



## The SKA and MeerKAT projects



Presentation to the  
Parliamentary Portfolio  
Committee  
3 September 2014



science  
& technology  
Department  
Science and Technology  
REPUBLIC OF SOUTH AFRICA

## Reaching Africa's potential

- To make Africa the next great business destination needs
  - Infrastructure
  - Skills and expertise (see e.g. comments by US companies)
  - Wealth creation in the knowledge economy
- Effect of STI training is very broad
  - Skills to build, operate and maintain infrastructure and services (equal partners with contractors; develop the industrial base through infrastructure and innovation)
  - Innovation for business development and improving public administration and service delivery
  - Evidence-based policy
  - Learning to deliver

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## SKA Africa - Building skills and expertise

- Mega-projects are high-profile
  - Science and tech visible to policy-makers and public
  - Exciting - attract and train the best young people
  - Strengthen universities
  - Reverse the brain drain and retain skills
  - Develop expertise and know-how in industry
  - Create a critical mass of skills and know-how in cutting edge technologies, e.g., Big Data
- Support from African Union Heads of State
- Resolution by European Parliament


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## Why astronomy - White Paper 1996

- “Scientific endeavour is not purely utilitarian in its objectives and has important associated cultural and social values.
- It is also important to maintain a basic competence in flagship sciences such as physics and astronomy for cultural reasons.
- Not to offer them would be to take a negative view of our future - **the view that we are a second class nation, chained forever to the treadmill of feeding and clothing ourselves”**

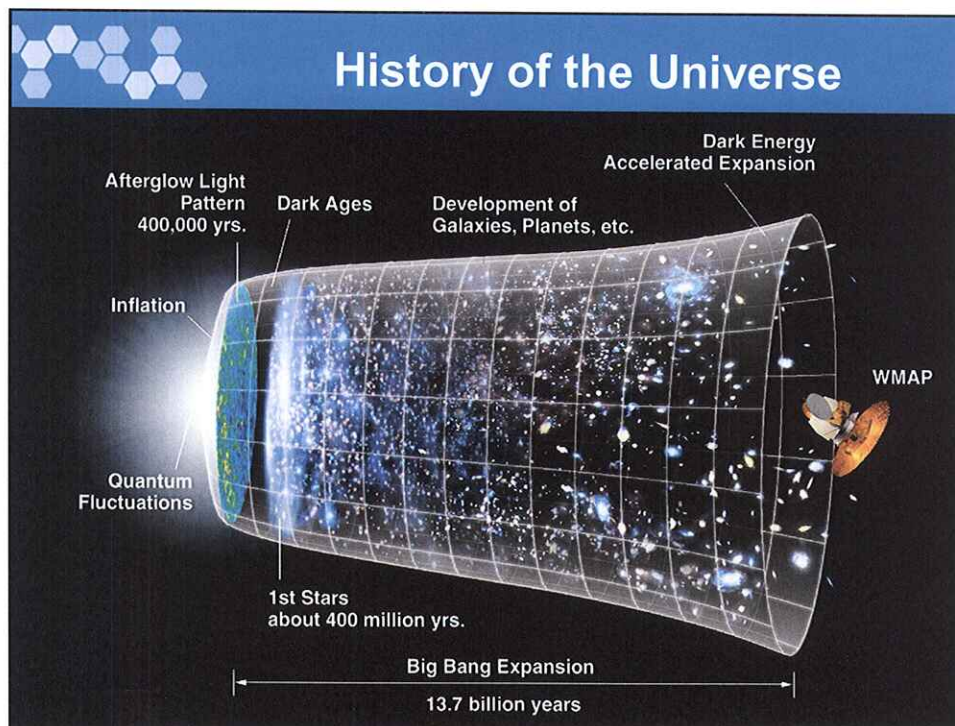
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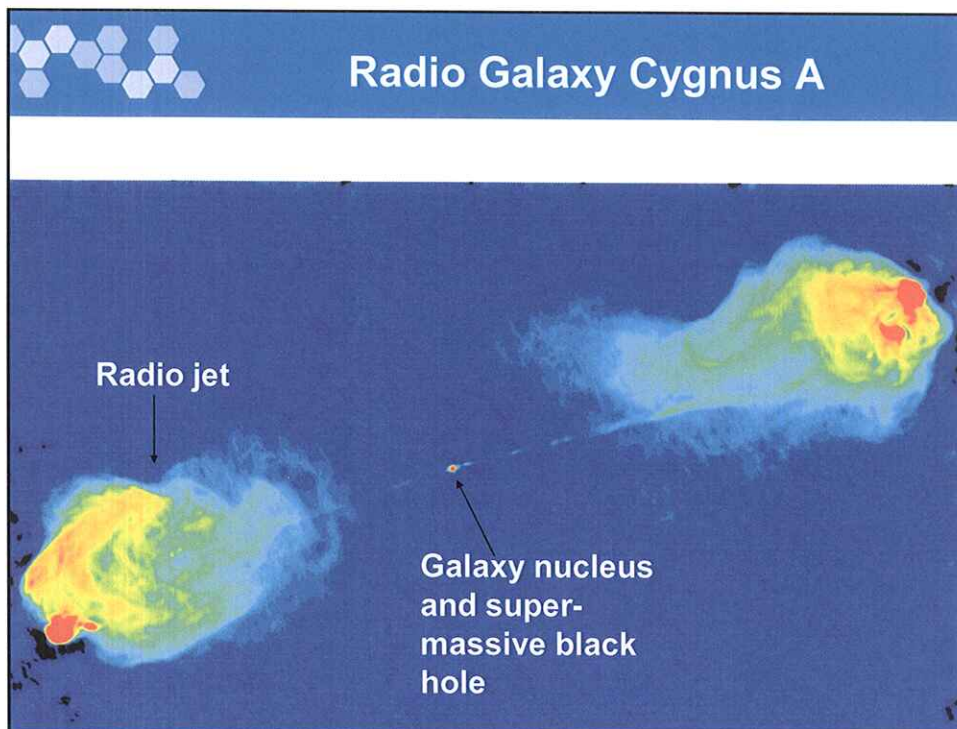
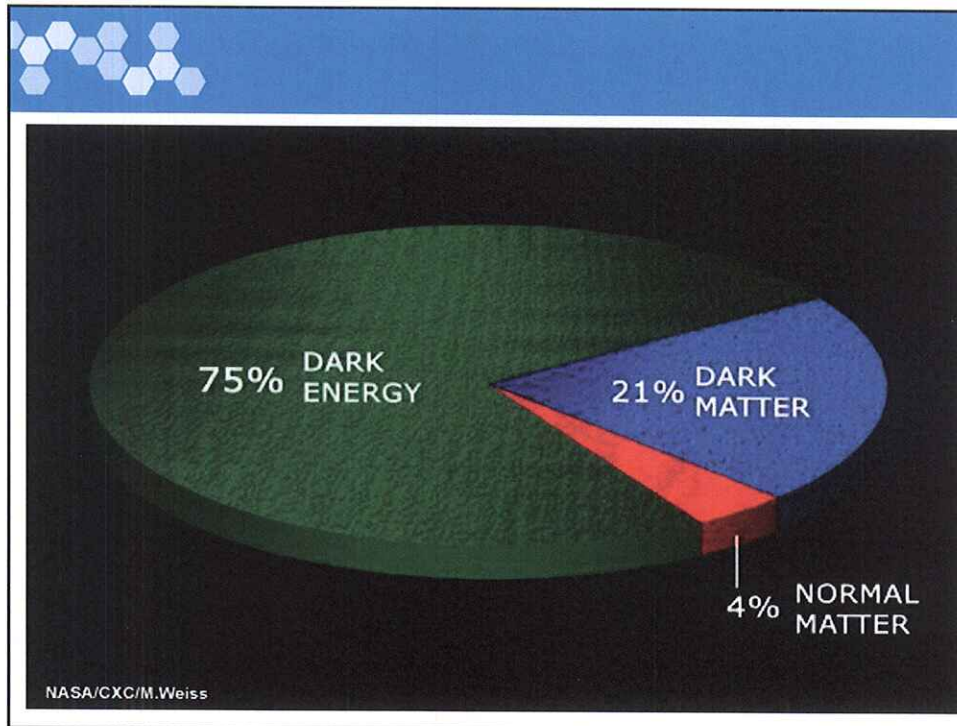


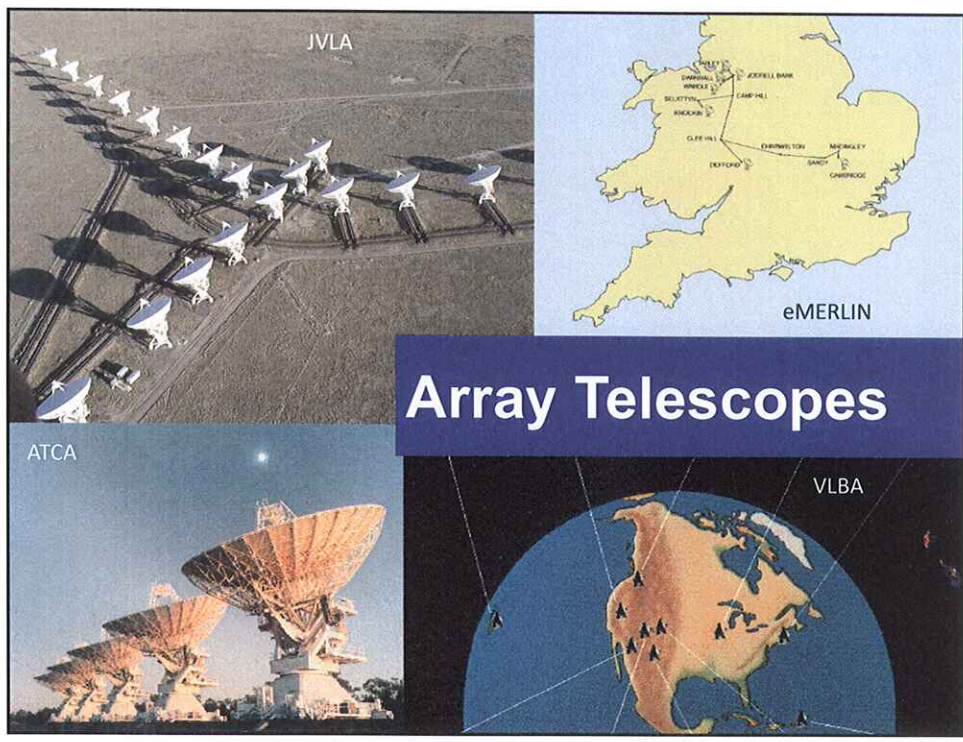
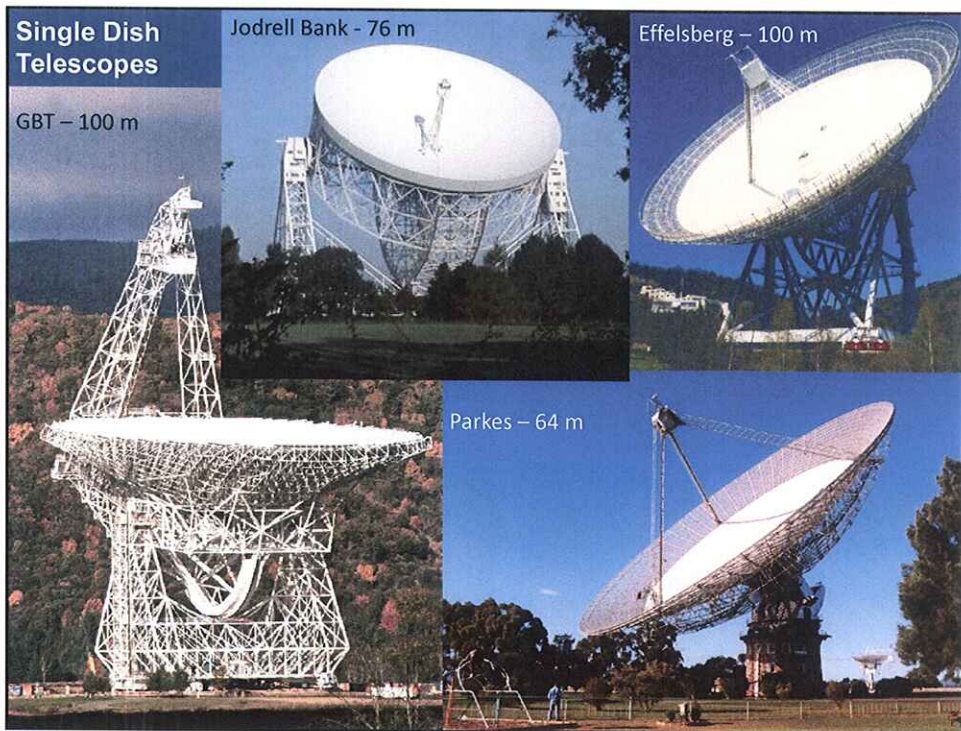
## SQUARE KILOMETRE ARRAY

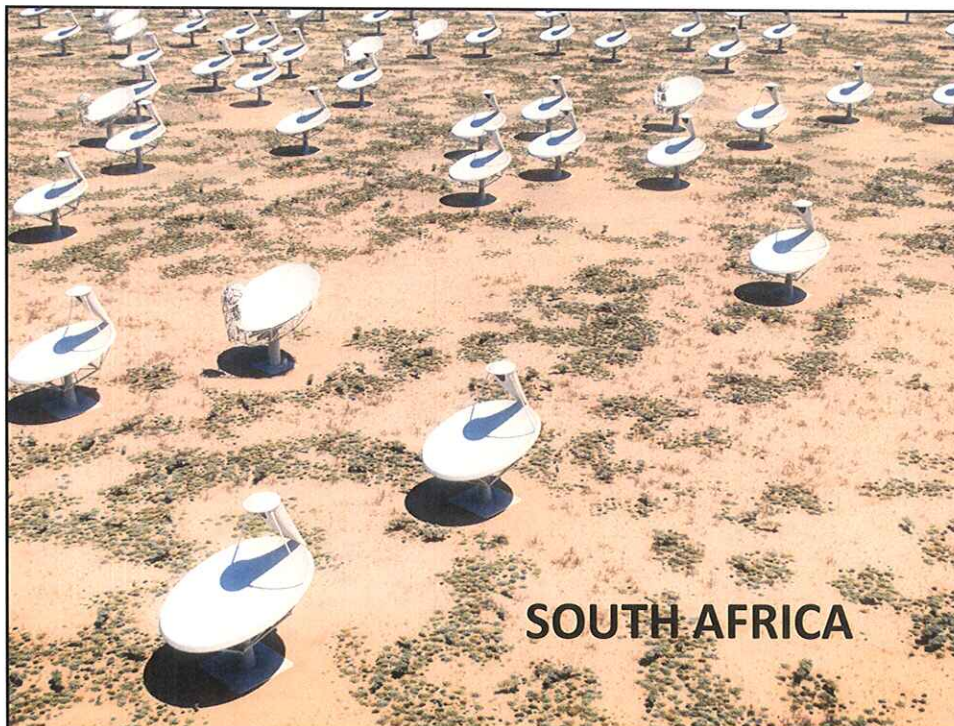
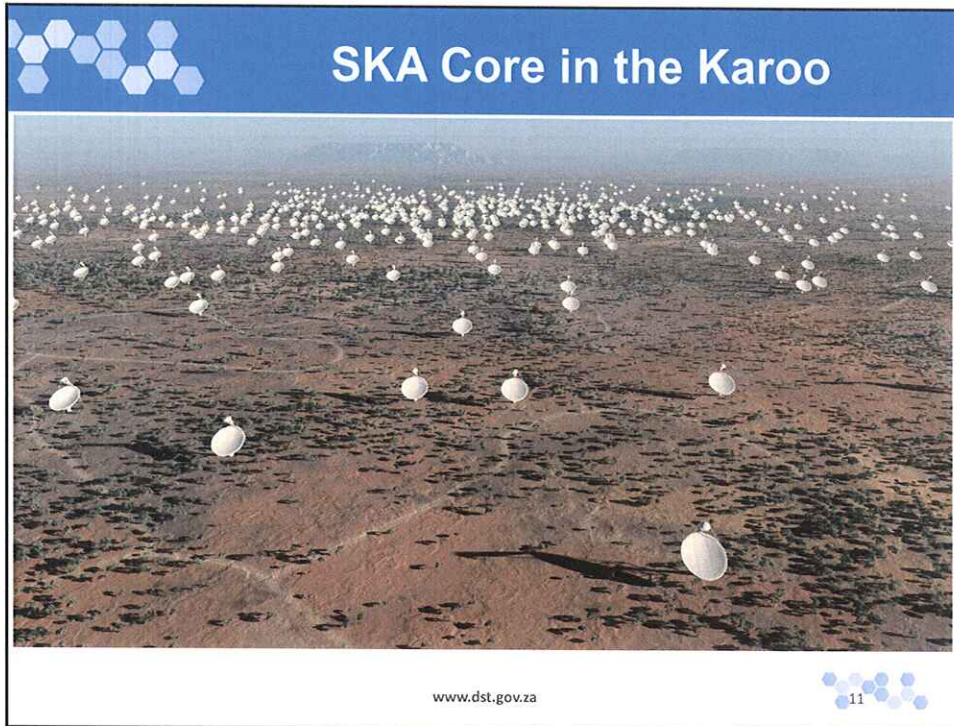
- Largest radio telescope ever built - will dominate radio astronomy for decades.
- Largest science infrastructure
- Frontier science in fundamental physics and astronomy – formation of first stars and galaxies; evolution of the universe and galaxies - dark matter and dark energy; was Einstein right? cradle of life; cosmic magnetism; SETI; serendipity
- Pushing boundaries of technology
- AFRICANS WINNING NOBEL PRIZES IN AFRICA

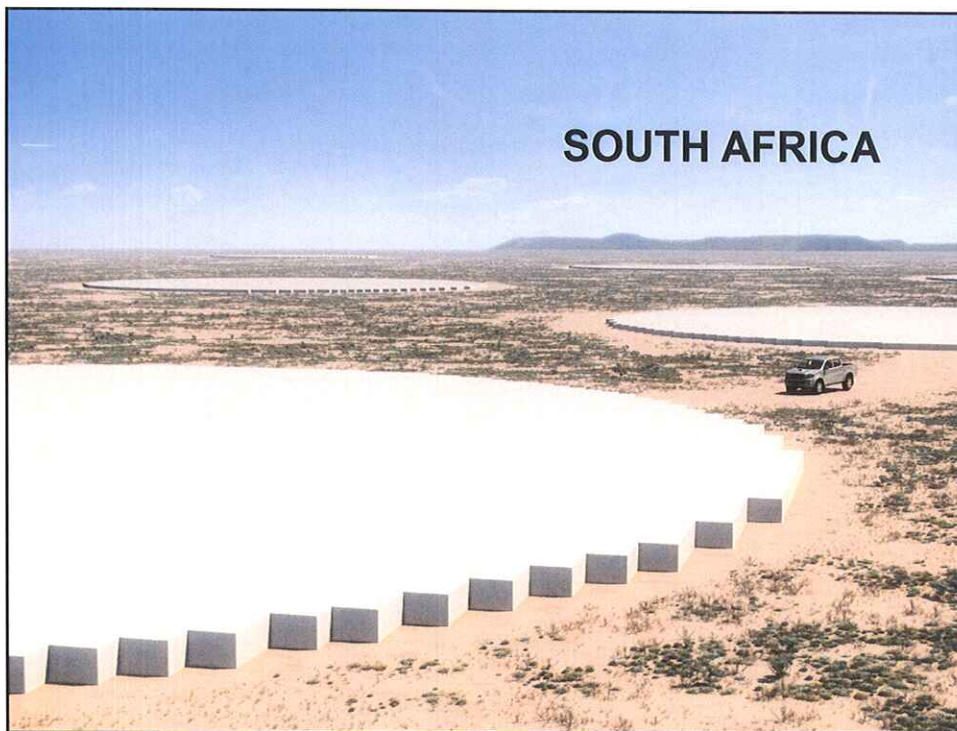
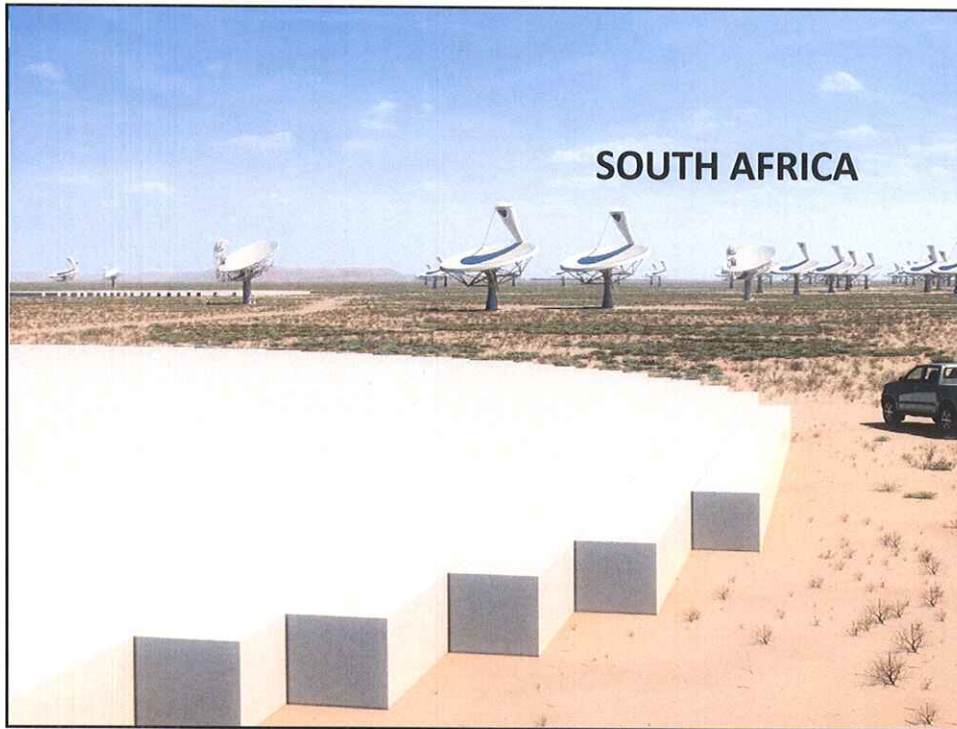
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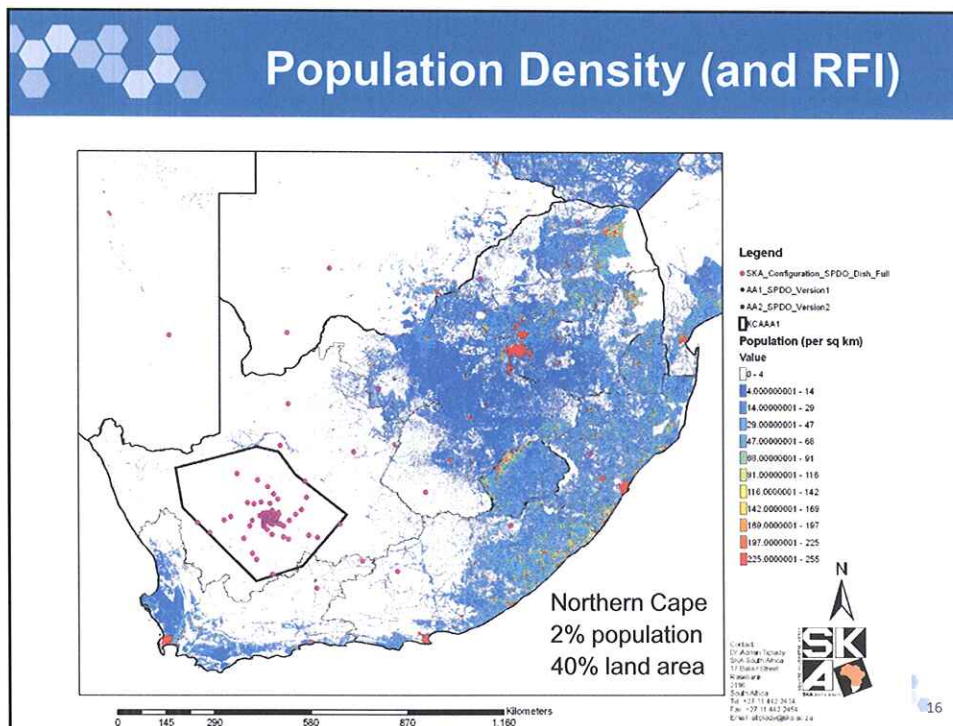
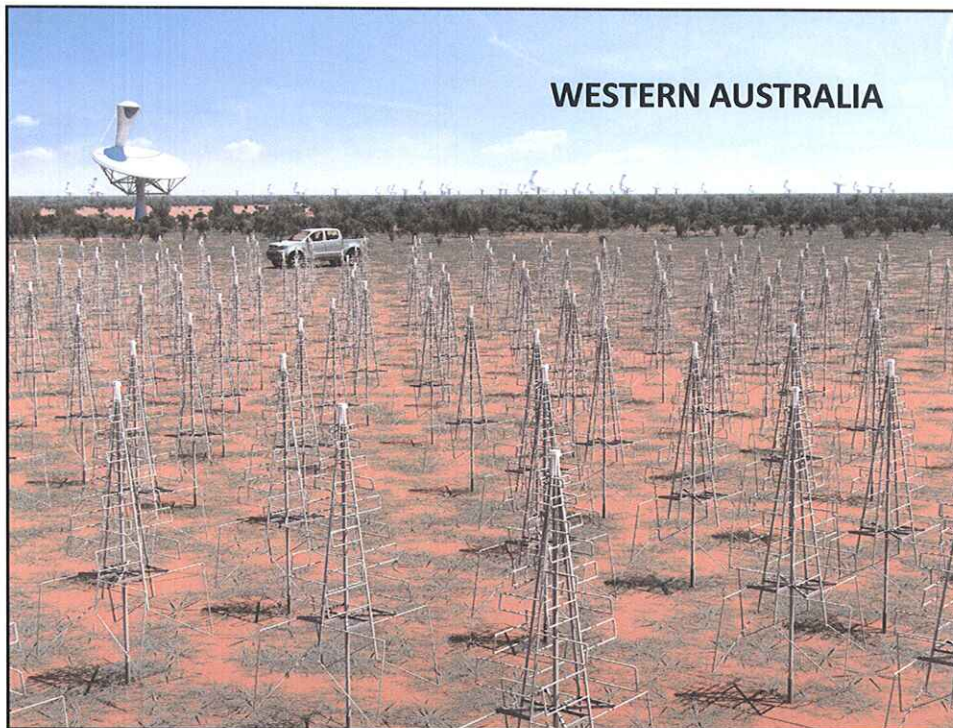




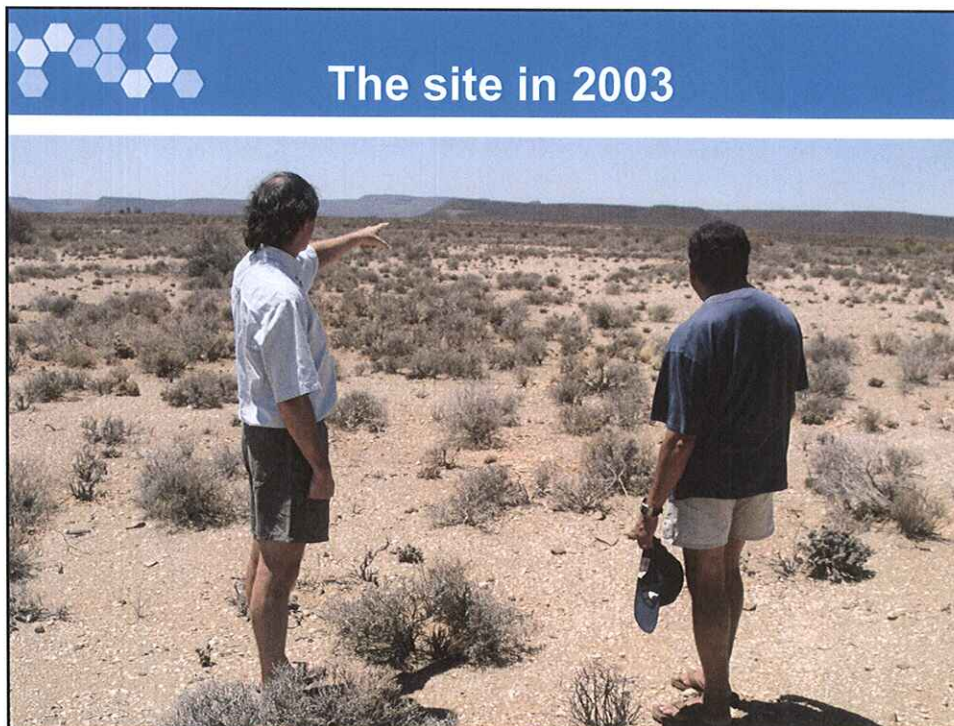
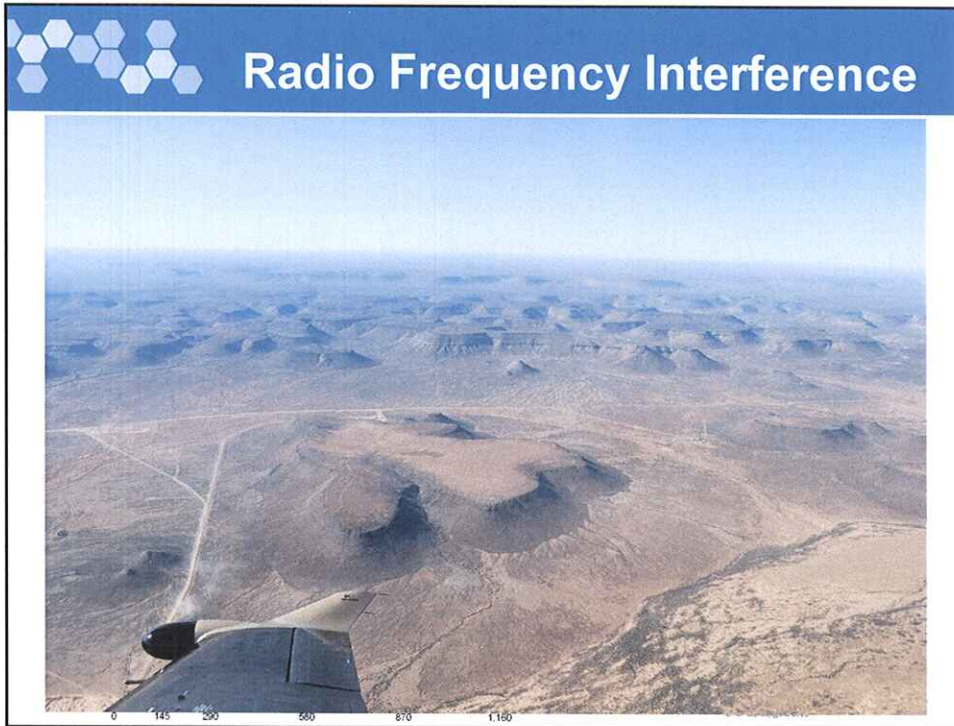


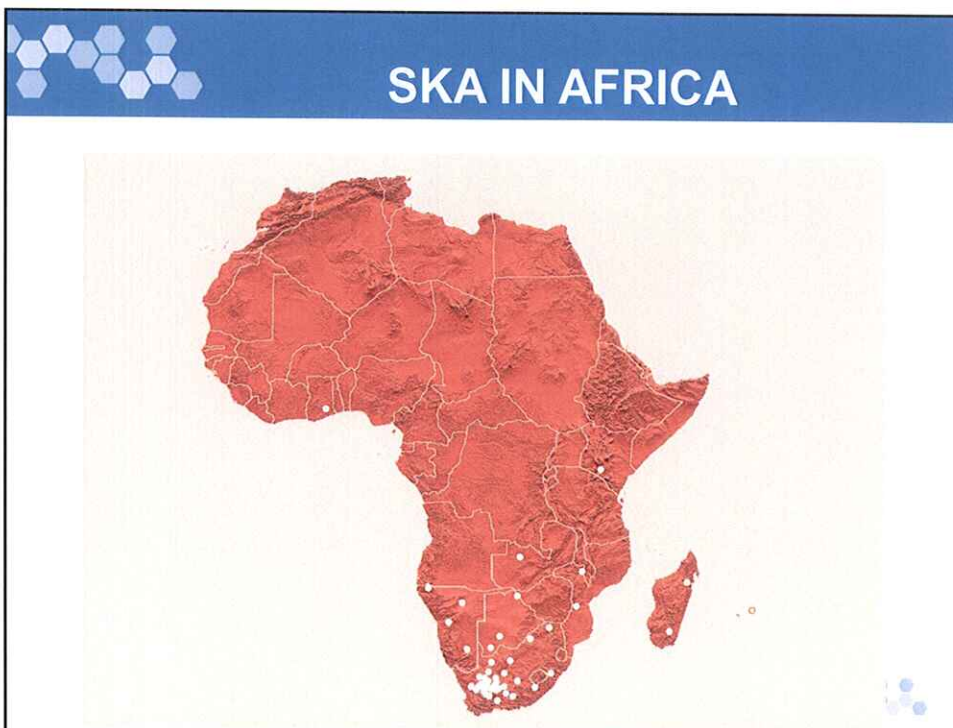
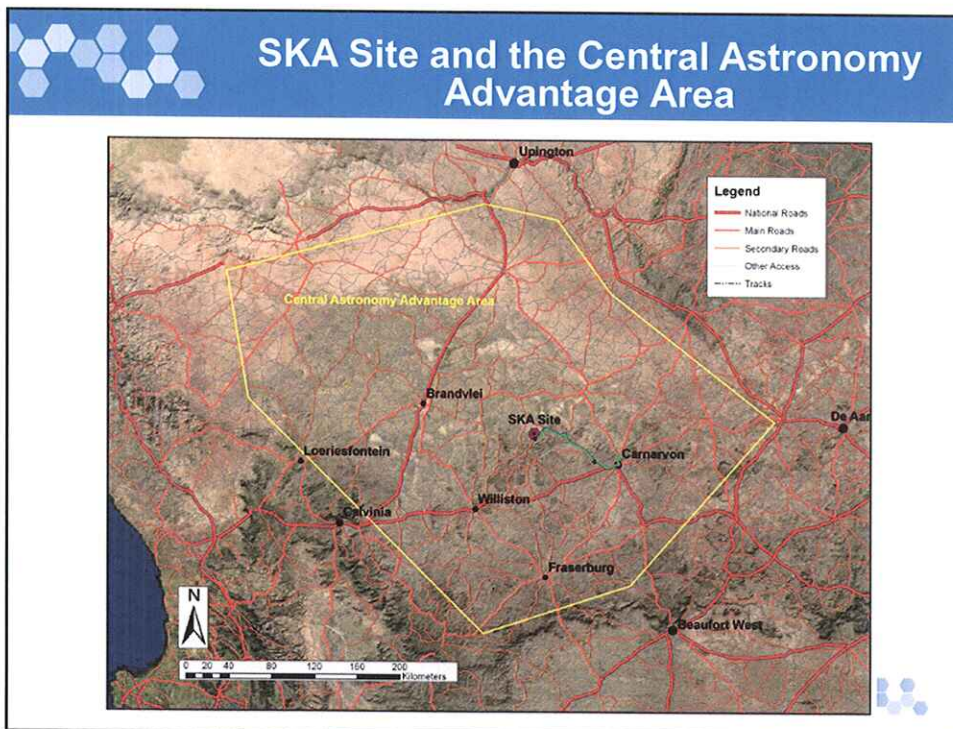














## GOVERNANCE

- SKA Organisation (SKAO) has eleven members
  - RSA; China; UK; Netherlands; Australia; New Zealand; Italy; Canada; Sweden; Germany; India
  - Spain and Portugal announced that they will join
  - France, Japan want to join
  - South Korea, USA attend as observers

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## SKA PHASES AND DATES

- Precursors (MeerKAT in RSA and ASKAP in Australia) start science about 2016, merge into SKA1 about 2020
- SKA pre-construction (design and prototype) 2013-2016
- Prototypes on the ground 2016 (includes, e.g., Chinese and Canadian dish antennas and Mid-Frequency Aperture Array in the Karoo)
- Tenders for construction of SKA Phase 1 (SKA1) in 2017
- Construction of SKA1 from 2018-2023
- Early science with (part of) SKA1 from 2020
- Design of SKA2 from 2018-2021
- Construction of SKA Phase 2 (SKA2) 2023-2028?
- SKA2 infrastructure probably earlier (2021-2022?)

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## SKA Africa Programme

- SKA site bid
- Develop greenfield site and infrastructure
- Build institutional capacity in African partners
- Build the MeerKAT telescope
- Build a vibrant astronomy and instrumentation community in SA and Africa
- Attract young people into SET - build a large human capital development pipeline on SKA and MeerKAT
- Expertise and know-how in institutions and industry
- Local socio-economic development

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## The MeerKAT Programme

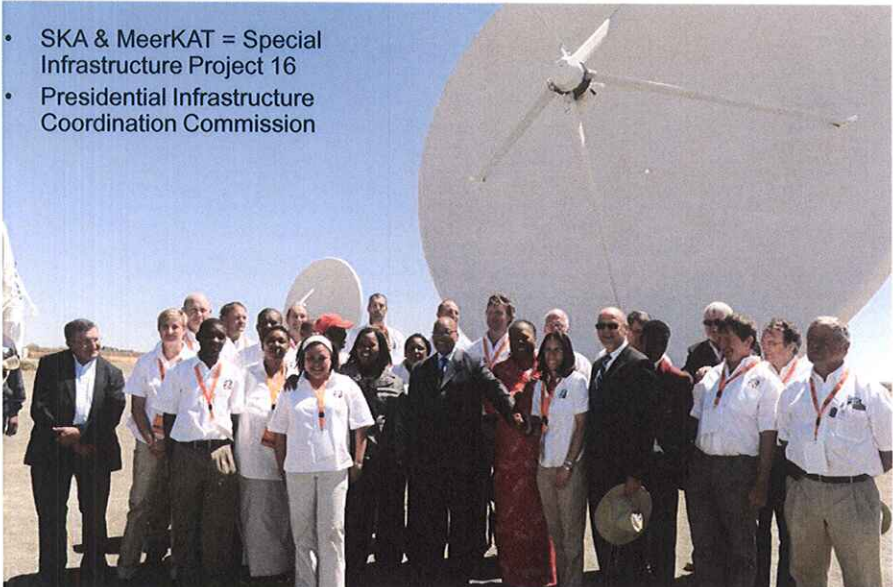
- MeerKAT is an SKA “precursor”
  - Largest array radio telescope in the world
- Build up a science and engineering team to construct and use MeerKAT and SKA
  - Over 200 engineers and scientists currently directly employed in project office; others in universities and industry
- Phased development
  - XDM, KAT-7, MeerKAT, SKA1, SKA2
- MeerKAT will be 25% of SKA1

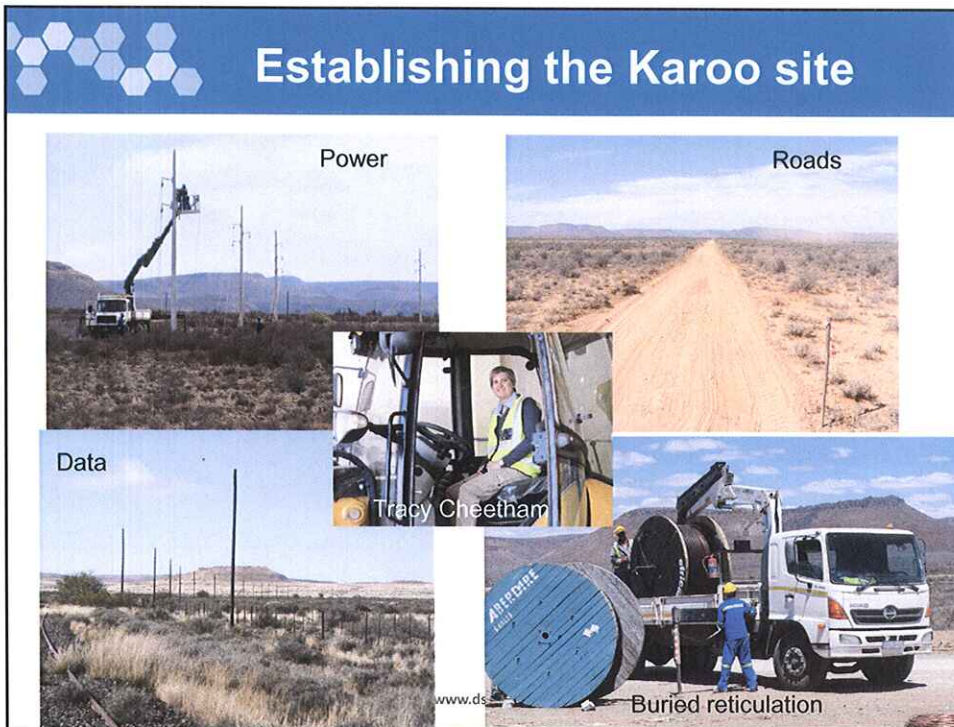
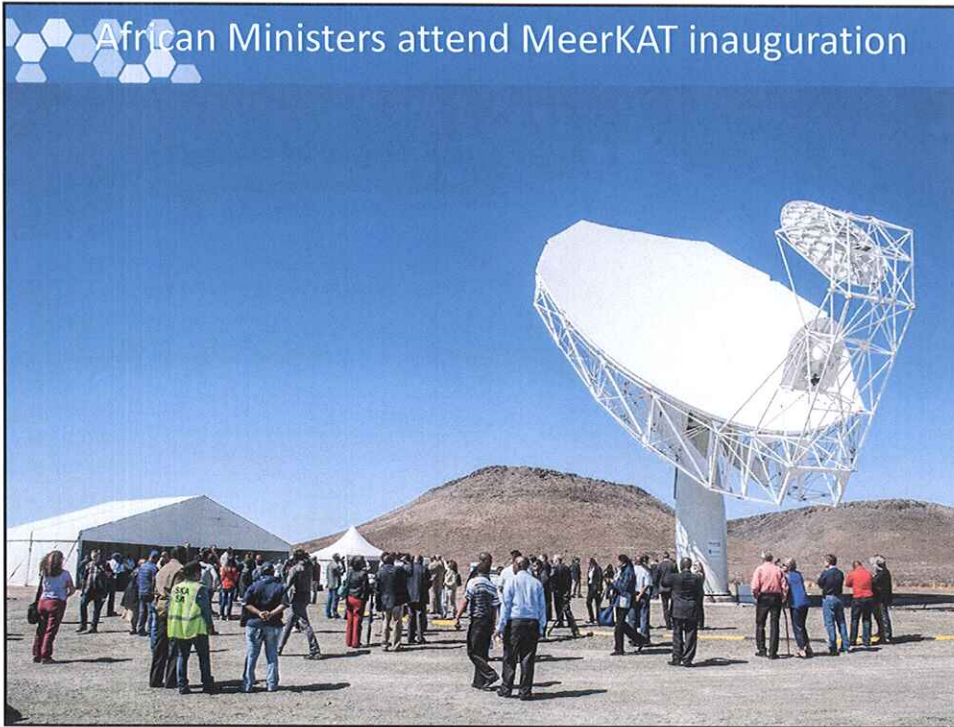
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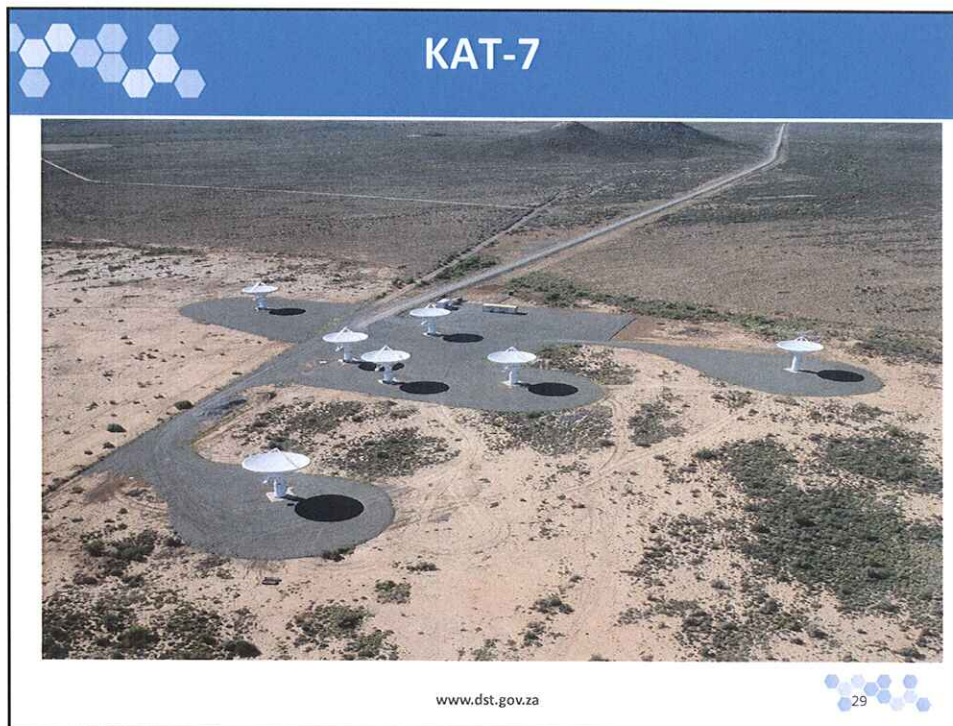
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## The President visits SIP 16

- SKA & MeerKAT = Special Infrastructure Project 16
- Presidential Infrastructure Coordination Commission

A group of approximately 20 people, including the President of South Africa, are standing in front of a large, white, circular radio telescope dish. The group is diverse in age and gender, and many are wearing white shirts with orange lanyards. The background shows a clear blue sky and another smaller dish in the distance.





An aerial photograph of the MeerKAT radio telescope array, showing a large number of smaller, white, parabolic dish antennas arranged in a circular pattern in a desert landscape. The image is framed by a blue header with the text 'MeerKAT' and a decorative hexagonal pattern on the left. At the bottom, there is a URL 'www.dst.gov.za' and a small logo with the number '30'.

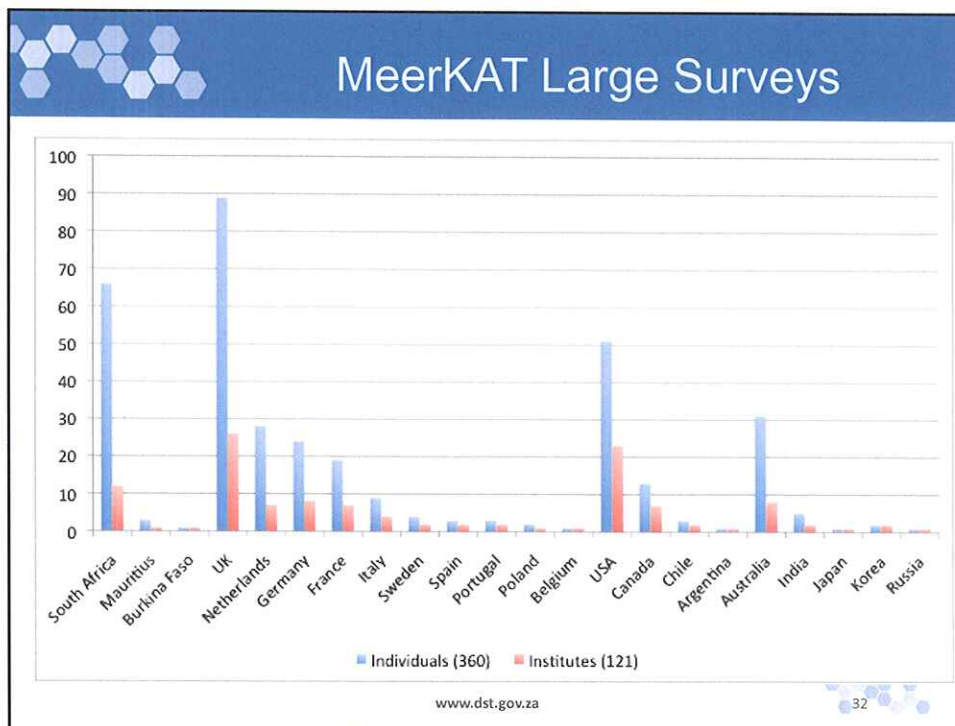
## MeerKAT

- The most sensitive cm-wavelength array telescope in the world
- Very reliable and low operating cost
  - long MTBF and short MTTR
- Built using system engineering processes, including frequent international reviews

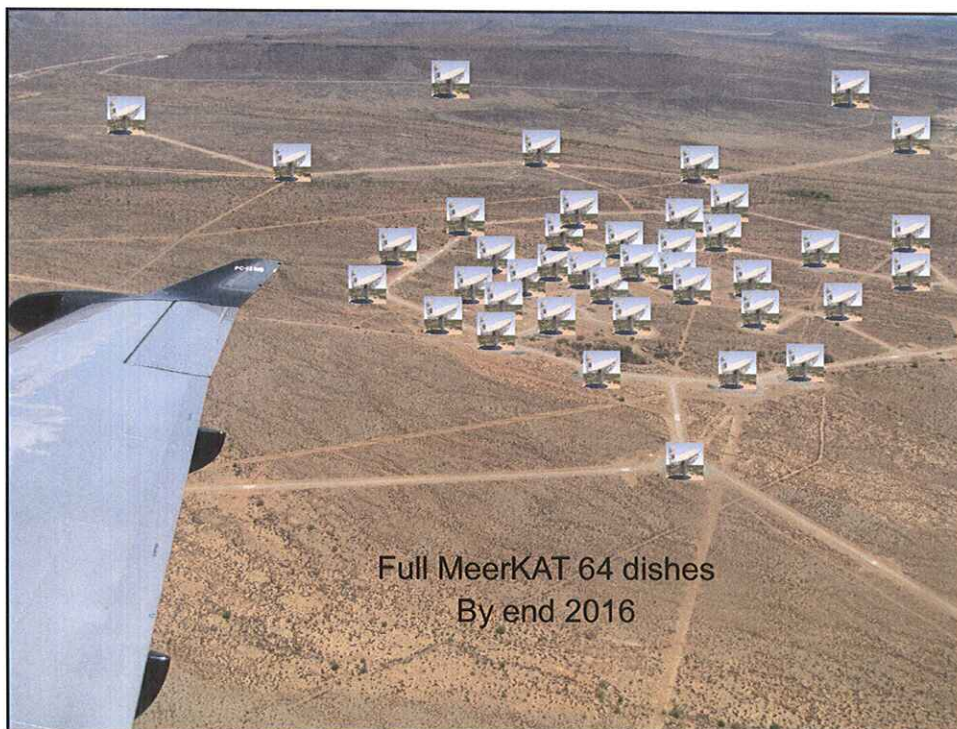
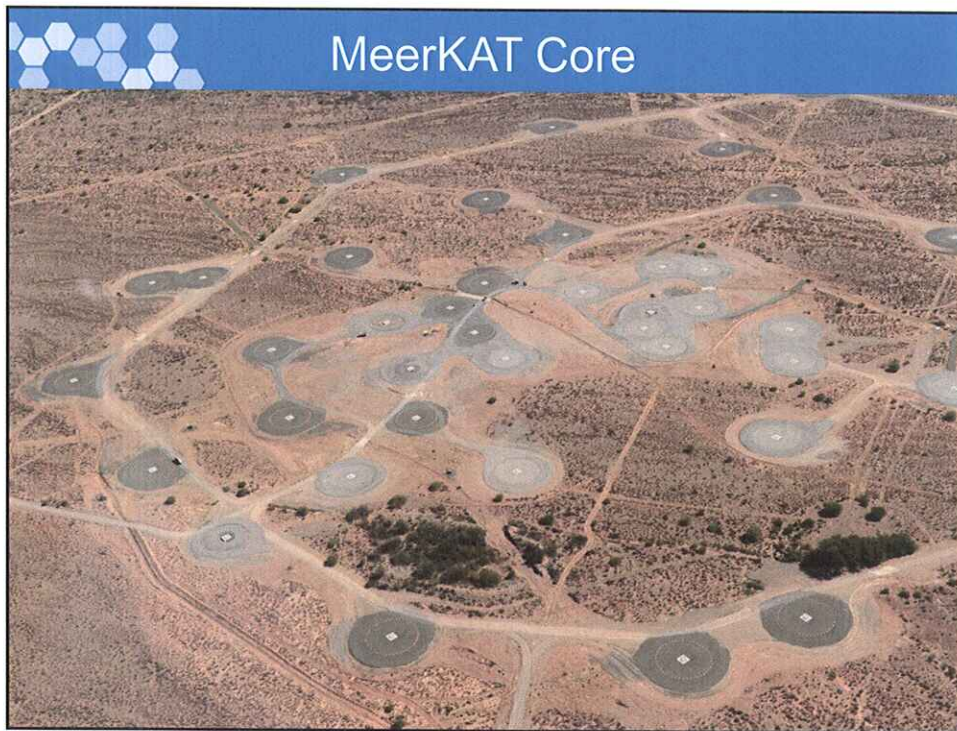
## MeerKAT

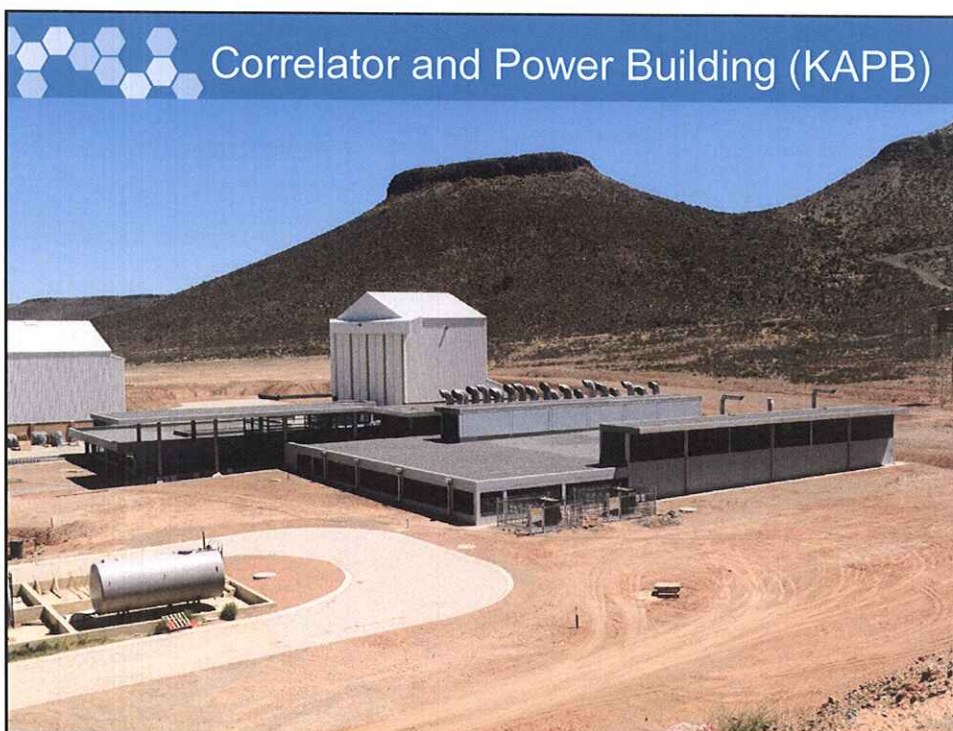
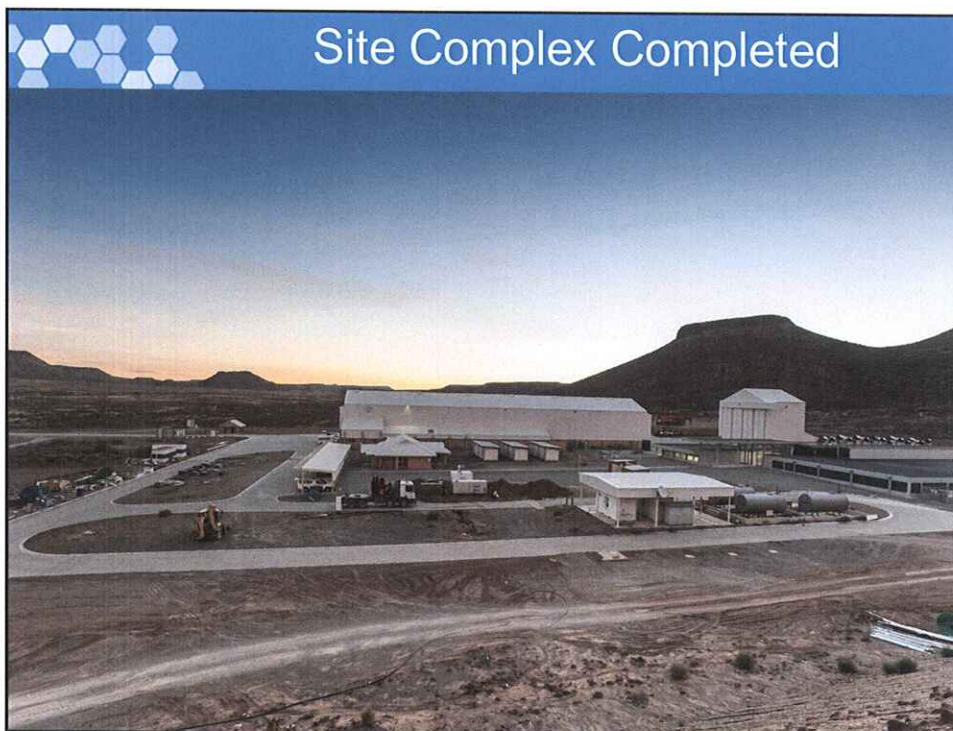
- System engineering and design
- System description
- Disciplined, science-led process
- MeerKAT large surveys

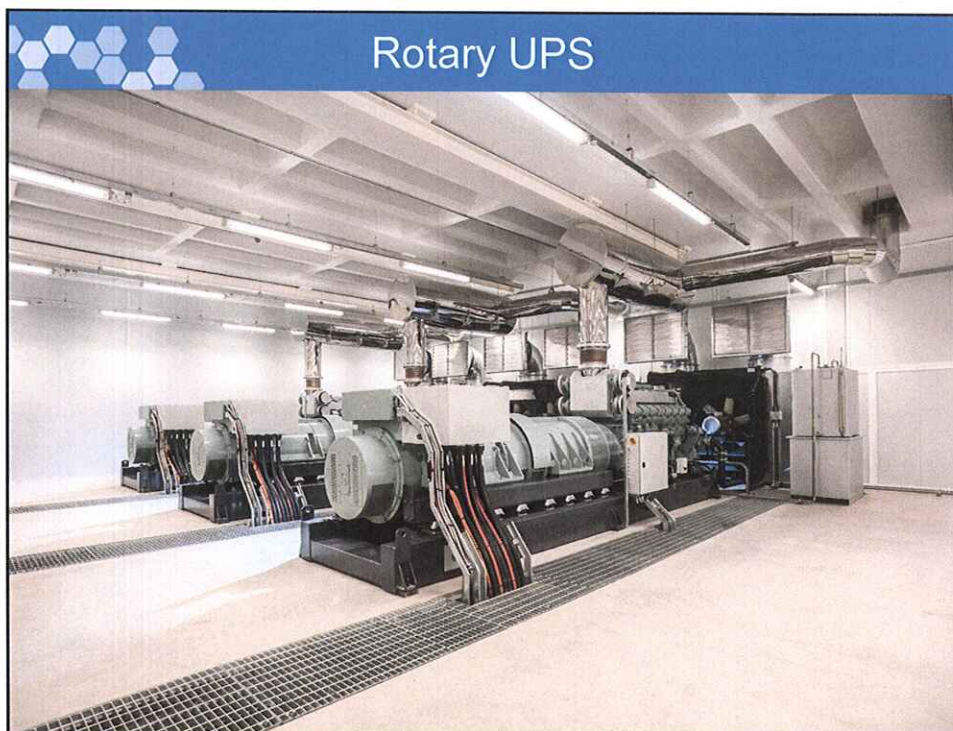
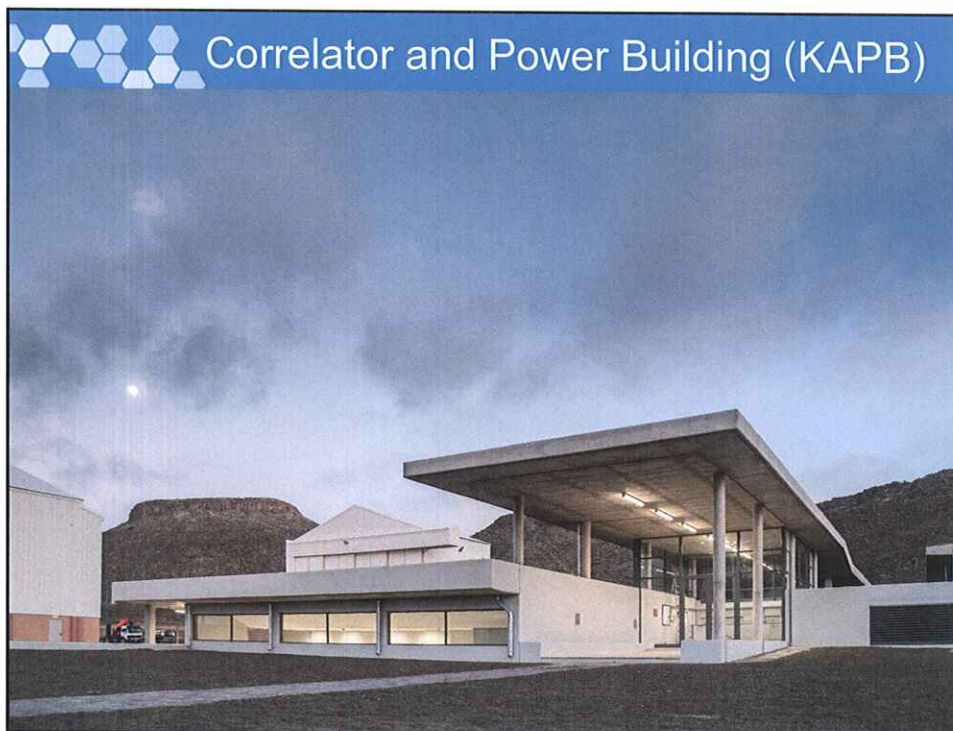
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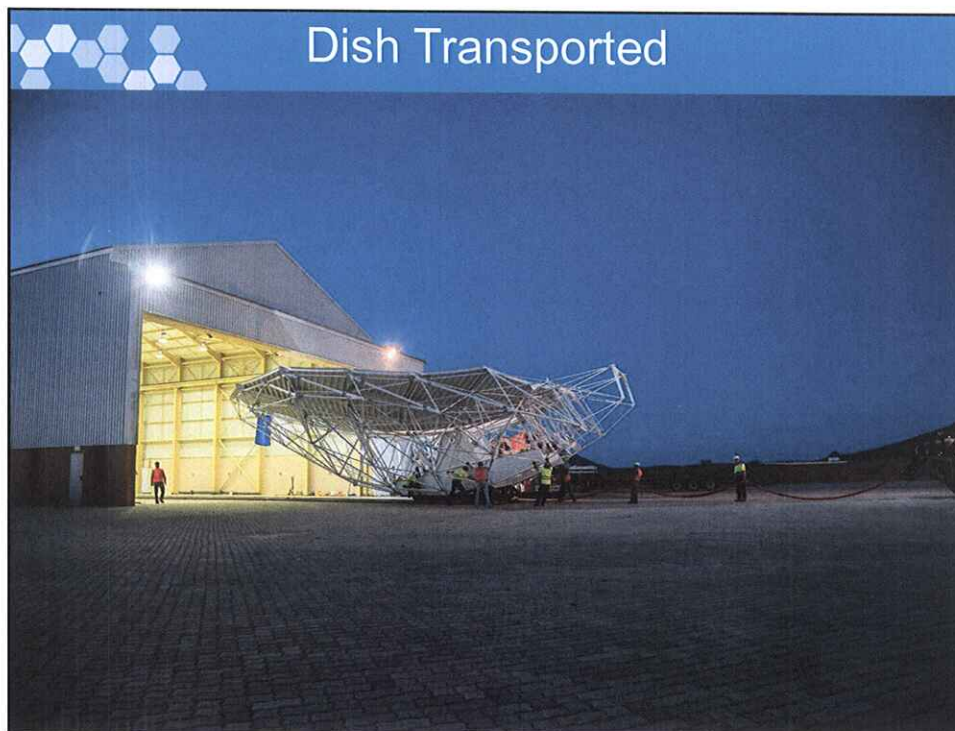


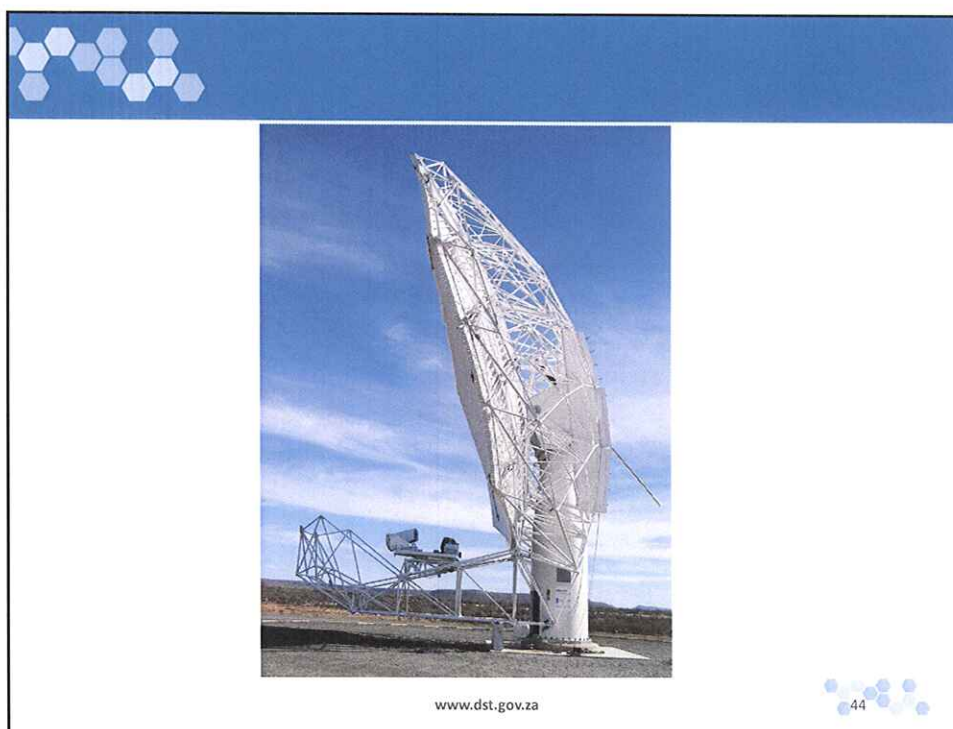
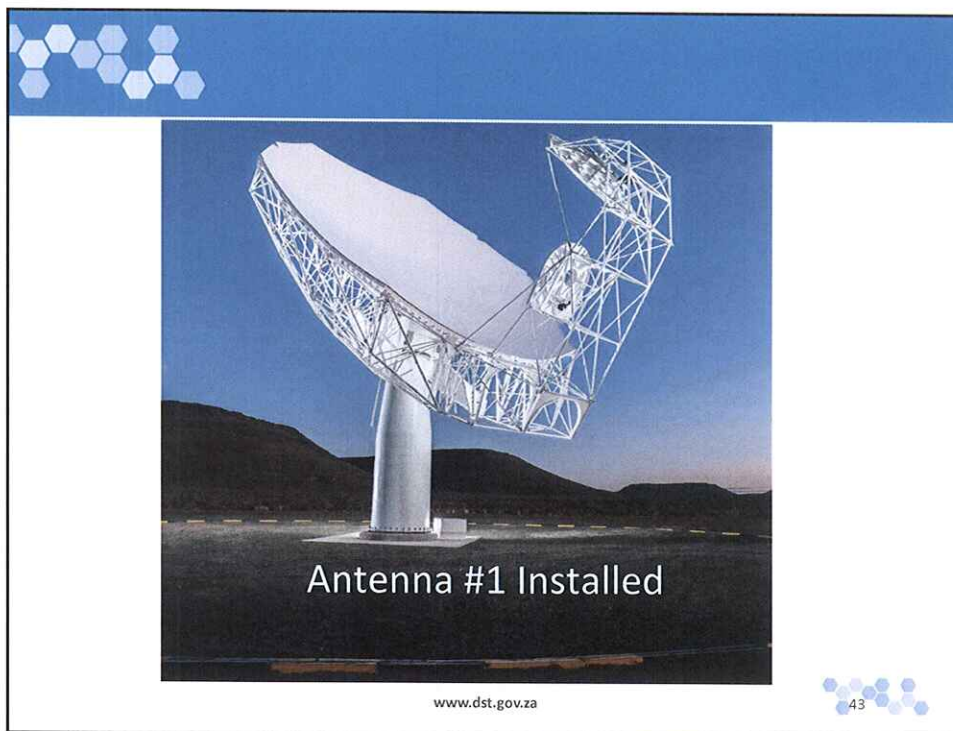


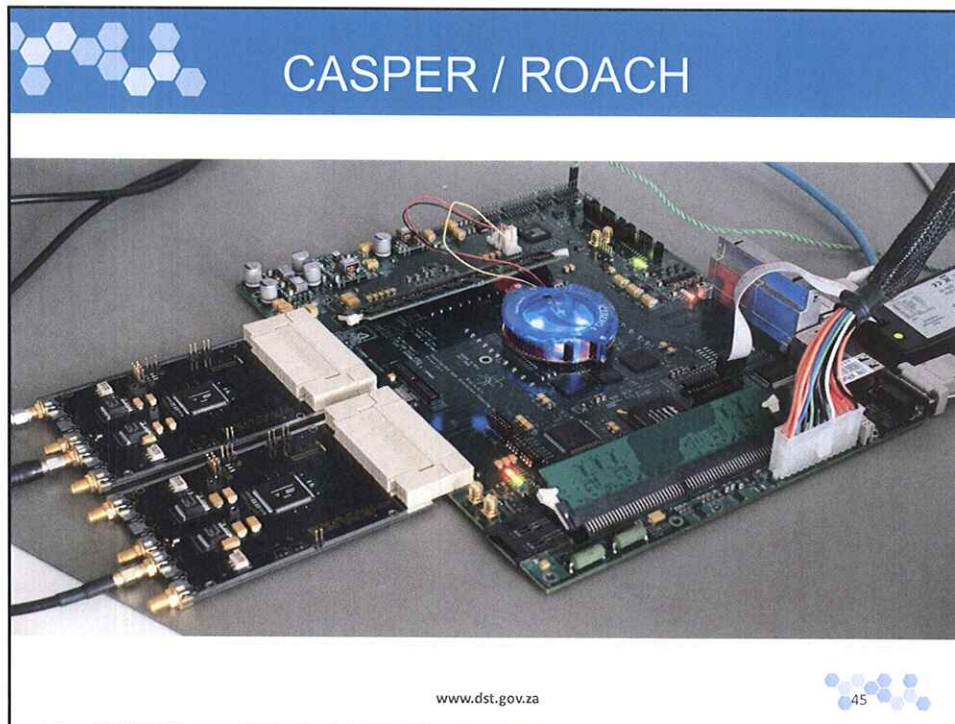






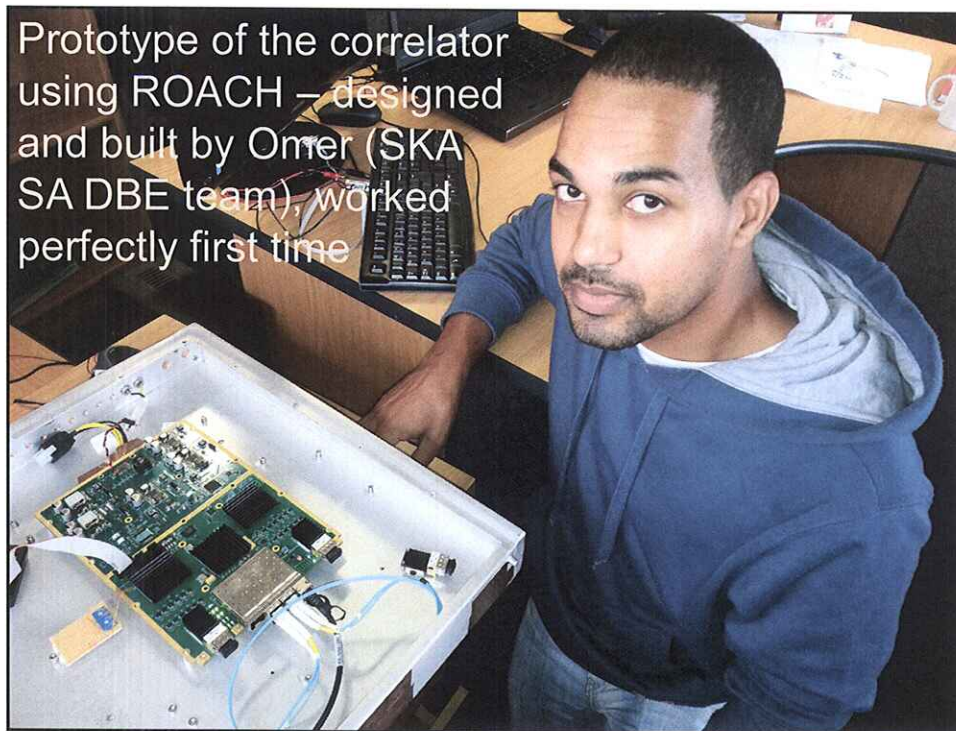






### Digitiser innovation

- First design in radio astronomy to sample directly at the receiver.
- Signal transfer between analogue to digital converter and processing unit using fibre optic cable.
- No electronic interference in MeerKAT frequency bands.
- Equipment expected to last for 30 years in extreme Karoo environment.
- No signal contamination inside Digitiser
- Most Digitiser components manufactured using South African industry partners.



## In-house expertise

- Circuit board design
- Circuit board assembly and testing
- Radio interference testing and characterisation expertise
- Digital signal processing design
- RF and fibre optic design



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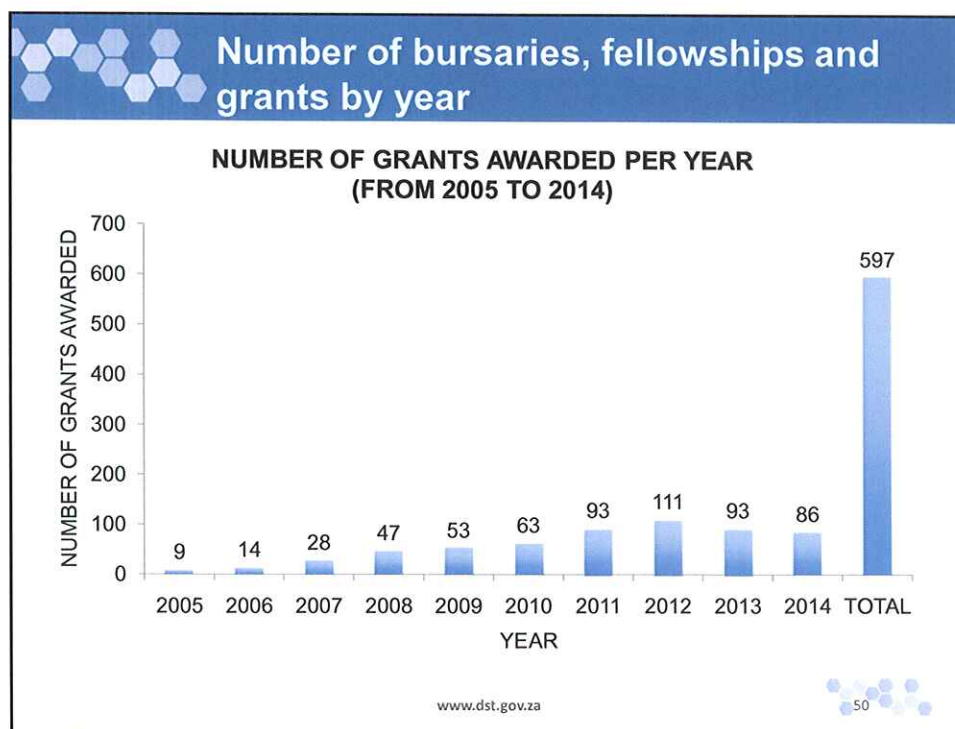
The slide features a blue header with a hexagonal pattern on the left and the title "In-house expertise" in white. Below the header is a list of five bullet points describing technical expertise. To the right of the list is a photograph of a woman in a black hijab sitting at a desk in a laboratory, with a microscope and other equipment visible. To the left of the list is a photograph of a man in a red hoodie standing in an anechoic chamber, surrounded by technical equipment. At the bottom left is the website URL "www.dst.gov.za" and at the bottom right is the number "48" next to a small hexagonal pattern.

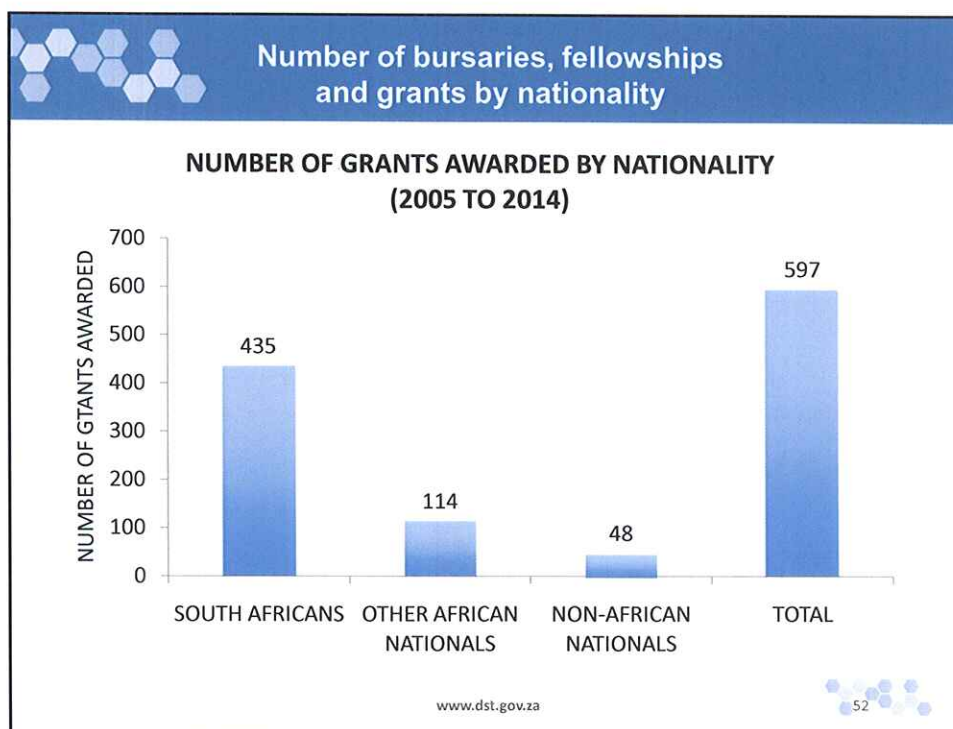
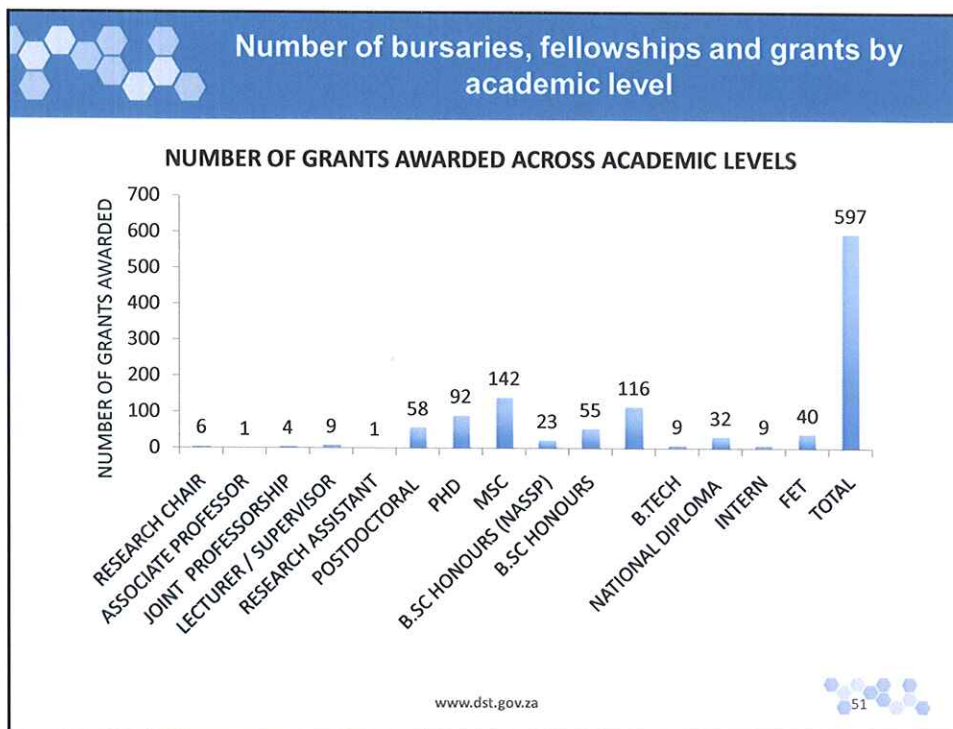


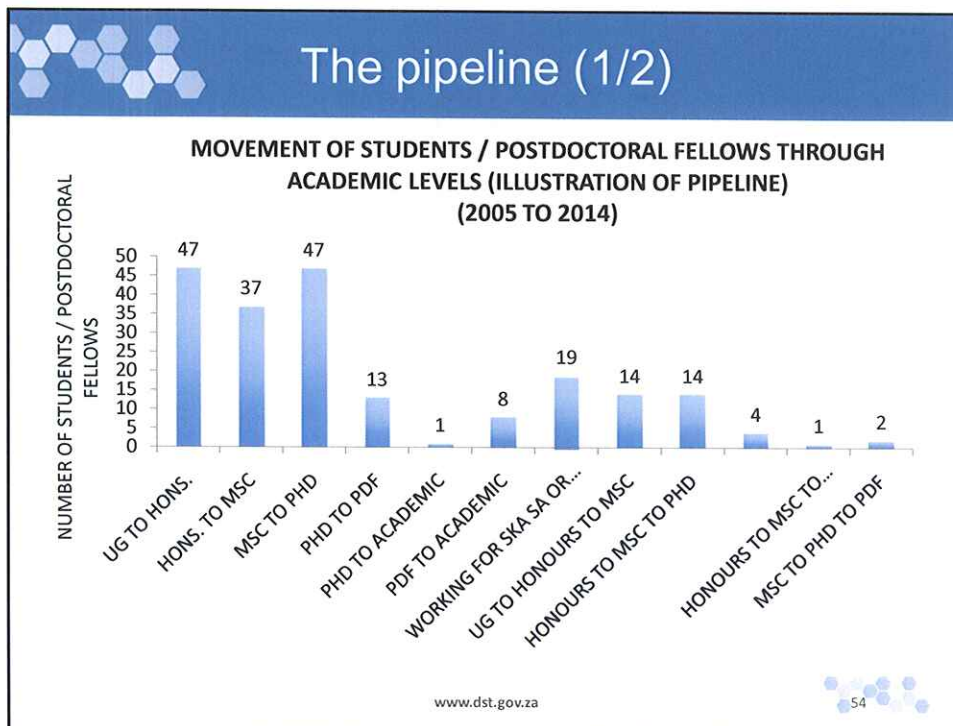
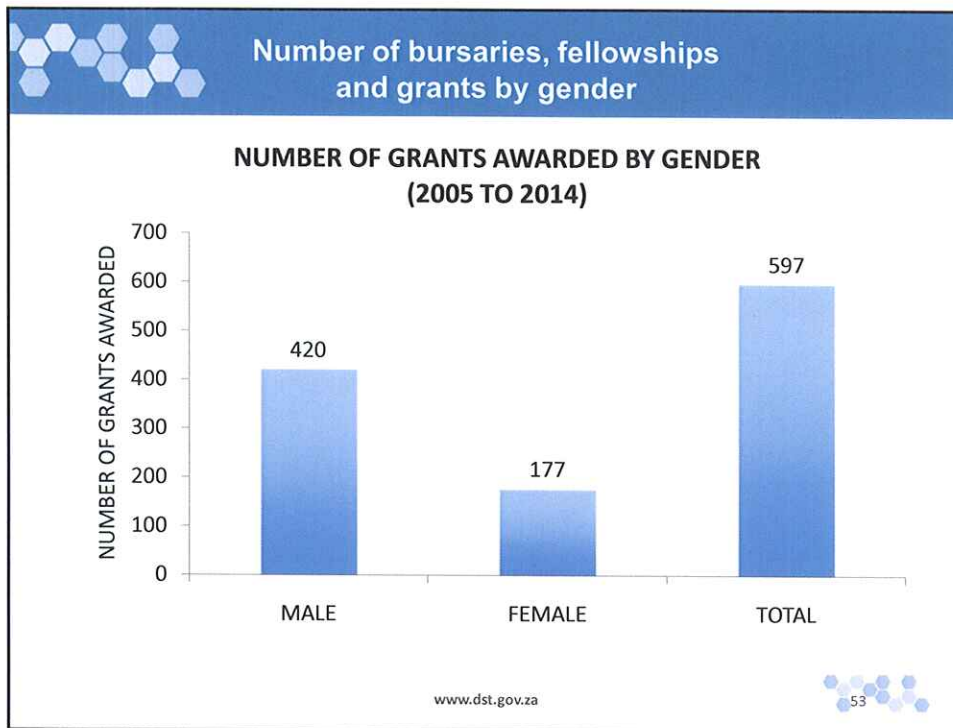
## SKA Work Packages

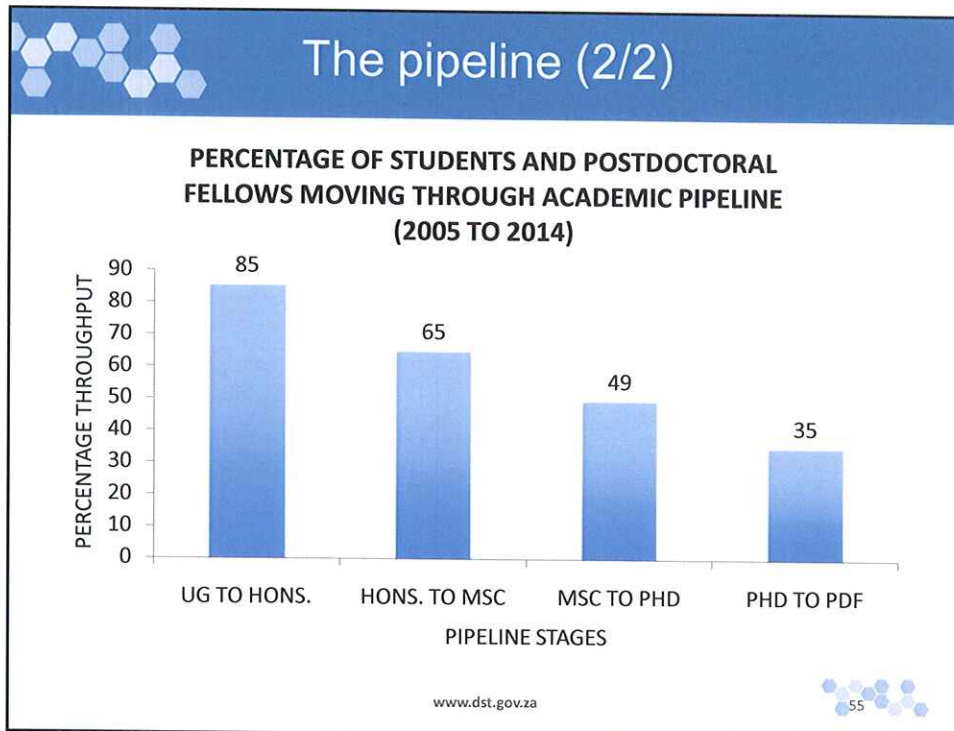
Work Packages	
Assembly, Integration and Verification (AIV)	Lead/SE
Central Signal Processor (CSP)	SE
Dish (DSH)	SE, Feeds, Optics, Prototype
Infrastructure Australia and Africa (INFRA AU/INFRA SA)	Lead/SE
Low-Frequency Aperture Array (LFAA)	
Mid-Frequency Aperture Array (MFAA)	
Signal and Data Transport (SaDT)	
Science Data Processor (SDP)	SE, LMC, LINFA, PIP.IMG
Telescope Manager (TM)	
Wideband Single Pixel Feeds (WBSPF)	

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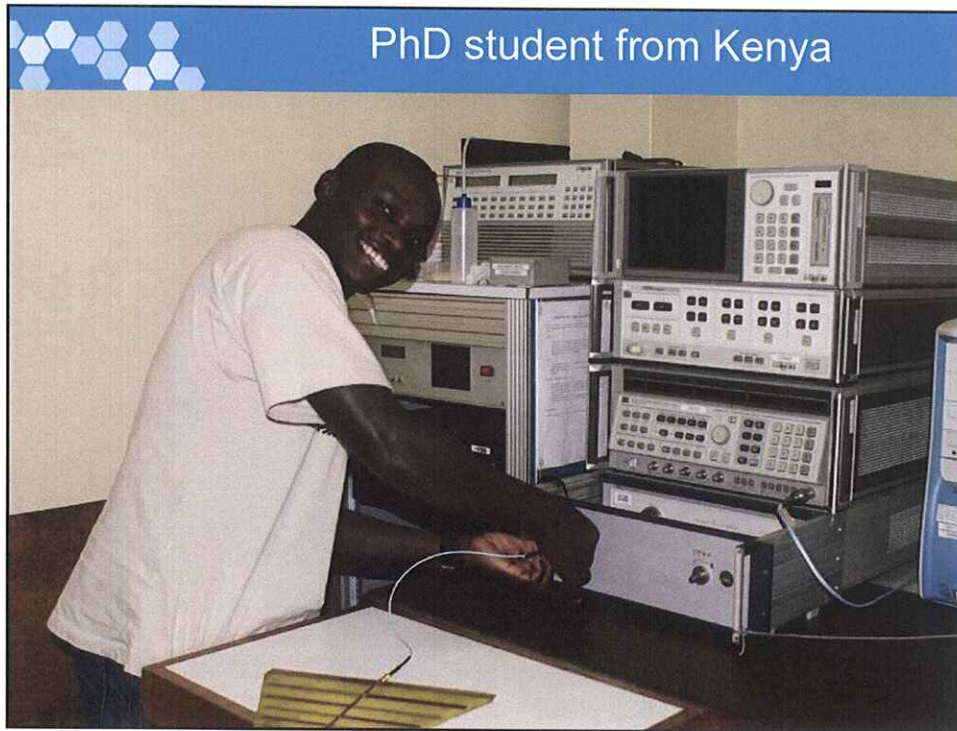
### Maths and science in the Karoo

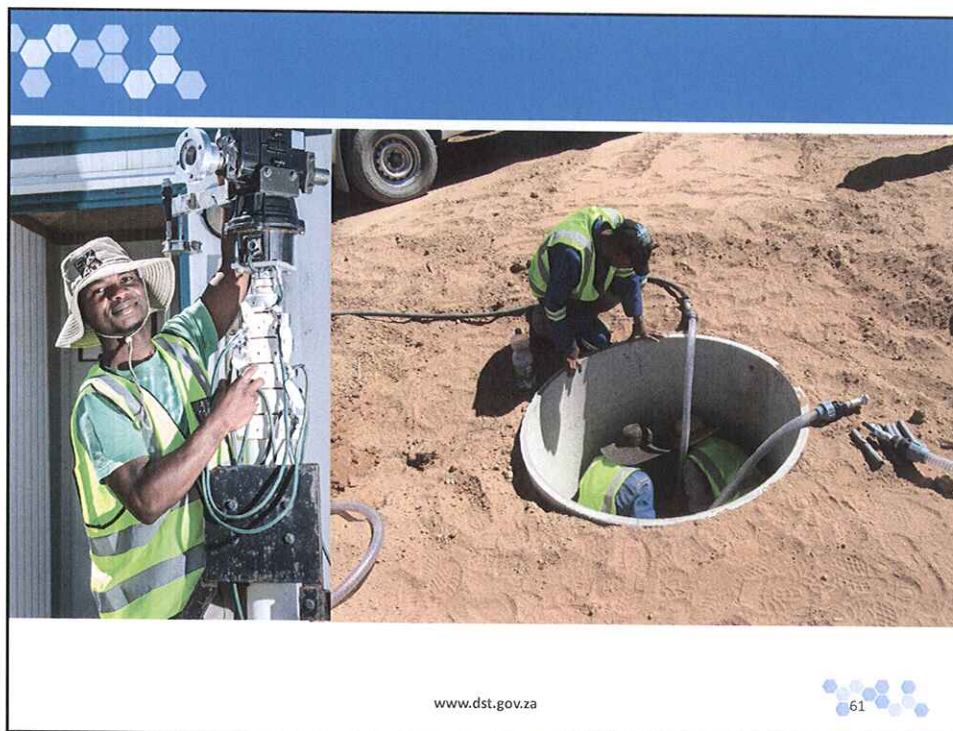
- Brought teachers in
- Bursaries for children from surrounding towns

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## Community Projects

- e-school initiative
- Community knowledge centre
- SKA tourism/science visitor centre
- Contractors empowerment programme

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E-LEARNING PROJECT IN CARNARVON



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The image shows a classroom where several students in school uniforms are seated at desks, each using a laptop. The background features a large mural of a landscape with several satellite dishes mounted on hills. The title 'E-LEARNING PROJECT IN CARNARVON' is displayed in a blue header bar at the top. The website 'www.dst.gov.za' and the number '63' are visible at the bottom.

Maths and science in the Karoo

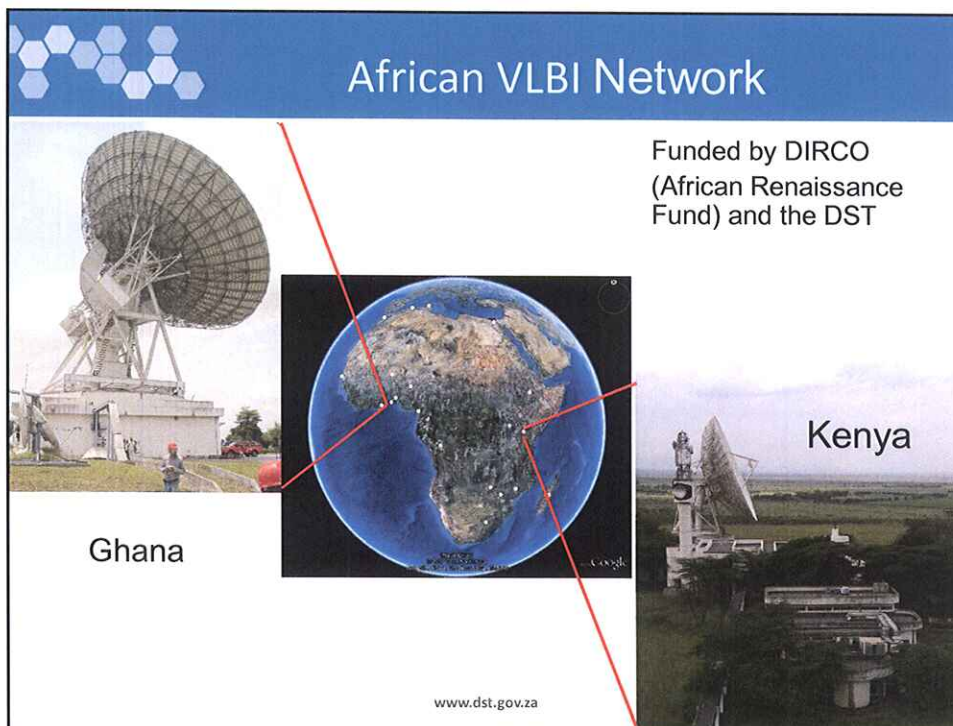
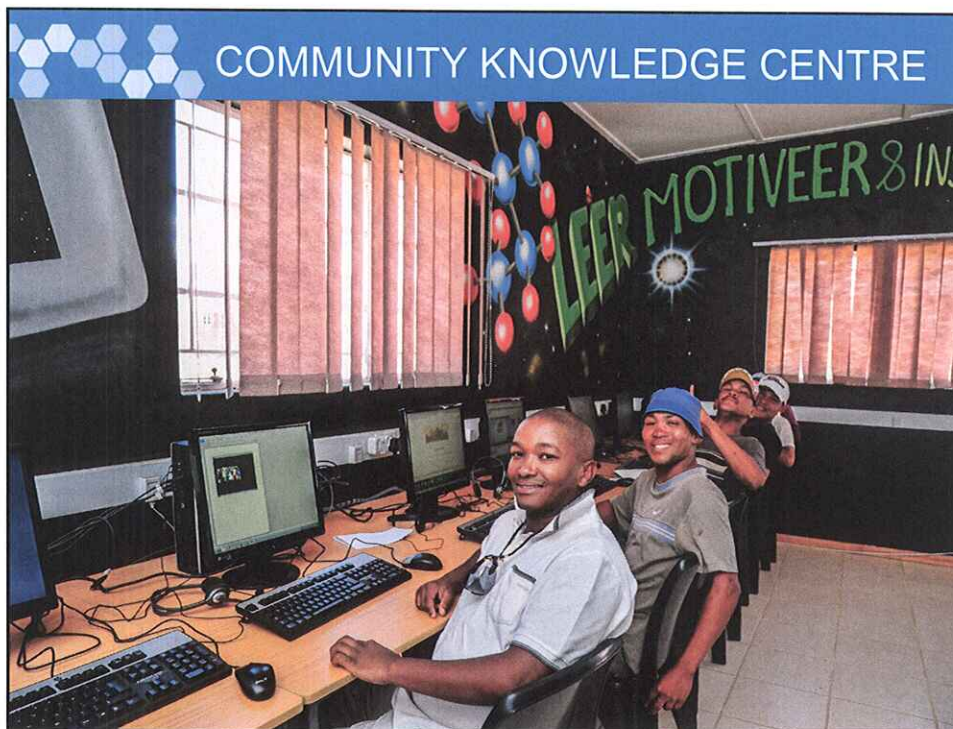
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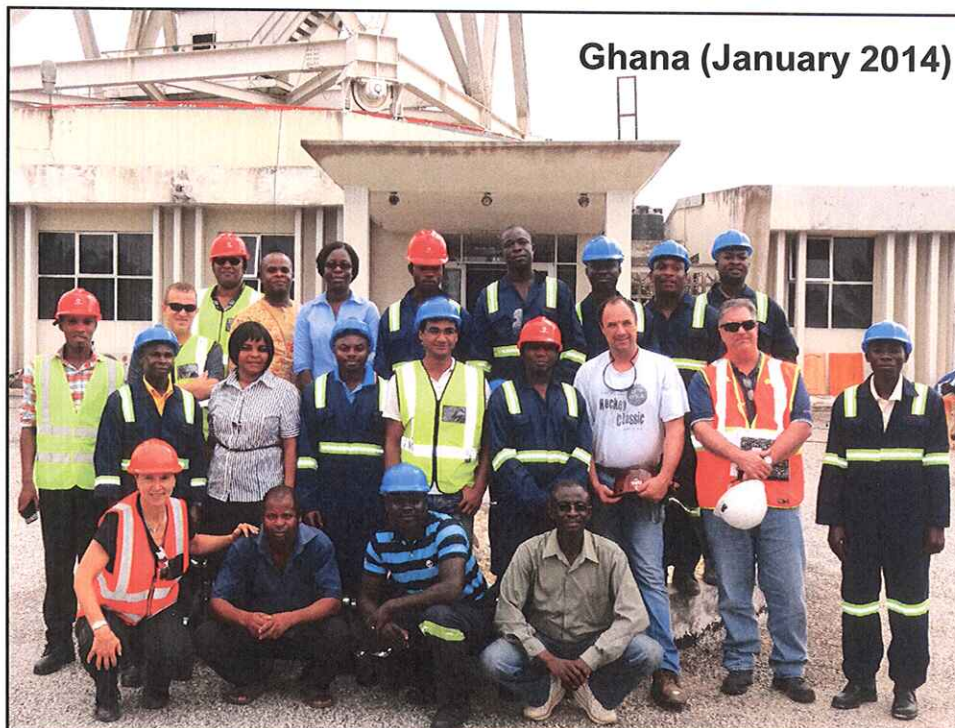
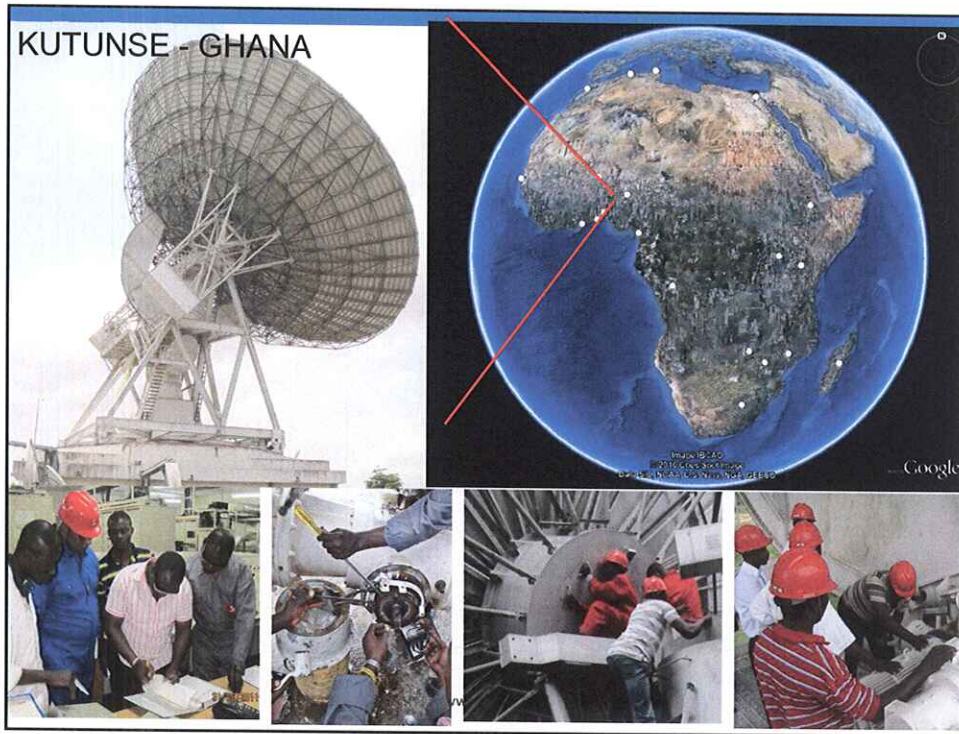
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The slide has a blue header bar with the title 'Maths and science in the Karoo'. Below the header, there is a bulleted list with two items. The website 'www.dst.gov.za' and the number '64' are located at the bottom of the slide.









## The data flood

- Dish array will produce about 10 x total data of the worldwide web
- Aperture arrays will produce about 100 x total data of the worldwide web
- Computing without buffering
- Storage challenge
- Power challenge is the key – “green computing”
- Major incentive for big IT companies to work with us – facing challenges they will face in 5-10 years time

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## Big Data


- \$ trillion industry by 2020
- We want a share of that
- No backlog – no need to play catch-up: all countries are rushing to develop capacity and expertise in high-performance computing, storage, processing, analysis, visualization, use of Big Data
- We can be world leaders – SKA gives us a head start

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## Science Data Processing

- Computing, and especially electrical power, likely to be limiting factor for SKA-1 and certainly for SKA-2
- Current baseline design calls for the following aggregate compute across three telescope sites:
  - Input data rate: 50+ Tbps
  - Total FLOPs: 500+ PFlops
  - Buffer Storage: O(100) PBytes
  - Final data products: O(10) EBytes
  - Power Consumption: 50 MW
  - Rack Space: 1200+ racks
- SKA is, almost uniquely, ahead of the curve in its requirements – this makes it an ideal investment for spin off technologies of significant relevance over the next few decades.

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## The data challenge

	MeerKAT	SKA Phase 1	SKA Phase 2*
Into Correlator	2 Tbps	50 Tbps	up to 5 Pbps
Into Science Processor	0.4 Tbps	20 Tbps	up to 500 Tbps
Into Archive	35 Gbps	300+ Gbps	up to 2 Tbps
Compute load	200 TFlops	30+ PFlops	3+ EFlops

```

graph LR
    A[Incoming Data from collectors] --> B[Switch]
    B --> C[Correlator Beamformer]
    C --> D[Switch]
    D --> E[Science Processor]
    E --> F[Science Archive]
  
```

\* SKA Phase 2 data rates are still fairly speculative

## Dome and other collaborations

- Collaboration with IBM Europe and ASTRON
  - Now including collaboration with IBM Thomas J Watson
- Roadmaps and chips from Intel
- CISCO and a SA university co-investing in a large laboratory

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## Big Data Africa

Big Data Africa	Research Themes (potential)	Industry Partners (potential)
<b>Activities</b> Funding Networks Workshops Staff exchanges Training Resource pooling Outreach, etc.	Astronomy Smart Cities Resource Management Finance/commerce Bioinformatics, etc.  Machine Learning Visualization Storage Streaming Accelerators Green computing, etc.	IBM Intel NVIDIA Software AG CISCO Oracle Cray Huawei etc.
		Funding Partners (potential)
		Industry IDC AERAP Local Gov NRF African Devel Bank etc.

## Business Development


- The Big Data Africa (BDA) Programme:  
 Creating a critical mass of expertise and infrastructure to enable Big Data research and application
- Egg Box PC:  
 Fully-fledged small form factor PC tailored to educational needs in rural areas
- ASTT ('BabyKAT'):  
 African VLBI small scale training telescope

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## Business Development

Commercialisation Programmes:  
PCB Technology Cluster

- Local high end PCB Manufacture
- Reconfigurable open architecture computing hardware development ('ROACH 3')
- Real Time Transient Analyser hardware and software development ('RATTY')c



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## Partnerships

- Science
  - Investment in MeerKAT (e.g. MPI and others)
  - Observing and development
  - Exchange programmes
  - Co-supervision
- Technology development
  - Industry (DOME etc.); institutions
- Human capital development
  - Young professionals programme
  - Technicians and artisans programme
- Teaching and research
  - Joint positions; post docs
- Big Data
  - Industry with universities
  - Workshops
  - Research institutes

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## Programmes are ready

- Big Data – 2 x workshops per partner p.a.
- Big Data – industry / university partnerships (as e.g. CISCO) for research and infrastructure
- Extend bursary programmes at all levels
- Joint appointments
- Support for researchers to participate in MeerKAT development and observations
- Invest in infrastructure – optical fibre cables and equipment; power lines; roads
- AERAP is an example

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## Benefits Accrued

**KAT 7 benefits (July 2008 to August 2010):**


- Total job opportunities created: 618 (50 female; 335 male, 232 youth, 1 disabled)
- Total cost for job opportunities: R8,9 million
- Contribution to Affirmable Business Enterprises (ABEs): R7,8 million
- Total contribution: R16,7 million

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## Benefits Accrued

**MeerKAT benefits from infrastructure & site operations (April 2013 - June 2013):**


- Total job opportunities created: 196 (165 Male, 31Female)
- Total cost for job opportunities: R13 110 250-79
- Total contribution to Affirmable Business Enterprises (emerging contractors): R4 780 922-57
- Total contribution to local suppliers: R32 648 862
- SKA SA long-term contracts: 27 local people (Carnavon) appointed by SKA A on site operations.
- SKA SA has employed over 100 people in Cape Town and Rosebank offices


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## SKA and Fracking



- Core and Central Astronomy Advantage Areas in Karoo and Sutherland have been declared in terms of the AGA Act (Act 21 of 2007)
- Declared areas to be protected and preserved – RFI and optical pollution
- Need for SKA and Fracking to co-exist, if not SKA must be protected






## SKA and Fracking


- DST participates in the Monitoring Committee of DMR to ensure astronomy interests are protected
- Need for buffer zones around astronomy reserves
- There **MUST** be concurrence from the Minister of Science and Technology on the license to explore and exploit potential shale gas reserves



- [www.ska.ac.za](http://www.ska.ac.za)
- [www.skatelescope.org](http://www.skatelescope.org)

[www.dst.gov.za](http://www.dst.gov.za)





Dankie  
Enkosi  
Ha khensa  
Re a leboga  
Ro livhuwa  
Siyabonga  
Siyathokoza  
Thank you

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