



Science Requirements from the Office Perspective:

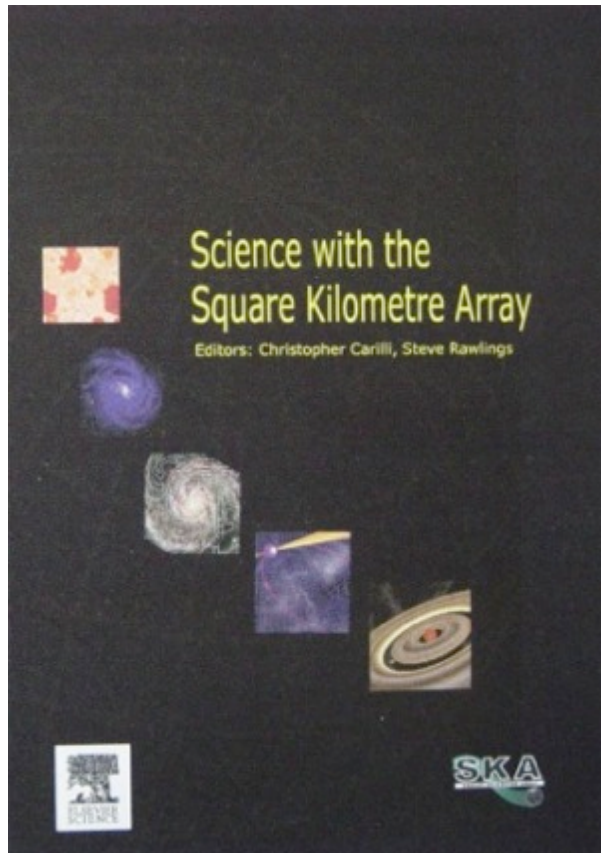
The Design Reference Mission

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Science Case, DRM, Requirements, Oh My!



Science Case
Lays out **overarching** goals, full suite of science

THE SQUARE KILOMETRE ARRAY DESIGN REFERENCE MISSION: SKA PHASE 1

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Design Reference Mission
Set of science observations to set **envelope** of science requirements

- SCI-SYSR-0010
- SCI-SYSR-0020
- ...
- SCI-S-REQ-0110
- SCI-S-REQ-0120
- SCI-S-REQ-0130
- SCI-S-REQ-0140
- SCI-S-REQ-0150
- ...
- SCI-T-REQ-0110
- SCI-T-REQ-0120
- SCI-T-REQ-0130
- SCI-T-REQ-0140
- SCI-T-REQ-0150
- ...
- OPS-REQ-0010

Requirements Document
Input from science, but from other areas as well

The Design Reference Mission: Intro



- Intended to establish a baseline set of observations required to achieve science goals
- Set the “envelope” of possible technical specifications for the telescope
 - Push capabilities of the telescope
- Analogous to similar documents of other large projects:
 - “Science Goals and Technical Requirements” for eVLA
 - ALMA Reference Science Plan
 - JSWT Design Reference Mission
 - LSST Science Requirements Document
 - Pan-STARRS PS1 Design Reference Mission

Design Reference Mission Structure



Chosen to

- I. Describe fundamental science for the SKA1
- II. Identify “**envelope**” for SKA1 (e.g., frequency coverage)

Chapters

1. Scientific Motivation
2. Observational Summary
3. Scientific Requirements
What does the Universe control?
(e.g., H I mass, gravitational wave amplitude spectrum, ...)
4. Technical Requirements
What do we control? (e.g., A_{eff} , T_{sys} , Ω , ν , baselines, ...)
5. Data Products

Design Reference Mission Status

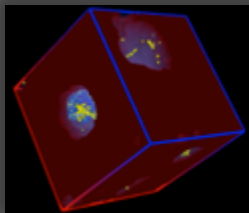


- Provides “traceability” or flow from science to technical specifications
- Version 1.0 is the current for Phase 2
- Version 3.0 is the current for Phase 1
 - **Baselined in May 2012**
- Phase 1 DRM -> Phase 1 Baseline Design
 - Change process currently being finalised
 - New chapters possible?

Phase 1 Design Reference Mission: Chapters



2. Probing the Neutral Intergalactic Medium During the Epoch of Reionization
3. Tracking Galaxy Evolution over Cosmic Time via HI Absorption
4. Probing the Epoch of Reionization using the 21cm Forest
5. Pulsar Surveys with Phase 1 of the SKA
6. Pulsar Timing with Phase 1 of the SKA
7. Pulsar Astrometry with Phase 1 of the SKA
8. Gas in Nearby Galaxies
9. Additional Science Capabilities of Phase 1
10. Additional Telescope Considerations: Phase 1 to Phase 2



No Continuum Survey Chapter?



- SKA1 DRM constrained by Memo 125, SKA1 science priorities:
 - Understanding the role of neutral hydrogen in the universe from the dark ages to the present day (EoR, HI in galaxies)
 - Detecting and timing pulsars in order to test theories of gravity and detect gravitational waves
- “If we designed and built an SKA that could not undertake deep continuum observations then we would have failed.”
 - Phil Diamond, Feb 2013

Possible Continuum Survey Chapters



- So in March some members of SKA science working group were asked to consider continuum science chapters for the DRM
 - Ultra-deep survey for galaxy evolution
 - Medium-deep survey for weak lensing (>5000 sq deg)
 - Large all-sky survey for cosmology (>20000 sq deg)

Galaxy Evolution with a Ultra-Deep Continuum Survey in Phase 1 of the SKA : Science Targets



Star formation rate

- *The SKA Phase 1 shall be capable of detecting galaxies with a star formation rate of 5 M_{sun} / yr out to redshift 1.5, and galaxies with a star formation rate of 50 M_{sun} / yr to redshift 5.*

Cosmic Volume and Survey Area

- *A deep continuum survey with SKA Phase 1 shall probe a cosmic volume of at least 0.05 Gpc^3 and have a survey area of at least 10 square degrees on the sky.*

Angular Resolution

- *The SKA Phase 1 shall have an angular resolution better than or equal to 0.5 arcsec.*

Galaxy Evolution with a Ultra-Deep Continuum Survey in Phase 1 of the SKA : Technical “Targets”



Sensitivity

- *The SKA Phase 1 shall have a sensitivity of at least 1300 m²/K (for 15m dishes) or survey speed greater than 2.4×10^6 m⁴/K² deg²*
- RMS of 50 nJy in 3000 hours

Central Observing Frequency and Bandwidth

- *The SKA Phase 1 shall provide a central observing frequency of 1.3 GHz.*
- *The SKA Phase 1 shall have a bandwidth of at least 1 GHz*

Maximum Baseline and Array Configuration

- *The SKA Phase 1 shall provide a maximum baseline of at least 100km.*
- Statement that to achieve a good beam may require down-weighting of the shortest baselines, leading to loss in sensitivity.

Galaxy Evolution with a Ultra-Deep Continuum Survey in Phase 1 of the SKA : Technical “Targets”



Polarization

- *The SKA Phase 1 shall provide full polarization capabilities and residual instrumental polarization will be less than 0.5% out to the FWHM of the primary beam*

Imaging Dynamic Range

- *The SKA Phase 1 shall have an imaging dynamic range better than 73 dB*

Galaxy Evolution with a Ultra-Deep Continuum Survey in Phase 1 of the SKA



Scientific “Targets”

Parameter	Value
Star formation rate	5 Msun/yr at $z = 1.5$, 50 Msun/yr at $z = 5$
Cosmic Volume	$> 0.05 \text{ Gpc}^3$
Survey Area	$> 10 \text{ deg}^2$
Angular Resolution	$\leq 0.5 \text{ arcsec}$

Technical “Targets”

Parameter	Value	Comment
Sensitivity	$> 1300 \text{ m}^2/\text{K}$	SFR requirement
Observing Frequency	1.3 GHz	Resolution and spectral index
Bandwidth	1 GHz	Sensitivity, spectral indices
Maximum baseline	$> 100 \text{ km}$	Angular resolution
Polarization	Full Stokes, $< 0.5 \%$ residuals	SF/AGN discrimination
Imaging Dynamic Range	73 dB	Expected bright sources

Summary



- Design reference mission describes a baseline set of observations required to achieve science goals
 - Push capabilities of the telescope
- Constrained by Memo 125, so does not have continuum science chapter
- SKAO recognises importance of continuum science ability and are trying to capture requirements or goals/targets
 - New DRM chapter -> top level document TBD
 - Science assessment workshop