Early-science SKA to Full SKA: Upfront, Deferred, and Descoped

Translation: What science will be delayed or lost depending on how and how much of the SKA is built and in what order?

It depends on the starting point

10% concept (TBD)

and the end point.

Strawman? Reference? Other?

L. Greenhill

Early-science SKA to Full SKA: Upfront, Deferred, and Descoped

Translation: What science will be delayed or lost depending on how and how much of the SKA is built and in what order?

It depends on the starting point

10% concept (TBD)

and the end point.

Strawman? Reference? Other?

L. Greenhill

Proposal

- The science case is diverse, competitive, & substantive
  - worth preserving
  - merit in a science path well beyond present capability
  - enables a foundation for discovery beyond KSPs
- No key programs should be lost
  - Plan a full project with stages (phasing)
- Opportunities in fiscal circumstances & science politics
  - Individual (supra)national priorities and timelines
  - pitfalls and opportunities if manipulated constructively
- Looking like existing facilities only bigger is no sin
  - What counts is transformational capability and

De…de…descope Drivers

- Competition
  - superior science and technical cases from elsewhere
- Technical infeasibility
  - growth of the blue-sky SWG requirements
- Cost (I)
  - full build appears to cost €5 Bn: too high
  - cost “cap” of €1Bn appears too low. Is this soft?
  - a more liberal analysis
    - an extended buildout (15 yr) enables a larger budget
    - the target for “big science” grows over time worldwide
    - h/w costs decline over time (e.g., composite mfg;

- Descoping / Cost (II)
  - future funding environments are unknown
    - avoid placing KSPs on an “upgrade” path
    - low-frequency science necessarily up front
    - high-frequency, long baseline thermal science deferred
- Evasion
  - upfront sale of long-term staged deployment
    - 2015 - 2030 (it’s a BIG array!)
    - practicality of the “Wilkinson Opening” (?)
  - circumvent asynchrony in world and US funding cycles
    - major world funding available 2010-2020(+)
      - broad interest in lower frequencies
    - no major US funding until ~2022 apart from EOR
      - US planning exercises 2008-2010, 2018-2020.
      - broad interest in low & high frequencies
      - no radio constituency for low frequencies / ineffective outreach
  - what are the longer deployment times among

De…de…deferral
Early Science Array

- Sell full science concept
  - defer according to communities' ability to pay
  - but create hooks early-on for future stages
  - drive stakes - helps resist descope
- Reuse ESA components
  - identify common elements among stages
    - design these well
      - antenna structures
      - data transport infrastructure
  - identify elements extendable during build-out
  - if there are dishes upfront
    - design for 24 GHz ?
    - design for 300 MHz - in the event AA's are too expensive ?

Upfront Science

- Depends on
  - initial conditions
    - shape of Early Science Array TBD
  - final conditions
    - full adherence to full KSP range TBD
  - path from here to there (uncertain)
- Parameters
  - $A_e(R, \nu)$
    - thermal limit on long baselines,
    - dynamic range and survey capability
  - Ω (survey speed)
  - ν_{max}
  - $\nu_{transition}$ among mid and high-range receptors
  - σ (point source sensitivity)

Row	C (3-Jul-06)	Frequency Coverage (E 50-100 MHz, F 100-200 MHz, G 200-400 MHz, H 400-1000 MHz, I 1-2 GHz, J 2-4 GHz, K 4-10 GHz, L 10-20 GHz, M 20-35 GHz)	O: Beta (simultaneous fractional bandwidth coverage)	Q: FOV (instantaneous FOV)	R: Resolution (resolution at key survey frequency)	S: Baseline (maximum baseline assuming key freq in prev column)	T: Dynamic Range	U: S/N	V: Calibration (total power calibration)	W: Multi-field	Y: Polarisation	Z: full array useful (Y/N)?	AA: sky area that needs to be covered
2	**SKA Key Science Projects (KSP) 2005/6**												
3	**The cradle of life**												
4	Planet formation in Protoplanetary Disks - milliarcsecond imaging of YSOs in nearby molecular clouds	10 - 35 GHz	=0.1	few arcsec - targeted ot	2 mas at 20 GHz	1000km	good		tbd	N any			
5	SETI observations of stellar systems within FOV of other programs	1 - 20 GHz	0.2	1 sq deg	n/a	n/a	unimportant			N any			
6	Astrochemistry mini-surveys of nearby molecular clouds for bio molecular lines	1 - 35 GHz	0.04	0.5 - 1 sq deg	100 mas at 10 GHz	60 km	good			N any			
7													
8	**Strong field tests of gravity using pulsars & black holes**												
9	Pulsars - tests of gravity using binary pulsars w NS & BH companions												
10	- survey of galactic plane & globular clusters	1-2 GHz (0.5 - 3 GHz)	20%	1 sq deg	full FOV pixelization	compact core (few km)	NA			N	dual - total I	No	GP & target globular clusters, 1000
11	- timing follow-up	1-2 GHz (0.5 - 3 GHz)	20%	1 sq deg	form N beams per FOV (N=10)	200 km	NA			Y/S	dual - total I	Yes, sometime	globular clusters, 1000
12	- high precision timing	0.5 - 3 GHz	20%	single source	NA	all can be phase	NA			N*	full Stokes, hig	Yes, sometime	single targets
13	- astrometry of pulsars	3 & 8 GHz	20%	single source	1 mas at 5 GHz	6000 km	moderate			N	total I	No	single targets
14	Pulsars - nHz gravitational waves using MSP timing array												
15	- survey of galactic plane & globular clusters	1-2 GHz (0.5 - 3 GHz)	20%	1 sq deg	full FOV pixelization	compact core (few km)	NA			N	dual - total I	No	GP & target globular clusters, 1000
16	- timing follow-up	1-2 GHz (0.5 - 3 GHz)	20%	as large as possible	form N beams per FOV (N=10)	200 km	NA			Y/S	dual - total I	Yes, sometime	globular clusters, 1000
17	- high precision timing	0.5 - 3 GHz	20%	single source	NA	all can be phase	NA			N*	full Stokes, hig	Yes, sometime	single targets
18	- astrometry of pulsars	3 & 8 GHz	20%	single source	1 mas at 5 GHz	6000 km	moderate			N	total I	No	single targets
19	Pulsars - in SgrA* star cluster												
20	Strategy - survey GC	9 - 10 GHz		1 sq deg	NA pixel	n/a	n/a			No	total I	N	GC only
21	- followup & time GC pulsars	9 - 15 GHz		single targeted sources	NA	n/a	n/a			No	full stokes	N	single pointing
22													
23	**The origin & evolution of cosmic magnetism**												
24	The origin & evolution of cosmic magnetism: All-sky rotation measure survey												
25	- Map RM grid	1.4 GHz		1 sq deg	500 mas	450 km	moderate	10 across BW		N any	Y - eq		
26	- deep fields: Stokes I imaging v faint unres synch extragal sources	1.4 GHz		~10 arcmin sq(?)	500 mas	100 km	good	3 across BW		N any	Y - eq		
27	- polarisation silhouettes	500 MHz - 10 GHz		1 sq deg	100 mas at 1.4 GHz	450 km	moderate	10 across BW		N any	Y - eq		
28	- tomography	500 MHz - 1.5 GHz		1 sq deg	1 arcsec at 700 MHz	180 km	moderate	3 across BW		N any	Y - eq		
29	- deep polarisation imaging - Stokes Q & U imaging of diffuse ISM & galaxies	5 - 10 GHz		0.1 sq deg	100 mas at 5 GHz	125 km	moderate	5 across BW		N any	Y - eq		
30													
31	**Galaxy evolution & cosmology**												

Five Key Science Projects
Digest of Prime Drivers Enabled by ESA

Full Array

Strong-field gravity: pulsars & black holes

Tests using binary pulsars with NS & BH companions

Gravitational waves with MSP timing array

Cradle of Life

Planet formation in Protoplanetary disks

Cosmic Magnetism

RM grid

Galaxy Evolution & Cosmology

Galaxy evolution (emission to z~3, abs z>3)

Dark energy (HI baryon oscillations)

Probing the Dark Ages

Map EoR from redshifted HI

Early Science Array

Strong-field gravity

1-2+ GHz

Cradle of Life

------- *

Building Galaxies

500 MHz – 1.4 GHz

200 MHz – 1.4 GHz e|a z~2

500 MHz – 1 GHz

Probing the Dark Ages

70/100 – 300 MHz

* Prebiotic molecules 1-10 GHz

(Adapted from Jackson)

Upfront, Deferral, Descope Concerns Re EWG Assessments

- Descope to 1/3 scale is a red flag
- What happens when scientists ask to avoid design-outs?
- Abandonment of high frequencies $\Rightarrow$ worries (among some)
  - What would be lost now to obtain ν_{max}~24 GHz?
  - Is this cast in concrete?
- Trade-off between multi-beaming and sensitivity
  - are aperture arrays practical (vs dishes)?
  - are FOV expansion measures practical?
- Is a conservative base + innovation path constraining?
- Is an extended buildout really inflationary?
- Does (remote) power consumption force descope?
- Is reuse of ESA components in later stages factored in?
- Are maintenance costs for blue sky systems factored in?

New Speak

[Vocabulary defines the discussion.]

Future?	Current
10% SKA Early Science Array	Phase 1 SKA
Staged Extended buildout	Phase 2, 3 Upgrade Path
?	Square Kilometer (SKA)

Is it time to depart reference to sq. kilometer by name?

end