

Overview of the Square Kilometre Array

Richard Schilizzi COST Workshop, Rome, 30 March 2010



The Square Kilometre Array A global program

<u>Time line</u>

- ■2000-07 Initial Concept Stage
- **2008-12** System Design Stage + cost
- **2013-23** Detailed design &
- construction
- **2020-50+** Operations

A Global Collaboration THE STAR

Science SKA Science & Engineering Committee

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Policy Agencies SKA Group

Coordination SKA Program **Development Office**



The SKA concept

a large radio telescope for transformational science

- up to 1 million m² collecting area distributed over a distance of 3000+ km,
- operating at frequencies from 70 MHz to 10 GHz with two and possibly more detector technologies
- connected to a signal processor and high performance computing system by an optical fibre network

providing

40 x sensitivity of current world's best radio interferometers (EVLA, GMRT, LOFAR)



> up to 1 million x survey speed of current world's best





Construction will proceed in two phases

Phase 1 will be a subset of Phase 2 (~10%)

Major science observations already possible with Phase 1

SKA 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

Cradle of Life Is there life elsewhere?

FUNDAMENTAL FORCES Pulsars, General Relativity & gravitational waves Was Einstein correct?

Origin & evolution of cosmic magnetism Where does magnetism come from?

TRANSIENTS (NEW PHENOMENA)



Science with the Square Kilometre Array





Science with the Square Kilometre Array (2004, eds. C. Carilli & S. Rawlings, New Astron. Rev., **48**)

Key Science for Phase 1 (SKA₁)

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

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SKA Array & Receptor Technologies



Productions





SKA baseline

- n Low frequency array from 70-300 MHz for measurements of redshifted hydrogen → Epoch of Reionisation
- n Dish array from 450 MHz to 3 GHz

for pulsar timing \rightarrow tests of strong gravity and gravitational waves

and

Small-scale demonstrators of innovative "radio camera" technologies dense aperture array phased array feeds (PAFs) on the dish array

- > Dishes, feeds, receivers (3000)
- > Aperture arrays (250)
- Signal transport (800 Tbit/s)
- Signal processing (exa-MACs)

PrepSKA

Verification programs

- Software engineering and algorithm development
- High performance computing (exa-flop capability)
- Data storage (exa-byte capacity)

mw)



Sparse aperture arrays for the lowest frequencies



LOFAR (Netherlands et al)



MWA (USA, Australia)



Baseline design component: **Dishes + single pixel feeds**





MeerKAT Precursor Array 80x12m composite dishes





Radio camera 1: dishes+multi-pixel feeds





















Physical requirements

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

Site selection process

		decision	
		Site evaluation	
	Site selection criteria established		
Site characterisation			
2010	2011	2012	2



South Africa + 7 countries



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The International SKA Collaboration





<u>Agencies SKA Group</u>

- Funding agencies and governments from 12 countries agreed in February 2009 to form the ASG under the leadership of the UK Science and Technical Facilities Council
- Aim is to deliver a Joint Agreement on the Implementation of the SKA in 2011/12
- Work streams
- Project Schedule
- Pre-construction Funding and Interim Governance
- Site selection process
 - Joint ASG-SSEC Working Group to establish selection criteria
- + PrepSKA policy WPs

Top level schedule for the SKA

Technical

- 2008-12 telescope system design and cost
- 2013-15 detailed design & pre-construction phase
- 2016-19 Phase 1 construction
- 2018-23 Phase 2 construction
- 2019→ full science operations with Phase 1
- 2024→ full science operations with Phase 2

Programmatic

2011	establish SKA organisation as a legal entity
2012	site selection
2014 2007)	construction funding approved for Phase 1 (350 M€,
2017 2007)	construction funding approved for Phase 2 (1.2 B€,
	Operations: 160 M€/year



END





Target construction cost: 1.5 billion € (2007) for Phases 1+2

- Civil works
- Antennas & RF systems
- Signal transmission
- Signal processing
- Software development & computing hardware
- Design, integration, testing, and management
- Contingency

Expected operating costs: 180 million €/year

- Salaries (400-500 staff)
- Power
- Materials & services including dark fibre lease
- Renewal of instrumentation and computing
- > Degional Support Centres





Sensitivity

The SKA could detect airport radars on planets 50 light years away

Data communications

- The dishes of the SKA will produce 20 times the current global internet traffic
- The aperture arrays in the SKA will produce 250 times the current global Internet traffic.
- Laid end to end, the fibre optic strands used in the SKA could circumnavigate the globe over 10 times.
- If the raw data produced by SKA were saved it would require about one thousand million 1Gb memory sticks per day.

Computer

SKA processing power is equivalent to 1 billion PCs