Overview of the SKA

Richard Schilizzi

Signal Processing Conceptual Design Review
14 April 2011

This talk

- SKA overview
- Science drivers
- Baseline Design
- Advanced Instrumentation Program
- Engineering progress
- Pre-construction phase
- Governance
- Site selection
- Schedule

Timeline

1995-00 Preliminary R&D

2000-07 Initial Concept Phase

2008-12 Preparatory Phase

- System design

2012-15 Pre-construction Phase

- Detailed design, Production readiness

2016-23 Construction

2020-50+ Operations

Top-level description

a large radio telescope for transformational science

- up to 1 million m^2 collecting area distributed over a distance of 3000+ km
- operating as an interferometer at frequencies from 70 MHz to 10 GHz (4m-3cm) with two or more detector technologies
- connected to a signal processor and high performance computing system by an optical fibre network

providing

- 40 x sensitivity of EVLA, and
- up to 10000 x survey speed

67 institutes in 20 countries are participating

The Square Kilometre Array

Top-level description (2)

Construction will proceed in two phases: SKA_1, SKA_2

SKA_1 will be a subset (~10%) of SKA_2

Major science observations already possible with SKA_1 in 2020

Phased construction allows maximum use of advances in technology

Science Drivers

SKA_2 Key Science Drivers

ORIGINS

➢**Neutral hydrogen in the universe from the Epoch of Re-ionisation to now**

When did the first stars and galaxies form?
How did galaxies evolve?
Dark Energy, Dark Matter

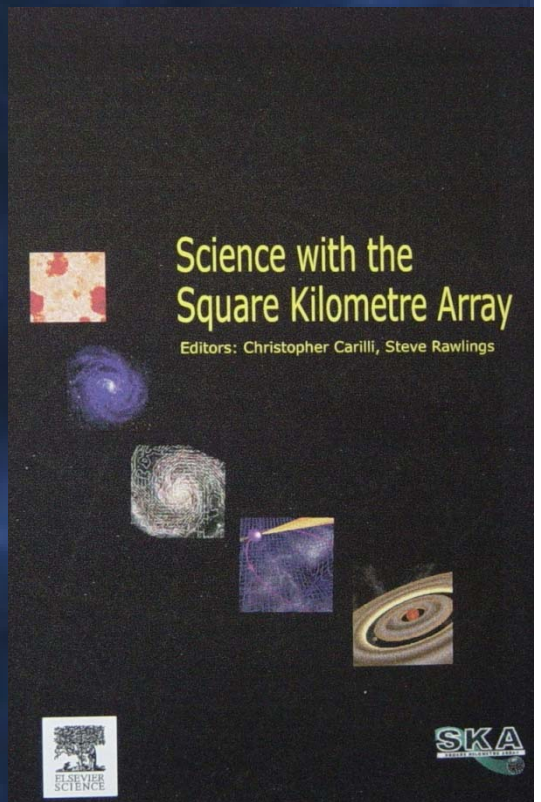
➢**Astro-biology**

FUNDAMENTAL FORCES

➢**Pulsars, General Relativity & gravitational waves**

➢**Origin & evolution of cosmic magnetism**

TRANSIENTS (NEW PHENOMENA)



Science with the Square Kilometre Array

(2004, eds. C. Carilli & S. Rawlings, *New Astron. Rev.*, **48**)

SKA_1 Key Science Drivers

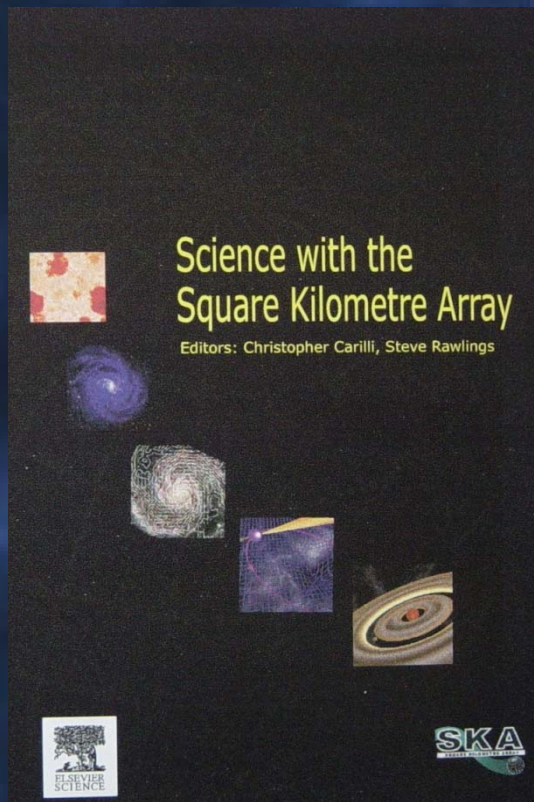
ORIGINS

- **Neutral hydrogen in the universe from the Epoch of Re-ionisation to now**

  When did the first stars and galaxies form?
  How did galaxies evolve?
  Dark Energy, dark matter

FUNDAMENTAL FORCES

- **Pulsars, General Relativity & gravitational waves**



Science with the Square Kilometre Array

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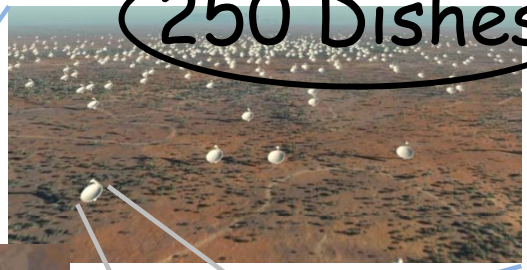
Baseline design and Advanced Instrumentation Program

Exploring the Universe with the world's largest radio telescope

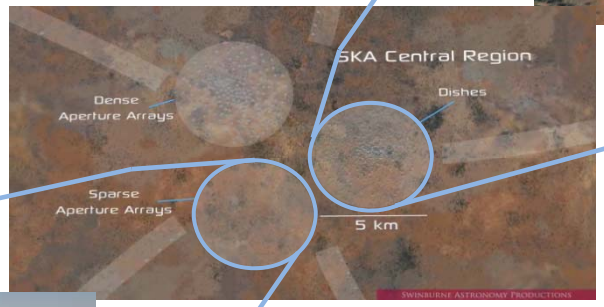
SKA_1 baseline design

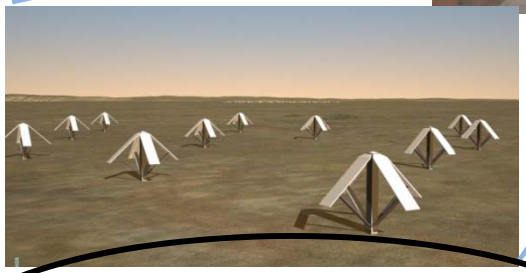
Baseline technologies are mature and demonstrated in the SKA Precursors and Pathfinders

250 Dishes



Central Region





50 Sparse Aperture Arrays

Single pixel feed

Artist renditions from Swinburne Astronomy Productions

Advanced Instrumentation Program

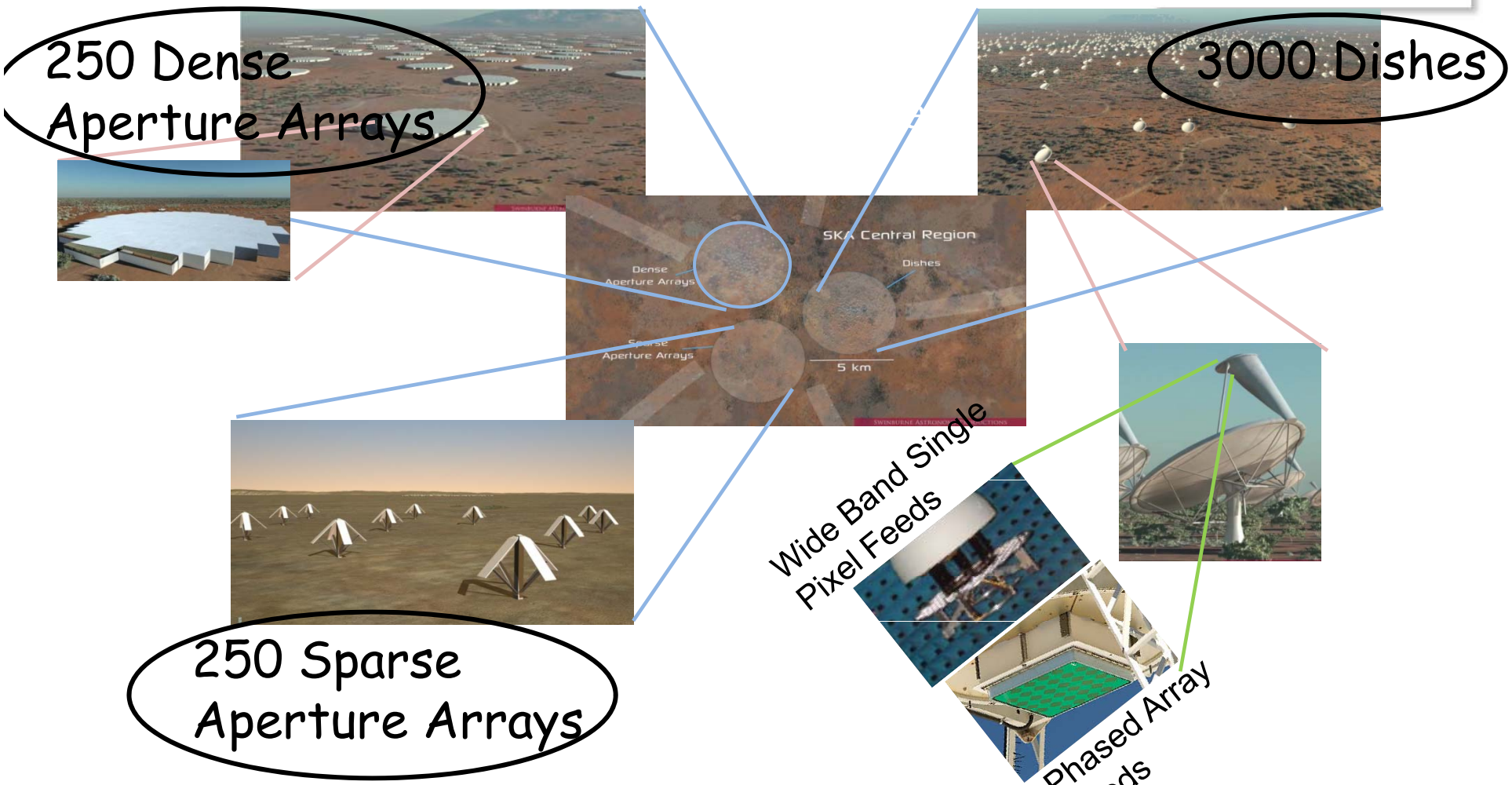
1. Development of innovative wide-field “radio camera” technologies at mid-frequencies
   - phased array feeds (PAFs) on the dishes (FoV ~ 30 deg^2)
   - mid-frequency aperture array (FoV ~ 200 deg^2)
2. Ultra-wideband single pixel feeds

The AIP is designed to build maturity and retire risk

Has the potential for enhancing SKA_1 and being a major part of SKA_2

- Evaluation point in 2014
- Final decision in 2016

SKA_2 including AIP technologies



Artist renditions from Swinburne Astronomy Productions

SKA is driving development of new science & technical solutions

- Dishes, feeds, receivers (N=3000)
- Low and mid aperture arrays (N=250)

} ongoing verification programs

- Signal transport (10 Pbit/s)
- Signal processing (exa-MACs)
- Software engineering and algorithm development
- High performance computing (exa-flop capability)
- Data storage (exa-byte capacity)
- (Distributed) power requirements (50 -100 MW)

INDUSTRY ENGAGEMENT IS CENTRAL TO THE SKA

Current engineering developments

SKA System Design (2007-2012)

Contributing programs

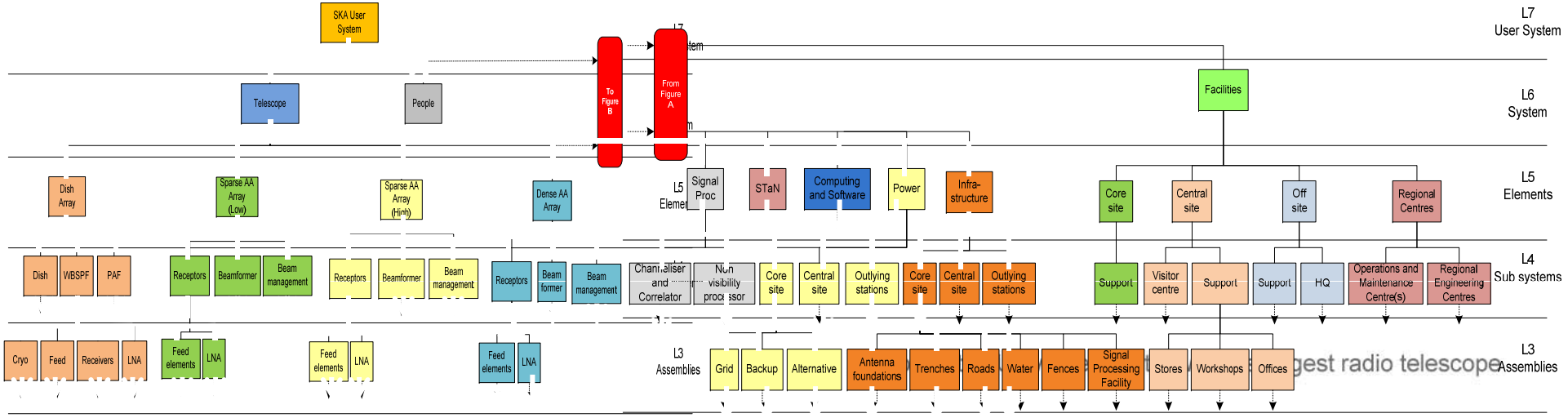
EC FP6 SKA Design Study (SKADS)

EC FP7 Preparatory Phase (PrepSKA)

US Technology Development Program

“Precursor” telescopes on the candidate sites (ASKAP (AU), MeerKAT (SA))

“Pathfinder” telescopes like LOFAR, APERTIF



Baseline design component:
Low frequency aperture arrays

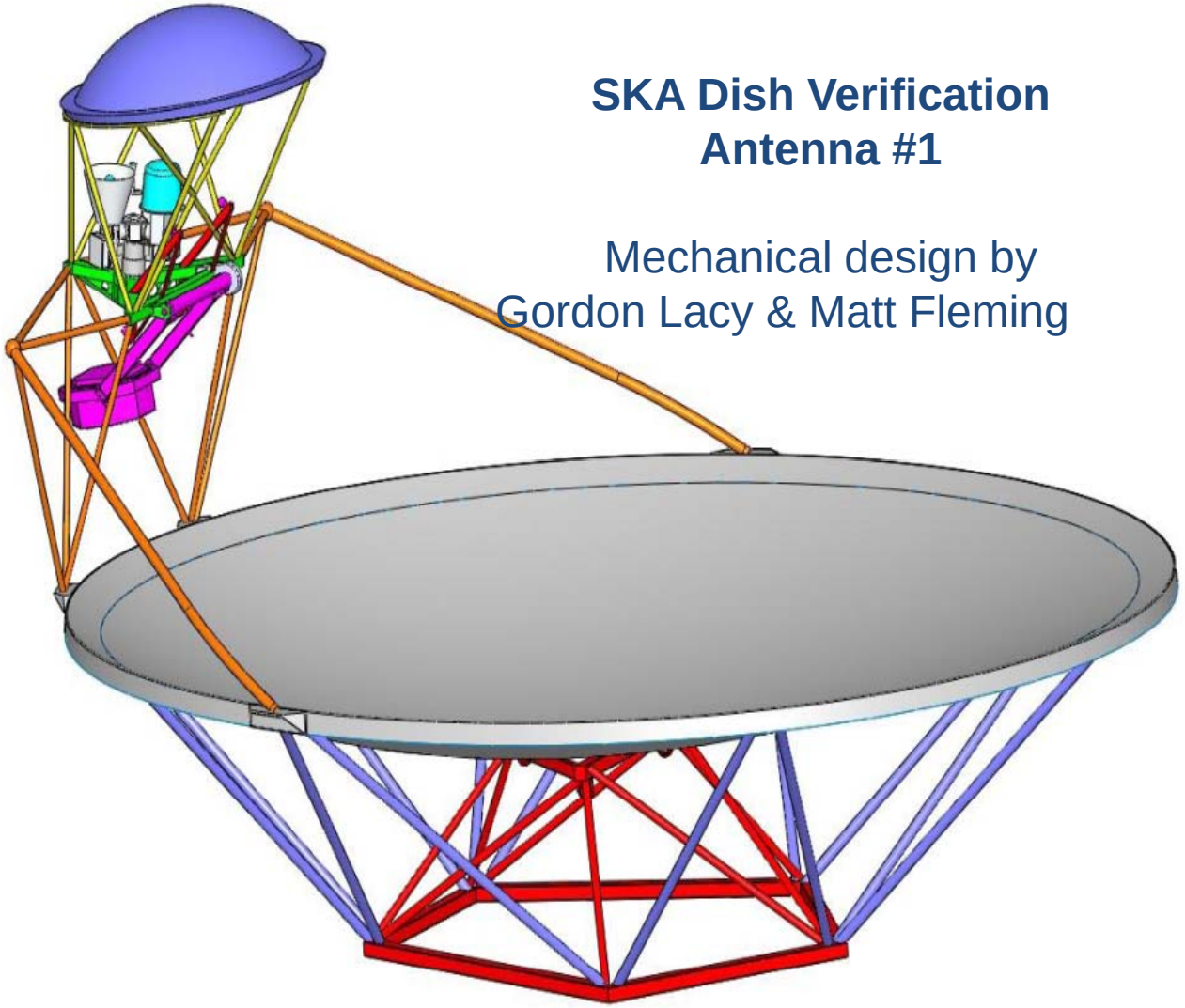
LOFAR (Netherlands et al)

MWA (USA, Australia, India)

Baseline design component: Dishes + single pixel feeds

SKA Dish Verification Antenna #1

Mechanical design by
Gordon Lacy & Matt Fleming



ATA (U

42x6m hydroform dishes

ASKAP

36x12m

ca)

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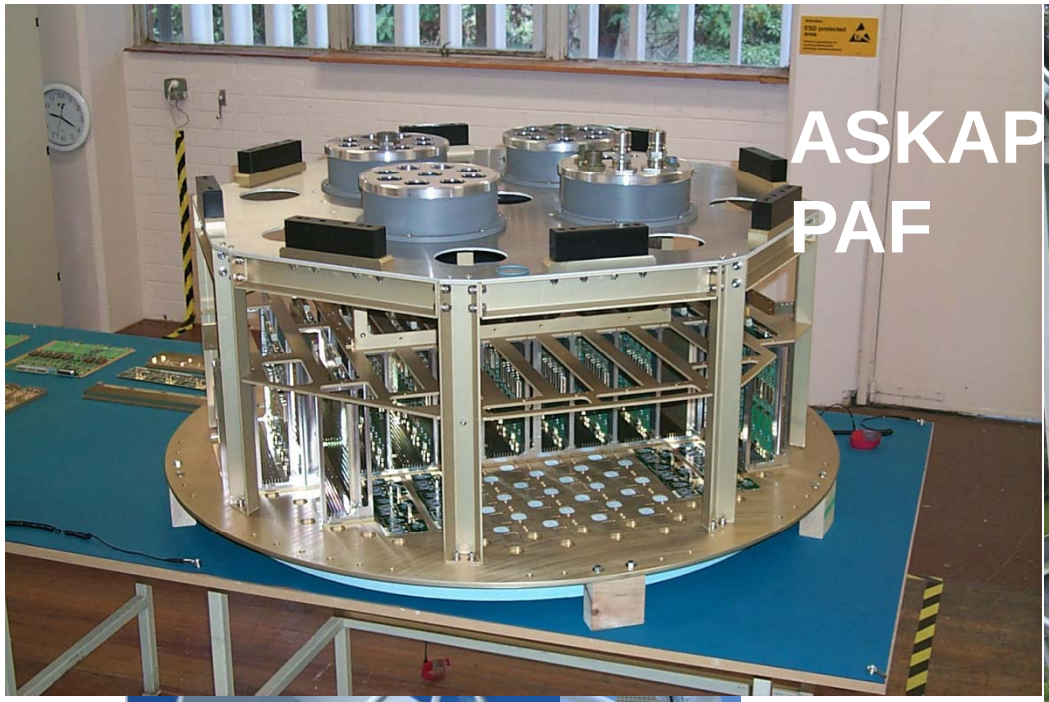
a)

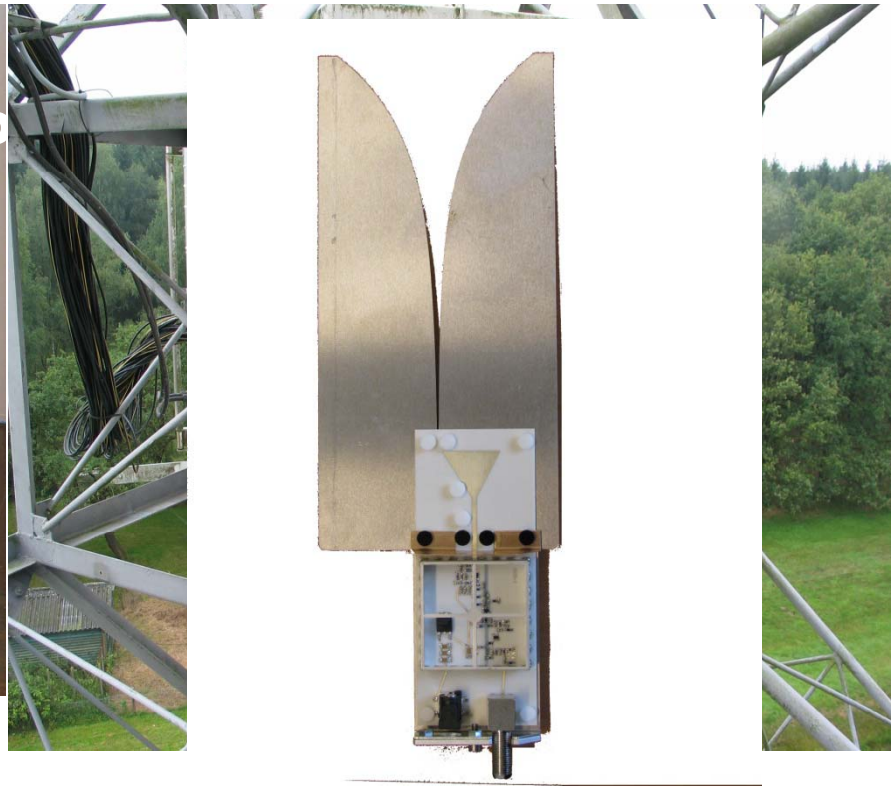
scope

10 m composite prototype

Advanced Instrumentation Program: dishes+multi-pixel feeds



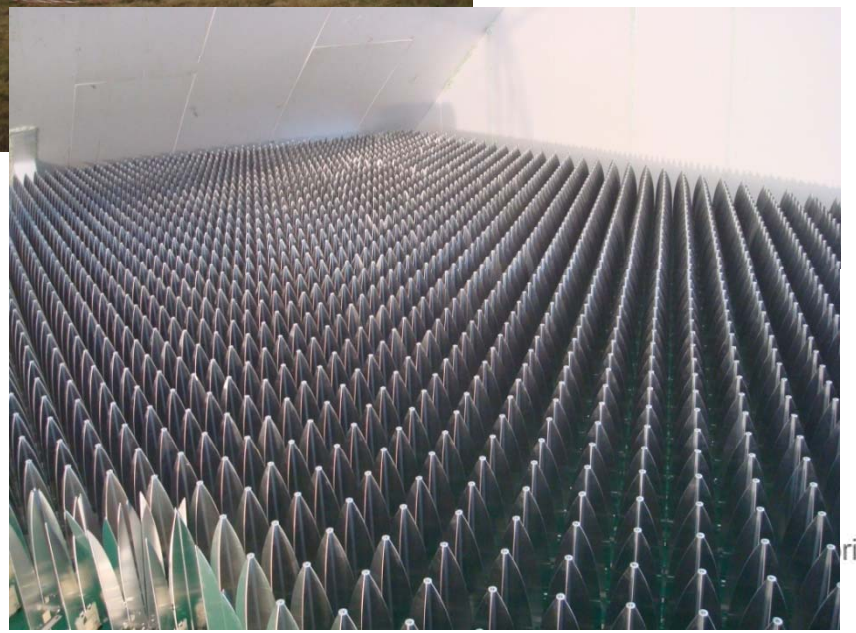
ASKAP PAF



DRAO Canada

Advanced Instrumentation Program: mid-frequency aperture array

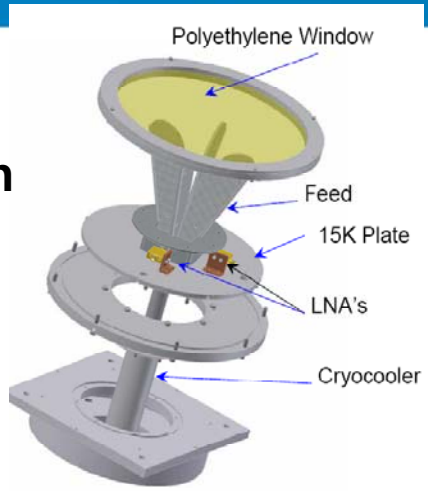
FP6-SKADS



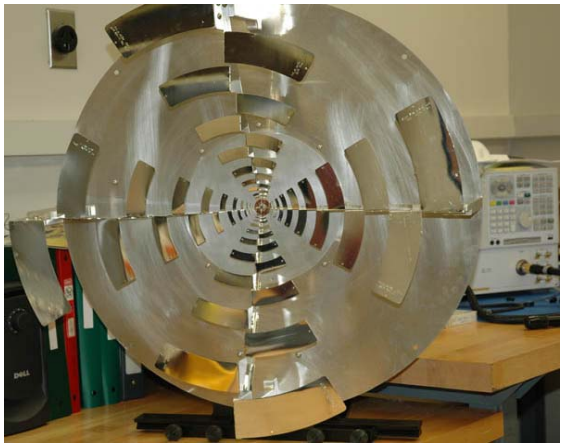
ring the Universe with the world's largest radio telescope

Advanced Instrumentation Program: wide-band single pixel feeds

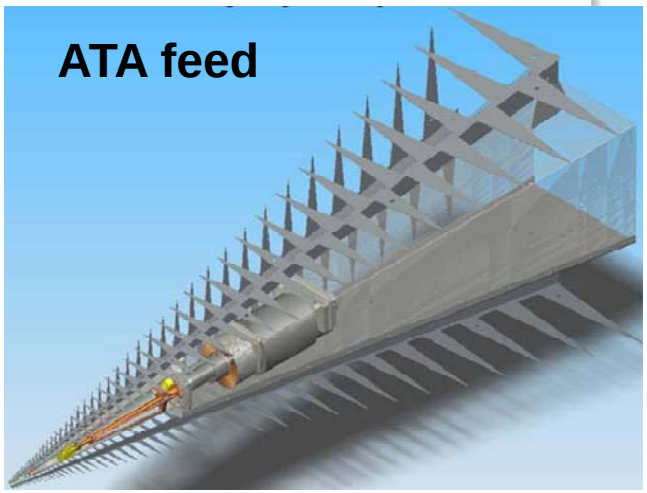
Quad ridge Lindgren horn

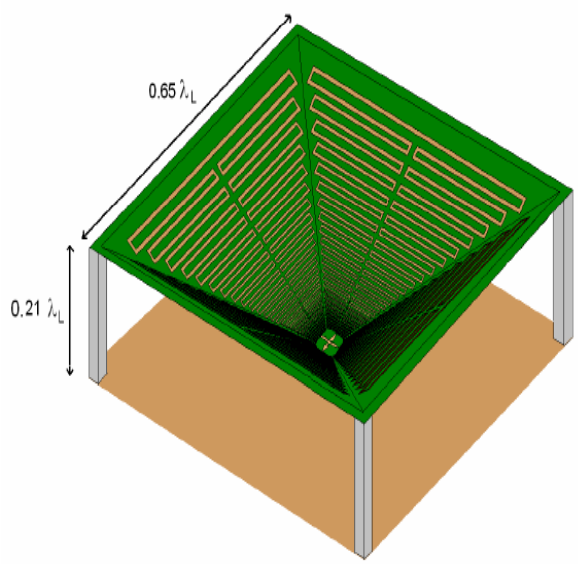


Quasi Self Complementary feed



ATA feed

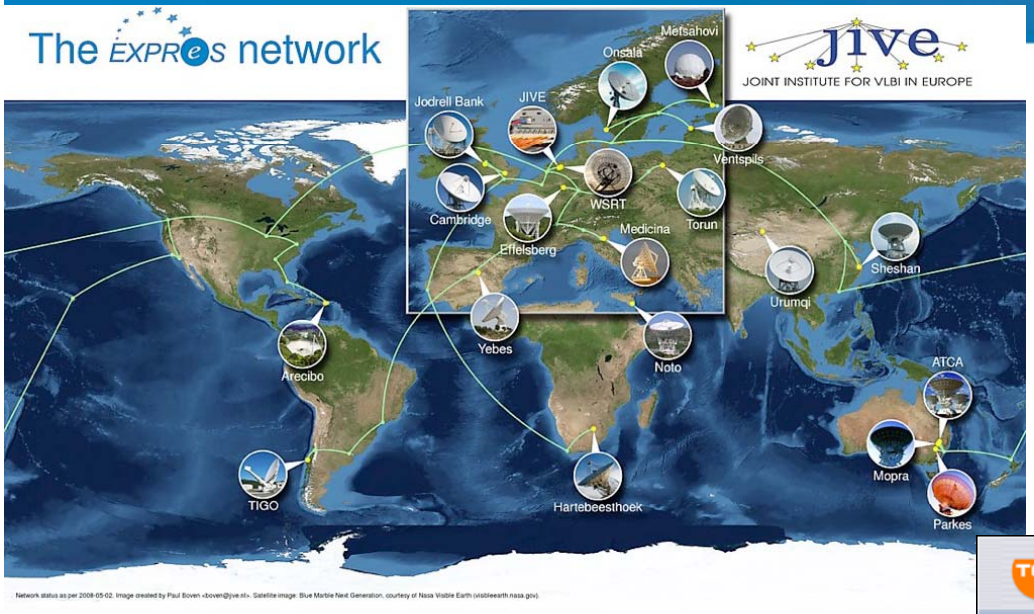




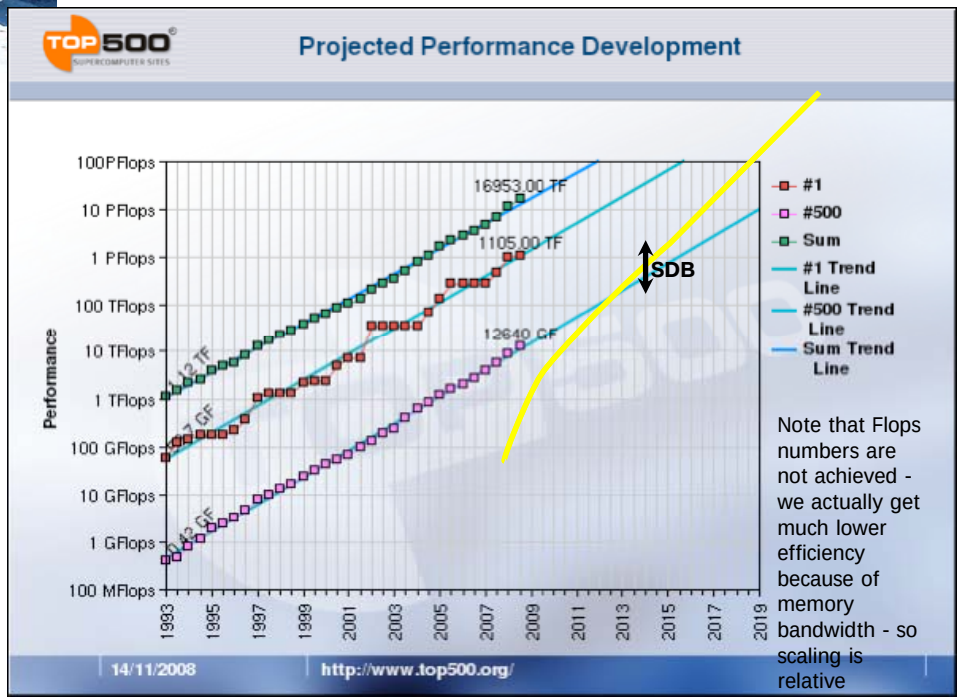
Chalmers "Eleven" feed

From German Cortes

Signal transport, signal processing, computing



Fiber optic transmission



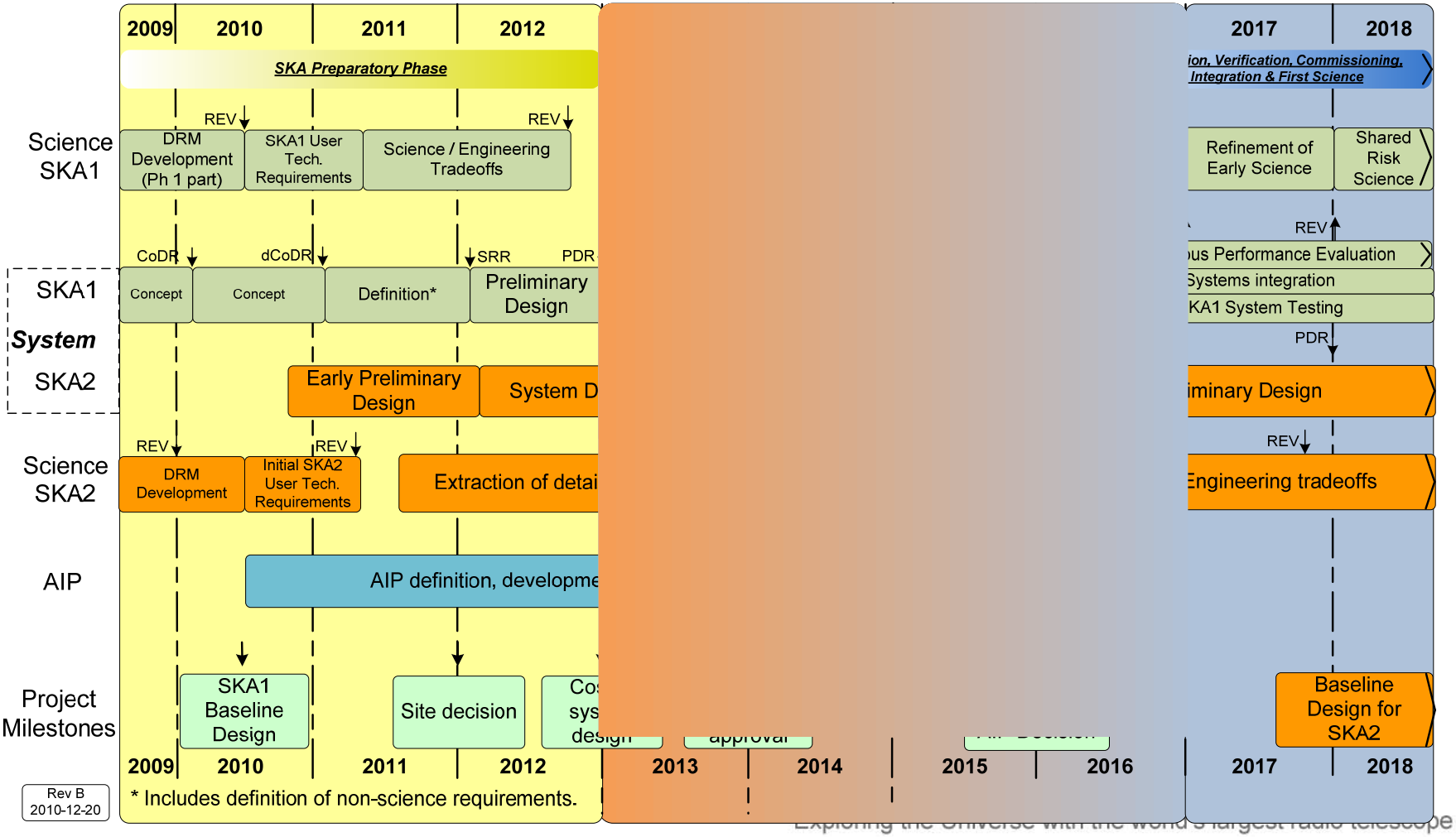
Note that Flops numbers are not achieved - we actually get much lower efficiency because of memory bandwidth - so scaling is relative

Current task in 2011 and 2012 is to convert this SKA-relevant design and development into PDR-ready SKA-specific designs and costs

Conceptual Design Reviews in 2011

- 23-25 Feb System delta-CoDR on SKA_1
- 14-15 Apr Signal Processing
- 19-20 Apr Aperture Arrays
- 28-30 Jun Signal Transport & Networks
- 13-15 July Dish and Dish Arrays
  - 2-3 Feb Dish Verification Antenna #1
- 12-14 Oct Software & Computing

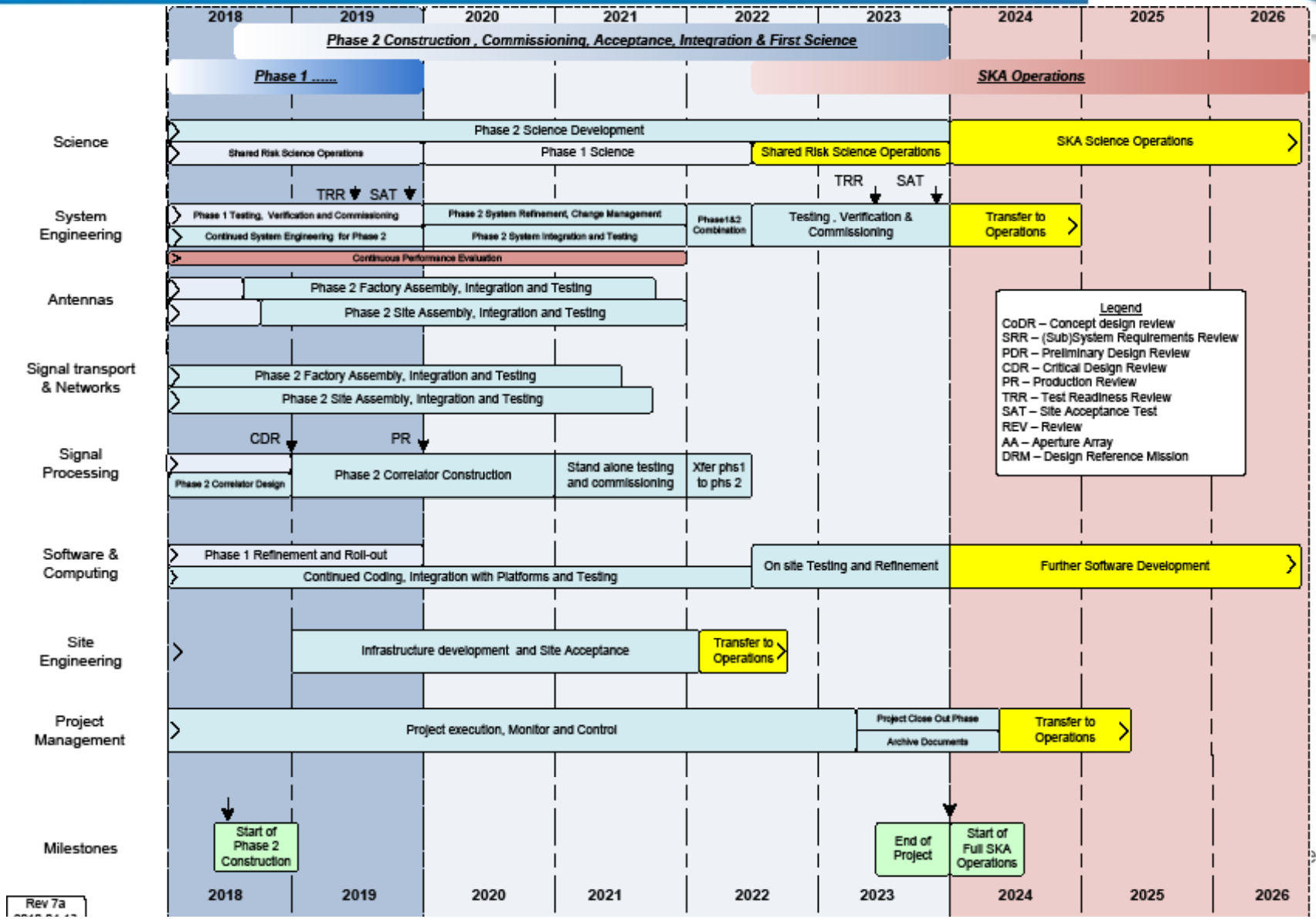
Schedule: Preparatory Phase → Preconstruction Phase → SKA_1 Construction



Exploring the Universe with the world's largest radio telescope

Schedule:

SKA_1 Construction→ SKA_2 construction



Pre-construction phase

Goals

1. Progress the SKA design to Production Readiness Review stage and let contracts for construction of major sub-systems

2. Progress infrastructure roll-out on selected site to allow sub-systems to be deployed

3. Mature the SKA legal entity into an organisation capable of carrying out the construction, verification, and operation of the telescope

Work Packages in the Project Execution Plan

1. Management
2. System
3. Science
4. Maintenance and support /Operations Plan
5. Dishes
6. Aperture arrays
7. Signal transport & networks
8. Signal processing
9. Computing & software
10. Power
11. Site preparation

Approach

- Strong central project office (SPO) with management and system design authority to ensure a coherent and effective effort.
  - System oversight and system-oriented leadership
- Employ an industry culture in managing and costing the project
- Close engagement of industry essential throughout Pre-Construction phase
- SPO will contract work on major sub-systems to a small number of Work Package Contractors (WPCs)

Resource Summary for 2012 - 2015

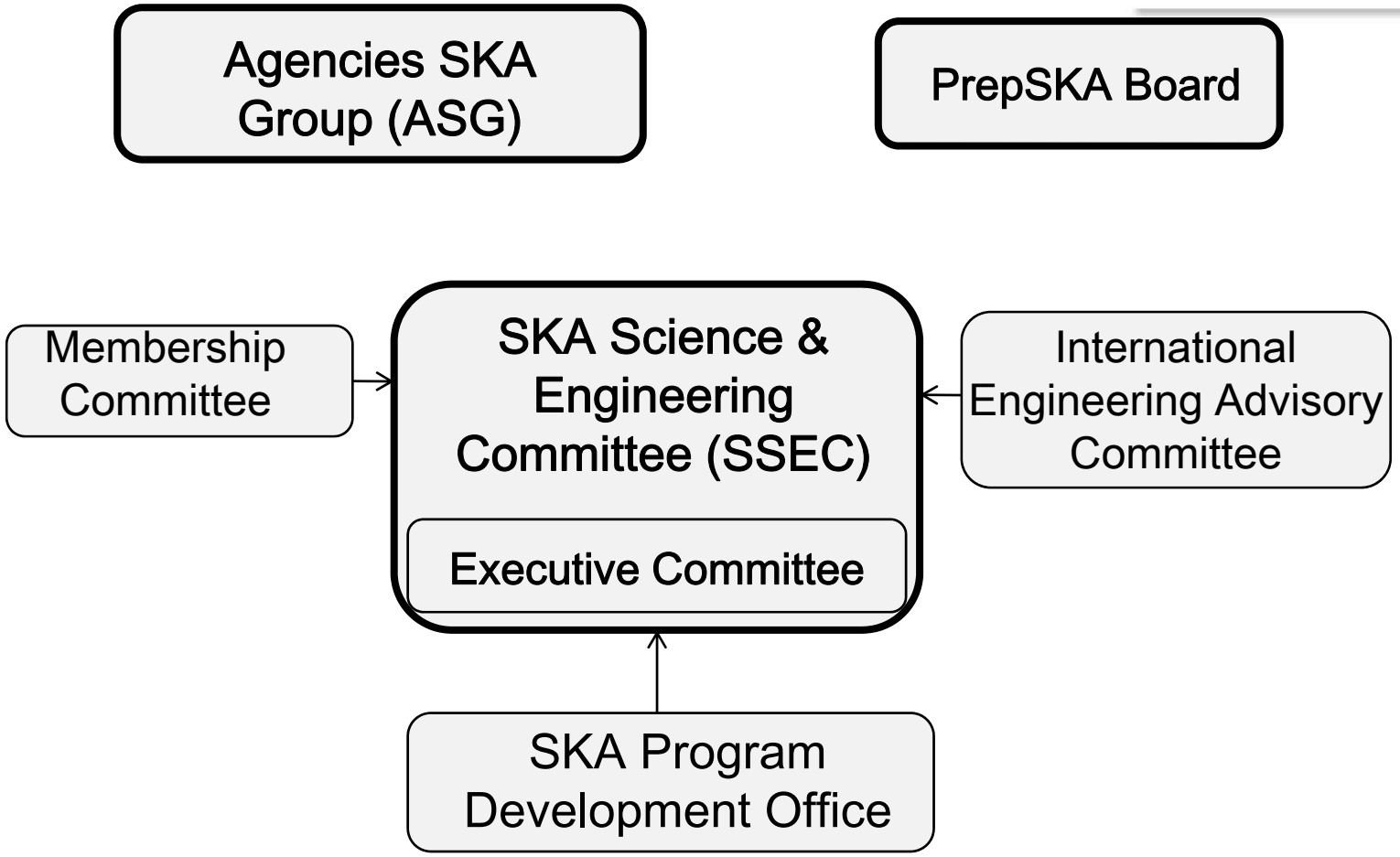
Total resources proposed (4 years): 90.9 M€

WPCs: 63.0 M€ (70%)

SPO: 27.9 M€ (30%)

Status of the project

Former governance structure: April 2008 – March 2011



PrepSKA: 7 work packages

WP1 PrepSKA management (STFC, U Oxford, U Manch'r)

WP2 Costed telescope design (SPDO)

WP3 Further site characterization in Australia+NZ and Southern Africa (SPDO)

WP4 Governance (NWO, NL)

WP5 Procurement and involvement of industry INAF, Italy)

WP6 Options for funding (STFC, UK)

WP7 Impact on broad government priorities (U Manchester)

All WPs will be completed by 31March 2012

Interim governance (April-July 2011)

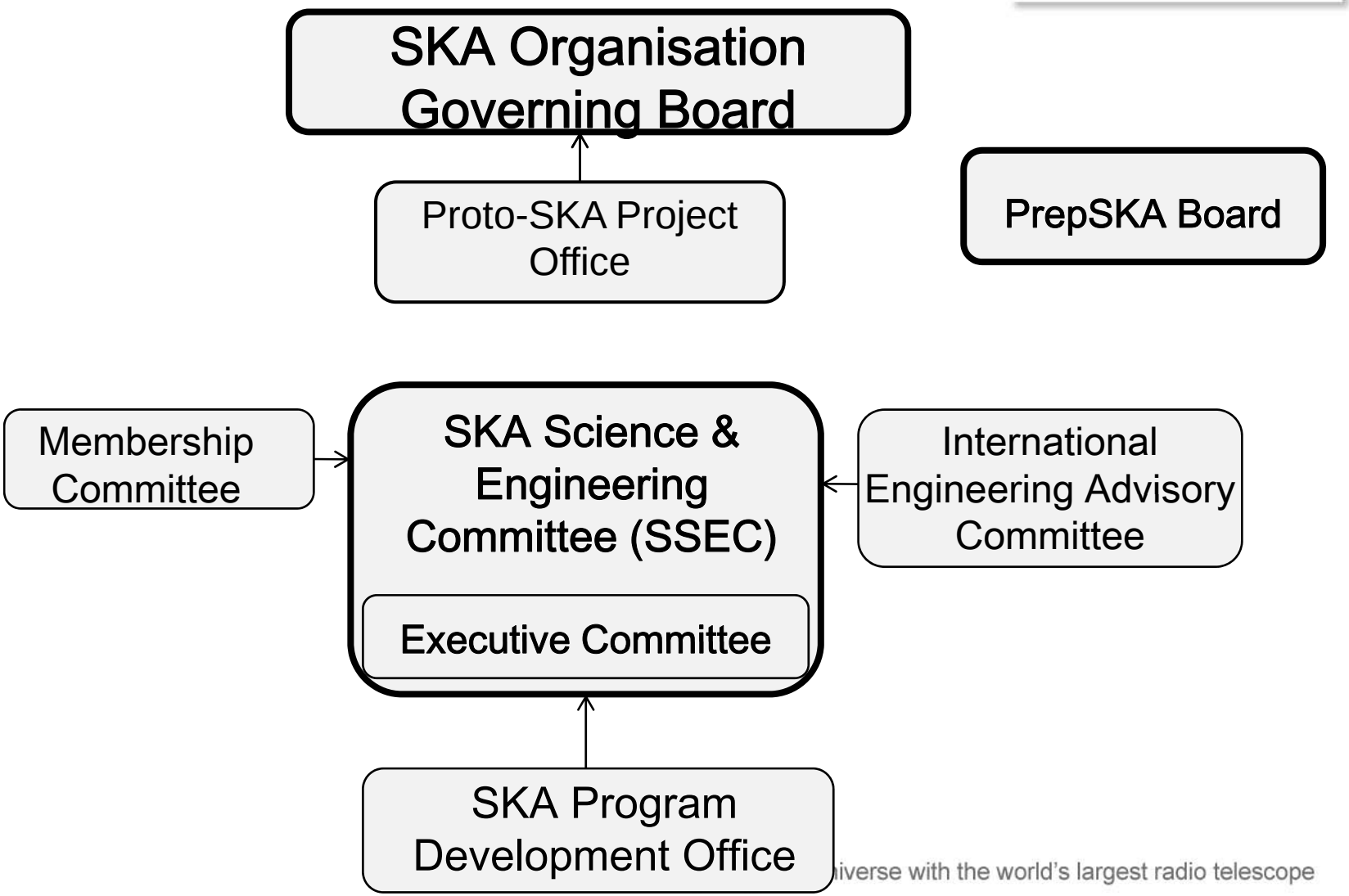
Founding Board Signatories

Australia
China
France
Germany
Italy
Netherlands
New Zealand
South Africa
UK

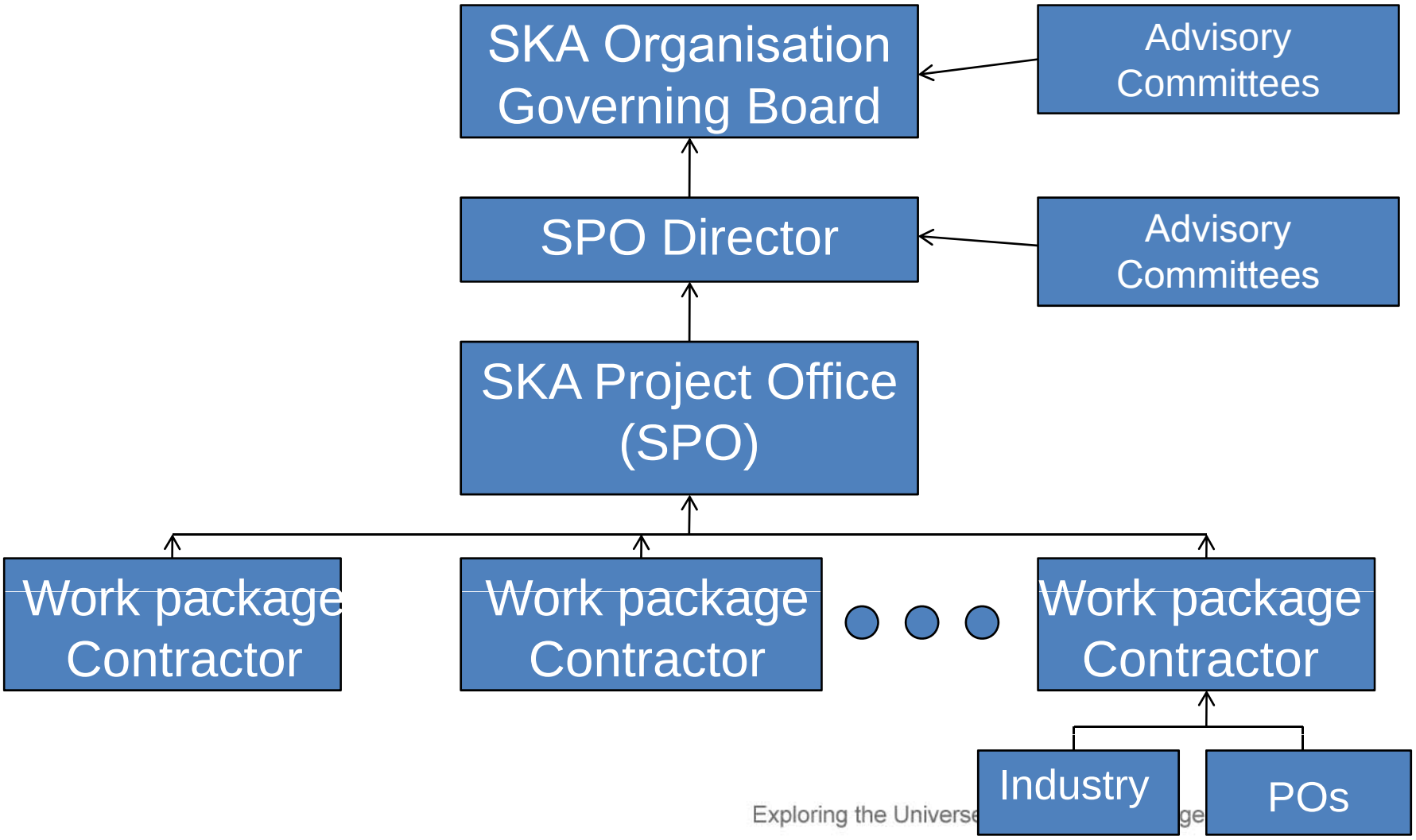
Tasks

1. Establish a legal entity for the SKA Organisation by July 2011
2. Decide location of the SKA Project Office **Jodrell Bank Observatory**
3. Agree a resourced Project Execution Plan for the pre-Construction Phase
4. Start recruitment of the SPO Director

Interim governance (July - Dec 2011)



Governance: January 2012 →



Site selection

Physical requirements

Extremely radio quiet environment
At least 3000 km in extent
Low ionospheric turbulence
Low tropospheric turbulence

Two candidates short-listed in 2006

Site selection process

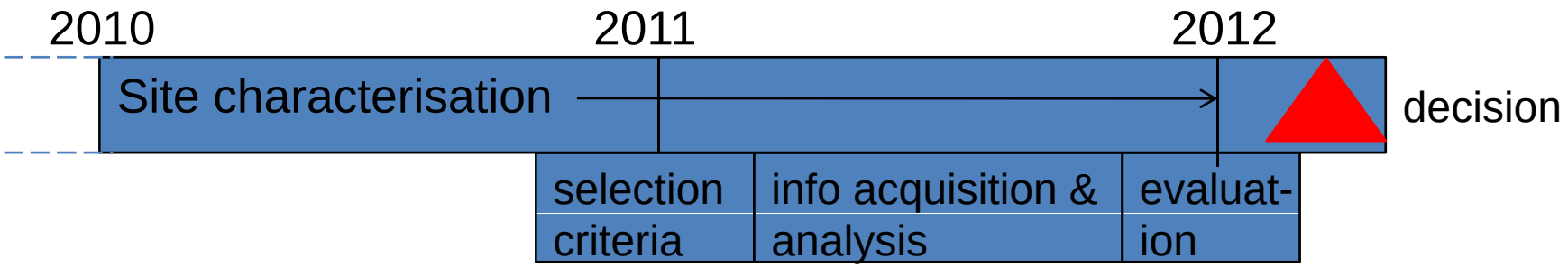



Image © 2007 TerraMetrics
Image NASA
Google

South Africa + 7 countries

largest radio telescope

Top level schedule for the SKA

Technical

2008-12	telescope system design and cost
2013-15	detailed design in the pre-construction phase
2016-19	Phase 1 construction
2016	Advanced Instrumentation Program decision
2018-23	Phase 2 construction
2020→	full science operations with Phase 1
2024→	full science operations with Phase 2

Programmatic

2011	approve funding for pre-construction phase
	establish SKA organisation as a legal entity
	select location for SKA Project Office
2012	site selection
2014	approve construction funding for Phase 1 (350 M€, 2007)
2018	approve construction funding for Phase 2 (1.2 B€, 2007)

END