SKA SA PROJECT

ON TRACK, ON SCHEDULE AND WITHIN BUDGET

SCIENCE & TECHNOLOGY PARLIAMENTARY PORTFOLIO COMMITTEE – 31 MAY 2017

PRESENTER: Dr Rob Adam

Background

Currently five broad sets of activities are taking place within the South Africa radio astronomy portfolio:

- Operation of research facilities on behalf of a local and international user community (including in-house researchers);
- Construction and engineering of MeerKAT, AVN and other facilities;
- Planning for SKA Phase 1 and conceptualisation of SKA Phase 2;
- Human Capital Development in:
  - South African university based radio astronomy;
  - Artisan programmes in the Northern Cape; and
  - Primary and secondary schools in the Northern Cape.
- Commercialisation of Radio Astronomy related technologies and expertise.

What is SKA and where does it fit?

- The Square Kilometre Array (SKA) mega-project is an international effort to build the world's largest radio telescope;
- Originally SKA South Africa was administered directly by the DST;
- In 2005 the National Research Foundation was requested by DST to take over the administration of SKA South Africa;
- However, the Minister requested that SKA SA and HartRAO merge to become a single Radio Astronomy Observatory
  - To be declared a national facility;
  - The intent of this consolidation is to enable South Africa to optimally respond to the management and operational responsibilities placed on South Africa for the operations of MeerKAT, the hosting of the SKA telescope, and the operations of other radio astronomy and space geodesy activities.
- This transition to the single entity started on 1 April 2017.

25 May 2012 – Bid Outcome

SKA Org

An International Organisation

- Organisations from ten countries are members of the SKA Organisation – Australia, Canada, China, India, Italy, New Zealand, South Africa, Sweden, the Netherlands and the United Kingdom;
- Portugal is joining as a full member, Germany is to become an associate member (similar to Canada). There are observer members (e.g. France, Spain, Japan, Switzerland) with the potential to join;
- The headquarters of the SKA Organisation is at the Jodrell Bank Observatory near Manchester in the UK;
- Approximately 100 organisations and companies from 20 countries are participating in the design and development of the SKA.

More than 260 delegates from 18 countries attended 25 plenary talks and 85 timetabled meetings at the SKA Org Engineering meeting held in Stellenbosch in October 2016.

SKA Inter-Governmental Organisation (IGO)

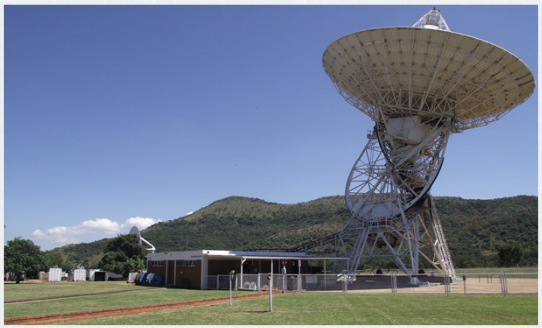
An International Organisation

- Mandate of the SKA Org is to develop the cost and design of the SKA Telescope – members of board agreed that an IGO needs to be established known as the SKA Observatory and South Africa is involved in the establishment of this IGO;
- South Africa will be a founding member in the establishment of the IGO;
- Negotiation of the convention documents is supported by the Office of the Chief State Law Adviser;
- Signing of the IGO Treaty Agreement is planned for later this year in Rome;
- As part of the adoption process of the treaty convention it will be presented to Parliament for ratification.

SKA in South Africa (SKA SA)

A South African Radio Astronomy Observatory

- Until 31 March 2017 the SKA SA programme was structured around specific projects with project teams defined and recruited on the basis of the needs of the specific engineering projects and interventions;
- With the SKA SA & HartRAO merger, the newly formed entity will become an National Research Foundation facility and will be re-structured in order to maximise efficient use of resources;
- Current engineering projects and initiatives within SKA SA include:
  - The global SKA telescope project;
  - The MeerKAT telescope project;
  - The African Very Long Baseline interferometry network of telescopes (AVN) project(s);
  - The Hydrogen Epoch of Reionisation (HERA) telescope project;
  - Infrastructure for MeerKAT, SKA and other telescope or geodesy projects.



SKA in South Africa (SKA SA)

A South African Radio Astronomy Observatory

- It also includes the operations of existing facilities or instruments:
  - KAT-7
  - C-BASS;
  - Sub-arrays of HERA that are commissioned with the growth of the array;
  - Significant land/farm management (130,000 hectares).

- Significant Human Capital Development interventions:
  - A grants and bursary programme that has awarded in excess of 900 grants and bursaries to date, from undergraduate to postgraduate;
  - University chairs;
  - Technical training and training facilities for artisans as needed by all projects within the programme;
  - Collaborative human capital development, e.g. Newton Fund (UK).

Objectives of SKA SA

- To optimise South Africa's contribution to, and benefit from, the international SKA Project;
- To establish and sustain globally competitive and transformed radio astronomy and space geodesy research and infrastructure in South Africa and abroad, where appropriate;
- To optimise the associated national socio-economic benefit from radio astronomy and space geodesy activities;
- To promote radio astronomy and space geodesy capacity in Africa.

"SKA South Africa is committed to ensuring that South Africa's involvement in SKA remains significant and above par." Dr Rob Adam (SKA SA MD)

Phasing of projects within SKA SA

- The SKA is being developed in two phases, between 2018 and the late 2020s:
  - In Phase 1, Australia will host the low-frequency instrument with more than 500 stations, each containing around 250 individual antennas, while South Africa will host an array of some 200 dishes, incorporating the 64-dish MeerKAT telescope;
  - Phase 2 will complete the telescope arrays at both sites and become fully operational in the late 2020s with some 2000 high and mid frequency dishes and a million low frequency antennas;
  - The SKA will already start conducting science observations in 2020, with a partial array and the MeerKAT portion of SKA Phase 1 much sooner than that.
- MeerKAT is currently under construction (until end of March 2018), engineering and science commissioning is implemented as the telescope grows;
- The AVN is launching its first telescope in Ghana in August 2017. The optimistic plan is to deploy other systems in 7 more African partner countries toward the end of 2023;
- HERA will be completing construction at the end of 2019 - science to continue for approximately 3 years after that.

South Africa's role in SKA

2023 and beyond

- As a final step in construction, MeerKAT will be integrated into SKA Phase 1, after 5 years of scientific observations;
- The National Research Foundation is contracted to operate the telescope by the Director General appointed by the SKA Council;
- The South Africa Tier 1 Data Node (or Regional Science Data Centre) effectively becomes South Africa's SKA National Facility, processing and distributing data on behalf of SA's radio astronomy community;
- The National Research Foundation manages the 132,000 hectare site on behalf of South Africa, possibly in partnership with SANPARKS;
- The Astronomy Geographic Advantage Management Authority is established as a Government Component in terms of the Act, to regulate the AGA Area.

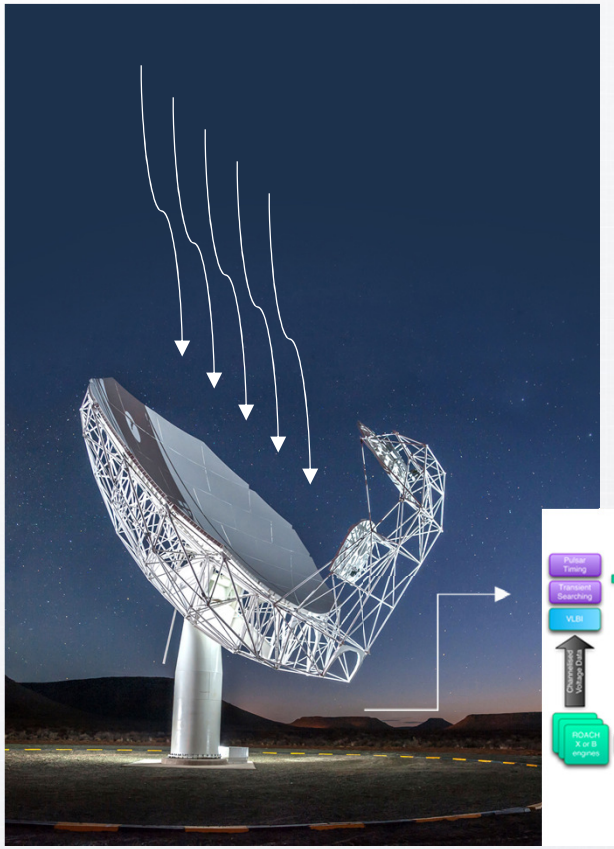
MeerKAT

Its place within SKA and South Africa

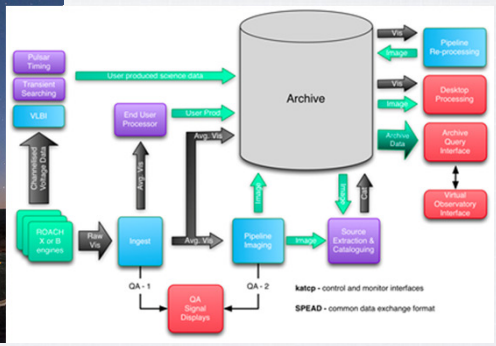
- MeerKAT, managed by SKA South Africa, was conceived as a *South African precursor* to the larger and more capable *international Square Kilometre Array (SKA)* radio telescope;
- MeerKAT is a world-class radio telescope in its own right: 64 high efficiency dishes spread over 8km with some of the best radio receivers in the world;
- South African industry is well positioned to develop this high technology programme;
- SKA SA's Human Capital Development programme investing in the students, engineers, and scientists in South Africa that are building and will use MeerKAT;
- In order to build MeerKAT, SKA SA developed the *engineering testbed KAT-7* (Karoo Array Telescope), with 7 dishes spread over 200 metres producing the first radio images of galaxies in 2012;
- The first MeerKAT dish was completed in 2015 - initial images using 4 dishes were produced in 2016.

MeerKAT

The 3 key components …



- Scientists schedule the telescope for observation time.
- Electromagnetic signals are collected by the parabolic dishes and focused at the receiver phase centre and is converted to an analogue signal;
- The analogue signal is converted to a digital signal at the antennas before being transported over long distances to prevent losses;
- In the processor building the signals are processed and converted to scientific images
- Scientists are then able to access and interpret the data.



MeerKAT

The world's first

- Most sensitive radio telescope in its frequency band until SKA Phase 1 is built;
- First successful implementation of Offset Gregorian Antennas into an Array;
- Correlator solution based on consumer electronics – reduces cost and increases upgradability;
- One of a few big science projects that involves research where System Engineering process successfully implemented – translating into SKA SA leading the System Engineering effort for many of the international SKA Consortia;
- Most sensitive L-band receiver in the world;
- The initial sensitivity spec would make MeerKAT the most sensitive radio telescope in L-band – without increasing cost, this sensitivity specification was improved on by between 40 – 100%.

MeerKAT schedule

On track …

Target/Milestone	**Date**	**Status**
Concept Design Review	July 2010	**Completed**
Preliminary Design Review	July 2011	**Completed**
1st Dish on Site	March 2014	**Completed**
16 Antenna Array	June 2016	**Completed**
32 Antenna Array	March 2017	**Completed**
64 Antenna Array	March 2018	…

MeerKAT Antennas

Built by South Africans

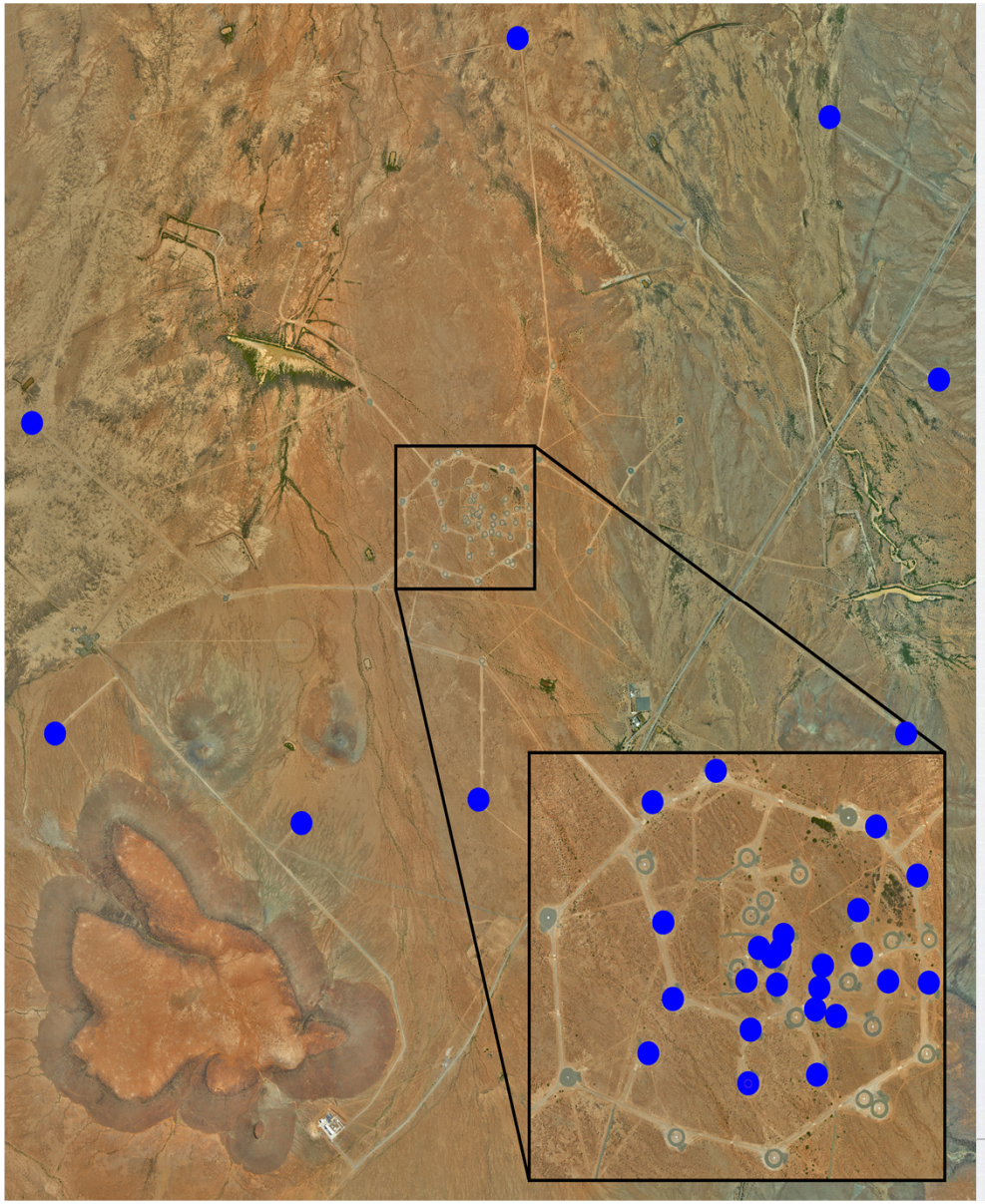
- Contracted to local company (Stratosat Datacom) with support from General Dynamics (constructed Greenbank, ALMA, etc.) in July 2012;
- Skills transfer to South Africa – e.g. panel shop;
- 75% local content – positioned South Africa for SKA Phase 1 procurement;
- Fixed price (no inflation / exchange rate risk);
- After 5 years
  - No specification or ICD changes;
  - No cost increases;
  - Contractual provision for non-performance;
- 36 antennas handed over, 46 dish lifts completed – to date.

MeerKAT Summary

On track, on schedule and within budget

- MeerKAT cost to completion is stable;
- Project managed tightly (evidence by lack of CVO's on big projects);
- Project on schedule – goals agreed with DST are being met;
- Significant local content and skills transfer associated with MeerKAT;
- Highly skilled team has been established that is also involved on SKA international related work;
- MeerKAT sensitivity between 40 – 100%, better than specified without increasing cost or compromising timescales;
- Initial results are very promising.

"Work on Control and Monitoring at SKA SA is the best that I have seen in the last few years anywhere in the world," says Dr Paul Alexander, Head Astrophysics at Cambridge University.



MeerKAT progress update

June 2016 – 16 antenna array completed

March 2017 – 32 antenna array completed

March 2018 – 64 antenna array completed

32 MeerKAT antennas in the Karoo. The square box (which is 1.2 kilometers on the side) shows a zoomed in version of the MeerKAT core;

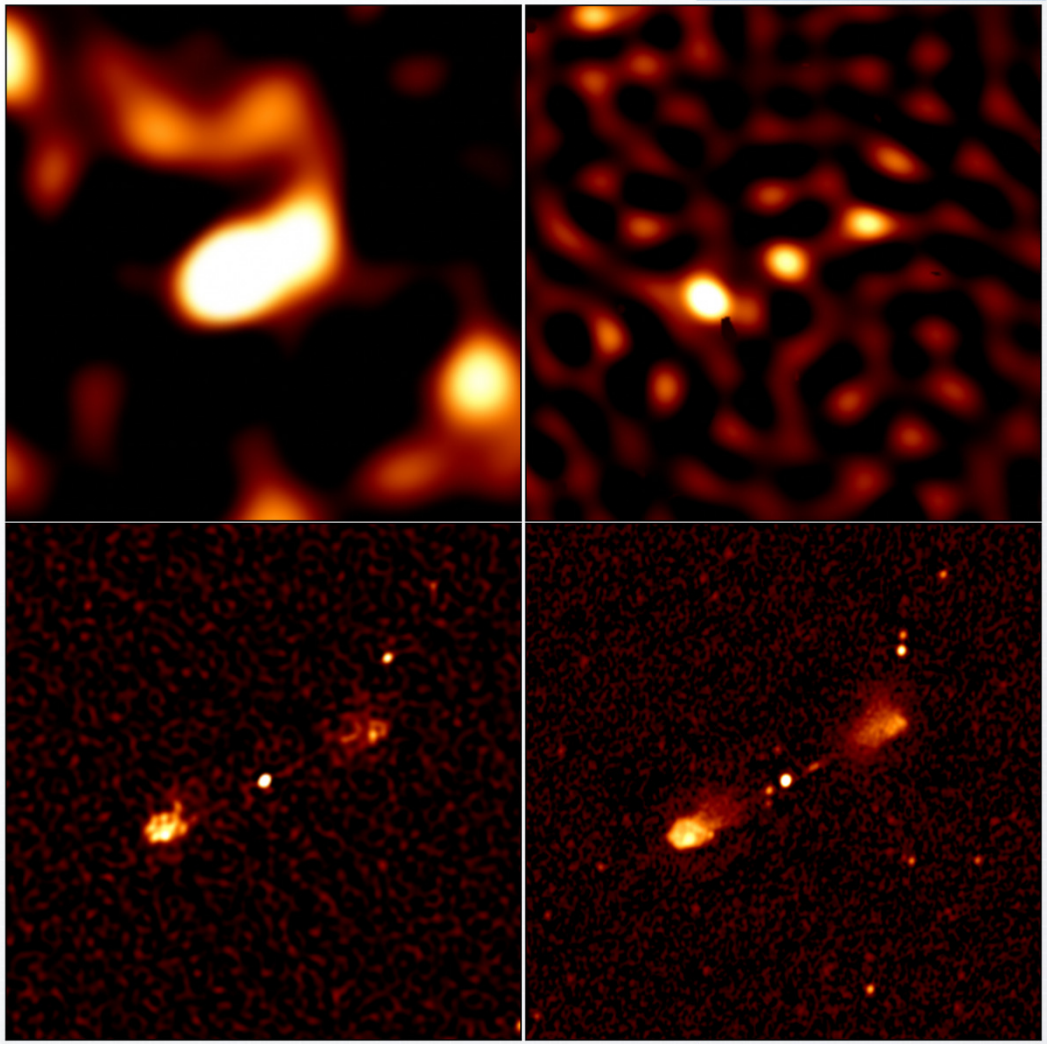
SKA SA commissioning team making a variety of observations to test the telescope;

Large science projects will be done with MeerKAT starting in 2018;

In the meantime, some commissioning observations are already leading to genuine scientific discoveries.

KAT-7 in 2012

MeerKAT-4 in 2016



MeerKAT-16 in 2016

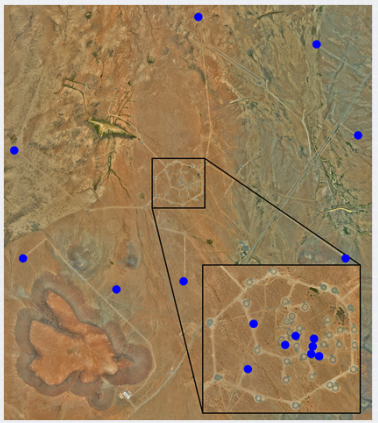
MeerKAT-16 in 2017

Increased observation power of MeerKAT

A galaxy in the distant universe imaged with ever better South African radio telescopes

Same black hole observed with increasingly improved arrays of antennas.

Jets of particles accelerated by the black hole at the centre to near the speed of light emit radio waves.



Credit: SKA South Africa.

MeerKAT identifies a new Giant Radio Galaxy

Infrared emission in blue and MeerKAT radio emission in orange.

MeerKAT images typically show radio galaxies in the distant universe.

A small number of these galaxies are gargantuan in size.

The image on the left shows a linear feature – a radio galaxy – that is 4 million light years long.

This identifies it as a Giant Radio Galaxy, the first such extreme object identified by MeerKAT.

Credit: infrared data from NASA's Wide-field Infrared Survey Explorer (WISE); radio data from SKA South Africa's MeerKAT telescope (made using 14 dishes within the core of the array and 2 more at a distance of 4 kilometres.)

The MeerKAT Science Programme

- 2010: call for scientific proposals by SKA SA results in several approved “Large Survey Projects” (LSPs, requiring more than 1,000 hours of MeerKAT observing time over 5 years);
- This leads to strong support and interest in MeerKAT, including international investment;
- 2016: MeerKAT is a better telescope than planned in 2010 and science has evolved;
- SKA SA requested approved LSPs to submit revised scientific proposals (review underway);
- 2/3 of telescope time to be used by LSPs, remaining ‘open time’ for other programmes – strong focus on South African participation at all levels;
- 64 dishes to be operational by April 2018 (and continued development of capabilities);
- Eventually, MeerKAT will be integrated into the SKA telescope.

Big Data

- MeerKAT Science Data Processor will complete the implementation of the largest data storage system of its kind, hosted at the Centre of High Performance Computing (CHPC);
- The storage system is geared for next-generation large survey telescopes such as MeerKAT and the SKA;
- The component has applicability in industry, with low costs, while offering high performance and capacity;
- The key component in the storage system was co-developed locally as part of our beneficiation of the South African High Tech industry.

Big Data

- MeerKAT has partnered with other stakeholders in the Science and Technology ecosystem to realise the national goal of building a multi-tiered data centre network that forms part of the National Research Infrastructure System;
- Together with the CSIR and the Inter-University Institute for Data Intensive Astronomy (IDIA), MeerKAT is supporting the building of a shared platform where researchers can further process and analyse MeerKAT data;
- This is a precursor model on how SKA infrastructure will be developed, providing an opportunity for fellow African countries to participate in the SKA;
- MeerKAT has partnerships with global technology companies such as IBM to explore future technologies in, e.g. Machine Learning and high performance cloud computing.

Phased roll-out of the AVN

Fast-track of Namibia and Botswana to ensure readiness for SKA Phase 2

Phased roll-out of the AVN

Fast-track of Namibia and Botswana to ensure readiness for SKA Phase 2

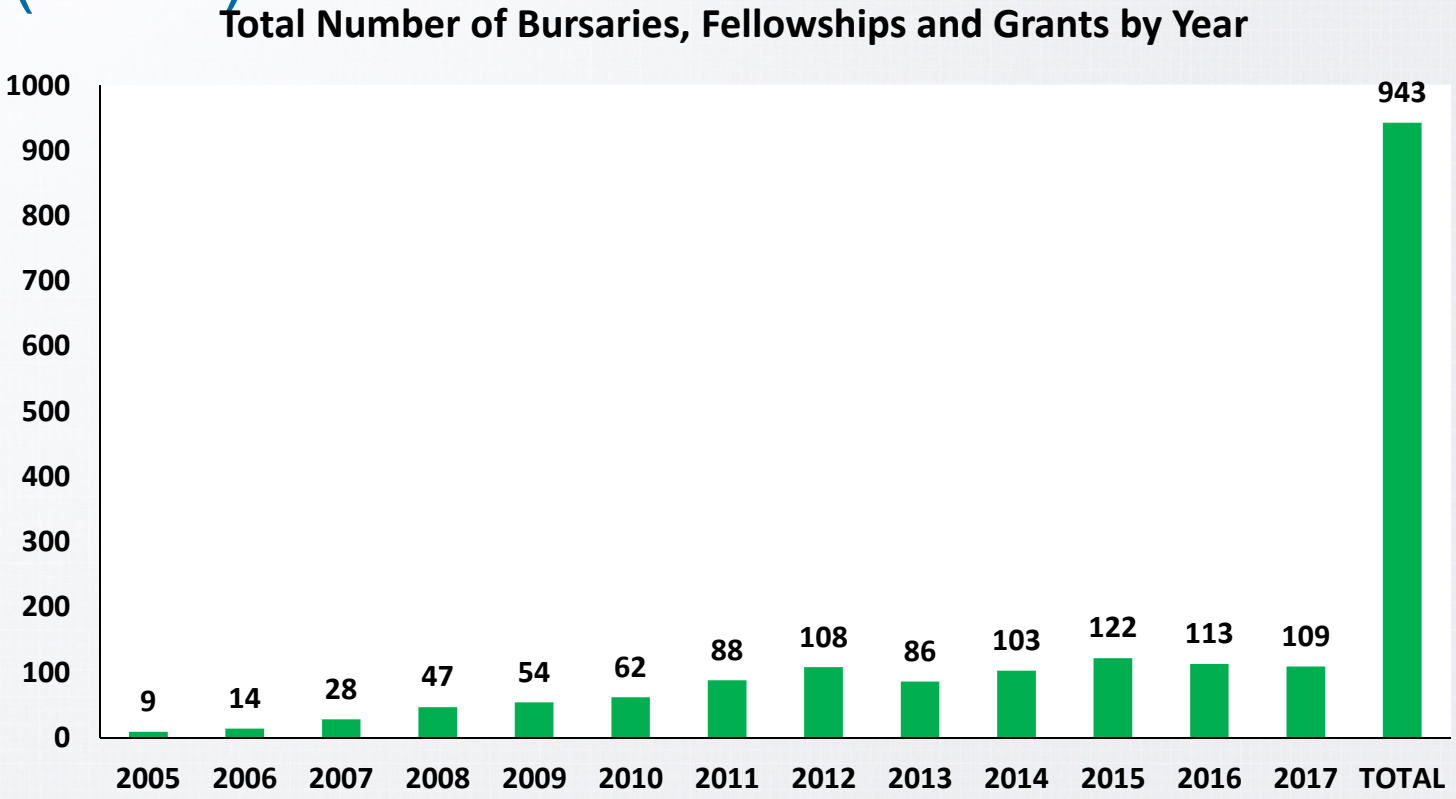
		Year ending 31 March										
Engineering projects		2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
Phase 1:	Ghana											
Phase 2:	Zambia or Madagascar											
	Botswana											
	Namibia											
Phase 3:	Kenya											
	Madagascar or Zambia											
	Mauritius											
	Mozambique											

Conversion project

New-build project

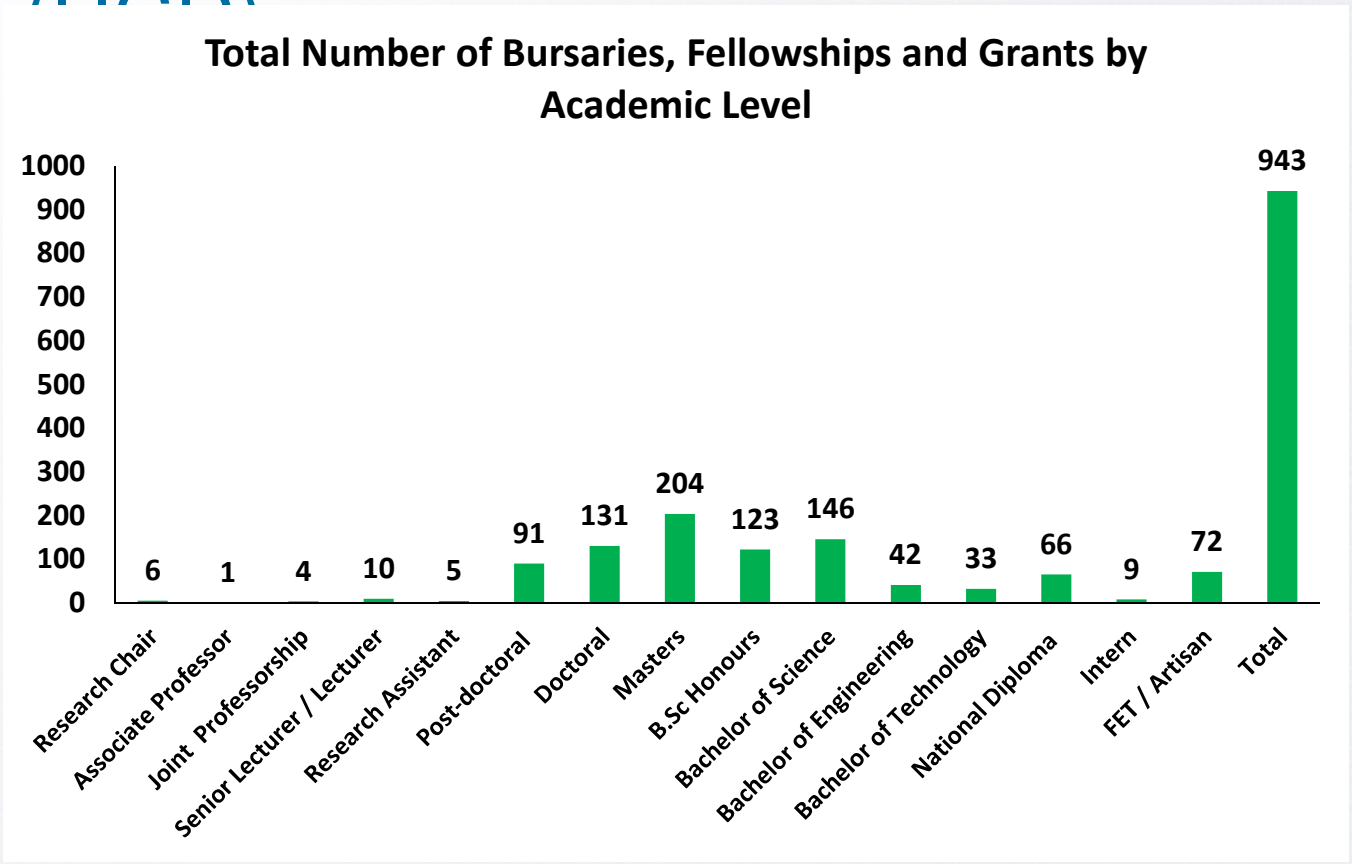
Operations support

SKA SA Human Capital Development (HCD)



Delegates at the 2016 SKA SA Postgraduate Bursary Conference, held in Cape Town.

SKA SA Human Capital Development (HCD)



- 707 South Africans
- 166 other African Nationals
- 70 Non-African Nationals
- 257 Women
- 686 Men

SKA SA HCD Programme

Schools & Artisan programmes in local communities

Carnarvon Primary Team takes 3rd place at Virtual Gear Robotics Competition

- Carnarvon Primary School
  - Two Teach SA graduates placed at CPS to teacher numeracy and literacy
  - Teacher Development Programme in Mathematics and Literacy with UCT established
- Carnarvon High School
  - One science Teach SA graduate placed at CHS
  - Four CHS learners with university exemption, provided with SKA SA under graduate bursaries to study at university in 2017;
  - The Five 2015-CHS bursary-students all passed first-year University, some obtaining distinctions;
  - Learners participated in Eskom Expo (went to Provincial level), and in Mathematics and Physics Olympia;
  - 21 Learner Bursaries awarded for 2017 (one at Williston High School)
- Five students qualified as artisans in 2016/2017, 72 FET students funded by SKA in the Northern Cape since 2011

SKA SA and Local Communities

- Land Acquisition Purchase
  - 75% complete
  - TOTAL – 36 properties totalling 117,968 hectares
- R134 million spent at local suppliers for the construction of MeerKAT and other related projects;
- R1,7 million spent on material sourced from local suppliers for equipment for the building of the Hydrogen Epoch of Reionisation Array (HERA);
- 7,284 employment opportunities were created through the construction of KAT-7, MeerKAT and other related projects;
- R1 million spent on training 351 people from the Northern Cape communities;
- 8 local school are included in the HCD programmes involving more than 4,000 learners;
- 9 SKA SA funded students from local communities enrolled at universities;
- 72 FET students funded by SKA in the Northern Cape since 2011
- 219 farmers and farmworkers provided with fixed broadband connectivity via satellite (V-SAT) since December 2015.

Local & Indigenous Communities

Our neighbours for at least 50 years … in it for the long haul!

- SAN Council Agreement – through this agreement:
  - Promote and protect San culture and heritage; and
  - Develop youth of the San peoples.

- Agri SA Agreement
  - Through this agreement, both organisations commit to continuously explore ways where affected agricultural land is optimised to accommodate ongoing farming activities where possible, as long as the functioning of the radio observatory is not compromised.

- Community Information Sessions & Development Projects
  - **Key:** contribute to the diversification of the local economy, thereby reducing the dependence on the agriculture sector only.

- Relationship with local municipalities
  - Inclusion on Integrated Development Plan (IDP) and Spatial Development Framework (SDF);
  - SKA SA continues to build on the positive relationship with local municipalities through collaborations on different levels and affecting all sectors of the local communities around the project.

In his address to the San Council delegation at the cleansing and blessing ceremony at the SKA site, the Kareeberg Mayor Mr Norman van Wyk reiterated his commitment that the municipality is in full support of the success of the SKA project.

San Council Agreement

Agri SA Agreement

Science Engagement, Outreach & Awareness

Working with Kareeberg Municipality

Engaging with local communities – community information sessions

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

SKA South Africa, a Business Unit of the National Research Foundation.

We are building the Square Kilometre Array radio telescope (SKA), located in South Africa and eight other African countries, with part in Australia. The SKA will be the largest radio telescope ever built and will produce science that changes our understanding of the universe

Contact information

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