

# The South African SKA/meerKAT Project

Kobus Cloete

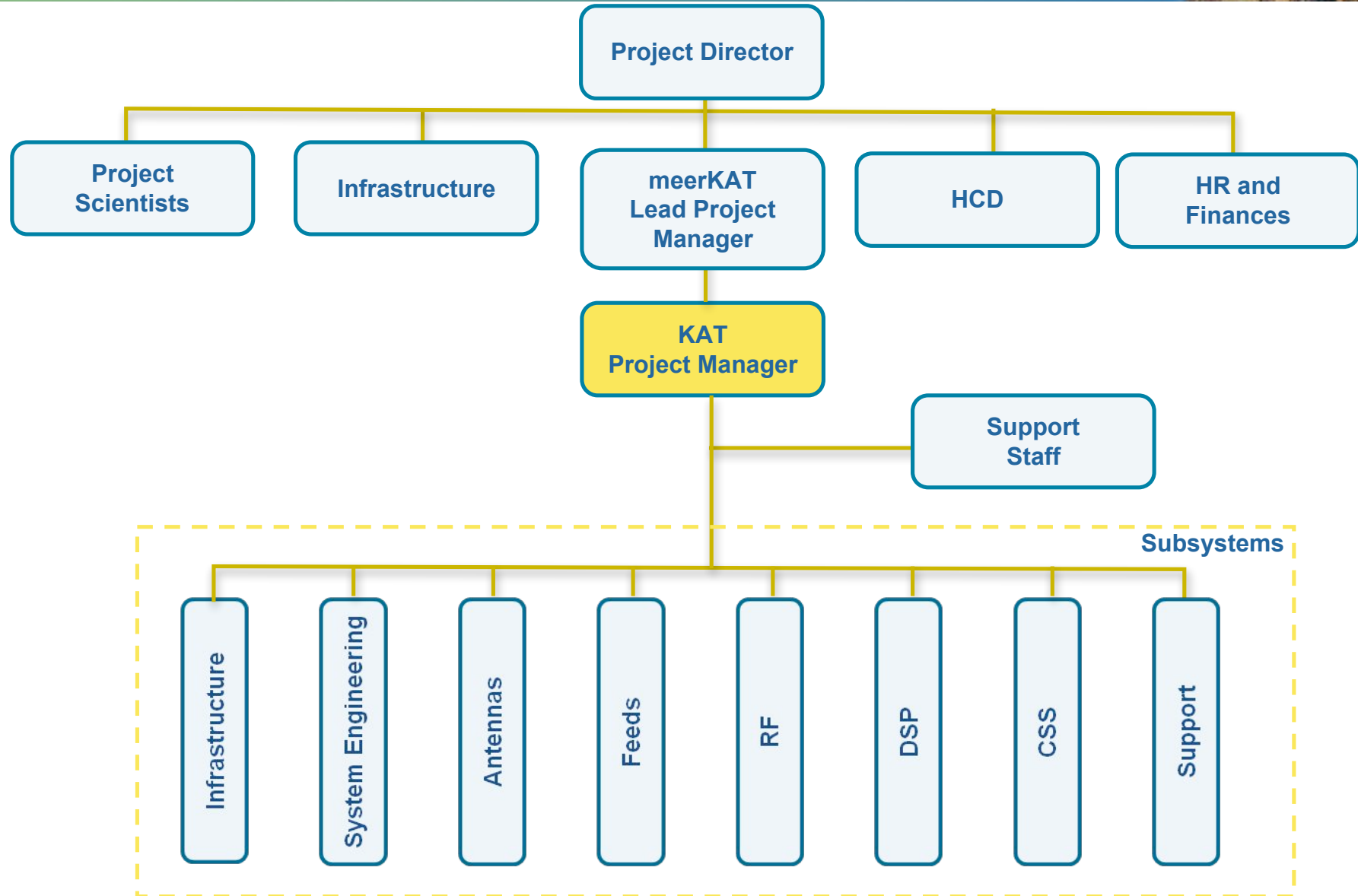


science and technology

Department:  
Science and Technology  
REPUBLIC OF SOUTH AFRICA



# Team

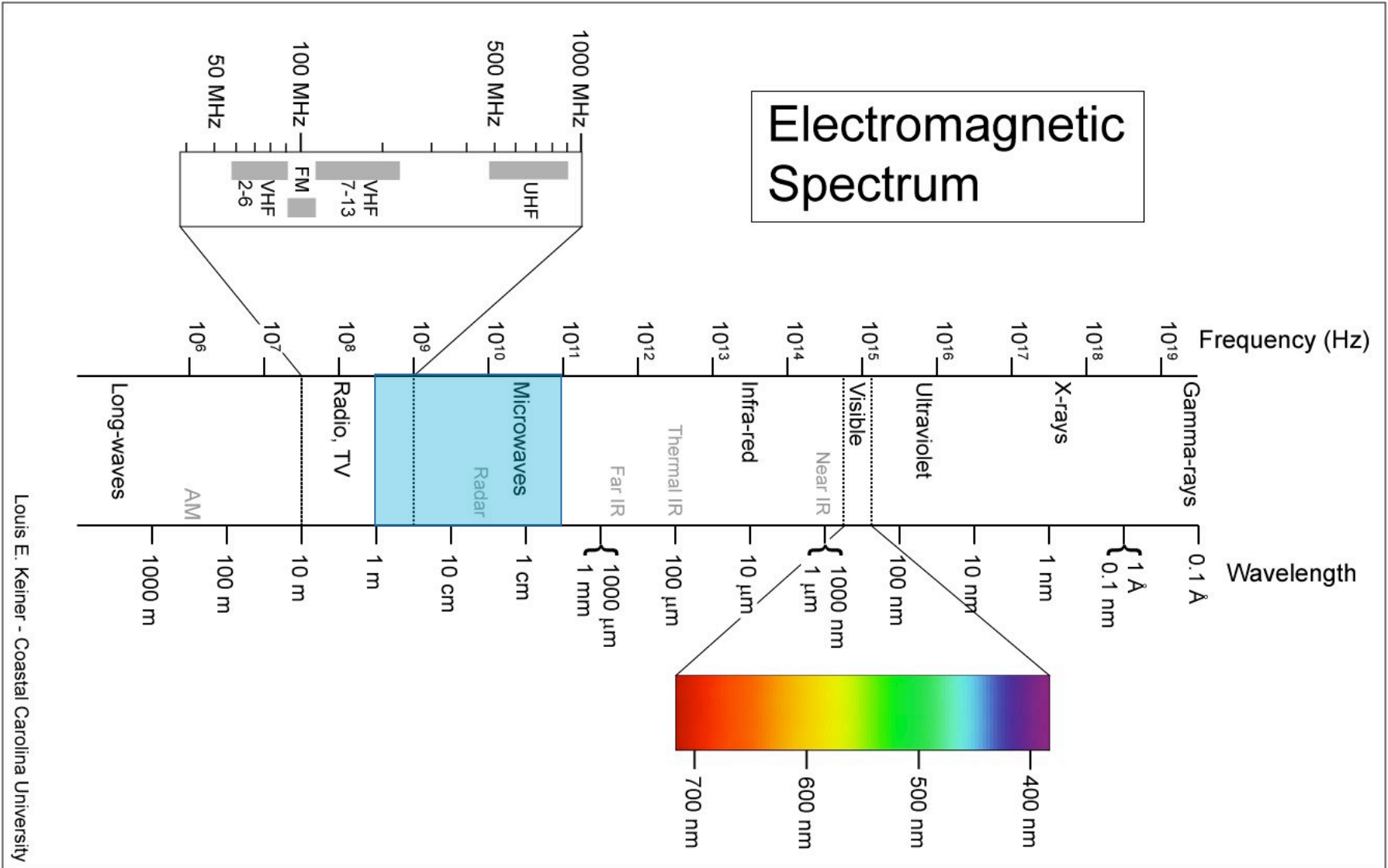


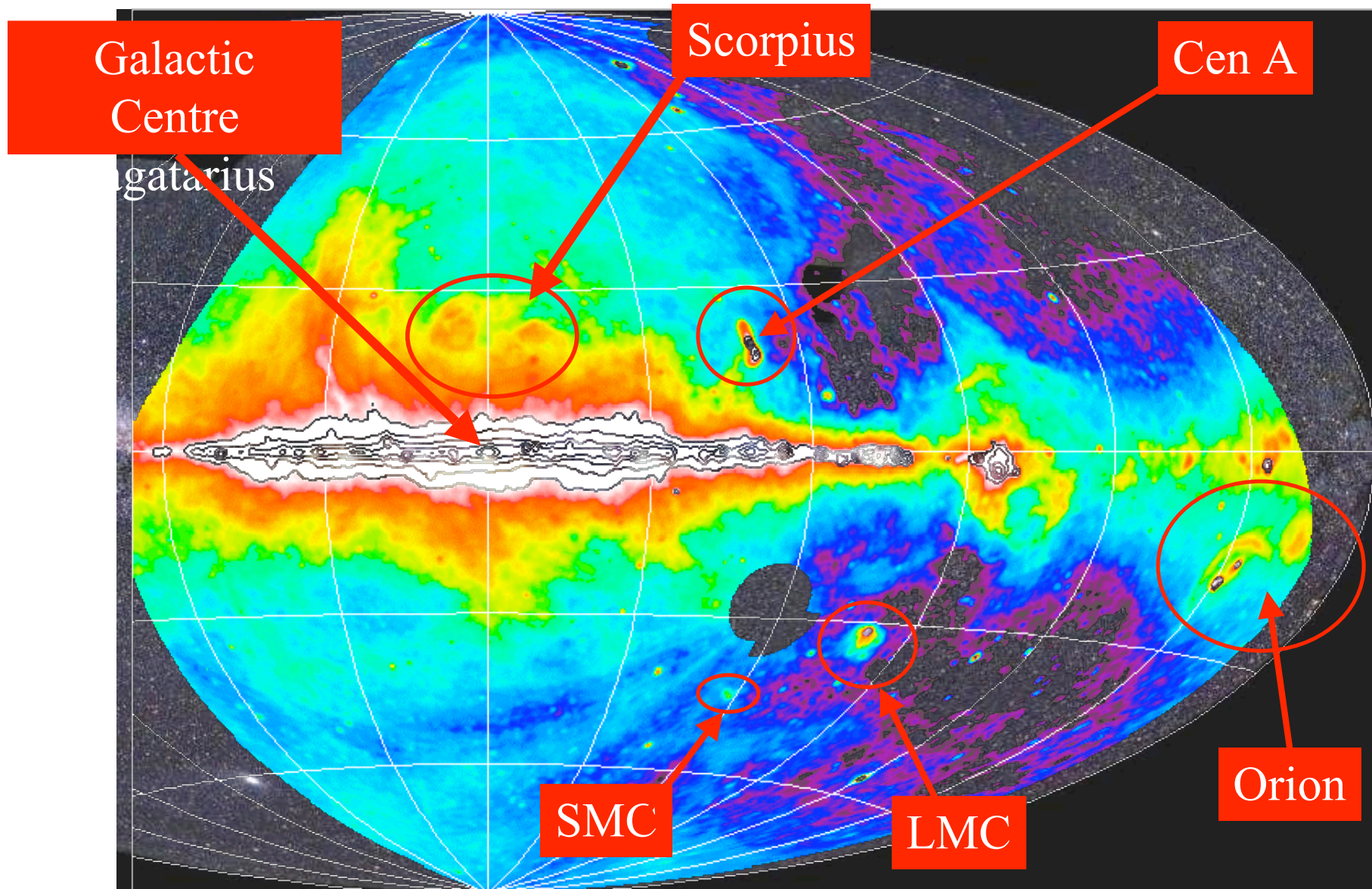
# Overview



- Radio astronomy
- SKA
  - What is SKA
  - Science
  - What will it look like
  - Configuration
- KAT Project in South Africa
  - What it is
  - Objectives
  - Progress and activities

# EM Spectrum





Galactic  
Centre

Magatarius

Scorpius

Cen A

Orion

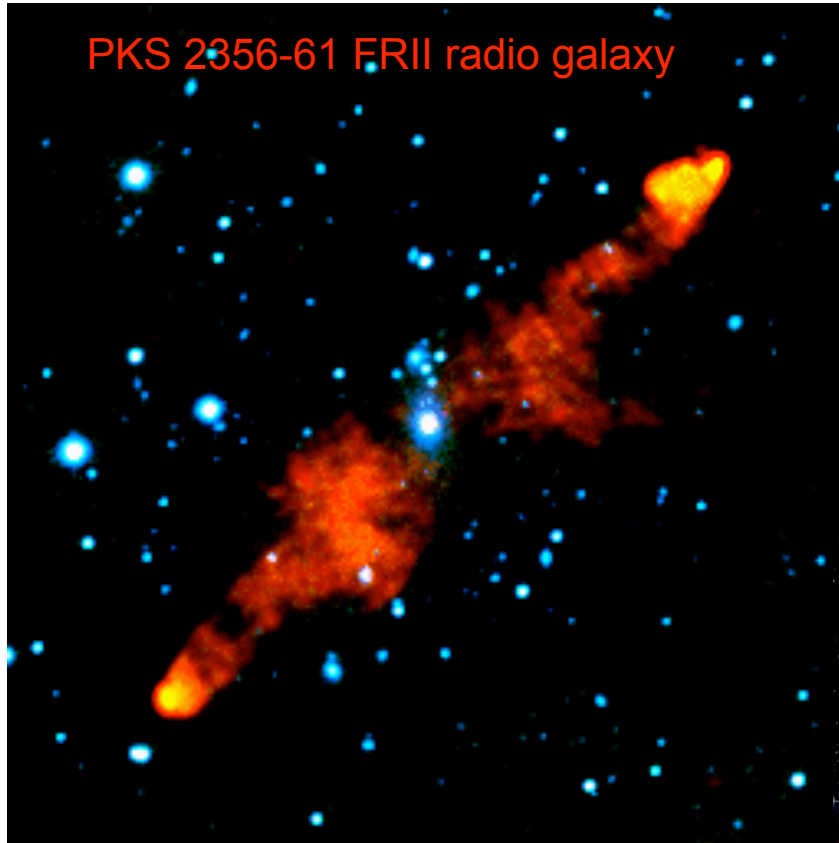
SMC

LMC

# Powerful radio galaxies



PKS 2356-61 FR II radio galaxy



M51 (Spiral Galaxy)

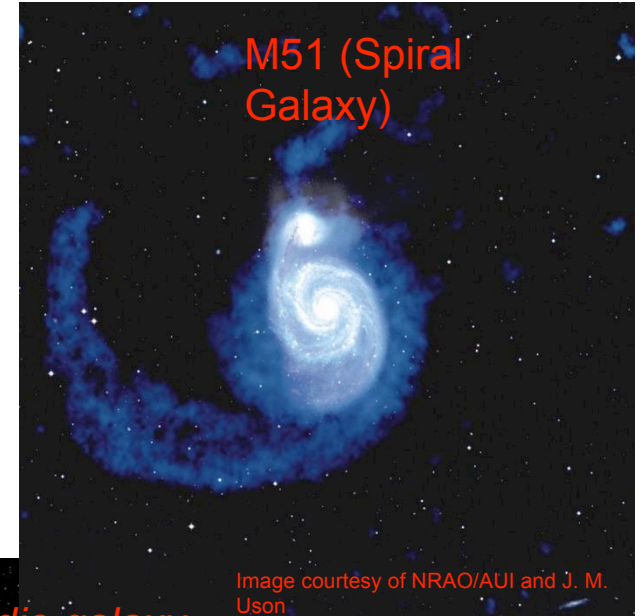


Image courtesy of NRAO/AUI and J. M. Uson

Fornax A FRI radio galaxy

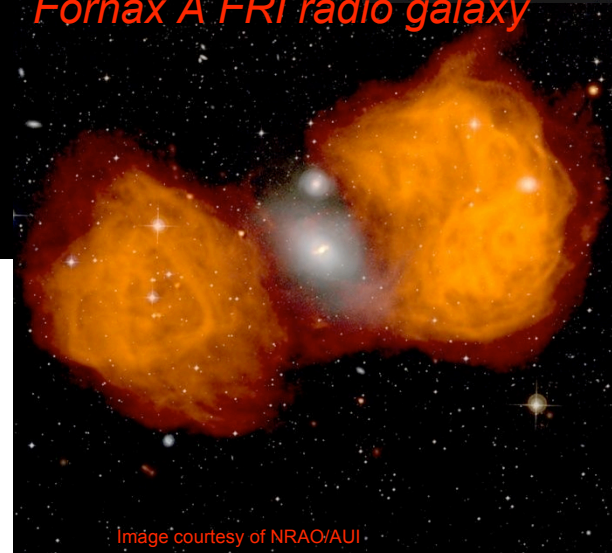
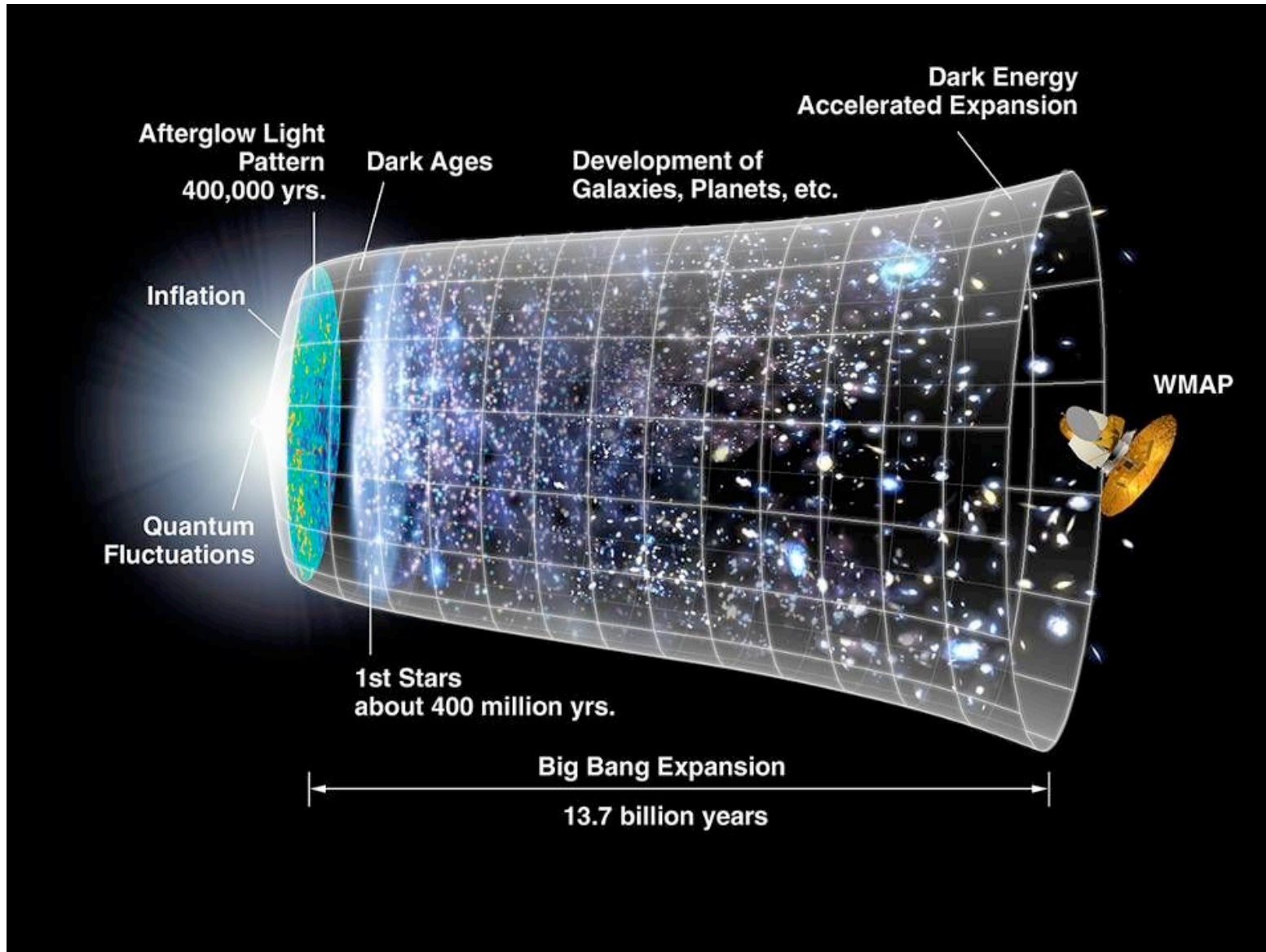


Image courtesy of NRAO/AUI

# Radio Telescopes



# Looking back



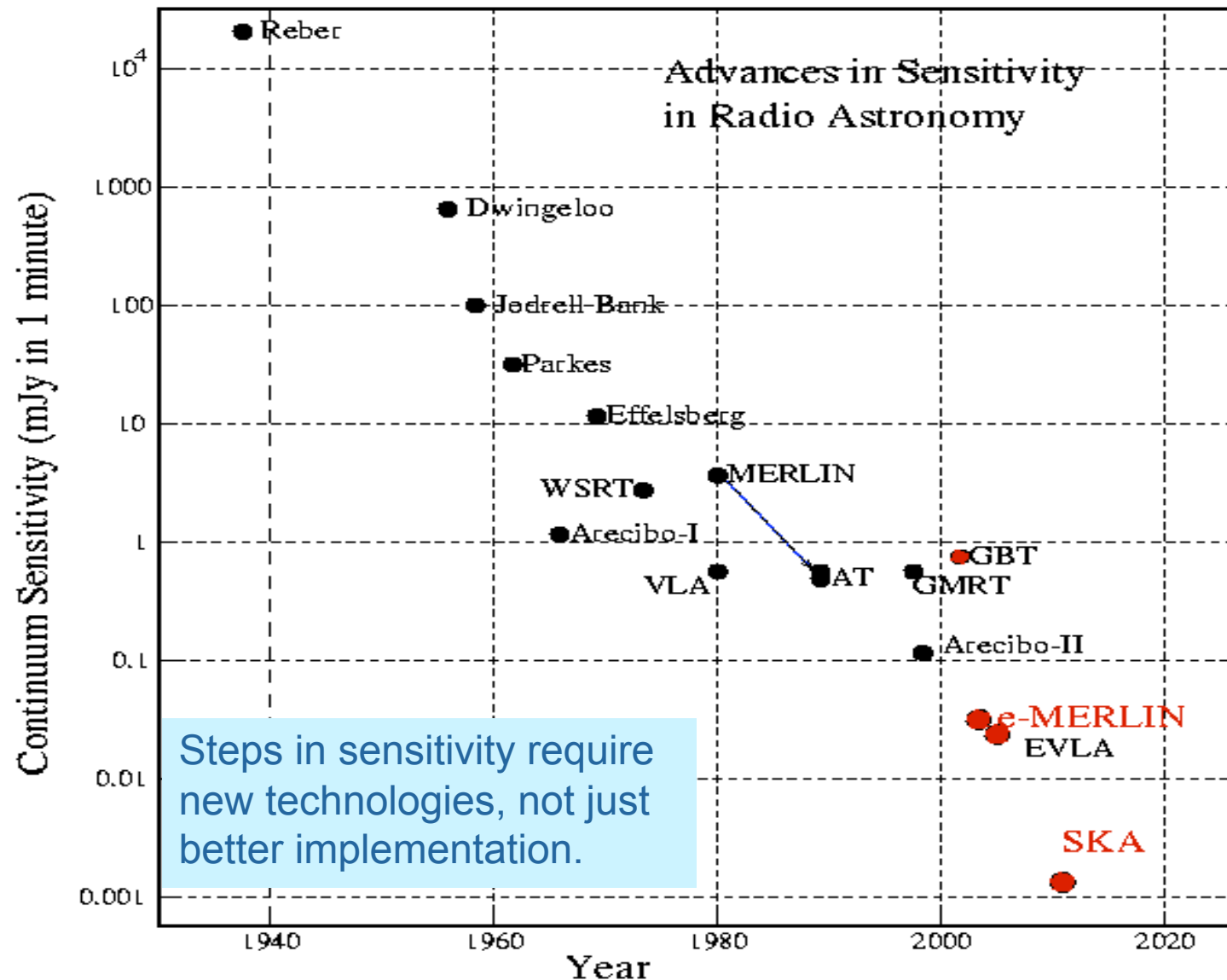


# What will SKA be?



- A “Mega-science” instrument.
- 1 million square metres of effective collecting area.
  - Probably a mid-range array of 4500 x 15m dishes (or equivalent),
  - Probably with a low frequency array (dipoles or phased aperture arrays)
  - Possibly a high frequency array (small dishes), all co-located.
- 100 times more sensitive than today’s best instruments.
- Proposed capital budget of €1.5 billion.
- Operational circa 2022.
- An international enterprise from the outset and at all levels

# Sensitivity



# SKA Science



- *Transformational Science*
  - Probing the Big Bang, the early Universe and the Dark Ages
  - Dark energy and dark matter
  - Observing the first astronomical objects
  - Tracing the evolution of galaxies
  - Detection of gravitational waves and tests of strong field relativity (pulsars)
  - The magnetic universe
  - Cradle of life (planets & SETI)
  - Pulsars, Gamma-Ray Bursters, transients
  - Serendipitous discoveries ...  
(as with previous large telescopes)

# Key Science Projects



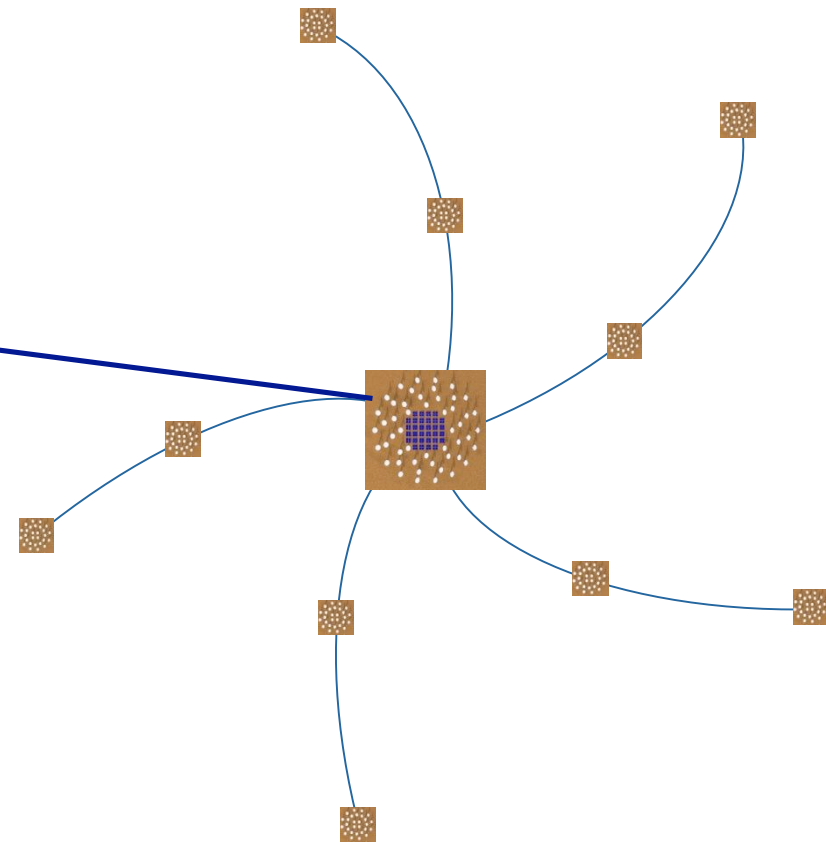
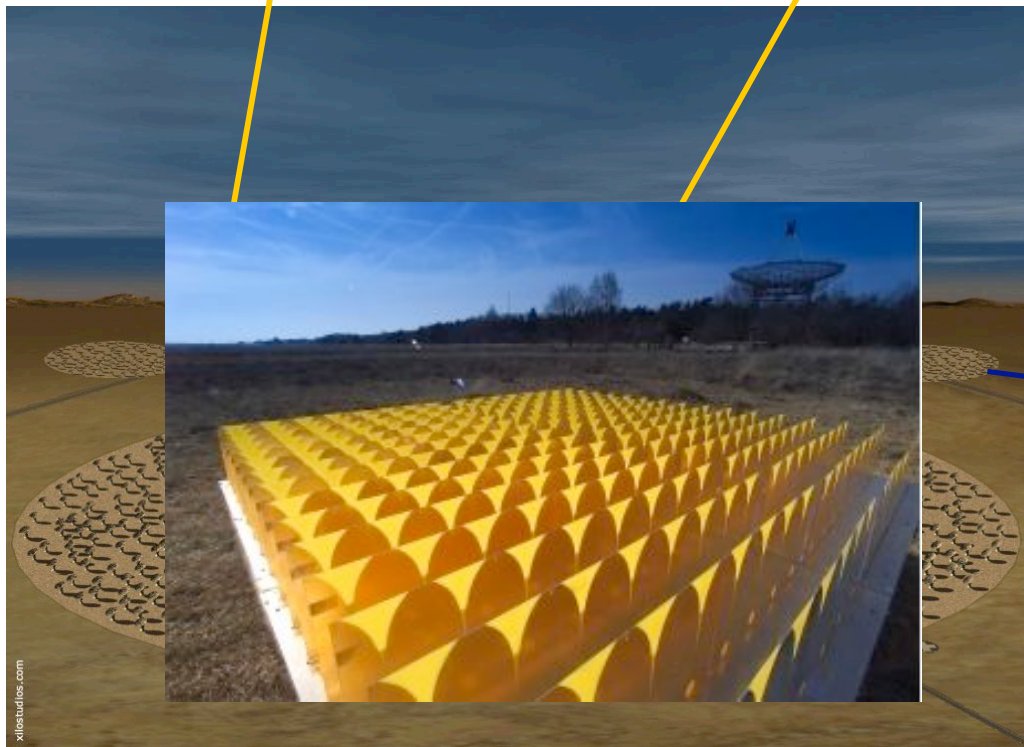
- Gravity – probing strong field gravity via timing of pulsars in very compact binaries
- Probing the Dark Ages – epochs of reionization, star formation, black hole formation
- Cosmic Magnetism – origin and evolution of magnetic fields in galaxies and clusters
- The Cradle of Life – terrestrial planet formation, SETI, astrochemistry
- Evolution of Galaxies and Large Scale Structure – observations of HI in galaxies at high redshifts leading to the strength of dark energy as a function of cosmic epoch

# What will SKA look like?



Digital radio camera  
(thousands of dishes)

Radio fish-eye lens consisting of  
aperture array tiles



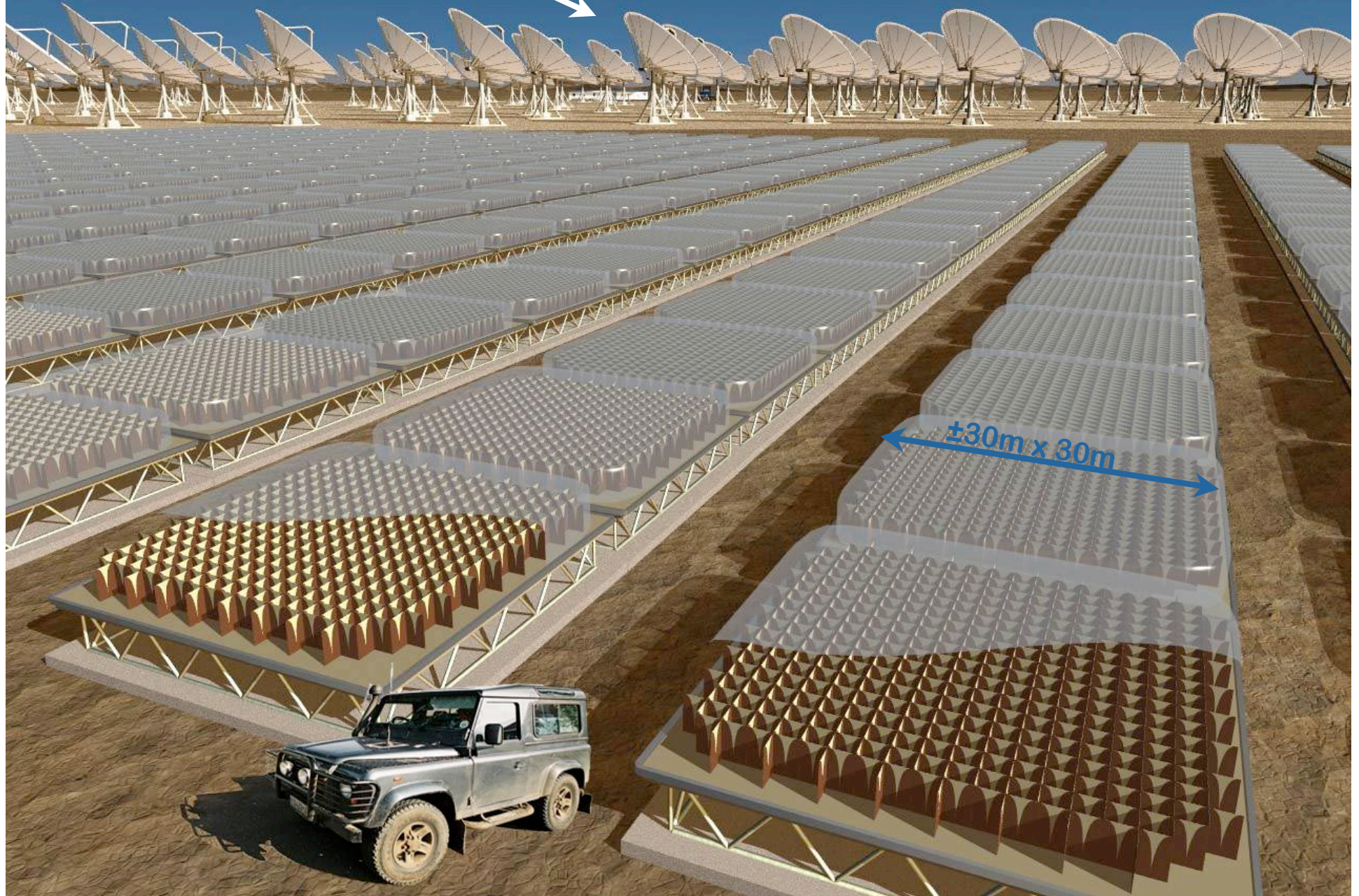
**Stations**

Typically 25 Antennas

Linked to core via Fibre network



10-15m dishes standing 15-20m high



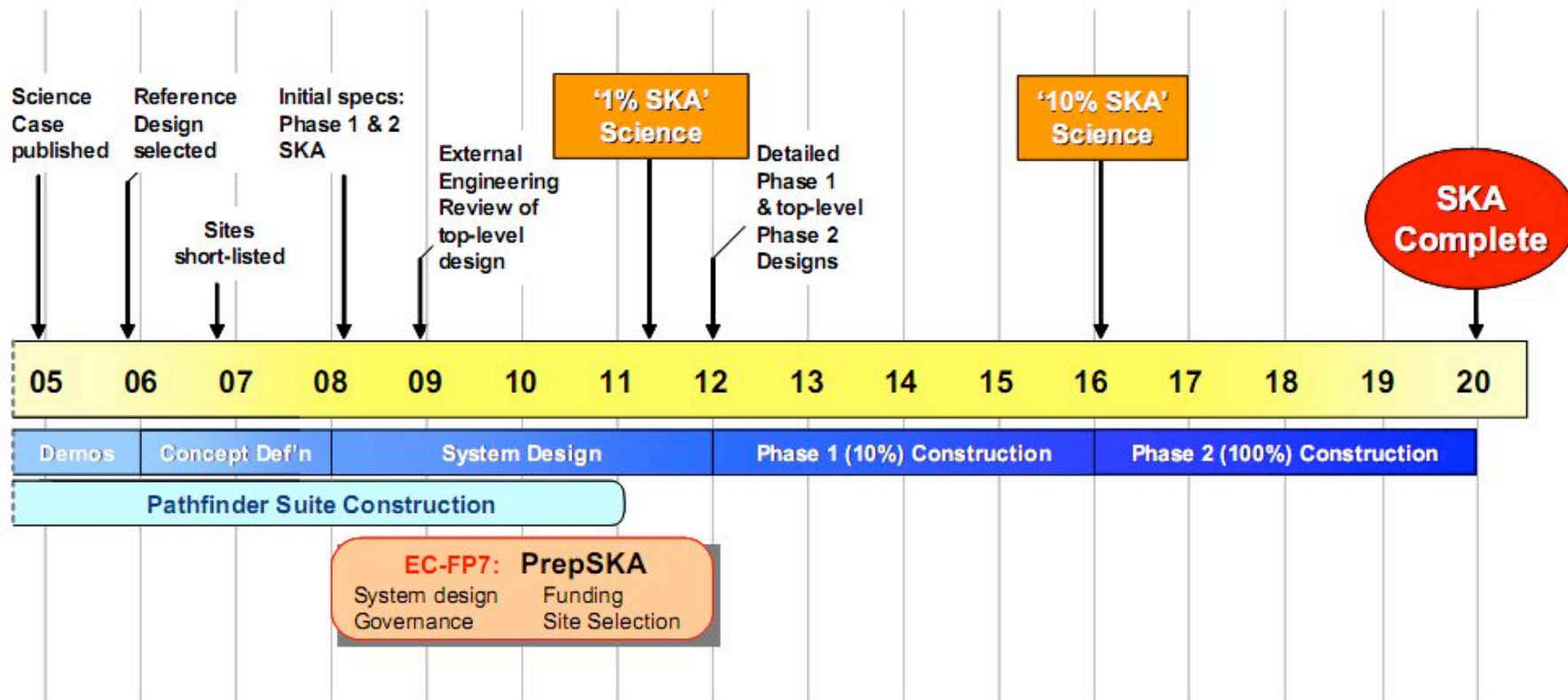
# Configuration



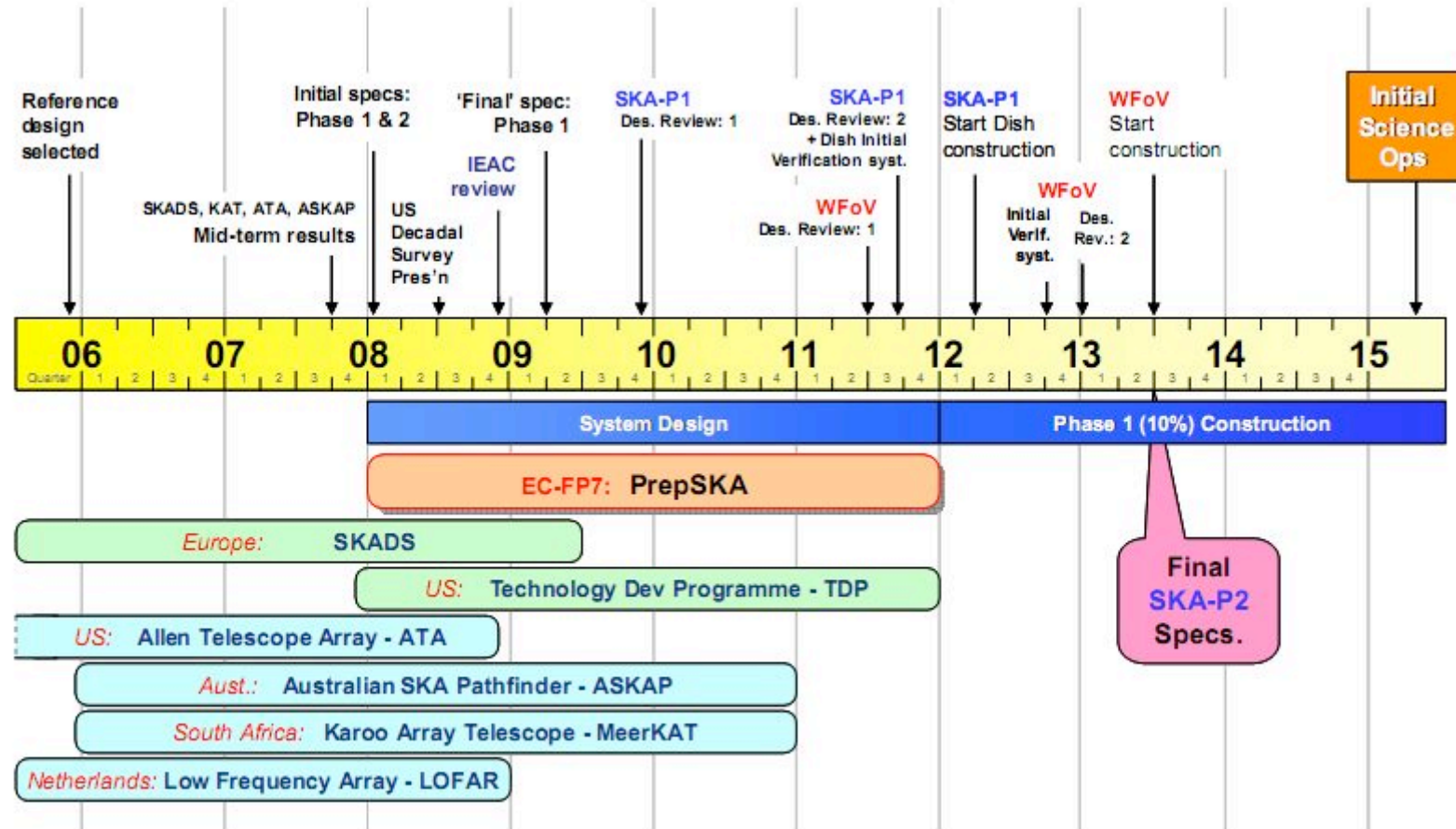
- Baselines from a few tens of meters to a few thousand kilometers are required.
- The parameters for the proposed distribution of collecting area are:
  - 20% within a central area of 1 km diameter
  - 50% within an area of 5 km diameter
  - 75% within an area of 150 km diameter
  - and maximum baselines extending to at least 3000 km.



# SKA Timeline



# SKA Timeline



# SITE SELECTION



- RFP end 2002
- Five countries bid – Argentina, Australia, China, South Africa, USA
- Short list September from International SKA Steering Committee September 2006 – Australia and South Africa

# South African Radio Frequency Measurement Campaign



Permanent cabin at SKA Core Site



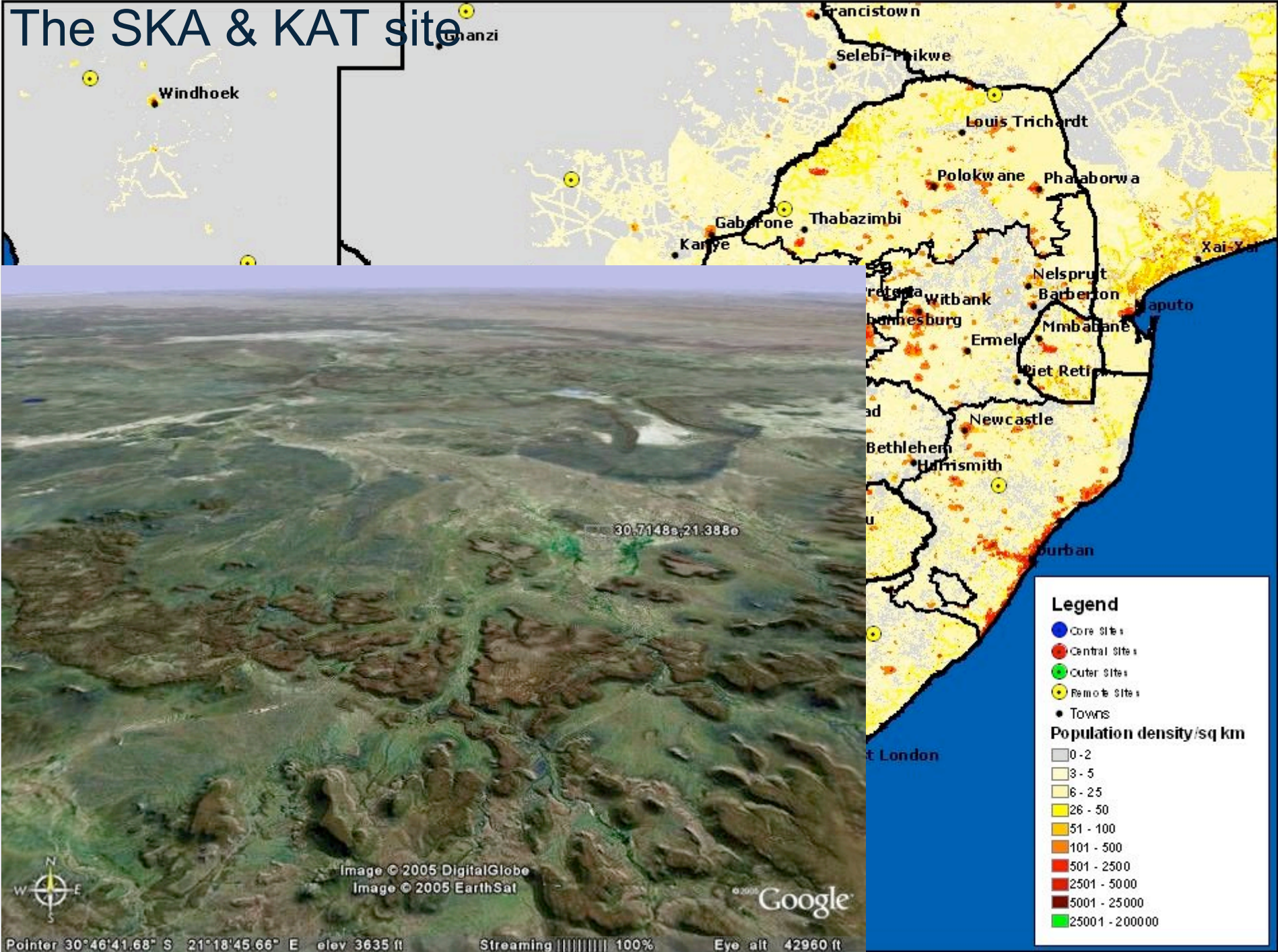
Trailer in tow



# Remote sites



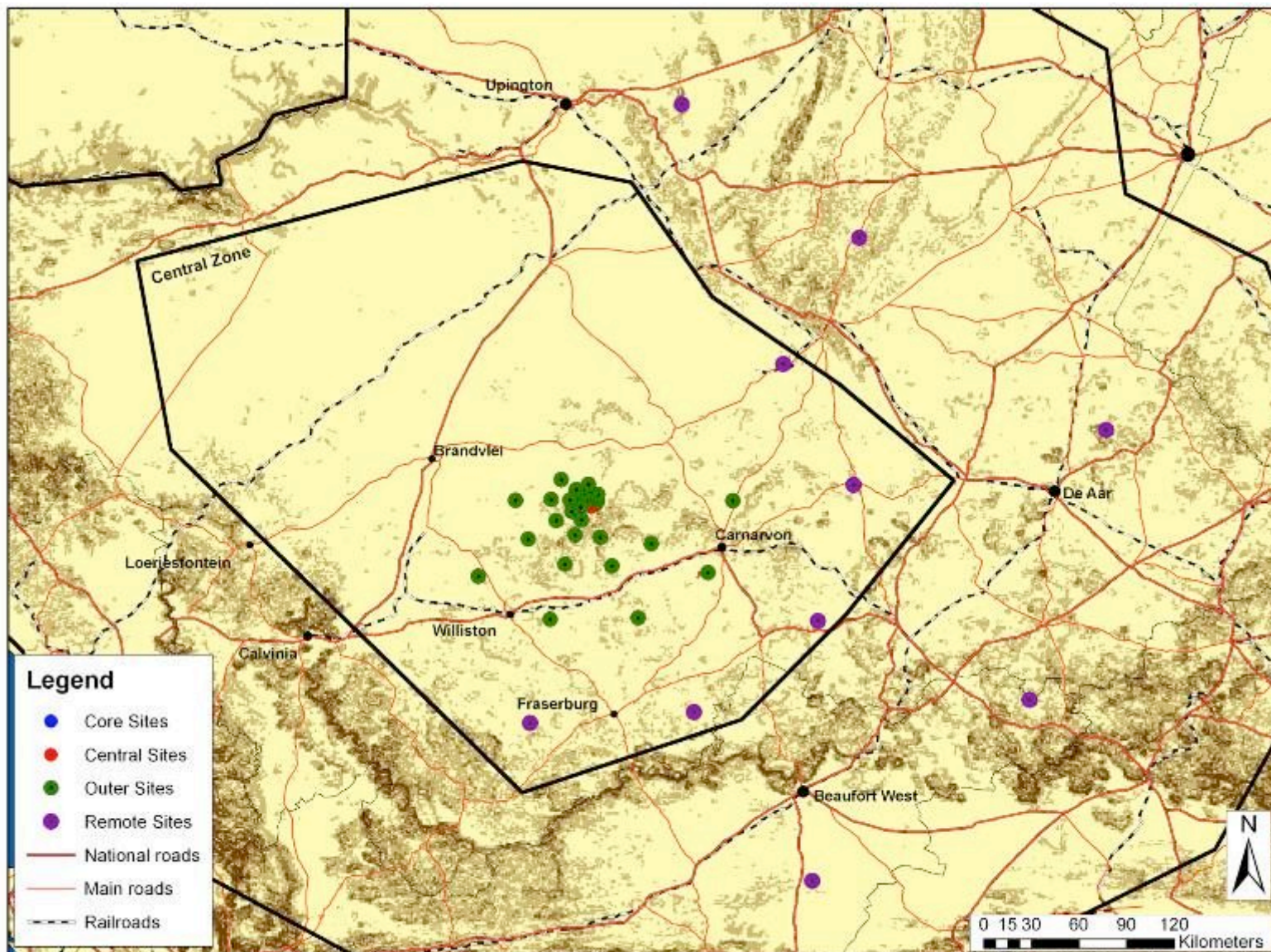
# The SKA & KAT site



# Site

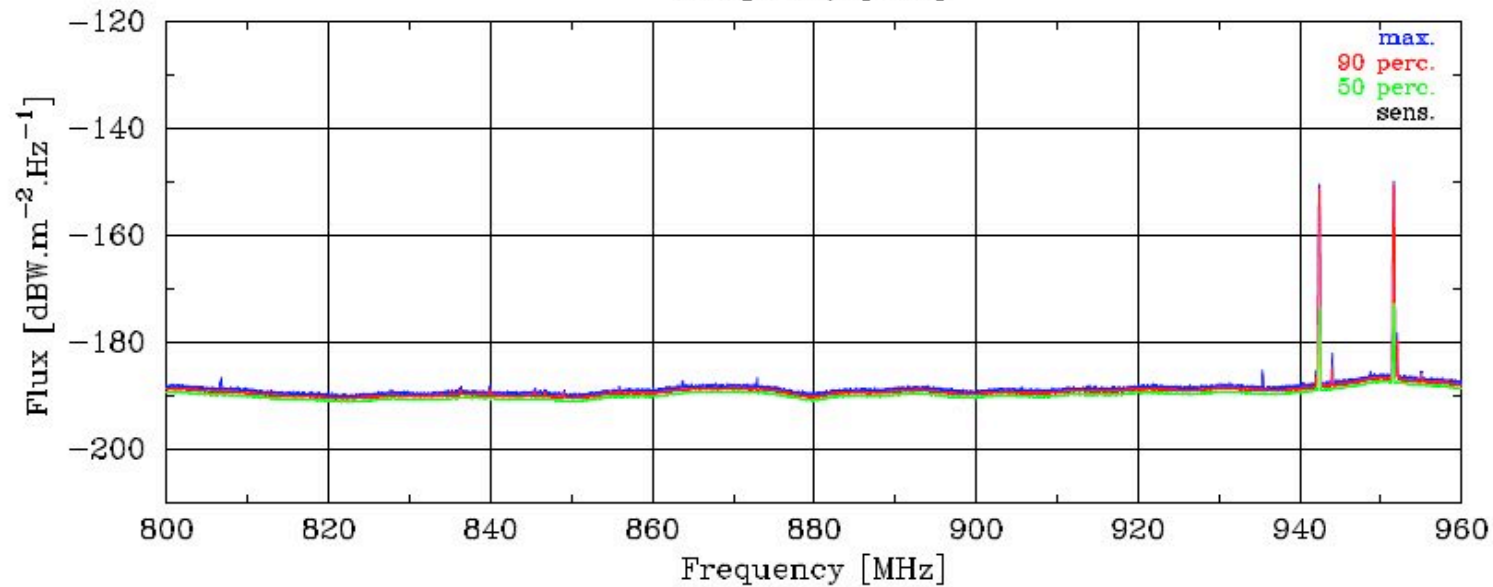
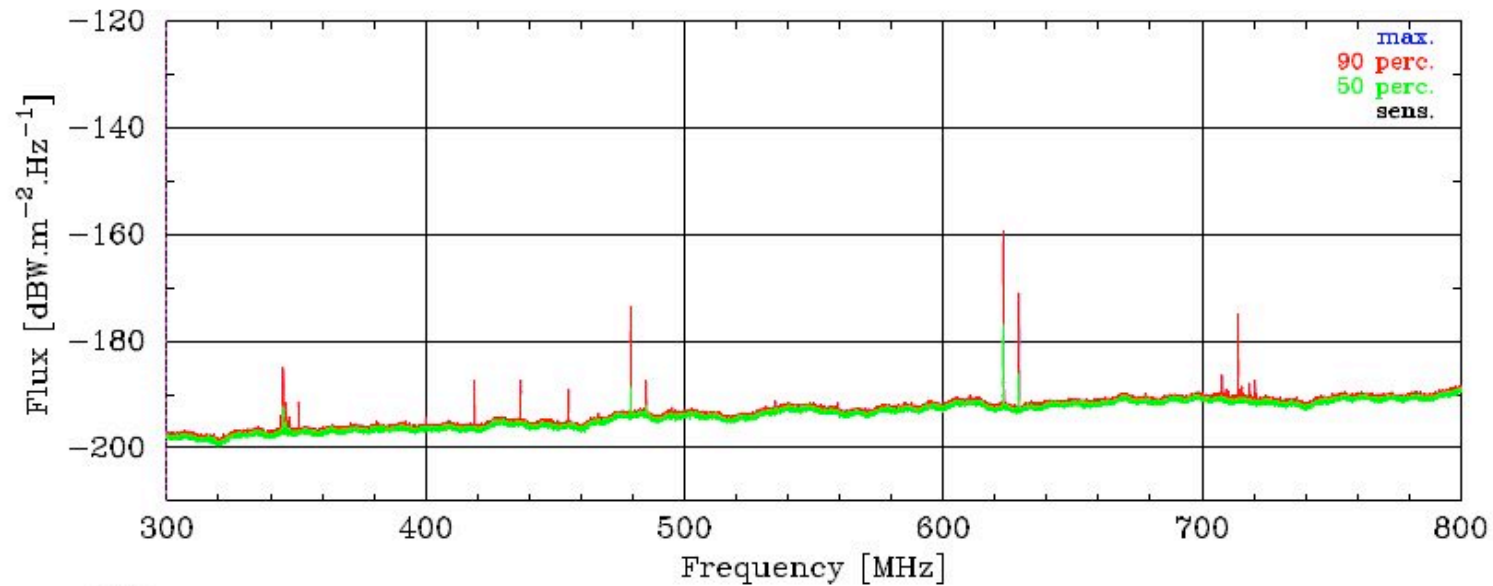


# Site

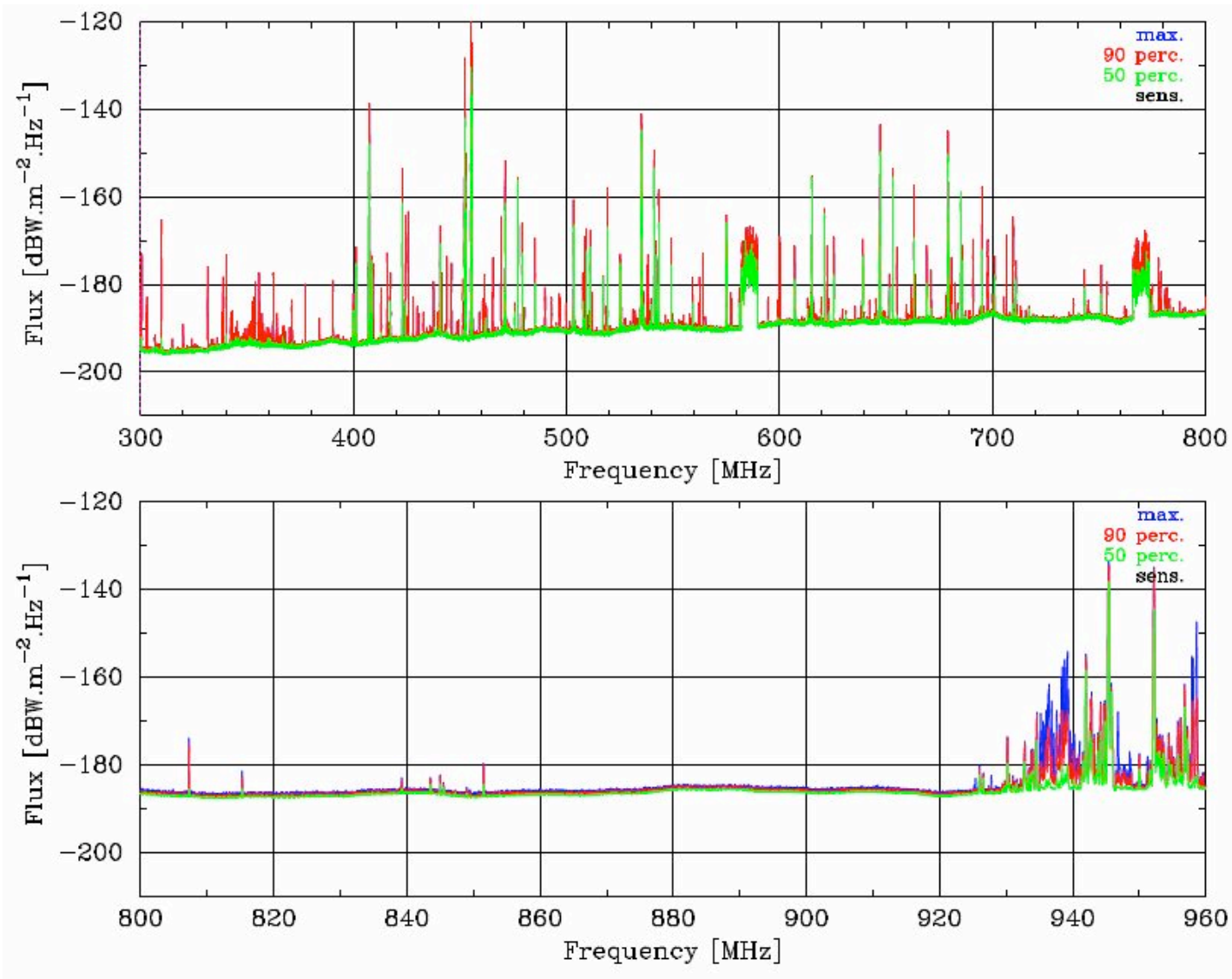




# South African Radio Frequency Measurement Campaign



# Radio Frequency Environment HartRAO

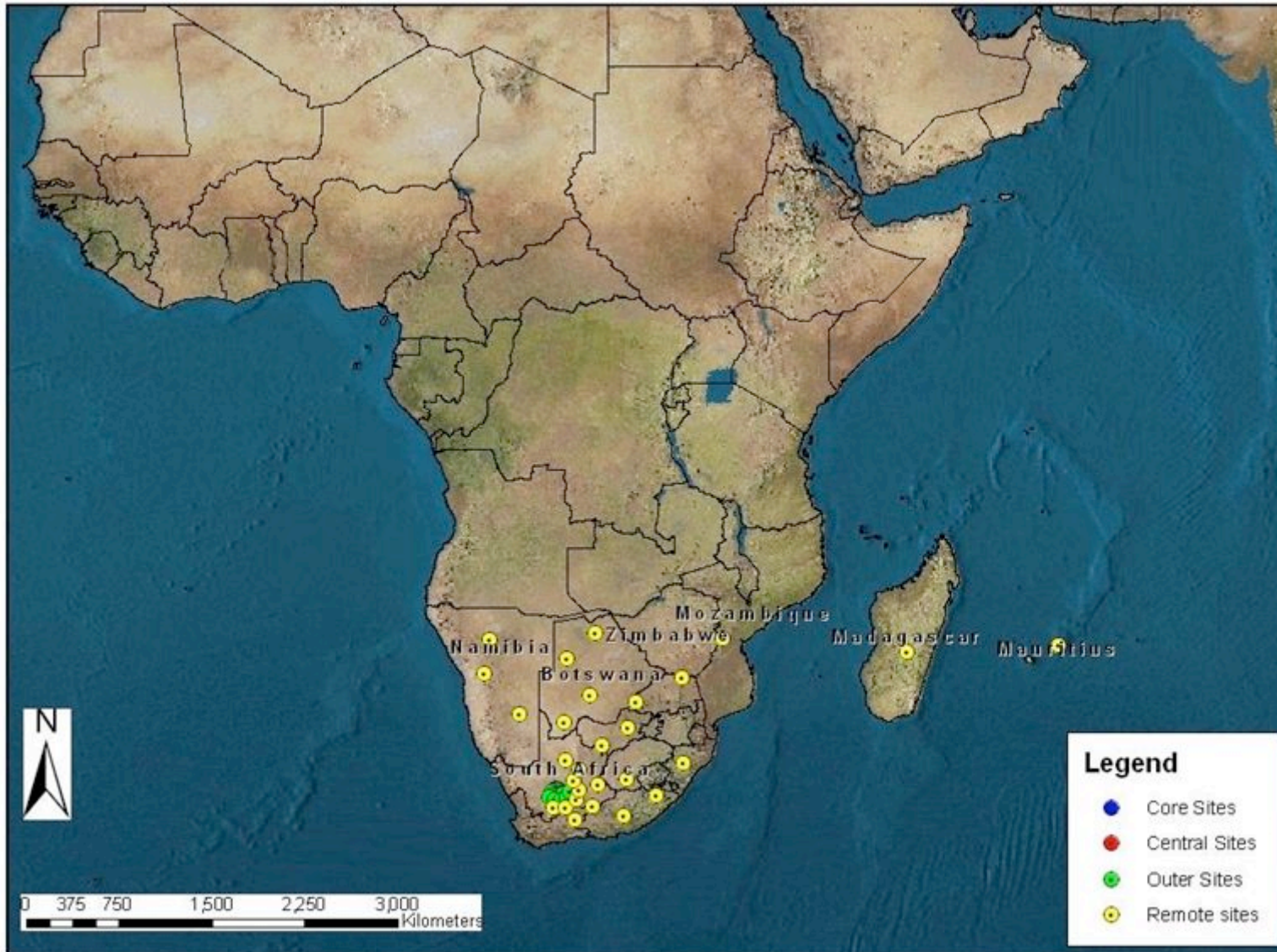


# SKA: Why in South Africa?



- Viable site
  - Good RFI environment
  - Stable ionosphere
  - Dry and stable troposphere
  - Remote but accessible
  - Common sky coverage with existing telescopes
- Capacity to construct and support the SKA
  - Proven project management track record
  - World-class manufacturing and construction industry
  - Good universities and skills
- Government commitment
  - Astronomy Geographic Advantage Act
  - Astronomy Geographic Advantage Programme
  - Implementation of basic infrastructure
    - Power
    - Data transport
    - Roads and civil infrastructure

# Stations





k a r o o a r r a y t e l e s c o p e

# KAT Project in South Africa

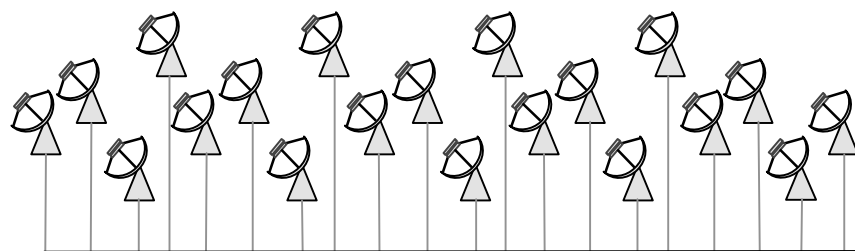


- In 2005/6 the Treasury allocated funds to the construction of the Karoo Array Telescope (KAT)
  - Funding was allocated for the development and construction of a 20 dish telescope (cluster feeds)
    - Initiated development of the XDM
- November 2006 further funds were allocated
  - This will be enough for “few percent” SKA hence ...

# meerKAT (more KAT)



# What is the KAT/MeerKAT?



**Dishes and Feeds:**  
80 x 12 m dishes, each equipped with a single pixel prime focus feed

### Key interfaces

**Optical RF links:**  
80 x 2 optical links  
(80 dishes, 2 polarisations)

Digital Receiver

Front end station processor

**Station data:**  
High speed, large data volume, long distance data transfer Karoo Station to off-site data processing facility.

Back end station processor

**Station data:**  
Distribution internationally, typically over TCP/IP.

Station Controller (Karoo)

Operations Centre (Cape Town)








Internet access

User (Scientist)



# KAT/MeerKAT Objectives



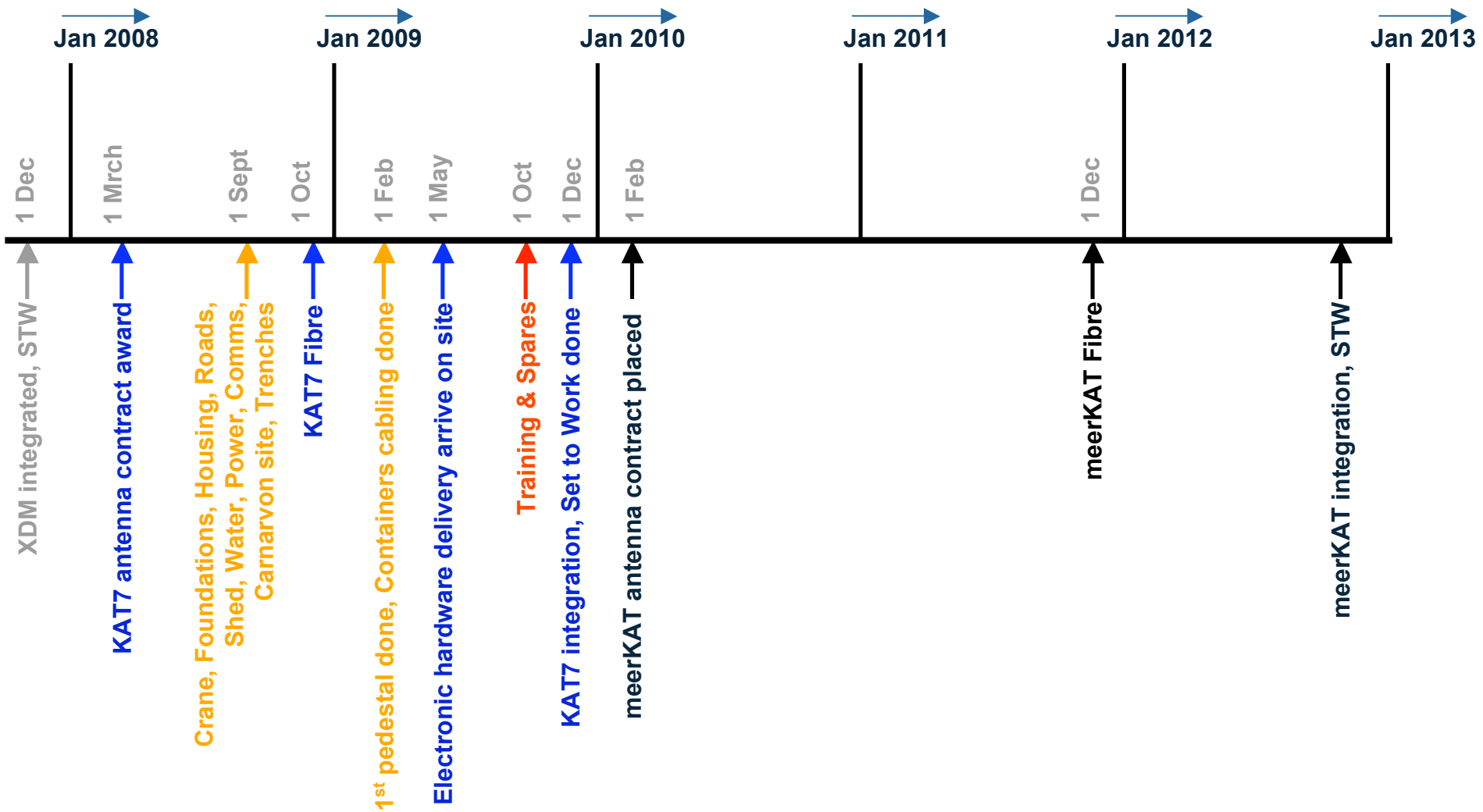
-  Build a world class radio telescope (up to 80 dishes)
-  Choose a frequency range that is likely to have high science impact.
-  Commission a 7 dish system from end of 2009, do early science.
-  Train a new generation of scientists and engineers who are capable to participate in large international projects, such as the SKA.
-  Provide an excellent facility for local and international scientists.
-  Implement mission-driven innovation to mobilise industry, academia and research fraternity.
-  SKA pathfinder

# MeerKAT Science



- Mid frequency science (0.5-3 GHz):
  - Galaxy evolution
  - Cosmic magnetism
  - Transients & Pulsars
- A mixture of blind and directed surveys, therefore two performance metrics:
  - Survey speed for large area blind surveys (e.g. diffuse hydrogen).
  - Sensitivity for small area and directed surveys (e.g. “stacked” HI and pulsar timing).
- A mixture of high and low resolution observing:
  - Low resolution / high filling factor for extended low brightness emission and monitoring of point sources/transients.
  - High resolution for cross-wavelength identification, defeating confusion and classification of morphology.

# MeerKAT timeline

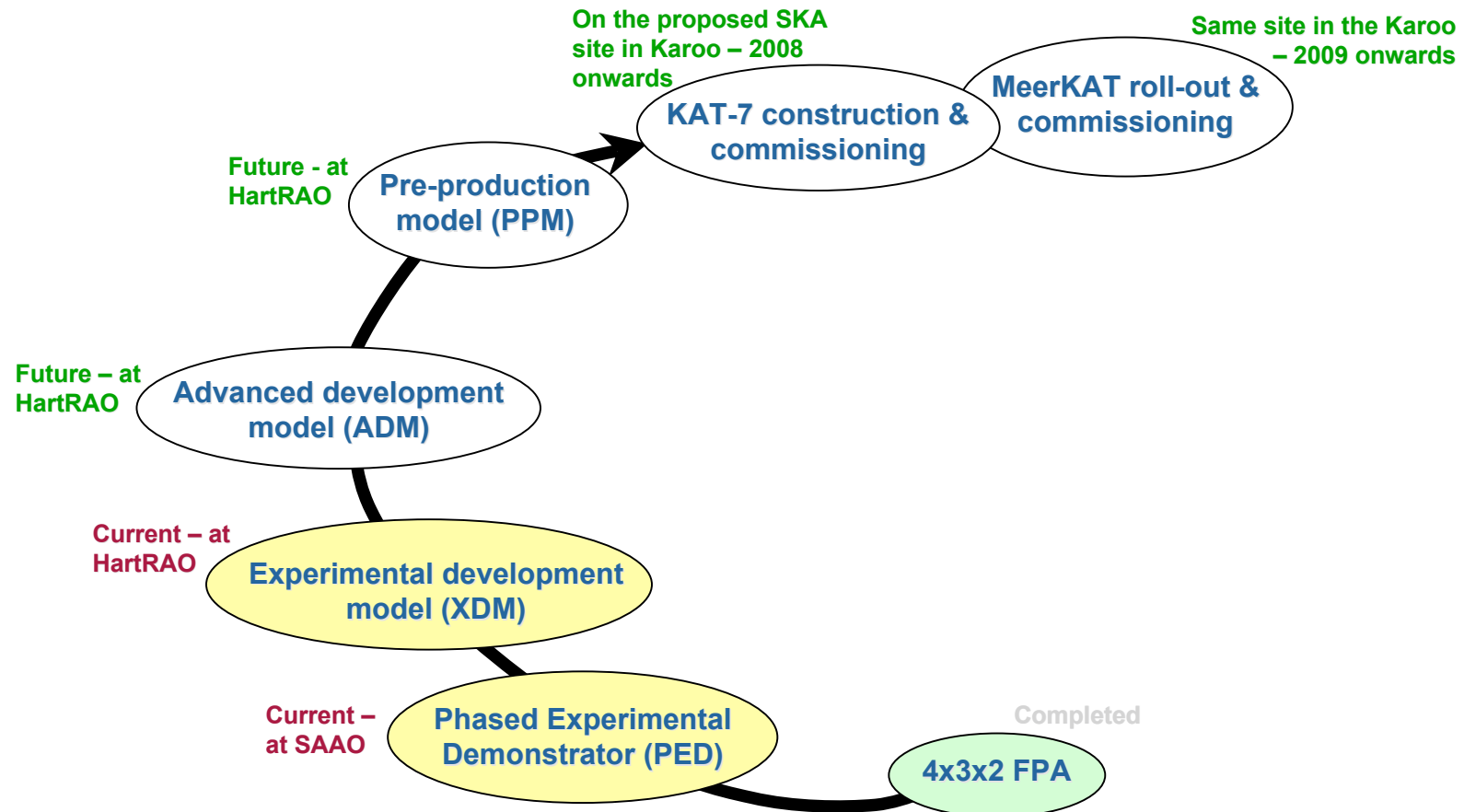


# MeerKAT Technology

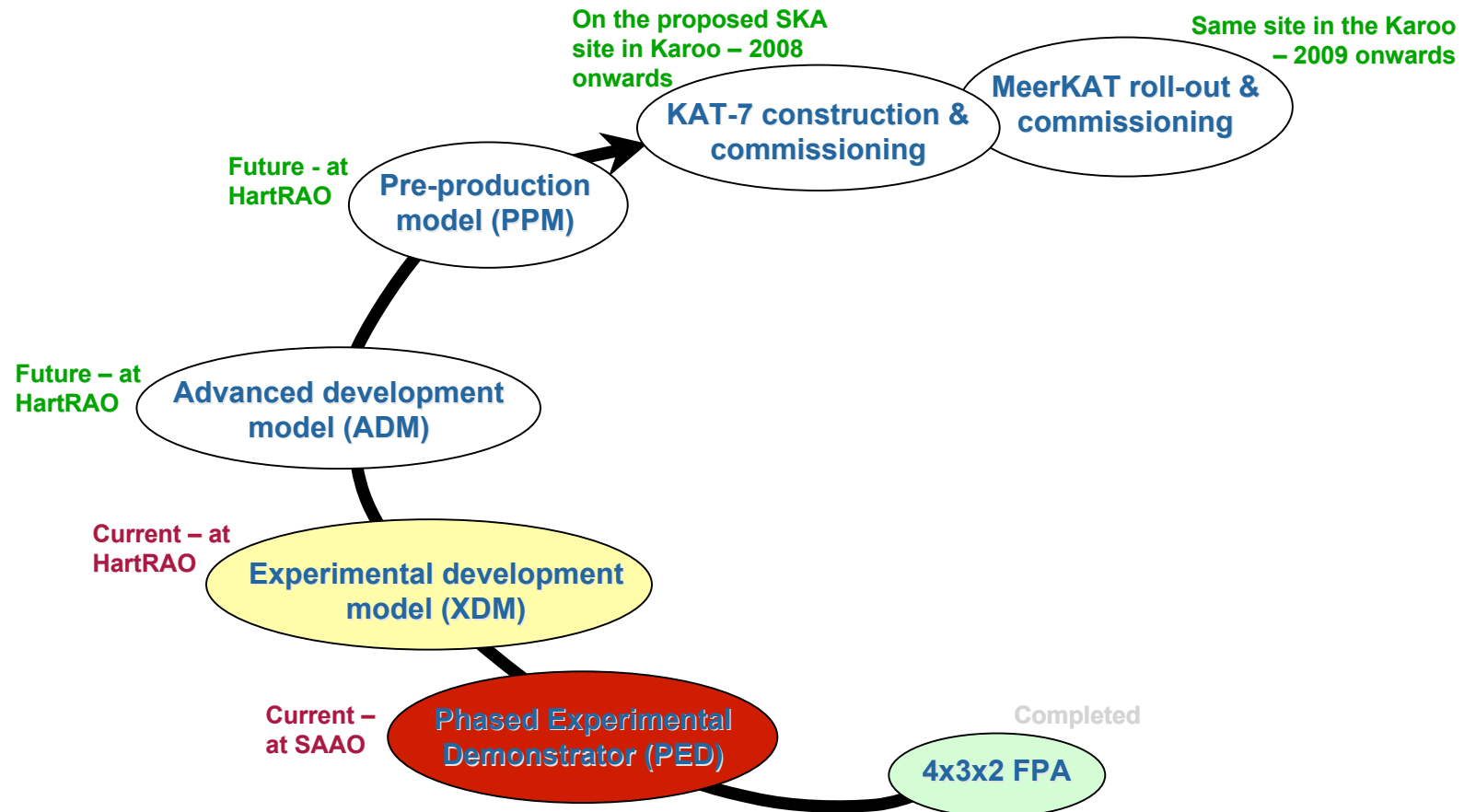


- Low-cost dishes
- Wide-band feeds and receivers
- Digital signal processing
- Calibration and imaging
- High-performance computing
- Operations and logistics

# The prototyping phases








# The prototyping phases

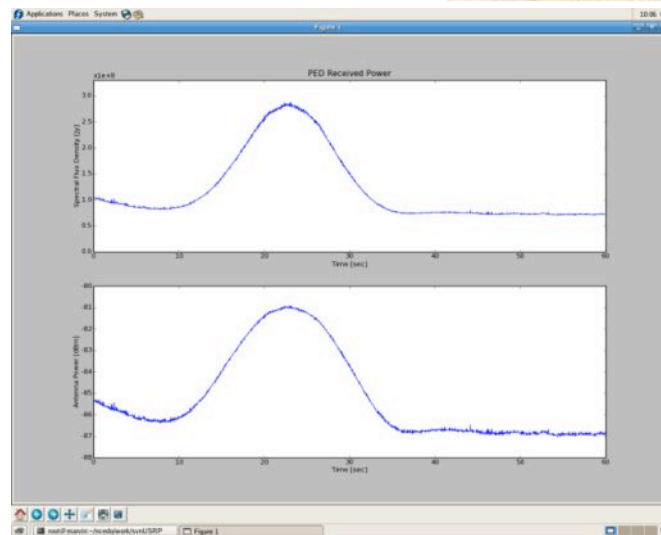
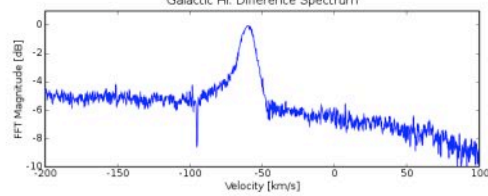
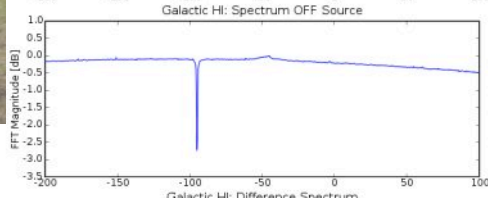
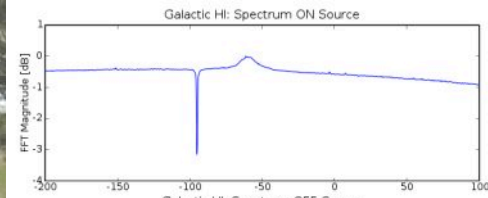


# Phased Experimental Demonstrator (PED)



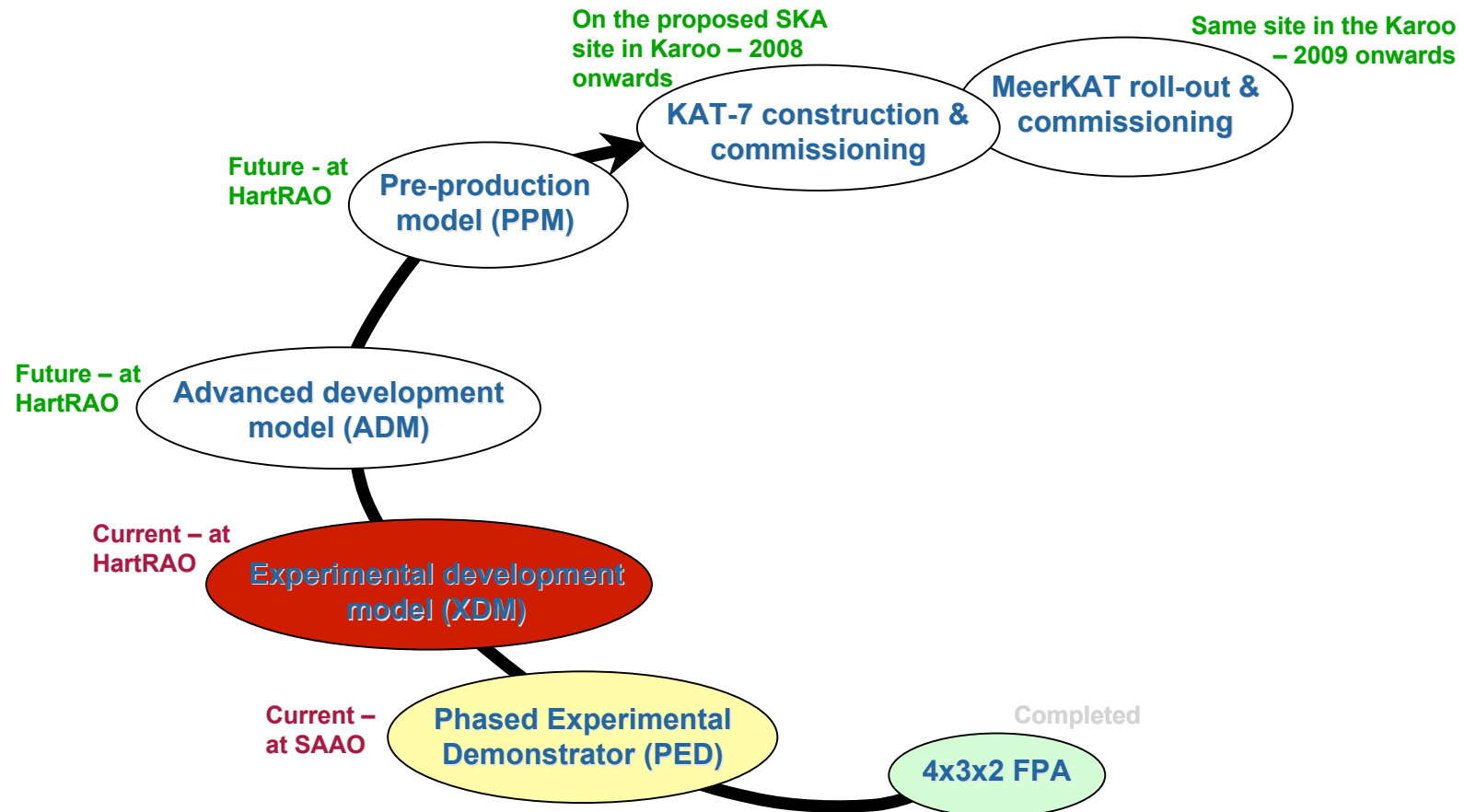
-  Demonstration interferometric telescope to be constructed at the South African Astronomical Observatory (SAAO).
-  Consists of 6 TVRO dishes of 2.5 m diameter each.
-  Test bed for the operational and scientific software.
-  Learning tool for the engineering team as well as a student instrument.
-  Science capability to support student projects.

# PED Pics





# The prototyping phases



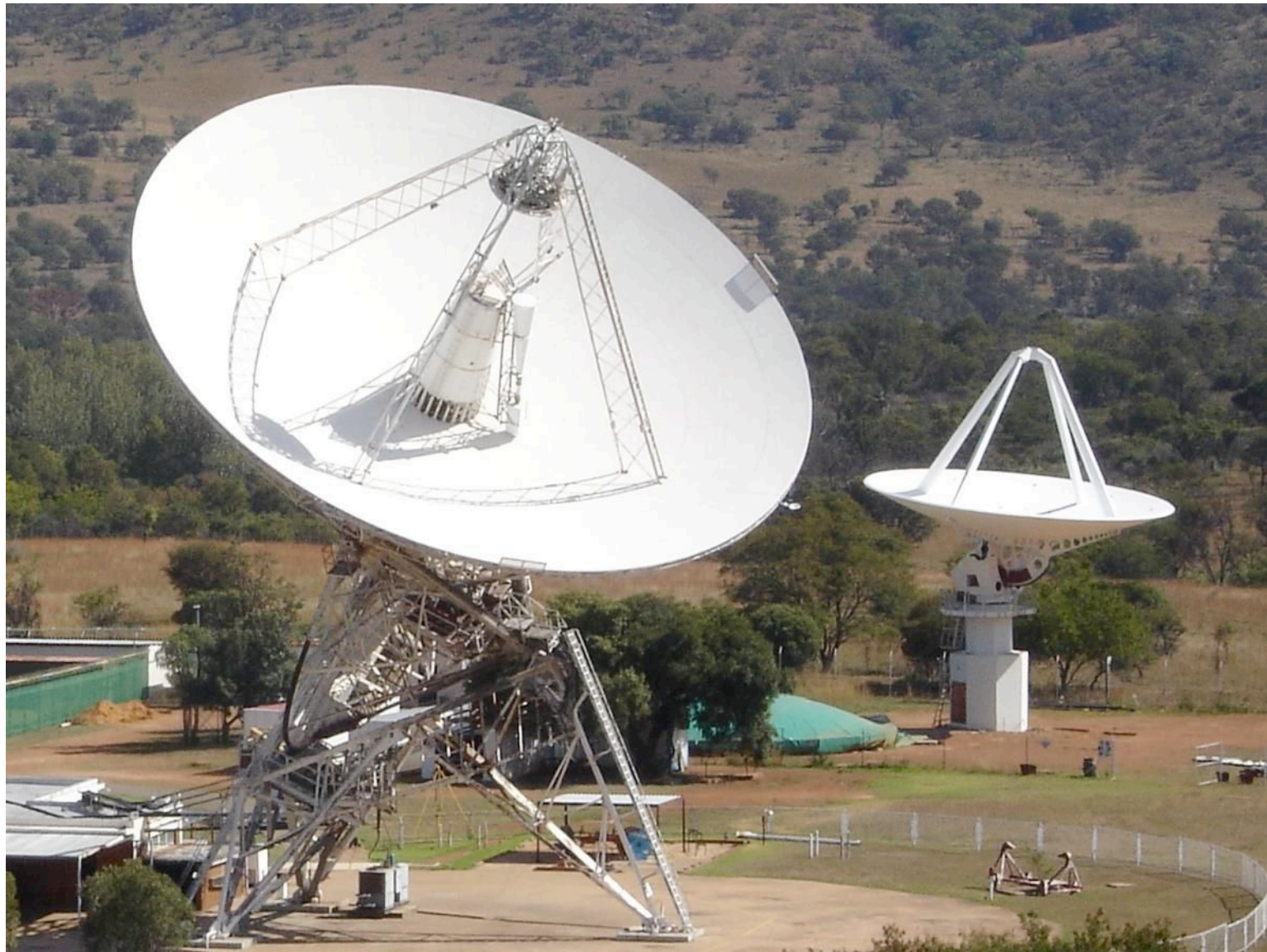
# XDM – Launch (2 Nov 2006)



# The KAT XDM ... work in progress







# Human Capital Development



The SA SKA Human Capital development Programme was initiated in 2004 to leverage the project to get young people into science and engineering and to ensure future strength in South Africa in radio astronomy, fundamental physics, radio frequency engineering, digital signal processing, software engineering and computing.

Number of bursaries awarded per academic year and academic level

## NASSP

	(honours)	MSc	PhD	Postdoctorate	Totals
<b>2005 intake</b>	0	7	2	0	<b>9</b>
<b>2006 intake</b>	0	8	5	2	<b>15</b>
<b>2007 intake</b>	4	14	8	2	<b>28</b>
<b>Total</b>	<b>4</b>	<b>29</b>	<b>15</b>	<b>4</b>	<b>52</b>

# Human Capital Development



	<b>South Africans</b>	<b>Non South Africans studying at SA HEI</b>	<b>Non South Africans studying at a HEI in SA SKA Partner Country</b>	<b>Totals</b>
<b>2005 intake</b>	7	2	0	9
<b>2006 intake</b>	11	3	1	15
<b>2007 intake</b>	20	8	0	28
<b>Total</b>	<b>38</b>	<b>13</b>	<b>1</b>	<b>52</b>

# Targets for postgraduate bursaries for 2008



<b>South Africans</b>	
Postdoctorate Fellowships	2
PhD	9
MSc	13
<b>Non South Africans studying at SA HEI</b>	
PhD	2
MSc	3
NASSP (honours)	3
<b>Non South Africans studying at a HEI in SA SKA Partner Country</b>	
PhD	2
MSc	2



# Targets for postgraduate bursaries for 2008



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# NASSP



## NASSP

### National Astrophysics and Space Science Programme

- Intro to Programmes
- Quotes From Industry
- Colloquium Series
- Summer School
- Lecture Timetables
- NASSP Students
- Available Projects
- NASSP News
- Student Workshop
- Computer Lab
- Annual Report
- NASSP Sponsors
- NASSP Consortium
- Student Handbook
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#### Postgraduate Degrees in Astrophysics and Space Science

South Africa has a long history of excellence in astronomy, a sound high-tech infrastructure and clear skies. Researchers from around the region have joined forces to create a cooperative, combined graduate programme, hosted at the University of Cape Town where South African students and students from around Africa and the rest of the World can study under the guidance of some of South Africa's leading scientists. Two degree programmes are on offer:

- Honours in Astrophysics and Space Science
- Masters in Astrophysics and Space Science
- PhD in Astrophysics and Space Science

Lectures will be given by staff in the NASSP consortium and will cover most areas of modern Astronomy, Astrophysics and Cosmology. In addition to lecture courses, students will be expected to take a substantial practical component which will involve several field trips to some of southern Africa's space science research facilities. These include the South African Astronomical Observatory site at Sutherland where the Southern African Large Telescope (SALT, the largest optical telescope in the southern hemisphere) is located; the radio telescope facility at Hartebeesthoek and the High Energy Stereoscopic System (HESS).

Students graduating from this programme will be both equipped to do research at the cutting edge of Astrophysics and have the broad science skills needed in any modern technological society. Here are some quotes from people trained in astronomy who are now working in industry and commerce.



©NASSP

peter | 02/10/2007 08:05:55

# Bursars conference 2006



The logo graphic consists of three curved, overlapping orange and white shapes that resemble a stylized 'K' or a signal wave. To the left of the main text are three black dots of increasing size, arranged in a diagonal line.

***meerKat***  
k a r o o   a r r a y   t e l e s c o p e

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[www.kat.ac.za](http://www.kat.ac.za)

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