SKA Phase 1 Design
Reference Mission
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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 review occurring.
- New stage in process as change control being implemented.
SKA Specifications Review Committee (2008 January):

With the assistance of the Science Working Group and the broader community, develop a [Design Reference Mission] which includes a detailed description (cases) of several representative observations in each of the key science areas; the observation descriptions should include quantitative information on the scientific requirements the array should meet (sensitivity, polarization, spectral & angular resolution, observing time, expected observing modes,…).

- **Not** an effort to “re-do” science case!
- **Does not** establish priorities.
**Science Case, DRM, Requirements, Oh My!**

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

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**Design Reference Mission**
Set of science observations to set *envelope* of science requirements
SKA Phase 1
(SKKA 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.

Exploring the Universe with the world’s largest radio telescope.
## DRM and Telescope Envelope

<table>
<thead>
<tr>
<th>Component</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Probing the Neutral Intergalactic Medium During Reionization</td>
<td>Frequency range, sensitivity</td>
</tr>
<tr>
<td>3. Tracking Galaxy Evolution over Cosmic Time via H I Absorption</td>
<td>Frequency range, spectral resolution, survey speed</td>
</tr>
<tr>
<td>4. Probing the Epoch of Reionization Using the 21-cm Forest</td>
<td>Frequency range, spectral resolution, sky coverage, sensitivity</td>
</tr>
<tr>
<td>5. Pulsar Surveys with Phase 1 of the SKA</td>
<td>Sensitivity, array configuration, frequency range, sky coverage, non-imaging processing</td>
</tr>
<tr>
<td>6. Pulsar Timing with Phase 1 of the SKA</td>
<td>Sensitivity, polarization performance</td>
</tr>
<tr>
<td>7. Pulsar Astrometry with Phase 1 of the SKA</td>
<td>Baselines, image processing</td>
</tr>
<tr>
<td>8. Galaxy Evolution in the Nearby Universe: H I Observations</td>
<td>Spectral resolution, array configuration, sensitivity</td>
</tr>
<tr>
<td>Description (Year)</td>
<td>Frequency Range</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Phase 1 Science Case (2006-2007)</td>
<td>0.1-25 GHz</td>
</tr>
<tr>
<td>SKA Memo 100 (2007)</td>
<td>0.5-10 GHz (0.1-10 GHz)</td>
</tr>
<tr>
<td>SKADS Virtual Telescope (2007-2009)</td>
<td>0.3-10 GHz</td>
</tr>
<tr>
<td>SKA Memo 125 (2010)</td>
<td>0.07-3 GHz</td>
</tr>
</tbody>
</table>

Need to ensure that overall performance of SKA Phase 1 remains well above performance of all other radio astronomy facilities ca. 2015-2020.
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
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
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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.

Exploring the Universe with the world’s largest radio telescope
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.

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.”
• …
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
Chosen to

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

Chapters

1. 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., $A_{\text{eff}}$, $T_{\text{sys}}$, $\Omega$, $v$, baselines, …)
5. Data Products
Design Reference Mission

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