The Giant Metrewave Radio Telescope (GMRT) in Pune India.

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Wide angle view of the Universe

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The unimaginably arid, empty, remote Western Australian outback is hardly a place one associates with Indian scientists. Murchison, 700 km north of Perth and traditional home of the Warrari aborigines, is the size of the Netherlands and has about 140 people. This is where Ravi Subramanyam, director of Raman Research Institute (RRI), Bangalore, headed some six years back, to work out India's role in the world's largest radio telescope, the Square Kilometre Array (SKA).

Vast, remote areas such as Murchison offer the perfect backdrop for instruments to study radio waves – very low energy waves with large wavelengths, often upto metres, emitted by stars, galaxies and black holes. They are susceptible to signals from mobile phones, television stations, airplanes, satellites and even vehicles. Large telescopes study big wavelengths, often with dish-shaped antennas with a large collecting area.

When complete, the SKA will be the world's biggest telescope with millions of square metres of collecting area, and 50 times more sensitive than today's best. "It's not one huge dish, it will be thousands of radio antennas spread over hundreds of kilometers and connected by supercomputers," explains Peter Hall, director, engineering at the International Centre for Radio astronomy Research (ICRAR), Perth. The antennas will work together as one giant telescope to study the sky in in radio frequencies ranging from 50 MHz to 14 GHz.

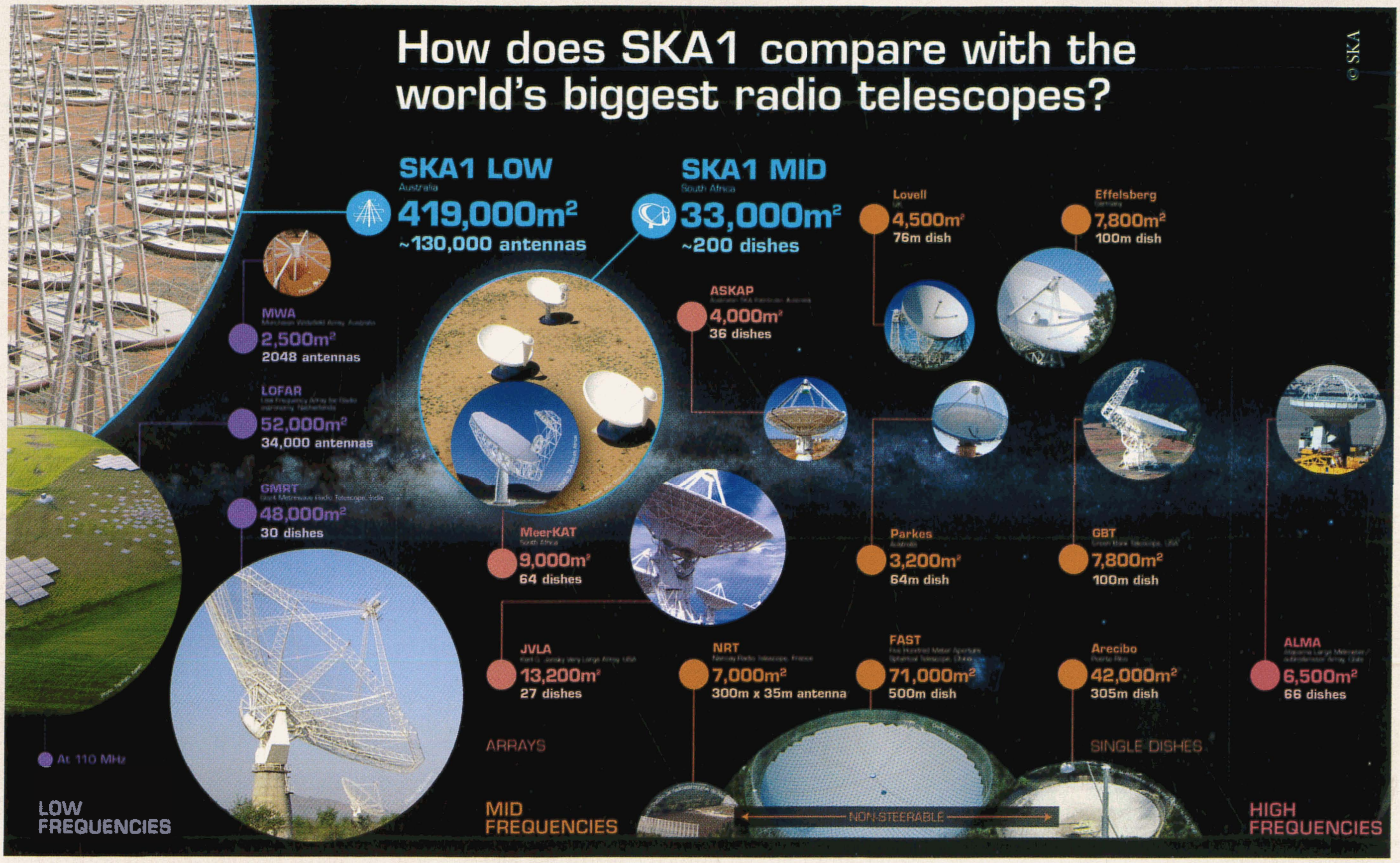
The SKA will be located on two sites on either side of the Indian Ocean – in South Africa's Karoo desert covering mid- and high frequencies with 60-metre-wide receivers; and in Australia's Murchison region, covering low frequencies with five million 1.5 metre-high radio receivers.

"The SKA is modular and one can expand or reduce the number of dishes. It aims to study the 'cosmic dawn' – or image the Universe when the very first stars were beginning to form," says Sarah Pearce, deputy director of CSIRO's Astronomy and Space Science division.

"All the nine design consortia of SKA have submitted their designs. The final design of the SKA will be ready in 18 months," SKA director Phil Diamond told *Nature India*. "We hope to start construction by the end of 2018."

Precursors and pathfinders

As a stepping stone towards the gigantic effort, the SKA project has two 'precursors' – MeerKAT observatory in South Africa



and the Murchison Widefield Array (MRA) observatory. MeerKAT's 64 dishes will eventually be integrated with the first phase of SKA involving 200 dishes in South Africa and covering the 350 MHz to 14 GHz range of the spectrum (SKA1 MID), says Diamond.

SKA's low-frequency precursor, the MWA, built by an international consortium led by ICRAR and comprising research institutions from Australia, India, New Zealand and the US, has been operating for the last three years. The MWA telescope has 2048 antennas, split into 128 groups called tiles. Each tile has 16 spider-like structures (4m X 4m) called dipoles. The majority of the tiles are placed in a core region 1.5 km in diameter, and the rest distributed more widely, as far as 3 km apart. It can look in many different directions at once and survey large parts of the sky quickly to help scientists observe spinning neutron stars called pulsars and fast transient events in which bursts of radio waves appear briefly and without warning.

Its resolution is one arc minute ($1/60^{th}$ of a degree), says MWA director Randall Wayth. The 188-pixel radio cameras can cover 30 square degrees, or the area of 150 full moons. Together, they can scan almost three-quarters of the sky in the southern hemisphere, and see very faint sources of radio waves.

Subramanyam's team at RRI landed in the remote outback for this MWA. RRI helped design and build the MWA's receivers that pick up signals from the antennas, process them using complex high-speed algorithms, and transmit the data via optical fibres to a central processing unit, where the imaging information is computed.

RRI is also engaged with India's Giant Metrewave Radio Telescope (GMRT) near Pune, recognised as a 'pathfinder' telescope – not part of the SKA site but contributing to the SKA's technology. NCRA is working on the design of the 'Telescope Manager' (TM) that will control the humongous amount of data from the various antennae, and convert human instructions into machine instructions to ensure that the telescope points in the exact direction needed, says Yashwant Gupta, scientist at the National Centre for Radio Astronomy (NCRA), Pune and head of the SKA-India Consortium. Indian scientists are also part of the scientific working groups of SKA.

"The telescope manager is, in effect, the 'brain and nervous system' of the SKA observatory, as it receives signals from all systems of the observatory and coordinates and synchronises its operations," says Gupta.

An SKA-India consortium set up in February 2015, comprising astronomy research institutes, astronomy departments of a few universities and industry partners, is currently identifying areas that "Indian astronomers are traditionally good at and areas that India would like to work on in the future," says Gupta. The TM is working on the detailed design expected to be ready by August 2017. Construction is expected to begin by mid-2018.

As a spinoff, India's leading role in the TM is helping the country upgrade the GMRT, operating since the 90s. It has 30 antennas working in five low frequency radio bands (100 to 1500 MHz). "The NCRA will test significant aspects of the SKA Telescope Manager design on its upgraded GMRT," says Gupta.

All these mammoth efforts are in the quest of the 'cosmic dawn' or 'epoch of reionisation' when the first light began to shine, and to help understand what the Universe looked like when stars and galaxies started forming.