



# SKA Africa eNews

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## Innovative new design for SA's MeerKAT

Following an extensive engineering design process, the baseline design concept for the South African MeerKAT precursor telescope has been decided. This design process consisted of an in-depth design study that investigated implementation options and tradeoffs for all key subsystems, and culminated in a Concept Design Review (CoDR) undertaken by an independent panel of international experts. The recommendations of the CoDR panel have informed the baseline concept, and the most visible design decision is that the MeerKAT will consist of 64 Gregorian offset dishes, each with an effective diameter of 13.5 metres.

An offset dish configuration has been chosen because its unblocked aperture provides uncompromised optical performance and sensitivity, excellent imaging quality, and good rejection of unwanted radio frequency interference (RFI) from satellites and terrestrial transmitters. The offset optical configuration also facilitates the installation of multiple receiver systems in the primary and secondary focal areas, and is the reference design for the mid-band SKA concept.

"This is the most innovative option of the design solutions that we considered, but it will allow the MeerKAT to operate at a sensitivity of over 220 m<sup>2</sup>/K" explains Anita Loots, Associate Director of the SKA South Africa Project.

With all seven dishes of the MeerKAT precursor array (known as KAT-7) now in place, the construction of MeerKAT itself is the next big step for the SKA Africa team. "We will start by building a qualification (prototype) dish of the new design, on site in the Karoo," Loots adds. This first dish will be located near the KAT-7 array, which will allow extensive testing of the performance of the new design against the existing array. This work will inform the international SKA Dish Verification Programme (DVP), an important component of the PrepSKA study and the international SKA pre-construction phase.

"The completed KAT-7 array is an important engineering test-bed for technologies and systems for MeerKAT, but it will also be used to do science. We have already received several requests from radio astronomers around the globe who ... *page 2*

"The overall impression of the state of the project was very positive and the review panel noted that in several instances, the technical development for KAT-7 produced unique new technical knowledge." Report of the International panel for the MeerKAT Concept Design Review, 5 - 8 July 2010

## MeerKAT milestones

### 20 July 2009

First antenna for KAT-7, an engineering test bed for the Karoo Array Telescope (MeerKAT), installed on site in the Karoo.

### 3 December 2009

Interference fringes seen between two of the dishes which have been constructed on the MeerKAT site.

### 10 February 2010

All seven KAT-7 dishes in place, but not yet fully operational.

### 15 March 2010

Twenty-one proposals for MeerKAT science received in response to a request for proposals to the scientific community.

### 30 March 2010

South Africa's Minister for Science and Technology and the Premier of the Northern Cape visit KAT-7 in the Karoo. Seven dishes installed, with four dishes operational.

### 10 May 2010

Four KAT-7 antennas linked together as an integrated system to produce the MeerKAT's first interferometric image of an astronomical object.

### 5 - 8 July 2010

MeerKAT Concept Design Review Panel meets in Cape Town to review the options presented by the technical team in order to define MeerKAT. The outcome of this meeting was very positive, with the panel validating recommendations from the team.

### 14 September 2010

Conclusion of a month-long radio frequency interference testing campaign at South Africa's proposed Karoo site.

### 20-22 September 2010

MeerKAT Time Allocation Committee meeting to rank the large survey proposals.

### 20 October 2010

First "cold" receiver (i.e. receiver with low noise amplifier and ortho-mode transducer that are cryogenically cooled) scheduled to be installed in the Karoo on one of the KAT-7 dishes.

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want to use it as a science instrument." explains Professor Justin Jonas, SKA South Africa's Associate Director for Science and Engineering. The commissioning of KAT-7 is led by Dr Debra Shepherd, currently on secondment to SKA South Africa from the National Radio Astronomy Observatory in the USA. It is expected that KAT-7 will be ready to do science early in 2011, while MeerKAT should be operational by 2015.

The MeerKAT sub-systems employ a number of novel technologies which are in the mainstream of SKA development. The MeerKAT design process will provide important deliverables for the SKA project, as expected from the precursor instruments. In addition to the pioneering use of composite materials for the dish reflector surfaces and structural components (KAT-7 is the world's first radio telescope with dishes made of fibre glass), design challenges include the development of very wide band waveguide feeds and receivers, low-cost cryogenic systems for cooling the receivers, direct digital sampling systems, high speed digital signal processing systems, algorithms for astronomy data processing, high performance computing platforms that match the algorithms, and very fast data transport networks.

### Looking forward to MeerKAT science

Towards the end of 2009, the SKA South Africa Project invited the international astronomy community to submit proposals for science with MeerKAT. Twenty-one proposals for large science projects were submitted by multi-national teams, including about 500 international astronomers and 58 based in Africa. The proposals cover large and deep surveys of neutral hydrogen, the continuum sky, pulsars and molecular lines. An announcement on the prioritisation of these proposals has been made by a Time Allocation Committee (TAC) comprised of South African and international astronomers (see [www.ska.ac.za](http://www.ska.ac.za)). All of the proposals are linked to SKA science topics, and the science goals include pulsar timing and tests of general relativity, the evolution of galaxies and the nature of cosmic magnetic fields.

## New measurements of radio frequency interference at the proposed South African and Australian SKA sites

The radio quietness of a proposed site for a radio telescope - in other words, the absence of interfering radio signals from mobile phones, televisions, radios and other electrical devices - will be one of the key considerations in selecting whether the core array of the Square Kilometre Array (SKA) will be built in South Africa or Australia. The ability of the SKA to study very weak radio signals that come from the early universe is impacted by the presence of radio interference.

For this reason, the international SKA Project Development Office commissioned a new series of ultra-sensitive RFI (radio frequency interference) measurements at the two sites from mid-August to mid-September 2010. Two sets of equipment were developed in the months leading up to the measurement campaign to ensure that the RFI data collected were comparable and that the measurements could be undertaken simultaneously at the proposed South African and Australian SKA core sites. An external advisory committee will review the data and make recommendations to the SKA Science and Engineering Committee and a committee of governments and international science-funding agencies.

"The equipment was developed jointly by the South African and Australian teams, and is a significant improvement in sensitivity and performance on the equipment we used for the initial RFI measurements five years ago," explains Dr Adrian Tiplady, who is leading the SKA RFI project in Africa.

Besides the levels of RFI, the cost of building and operating the telescope will play a key role in site selection. Construction costs are expected to be considerably lower in South Africa than in Australia.

In South Africa, the proposed core site for the SKA is in the Northern Cape Province, near the towns of Carnarvon and Williston. The alternative site is in Western Australia, north-east of the town of Geraldton. The final site decision is expected early in 2012.

# Africa unites behind continent's SKA bid

*By Kim de Boer, Manager: SKA African Human Capacity Development Programme*

The African SKA Working Group held its 5th meeting in Accra, Ghana from 1-2 September 2010. Although representatives from the nine African countries have been collaborating since 2004, the Working Group was officially established in April 2008. Since then the Working Group has met approximately every six months. The purpose of the African SKA Working Group is to facilitate action on issues relevant to Africa's bid for the SKA, including site characterisation and readiness and the development of radio astronomy in Africa and science and engineering capacity development at local universities.

The Accra meeting was opened by the Ghanaian Minister responsible for Environment, Science and Technology and was attended by more than 30 representatives from the nine countries participating in the African SKA bid. The delegates included Permanent Secretaries, representatives from science and technology government agencies, telecommunications and regulatory engineers and physics and engineering university academics. Most of the delegates have been part of the African SKA bid since before the establishment of the Working Group and the level of consistency continues to contribute to the success of the work taking place for the SKA in Africa.

All participating countries brought a strong message of continued support for the African SKA bid and recognition of the benefits that the SKA could bring (and is already providing) to Africa, especially in the development of very high level skills and expertise in science and technology (very fast grid computing, very fast data transport, data storage, wireless engineering, digital electronics, and image processing and software development, etc.).

This message of support was reinforced by the recent endorsement by the African Union (AU) at its 15th ordinary session of the assembly of Heads of State and Government that ended on 27 July 2010. The AU recognised the importance of the science, technology and innovation emanating from the SKA project and that the SKA will drive human capital development programmes on the continent.

The Working Group meeting focused on three main issues, namely site readiness, the Africa Array and the new human capacity initiatives for Africa. The Working Group members reported on the characterisation of the sites in their countries proposed for SKA remote stations. The reports included information on nearby infrastructure, radio interference and land availability. The delegates were notified about the RFI measurement campaign and although the sites where these measurements will take place are still to be communicated by the International SKA Project Office, countries are putting in place measures to ensure the smooth running of these measurements.

The concept of an African Array was discussed in great detail and with a lot of enthusiasm from the delegates. The concept proposes the establishment of an array of radio telescopes throughout Africa as an extension of the existing VLBI network. Africa is very well positioned to participate in VLBI measurements because it is on the same time line as Europe. The proposal is to utilise existing dishes previously utilised for telecommunication, which are no longer in commission. One country has already identified three 30 metre dishes and is in the process of acquiring them for use in the African Array. At the same time, Dr Mike Gaylard (Acting Director of the Hartebeesthoek Radio Astronomy Observatory) has identified other de-commissioned dishes in many other African countries that can be used as VLBI dishes.

The SKA continues to boost human capacity development in the SKA African countries. At the meeting it was reported that since 2009 the universities in Mozambique, Botswana and Kenya have started undergraduate programmes and courses in astronomy and astrophysics and the Namibian Polytechnic now offers degrees in Geo-information Technology and Geomatics (surveying). The University of Mauritius has been teaching undergraduate courses in astronomy for a number of years and plans on extending its existing post-graduate programme in the future. A total of 114 undergraduate students have participated in the courses mentioned above in 2010 and this number is expected to increase to approximately 134 in 2011.

This is in addition to the 39 postgraduate students and postdoctoral fellows supported through the South African SKA Project's bursary programme. The meeting was told that Oxford University is keen to participate in some of the teaching. To enhance the human capacity development initiatives in Africa, the South African SKA Project announced the initiation of the African Technician Training Programme and the African SKA Postgraduate Bursary Programme. The South African SKA Project will support students from Africa to study and train as electronic and mechanical engineering technicians to ensure sufficient capacity for the maintenance of the telescope systems at the remote SKA stations in Africa. The programme will start in 2011.

The South African SKA Project has also increased the number of bursaries available to PhD and MSc students wishing to pursue research in areas relevant to the SKA and MeerKAT.

It was agreed at the meeting that the South African SKA Project will coordinate an Astronomy Education in Africa and Human Capital Development conference to take place in South Africa early in 2011. The aim of the workshop is to:

- Understand why developing astronomy at universities is important
- Outline the opportunities for astronomy education in Africa
- Create a broader community around astronomy in Africa by linking universities in Africa with each other and with universities from the rest of the world - encourage bilateral and multilateral cooperation
- Investigate practical collaboration between universities in terms of
  - Co-supervision of postgraduate students
  - Academic sabbaticals
  - Postdoctoral fellowship exchange programmes
  - Exchange of course material
- Outline funding opportunities for students in partner countries



# IAU Astronomy Development Office will be in South Africa

The international astronomy community has decided to base its new 10-year programme to promote astronomy in the developing world in South Africa. The new International Astronomical Union (IAU) Office for Astronomy Development will be at the South African Astronomical Observatory (SAAO) in Cape Town. This positions South Africa as a leader in an ambitious global strategy to bring astronomy to developing countries across the world.

Following the selection of South Africa from 20 other proposals from around the world, an agreement was signed between the IAU and South Africa's National Research Foundation (NRF) on 10 July 2010.

"I am particularly pleased that our Executive Committee chose South Africa and the SAAO," said Professor George Miley, IAU Vice President for Development and Education. "South Africa is a role model for us because it combines world-class astronomical research facilities with a pioneering programme of astronomical outreach."

Dr Ian Corbett, General Secretary of the IAU noted that: "This is the start of something

really new and challenging, but also something which should have profound, far-reaching long term consequences for us all and not just for developing countries. It is wonderful that South Africa has joined with the IAU in this endeavour, and has demonstrated the determination and commitment necessary to make this a success."

The SKA Africa Project will work closely with this new office to use astronomy as a unique and inspirational gateway to build science, engineering and technology capacity in Africa. Kevin Govender of the SAAO, who was instrumental in preparing South Africa's proposal for hosting the IAU Office for Astronomy Development, emphasised that this office would not serve Africa only, but rather all developing regions of the world, but added that "its new home brings prestige to the whole African continent and puts Africa in the driving seat of developing astronomy".

The Office for Astronomy Development will set out to build on the momentum of the IAU-UNESCO International Year of



*Shaking hands on the new IAU Astronomy Development Office: Dr Albert van Jaarsveld, President of NRF and IAU General Secretary Ian Corbett. [Photo credit: IAU]*

of people in 148 countries. Although the focus will be on developing regions, the involvement and participation of all countries around the world will be essential, both to build the field of astronomy and to realise the significant role that astronomy can play in development.

Support for the Office comes from the IAU and the South African Department of Science and Technology.

## Developing skills for the future



*By Kim de Boer, Manager: SKA African Human Capacity Building Programme*

The SKA Africa Project has energised the development of high level skills in radio astronomy and related engineering disciplines in Southern Africa. The number of professionals working in radio astronomy increased from 12 in 2003 to 54 in 2010.

There are now also about seventy engineers, scientists and technicians in the Project's office working on the development and construction of the MeerKAT telescope.

### Targeted human capacity development

Since its inception in 2005, the South African SKA Project's human capacity development programme (HCDP) has spent nearly R42 million on capacity development in radio astronomy and the disciplines of engineering relevant to radio astronomy.

Support has been provided to 216 university lecturers and professors, postdoctoral fellows, postgraduate and undergraduate students, interns and engineering technician students and students from schools in the towns close to the South African SKA site. This includes 38 PhDs, 63 MScs and 15 postdoctoral fellowships. Grants have been made to 72 women and 39 students from other African countries. In addition, six research chairs have been established at South African universities.

From 2011 to 2014 the investment in capacity development will increase to about R50 million a year (an additional R200 million investment) and R35 million a year from 2015 to 2025 (a further boost of R350 million). This is because from next year the Project's HCDP will be introducing six new capacity development and research programmes:

1. The Research Chairs Programme;
2. The Research Groups Programme;
3. A BTech Bursary Programme;
4. The Summer/Winter Schools in Radio Astronomy Skills Development Programme;
5. The African Postgraduate Bursary Programme; and
6. The African Technician Training Programme

# Global partnerships to meet SKA demands

By Jasper Horrell and Francois Kapp, SKA South Africa Project Office, Cape Town

The SKA South Africa Project works closely with leading science and engineering teams around the globe. These collaborations make it possible to push the boundaries of science and technology towards fulfilling the scientific, engineering and technical requirements of the SKA. Some of the ongoing collaborations are:

- An agreement with ASTRON (Netherlands Institute for Radio Astronomy) involving technical collaboration in the areas of:
  - simulation and data reduction for commissioning, using the MeqTrees package;
  - investigation of optimal data formats and storage architectures for the processing of large interferometric datasets; and
  - investigation of the possible re-use and joint development or extension of observatory tools.
- An addition to the existing agreement with the National Radio Astronomy Observatory (NRAO) in the USA to provide for collaboration in the areas of:
  - radio astronomy calibration and imaging, focused on the scalability and performance speed-ups for the CASA software package;
  - development of auto-flagging hardware (GPU-based) and software for the removal of corrupted data from the live data streams; and
  - further development of CASA-based simulation tools for MeerKAT and EVLA/ALMA.
- Participation in CASPER (Centre for Radio Astronomy Signal Processing and Electronics Research) - a large collaborative project with groups from the USA, UK, France, Germany, Italy, India, Australia, Spain, Canada and more. CASPER's primary goal is to streamline and simplify the design flow of radio astronomy instrumentation by promoting design re-use through the development of platform-independent, open-source hardware and

software, including the design of ROACH Reconfigurable Open Architecture Computing Hard Ware). South Africa plays a major role in this collaboration for astronomy signal processing and electronics research, creating radio astronomy hardware and software tools.

- Collaboration with the National Centre for Radio Astrophysics, TIFRA, India and scientists at the Giant Metrewave Radio Telescope (GMRT) to focus on the development of next-generation radio astronomy tools.
- Collaboration with the Istituto di Radioastronomia (INAF) in Italy on developing digital back-end technologies.
- Collaboration on the PAPER (Precision Array to Probe Epoch of Re-ionization) experiment, which involves an agreement with the University of California at Berkeley, the University of Pennsylvania and the NRAO. The main science objective is to image the formation of the first stars about 13 billion years ago by imaging the re-ionization of hydrogen. The Southern Hemisphere PAPER array is situated next to the MeerKAT site in the Karoo.
- Collaboration on the C-BASS (C-Band All Sky Survey) experiment with the University of Manchester, Oxford University and the California Institute of Technology, to observe the Galactic Plane at a wavelength of 5cm in order to accurately measure the polarised foreground emission, mainly from the Milky Way. This will allow the accurate subtraction of the foreground emission from the emission of the Cosmic Microwave Background, to allow the detection of polarisation irregularities in the CMB.
- Agreements with the Universities of Cambridge and Oxford to focus on the requirements document for MeerKAT, the overall MeerKAT project plan and its possible upgrades and MeerKAT technology developments.

## Northern Cape communities gear up to support Africa's SKA bid

The SKA South Africa Project has established stakeholder forums in the towns of Carnarvon and Williston, and is in the process of setting up a similar forum in Van Wyksvlei. These small Karoo towns are located in the region of the proposed site for the core of the SKA. The forums will keep these communities up to date on Africa's bid to host the SKA, as well as the building of the MeerKAT radio telescope in the same area.

"The forum provides an opportunity to support the SKA Africa, but also to look after the interests of our community and make sure we can make the most of the future potential of this exciting project," says Willem Symington, Chair of the Williston forum. "We are satisfied that our community is well represented and look forward to being part of these exciting developments near our town."

The forums will address issues such as alternative communication options in the radio astronomy reserve, development of human capital and business opportunities. "We want local communities to benefit optimally from opportunities created by the construction of KAT-7, the MeerKAT and, hopefully, the SKA itself," says Pieter Snyman, manager of SKA Africa stakeholder relations. "We are planning a series of community workshops to ensure a full understanding of Africa's bid to host the SKA and key role that these communities can play in a successful African bid." On 28 September 2010 and 1 October 2010 forum members will visit the KAT-7 site, 91 km from Carnarvon. Their visit will include stops at Klerefontein, Losberg Farm, the dish assembly shed and the KAT-7 array.

## Joining forces with the Northern Cape farming community

Agri Noord-Kaap, a civil organisation looking after the interests of commercial farmers in the Northern Cape Province, is a key partner for SKA Africa. "The farming community in the Northern Cape is united behind the SKA Africa project, because we want the SKA here," says Agri Northern Cape President Wessel van der Merwe. "At our regular meetings in Kimberley, we are 100% solution-driven, because we are convinced that it will be a win-win outcome for farmers, the province, the country and the continent if the SKA comes to Africa."

