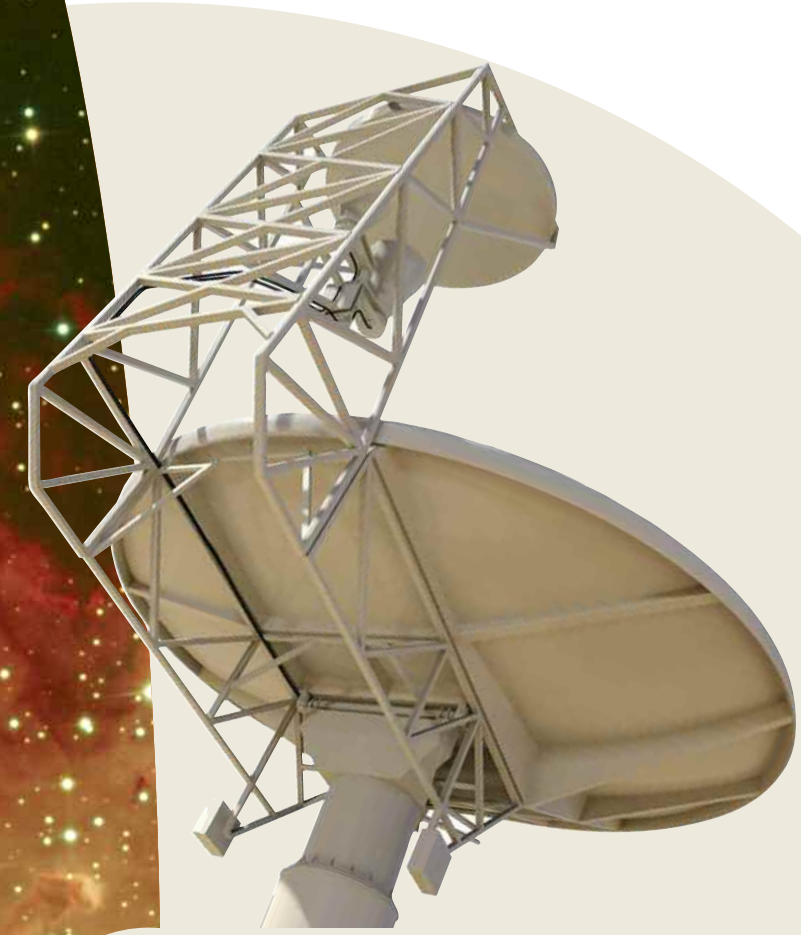


# SOUTH AFRICA'S **MEERKAT ARRAY**

**THE MEERKAT ARRAY,** currently taking shape in South Africa's Karoo region, is a world-class radio telescope designed to do ground-breaking science. It will be the largest and most sensitive radio telescope in the southern hemisphere until the Square Kilometre Array (SKA) is completed around 2024. Via MeerKAT, South Africa is playing a key role in design and technology developments for the SKA.

Close to 100 young scientists and engineers are working on the MeerKAT project. Based at the engineering office in Cape Town, and at universities and technology companies across South Africa and Africa, these researchers interact closely with SKA teams around the world. In collaboration with South African industry and universities, and collaborating with global institutions, the South African team has developed technologies and systems for the MeerKAT telescope, including innovative composite telescope dishes and cutting-edge signal processing hardware and algorithms.

SKA AFRICA
SQUARE KILOMETRE ARRAY

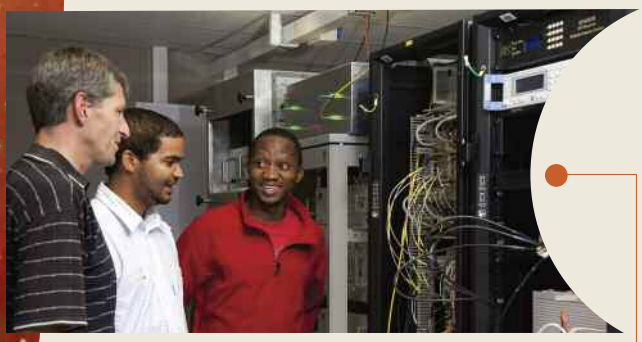
AFRICA

A seven-dish MeerKAT precursor array, KAT-7, is already complete on site in the Karoo region of South Africa's Northern Cape Province. It is the world's first radio telescope array consisting of composite antenna structures.

## TECHNICAL SPECIFICATIONS FOR MEERKAT

MeerKAT will consist of 64 dishes of 13.5 m diameter each with an offset Gregorian configuration. 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 from satellites and terrestrial transmitters. It 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.

MeerKAT supports a wide range of observing modes, including deep continuum, polarisation and spectral line imaging, pulsar timing, and transient searches. A range of standard data products are provided, including an imaging pipeline. A number of "data spigots" are also available to support user-provided instrumentation. Significant design and qualification efforts are planned to ensure high reliability in order to achieve low operational cost and high availability.



Paul Swart, Roufurd Julie and Obert Toruvanda with some of the hardware in the digital back-end laboratory at the Cape Town MeerKAT engineering office.

# MEERKAT: SPECIFICATIONS FOR ARRAY, ANTENNAE AND RECEIVERS

| | |
|---|---|
| Number of antennas | 64 |
| Dish diameter | 13.5 m |
| Minimum baseline | 29 m |
| Maximum baseline | 20 km |
| Frequency bands (receivers) | 0.58 – 1.015 GHz<br>1 – 1.75 GHz<br>8 – 14.5 GHz |
| Continuum imaging dynamic range at 1.4 GHz | 60 dB |
| Line-to-line dynamic range at 1.4 GHz | 40 dB |
| Mosaicing imaging dynamic range at 14 GHz | 27 dB |
| Linear polarisation cross coupling across -3 dB beam | -30 dB |

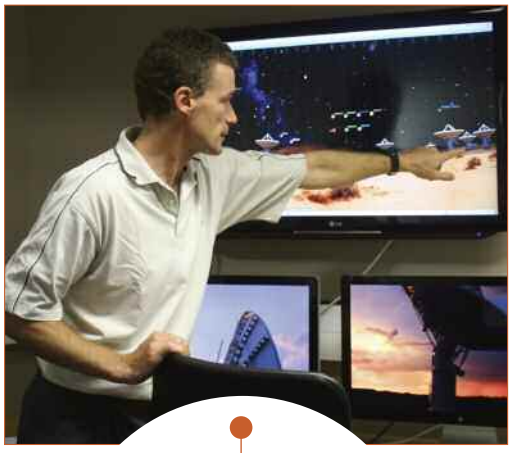
Structural layout of MeerKAT dish (left) and elevation angle where highest gravity-induced feed and sub-reflector displacements are recorded (right).

## CONFIGURATION OF THE MEERKAT ARRAY

MeerKAT's 64 dishes will be distributed over two components:

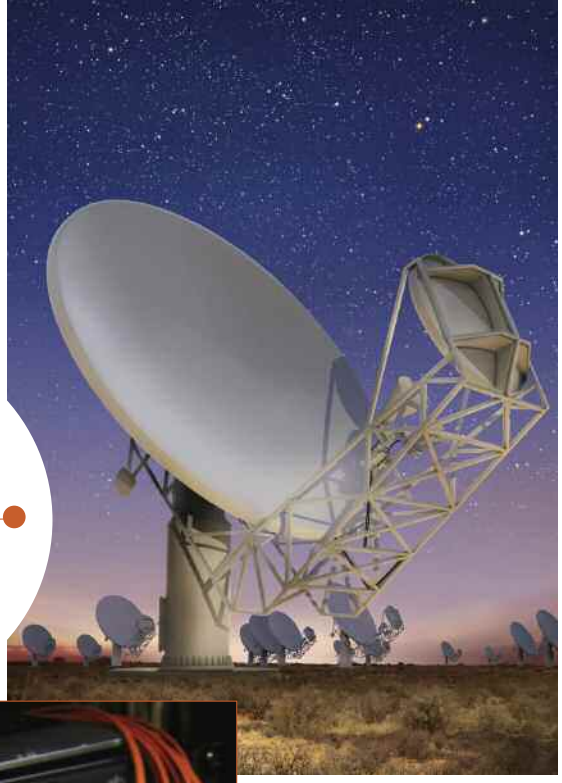
- A dense inner component containing 70% of the dishes. These are distributed in a two-dimensional fashion with a Gaussian uv-distribution with a dispersion of 300 m; a shortest baseline of 29 m and a longest baseline of 1 km.
- An outer component containing 30% of the dishes. These are also distributed resulting in a two-dimensional Gaussian uv-distribution with a dispersion of 2 500 m and a longest baseline of 8 km.

For Phase 2, seven additional antennas will be added to extend the longest baselines to about 20 km.



Jasper Horrell, science processing sub-system manager on the MeerKAT project, with the real-time virtual sky display in the control room at the Cape Town MeerKAT project office.

Anita Loots is the Associate Director for the South African SKA Project.



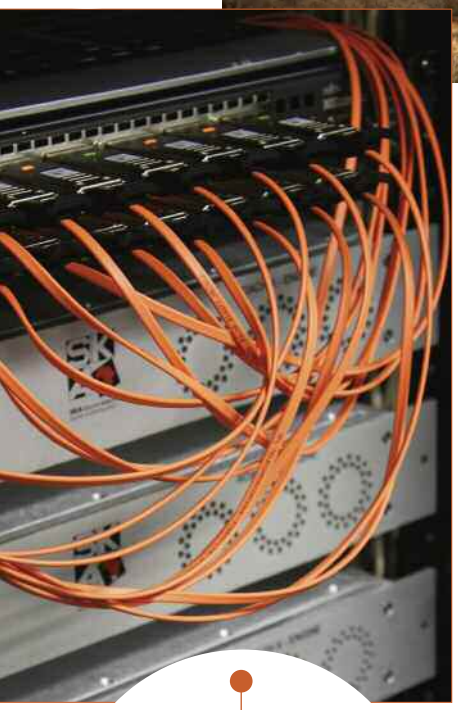
An artist's impression of the new MeerKAT array on site in the Karoo, South Africa.

## MEERKAT CONSTRUCTION PHASES

The KAT-7 precursor array has been constructed and is being used as an engineering and science prototype. MeerKAT itself will be delivered in three phases. The commissioning of MeerKAT will take place in 2014 and 2015, with the array coming online for science operations in 2016. This phase will include all antennas, but only the first receiver will be fitted, and a processing bandwidth of 750 MHz will be available. For the second and third phases, the remaining two receivers will be fitted and the processing bandwidth will be increased to at least 2 GHz, with a goal of 4 GHz.

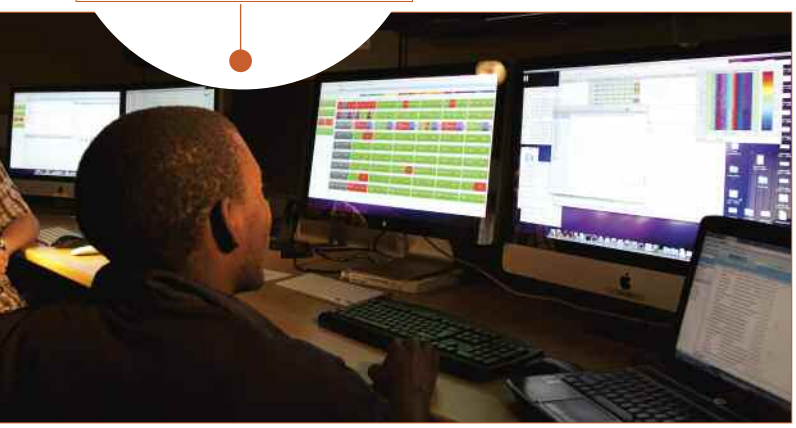
## MEERKAT PHASING SCHEDULE

| | 2011 | 2016 | 2018 |
|---|---|---|---|
| | Precursor (KAT-7) | MeerKAT Phase 1 | MeerKAT Phase 2 & 3 |
| Number of dishes | 7 | 64 | 64 |
| Receiver bands (GHz) | 0.9 - 1.6 | 1.00 – 1.75 | 0.58 – 1.015<br>1.00 – 1.75<br>8 – 14.5 |
| Max processed BW (GHz) | 0.256 | 0.75 | 2 (goal 4) |
| Max baseline (km) | 0.2 | 8 | 20 |
| Min baseline (m) | 20 | 29 | 29 |



A 10 GB switch in the digital back-end lab at the MeerKAT engineering office.

Commissioning scientists (fltr) Nadeem Ozeer, Maik Wolleben and Siphelele Blose in the MeerKAT control room at the Cape Town-based MeerKAT engineering office.



Francois Kapp, digital back-end sub-systems manager on the MeerKAT project, testing the newly-developed reconfigurable open architecture computing hardware board – ROACH-2. The ROACH board is a cutting-edge innovation that enables highly specialised and superfast computing. Designed and produced in South Africa, about 300 of these ROACH boards are already in use at high-tech facilities around the globe. ROACH-2 is much faster and more versatile than its predecessor.

# MEERKAT SCIENCE

Five years of observing time on MeerKAT have been allocated to leading radio astronomers who have applied for time to do research with this unique and world-leading instrument. The science objectives of the MeerKAT surveys are in line with the prime science drivers for the first phase of the SKA telescope itself, confirming MeerKAT's designation as an SKA precursor instrument.

Professor Patrick Woudt, and Professor Rob Fender, UK are co-principal investigators on a MeerKAT science project called ThunderKAT .

| MEERKAT SCIENCE PROJECTS | RESEARCH LEADERS |
|---|---|
| Testing Einstein's theory of gravity and gravitational radiation – Investigating the physics of enigmatic neutron stars through observations of pulsars. | Professor Matthew Bailes, Swinburne Centre for Astrophysics and Supercomputing, Australia |
| LADUMA (Looking at the Distant Universe with the MeerKAT Array) – An ultra-deep survey of neutral hydrogen gas in the early universe. | Dr Sarah Blyth, University of Cape Town in South Africa; Dr Benne Holwerda, European Space Agency, The Netherlands; Dr Andrew Baker, Rutgers University, United States |
| MESMER (MeerKAT Search for Molecules in the Epoch of Re-ionisation) – Searching for CO at high red-shift (z>7) to investigate the role of molecular hydrogen in the early universe. | Dr Ian Heywood, Oxford University, UK |
| MeerKAT Absorption Line Survey for atomic hydrogen and OH lines in absorption against distant continuum sources (OH line ratios may give clues about changes in the fundamental constants in the early universe). | Dr Neeraj Gupta, ASTRON, The Netherlands; Dr Raghunathan Srianand, Inter-University Centre for Astronomy and Astrophysics, India |
| MHONGOOSE (MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters) – Investigations of different types of galaxies; dark matter and the cosmic web. | Professor Erwin de Blok, University of Cape Town, South Africa |
| TRAPUM (Transients and Pulsars with MeerKAT) – Searching for, and investigating new and exotic pulsars. | Dr Benjamin Stappers, Joddrell Bank Centre for Astrophysics, UK; Professor Michael Kramer, Max Planck Institute for Radio Astronomy, Germany |
| A MeerKAT HI Survey of the Fornax Cluster (Galaxy formation and evolution in the cluster environment). | Dr Paolo Serra, ASTRON, The Netherlands |
| MeerGAL (MeerKAT High Frequency Galactic Plane Survey) – Galactic structure and dynamics, distribution of ionised gas, recombination lines, interstellar molecular gas and masers. | Dr Mark Thompson, University of Hertfordshire, UK; Dr Sharmilla Goedhart, South African SKA Project |
| MIGHTEE (MeerKAT International GigaHertz Tiered Extragalactic Exploration Survey) – Deep continuum observations of the earliest radio galaxies | Dr Kurt van der Heyden, University of Cape Town; Matt Jarvis, University of the Western Cape, South Africa and the University of Hertfordshire, UK |
| ThunderKAT (The Hunt for Dynamic and Explosive Radio Transients with MeerKAT) – eg gamma ray bursts, novae and supernovae, plus new types of transient radio sources. | Professor Patrick Woudt, University of Cape Town, South Africa; Professor Rob Fender, University of Southampton, UK |

Dr Sharmilla Goedhart of South Africa is a co-leader on the MeerGAL science project with MeerKAT.

MeerKAT will also participate in global VLBI operations with all major radio astronomy observatories around the world and will add considerably to the sensitivity of the global VLBI network, and enhance the southern VLBI arrays. Further potential science objectives for MeerKAT are to participate in the search for extra-terrestrial intelligence, and collaborate with NASA on downloading information from space probes.

The MeerKAT engineering office in Cape Town, South Africa boasts state-of-the art equipment and laboratories. Ludwig Schwardt, Simon Cross, Simon Ratcliffe, Tshakule Nemalili and Mattieu de Villiers are some of the nearly 100 engineers working on the MeerKAT project.

*Artists impressions. Luma. Design and layout. Loretta Steyn Graphic Design Studio (loretta@icon.co.za)*