SKA SOUTH AFRICA **INDUSTRY PARTNERSHIPS**

Engineers from EMSS Antennas installing a cryogenic receiver on one of the KAT-7 receptors.

THE SKA WILL BE A MASSIVE scientific infrastructure, and its development and construction will require participation by a wide range of industries to achieve its ambitious performance, schedule and cost targets. These industries bring various competencies and capabilities to the project, and range from SMEs to global multinational organisations. The MeerKAT project has had a wide range of interaction with local and international industries, and these interactions provide valuable input into the SKA project (as it should as an SKA precursor). The modes of interaction with industry have been varied, from standard procurement of commodity devices, through "build to spec" contracts for antenna components, to shared risk development of specialist technologies.

SKA AFRICA
SQUARE KILOMETRE ARRAY

AFRICA

Engineers and technicians from industrial partners installing KAT-7 antennas

Local and international industrial partners have participated in all aspects of the project, from the establishment of the infrastructure to service the Karoo radio astronomy reserve to the development of the specialist telescope sub-systems. Our partnerships with industries in the engineering, construction and high-tech sectors developed an industrial base that has expertise in critical areas of radio telescope development and construction.

This is a brief case study of the involvement of a wide range of industries in the SKA SA project.

ESTABLISHING THE RADIO ASTRONOMY RESERVE

One of the most important characteristics of the radio astronomy reserve is that it must be radio-quiet. Although the Karoo site is intrinsically radio-quiet there are residual radio signals that originate from terrestrial transmitters operated by broadcasters and cellular telephone companies. These commercial operators are working closely with the SKA South Africa project office to remove or reduce the levels of the signals they transmit into the reserve, illustrating the interest that many large commercial companies have in the SKA project.

The network planning consultants **LS Telcom (SA)** have been contracted to provide guidance in reconfiguring commercial transmitters in and around the radio reserve, and this information has been used in collaboration with the commercial operators to assist their planning. **Sentech**, the commercial provider of all broadcast transmissions in South Africa, is adapting its FM radio and digital TV band plans and transmitter locations to accommodate the regulations in the Astronomy Geographic Advantage (AGA) Act, Act No. 21 of 2007, legislation protecting the radio reserve. The two cellular telephone companies operating in the area, **Vodacom** and **MTN**, are developing and implementing directional antenna technologies that will ensure that towers surrounding the reserve do not transmit signals into the reserve that contravene the AGA regulations.

A wide range of South African industries was involved in establishing the Karoo radio astronomy observatory. The RFI-shielded containers were supplied by Comtest Engineering b.v. and the cooling systems by TF Design.

INFRASTRUCTURE

The provision of infrastructure consumes a significant fraction of the capital cost of establishing a radio observatory at a remote site. The operational costs of the observatory are also dominated by the recurring costs associated with infrastructure. The expertise of consulting engineers with knowledge of local conditions and global trends is required to design and implement the most suitable and affordable infrastructure elements.

Erection of the poles that provide 22 kV electrical power to the MeerKAT and SKA core site from the Eskom utility grid substation in Carnarvon. This 100 km power line was installed to stringent specifications by OPTIC 1, and will be maintained by Eskom. The poles also carry dark fibre from the site to a SANReN point of presence (POP) in Carnarvon.

BVi Consulting Engineering, a local company with extensive experience in developing large projects in the Northern Cape Province, was contracted to plan and manage the provision of bulk infrastructure for the initial site establishment, KAT-7 prototype array and C-BASS. Subsequently the international consulting company **Aurecon** has been contracted to work with the MeerKAT engineering team to develop infrastructure solutions for the MeerKAT, and assist in planning of the SKA.

Power and data connectivity are two major components of the infrastructure segment of the Karoo observatory. Besides being affordable and reliable, the provision of power to the site must not compromise the radio quietness of the area. In designing the radio-quiet medium voltage power line from the **Eskom** national utility grid substation at Carnarvon to the site, **BVi Consulting Engineering** worked closely with **MESA Solutions Pty (Ltd)**, a company associated with Stellenbosch University that specialises in electromagnetic compatability (EMC) and radio frequency interference (RFI) issues. **MESA Solutions** has developed a deep competency in all aspects of EMC and RFI in the context of radio astronomy. The line was constructed by **OPTIC 1** in conjunction with **Eskom**.

Steel poles replace wooden poles as the power line approaches the MeerKAT and SKA core site. MESA Solutions, working in conjunction with Eskom, specified components for the power line that will not cause radio interference. MESA Solutions have conducted live line tests to verify the efficacy of their recommendations.

KAT-7 yoke and four pedestals during the welding process at BAE Systems Dynamics (SA).

Engineers from BAE Systems installing feed support on a KAT-7 antenna.

Moulding of KAT-7 dishes took place in the on-site dish complex

Heinrich Bauermeister (MMS Technology) and Willem Esterhuyse (MeerKAT Project Manager) inspecting the mould for the KAT-7 antennas prior to production of the seven composite reflectors. MMS is working closely with the MeerKAT project team, BAE and EMSS in defining the MeerKAT antenna optical and mechanical design.

The basic components required for data connectivity are national and international long-haul fibre, local fibre reticulation, and termination equipment. The MeerKAT data network will form part of the **SANReN** national research network, with the main fibre link between Carnarvon and Cape Town being provided by **Broadband Infraco. OPTIC 1** installed the fibre link between Carnarvon and the site, following the power line. Local and international data connectivity solutions for the SKA are being investigated in collaboration with the submarine cable operator **SEACOM** and national dark fibre provider **FibreCo Telecommunications.** Collaborative work is being undertaken with **Nokia Siemens Networks** to develop termination equipment solutions for both the MeerKAT and SKA.

An important consideration in developing infrastructure in a radio-quiet reserve is the ensuring that all equipment that could compromise the radio quietness (e.g. correlator, UPS, computers) has to be contained within structures that shield the environment from the emitted RFI. The consulting engineers have been guided by **MESA Solutions** in the integration of innovative and effective RFI shielding into buildings and other infrastructure components. RFI shielded containers have been procured from the Dutch company **Comtest Engineering b.v.**

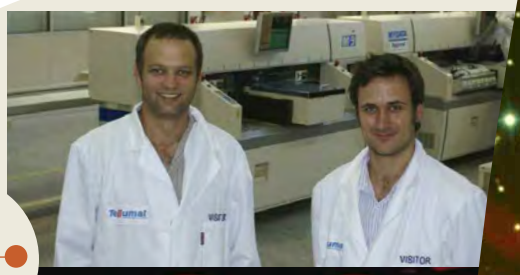
ANTENNA STRUCTURES

The MeerKAT engineering team has produced two antenna prototypes to date, the XDM and KAT-7 antennas, and are working on the design of the MeerKAT antenna (which is an SKA precursor). The optimal design of MeerKAT and SKA antennas involves interplay between mechanical and electromagnetic principles, and requires a close interaction between both mechanical and electromagnetic specialists employing advanced computer modelling systems to predict electromagnetic performance and mechanical stability. The mechanical expertise has been sourced from two companies, **BAE Systems Dynamics (SA)** and **MMS Technology**. The electromagnetic modelling is being done by **EMSS Antennas** using the **FEKO** full-wave electromagnetic code. **BAE Systems Dynamics (SA)** has been the prime contractor for all antenna construction, and **MMS Technology** has undertaken all design and fabrication of the novel composite reflector structures.

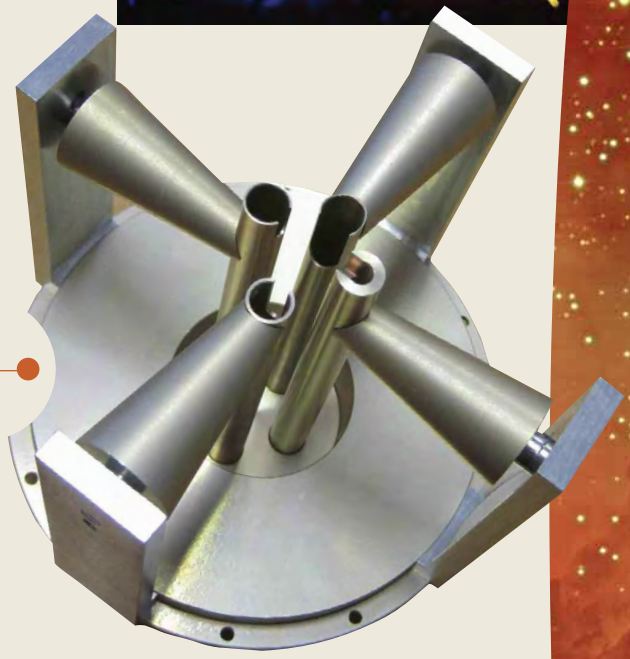
An important role of the prototype antennas is the testing of components and design principles. The **Council for Scientific and Industrial Research (CSIR)** division for Materials Science and Manufacturing has been conducting accelerated environmental tests and investigating mechanical fatigue in key components.

RECEIVERS

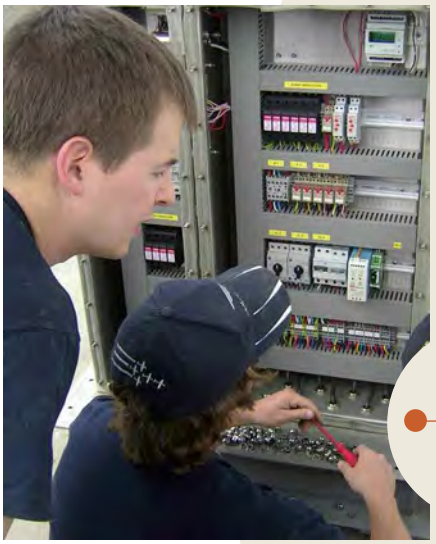
The most important component of a radio telescope is the receptor, which for dish antennas is an integrated system including the reflector and receiver. **EMSS Antennas** has overseen the development and integration of the KAT-7 receivers, and is taking the lead in designing the MeerKAT receivers (which are SKA precursors). **EMSS** has been investigating novel and innovative techniques and technologies for implementing feed horns, ortho-mode transducers and cryogenic systems, and has engaged with **Sunpower** and **Oxford Cryosystems** to provide cryogenic systems that are optimized for radio astronomy receivers. A partnership has been developed with **Miteq** to develop low-noise amplifiers for MeerKAT. Two local companies, **Tellumat (Pty) Ltd** and **ETSE**, have provided specialist radio frequency (RF) design expertise and fabrication facilities.



Francois Kapp (digital back end sub-systems manager at the MeerKAT project) and David George (lead designer of ROACH-2) at Tellumat, the South African company where the boards are assembled.



The MeerKAT compact low-loss ortho-mode transducer (OMT) prototype, developed by EMSS, South Africa. The OMT is a critical component of a radio telescope receiver.



TF Design technicians connecting the control system for the KAT-7 pedestal chiller plant.

SIGNAL PROCESSING AND COMPUTING

Modern radio telescopes may be considered to be "software radios" that rely heavily on digital systems. The high-speed front-end and array processor digital systems are based on the CASPER concept. The CASPER community includes the major commodity electronics companies **XILINX** (suppliers of FPGAs) and **Fujitsu** (suppliers of Ethernet switches). The ROACH-2 processing board, a key component of the CASPER concept, was designed by the MeerKAT engineering team, and **Tellumat (Pty) Ltd** have fabricated this complex board using their automated production line.

The processing of SKA and MeerKAT data will require significant high-performance computing resources, and the most modern computing platforms will be employed. A partnership has been developed with **Intel South Africa Corporation** to evaluate the highest Intel technologies for processing the enormous data rates produced by radio telescopes. Quarterly meetings are held with **IBM South Africa** and the **IBM Watson Research Center** to track the latest applicable computing technologies.

SIA Solutions (Pty) Ltd, a South African company specialising in fibre optic infrastructure, installed 8 km of fibre optic cable at the KAT-7 site.

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