



# NEWSLETTER

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## FROM THE INTERNATIONAL SKA PROJECT OFFICE

It has been a noteworthy six months since the last Newsletter. The short-list of acceptable sites for the SKA was selected by the ISSC, the Memorandum of Agreement on Collaboration on the SKA was extended by one year until the end of 2007, the SKA was included on the roadmap of future scientific infrastructures by the European Strategic Forum for Research Infrastructures (ESFRI), the Funding Agencies and Government Departments of countries interested in the SKA decided to establish an International SKA Forum with membership from the FAs and the SKA project, and a meeting of the EWG, SWG and OWG narrowed down the technical options for the telescope.

The city of Dresden in Germany was the setting last August for the ISSC to reduce the four candidate locations for the SKA to a short-list of two, Australia and Southern Africa. An acceptable site is defined by the ISSC as being "one for which the usable frequency range, configuration, sky coverage, and physical characteristics allow the key scientific goals of the project to be achieved efficiently over the lifetime of the telescope". The short-list represents the culmination of a more than four year process starting with a call for initial expressions of interest issued by the ISSC in November 2001.

The ISSC decision on the short-list has gone to the Funding Agencies and Government Departments, but it will be some years yet – end of this decade - before a final selection of the site for the SKA is made. This appears likely to be taken in conjunction with a decision on construction funding for the telescope. Additional studies of the two sites will be made in the intervening period, as well as agreeing on the process by which the site selection will be made.

The ISSC also decided to extend its governing MoA for a year in the expectation that a new governance structure will be established in the course of 2007. This will be a priority for the International SKA Forum.

The Dresden meeting was Phil Diamond's last as ISSC chair, and he has been succeeded by Brian Boyle for the next two years. Ken Kellermann was elected vice-Chair. Wim Brouw stepped down as ISSC Secretary at the end of 2006 after more than three years of doing a marvellous job of organising and recording ISSC and Executive Committee meetings. Wim was recently elected as the second at-large member of the ISSC. The ISPO will take over the tasks of the ISSC Secretariat.

A lively exchange between astronomers and engineers took place in Paris in September on the science-engineering tradeoffs for the SKA. This was a substantial step along the way towards setting the initial engineering specifications scheduled for the end of 2007. Peter Hall reports on this in more detail in this Newsletter.

Substantial increments in funding for two of the Pathfinder projects were approved towards the end of 2006 - for the Karoo Array Telescope and the xNTD in Australia. Both these projects have been re-named, KAT to MeerKAT ("meer" means "more" in Afrikaans, and MeerKAT is itself a small furry animal), and xNTD to MIRA, Mileura International Radio Array. The Chinese FAST project also made a giant stride towards full funding with its inclusion as one of the nine large facilities for basic science and technology to be constructed during the national 11<sup>th</sup> Five-Year Plan. Congratulations to all concerned for these successes! Reports on these and the other national and regional Pathfinder projects and design studies

can be found elsewhere in this Newsletter.

The ISPO WGs have been particularly active in the science, engineering, site and outreach areas of the project in the last six months. The SWG is in the process of completing the Phase 1 Science Case; the EWG has been concentrating on system and sub-system design, tradeoffs, and cost estimation; the SEWG on defining the additional studies needed for the short-listed sites; and the Outreach Committee, and its chair, Michael Kramer, in particular, did a magnificent job in presenting the SKA at the IAU General Assembly in Prague in August. See the reports.

Following the inclusion of the SKA in the ESFRI Roadmap, the European Commission issued a (sub) call for a proposal to the Seventh Framework Programme for an SKA Preparatory

Phase. Preparations under the leadership of Phil Diamond are now in full swing around the world to respond to this opportunity. More in later Newsletters.

This is the final Newsletter to be organised and put together by Astrid Marx. Astrid is leaving the ISPO on 31 January to concentrate on her career as a personal coach. We will miss her enthusiasm and dedication to all matters concerning the SKA, and wish her all the very best in her new endeavours.

*Richard Schilizzi*  
*Director*

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## NEWS FROM THE WORKING GROUPS

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### ENGINEERING

Looking back over the past year there is no doubt that engineers in the SKA community have become far more focused on “real-world” challenges – either technical challenges thrown up in the course of a burgeoning suite of pathfinder instruments or planning issues raised by the need to define, and ultimately deliver, the SKA project. One thing is now certain: SKA is no longer “tomorrow’s telescope”. Pathfinders and prototypes becoming operational from this time ensure that technology and techniques incubated in the SKA environment have tangible form. In addition, much engineering and related effort is now being devoted to making SKA Phase 1, with its projected 2012 construction start, a reality. Importantly, the innovation paths needed to support wide-field technologies for the full SKA continue to be pursued vigorously and are an integral part of our implementation strategy.

Recent engineering progress might be summarized under the following headings:

- 1 Expansion of our collective insight into the system and sub-system design issues for the SKA, including more understanding of the importance of computing hardware, software, calibration and imaging;
- 2 Interaction with the wider SKA community, especially the Science and Operations working groups, leading to more consensus on what constitutes a viable base-level instrument, what the wide field-of-view (FoV) options are, and what is an acceptable staged implementation strategy;

- 3 Growing understanding of cost and performance trade-offs in the SKA Reference Design and its variants;
- 4 Growing understanding of infrastructure engineering and related issues, especially as they relate to final site selection and construction of SKA Phase 1;
- 5 Definition of various European Seventh Research Framework Program (FP7) work packages, including a system design work package enabling the exposition of the SKA concept and the formation of a central design and integration team within the ISPO.

Much of the progress in system and sub-system areas is contained in the white papers prepared for the recent Paris joint meetings these papers are available at

[http://www.skatelescope.org/SKAmeeeting\\_Paris/discussion\\_documents.htm](http://www.skatelescope.org/SKAmeeeting_Paris/discussion_documents.htm)

EWG task force activities also continue to foster important discussions. For example, the recent Calibration and Imaging Workshop held in Cape Town (<http://www.kat.ac.za/calim2006>) and the forthcoming Focal Plane Array workshops

(<http://www.atnf.csiro.au/projects/ska/fpa.html>) being planned for Sydney

point to a vigorous engineering community, with excellent international and regional collaborations.

The Paris joint meetings were excellent forums for frank and constructive discussions, with the collective will to produce a path forward being very strong. Pathfinders and design studies are now challenging engineers to make their ideas work, and it was clear that those

attending the gathering appreciated the opportunity to discuss new technical results and likely impacts on SKA directions. As part of its business meeting the EWG looked at international engineering resource requirements for SKA development and design and, while no easy match of requirements and manpower was evident at the time, subsequent funding opportunities have arisen under the FP7 program (see below).

In addition to the various EWG and task force activities, important progress has been made by two ISPO Tiger Teams. Relying heavily on engineering inputs, the Tiger Team dealing with options for SKA implementation has produced a draft strategy for consideration by the ISSC. This strategy, in essence, involves an SKA Phase 1 based primarily on dishes with single FoV feeds. Current pathfinders and design studies will demonstrate which wider FoV options are viable and, as in previous thinking, technologies will be selected on the basis of demonstration. Importantly, SKA Phase 1 will be designed to support whichever wide FoV technologies are chosen and will serve as a platform for extensive further verification of those concepts in an operating telescope.

A second Tiger Team looking at SKA infrastructure requirements has received valuable engineering contributions from several quarters, including the South African SKA group and its consultants; a significant additional Australian input is expected shortly. Both the options and infrastructure documents will be available as SKA memos when the Teams complete their work over the next few months.

Joint ISPO-ATNF work on SKA cost and performance estimation is also progressing, with the most recent initiative being a working link to the relevant SKADS activities. ATNF will concentrate on producing software

tools, while the SKADS emphases will be on formulating new architecture descriptors and generating high quality descriptive data (e.g. cost) for various sub-systems. Recent work has involved formulation of phased array feed and all-digital aperture array software modules; the next step will be construction of analog (RF beam-formed) aperture array descriptors. The estimation software now includes elementary computing and calibration stage modules, adding to the realism of the calculated results. First versions of the Python scripts should be completed by Aaron Chippendale, John O'Sullivan and Paul Alexander by the end of February this year. These will be useful in refining our cost estimates for several SKA pathfinders, SKA Phase 1, and variants of the Reference Design. Indications are that the Python environment provides good portability and maintainability, as well as easy connection to future web interfaces.



*Attendees at the Cape Town EWG Calibration and Imaging Task Force Meeting display a level of personal decoration not often seen at SKA gatherings! From right to left, Tim Cornwell, the Task Force Chairman, Cormac Reynolds, chair of the ISPO Simulations Working Group, and Thijs van der Hulst from the University of Groningen. Jasper Horrell, chair of the LOC and a key SOC member was the photographer.*

At the time of writing (early January), a number of EWG members and associates are involved heavily in framing work packages for the European FP7 funding proposal to be submitted in 2007/Q2. While there are significant engineering components to WP3 (continuing site studies) and WP4 (industry involvement and

procurement), most activity is associated with WP2: the SKA system design study. The model envisaged has a new international engineering team interacting strongly with augmented regional programs. Deliverables include an SKA concept exposition, a detailed SKA Phase 1 system design, and relatively small-scale system verification hardware to be used in association with pathfinders. The concept exposition process includes the previously-slated International Engineering Advisory Committee review, while the design

activities focus on SKA imperatives not addressed comprehensively by regional programs and on integration of hardware produced by regional groups.

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

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## OUTREACH

In the last six months the Outreach Committee has been extremely active. The main activity was the preparation for the IAU General Assembly in Prague where the SKA was represented with its own booth. In time for the IAU GA, a new animation was completed which shows a flight over the core region of the SKA as defined in the reference design. This animation was produced by the Italian Xilostudios and was the centre piece of the exhibition. It can now be downloaded from the SKA website. Another attraction was a physical model of a part of the core area, showing aperture arrays and dishes, which was manufactured by the ASTRON workshops. We are in particular grateful to Leonid Gurvits for organizing this piece of the exhibition. We are also grateful to the SETI Institute for providing us with an example of an ATA feed. Its interesting design attracted a lot of attention during the GA. It was supplemented by examples of a THEA element provided by ASTRON. We also produced a new

flyer which summarizes the key features of the SKA and offers an SKA poster on its reverse side. The same motive was also used as the large backdrop for the booth, produced with the help of Alastair Gunn. The flyer, which can also be downloaded from the SKA website, was very popular and was often picked up with the new SKA bookmarks and stickers. An image of the booth is shown. Personally, I would like to express my gratitude to all colleagues who have helped during the exhibition during the coffee and lunch breaks to answer the questions of the visitors. A huge "Thank You" goes to Hendrik Jan Boer who travelled all the way from Dwingeloo by car to help us put the booth together. Without his contribution, it would have been so much more difficult. I would also like to thank all colleagues who helped with dismantling the booth, in particular Leonid again who also transported many of the items back to Dwingeloo.



SKA booth at IAU, Prague

In the months following the IAU, the SKA featured also in the media and a number of journal articles. Most of the media coverage was associated with the publication of the short list for the potential SKA sites and included reports by the BBC, SCIENCE and the Australian COSMOS magazine. The SKA also made an appearance in a NATURE article about LOFAR and in NEW SCIENTIST cover story about cosmic magnetism. A very nice SKA review article was written by Rainer Beck as the cover story for the German magazine STERNE &

WELTRAUM. Another article for SKY & TELESCOPE by Joe Lazio, Bryan Gaensler and myself has been submitted and will be published soon. Most of these articles, as well as a short coverage of the SKA by the German Television ZDF, used the animation and still images of Xilostudios. The same material also proved useful for advertising the US SKA meeting and in conducting an SKA industry day in New Zealand. We are very grateful to Xilostudios for their help and short response time in accommodating our requests.

Finally, it is a pleasure to welcome Kim de Boer as a new member of the Outreach Committee, and to thank Astrid for all her help and patience during the organization of the IAU exhibition.

*Michael Kramer*  
*Chair Outreach Committee*

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## SITE EVALUATION

In the Fall of 2006 the SKA project achieved a milestone when the International SKA Steering Committee decided on two acceptable locations to site the SKA, one in Australia and the other in Southern Africa.

The core site in Australia is proposed to be at Mileura station, some 100 km from Meekathara in the Western region of the country. The long baseline stations would be distributed across the country with the possibility of an extension to New Zealand. The core site in South Africa is proposed to be in the Karoo region in Northern Cape Province with stations across the

country and some in neighboring countries.

The process of selecting a site for the SKA began in 2001 when the ISSC invited all regions of the world to submit expressions of interest to host the SKA. After preliminary evaluations the ISSC invited six countries/regions to submit Initial Site Analyses by mid 2003. Four such documents were received and were carefully evaluated by the Site Evaluation and Selection Committee. Two additional candidate countries submitted Initial Site Analyses in early 2004 and after evaluation one of these two was found

promising. At the same time one of the original prospective sites withdrew from the competition, leaving a total of four sites to prepare final proposals. In 2004 the ISSC issued an official Request for Proposals to site the SKA with a deadline to receive Final Proposals December 31, 2005.

Four proposals were received by the deadline from Argentina/Brazil, Australia, China and South Africa. The assessment of the proposals began immediately by the SEWG (advising the ISPO) and by the independent International Site Selection Advisory Committee Chaired by Professor Richard Hills from the UK. The ISSAC completed its assessment by the end of July 2006 and made its recommendations to the ISSC. The ISSC met in Dresden at the end of August and decided on a short list of acceptable sites. The results were communicated to the Funding Agencies and a press release was issued on September 28, 2006. The Director of the ISPO, Professor Richard Schilizzi stated "Both Australia and Southern Africa can meet the full range of requirements for the SKA". Figures 1 (Australia) and 2 (South Africa) show sections of the proposed sites.



*Fig. 1. The proposed SKA core site in Western Australia*

The SEWG is continuing its efforts in assisting the ISPO coordinate additional site related studies of the two short listed regions. These include:

- Further RFI studies
- Preparations for establishing Radio Quiet Zones
- Ionospheric and tropospheric studies
- Array configurations

It is anticipated that the selection of the SKA site will be done by the Funding Agencies sometime in the next few years.

*Yervant Terzian  
Chair SEWG*



*Fig. 2. The proposed SKA core site in South Africa*

## SCIENCE

In the second half of 2006, the SWG welcomed Matt Jarvis (Oxford) and Cormac Reynolds (JIVE) as new members, and invited Steve Torchinsky (Obs. Paris-Meudon), Simon Johnston (ATNF), John Dreher (SETI Inst.), Justin Jonas (Rhodes U.) and Heino Falcke (ASTRON) to join the SWG with "observer" status. Matt & Cormac's presence on the SWG will allow coordination of the science simulations taking place within SKADS with other simulation work being done in the broader community. Steve, Simon, John, Justin and Heino will provide formal representation on the SWG for the SKADS, xNTD, ATA, KAT and LOFAR projects, respectively.

Much of the focus for the SWG throughout 2006 has been on developing a science case for a Phase I SKA. The Phase I SKA is envisaged as having 10% of the full SKA collecting area and with maximum baselines limited to approximately 50 km, but otherwise with specifications as laid out in the Reference Design. As reported in the previous newsletter, the SWG envisages three key topics for this Phase I instrument:

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

About a dozen other secondary experiments for the Phase I SKA have also been identified, including X-ray binaries, the cosmic web and interstellar scintillation. The Phase I science case will also feature separate chapters on "early science" and "discovery space" with the Phase I SKA. A full draft of this document is now nearing completion; it will soon be circulated to the SWG for comment,

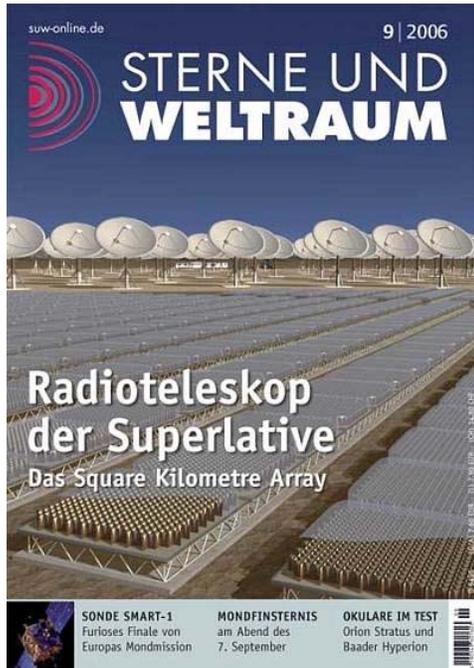
before final editing and then submission.

The SWG is also in the process of writing a series of reports which lay out the how the science drives the instrumental specifications, and how the specifications affect the science. Recent memos now available from the SKA WWW page include a detailed response to EWG questions about science / engineering trade-offs ("the Magnificent Memo Series"), a report on "SKA Discovery Space", a discussion of uniqueness and complementarity of SKA science, and summaries of all the various SKA-specific scientific conferences held throughout 2005/2006.

Discussions at the inter-working group meeting held in Paris in September 2006 indicated the need for further SWG reports and discussion papers, on which work has begun, and which will be completed in 2007. These include a statement on the scientific utility of a "minimal risk" SKA design, a scientific view of what "a year in the life of the SKA" might look like (especially with regard to the relative roles that large surveys and individual projects will play in SKA operations), and a report which defines and quantifies survey metrics for SKA science.

SKA science continues to be enthusiastically promoted by many individuals, both from the SWG and from the broader SKA community. Throughout 2006, there were clear indications that these efforts are now bearing fruit. In September 2006, two SKA-related cover stories appeared in widely read magazines: a feature article on the SKA, written by SWG member Rainer Beck, appeared in the German astronomy magazine "Sterne und Weltraum", while the British magazine "New Scientist" carried a story on cosmic magnetic fields, and

made many references to what the SKA can accomplish in this area. The SKA and its Pathfinders were also the subject of a news feature in "Nature" in November 2006. (Links to all of these articles are available from the SKA WWW site.)



Source: *Sterne und Weltraum Magazine*

Looking ahead to 2007, SWG members Michael Kramer, Joe Lazio and Bryan Gaensler are in the process of making final edits on a feature article on the SKA, to be published in the US astronomy magazine "Sky & Telescope" in the coming months.

On the scientific front, a variety of recent reports have highlighted the SKA's planned contribution to 21st century astronomy. In the United States, a comprehensive review by a national "Dark Energy Task Force" concluded that the SKA, LST and JDEM are the three future major projects needed to advance our knowledge of dark energy, and recommended "continued research and development ... to optimize [these] programs". A corresponding UK review, carried out by the PPARC Science Committee, emphasises that the two techniques that the SKA will use to study dark energy, namely weak lensing and acoustic oscillations, together hold the most promise for future studies of dark energy. The strong scientific case for the SKA was highlighted in the 2006 NSF Senior Review, and is expected to also feature in the Science Vision for European Astronomy and the Roadmap for Astroparticle Physics in Europe, both to be published in 2007.

*Bryan Gaensler  
Project Scientist,  
Joseph Lazio  
Deputy Project Scientist*

## MEETINGS

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### Paris SKA Engineering and Joint Working Group Meetings

A very successful series of working meetings was held in Paris over the week 3-7 September, 2006. On Monday 3<sup>rd</sup>, the European SKADS community hosted international colleagues and show-cased a range of developments, principally in engineering areas. Over the following two days the ISPO Engineering Working Group and its task forces examined recent international progress and considered future SKA directions. Finally, on 6-7 September the EWG combined with the Science Working Group (and a small Operations Working Group contingent) to look at updated SKA requirements, representative specifications, trade-offs and optimizations, and possible implementation strategies. All the meetings were held at the Institut d'Astrophysique de Paris (IAP) and were sponsored by the Observatoire de Paris, IAP, ISPO and SKADS. About 80 people attended the mid-week sessions and special thanks go to Wim van Driel and his team, and to Astrid Marx, for their hard work in organizing the logistics.

Records of the SKA and SKADS meetings can be found at [http://www.skatelescope.org/SKAmeeting\\_Paris/program.htm](http://www.skatelescope.org/SKAmeeting_Paris/program.htm) and <http://www.skads-eu.org/ParisWorkshop20060904/index.php> respectively. Note that the SKA meeting site contains links to both oral and poster presentations, and to important engineering and science discussion documents. From an organizer's perspective the surprise of the week was the appearance of nearly 20 high quality posters, all of which dealt with pertinent technical topics.

Big discussion issues included the SKA Reference Design, consideration of an "affordable" engineering strawman design based on the RD, the merits of what was termed a "low-risk" design based on technology which is already largely demonstrated, and a first pass at what will ultimately be prioritization of SKA science goals. In tackling the science goals and related specification updates the work of the SWG in producing the "Magnificent Memos" was invaluable. Similarly, the efforts of the EWG and its task forces in compiling system and sub-system white papers effectively informed large parts of the discussion. The strawman – who survived with light bruising – was also crucial in promoting debate. Finally, important papers on SKA uniqueness and complementarity, and on survey requirements, set the scene for a number of cross-disciplinary exchanges. All of these papers are available via the meeting web site (above) and all form essential reading for those wishing to be informed of contemporary SKA project issues.

Meeting outcomes have been summarized by Richard Schilizzi in his closing presentation but, overall, the consensus of the gathering was that there is a high degree of adjacency in the required SKA specifications, allowing a staged implementation approach to satisfy many science goals. Broadly speaking the stages might be: (i) a 10% collecting area instrument, with maximum baselines <50km and operating below ~10GHz; (ii) a full-area telescope, with very long baselines, still operating at < 10GHz; and (iii) an expanded instrument, including more area on long baselines and higher frequency capability. The meeting recognized the importance of

surveys to the SKA and the ISPO has commissioned an SWG and EWG investigation, under the chairmanship of Jim Cordes, to examine further the trade-off between single-field sensitivity and field-of-view. As well, the importance of new science simulations, cost and risk estimates, an international work breakdown structure, and SKA operational models were also stressed. Notably, the writing group preparing the FP7 design study proposal (see Engineering report) are already incorporating much of the Paris thinking on SKA implementation in their work. The work breakdown structure – needed for both FP7 and the US Technical Development Program – is also emerging from this group.

(see [http://www.skatelescope.org/PDF/FIRST\\_ANNOUNCEMENT.pdf](http://www.skatelescope.org/PDF/FIRST_ANNOUNCEMENT.pdf) for preliminary details of the associated science meeting) will be an important one since it precedes the formal setting of initial SKA and SKA-Phase 1 specifications, and a subsequent concept exposition and external engineering review. Interested people should ensure that they participate in working group activities preceding the meeting and, if possible, set aside the time to attend the UK gathering.

The next annual SKA meeting, to be held in Manchester in October 2007



*Lively debate at the Institut d'Astrophysique in Paris last September*

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## SKA Calibration and Imaging Workshop 2006

The SKA Calibration and Imaging Workshop for 2006, held in Cape Town, South Africa from 4 to 6 December 2006, attracted 50 people, more than 30 of them experts from outside the country. The workshop was hosted by SKA South Africa at the South African Astronomical Observatory (SAAO) headquarters.

The workshop covered a number of radio astronomical calibration and imaging topics important for extending

the capabilities of existing facilities, as well as for the next generation radio telescopes such as LOFAR, KAT, xNTD, MWA, and SKA itself. The workshop presentations were complemented by a number of excellent discussions, at the workshop and at a work-session at the KAT offices in Pinelands. A range of issues including, ionospheric calibration, primary beam effects, large-scale high-fidelity simulations and calibration /imaging pipelines to name but a few, were discussed. While it is clear that there is much work to be done in this area to support the new telescopes, good progress is being made in a number of areas.

After much exercising of mind and the enjoyment of some good workshop fare over a couple of days, most of the participants enthusiastically took part in a walk up the front face of Table Mountain on one of the evenings and descended again via the cable car.



*Delegates from the SKA Calibration and Imaging Workshop accepted the challenge to walk up Table Mountain.*

Presentations and more photos from the workshop and the Table Mountain excursion are available at: <http://www.kat.ac.za/calim2006>

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## NEWS FROM THE CONSORTIA AND INSTITUTES

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### AUSTRALIA

#### NTD/xNTD project progress

##### NTD

The NTD project, which has the goal of testing Focal Plane Array performance on a two-element interferometer, has entered into a phase of continuing observations and experiments. The infrastructure is now in place at the ATNF headquarters in Marsfield and consists of: two re-purposed Fleurs antennas on a 100m baseline, observing at 20cm, one element with an ASTRON ThEA tile, using a 21-element input/1 beam output beamformer/correlator, all controlled by a python-based control system (see Figure 1). Fringes on a satellite Optus B were demonstrated (see Figure 2). Recent work by Doug Hayman, Tim Cornwell, and a summer student, Antony Whelan, has concentrated on improving the calibration, mostly by using a noise source on the surface of the antenna.



Figure 1: Noise measurement of the ATNF-Marsfield dish with the ASTRON THEA tile used as a phased array feed.

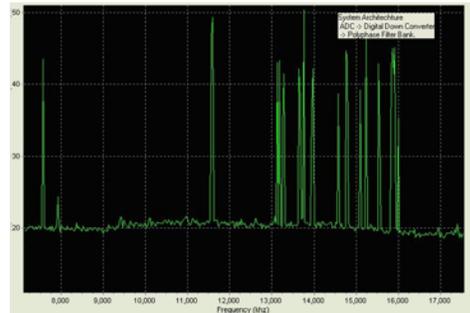


Figure 2: First beamforming results from the ThEA tile viewing the Optus B satellite. A beam formed from 5 of the tile elements is correlated with the signal from a reference antenna to produce this spectrum.

#### Feeds/Receivers

The Focal Plane Array development efforts have been proceeding along a number of complementary paths. As mentioned above, the ThEA tile from ASTRON has been installed on the test interferometer at Marsfield and is being used with a prototype digital beamformer and receiver system and, while not yet fully optimised, has thrown up a number of interesting results that are under scrutiny.

Development efforts at the ATNF have concentrated on a linear connected array (i.e. connected dipole-like elements) with extensive modelling and a small prototype array which has been measured and has validated the modelling (see Figure 3). Key challenges found were related to connection of the array elements to the low noise receivers without disturbing the radiation properties of the array. A newer variant of this approach is one where the dipole wires have been "fattened" to be square elements arranged in a checkerboard pattern. This solution has been found to have very good

performance as shown by modelled antenna beam patterns and gains, and also has good receiver matching characteristics. Interestingly, this checkerboard structure is also known as a self-complementary screen which leads to predicted properties which are confirmed by our modelling. A prototype checkerboard array is being constructed.



Figure 3: Stuart Hay testing the 5x1 prototype linear connected array.

Through collaboration with DRAO in Canada, measurements and modelling of phased array feeds based on Vivaldi elements remains on-going with the intention to test various phased array feeds on the Parkes FPA test antenna.

A partnership project with Peregrine Semiconductors and La Trobe University to investigate the usefulness of the CMOS Silicon-on-Sapphire process for xNTD LNAs has recently commenced. This is a short (approx 6-month) project, with the result being a number of LNAs fabricated by Peregrine (fabrication costs donated by Peregrine) and tested by CSIRO.

#### Antennas

CSIRO has recently awarded a contract to Patriot Antenna Systems of Michigan, USA to install a 12-meter antenna at Parkes Observatory. This antenna will be used to continue the study of phased array feeds in the more benign electromagnetic climate of Parkes, as opposed to the Sydney metropolitan area. The antenna is

scheduled for delivery in July 2007 and will be operational in the final quarter of the calendar year.

A series of studies for the xNTD antenna is on-going and on 12 December an xNTD antenna design working meeting was held at CSIRO ATNF with participants from CSIRO, DRAO and a team of 5 engineers from Connell Wagner. The DRAO team visited ATNF for the week of 11-15 Dec 2006 and meetings included discussions on a whole range of xNTD/MIRA activities. Given the goal to conduct wide field-of-view high dynamic range studies, novel antenna configurations for the xNTD antenna are under investigation. The project will progress to design xNTD antenna options in readiness for the xNTD antenna CDR in September 2007.

#### Staff

The xNTD project is pleased to welcome five new staff members. David DeBoer recently came on board to direct the xNTD and SKA technical activities at ATNF, taking over from Colin Jacka, who remains with the project on a part-time basis. Formerly, David was the Project Manager of the Allen Telescope Array (ATA) in California. Antony Schinckel, formerly the Director of Operations for the Smithsonian Submillimeter Array (SMA) in Hawai'i, has also joined the project as a manager. In the xNTD computing group, Yuantu Huang, and Juan-Carlos Guzman have been hired to work on the xNTD archive and central processor respectively. Both are very experienced software developers with recent backgrounds in the commercial sector. Yuantu trained in China and ANU as a mathematician, and Juan-Carlos worked for a number of years at La Silla Observatory in Chile in real-time control systems. We expect to hire one more software developer in the next few months. Tim Bateman has also joined the xNTD team, where he will be programming the Parkes digital beamformer, 192 inputs at tens of MHz bandwidth. Tim

comes to us from industry where he has extensive experience in programming ASICs as well as hardware experience.

### Government support for Radio Astronomy

On 27th November 2006 the Australian Government Minister for Education, Science and Training, the Hon Julie Bishop MP, announced funding of A\$45M for optical and radio astronomy infrastructure under the National Collaborative Infrastructure Strategy (see [http://www.ncris.dest.gov.au/capabilities/optical\\_and\\_radio\\_astronomy.htm](http://www.ncris.dest.gov.au/capabilities/optical_and_radio_astronomy.htm)). A\$19.2M of this has been earmarked towards funding an SKA pathfinder instrument in Western Australia in line with the international SKA Reference Design.

Funding for SKA-related research has been further boosted by grants to the group led by Prof. Rachel Webster at the University of Melbourne who have received A\$283k from the Australian Government's Department of Education, Science and Training, and A\$494k from the Australian Research Council. These grants are to support Australian collaboration with the US-led Low Frequency Demonstrator telescope project, to be constructed in Western Australia.

### International Collaborations

#### CONRAD

CSIRO and South Africa are formalizing the Convergent Radio Astronomy Demonstrator (CONRAD) collaboration, aimed at producing common computing structures and systems for the xNTD and South Africa's Karoo Array Telescope (KAT). This collaboration leverages the expertise of both groups to efficiently produce a computing/control system appropriate for multiple arrays. The collaboration covers the areas of software architecture and design, archiving, calibration and imaging,

array configuration, radio frequency interference mitigation, simulation, software engineering, monitoring and control and systems integration and testing.

### Australia-Canada Memorandum of Understanding

Australia and Canada have signed a Memorandum Of Understanding -- an "Agreement to Cooperate" to realise MIRA – Mileura International Radio Array. The collaboration, between CSIRO and the Canadian Dominion Radio Astrophysical Observatory (DRAO), has already been established and is running well.

A visit to DRAO in October by ATNF astronomers and engineers included a preliminary design review of the Canadian project to develop a prototype 10-m composite reflector. ATNF scientists and engineers are working closely with the Canadians to advance the work to a fully costed and tested state by 30 September 2007.



*Australian xNTD team visit to DRAO, October 2006 - tour of DRAO reflector prototyping facility at the Penticton site. Left to right: Richard Hellyer (DRAO antenna engineer, infrastructure); John Bunton (CSIRO ICT); Matt Fleming (ATA antenna engineer); Dave DeBoer (new xNTD theme leader at ATNF); Belle Gall (Technical advisor, DIAB inc - a composite component supplier)*

### Design Concept for SKA Visitors Centre

In 2006 Tenix Pty Ltd, a partner in the Australian SKA Industry Cluster Mapping project, commissioned renowned architect Jan Utzon to prepare a schematic design proposal for the SKA visitor centre in Western Australia. At a presentation on 9 November, Tenix bequeathed this design to the Australian SKA project.



Photo: Presentation of the SKA Design Concept - (from left) Mr Kim Scott, General Manager, Electronic Systems Division, Tenix, Dr Paul Scully-Power AM DSM, Chief Technology Officer, Tenix, Mr Jan Utzon, Utzon Architects, Mr Robert Leece AM Chief Operating Officer, Tenix, Dr Lewis Ball, Deputy Director CSIRO ATNF, Dr Carole Jackson, Business Development Manager CSIRO ATNF



Utzon's concept design for an SKA visitor Centre: credit Utzon Architects

### SKA Meetings in Australia, Feb – Mar 2007

#### FPGAs in Radio Astronomy, Tasmania 5-8 February 2007

This 4-day workshop is aimed at the developers of FPGA-based radio astronomy instruments and will include discussion of state-of-the-art techniques, including optimal strategies for digital signal processing, communication and data transport, hardware selection, networking and cluster computing, user interface design and many other topics. The workshop will provide a chance for interested parties to discuss their ideas with other members of the Australian (and international) radio astronomy community, and also with industry representatives. Further details can be found at <http://www-ra.phys.utas.edu.au/fpga/>

#### Australian Symposium on Antennas in Sydney, 14-15 February 2007

This meeting is being sponsored by the CSIRO ICT Centre with the aim of bringing together engineers, scientists and industry representatives working in antennas and related areas to discuss current and future developments. See <http://www.ict.csiro.au/asa> for details.

#### SKA pathfinder instruments, the challenges ahead, Sydney 12-16 March 2007

An international meeting looking at the challenges ahead in designing the SKA is to be held in Sydney in March 2007. Engineers and astronomers from Europe, South Africa, Canada and Australia will meet to review progress to date on the various pathfinder instruments under development, and to discuss design options and techniques for the future. The week-long meeting entitled "Technology challenges & the science potential of the SKA Pathfinders" will also include talks on the science projects that these pathfinder instruments are designed to carry out. Further details of the meeting can be found at <http://www.atnf.csiro.au/projects/ska/fpa.html>

#### News from the SKA Molonglo Prototype (SKAMP)

Astronomical images are now being produced from SKAMP1, the continuum correlator (cf. image in ASPO Newsletter #8), and the analysis of these is proving invaluable in understanding subtle second order effects relating to the cylindrical parabolic reflector and making effective use of the large number of redundant baselines available.

Earlier this year the SKAMP team contracted Domain-42 Pty. Ltd., two digital designers in Tasmania, to assist with the design of the spectral line correlator for SKAMP II. They have made rapid progress and designs and

layouts for the two FPGA boards are being finalised. We are delighted to report that this pioneering design work has been boosted by a donation of over \$30,000 worth of chips from the company **Xilinx**.

The 415V switch board and power distribution wiring at the Molonglo Observatory have been replaced and rewired so that there is sufficient power available for the new correlator. Good progress has also been made in designing a new wideband receiver and digitiser required for SKAMP II. This work has to be compatible with the existing feed as well as with the new wideband line feed which will be installed for SKAMP III.

Work has also continued with **Argus Technology**, who have supported and funded a PhD student to develop the dual polarised line feed required for SKAMP III

#### [Swinburne University SKA Update](#)

The Swinburne software correlator is now operational and supports disk-based VLBI experiments made with the Australian Long Baseline Array (LBA). Data obtained from the LBA in the March, May and August VLBI sessions (cf Australian SKA Planning Office newsletter #5) have been correlated at Swinburne and the data distributed to PIs. Already the more advanced capabilities of the correlator are being used to produce datasets that are challenging standard data analysis packages.

With the completion of the software correlator Swinburne has now produced a licensing agreement covering distribution of the software. International institutions such as the NRAO in the US and MPIfR in Germany have expressed a strong interest in obtaining software to provide upgraded correlation facilities for astronomy and geodesy. The Swinburne team are currently in negotiations with these institutions regarding distribution of the software.

Swinburne are also full partners in the EU Framework Program 6 SKA Design Study (SKADS) and are providing supercomputer resources and SKA simulations software and experience to the SKADS consortium. Staff exchanges are planned between Swinburne and European institutions as part of the DS2T1 and DS2T2 work packages.

Swinburne is involved in preliminary discussions with a number of other Australian and Indian institutes regarding joint Australian/Indian science collaborations. The overall theme of the proposal under discussion will be SKA technology development. Swinburne will likely contribute to this proposal through a project aimed at providing a software correlator for the GMRT (Giant Metrewave Radio Telescope), to extend the capabilities of this telescope and enable new science in the areas of deep imaging and HI imaging. The project will be an entrée into a much more ambitious project to beamform in software to provide excellent pulsar searching capabilities with the GMRT.

A new staff member has joined the Swinburne SKA group, Dr Indra Bains. Dr Bains will be working on wide-field VLBI observations, developing algorithms and techniques that are relevant for future wide-field imaging observations with the SKA. This position is partly funded by new money from a successful Australian Research Council Discovery Project grant of \$268k over three years.

#### [Industry briefing, Perth, 6<sup>th</sup> December 2006](#)

The sixth Australian industry SKA briefing was held in Perth on 6 December 2006, hosted by the Western Australia Government's Department of Industry & Resources (DOIR).

Interest in the Industry Cluster and its activities remains very positive, and we are very grateful to our core sponsor members for their support. A number of additional companies have expressed the desire to become sponsoring (funding) members and their admission is in progress.

regular Australian SKA Planning Office Newsletters at:  
<http://www.atnf.csiro.au/news/aspo-newsletter/>

*Michelle Storey & Helen Sim  
Australian SKA Consortium*

For further information on Australasian SKA-related activities, please see the

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## CANADA

### **Square Kilometre Array Developments in Canada**

A Memorandum of Understanding between the Herzberg Institute of Astrophysics and the University of Calgary establishes a partnership between the two Institutes on the Canadian SKA program over the next five years. The MOU recognizes the intent of Canada to participate in the SKA project, as described in the Canadian Astronomy Long Range Plan, and to continue our role in the international SKA governance and our commitment to the international project office as a signatory to the International MOU on Collaborative Development of the SKA.

During 2006 the Canadian SKA Consortium Board, Canadian SKA Science Advisory Committee and the Herzberg Institute of Astrophysics have redirected the Canadian SKA technical program to align with the international SKA reference design. Canada is now concentrating on two key technologies for the Reference Design. This technology development builds upon the expertise in focal-plane phased arrays and advanced materials engineering that is

the legacy of the Large Adaptive Reflector project.

### **Focal-Plane Phased Arrays**

Development of focal plane arrays based on broadband Vivaldi antennas continues apace at HIA DRAO in Penticton. The Phased Array Demonstrator (PHAD) project aims to build a 180-element array using commercial off-the-shelf (COTS) receivers and digital signal processor (DSP) to expedite design and provide an array for engineering tests. All components of the system, from array elements to receiver boards, to the analogue signal transmission system and to the DSP beam former have now been prototyped. These components are currently being put through qualification testing, before fabrication of the full 180-element array.

Many PHAD tests will be made in the new anechoic chamber at DRAO with a state-of-the-art spherical near-field scanner. A renewed effort in systems simulations of phased arrays on radio telescopes is underway currently, to prepare for placing the PHAD array on a radio telescope (see below).

At the University of Calgary Department of Computer and Electrical Engineering, recent successful prototyping of an uncooled, low-noise, broadband amplifier promises to provide a solution to the integration of high-performance, inexpensive receivers into the very large number of receiver array elements that will be required for the SKA.

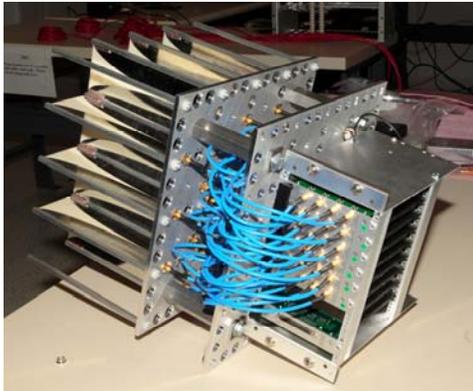


Figure 1. The proto-type 24-element PHAD phased-array feed and receiver system. The Vivaldi elements are visible on the left with the COTS receivers on the right. This system is being used for end-to-end system tests prior to fabrication of the full 180-element array.

### Phased-array simulations

At DRAO, the *MeqTrees* package, developed by Jan Noordam and his colleagues at ASTRON, is being used to simulate observations made with an SKA using Vivaldi focal plane arrays. The goal is to study the aberrations associated with these types of focal plane arrays, and then to develop correction algorithms in order to obtain the high dynamic range specified for the SKA.

A set of Vivaldi beams calculated by Walter Brisken for the VLA at 311 MHz have been scaled to a half power width of about 1 degree at 1400 MHz, approximately that of a 10-m dish. For a given polarization there are 90 Vivaldi beams on the sky, each of which is loaded into the *MeqTrees* system where the beams are weighted in a 'beamformer'. A simple beamformer that maximizes the gain of the 'formed' beam centre in a

specified direction can be obtained by determining the complex electric field of each Vivaldi beam in that direction and then using the complex conjugate of this value as a weighting function for that beam. Using this technique on the 90-element Vivaldi array, the central beam that would be 'formed' along the boresight of a synthesis array dish is shown in the Figure 4. While this beam is reasonably symmetric, it has quite high sidelobes - approximately 40% in the E-field pattern and significant instrumental polarization (approx. 5 percent) is found at the field centre. The present simulation system already allows us to investigate various aspects of SKA design such as differences in dynamic range between observations with dishes using Alt-Az mounts versus those having equatorial mounts.

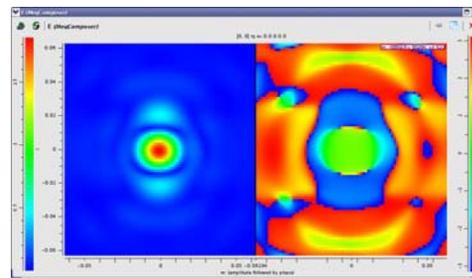
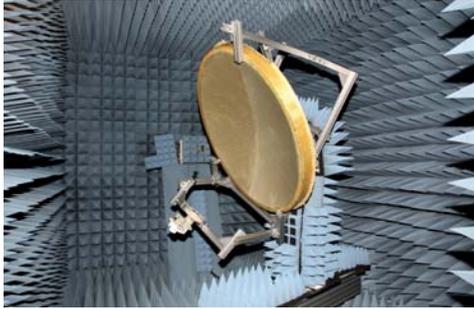


Figure 2. The weighted beam formed along the boresight of the simulated telescope - voltage pattern amplitude (left) and phase (right). Although the beam is reasonably symmetric, it has high sidelobes and significant instrumental polarization.

### Composite Applications to Radio Telescopes

Before the announcement of the SKA reference design, some exploratory design studies of composite parabolic reflectors had been carried out at DRAO as an alternative to the LAR for addressing the challenge of designing cost-effective collecting area for the SKA, which remains one of the outstanding technology challenges facing the SKA project. The results of those studies showed great promise and resources were redirected toward a new project, Composite Applications to Radio Telescopes (CART), targeting the fabrication of antennas for the SKA Reference Design.

CART is being carried out in two phases. The first phase, near completion, is the investigation of preliminary designs and cost estimates, fundamental material properties testing, culminating in the construction a small (~1-m diameter) reflector to verify RF performance of composite reflectors.



*Figure 3. A 1-metre CART prototype reflector under test in the near-field scanner range at HIA DRAO.*

The second phase is the design and construction of a prototype 10-m diameter radio telescope to demonstrate the complete concept feasibility of composite antennas and verify cost estimates. This phase has been in progress since summer 2006 and a Preliminary Design Review was held in October at DRAO, with a board of reviewers from the Australia Telescope National Foundation, the Allen Telescope Array, AMEC Dynamic Structures and DIAB (composite core materials manufacturer). The panel was impressed with the project concept and objectives, the progress to date and the team's expertise. They provided constructive feedback and

gave a strong positive endorsement to continue with the prototype development for this competitive antenna technology. Currently the team is hard at work preparing to build the 10-m prototype. The necessary mold is on order and the LAR aerostat hangar is being converted into a production facility for the prototype. In parallel, the reflector design is nearing completion and several options are being explored for the telescope mount. The aim is to commission the 10-m prototype in the late spring of 2007 for assessment during the summer months.



*Figure 4. Rendering of a 12-m CART antenna currently under development at HIA DRAO.*

*Sean Dougherty  
Herzberg Institute of Astrophysics,  
Russ Taylor  
University of Calgary*

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## CHINA

### 1 Appraisal Review on FAST by CIECC and NDRC

As one of the nine large facilities of basic science and technology in China to be constructed during the national '11th Five-Year Plan', the FAST project was reviewed and evaluated by China International Engineering Consulting Corporation (CIECC), which was appointed by the National Development and Reform Commission (NDRC), a prestigious high level state organization to take charge of national significant strategy and policy. As a preliminary step, CIECC arranged for appraisal experts to hold work meetings on the FAST model at Miyun in Beijing on November 10 of 2006, and later for the experts to visit the selected telescope site in Guizhou province from November 16 to 17. The formal appraisal meeting was held in Beijing between November 22 and 23, and was attended by many leaders and experts from the important organizations of China (see Fig.1). The appraisal expert team was composed of six members of Chinese Academy of Engineering (CAE) and Chinese Academy of Science (CAS), eight designers and some recognized experts from the related regions. As the responsible officials, vice director Liu and deputy division chief Shen of the high technology department of NDRC attended the meetings in Beijing and Miyun, and they personally surveyed the telescope location in Guizhou as well. Moreover, the other officials from CAS, National Astronomical Observatories (NAOC) and Guizhou province also participated in the above review meetings and procedures. As expected, the review outcome results were excellent, although many arguments and confrontations happened in the meetings on the

funding items and their support strengths. At the moment, in line with the requirements of NDRC, the FAST proposal is being modified to satisfy the needs of the newly issued engineering design norm. Some support items for FAST may be slightly reduced or shifted to Guizhou province, however the proposal application procedure has made positive progress.



Fig. 1. Formal FAST appraisal review meeting held in Beijing, November 2006.

In retrospect, experiencing the hard struggles for 12 years, NAOC, together with more than 20 cooperative teams and international colleagues, has made a great deal of preparations, including the theoretical analysis of the engineering plan, model test, and site selection surveys. Meanwhile, Guizhou provincial CPC general secretaries and governors of three consecutive terms, the related bureaus and departments, municipal local governments and ordinary people have paid much attention and given full support to the FAST project. On September 29, 2006, the FAST proposal was formally submitted to NDRC by CAS for the review application. On October 19, the deputy division chief Shen, who is responsible for the pivotal scientific project of NDRC, was invited to attend the assessment meeting on "FAST key technology optimizing study", investigating the FAST model at

Miyun. On November 17, 2006, vice director Liu and deputy division chief Shen of NDRC went to Guizhou to inspect the FAST site preparatory work, where a FAST preparation meeting was held by vice governor, Kexin Bao, of Guizhou province (see Fig. 2). Accompanied by Rendong Nan and Bo Peng, they also went to the FAST site, Dawodang (see Fig. 3), 170 km south of the capital city Guiyang, for a live view and inspection, where the government leaders thoroughly enquired about the geological structure, local climate, communications, traffic and society status.

No doubt, with the completion of the FAST appraisal review meeting, the FAST has made a determined step forward.



Fig. 2. FAST site survey and investigation meeting held in Guizhou, November 2006.



Fig. 3. Satellite picture of FAST site, shown by the arrow, is taken by "Quick Bird"

## 2 Miyun FAST model construction is success

After considerable effort, the 50-m FAST model has been erected in

Miyun, 150 km north of Beijing (see Fig.4). This mini FAST is a test lab for the real FAST, in which many of the construction issues are being tested to show the feasibility of the FAST. Albeit mini, it includes almost all the fundamental features of telescope, i.e. the receiver, feed support, an adaptive cable-mesh reflector with aperture of 30 meters, etc. Excitingly, first 'light' observations of a neutral Hydrogen spectrum were made by the model on September 6, 2006, (see the upper-right panel of Fig. 4), using a room temperature L-band receiver in the frequency range 1370-1470 MHz. This means the model has been an operational telescope though many improvements are required for reliable precision. At present, the on-site experiments have been being carried out, and the computer simulations for the Stewart platform stability is being processed. Furthermore, we are making the linkage adjustment of the feed suspension and Stewart platform, the modulation of the reflector from a spherical surface to paraboloid, after which the further astronomical observations with the FAST model will be carried out.

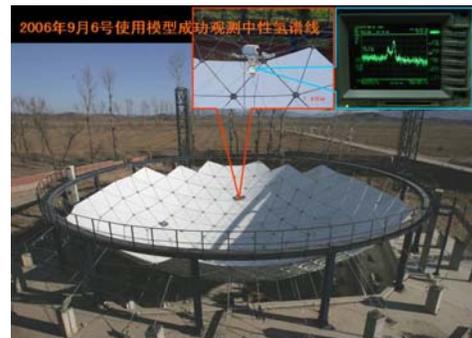


Fig. 4. 50-m FAST model is constructed and successfully observes the neutral hydrogen spectrum

## 3 The team is expanding up

Up to date, the FAST group has been expanded by absorbing 5 new hired positions and 2 contracted engineers, among whom six have the engineering backgrounds and one has an astronomy background with long-term international cooperative experience. Together with the new students, the

group becomes a 40-people team. To satisfy the future construction requirements of the FAST, about another 30 members will be recruited after the project is officially funded. In addition, international partners and experienced experts on telescope construction will be also encouraged to join the project; a preliminary plan for this is in preparation. To accomplish the FAST target, the international compositions will be absorbed, so the

future team would be a group of worldwide elements.

NAOC, China

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## EUROPE

### ESKAC

The ISSC meeting in Germany was hosted by the Max-Planck-Institute fuer Radioastronomie in Dresden, Germany, on behalf of ESKAC and with partial support from RADIONET. Two potential sites were identified for the SKA: South Africa and Australia. The European members in the ISSC (UK, RADIONET, MPIfR, INAF, CNRS, ASTRON, and the Dutch Scientific Community) have agreed to unilaterally increase their individual contractual contribution to the ISPO cost contributed by each member organisation represented in the ISSC. This will provide in 2007 much-needed funds that will allow the appointment of an ISPO executive officer.

*A. Zensus  
Chair ESKAC*

### SKADS

#### SKADS Workshop, 4 September 2006

The first SKADS Workshop was organised in Paris together with the International SKA Engineering and Joint Working Group meetings. The

combined event was a great success, bringing together not only SKADS partners, but many of our global SKA partners for a week of SKA discussions and presentations.

All the presentations are available on the website at <http://www.skads-eu.org/ParisWorkshop20060904/> and [http://www.skatelescope.org/SKAmeeting\\_Paris/program.htm](http://www.skatelescope.org/SKAmeeting_Paris/program.htm).

The SKADS Workshop was a forum for discussion and presentation of progress after nearly a year of SKADS since the kickoff in November 2005. Some partners had a bit of a slow start, but overall considerable progress has been made. The opportunity to review each others work and interact closely with the rest of the SKA community was invaluable, and there was considerable exchange of views and ideas.



Figure 1: Participants at the first SKADS Workshop in Paris, 4 September 2006. The workshop and SKA meeting were hosted by the Institut d'Astrophysique de Paris and the Observatoire de Paris.

### The SKADS Benchmark Scenario

The SKADS Benchmark Scenario was published last September as part of an initiative led by SKADS Project Engineer Andy Faulkner to focus the technological effort of SKADS and its contribution to the International SKA effort. The SKADS Benchmark Scenario is a particular case of the SKA Reference Design (SKA memo 69) for which the mid frequencies are covered by a technology based on aperture-plane phased-arrays. The development of densely packed aperture-plane phased-arrays for the mid frequencies is the main technological thrust of the European Square Kilometre Array Design Studies. With this emphasis on aperture-plane phased-arrays at the mid frequencies, the SKADS Benchmark Scenario would enable the use of small dishes at the higher frequencies since these dishes would not have to operate to such low frequencies.

SKADS aims to provide a cost-effective technology which satisfies the SKA science requirements in the mid frequency range. In particular, the emphasis is on maximising Field-of-View at the mid frequencies, and the SKADS Benchmark would improve on the Reference Design in this frequency range.

The Benchmark Scenario will evolve as the technology matures. Further

information can be found on the SKADS website at <http://www.skads-eu.org>. Comments are welcome.

### SKADS Design and Costing

The International SKA Steering Committee has called for a first iteration on the costs of the SKA by March 2007 and has asked the ISPO to coordinate the effort internationally. Since one of the main deliverables of the SKADS project is a costed SKA, SKADS is making a major contribution to this international effort through Design Study 3, led by Cambridge University. The first SKADS Design and Costing meeting was held in Cambridge in November, organised by Paul Alexander, and SKADS Project Engineer Andy Faulkner. Since then, Cambridge engineer Rosie Bolton has taken on the task of managing the SKADS effort on costing, and she has mobilised the effort within SKADS partners. A second meeting was held in Cambridge on January 15<sup>th</sup>. Close contact has been maintained with the ATNF team (Aaron Chippendale and John O'Sullivan) working on cost estimation under contract to the ISPO.

The SKADS design and costing is based on a projected realistic system and is implemented in an extensive Excel spreadsheet which shows the individual contributions of various subsystems to the overall cost. The spreadsheet can also be used to adjust a number of design decisions to see how changes affect cost.

An initial paper on the SKADS Design and Costing will be submitted to the International SKA Steering Committee in March.

### A Year in the Life of SKA

While much of the science justification for SKA has concentrated on the five Key Science Projects, there will certainly be numerous new ideas to use such a powerful instrument. SKADS is providing a major

contribution to international thinking on SKA operations by investigating how a typical year might be scheduled on the SKADS Benchmark Scenario for the SKA during the period when the first 10% of the array is being constructed. This is being coordinated by Steve Rawlings at Oxford.

### EMBRACE Development

The primary technology demonstrator for SKADS is the Electronic MultiBeam RadioAstronomy ConcEpt. The prototype tile is almost fully integrated. It has 64 Vivaldi antenna elements mounted on a single circuit board which is half populated with its electronic components. Beamformer chips developed at Nancay in France are being considered for integration into the tile. Meanwhile, characterisation of the frontends is fully underway at ASTRON in Dwingeloo.

The EMBRACE Project is on target to have 10 working tiles by October this year.

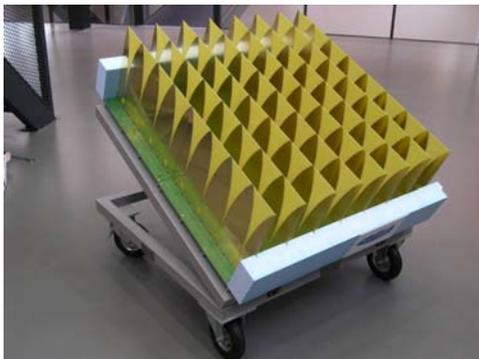


Figure 2: The prototype EMBRACE tile is currently being tested at ASTRON.

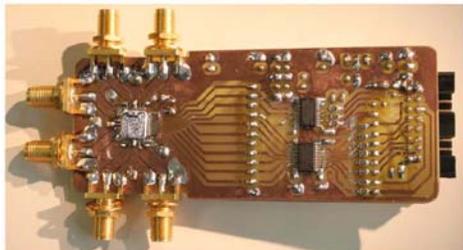


Figure 3: The beamformer chip developed in Nancay, and shown here in its test module will soon be integrated with the EMBRACE tile.

### CENTRA is a New SKADS Partner

CENTRA is the Multidisciplinary Centre for Astrophysics at the Instituto Superior Tecnico in Lisbon. Members of CENTRA have been active in the SKADS for nearly a year, and they have made important contributions to the science simulations activities. The group led by Domingos Barbosa and Mario Santos are especially interested in the Epoch of Reionisation and foreground contributions to an EoR experiment. At the recent SKADS Board meeting in January in The Hague, CENTRA/IST was unanimously and enthusiastically welcomed as a SKADS participant.

### Marie Curie SKADS

SKADS partners were pleased to hear that the proposal to the European Commission for a Marie-Curie training program has been awarded. This award is worth 555kEuro over the next three years and will be used to fund 14 events including Astronomy and Technical workshops, as well as funding for training visits by young researchers and students. Initially, the training aspect was missing from the SKADS programme, and this is an excellent addition to the project so that the future generation of scientists will be well prepared to exploit the SKA.

*Steve Torchinsky  
SKADS Project Scientist*

### LOFAR

#### LOFAR Progress Report

The LOFAR (Low Frequency Array) project is progressing well. Having completed a series of critical design reviews of various sub-systems in the second half of 2005, the first LOFAR core station (CS1) was constructed in the fields of Exloo in the North-East of the Netherlands during the summer of

2006. 96 low band antennas have been distributed over 4 station locations; 48 antennas were placed in a central field and 16 each were distributed over 3 stations around the central station – yielding baselines of up to 450 metres. The figure below gives an impression of a view over the central station. The set-up was chosen to enable not only performance tests of a single station at full bandwidth but also the emulation of LOFAR with 24 micro-stations at reduced bandwidth.

The LOFAR prototype station CS1 went on-line at the beginning of October 2006. Since then, data has flowed to the BlueGene-based correlator in Groningen and is being processed, stored and analysed. As is common with projects like LOFAR, every day offers its surprises. In the course of the past months of CS1 tests, a number of problems have been encountered and solved.

A major milestone for the LOFAR project was the Calibration Review held in Groningen in November last year. This review was dedicated to the question of the ability to calibrate LOFAR using the current calibration strategy. An international panel consisting of Richard Schilizzi (chair), Tim Cornwell, Simon Garrington, Huib-Jan van Langevelde, Rick Perley and Pramesh Rao reviewed progress. Although a lot remains to be done, no major show stoppers were identified. A number of the key recommendations made by the review panel have already been realised – others feature prominently in the work programme for the coming months.

With the delivery of a low band antenna station to the Max-Planck Institute for Radio astronomy in Bonn to be built in Effelsberg, LOFAR has grown beyond its current baseline planning. The Effelsberg station will

start to produce data in the spring of 2007 and soon thereafter the first correlation with CS1 data is expected. This year the LOFAR project expects to complete at least two more stations in Germany – close to Potsdam and Garching (Munich). There are also well-advanced plans to construct stations in the UK, France and elsewhere in Germany, while possibilities are also being explored in Sweden, Italy and Poland.

Based on CS1 experience gathered, the LOFAR project is preparing itself for the Critical System Design Review, to be held in April this year. After a successful review, the full LOFAR roll-out will start in the summer. Initially, mostly core stations will be completed in the fields near Exloo. In parallel, some remote stations will be assembled in the Netherlands and the project expects to roll-out stations to its foreign partners.

As the project gets ready to complete the critical design review and for its construction phase, exciting times are ahead of us. Many people, who have been working on the project for many years are eagerly awaiting the first real data.



## SOUTH AFRICA

### SA Science minister opens site for construction of Karoo Array Telescope (KAT) prototype

Astronomers, engineers, educators and journalists from around South Africa gathered at Hartebeesthoek Radio Astronomy Observatory on 2 November 2006 to celebrate the official kick-off of the construction of a prototype dish for the Karoo Array Telescope (KAT).

Mr Mosibudi Mangena, South Africa's Minister for Science and Technology, officially opened the site where a prototype of the Karoo Array Telescope (KAT) will be built by ceremoniously cutting a ribbon and unveiling a 1:50 scale model of the prototype dish. He noted that this is a significant step towards achieving the vision of providing another cutting edge window on the universe from the African continent and was confident that the country's investment in a science instrument that could look back in time 14 billion years to the immediate aftermath of the Big Bang, would deliver Nobel Prize winners in future.

The KAT engineering team will use the full size prototype dish, a single antenna 20m high and 15m in diameter, as the basis upon which to test all the components and systems of the KAT, and to stimulate and strengthen South Africa's industry's capacity to design and construct large dishes. The next phase will be to construct the twenty similar antennae of the KAT on a remote site near Carnarvon in the Northern Cape. The prototype dish structure will be finished by mid 2007, after which the receivers, computing and digital signal processing components will be added. A consortium led by IST Dynamics Pty Ltd, a South African engineering company, has been awarded the contract to design and construct the KAT prototype dish. The Department

of Science and Technology (DST) and the National Lotteries Board (NLB) are the joint funders of the first phase of the KAT, while the National Research Foundation (NRF) administers the project.

Once the KAT trials have been completed, the prototype dish will be used for ongoing radio astronomy research at HartRAO, including the study of pulsars.



South Africa's Minister of Science & Technology, Mr Mosibudi Mangena, addresses a gathering of astronomers, engineers, educators and media representatives at the launch of the construction site for the Karoo Array Telescope at Hartebeesthoek on 2 November 2006.



South Africa's Minister for Science and Technology, Mr Mosibudi Mangena, unveils a 1:50 model of the prototype dish of the Karoo Array Telescope (KAT).

## Students excel at first SKA/KAT bursars conference

More than 20 students who have been awarded bursaries from the South African SKA/KAT project had the opportunity to present their work to fellow students and local and international SKA scientists at the first annual SKA-SA Bursary Conference. Attended by several SKA personalities from abroad, the conference also provided an opportunity to showcase South Africa's commitment to developing the people, skills and technology required for the SKA. The conference took place from 28 November to 1 December 2006 at the South African Astronomical Observatory (SAAO) in Cape Town.

Students talked on topics ranging from abstract cosmology to practical SKA engineering applications. Local and international guest speakers also gave talks, including

- The SKA: Past, present and future by Peter Wilkinson;
- The science of SKA by Steve Rawlings;
- Sky simulations for KAT and SKA by Matt Jarvis and Hans-Rainer Kloeckner;
- SALT – The first year by Phil Charles;
- The ALMA Telescope by Roy Booth.

Supervisors from local universities presented their research and Anita Loots (KAT project engineer) gave a comprehensive talk on the development of the KAT, while Justin Jonas (KAT project scientist) talked about his discovery of radio astronomy from an early age and entertained the delegates with sound bites from British radio and David Bowie's Star Man.

The conference provided a very successful networking opportunity between SKA/KAT bursars from all over Southern Africa, and helped to strengthen the community of participants and stakeholders around the SKA and KAT projects.

In addition to current and future bursars and their supervisors, delegates from four of the SA SKA partner countries also attended. Discussions with these delegates from Mauritius, Madagascar, Mozambique and Ghana led to the initiation of a collaboration between the African universities, University of Cape Town and SKA. Four students from Madagascar and Mozambique have been enrolled into South Africa's NASSP (National Astrophysics and Space Science Programme) to begin a honours/masters' degree programme in astrophysics in January 2007. The SKA Project has also awarded a bursary to a PhD student from Mauritius.

The conference included a half-day student workshop on popular science communication and media skills to encourage the bursars to share their passion for engineering and astronomy with public audiences.



*The first SKA/KAT Bursary Conference was attended by students and their supervisors from all over Southern Africa, as well as local and international SKA pioneers and leaders*



*Prof Wilkinson congratulates Marten Lodewijk who won the "best student presentation" award. Marten is an MSc student at the University of Johannesburg and did his presentation on "Testing general relativity in binary pulsars using KAT".*

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## 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.

The second in a series of community meetings was held in Tucson in 2006 August. Entitled "Building the Foundation for U.S. Astronomy at m/cm Wavelengths in 2010 and Beyond," this meeting was aimed at develop more concretely the plans for the U.S. radio astronomy community, particularly as they relate to the preparation for the next decadal review. Intentionally, this meeting was not termed an "SKA meeting," in order to allow for a free-flowing discussion. Strikingly, though, the discussion quickly began to center on the capabilities and goals of the SKA.

A summary of the recommendations from that meeting directly relevant to the SKA is

- 1 The development of a roadmap for epoch of reionization observations;
- 2 The development of a roadmap leading to an array optimized for a very large-scale survey of H I in galaxies to  $z = 1.5$  (or higher

redshift) and for surveys for transients, pulsars, and Faraday rotation; and

- 3 Develop a roadmap that builds on existing capabilities in the U.S. at frequencies  $> 3$  GHz, including capabilities at Arecibo, the ATA, EVLA, VLBA, and GBT, that can be used to inform planning by the international SKA project. The roadmap planning should be done in cooperation with the international SKA project.

Full details on the meeting are at <http://www2.naic.edu/~astro/chicago/>

### Senior Review

As previously discussed here, the Division of Astronomical Sciences of the U.S. National Science Foundation undertook a "senior review" of its portfolio of facilities. The review was motivated by a combination of U.S. Government budget forecasts and the ambitions of the astronomical community, including the SKA. The senior review panel was comprised of U.S. astronomers from many disciplines and chaired by Roger Blandford.

The panel's report was released in 2006 November. Although the panel examined the full range of NSF astronomical facilities, relevant to the SKA are the following recommendations:

- 1 The Green Bank Telescope has been quite productive with the discovery of the fastest known pulsar and several organic molecules. It is expected to operate into the future.
- 2 The Very Large Array (EVLA) is extremely productive and its expansion shows continued

promise. It is expected to operate into the future.

- 3 The committee found that the current surveys being conducted at the Arecibo Observatory with the feed array (ALFA) show considerable scientific promise. However, given the possibility of the SKA, the scientific promise of Arecibo is less clear beyond 2010, so NSF support should be reduced, with the possibility of closure in the next decade.
- 4 The committee found that the scientific capabilities of the Very Long Baseline Array are increasing. Nonetheless, the committee also recommended that the NSF investigate external funding sources to assist with the cost of VLBA operations, with the recommendation that closure of the VLBA be considered in 2011 if sufficient external support could not be found.
- 5 The committee endorsed continued U.S. community involvement in the SKA, including precursor telescopes such as the ones described below.

More details on the senior review, including the full report, are at [http://www.nsf.gov/mps/ast/ast\\_senior\\_review.jsp](http://www.nsf.gov/mps/ast/ast_senior_review.jsp).

#### Technology Development Program (TDP) proposal

The original TDP proposal was submitted in 2004. At the time, budgetary pressures and other issues resulted in no available funding for the proposal. In 2006, national support for an increase in NSF funding increased substantially. Coupled with the European Seventh Framework Programme (FP7) and other developments in the SKA Program, a revised TDP proposal has been developed. This revised TDP proposal has been developed to complement on-going work on the development of an FP7 proposal. The goal has been to devise a closely-coupled, non-duplicative effort to lay the technical

foundation for an SKA construction proposal in the next decade.

At the time of this writing, submission of the revised TDP proposal to the NSF is expected soon. However, at this time, the NSF does not have a final budget for the fiscal year (FY) 2007.

#### U.S. Pathfinder Arrays

##### Allen Telescope Array (ATA)

The ATA has begun the commissioning phase of the array as 20 working antennas and feeds are now in operation. As of this writing, 36 antennas have been deployed on their foundations; with six more needed for completion of the ATA-42. These antennas are emplaced at the rate of about 1 per week, so the antennas are expected to be completed this winter. In addition to the 20 feeds on the antennas, there are 16 additional feeds waiting to be installed on the antennas. Initial feed difficulties were due to biasing problems that have now been fixed. An 8-element, fully lab-tested, dual-polarization correlator using the final design is due to be installed in January, and a 32-element dual polarization correlator shortly thereafter. Good progress is being made on the beamformers. The entire 42-element array is expected to be ready for astronomical observations before 2007 July 1. Planning is currently underway for an expansion from the current 42 antennas, to as many as 80 in the next 18 months.



Figure 1. A panoramic view of the ATA



Figure 2. Some of the equipment used to emplace an ATA antenna.

### Deep Space Network Array (DSNA)

The DSN prototype array of two hydroformed 6-m antennas and one Patriot 12-m antenna, all located at JPL, is complete and undergoing system tests to determine antenna efficiency, phase stability, and to gain experience for operation of a larger array. The next step is considered to be the construction at Goldstone of an array with equivalent sensitivity to a current DSN work-horse, 34m antenna. The future plan awaits NASA decisions regarding a long term plan for the DSN which is to be reported to the U.S. Congress in early 2007.

### Expanded Very Large Array (EVLA)

A total of nine antennas are in various stages of retrofit to the EVLA design. Six antennas are used routinely for astronomical observations, one is undergoing tests, another is being outfitted with electronics, and the mechanical outfitting of another has begun. Cryogenic cooling problems with the 1–2 GHz orthomode transducer (OMT) have been resolved, and the OMT has been installed on an EVLA antenna for on-the-sky testing. Two prototype 4–8 GHz OMTs have been fabricated and are being tested in the laboratory. The mechanical design of the 26.5–40 GHz receiver was completed, and the prototype of

this receiver should be complete in the summer of 2007. A prototype 3-bit, 4 Gbps digitizer was fabricated, and laboratory tests of the device show that it will meet project specifications. The problem with dropouts in fringe amplitude caused by the frequency synthesizer has been resolved. Delivery problems with the WIDAR correlator baseline boards have also been resolved. The boards are being tested at the DRAO in Penticton, British Columbia. A new VLA correlator controller, which allows the EVLA monitor and control transition system to control the VLA correlator, was installed. The NRAO scientific staff conducted internal tests of the Observation Preparation Tool and the CASA data analysis software. Hardware was purchased to support the ESO/ALMA Next Generation Archive System to evaluate how this data archive storage and access system might be used with the EVLA.

### Long Wavelength Array (LWA)

The Long Wavelength Demonstrator Array (LWDA) was completed in October of 2006, and took its first light images of the sky at 74 MHz. A sample image is shown below, and time-lapse movies of the sky can be found at <http://lwa.unm.edu/>. These images have been made from short integrations and no sidelobes have been removed by deconvolution. A FITS converter for the LWDA is currently being written to allow more sophisticated processing. At the same time, tests of the broader-band “big blade” antenna have been carried out, including using it to conduct RFI monitoring of the LWDA site. Daily waterfall plots of frequency and time since October can be found on the LWA web pages. In general these plots reveal a clean, Galactic background-limited sky during much of the time and over most of the spectrum below the FM band. RFI testing on other potential LWA sites has begun and the preliminary results look encouraging.

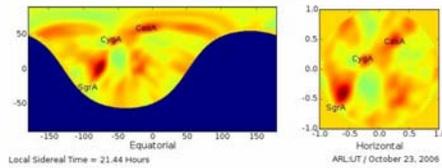


Figure 3. First light images at 74 MHz from the LWDA.

### Mileura Wide-field Array-Low Frequency Demonstrator (MWA-LFD)

All major funding components for the MWA-LFD are now in place, both in the US and Australia. The project has made strong technical progress in the last few months, as reported during project meetings in Sydney and Melbourne in September and December, respectively. The antenna system design is moving forward rapidly, and the first production tile is scheduled for delivery to Perth, Australia in early March. Work is progressing on the correlator system, including development and testing of FPGA firmware. Work on the digital receiver systems is now accelerating in response to the receipt of funding in Australia. The online software system, which includes real-time calibration, has seen major design progress

supported by an in-depth mathematical analysis effort, and the development and testing of calibration algorithms. The project is preparing for a formal technical review in March.

Efforts are currently focused on deploying a 32-tile testbed system during the second half of 2007. This testbed system will be ~ 300 meters in diameter, and will use early versions of the major digital subsystems to generate datasets suitable for a wide variety of diagnostic and system verification tests. The 32-tile array will also offer limited opportunities for scientifically interesting studies of certain objects, including the Sun. The testbed system will remain operational until completion of the full array, currently targeted for late 2008.

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