Radio Astronomy for Africa
and Africa for Radio Astronomy

Partnership opportunities with Portugal / Europe

Daan du Toit

South African Senior S&T Representative to the EU

SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

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

Presentation Overview

- Why radio astronomy in South Africa and Africa
- The Square Kilometre Array radio telescope in Africa
- Radio astronomy in Africa: Achievements and Impact
  - African cooperation programme
  - Physical Infrastructure
  - Scientific Infrastructure
  - Science, technology and industry collaboration
  - Africa VLBI Network
  - Human capital development
- Partnership opportunities with Europe and Portugal

Astronomy in Africa

Why radio astronomy in Africa: Reaching our Potential

- Growth of an African middle class currently based on resource extraction - not indefinitely sustainable
- Even for South Africa, resources are still a very large % of exports
- Diversification essential – especially into the global knowledge and technology economies
- We must have a long-term vision

Reaching our Potential

- Africa as the next great business destination and the next great growth continent (see McKinsey, Boston Consulting, etc.)
- Growth of business opportunities – multinational interest
- How do we get there?
  - Infrastructure and logistics
  - Skills
  - Effective governance and administration
  - Education
  - Entrepreneurial growth
- Importance of high-level ICT and science skills
  - Construction, maintenance and use of infrastructure
  - Facilitating business development
  - Improving quality of government and administration
  - Capacity for innovation and participation in the global knowledge economy

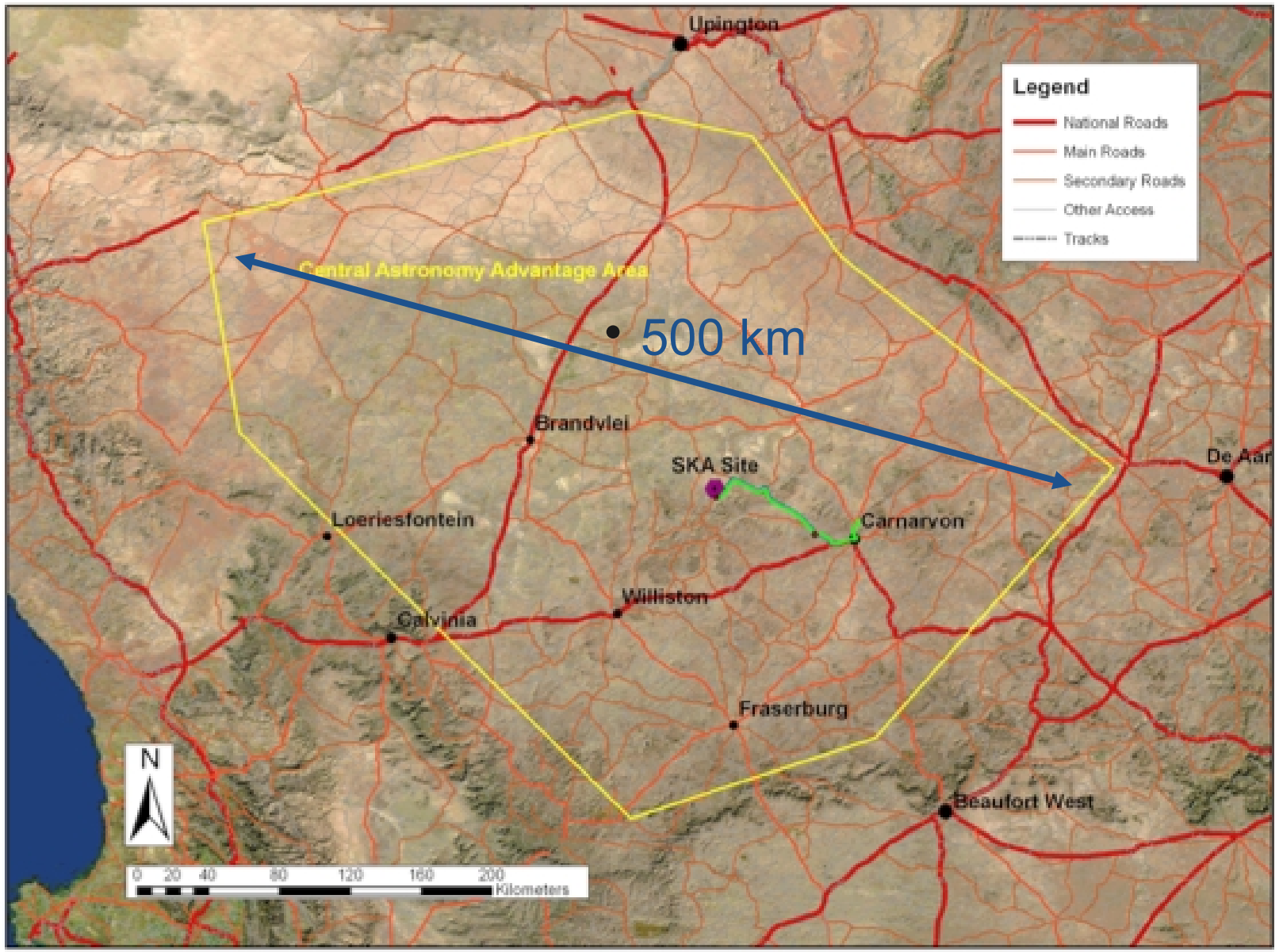
But why Radio Astronomy?

- Astronomy has great public appeal
- Radio astronomy has historically led to major technology spin-offs especially in ICT
- Mega-projects (e.g. science research infrastructures) can be uniquely productive:
  - Raise profile, raise money and drag unrelated development along
- Develop human capital
  - Profile science and engineering as key development issues
  - Attract young people into SET training and careers especially ICT
  - Strengthen universities and teaching
  - Develop high level technical and scientific capacity for innovation
  - Develop high level problem technical and problem-solving skills to strengthen administration and governance

Deliberate and long-standing government policy

- 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"**
- National R&D Strategy – 2002
  - "One way to achieve **national excellence** is to focus our basic science on areas **where we are most likely to succeed because of important natural or knowledge advantages. In South Africa, such areas include astronomy, human palaeontology and indigenous knowledge"**

Karoo Radio Astronomy Protected Reserve



Astronomy Geographic Advantage Act protects radio and optical (and other) astronomy

- Close cooperation with communities, regulator and broadcast and telecommunication operators
- Excellent support from Vodafone, MTN, Sentech etc.

Government Gazette
Staatskoerant

REPUBLIC OF SOUTH AFRICA
REPUBLIEK VAN SUID-AFRIKA

Vol. 516 Cape Town, Kaapstad, 17 June Junie 2008 No. 31157

THE PRESIDENCY

No. 666 17 June 2008

It is hereby notified that the President has assented to the following Act, which is hereby published for general information:—

No. 21 of 2007: Astronomy Geographic Advantage Act, 2007.

MOPRESIDENTE

No. 666 17 June 2008

Go itsiswi fano gore MoPresidente o saennwe Molao o o latelang o o phasalediwang kitso ya botlhe fano:—

No. 21 2007: Molao wa Mafelo a a Sametseng Bolepanaledi wa 2007.

9 771682 584003 31157

AIDS HELPLINE: 0800-0123-22 Prevention is the cure

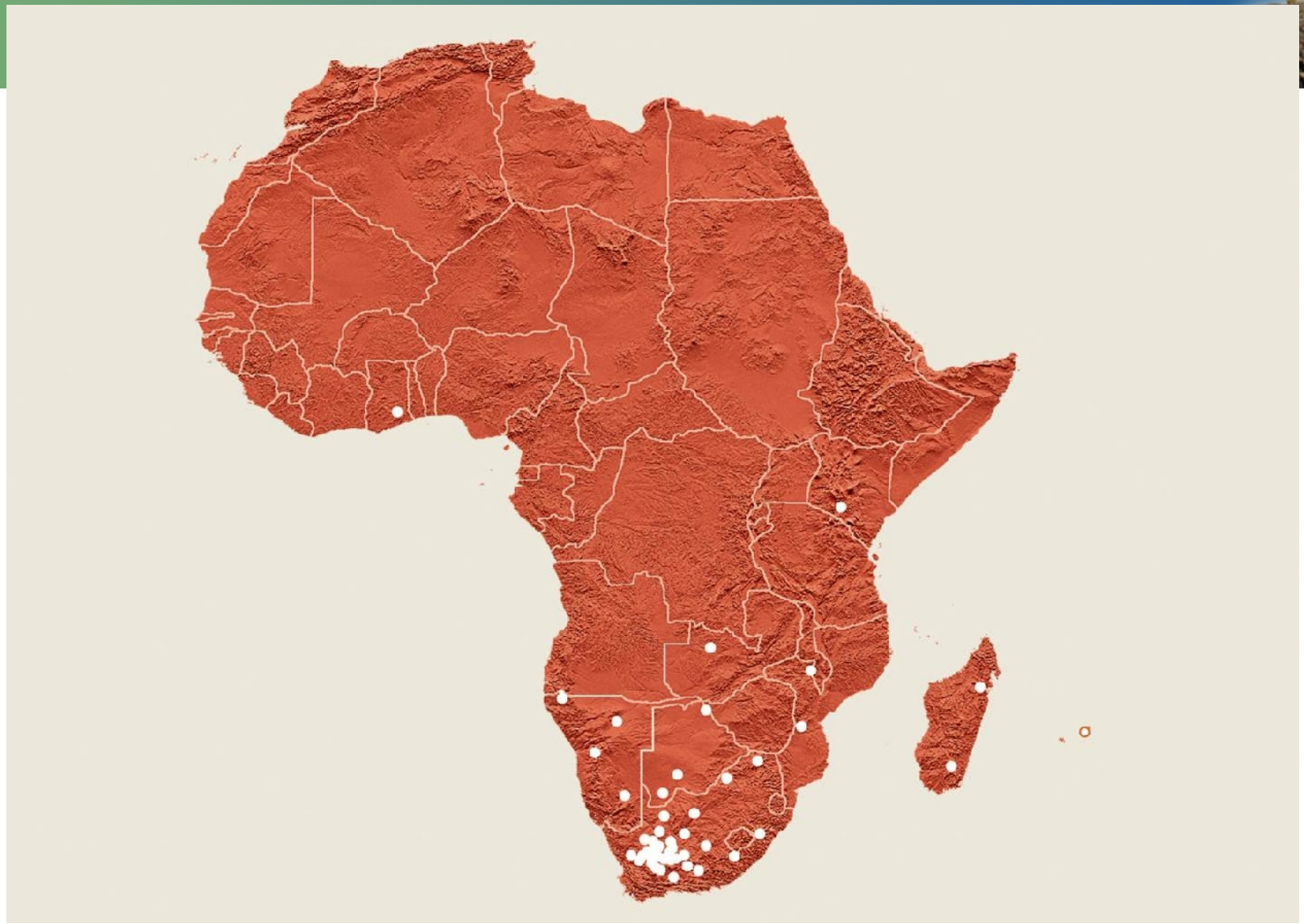
Radio astronomy in South Africa

- An integrated programme to advance scientific knowledge and contribute to Africa's future (building on capacity at HartRAO)
- SKA in Africa – Cabinet decision to bid in 2003
- Greenfield protected site
- Building the MeerKAT array telescope – a world-class telescope and the SKA precursor closes to the concept and design of the SKA
- MeerKAT science
- Human capital development programme
- Mission-driven innovation
- African VLBI Network
- World leadership role in contributing to the development of the SKA

Radio astronomy in Africa – excellent return on investment

- More telescope per € - less cost for infrastructure and operation
- Outstanding site for revolutionary science
- Helping to fulfill Africa's potential as the next great economic growth and business destination
- Developing young people from Africa and the world

The SKA in Africa



The SKA in Africa: Proposed stations

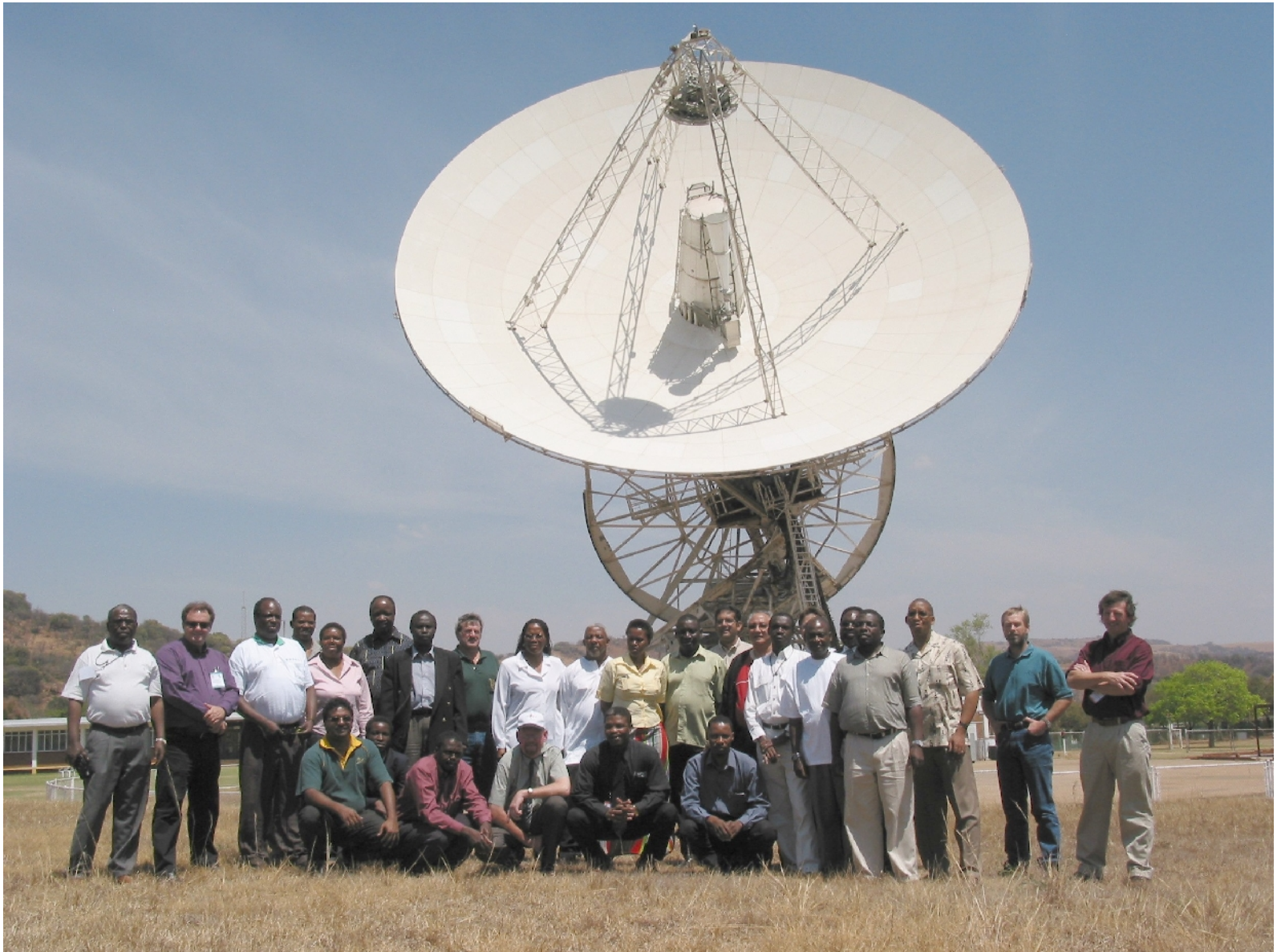
SKA Africa partner countries

- Botswana
- Ghana
- Kenya
- Madagascar
- Mauritius
- Mozambique
- Namibia
- Zambia

A United Africa for the SKA

- The African Union (AU) Heads of State July 2010 confirmed unanimous and continued support for the African SKA bid
- SADC Science Ministers unanimous support
- South Africa has an SKA Inter-Ministerial Committee
- SKA Africa Steering Committee and Working Group

African Partners – first meeting 2003



African Partners Steering Committee – Accra 2010

Commitment from the AU

Assembly/AU/Dec.303(XV)

2. **ACKNOWLEDGES** the importance of science, technology and innovation emanating from the SKA Project in development of our knowledge-based economies and driving human capital development programmes;

3. **APPRECIATES** the efforts of the Republic of South Africa in coordinating Africa's bid to promote space related science and technology matters on the continent;

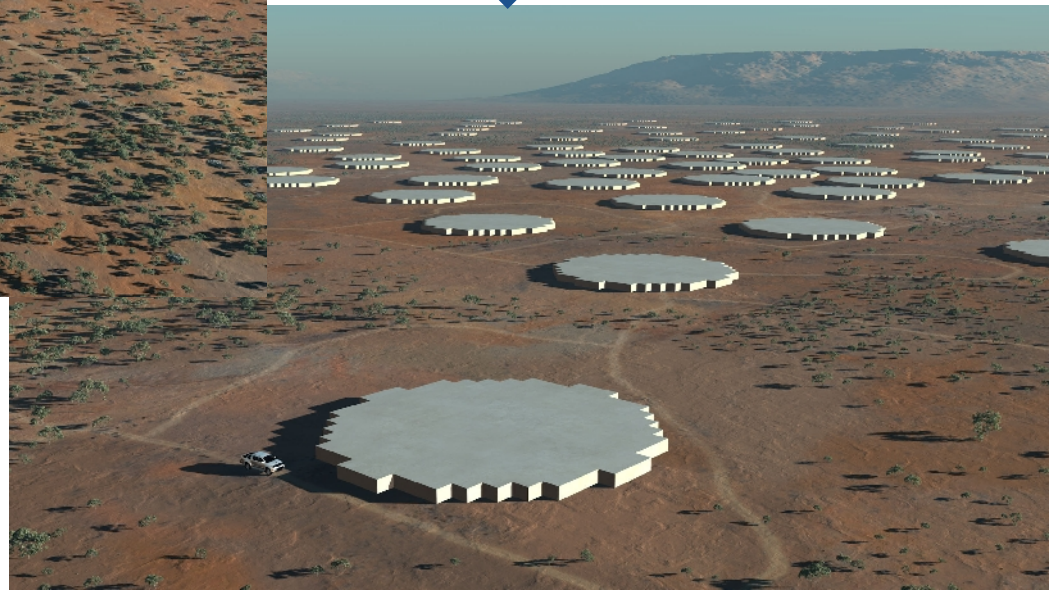
4. **ENDORSES** the African bid to host the SKA on the African continent, thereby providing the world with the unique instrument for frontier research and discovery, cementing Africa's commitment to contribute to global scientific excellence and enterprise;

5. **ALSO ENDORSES** the Republic of South Africa's bid to host, in collaboration with Botswana, Ghana, Namibia, Madagascar, Mauritius, Mozambique, Kenya and Zambia the Square Kilometre Array (SKA) Project on the African continent;

6. **CALLS ON** Member States, the Commission and the Regional Economic Communities to fully cooperate with the Republic of South Africa on this project by providing the necessary support to this bid;

SKA side decision

Africa (mid-frequency)



Australia (low-frequency)

Losberg

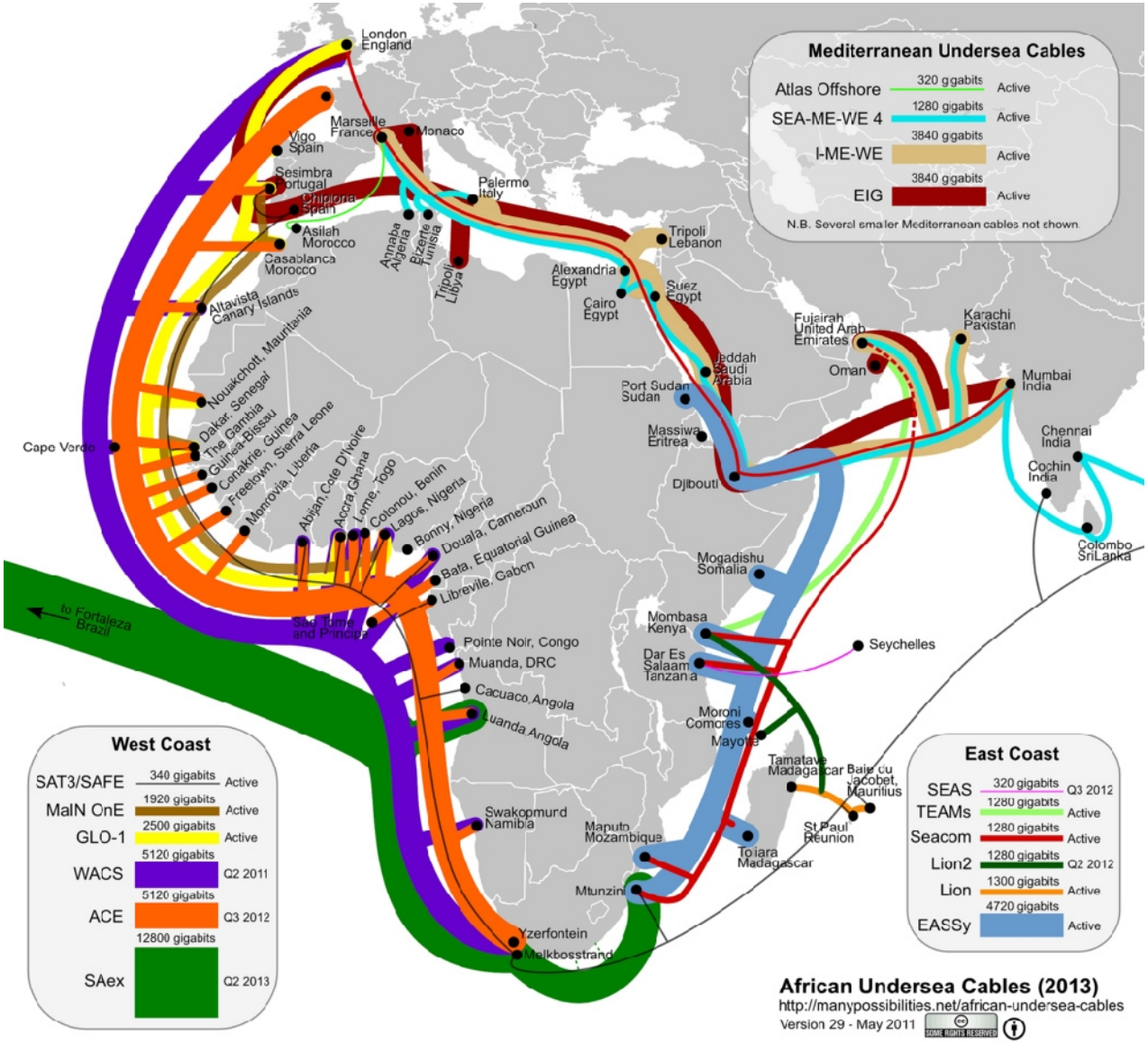
10 Gb/s from Cape Town to the heart of the Karoo

- Broadband InfraCo container arrives at Carnarvon SKA POP Station

- New overhead optical fibre cable being installed between Hutchinson and Carnarvon as part of Broadband InfraCo's long-haul fibre network

Data connectivity

African Submarine Cable Systems



Infrastructure: Renewable energy

- Wheeled through grid or connected directly
- Base load supply through the grid, so no storage required
- > 14% renewables available through the national grid by 2030, increasing
- Huge solar parks to be constructed by private – public partnerships in the Northern Cape and available to SKA
- Feasibility study for 10MW demonstration solar PV plant for MeerKAT
- Discussion with various international partners

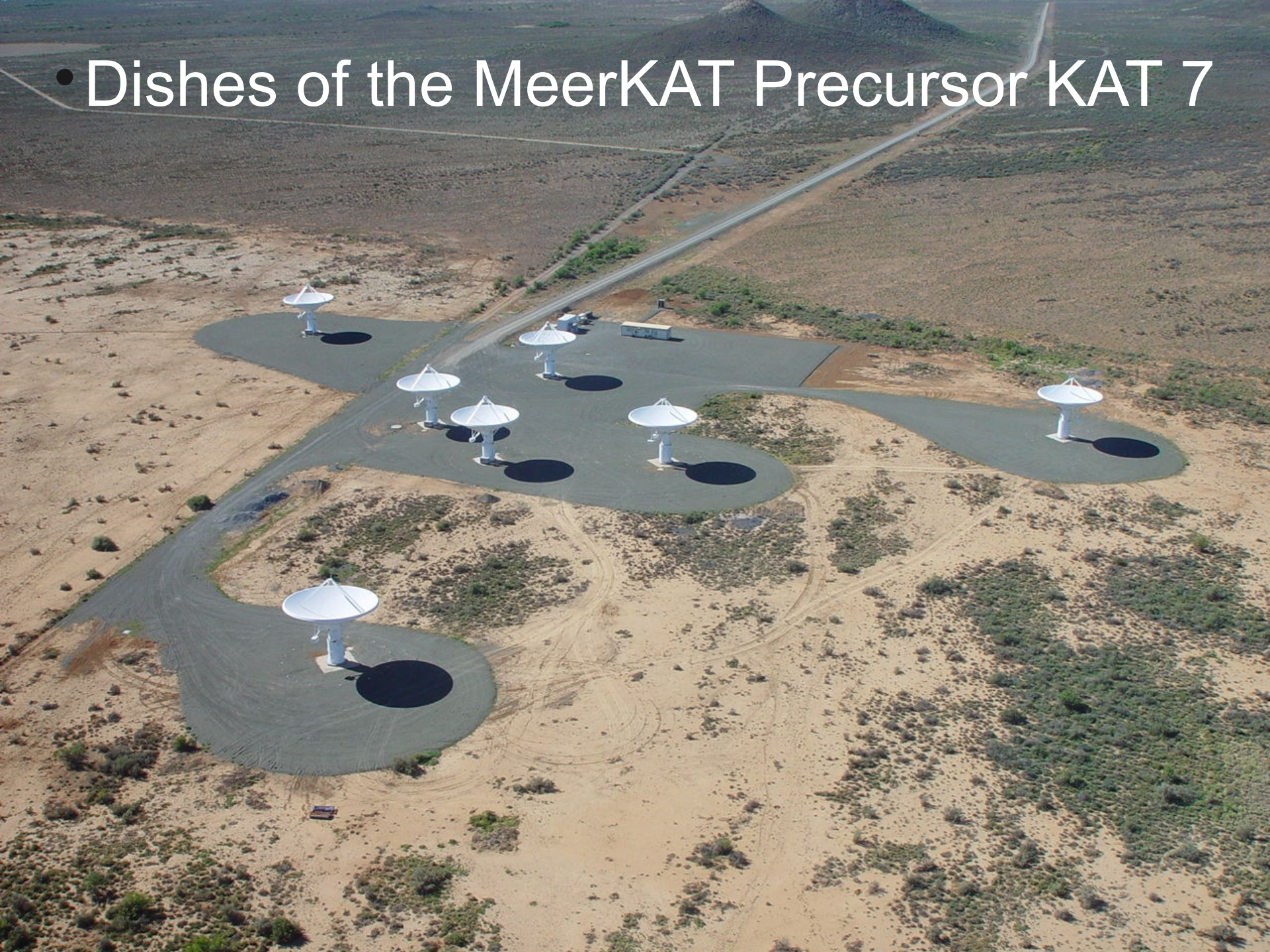
The MeerKAT Programme

- Vision: Africa will have a world-class large radio telescope
  - Irrespective of the outcome of the SKA site competition
  - Now to be integrated SKA Phase 1
- MeerKAT as an SKA “precursor”
  - Engineering prototype
  - Early science
  - Phased development: XDM, KAT-7, MeerKAT
  - Engaged local academia and industry

KAT 7 – MeerKAT prototype

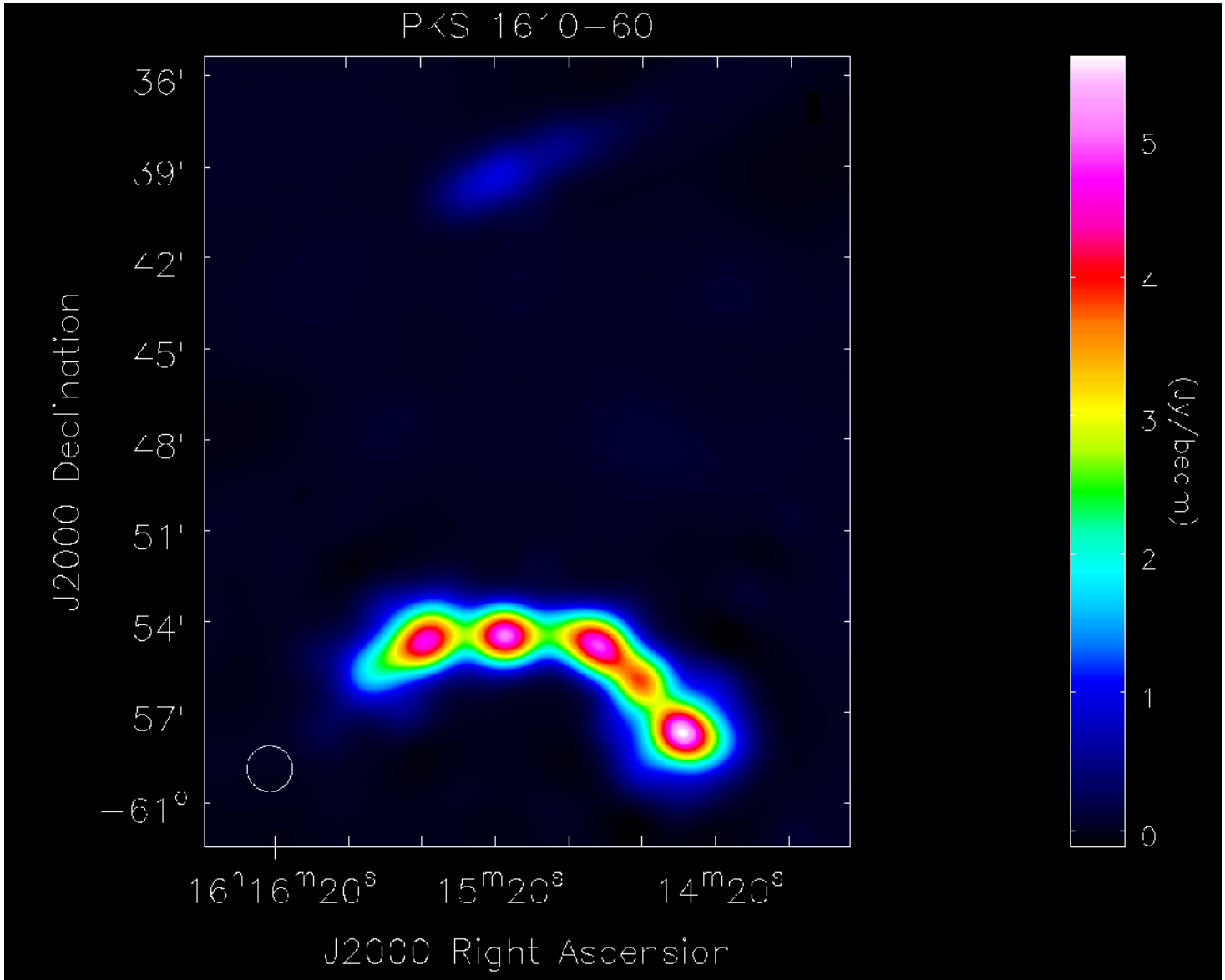
- Designed and built in South Africa
- Array of 7 antennas
  - Built and commissioned on time – and it works
- Component and system level prototyping
- Build experience in science and engineering teams
- Establish infrastructure in the Karoo
- Engage with local industry
- Produce publishable science
- “Build it and they will come”
  - Prof Steve Rawlings (Oxford), quote from *Field of Dreams*

Virtual MeerKAT


• Dishes of the MeerKAT Precursor KAT 7

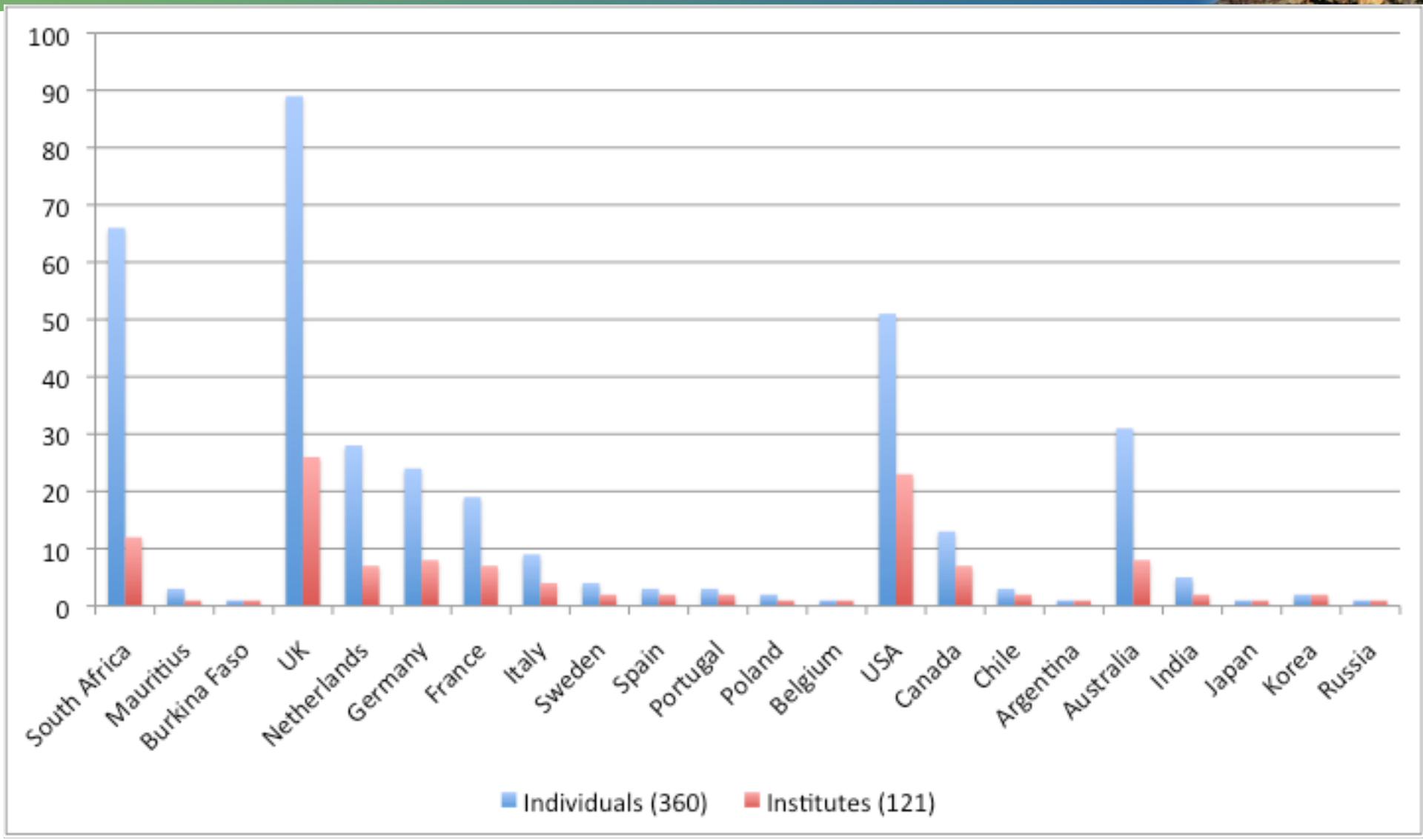
The President at KAT-7

Radio galaxy observed with KAT 7



Cape Town KAT 7 Control Room

MeerKAT Large Surveys: Time Awarded



Reconfigurable Computing

EU (34 institutions, 93 individuals)

- UK (25,88)
  - ATC
  - Birmingham
  - Bristol
  - Cambridge
  - Durham
  - Edinburgh
  - Exeter
  - Hertfordshire
  - JCU
  - Lancaster
  - Leeds
  - Leicester
  - Liverpool
  - Manchester
  - MSSL
  - Newcastle
  - Nottingham
  - Open U
  - Oxford
  - Portsmouth
  - RAL
  - Southampton
  - Sussex
  - UCL
  - Warwick
- Germany (8,24)
  - Bamburg
  - Bochum
  - Bonn
  - (ESO)
  - Jacobs
  - MPE
  - MPIfR
  - MPIA
- Netherlands (7,28)
  - Amsterdam
  - ASTRON
  - JIVE
  - Kapteyn
  - Leiden
  - Nijmegen
  - SRON
- France (7,19)
  - Bordeau
  - Inst Ast
  - Marceille
  - Obs Paris
  - OCA
  - Orleans
  - Saclay
- Italy (4,9)
  - Cagliari
  - INAF
  - Padova
  - SISSA
- Sweden (2,4)
  - Chalmers
  - Onsala
- Spain (2,3)
  - IAA
  - Valencia
- Portugal (2,3)
  - Lisbon
  - UTL
- Poland (1,2)
  - Cracow
- Ireland (1,1)
  - Dublin
- Belgium (1,1)
  - Brussels

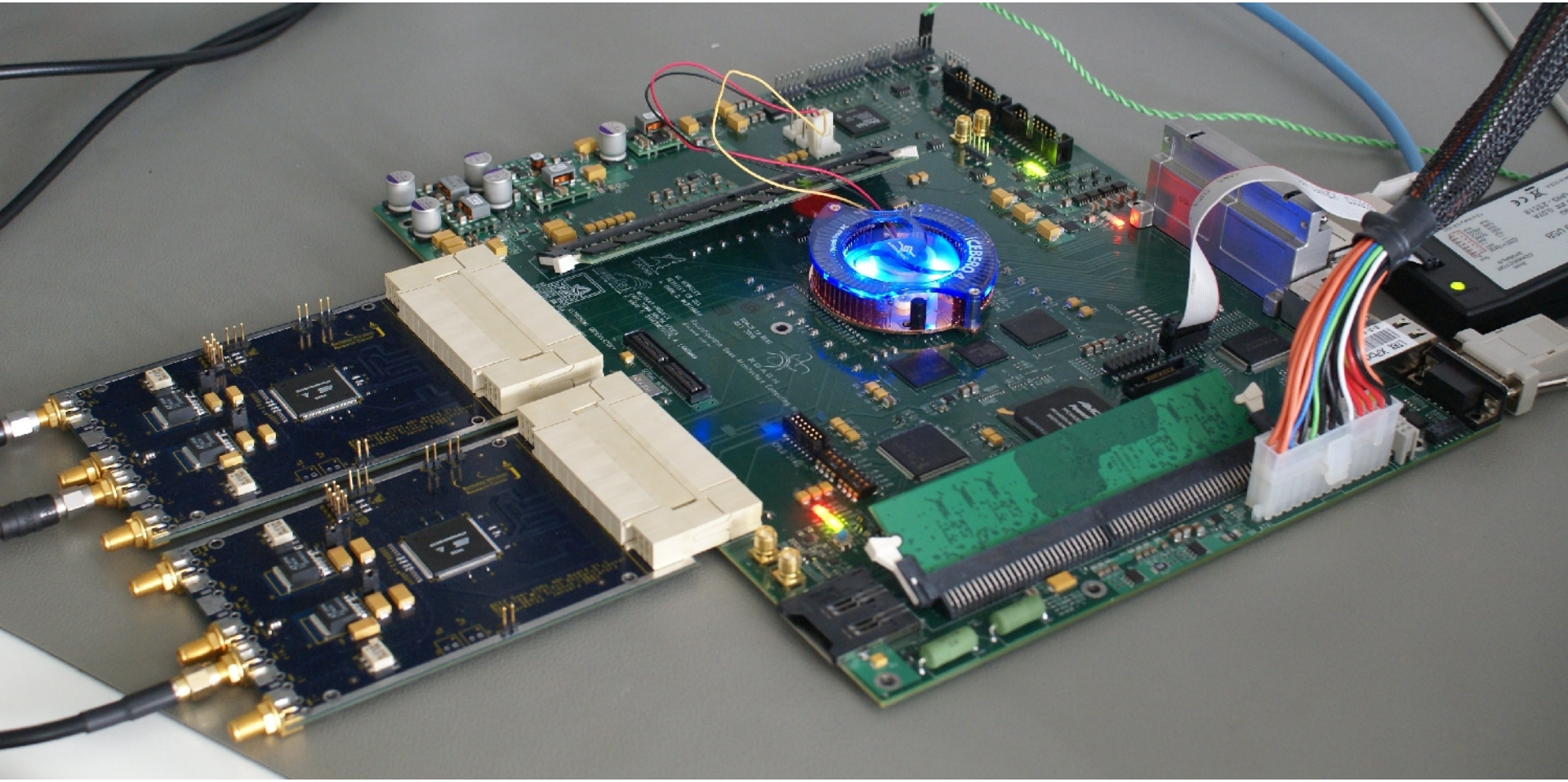
Science and Technology Collaborations

- **USA** : NRAO, UC Berkeley, Caltech, Illinois, Pennsylvania
- **Europe** : ASTRON, Oxford, Cambridge, Hertfordshire, Southampton, INAF, JIVE, Max Planck Institute for Radio Astronomy
- **India** : TIFRA
- **Examples**
  - **ASTRON**
  - Collaboration to model and understand the effect of beam-shapes in high precision imaging
  - **NRAO**
  - Collaboration in the further development of the CASA processing package for high performance computing, required by EVLA and MeerKAT
  - **GMRT**
  - Correlator development

International Industry Collaboration

- Close collaboration with Nokia Siemens Networks
- Mutual benefit R&D agreements with IBM, Intel; pending with Oracle
- And others
- **Partnerships for pre-competitive research benefit us all**

CASPER / ROACH



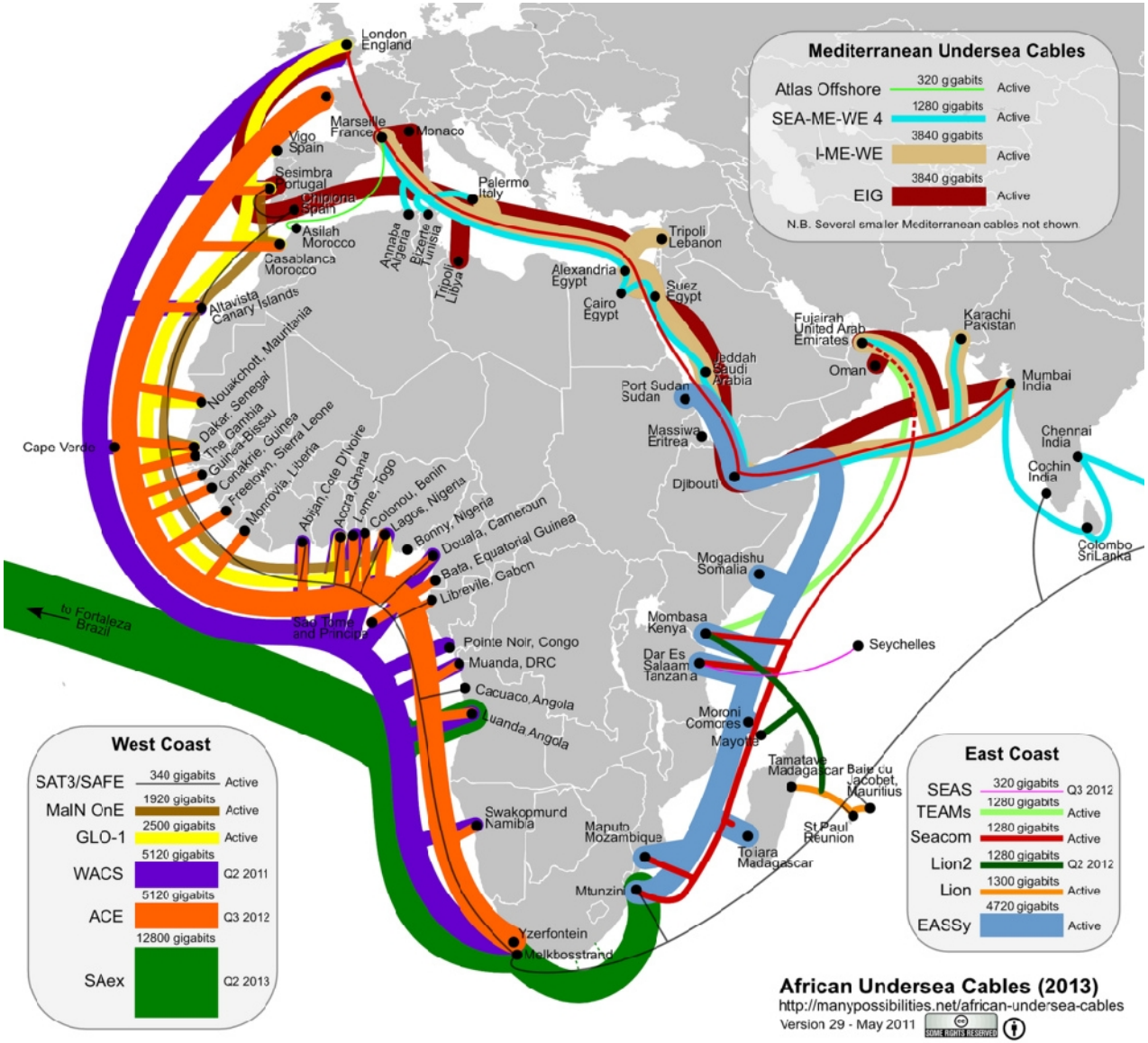
ROACH correlator

- Dan Wertheimer
- UC Berkeley:

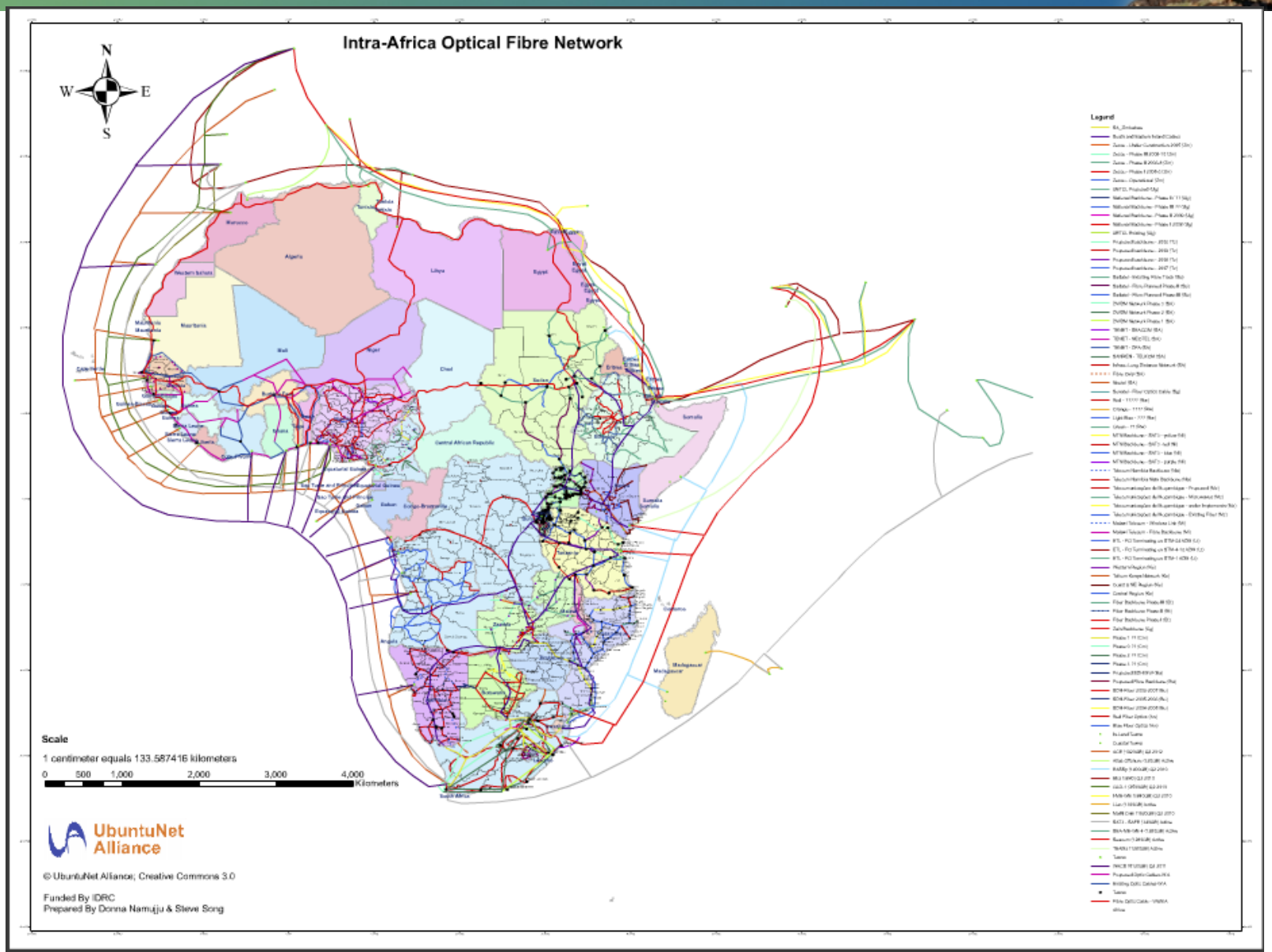
- … special thanks for getting South Africa involved from early days. SA has become the principal CASPER contributor and driver, and is enabling instrumentation and science around the planet.

CASPER / ROACH

African Submarine Cable Systems

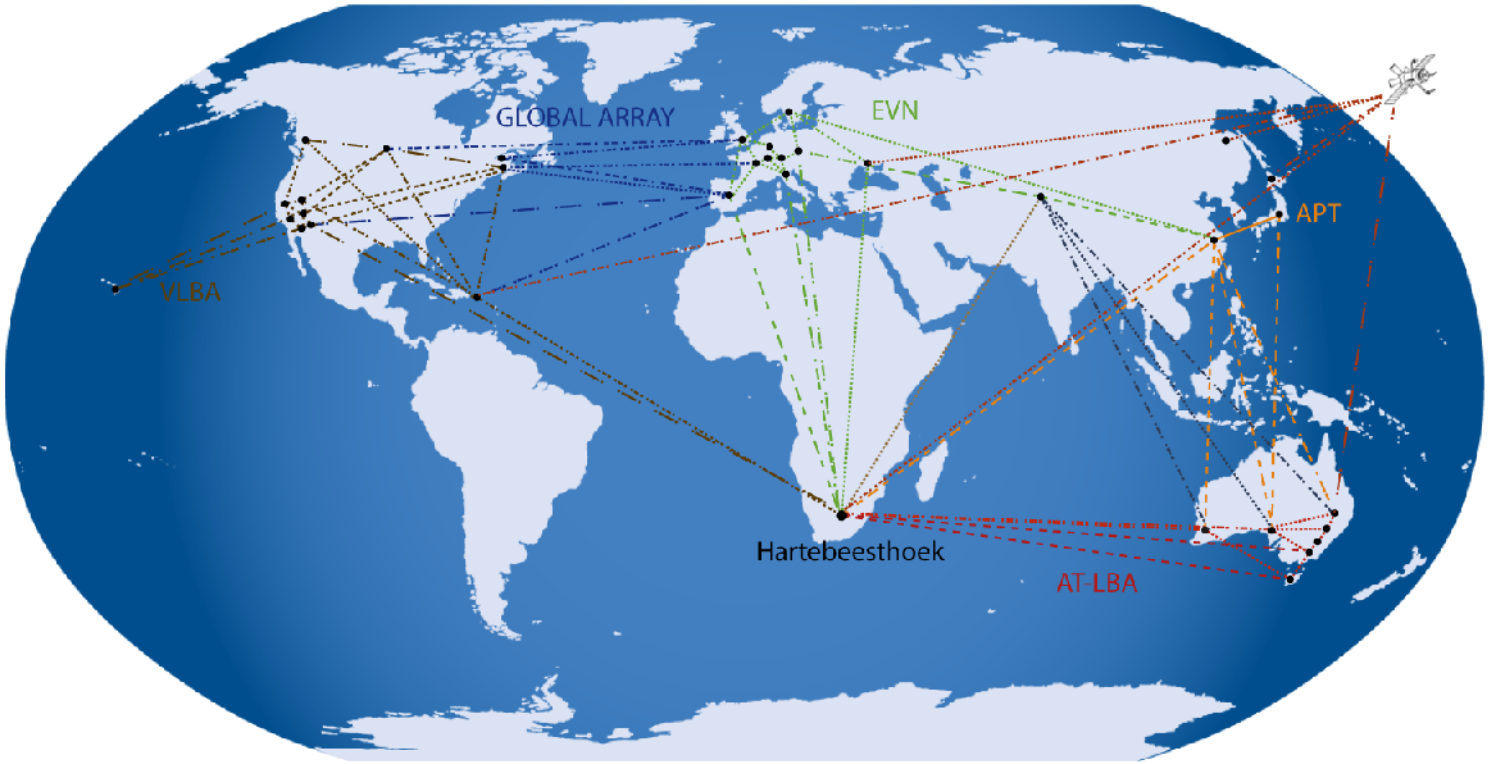


Africa Terrestrial Cable Systems



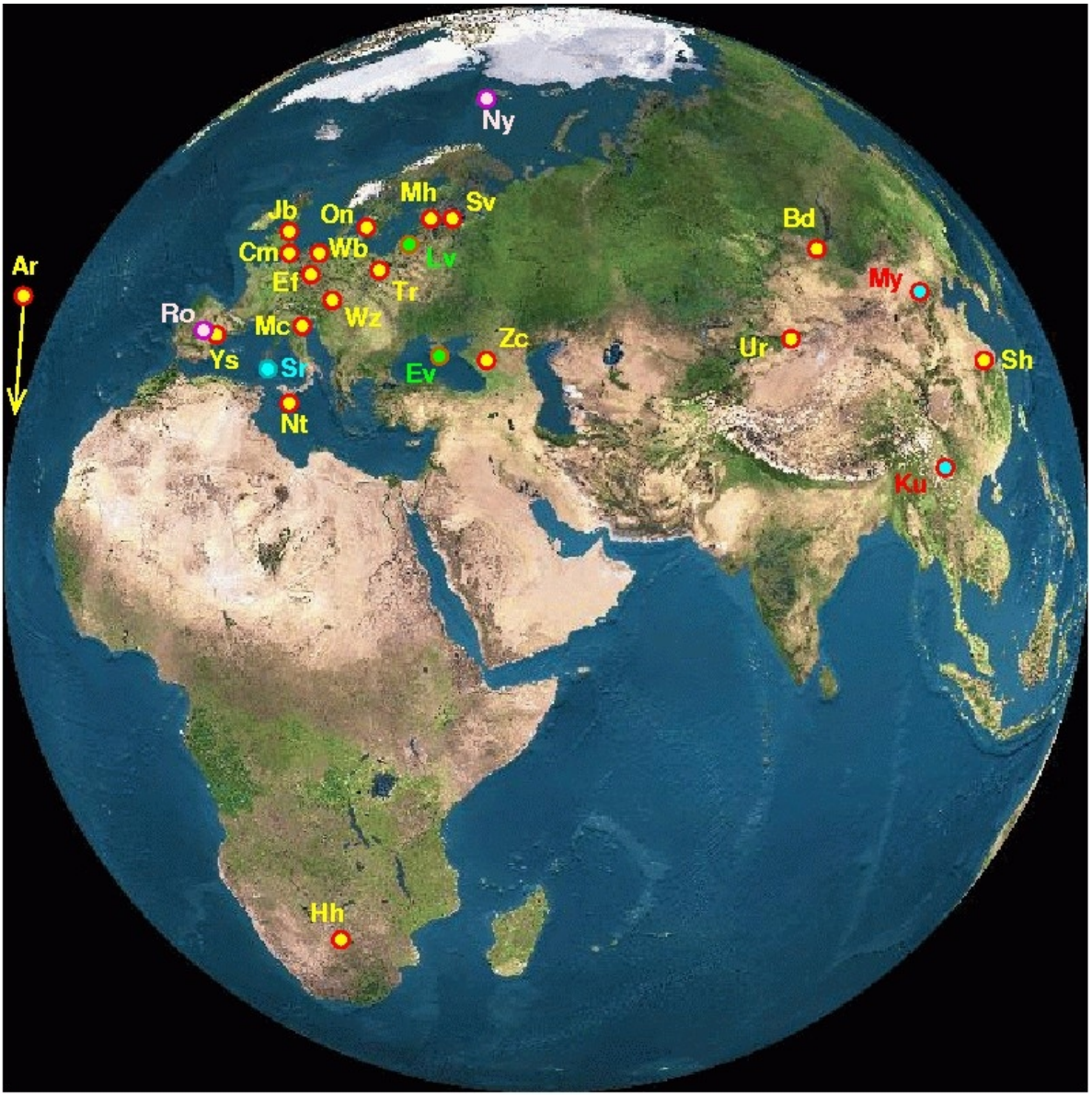
African VLBI Network

- Project launched to convert >20 obsolete 32m class satellite telecommunication dishes in Africa into radio astronomy facilities
- Result in the creation of VLBI network to complement the EVN and SKA and improve existing VLBI network UV coverage and performance

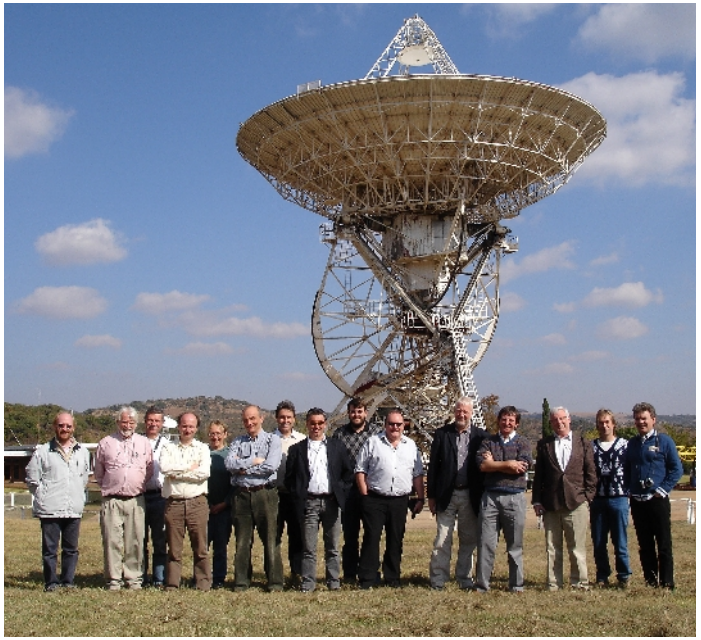


- Existing VLBI Networks

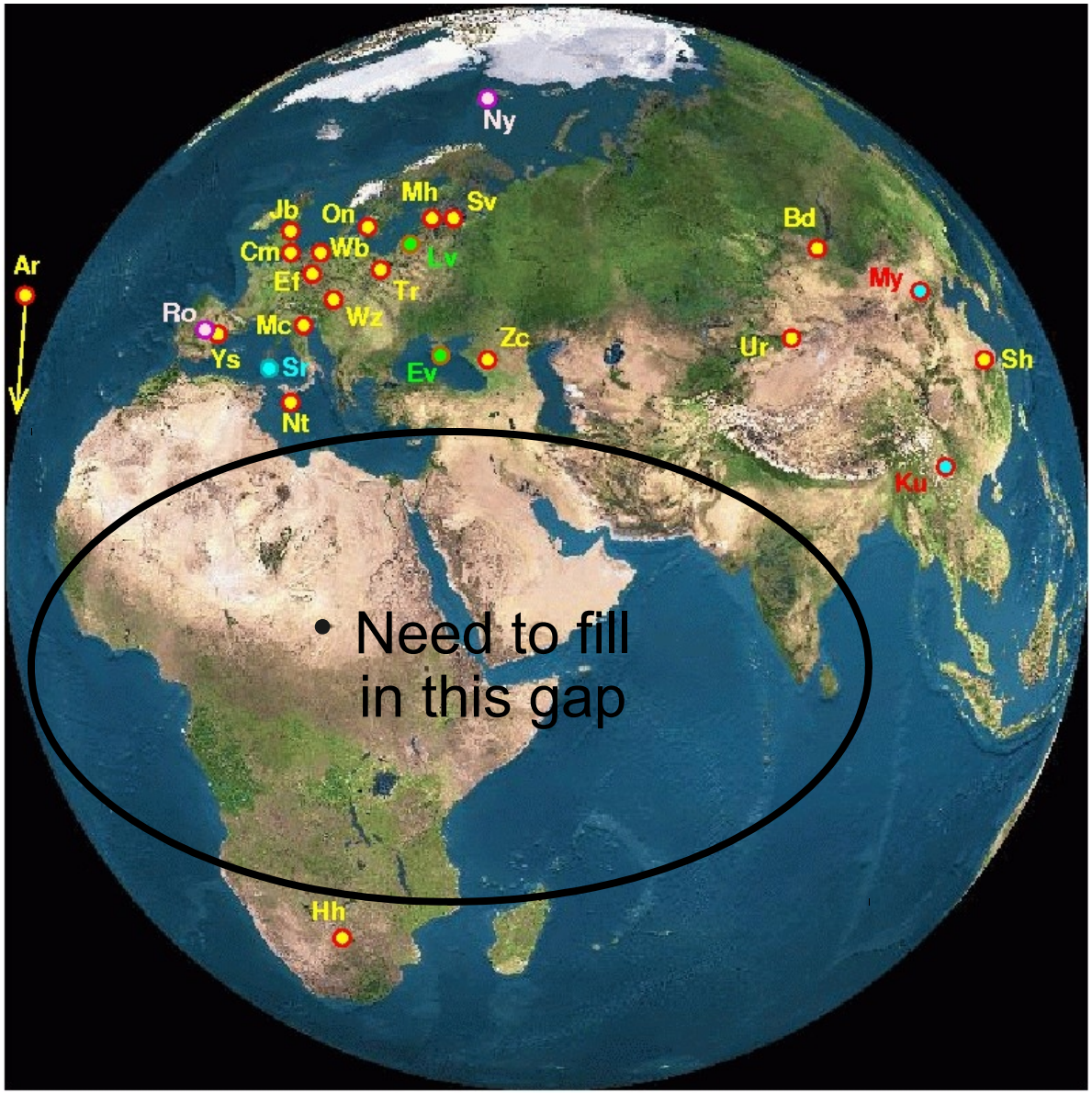
European VLBI Network



EUROPEAN vlbi NETWORK



Mind the Gap


Ny
Mh
Sv
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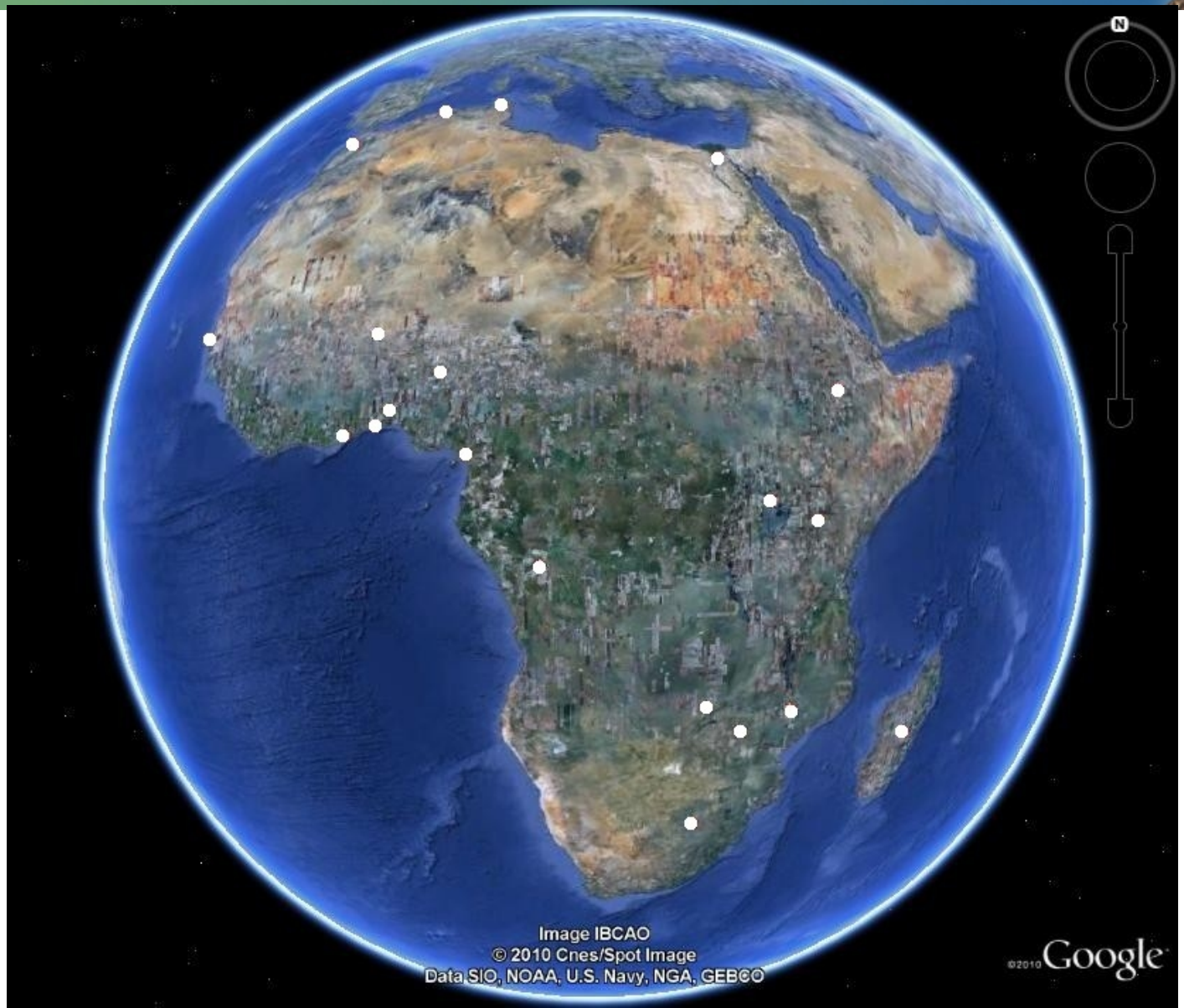
Hh
• Need to fill in this gap

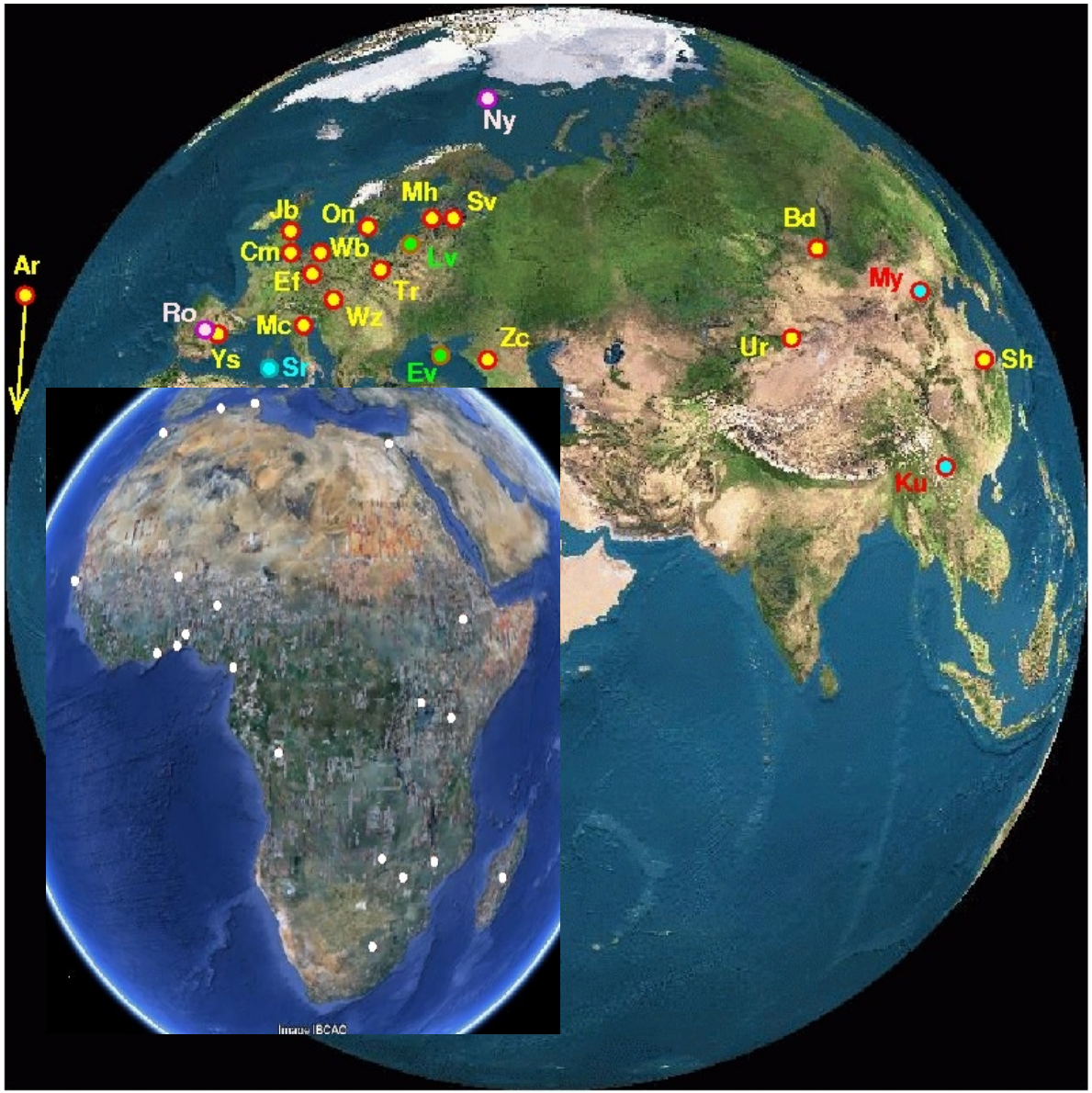
30-m class antennas in Africa



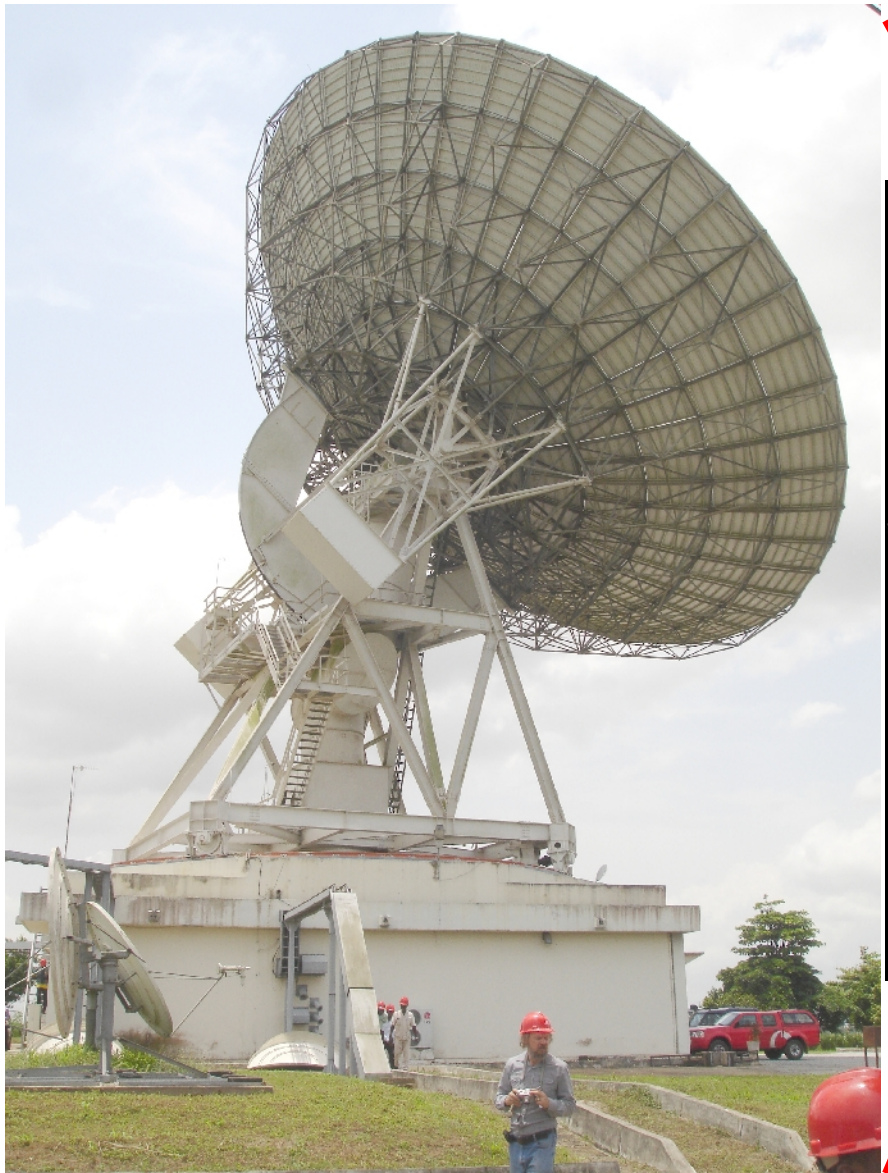
The African VLBI Network

- Convert existing communications antennas into radio astronomy facilities.
  - Maintain existing staff.
  - Install new receivers and instrumentation.
  - Create a VLBI array that will link with
  - MeerKAT
  - HartRAO
  - Europe, the USA and Australasia.
- Exciting potential synergy with geodesy and navigation programmes (e.g. EGNOS)

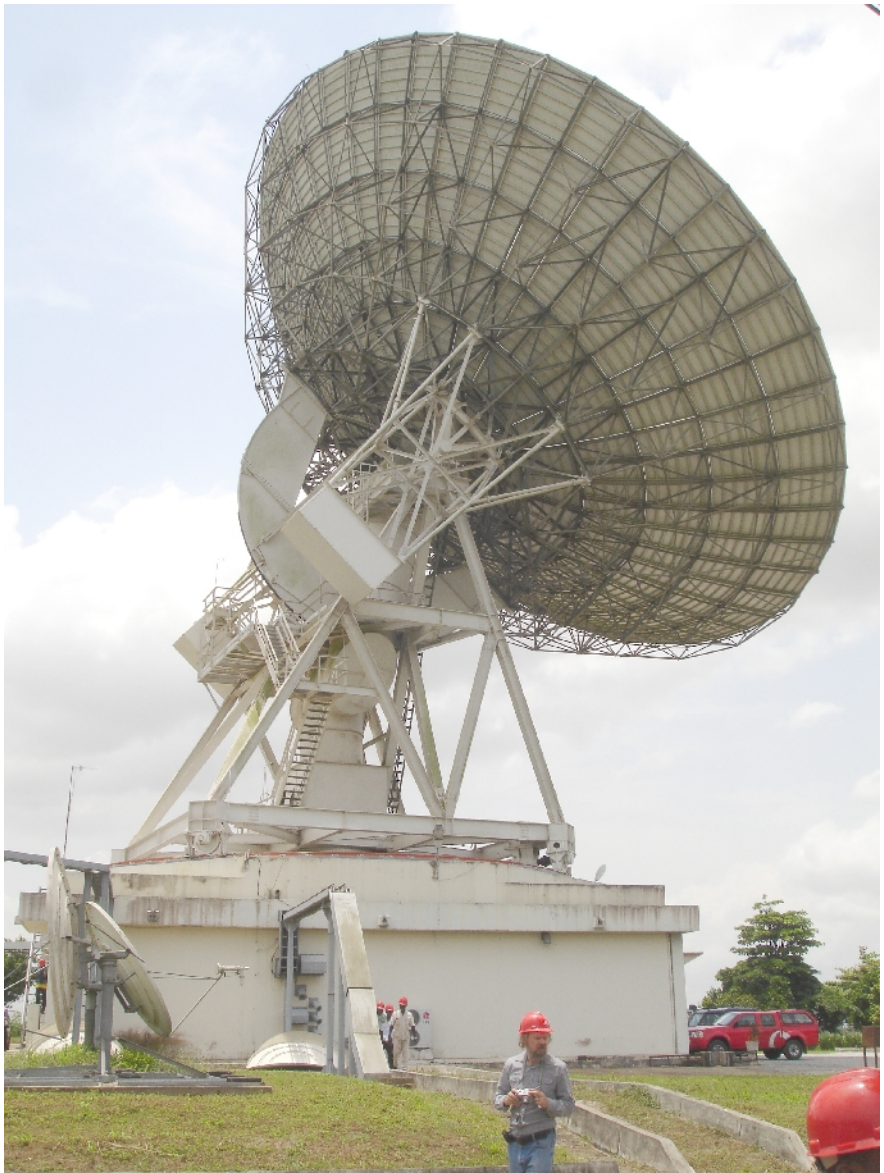
European + African VLBI Network



Nkutunse - Ghana



And its twin – Medicina, Italy



32m Vodafone dish at Nkutunse, Ghana

- Ghanaian team inspecting dish. The team has already initiated work. First light by December 2012?

Nkutunse

Why we started the Human Capital Development Programme?

Alignment of the SA SKA Human Capital Development Strategy with National Objectives and Policy

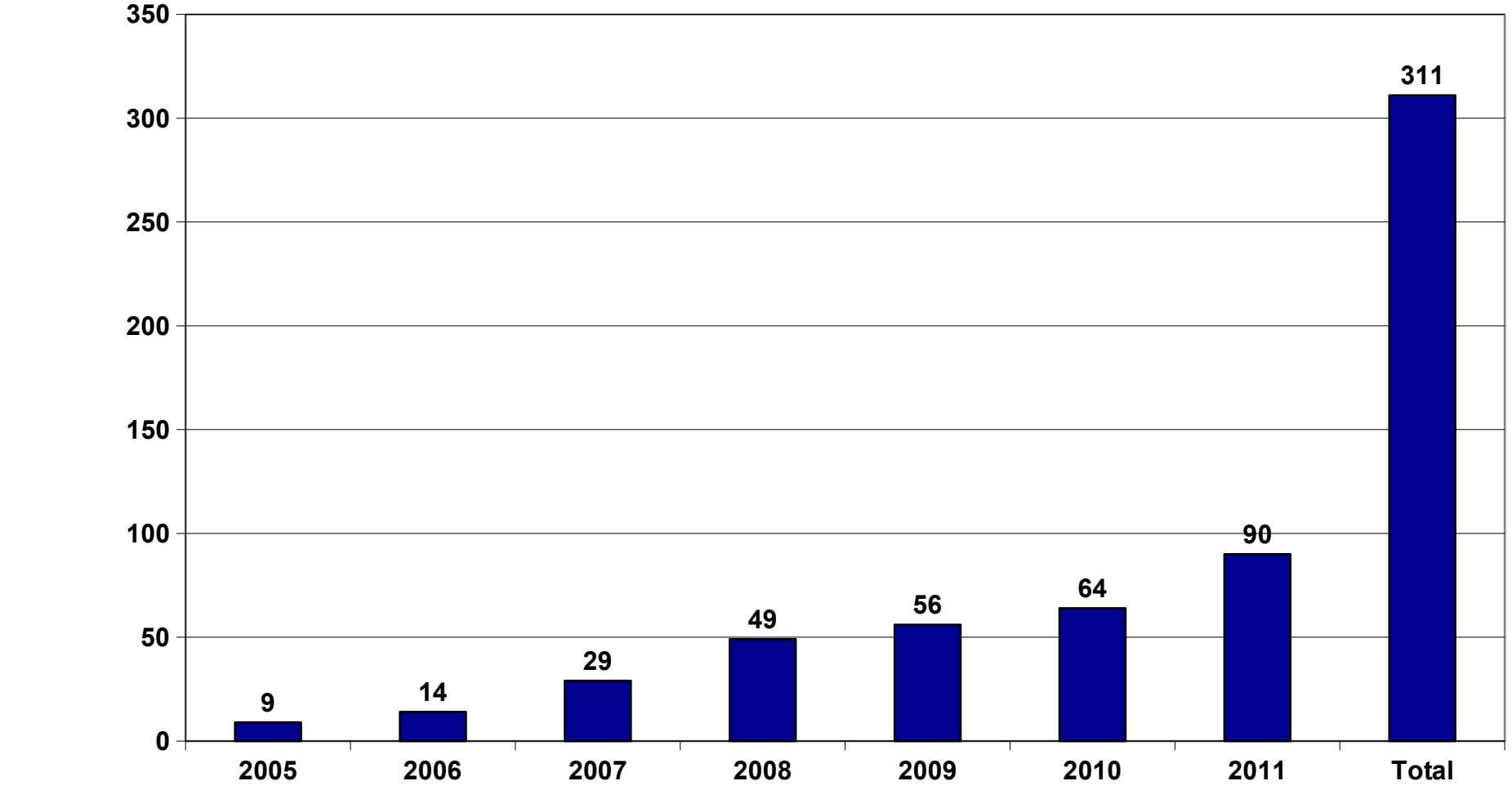
- *South Africa currently does not have sufficient human capacity in the SET sector to support the development of a strong innovation system and in order for the country to become competitive in an international knowledge economy. To ensure innovation-led growth, there must be an increase in the scientific workforce, i.e. an increase in the number of highly competent engineers, scientists and researchers. There is now a national focus to build high level SET capacity.*

Human Capital Development

- Research chairs
- Visiting / joint professorships
- University grants – support or lecturers
- Postdoctoral fellowships
- Postgraduate bursaries
- Undergraduate bursaries
- Internships
- Technician training – national diplomas at universities of technology
- FET (artisan) training
- Development of astrophysics and related engineering in Africa partner states
- Mobility grants

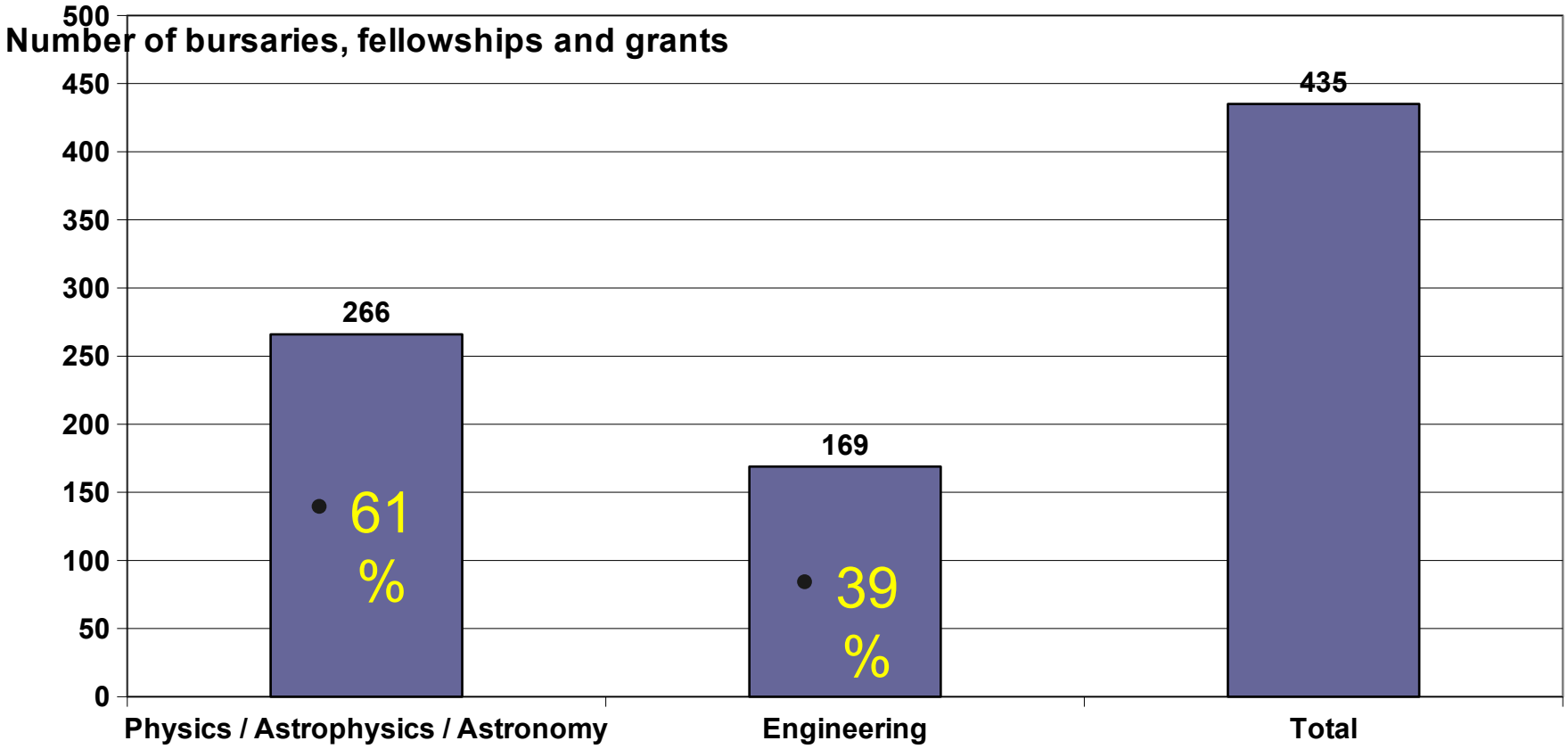
A focused and structured programme with a pipeline strategy

The South African SKA Project
Human Capital Development Programme



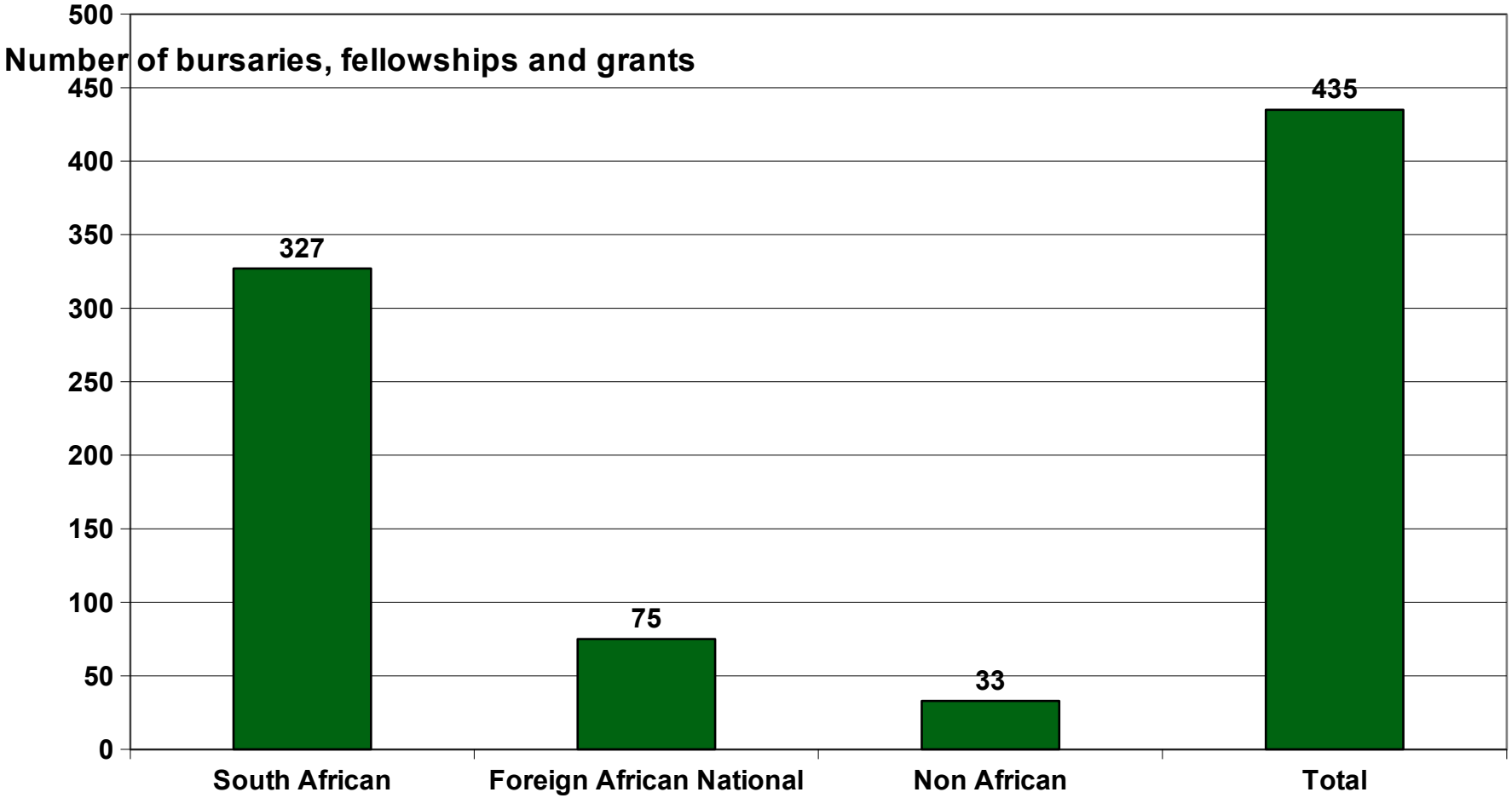
Human Capital Development

The South African SKA Project
Human Capital Development Programme
Intake by field of study



Human Capital Development

The South African SKA Project
Human Capital Development Programme
Cumulative statistics by nationality



SKA PhD Student from Kenya

African partners now teaching astronomy

Name	Current level of teaching	Status
Kenya	Undergraduate	Honours
Mozambique	Undergraduate	Honours
Mauritius	Postgraduate	MSc
Madagascar	Postgraduate	MSc
Zambia	Undergrad	In process
Botswana	Undergrad	In process
Ghana	Undergrad	In process

Postgraduate Bursary Conference 2011

Cyber lab

Launch of new labs at Carnarvon High

Visiting the Site

Trainee Technicians

Partnership opportunities

- Strong statement from the European Parliament Written Declaration 45: calling for radio astronomy to be a priority focus area for Africa-EU science, information society and space partnership
- Creation of dedicated platform: African-European Radio Astronomy Advancement Platform (AERAP)
- Harness different instruments for Africa-EU cooperation to support radio astronomy partnerships
  - Same policy perspective for development cooperation funds as EU structural / regional funds

Partnership opportunities (2)

- Scientific partnerships
- Researcher mobility and training programmes
- Technology development (instrumentation) – industrial partnerships
- Infrastructure investments (e.g. interface VLBI, navigation, geodesy)
- Renewable energy solutions for radio astronomy

Obrigado

- Portuguese leadership role in Africa-EU Science, Information Society and Space Partnership
- Strong cooperation with FCT in several Africa-EU cooperation initiatives
- Prospering links with Portuguese radio astronomy community – keen to expand scientific and industrial partnerships:
  - SKA, Africa VLBI and beyond

Concluding words from Prof George Miley

Big telescopes are the cathedrals of modern civilization.

The three signatures of an advanced country are technology, science & culture. Astronomy needs & enables them all.