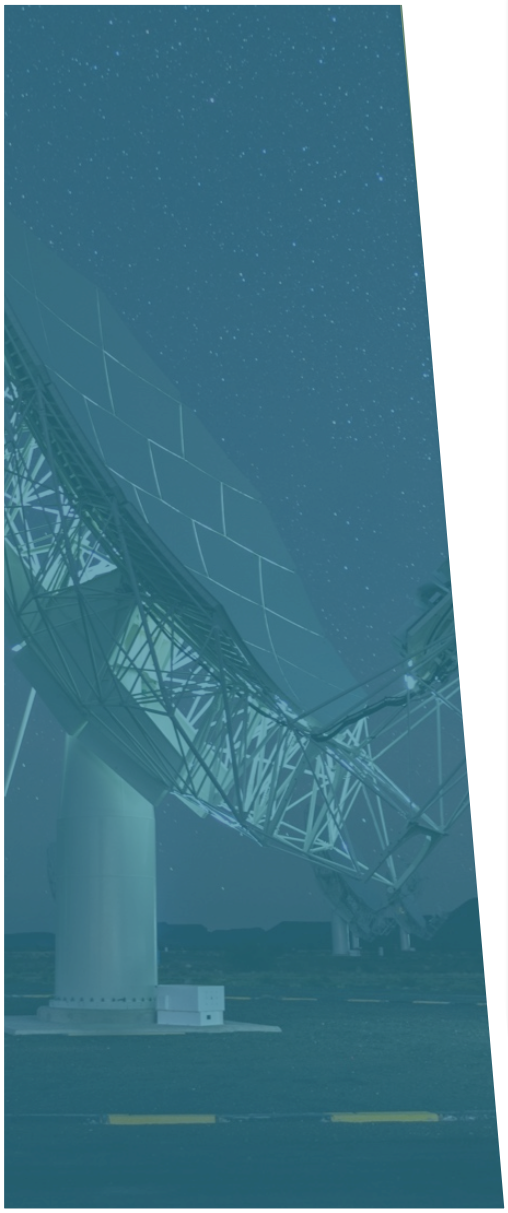


South Africa's motivation for joining the SKA

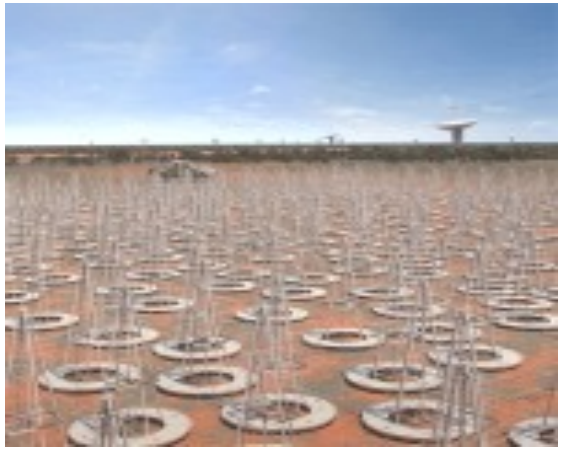
Dr Rob Adam
SARAO

Swiss SKA
03 October 2022

What is the SKA?

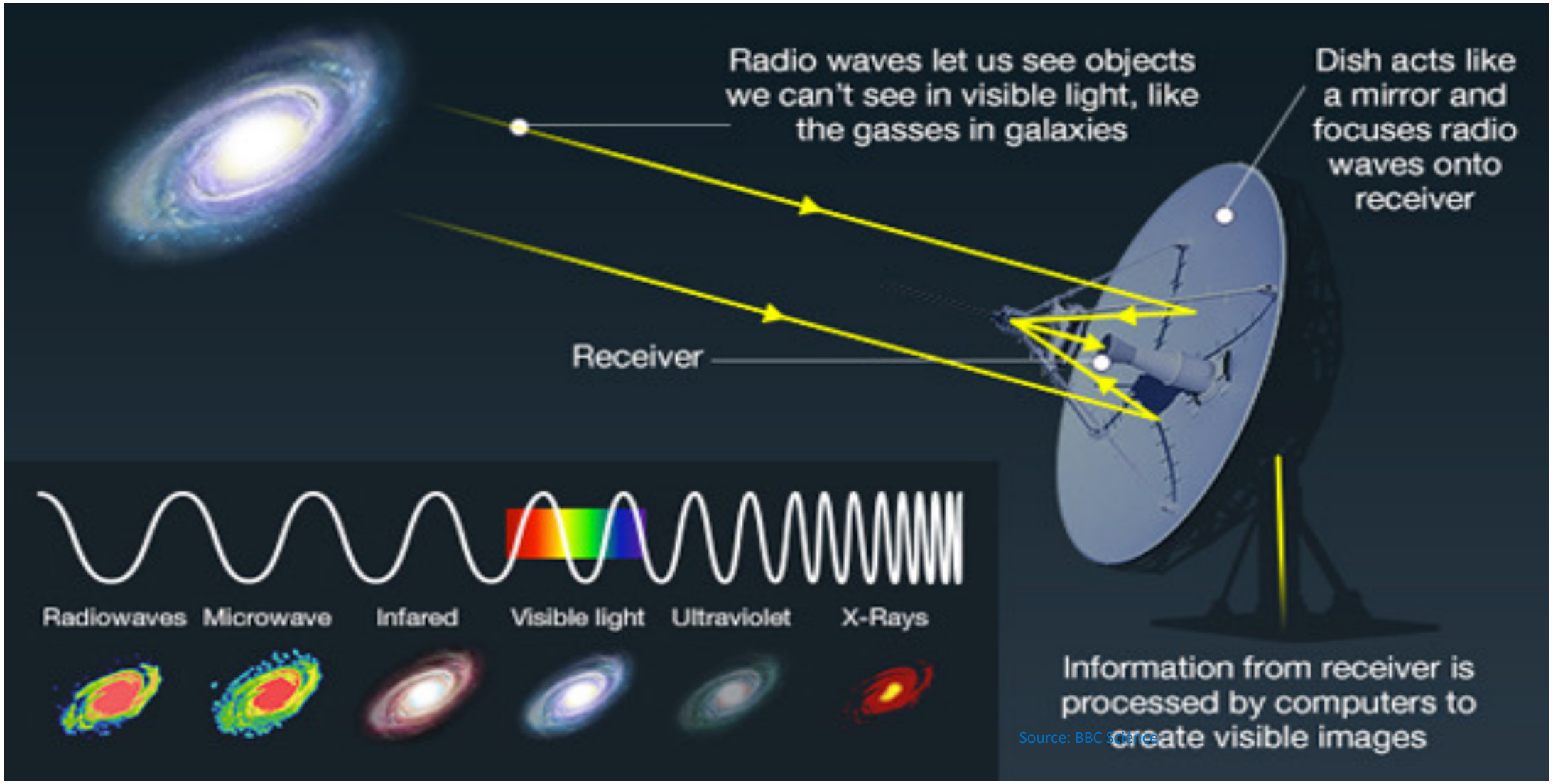
The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope, up to 50 times more powerful than any existing facility.

Hundreds and eventually thousands of mid frequency 15m dishes will be located in South Africa and Africa



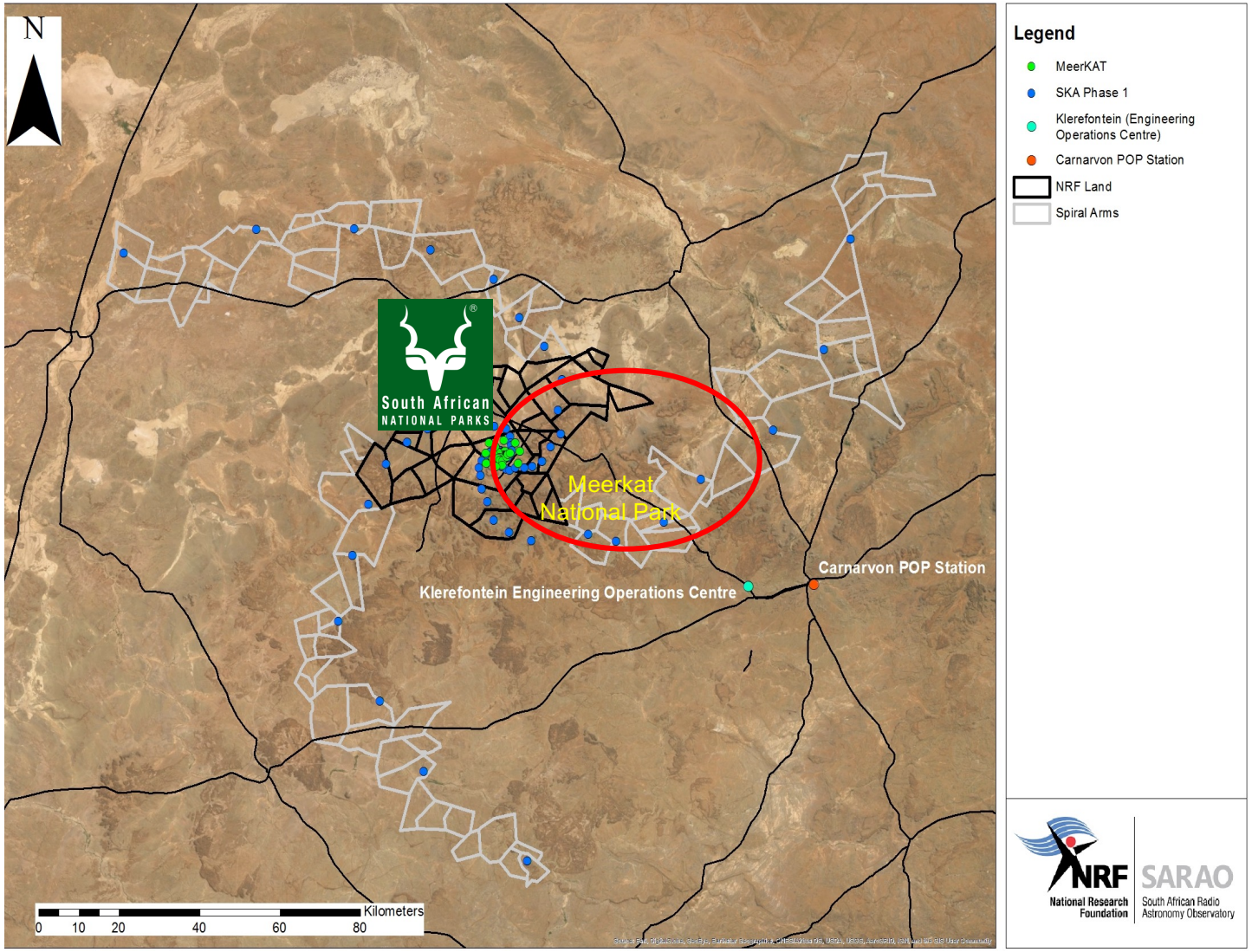
Hundreds of thousands and eventually up to a million low-frequency antennas will be located in Western Australia.

Collecting the radio signals




SKA– Key Science Drivers:
The history of the Universe
Cosmic Dawn
(First Stars and Galaxies)
Testing General Relativity
(Strong Regime, Gravitational Waves)
Galaxy Evolution
(Normal Galaxies z~2-3)
Cradle of Life
(Planets, Molecules, SETI)
Cosmology
(Dark Matter, Large Scale Structure)
Cosmic Magnetism
(Origin, Evolution)
Slide: Phil Diamond
Exploration of the Unknown
Broadest science range of any facility on or off the Earth.

Extent of the SKA site



Legend

- MeerKAT
- SKA Phase 1
- Klerefontein (Engineering Operations Centre)
- Carnarvon POP Station
- NRF Land
- Spiral Arms

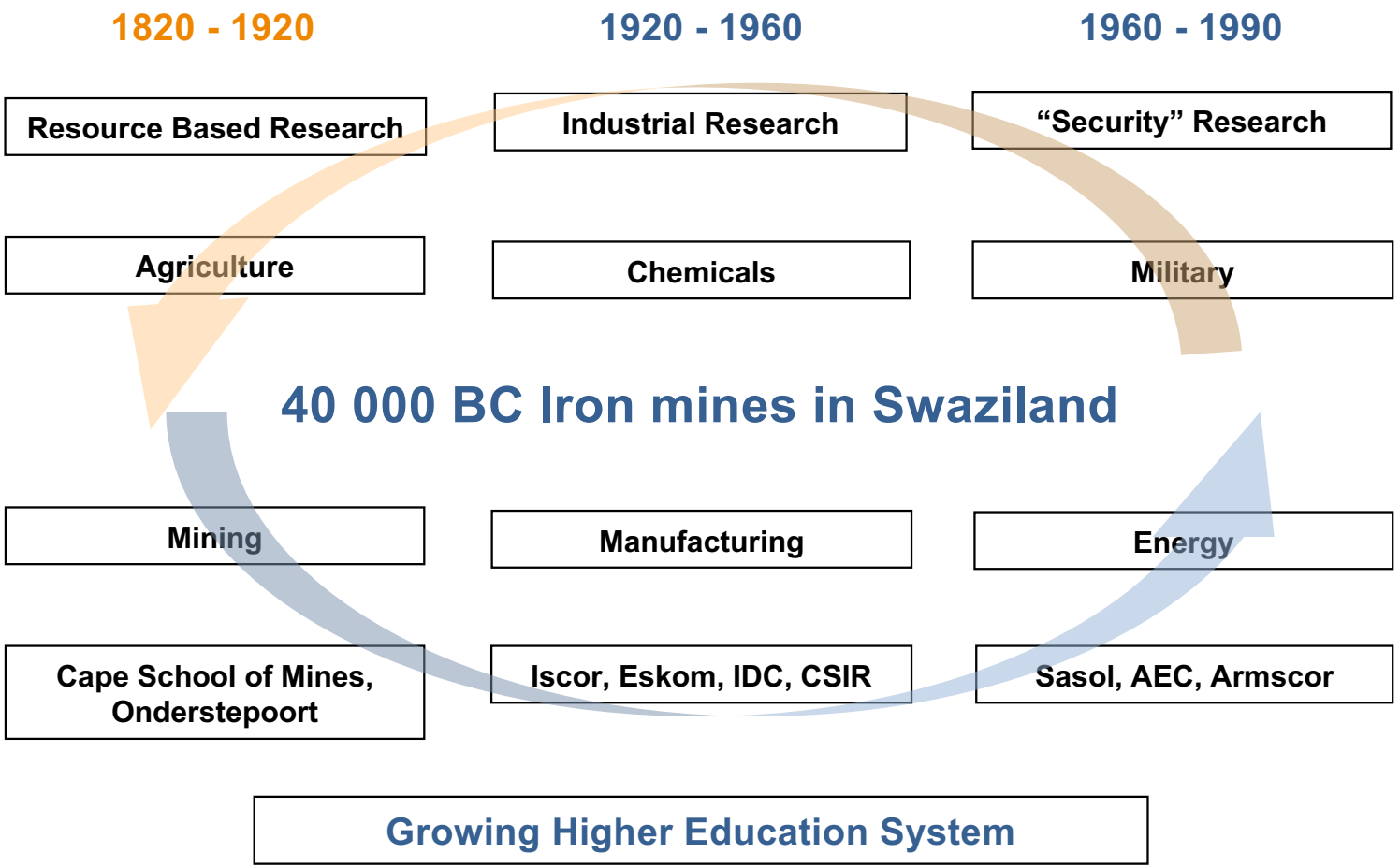
NRF National Research Foundation

SARAO South African Radio Astronomy Observatory

135,245 ha of NRF land declared as Meerkat National Park

Estimated 1200 ha of servitude for 3 spiral arms

History of the South African National System of Innovation



NRF National Research Foundation | SARAO South African Radio Astronomy Observatory

Problems to solve in 1994

1. Declining State investment in R&D - sharp drop between 1990 and 1994.
   Loss of major technology missions.
2. R&D not aligned to priorities of new government
3. Unstable and inequitable human resources base
4. Private sector R&D declining in many large companies
5. Fragmented governance

White Paper on Science and Technology - 1996

NRF National Research Foundation | SARAO South African Radio Astronomy Observatory

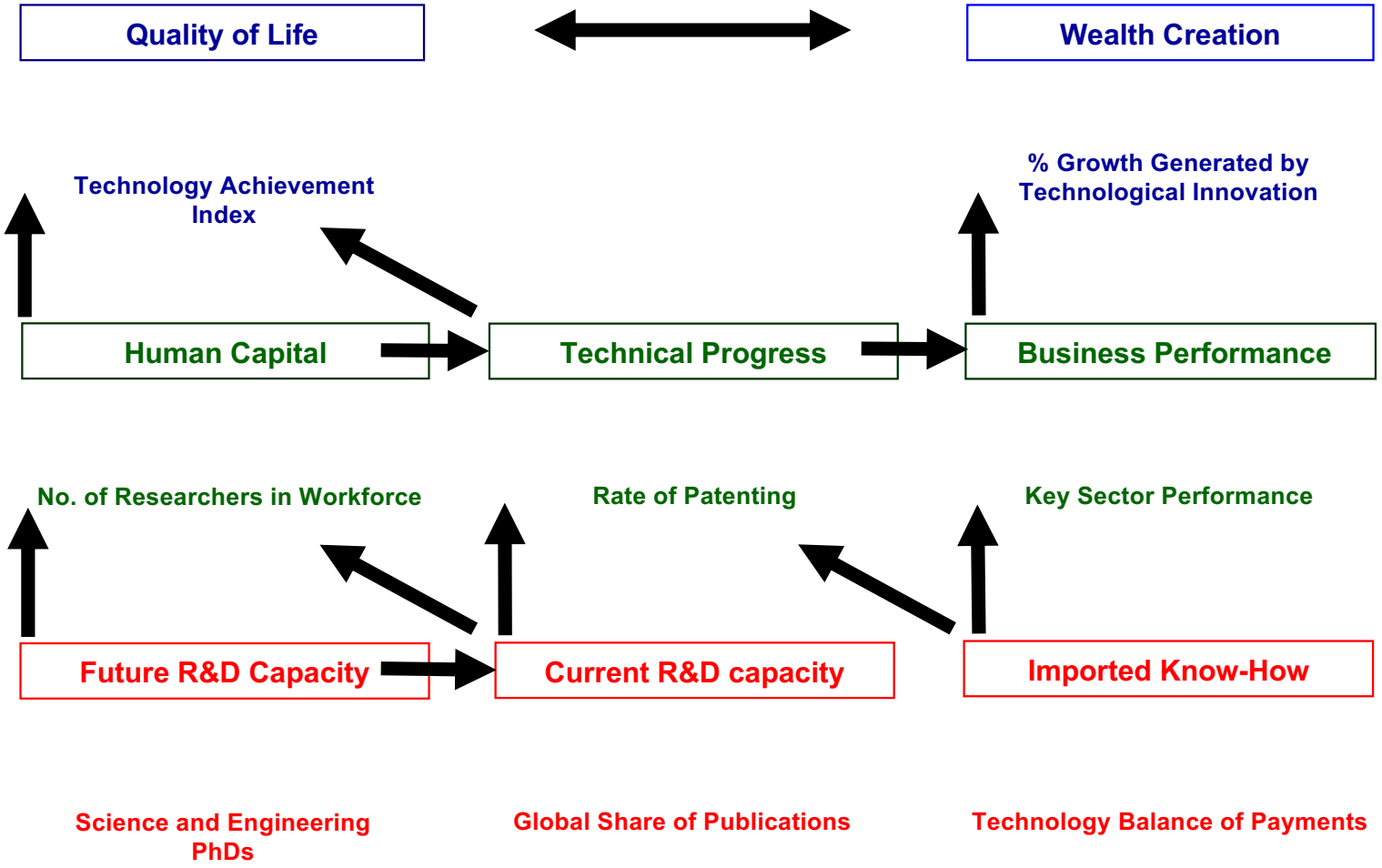
A few principles for selecting priority areas

1. Some areas are absolutely necessary for national competitiveness, for any size of country, e.g. information technology, biotechnology. Omit these at your peril!
2. Other areas present some “geographic” advantage, e.g. astronomy and “human origins” for South Africa
3. Other areas present a “problem” advantage, e.g. HIV/AIDS vaccine for South Africa
4. Other areas present a “knowledge” advantage, e.g. traditional knowledge or deep level mining for South Africa

A set of criteria for “core competence clusters”

1. A global competitive edge is possible, e.g. salmon production in Chile, deep level mining in South Africa
2. It is sustainable, e.g. does not depend just on a single research leader or funding window.
3. Hard to emulate, e.g. fluorochemicals or radiopharmaceuticals on the platform of a nuclear industry
4. Multiple applications are the norm - e.g. high performance computing, nanotechnology
5. Should be able to attract international investment and collaboration, e.g. astronomy and HIV vaccine development in South Africa

Expected outputs of a R&D Strategy



Pillars of the South African R&D Strategy (2002)

Human Capital

Developing and maintaining excellent and representative cohort of scientists

Innovation

Achieving mastery of technological change in our economy and society

Government System

Strengthening and re-aligning the S&T machinery of Government

Resulting in a set of South African R&D priorities

- Cradle of Humankind: Palaeontology
- Ocean currents
- Climate change
- Indigenous knowledge systems
- Biodiversity research
- Conservation
- Manufacturing
- Astronomy
- Mining and minerals

Australopithecus sediba was found at Malapa, South Africa, in 2008

An application of geographic advantage: multi-wavelength astronomy

Three bands of wavelengths available to ground based observations:

1. Optical: SALT was proposed as the largest optical telescope in the Southern hemisphere

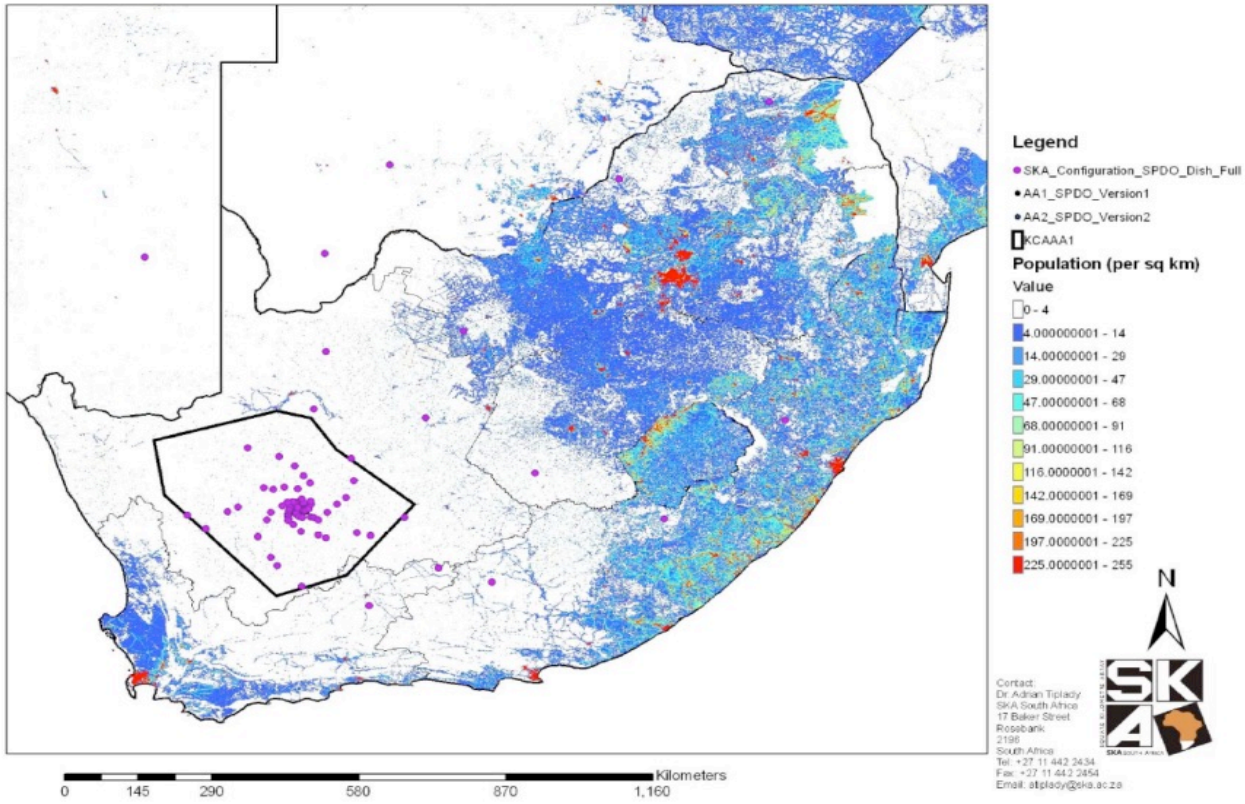
2. Gamma: HESS in Namibia is currently one of the premier gamma ray telescopes in the world

3. Radio: The SKA will be the most advanced radio telescope and the most extensive piece of research infrastructure ever built

Karoo geographic advantage area declared in terms of legislation

Declared Karoo Astronomy Advantage Area

- Astronomy Management Authority (DSI) mandated to protect in terms of regulations
- Co-Management Agreement
- Provision of 'radio astronomy friendly' communications necessary to enable protection



SKA: Global value proposition

- **Transformational Science:** Capable of addressing key questions in physics and astronomy
- **Excellent observing conditions:** Low radio frequency interference and dry conditions
- **Affordable infrastructure:** Power, telecommunications and transport costs reasonable
- **Available local skills:** Sophisticated engineering and maintenance sector to ensure competent operations
- **Cooperative Host:** SA Government sees SKA as the jewel in its research system
- **Good location:** Astronomical richness of the Southern skies

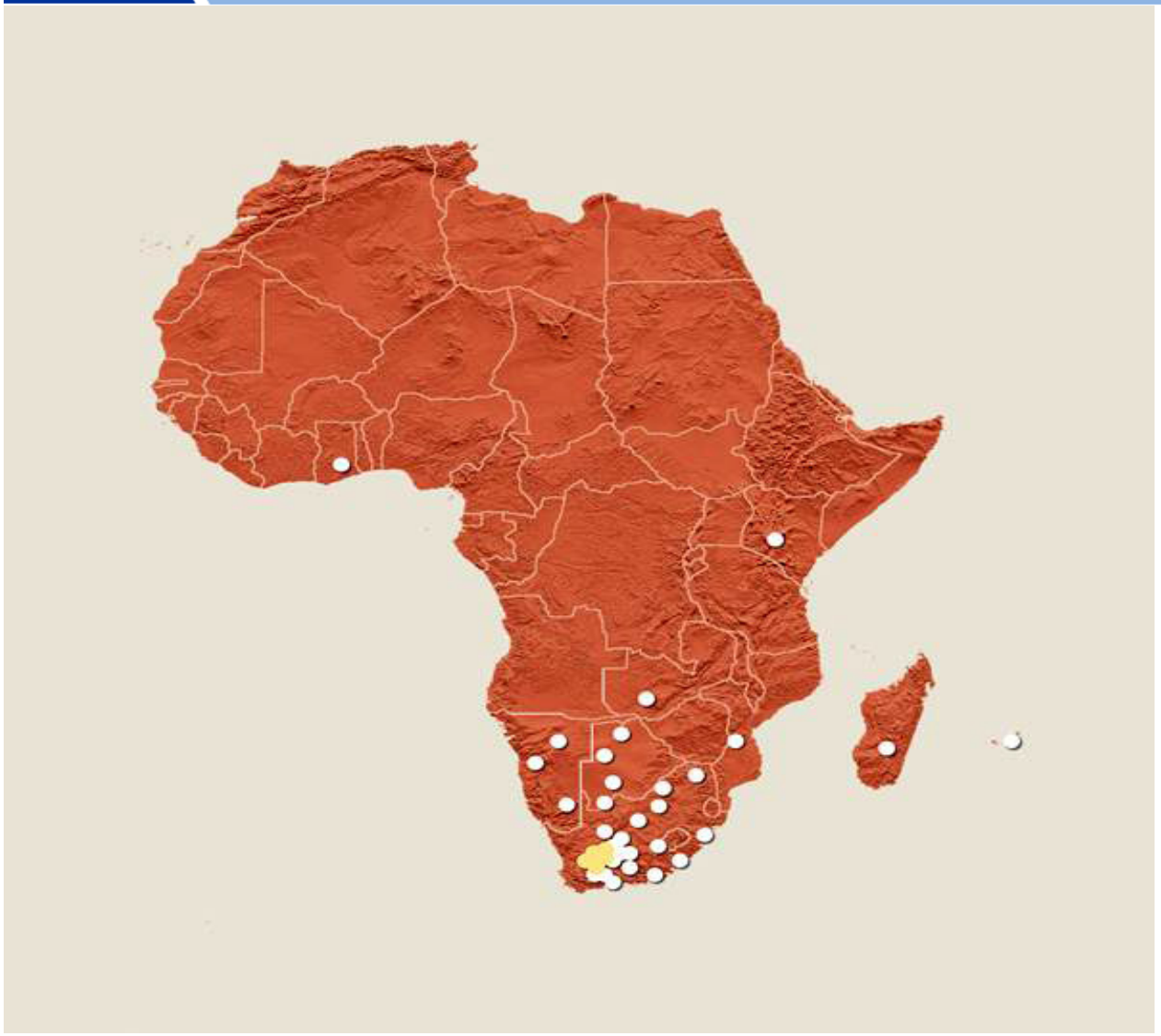
SKA: Local value proposition

- **Big data:** Development of South African capability in Big Data technologies.
- **Economic diversification:** Diversifying the Northern Cape economy towards technology and engineering support
- **Human resources:** Linking human resource development in South Africa with the best universities in the world.

.

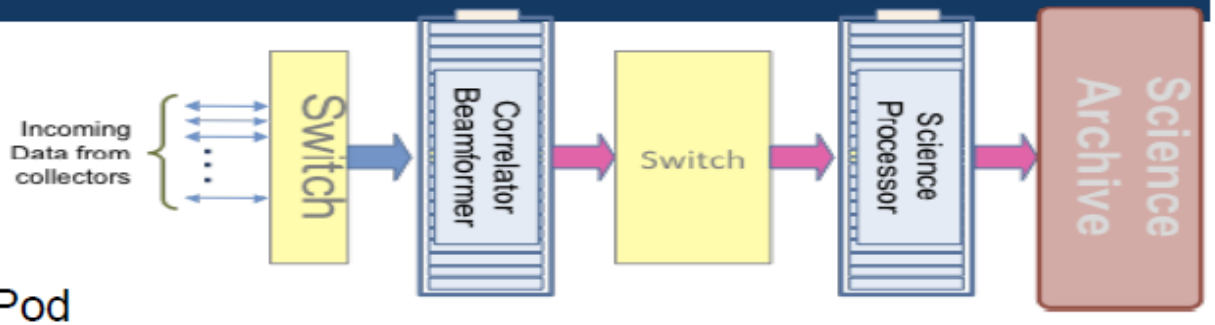
- **Raising our game:** Participation in a massive international engineering project, with deliverables and deadlines Promoting high quality human resource development
- **Geopolitics :** A powerful footprint of modernity on the African continent

Spiraling over Africa: SKA Phase II



The SKA Big Data Challenge

	MeerKAT	SKA1-Mid+	SKA2-Mid*
Into Correlator	2 Tbps (2k x office network) (700k x 32 GB / day)	50 Tbps (50k x office network) (17m x 32 GB / day)	up to 5 Pbps (5m x office network) (1.8b x 32 GB / day)
Into Science Processor	0.7 Tbps (240k x 32 GB / day)	20 Tbps (7m x 32 GB / day)	up to 500 Tbps (172m x 32 GB / day)
Into Archive	20 Gbps** (7k x 32 GB / day)	300+ Gbps (100k x 32 GB / day)	up to 2 Tbps (700k x 32 GB / day)
Compute load	200 TFlops	30+ PFlops	3+ EFlops



\+ Prior to rebaselining
* Data rates indicative only
** Sustained
32 GB –> large flash drive / mid iPhone / iPod

Multiple political stakeholders

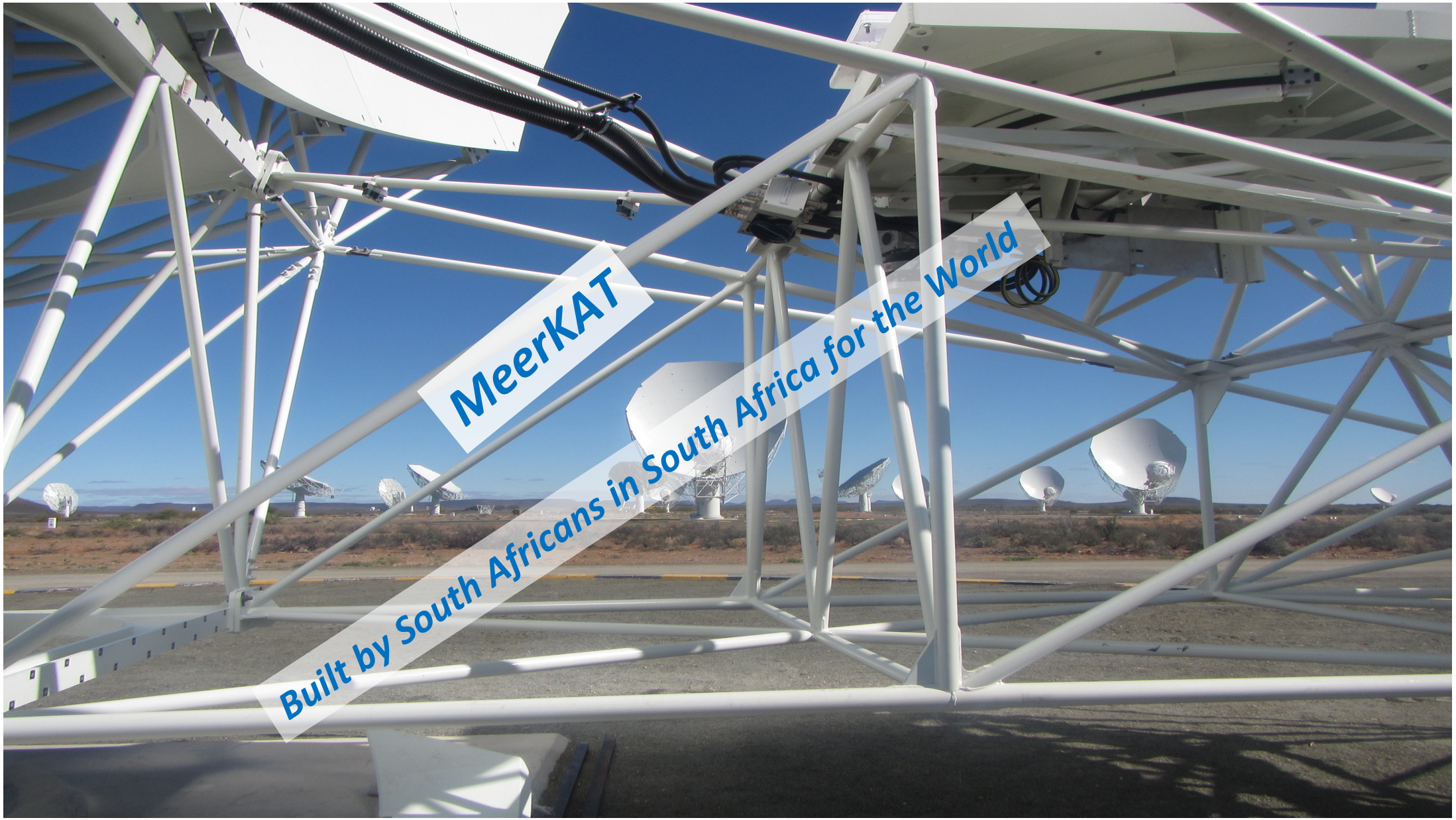
Key Ministers:

Science and Technology	(Science impact)
Communications	(Telecommunications)
Foreign Affairs	(African development)
Trade and Industry	(Industrial standards)
Provincial & Local Government	(Regional development)

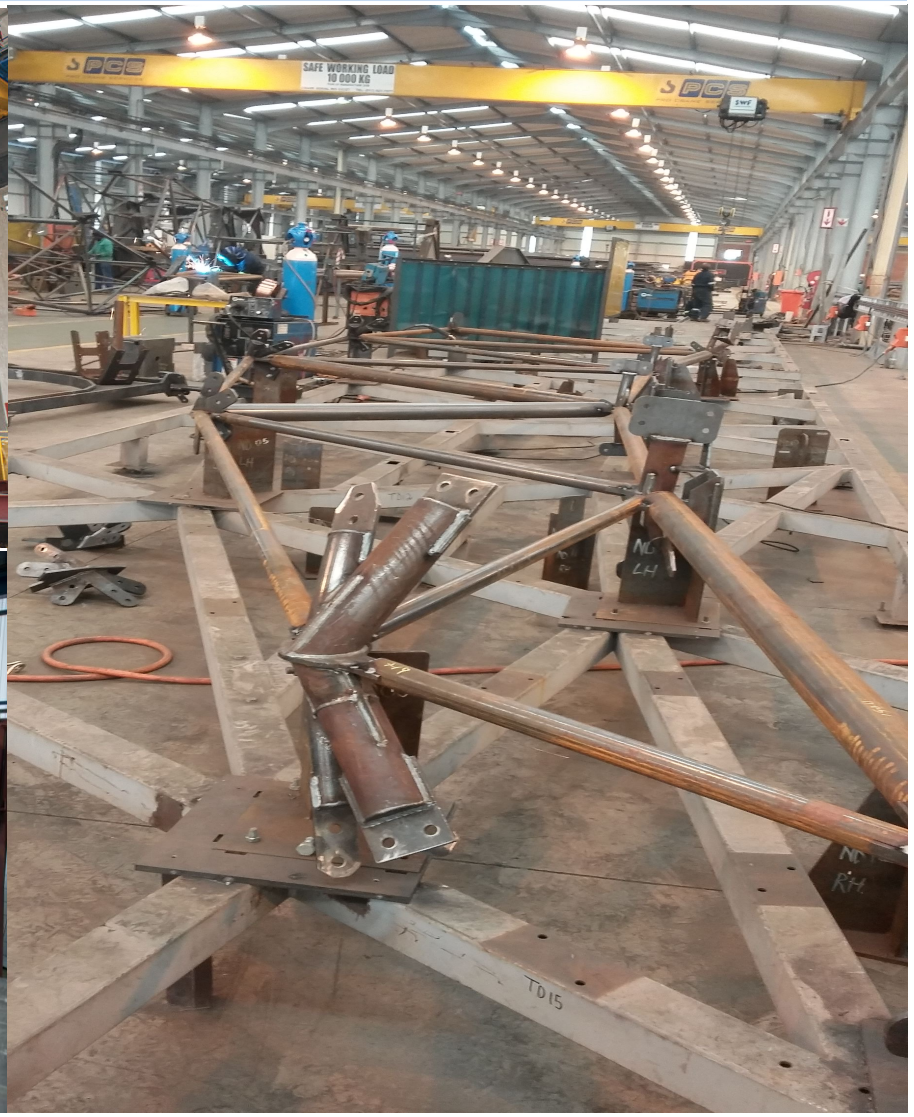
MeerKAT and SKA Roll Out

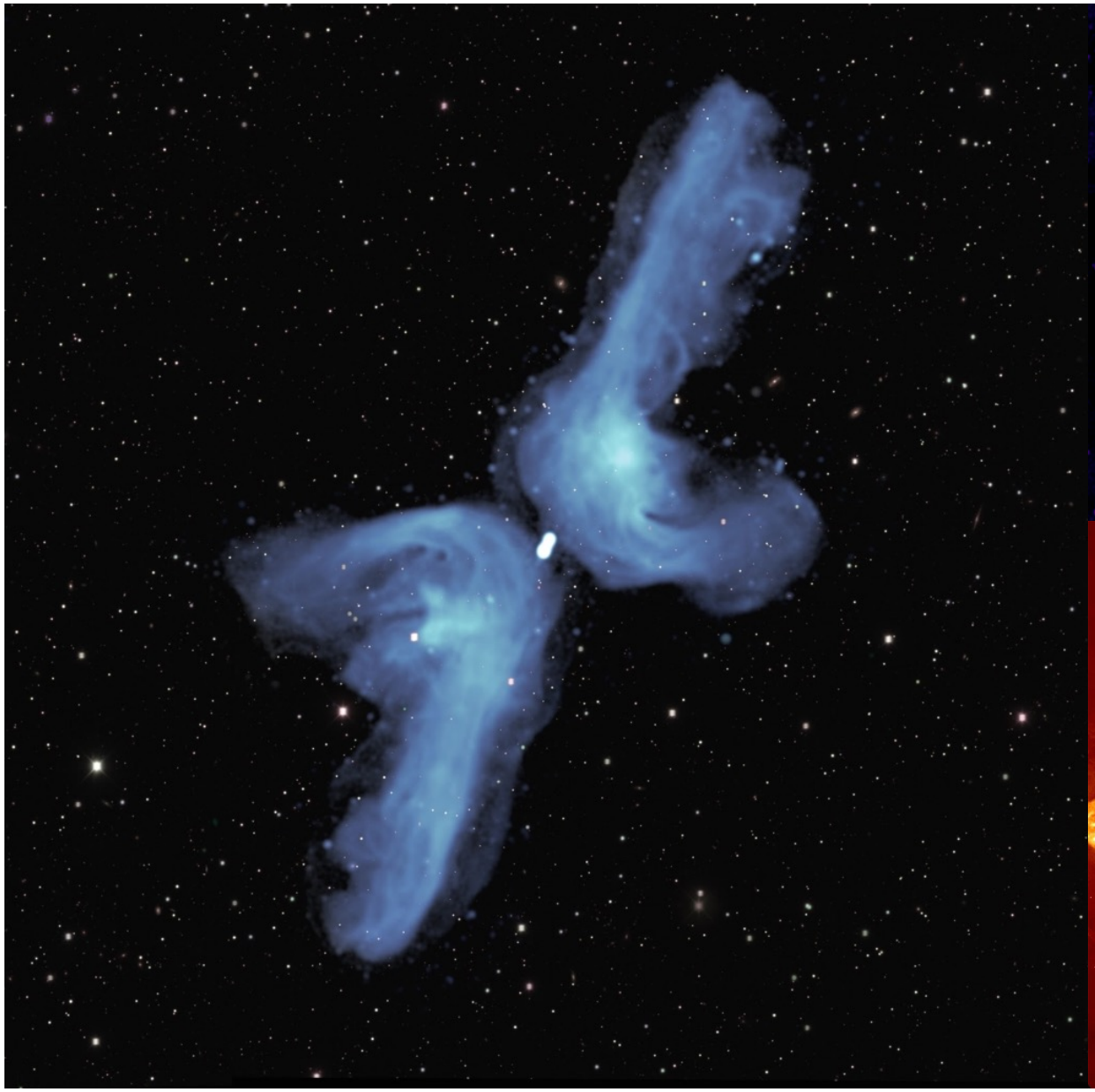
- SKA rolled out in a phased approach
- KAT-7 completed in 2010 as an engineering test bed - did some good science
- MeerKAT 64-dishes launched on 13 July 2018 by Deputy President Mabuza
- SKA Phase 1 (2021-2027)
  - MeerKAT (64) + 133 SKA dishes = 197 dishes
  - Up to 80 km baseline to core
- SKA Phase 2 (beyond 2030)
  - Full dish requirement (3000 dishes, 3000km baseline)
  - Full dense aperture array requirement (250 stations, 180km baseline)

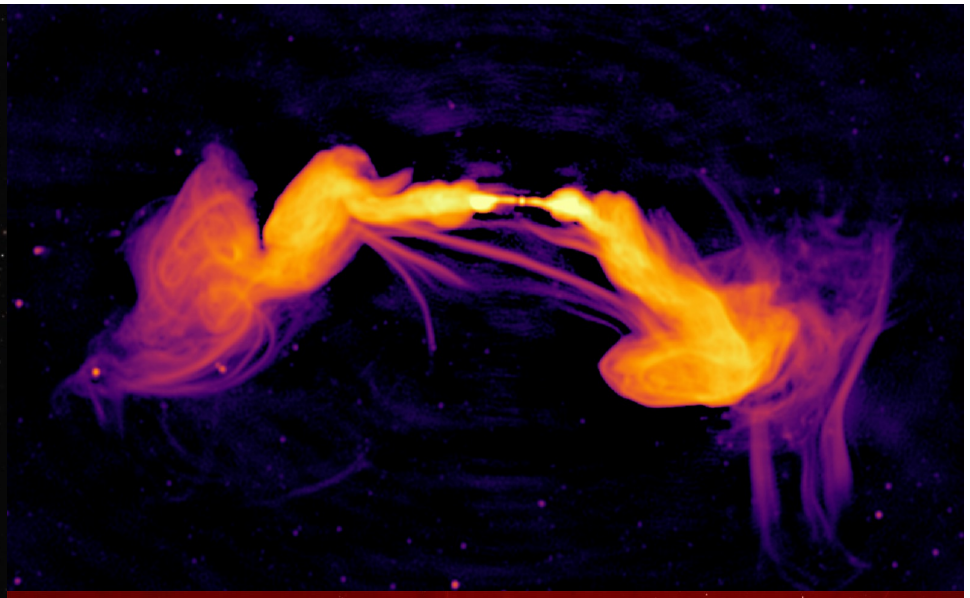
The MeerKAT infrastructure

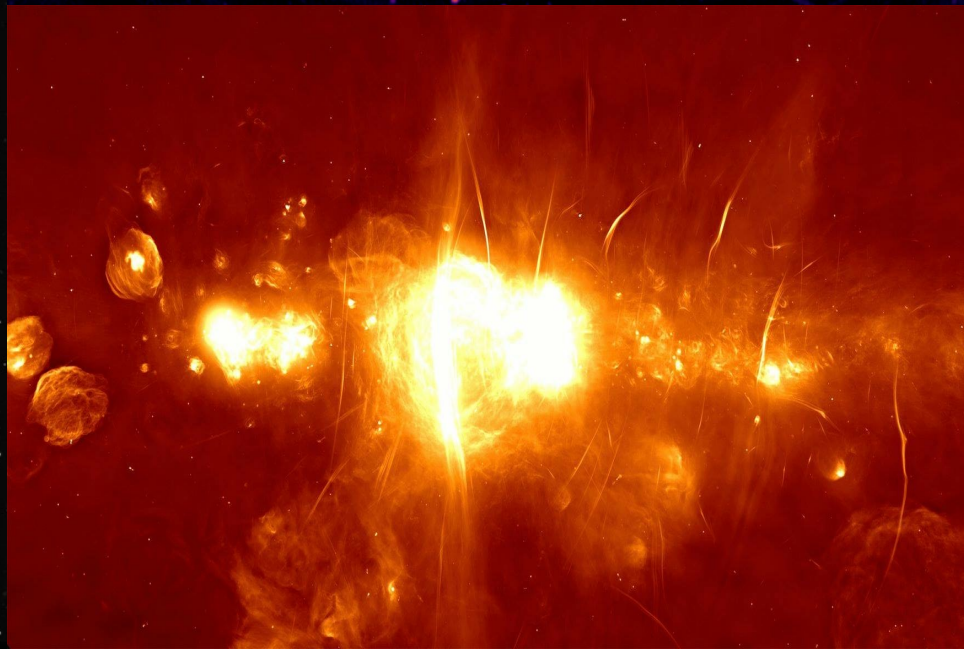

MeerKAT
Built by South Africans in South Africa for the World

Designed, manufactured and constructed in South Africa









Excellent science

Radio image made with MeerKAT of the centre of our Milky Way galaxy

Clearest such image ever made – unveiled at MeerKAT inauguration, July 2018

Socioeconomic benefits

Schools Programme

On-the-job Training

Contractors Forum

Community Knowledge Centre

Local expertise & business development

Building the next generation of astronomers

2018 SARAO Postgraduate Scholarship Conference

Some factors to consider

- For a developing country, prioritising science is very difficult.

- We want to attract young people into science and engineering. We want to keep the best of them in these subjects and in our countries. This means we have to provide them with exciting and challenging projects.

- The most exciting projects of all are in general the very expensive, multi-national science infrastructure projects. It is possible to participate in these projects through broadband connections. But having a project located in your country creates a centre of science and engineering, which stimulates technology in local industry and science and technology in universities. Bringing the most respected and most creative scientists and engineers to the centre creates a stimulating environment for local scientists and students.

Some factors to consider

- But there is an opposite point of view that says developing countries should only do science that is immediately relevant to their socio-economic development. Although there is nothing wrong with focusing on the most appropriate science for local nutrition, health and energy, the most likely citizens to solve these problems are those who have had their minds stretched by the big global science projects of the age.

- If the big projects are located only in the developed countries, you will never allow the developing countries to make significant progress in the hard sciences and technology, because you will always be draining off the best students and researchers (and engineers).

Some factors to consider

- We must prevent the growth of a scientific divide, which effectively denies the developing countries the science and technology expertise and capability which will allow them to participate in the growing percentage that high technology industries contribute to global trade.

- The big iconic science projects, if managed well, can provide a mechanism to develop indigenous high tech capabilities in developing countries.

The five musketeers

Thank you!