



SKA Design Reference Mission

Minh Huynh (SPDO, ICRAR/UWA)

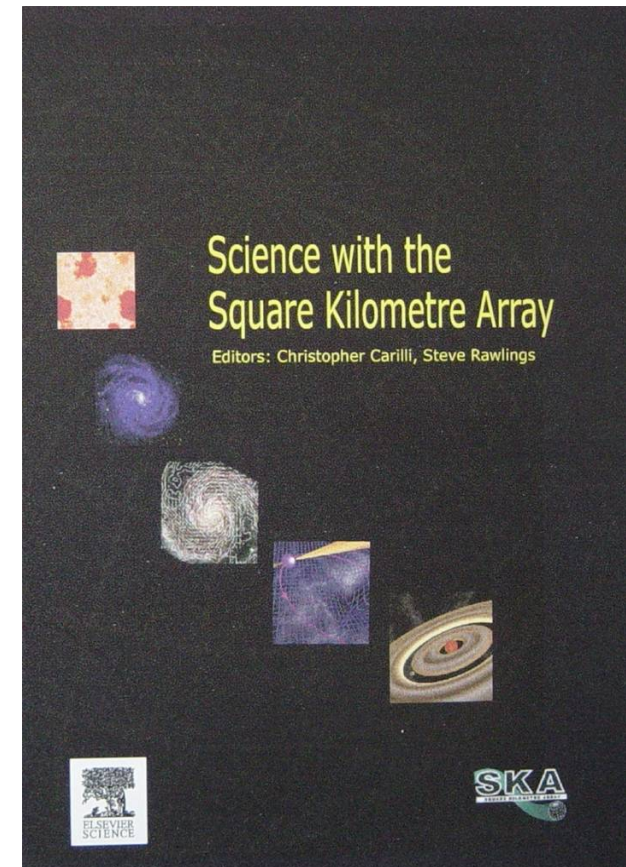
Joseph Lazio (SPDO, JPL/Caltech)

SKA Science



- Science case developed over 1+ yr by international group of astronomers and physicists
- Published as special issue of *New Astronomy Reviews*
- Five Key Science Projects (KSPs)
 - Probing the Dark Ages
 - Galaxy Evolution, Cosmology, & Dark Energy
 - The Origin & Evolution of Cosmic Magnetism
 - Strong Field Tests of Gravity Using Pulsars and Black Holes
 - The Cradle of Life & Astrobiology
- ... and **The Exploration of the Unknown** as an underlying philosophy for design

Both AstroNet and Astro2010 viewed these science areas highly.



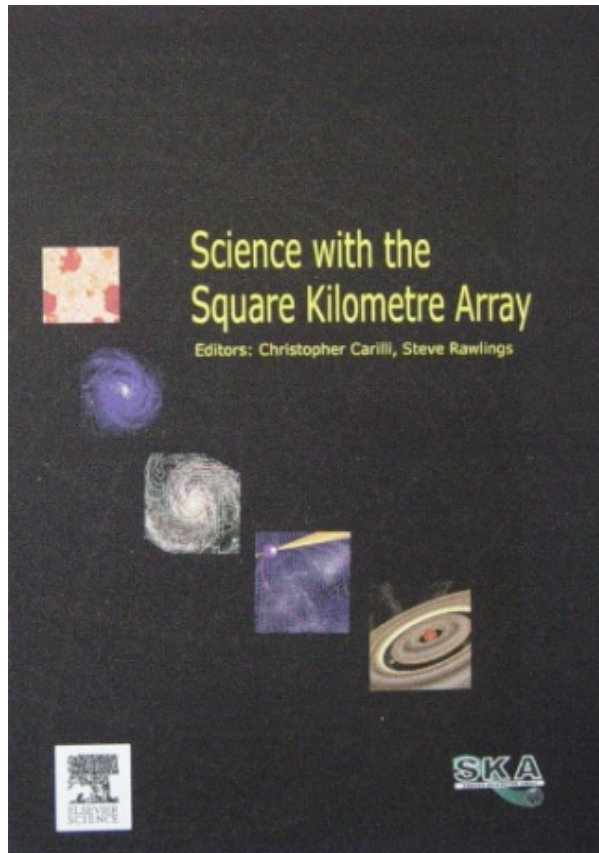
(Carilli & Rawlings)

SKA Phase 1 (SKA Memo 125)



- Understanding the history and role of neutral Hydrogen in the Universe from the Dark Ages to the present-day, and
 - Detecting and timing binary pulsars and spin-stable millisecond pulsars in order to test theories of gravity, to discover gravitational waves from cosmological sources, and to determine the equation of state of nuclear matter
 - low-frequency sparse AA with $A_{\text{eff}}/T_{\text{sys}}$ of up to 2000 m^2/K operating between 70 and 450 MHz
 - dish array with $A_{\text{eff}}/T_{\text{sys}}$ of up to 1000 m^2/K using approximately 250 15-m antennas
 - instrumentation package will use single-pixel feeds, provide high sensitivity and excellent polarisation characteristics over 0.45-3 GHz
- Array will be centrally condensed but some elements out to a maximum baseline length of 100 km from the core

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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 Revision A
 Author SKA Science Working Group
 Date 2011-09-26
 Status Draft

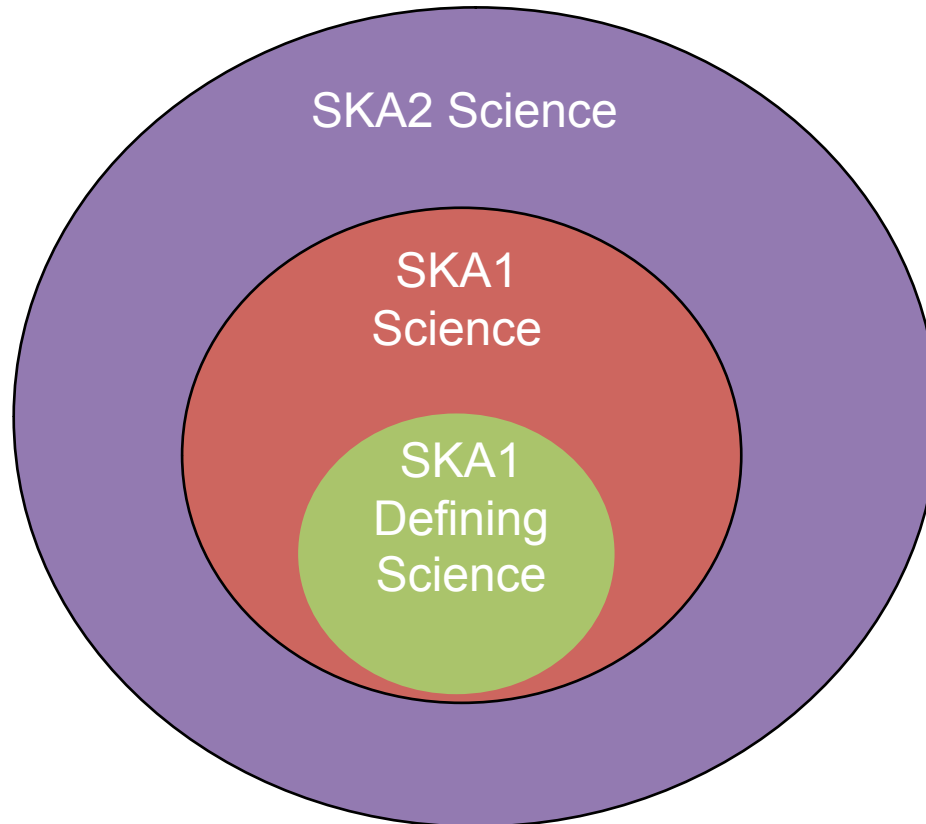
Name	Designation	Affiliation	Date	Signature
Submitted by:				
Joe Lazio	Project Scientist	JPL/SPDO	11-09-26	
Accepted by:				
Approved by:				

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

SKA2 and SKA1



Other Constraints

- Cost/Lifetime
10 yr lifetime
- Location
- Forward compatibility
“[C]omponents of receptors used in SKA1 that are difficult or impossible to change will be [...] SKA2 compliant.”
- ...

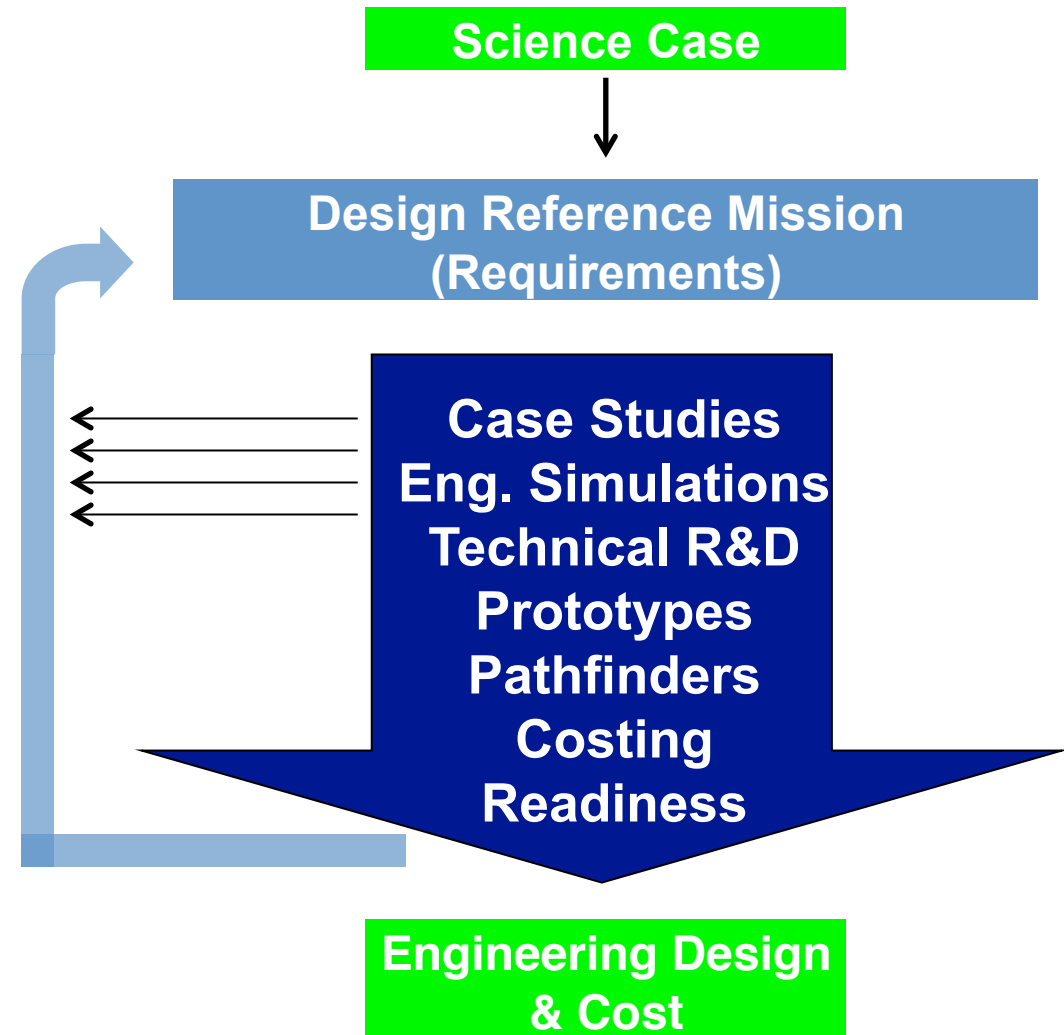
SKA1 Defining Science

- Understanding the history and role of [H I] from the Dark Ages to the present-day, and
- Detecting and timing binary pulsars and spin-stable millisecond pulsars in order to test theories of gravity (...), to discover gravitational waves from cosmological sources, and to determine the equation of state of nuclear matter.

Design Reference Mission and PrepSKA WP2



- Intended to capture science that provides the “envelope” of technical specifications
- Provides “traceability” or science to technical specifications flowdown
- Version 1.0 is the current for Phase 2
- Version 2.0 is the current for Phase 1



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 (Phase 1)



Current components (non-prioritized listing)

1. Introduction
 - SKA Phase 1 Science Case and Science Goals
 - Design Reference Mission and Science Traceability
 - Scope of this Document
 - Assumptions
 - System-Level Design Specifications
 - Data Products
2. Probing the Neutral Intergalactic Medium During the Epoch of Reionization
3. Tracking Galaxy Evolution over Cosmic Time via H I Absorption
4. Probing the Epoch of Reionization Using the 21-cm 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. Galaxy Evolution in the Nearby Universe: H I Observations
9. Additional Science Capabilities of Phase 1
10. Additional Telescope Considerations: Phase 1 to Phase 2
 - Frequency Coverage
 - Polarization Purity
 - Dynamic Range
 - Advanced Instrumentation Programme
11. Overall Telescope Characteristics

* AA relevant

DRM and Telescope Envelope




Component	Parameter
2. Probing the Neutral Intergalactic Medium During Reionization	Frequency range, sensitivity
3. Tracking Galaxy Evolution over Cosmic Time via H I Absorption	Frequency range, spectral resolution, survey speed
4. Probing the Epoch of Reionization Using the 21-cm Forest	Frequency range, spectral resolution, sky coverage, sensitivity
5. Pulsar Surveys with Phase 1 of the SKA	Sensitivity, array configuration, frequency range, sky coverage, non-imaging processing
6. Pulsar Timing with Phase 1 of the SKA	Sensitivity, polarization performance
7. Pulsar Astrometry with Phase 1 of the SKA	Baselines, image processing
8. Galaxy Evolution in the Nearby Universe: H I Observations	Spectral resolution, array configuration, sensitivity

Process to System Requirements Review



- DRM (Phase 1) v. 2.0 finalized ~ October 1
- Community review completed by **December 1**
- DRM (Phase 1) v. 2.1 finalized by **January 15**



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Joe Lazio	Project Scientist	JPL/SPDO	11-09-26	
Accepted by:				
Approved by:				

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Change Control



- Change control review forms (COAR)
- Requested changes
 - Typo
 - Minor numerical error
 - Minor logical error
 - Major numerical error
 - Major logical error
- Changes communicated to J. Lazio and T. Stevenson

REVIEWER WORKSHEET									
Document number		SCI-020.010.020-DRM-002							
Document title		THE SQUARE KILOMETRE ARRAY DESIGN REFERENCE MISSION: SKA PHASE 1							
Document date		11-09-26				Document revision		A	
Name of Reviewer			Reviewer's Comment			Type	Response	Reviewer name acronymn	
No.	Page	Section						Description/Action	Done?
1	1-1	1	This is the first time I read about a SKA Phase 3. Is this phase being recognized and considered in the higher level plans (like the PEI) for example?			Minor			
2	1-3	1.4.1	Would be more specific to add the 90% of the pointings in the requirement itself?			Minor			
3	1-3	1.4.1	What is exactly a major survey?			Minor			
4	1-3	1.4.1	How is thermal noise-limited defined? Till which scan angle (pointing) needs this to be true?			Minor			
5	1-3	1.4.1	There is a reference made to Table 1-2, should this be 1-1?			Typo			
6	1-4	1.4.1	FoV seems to be defined here as half-power level of the power pattern of the receptor. For SKA I think the general definition of FoV is different (sum of all the digital beams of a station).			Major			
7	1-4	1.4.1	Essentially constant sensitivity: is 3 dB considered to be constant?			Major			
8	1-4	1.4.1	Why is time also not included in the second definition of SSFoM?			Major			
9	1-4	1.4.1	Its probably better to use another symbol for the same definition of SSFoM.			Typo			
10	1-4	1.4.1	Typo in the last paragraph: "... of every point on the sky ..." should be "... of every point on the sky ..."			Typo			
11	1-4	1.4.2	Typo in last sentence: the s in the word intergrations should be deleted.			Typo			
12	1-4	1.4.2	To be honest requirements set by the argument that other major facilities provide that capability is a bit weak in my view. There really should be a need for the SKA phase 1 science case, because every requirement essentially cost money. Relaxing a requirement could mean for example more sensitivity for the same amount of \$s.			Minor			
13	1-4	1.4.3	Is this sensitivity based on total intensity of both polarisations or is it required for each polarisation?			Major			
14	1-5	1.5.1	Also here the motivation to have this bandwidth requirement based on current systems sounds a bit weak.			Minor			
15	1-6	1.5.5	In the equation antennas is defined as station? And how do we define loss of a station then? So with other words how many antenna elements may be defect in order that the station still is considered as ok?			Minor			
16	1-6	1.5.5	Last paragraph, sentence below the equation: "... is the any loss of time ..." should be "... is the loss of time ..."			Typo			
17	1-7	1.6.2	Why is the station location of importance for the meta-data? This will never change and could be considered fixed.			Minor			
18	1-8	1.6.2	System temperature: do you mean the environmental temperature or noise temperature.			Minor			
19	2-2	2.2	The 0.1% required instrumental polarization is not listed as a requirement further.			Major			
20	2-4	2.3.3	Last sentence: Why is the differential sky brightness temperature about 3 times less than seen with a 1° beam?			Minor			
21	2-6	2.4.3	Last sentence: reference to 2.4.4 should be 2.4.5.			Typo			
22	2-6	2.4.5	The sensitivity requirement is not written yet.			Minor			
23	2-6	2.4.5	Why is the dotted line of the black curve higher than the straight line?			Minor			
24	2-8	2.4.5	Figure is not so sharp.			Minor			
25	2-8	2.4.5	Table caption is above the figure and part of the text of the caption is not visible.			Minor			
26	2-8	2.4.5	For S' angular resolution 7600 m²/K is required at the lowest frequency and for 20' 560 m²/K. Are these numbers listed to determine how the stations are distributed over distance?			Major			

Change Control



- Received 9 COARs
 - From individuals and groups
- Working on responses
- New revision of DRM (Phase 1) expected in January.


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26	2-8	2.4.5	For 5' angular resolution 7600 m ² /K is required at the lowest frequency and for 20' 560 m ² /K. Are these numbers listed to determine how the stations are distributed over distance?		Major			

Process to System Requirements Review



- Locking of Phase 1 DRM will occur in Jan 2012 to provide a 'baseline'
- Allows engineering analyses
 - Allocation of requirements for SRR
 - Proposal of an architecture
- Subsequent 'baselines' expected to have small deltas



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SKA Phase 1 Design Reference Mission



- Designed to provide requirements on telescope envelope.
 - Part of larger set of system requirements
- Developed in close consultation with the science community.
- Community reviewed has happened and change control has been implemented.
 - New revision in response to COARs by Jan 2012



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