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South Africa ramps up SKA preparatory work as 'friendly' competition with Australia intensifies

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The €1,5-billion Square Kilometre Array (SKA) international radio telescope project has now started its 'Preparatory Phase,' known as PrepSKA, for short. And South Africa's own, but SKA-related, R900-million MeerKAT radio telescope array project will enter the second of its three phases this year.

Two countries have been shortlisted to host the SKA, which will be 50 times more sensitive than any existing radio telescope – South Africa and Australia. South Africa is offering a site in the Karoo, in the Northern Cape province. It is now expected that the decision on which country will host the SKA will be taken in 2011, instead of during this year, as originally intended.

Prepping the Project

PrepSKA is a €22-million programme, of which €5,5-million will come from the European Union's seventh research Framework Programme, with the rest being provided by the participating countries. Initially, these number 12 – Australia, Canada, France, Germany, Italy, the Netherlands, Portugal, Spain, South Africa, Sweden, the UK and the US.

No fewer than 24 institutions from across these countries are currently involved in PrepSKA, which is being coordinated by Britain's Science and Technology Facilities Council (STFC), which is one of that country's seven national research councils, roughly equivalent to South Africa's science councils. PrepSKA was initiated last month and will run until 2011, and it is hoped that actual construction of the SKA will start in 2013.

"The Square Kilometre Array has the potential to be one of the most exciting global endeavours in science, changing the way radio astronomy is done," highlighted STFC Science Programmes director Professor John Womersley, speaking at the launch of PrepSKA in Australia last month. "PrepSKA is an extremely important programme of work to pave the way for construction of the SKA," stated Professor Phil Diamond of Manchester University's Jodrell Bank Centre for Astrophysics at the same event.

Diamond has been appointed by the STFC to lead PrepSKA. "The SKA will take us on an incredible journey of scientific discovery – PrepSKA is the final planning phase, checking our route and making sure that everyone has a passport." "The PrepSKA project is a vital preparation stage that will allow the interested partners to bring together their different approaches and priorities and lay the goundwork for a world-class programme," added Wormsley.

And South Africa is at the centre of the process, its passport stamped, and vigorously developing its approach to the project. "We're part of the preparatory study for what the SKA will look like," stresses SKA South Africa project director Dr Bernie Fanaroff. "We're playing quite an important role in preparing the study for what the SKA will be – the engineering study, the costing study, and the technology development."

South Africa is in the SKA programme as part of the country's national development strategy. "There is an effort by the Department of Science and Technology (DST) to move the country from a resource-based economy to a knowledge-based economy," explains DST radio astronomy advances GM Dr Tshepo Seekoe.

The SKA will require massive bandwidth for data transmission and huge computing power for data analysis, and so will require the most advanced information and communciations technologies (ICT). "The SKA project is part of the collective of South African ICT initiatives that will contribute to the develop-ment of a knowledge-based economy." (Related projects include the Centre for High Performance Computing, in Cape Town, and the DST's effort to create the broadband National Research Network Internet.)

MeerKAT

"We're building one of the SKA pathfinders," emphasises Fanaroff. "This is very important because, first of all, it will be a world-class radio telescope for us, and secondly, it will be developing some of the cutting-edge technologies for the SKA in the long term. And there are some of these technologies that we hope South African com-panies will be able to play a leading role in, so that, wherever the SKA is built, South African companies will be able to be successful in tender- ing for large parts of the work."

The name MeerKAT derives from an earlier title, Karoo Array Telescope (KAT). As the original KAT concept was expanded, the Afrikaans word meer, meaning more, was added as a prefix, creating a name that referred both to the enlarged nature of the project – 'more KAT' – and to the lovable African mammal known for its alertness and sharp senses.

Australia is building a second pathfinder, prosaically designated the Australian SKA Pathfinder. A third pathfinder is the Allen Telescope Array, in the US.

"The development phases of the MeerKAT telescope are going very well," reports engineer and MeerKAT project leader Anita Loots. "We are deploying the telescope through a series of prototypes, and this is currently going very well. We've built the first full system at the Hartebeeshoek Radio Astronomy Observatory (HartRAO), west of Pretoria."

The MeerKAT will comprise an array of 12-m-diameter dish-shaped antennas, and a key element of the project is the reduction of the cost of building these antennas.

Hitherto, all radio telescope dishes were made from metal, for very good reasons, but the cost of constructing the dishes has accounted for some 40% of the budget of any radio telescope project. The SKA will not be viable unless that can be significantly reduced.

So, in a highly innovatory step, South Africa decided to embark on a research and development programme to develop a dish constructed from composite materials. The first such dish, designed and manufactured in South Africa, was erected at HartRAO last year, and all the necessary systems to turn it into an operational radio telescope have since been integrated into it.

"This first full system was deployed on time, despite a very tight timeframe," she spotlights. "Currently, engineering tests are going on, and these will be continuing until September." Thereafter, the prototype dish will be able to be used for training, for technology development and demonstration, and for radio astronomy, and, in particular, interferometry in conjunction with HartRAO's long-established 26-m dish.

In addition, the project is being supported by an array of seven small dishes located at the South African Astronomical Observatory, in Cape Town. This array is helping in the development of control and processing systems and software for the future arrays.

Phase two of MeerKAT will see the establishment of an array of seven of the 12-m composite dishes in the Karoo, some 100 km west-north-west of the small town of Carnarvon. The acquisition of 14 000 ha of land to create the MeerKAT/SKA estate has been finalised, and the necessary civils works to support MeerKAT – including the construction of facilities, the upgrading of roads, the provision of power cables (which have to be underground to avoid interference with the highly sensitive instruments which will be built there) and of an optical fibre to transport data – are under way and progressing well.

This work is being executed in conjunction with the Northern Cape government. Erection of the first of the seven-dish initial MeerKAT array will start in October, and all seven should be in place by the end of next year.

The third and final phase of MeerKAT is scheduled to start in 2010 and will see the instrument expand to its full size of 80 dishes. "The MeerKAT system consists of the antenna system – the dishes themselves, plus the feed systems and the receiver systems that go with them, cryogenically cooled – that feeds the data through to the correlator, which does the initial array processing, and then it goes to the post-processing facility," explains Loots.

In parallel with the development of the technology, the country is developing its human capital. "We have a very strong human capital programme, which we launched in 2005," affirms Fanaroff. "It includes a schools programme, undergraduate and postgraduate bursaries, post-doctoral fellowships, and international exchanges."

To date, 69 undergraduate and postgraduate bursaries, and seven postdoctoral fellowships have been awarded, the total of 76 being divided into 56 men and 20 women. "We have a significant number of students now doing PhD and MSc studies in physics and engineering related to the SKA and to the MeerKAT."

Should South Africa win the friendly competi-tion – the South Africans and Australians are cooperating on many aspects of the SKA programme – to host the SKA, then the idea is that the MeerKAT would form a core around which the SKA would be built.

Both the MeerKAT and the SKA, should it be sited in this country (and, indeed, the optical telescope complex at Sutherland, also in the Karoo) will be protected from radio interference (in the case of Sutherland, light polllution) by the Astronomy Geographic Advantage legislation, which has been approved by Parliament and should be enacted soon.

SKA, South Africa and Africa

The latest design concept for the SKA gives the instrument a central 'aperture array' composed of planar antennas which can be 'electronically steered' to look at any part of the sky, or act as the radiowave equivalent of a fish-eye lens, taking in the whole sky all at once, depending on the requirements of the astronomers. This central array will be surrounded by 'stations', each with ten dishes.

These stations will be arranged in a spiral pattern, the arms radiating out from the core. Although most of these stations will be close to the core, the spiral arms will extend over great distances, with the most remote stations lying some 3 000 km from the core. In all, there will be between 3 000 and 4 000 dishes, in up to 200 stations, giving a total collecting area of a square kilometre.
The plan is – assuming the funding is secured – to build the SKA in a phased manner over a period of seven years.

While Australia could accommodate the complete system within its own territory, South Africa cannot. This country has thus been in talks with other African countries about the possibility of their hosting remote SKA stations. South Africa's current intention is to place remote stations in Namibia, Botswana, Mozambique, and Mauritius, and probably in Madagascar, Kenya, and Ghana. Last month, saw the third meeting between South African and African representatives on the issue. The countries attending were Namibia, Botswana, Mozambique, Mauritius, Madagascar, Kenya, Zambia and Ghana.

"There was general agreement from all of our colleagues that they support the South African bid, that we will work on an African strategy for the bid, that they will help us in selecting sites in their countries, and then protect those sites against radio frequency interference," recounts Fanaroff.

"They're particularly enthusiastic about the human capital development programme, because all countries in Africa obviously want to get more people who have high-level skills in information technology, in communications, in wireless engineering, in physics." A working group will be established and South Africa will have bilateral relationships with each of these countries to develop the areas in which they can cooperate. Already, 26 bursaries have been awarded to students from other African countries.

"One of the important reasons for building the MeerKAT telescope and doing the human capital development programme is to show that South Africa, and Africa, in general, have the competence and the capacity to do a very high-tech project like this," he asserts. "And people have been very impressed with the progress we've made with the MeerKAT. We've been delivering very fast, we've been delivering good quality, and we're sticking to our deadlines."

South Africa has targeted certain key technologies that it seeks to develop for the SKA and prove on MeerKAT. "We have decided, through the development of technology in South Africa, to focus on novel technologies for the dishes, novel technologies for wide-band feed systems, and also in the digital signal processing domain," states Loots. "There are a number of international collaborations going on. The digital signal processing one is probably the most significant, and we're doing very well there." The main players in this collaboration are the South Africans, the University of California Berkeley, the California Institute of Technology (Caltech), the US National Radio Astronomy Observatory, and the Allen Telescope Array.

It aims to build software and hardware for the next-generation radio science instruments, including India's Giant Metre-Wave Telescope, the Allen Telescope Array, the Combined Array for Research in Millimetre-Wave Astronomy, BEST, MeerKAT, the Very Large Array, and a correlator for the Epoch of Reionisation Experiments. "Each of the teams has a different role," she explains. "The South African team is taking the lead in the design of the boards; the layout and manufacture of the boards are done in the US, and then they get processed through various other partners in the process."

To view the Real Economy Report clip on experts gathering to discuss the SKA bid, click here

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