoR. Paola joins team member Benoit Semelin at ODP under the leadership of Françoise Combes.

There are a number of SKADS positions available, all of which are posted on the SKADS website. We welcome all applicants and recommendations, so please have a look at

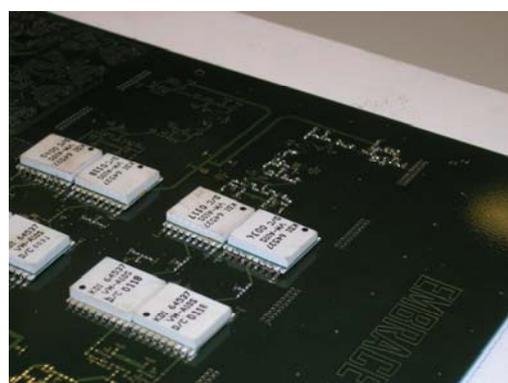
<http://www.skads-eu.org/p/jobs.htm>

EMBRACE

The principal hardware effort within SKADS is the EMBRACE demonstrator. EMBRACE is the Electronic MultiBeam Radio Astronomy ConcEpt and it will be an aperture-plane phased-array using tiles of Vivaldi feed antennas. This concept was initially developed by ASTRON as the "Thousand Element Array" or ThEA. EMBRACE will have installations at Westerbork and Nançay for a total collecting area of 400 square metres (equivalent to a 20m diameter single dish). The first EMBRACE antenna boards with integrated electronics have been manufactured and are currently being integrated (see photos). Testing of a prototype tile will begin this summer.



This picture shows the board containing the rf circuitry. The entire tile is visible.



The board shows some of the components being assembled. The KDI's Vector modulator are shown.



This is a picture of Vivaldis designed for the prototype tile. Both RF circuit board and the antenna are shown.

*Steve Torchinsky
SKADS Project Scientist*

SKADS BOARD

A very constructive second SKADS board meeting was held in Zaandam near Amsterdam in June with international representation from Canada (Peter Dewdney); South Africa (Justin Jonas); Australia (Steve Tingay); Russia (Rustam Dagkesamanskii) in addition to the ISPO Director and Project Engineer. Minutes will be made available on the SKADS web site but the main outcomes of relevance to the international project as a whole were as follows:

- Standing invitations to attend Board meetings will be offered to the USSKA Consortium and NAOC (China).
- A strong link between the ISPO costing effort and SKADS costings will be developed.
- The SKADS simulations can be the focus of a restructured international simulations effort within the international SWG.

In reaction to the ISPO Reference Design the Board agreed to concentrate on simulations (SKADS DS2 & DS3) and overall design and costing (SKADS DS8). Particular points were:

- Simulations of astronomical skies for SKA KSPs 1-4 are automatically covered within SKADS but KSP5 (Cradle of Life) is not formally covered. However the international thinking can readily be “captured” if a link between SKADS and the SWG is formalised. The ISPO Director has taken action on this point.
- The science and technical simulation teams will explore both the “Reference Design” and an evolution of the reference design in which:
 - Aperture Arrays (AAs) are included in a synthesis array extending part way along the arms; a principal aim of SKADS being to demonstrate that AA performance can be

understood well enough for long-integration synthesis.

- The “higher frequency” synthesis collectors should simply be small dishes + broad-band feeds but no focal plane phased arrays; this strategy simplifies the overall SKA costings (in SKADS DS8).
- Simulations of the sidelobe structure of focal plane phased arrays would be a major new activity and this was not supported for additional study within SKADS at this point.

SKADS Board reserves the right to make changes in strategy at any time. It was, however, agreed that there should be no change to the present engineering studies (SKADS DS4, 5, 6) since:

- The technology being developed is already relevant to phased FPAs;
- The phased FPA work being carried out in Australia/Canada/South Africa/Netherlands can be reported to SKADS and used in DS2/3 simulations;
- Phased FPA work may be undertaken in a RadioNet FP7 Joint Research Activity in 2008; this would follow on from the existing PHAROS JRA in RadioNet FP6.
- International R&D work on dishes can be incorporated as required into the SKADS final report and costing.

The SKADS Final Report (DS8) will also contain:

- A report on the high-frequency international programmes.
- A cost for the entire international SKA design as it is agreed at the end of SKADS. This is needed for EC to give them the full international picture.

Peter Wilkinson
SKADS Board Chair

SOUTH AFRICA



On Monday 28 May 2006, the South African Minister of Science and Technology, together with the Premier of the Northern Cape Province, visited the Karoo and inspected the sites proposed for the Square Kilometre Array (SKA), Karoo Array Telescope (KAT), C-Bass and other radio astronomy projects. Legislation, which will empower the Minister of Science and Technology to declare this area as an astronomy reserve, is in the final phase of consultation and should be presented to Parliament during the second half of this year.

The visit formed part of a three-day discussion that focused on the commitment from national and provincial government to establish the astronomy reserve and to build the KAT, as well as the siting of the C-Bass experiment in the proposed reserve.

The proposed reserve is located 94 km from the town of Carnarvon in the Northern Cape Province.

In discussions the following day, the DST and the Northern Cape Government agreed to establish a working group to ensure that the necessary infrastructure is installed for the site and that the EIA and

geotechnical investigations are carried out rapidly. The working group has already started its work. The Northern Cape Government has appointed a project champion – Edcent Williams (head of the Science and Education Department), a project executive – Michelle Ishmail, and a project manager, Paki Monyobo. Ferrial Adam will coordinate the work of the SA SKA Project Office on the infrastructure project. The working group will be supervised by a top-level team, consisting of the Directors General of the DST and of the Northern Cape, with senior officials, and will report to the Executive Committee of the Northern Cape Government and to the SA SKA Steering Committee. This senior committee will meet at least four times over the year.

A sub-group of the working group has been established to work on setting up courses at the National Institute of Higher Education in Kimberley on Digital Signal Processing and RF Engineering. Telkom has expressed interest in providing resources for these courses. The sub-group will also work on the development of artisan skills for the project with the further education institutions in the Northern Cape.

Dr Roy Booth, recently retired director of Onsala Space Observatory in Sweden, has joined the radio astronomy community in South Africa on a three-year contract to promote radio astronomy and support South Africa's bid to host the Square Kilometre Array.

Justin Jonas
South African SKA Project Team

USA

Decadal Review

Once a decade, the U.S. astronomical community assesses and ranks proposed projects with the goal of providing input to various national funding agencies. A project's rank within the decadal review is an important criterion by which funding decisions are made, particularly for large projects. The last decadal review was completed in 2001 ("Astronomy and Astrophysics in the New Millennium"). There is increasing interest in the next decadal review, particularly because various funding pressures coupled with the ambitious nature of many new telescopes may result in the review process beginning as early as 2008.

In February, the directors of the national radio astronomy facilities and a number of university-based astronomers gathered in Chicago (the "Chicago meeting") to discuss planning for the decadal review as well as assess the impact of the decision not to fund the second phase of work on the EVLA (EVLA-II). The SKA was among the topics of discussion, and there was widespread agreement that the Reference Design is likely to be technically feasible as well as broad support for ensuring that future facilities provide an operational capability at the higher frequencies proposed for the SKA.

Planning for a second "Chicago meeting" (likely to be held in Tucson in early August) is underway. The goal for the second "Chicago meeting" is to develop more concretely the plans for the U.S. radio astronomy community, particularly as they relate to the preparation for the next decadal review. There was also considerable discussion at the U.S. SKA Consortium's spring meeting (May 8, in Arlington, Virginia) on the incorporation of the SKA into radio astronomy planning for the decadal

survey, what the status of radio astronomy in the U.S. should be in 2020, and the role of the U.S. SKA Consortium in this planning.

The NSF Technology Development Program (TDP) proposal and Related Work

The Astronomy Division of the NSF continues with its "senior review" of the facilities and operations supported by that division. An external panel, chaired by Roger Blandford, has been visiting the NSF-operated astronomy facilities and holding a series of "town hall" meetings across the country. The original goal was for the external panel to deliver a report by March 31. Writing the final report is taking longer than the committee expected, and the Astronomy Division has emphasized that the March 31 date was never intended to be a hard deadline that would preclude developing a comprehensive report. A final decision on funding of the TDP awaits the outcome of the senior review. In the interim, however, recognizing the amount of time that has passed and the possibility of additional funding for NSF in the next fiscal year, a revised TDP proposal has been discussed and is under preparation.

In the meantime, various members of the U.S. SKA Consortium have decided to submit proposals to the Advanced Technologies and Instrumentation (ATI) program. These proposals are aimed at work that was initially part of the TDP as well as at SKA aspects that have been identified since then. One of these proposals was funded and another is still under review:

- Advanced correlation techniques (funded): Colin Lonsdale and collaborators have described techniques by which the computational costs for correlation may be reduced significantly (e.g., SKA Memo #54). This proposal

aims to develop these ideas further and begin simulations to verify the performance of advanced correlation algorithms.

- A proposal for SKA development using the ATA (under review): This proposal aims to characterize the high and low frequency performance and manufacturability of the current ATA feeds vis-à-vis SKA needs, the degree of mutual coupling between antennas, optimization of station beam forming, RFI mitigation, precision calibration, and wide-field imaging.

In addition, while a final decision is pending, work funded jointly by Cornell University and the National Astronomy & Ionosphere Center (NAIC) may begin on a prototype focal plane array for Arecibo covering 5–10 GHz.

U.S. demonstrator arrays

Allen Telescope Array (ATA)

All components necessary for ATA operation for the site, antenna and through the analog signal path are in production and are being installed in the erected 30 antennas at the Hat Creek Radio Observatory, alongside the busy integration and test program of the completed elements. The remainder of the first ATA-42 will follow this summer and fall. Boards for the digital signal path are largely designed and entering into production and the testing and coding of these boards is ongoing. A working "BEE-2" correlator has been delivered to the site, to be used in the initial integration, test and operation of the array.



Figure 1: Two of the ATA dishes showing the near-final assembly, including the feed shroud in place.



Figure 2: The azimuth drive (lower right), the drive electronics (lower middle), and antenna controller (middle) inside an ATA antenna alidade. The drive electronics box and controller box are field-replaceable units, needing only to undo a few connectors on the top. The black hose handles cooling air. The front-end is separately monitored and controlled—only 120V and fiber for the front-end pass through here.

Expanded Very Large Array (EVLA)

Four antennas have now been converted fully to EVLA antennas, and members of the ISSC were able to view an EVLA antenna during their tour of NRAO facilities during ISSC 15 in March. Thus far, experience with certain computerized components of these new antennas has not been rewarding, with far more reliability problems encountered than expected. Also, funding issues have slowed the transition of antennas. Nonetheless, the goal is for antenna transition to continue throughout this year, with potentially as many as 6 antennas to be converted and returned to operation.

Long Wavelength Array (LWA)

The first 16 dipole antennas were installed at the Long Wavelength Array (LWA) site during 2006 March and admired by participants of the ISSC meeting in Socorro. These small blade dipole antennas will not be the final design used for the LWA, but are being built as part of a Long Wavelength Demonstrator Array (LWDA) to gain experience with the technology. The dipoles are fixed (no moving parts) and see a field of view about 120 degrees across with full sensitivity, and from horizon to horizon with reduced sensitivity. Delays will be inserted at each station to steer electronically a combined ~8 degree beam around the sky. Cables were installed June 6 to take the signals to a shelter that will house the receivers, adder boards, and other electronics. The shelter is on schedule to be installed June 19.



Figure 3: The original eight dipoles of the Long Wavelength Demonstrator Array as deployed at the VLA site. (A VLA antenna is visible in the background.) Their locations relative to each other represent locations selected so that the full LWA station sidelobes are optimally low.

Mileura Widefield Array-Low Frequency Demonstrator (MWA-LFD)

Funding for this project has been secured from the NSF, and the kickoff meeting was in early June. An internal design review has been conducted, and work is underway on several work packages with the highest priority devoted to the antennas and receivers. A critical design review (CDR) is scheduled for the end of this calendar year. The goal is to have an initial operational capability within 2 to 3 years. Consideration is also being given to increasing the angular resolution of the array in order to

image solar bursts. (See also the report from Australia in this Newsletter).

NASA Deep Space Network Array (DSNA)

A breadboard array has been operating in a 2 6-m single-dish mode at 8.4 and 32 GHz for the past several months at JPL, and two element interferometer tests have started recently. These 6-m dishes work very well with efficiencies of the order of 55% at 32 GHz and receiver system noise temperatures of approximately 20K at 8.4 GHz and 35K at 32 GHz. The full array is expected to use 12-m antennas, and Patriot Antenna Systems has delivered a prototype 12-m antenna to JPL. The mounting structure has been undergoing tests and is performing within specifications, but no testing of the radio frequency properties of the antenna has been conducted yet. Additional 12-m antennas are expected over the next few years.

Science

Astrobiology: Cradle of Life

Astrobiology undoubtedly begins with the formation of biomolecules in interstellar clouds from which new solar systems eventually form. Approximately 140 different interstellar compounds have now been identified, ranging in size from 2 to 13 constituent atoms. The vast majority of these detections have been accomplished using radio facilities. The more complex species have 6 or more atoms and all are organic since each of these molecules contains carbon. Because many of the complex molecules found in space are also found in laboratory experiments specifically designed to produce prebiotic molecules under assumed primordial Earth-like conditions, this suggests that a universal prebiotic chemistry exists. The SKA will be important for detecting and studying prebiotic molecules for two reasons. First, it is becoming apparent that a number of complex interstellar

molecules are distributed on arcminute scales in cold halo regions. These will be regions easily probed by the SKA. Second, many of the recent detections have been obtained from the low energy transitions of the molecules. These low energy transitions occur at frequencies typically around 10 to 20 GHz, frequencies at which *spectral line confusion* is much less problematic than at higher frequencies (e.g., above 100 GHz). An illustration of the kind of molecules being discovered includes the detection of the sugar glycolaldehyde (CH₂OHCHO, Hollis et al. 2004, *Astrophys. J.*, 613, L45); the ring molecule cyclopropenone (c-H₂C₃O, Hollis et al. 2006, *Astrophys. J.*, 642, 933); and acetamide (CH₃CONH₂),

Future Large Ground-based Telescopes

This meeting was a special session at the joint American Astronomical

(CH₂OHCHO, Hollis et al. 2004, *Astrophys. J.*, 613, L45); the ring molecule cyclopropenone (c-H₂C₃O, Hollis et al. 2006, *Astrophys. J.*, 642, 933); and acetamide (CH₃CONH₂), one of the few interstellar molecules known with a peptide bond (Hollis et al. 2006, *Astrophys. J.*, 643, L25). Strikingly, some of the observations for these detections were conducted at frequencies as low as 1.5 GHz, a region of the spectrum not typically associated with the study of molecular lines!

Society-Canadian Astronomical Society meeting in Calgary on June 8. The focus was on both the SKA and future large optical telescopes (with apertures of 25 meters or more) and the scientific and technical aspects that the radio and optical instruments share. Details of the session are in the summary of the Scientific Working Group section.

Future Giant Telescopes

This session was part of the SPIE meeting "Astronomical Telescopes and Instrumentation 2006." Yervant Terzian presented an invited talk on the SKA. The talk was well received, and the resulting publication has been posted at the SKA Web site.

*Joseph Lazio
US SKA Consortium*
