S K A

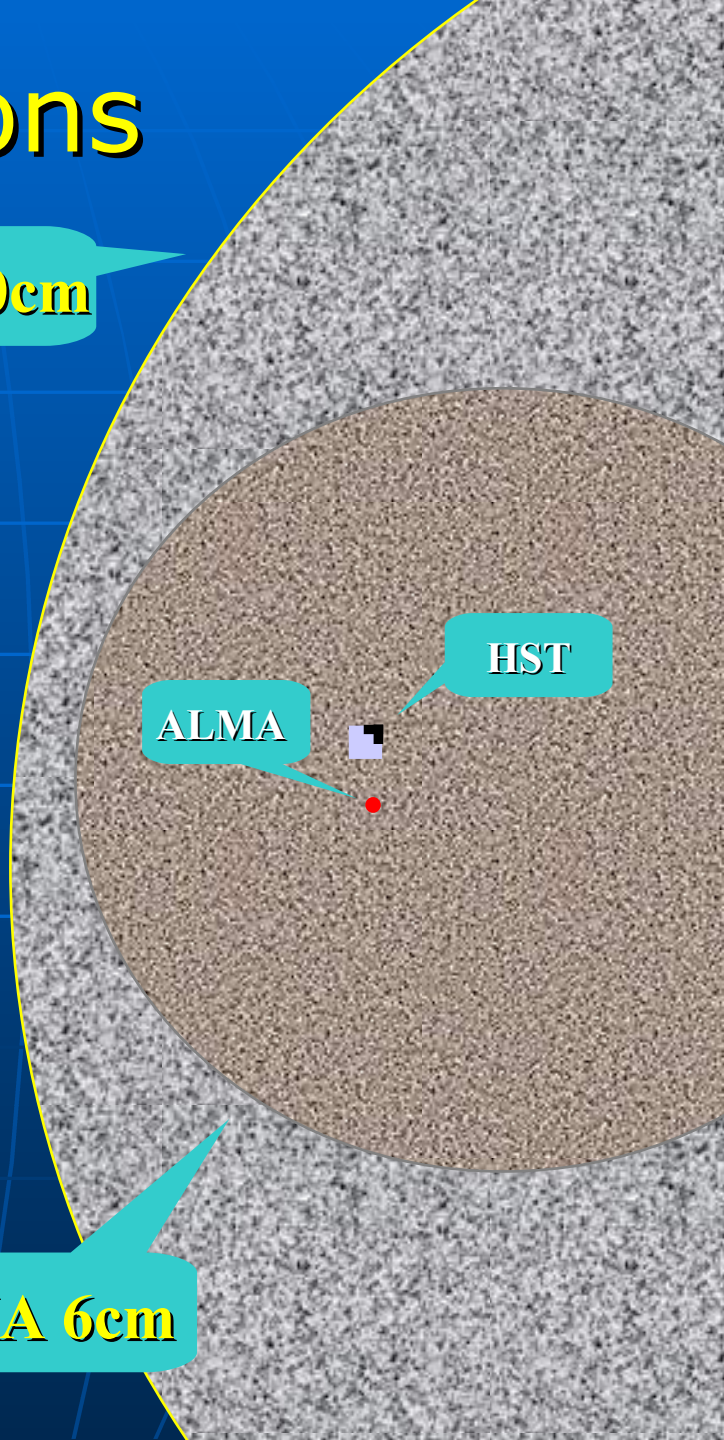
Square Kilometre Array

A very brief summary

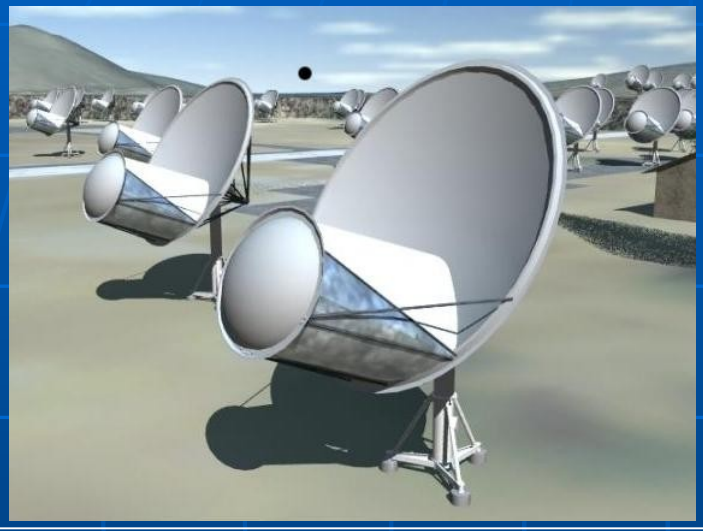
Rainer Beck, MPIfR Bonn

SKA Specifications

- Sensitivity (A/T): 4000 – 12000 $m^2 K^{-1}$
- Beamsize: 1 – 200 deg^2
- ≈ 8 independent beams
- Resolution: ≥ 10 mas
- Frequency range: 70 MHz – 10 (35) GHz
- Dynamic range up to 10^6
- Polarization purity: –30 dB over field



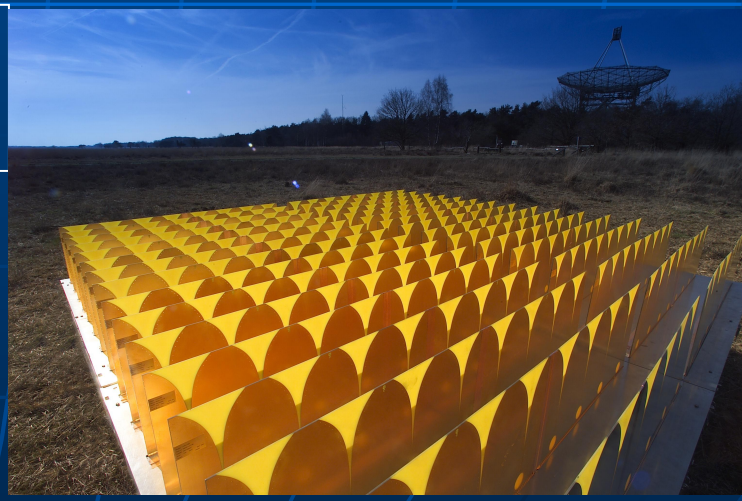
Early SKA concepts

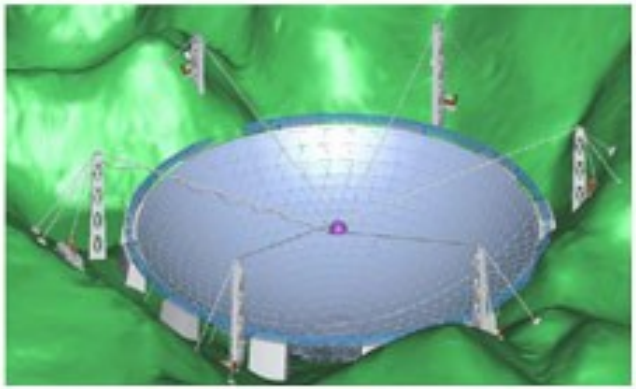


USA: Small parabolic reflectors

Australia: Focal plane arrays

Europe: Phased Array





FAST - 3D image (Courtesy of Dr. Cao Yang)

China: Large spherical mirrors

SKA Reference Design (2007)

1. Array of 15m parabolic dishes (Phase 1)

   ≈0.5-1.5 GHz: Focal-plane phased arrays, FoV 10-50 deg^2 ("radio camera")

   ≈1.5-10 GHz: Wide-band single-pixel feeds, FoV ≤10 deg^2

2. Aperture array (Phase 1)

   ≈ 0.5-0.8 GHz (or 0.1-0.5 GHz): Tiles (all-sky), independent multiple fields by software beam forming

3. EoR array (Phase 2)

   ≈ 0.07-0.2 GHz: Dipoles, FoV ≈200 deg^2

10. High-band (Phase 3)

    Upgrade to 35 GHz

SKA Specifications

Status: Dec 2007

15/11/07 (v2.3) Parameter	First Stage		Full SKA			
	Phase 1 *Mid-band – inc. dense AA*		Phase 2 scenarios *Low & mid-bands – all inc. AAs to 500MHz*			Phase 3 *High band*
	WBF only	WBF+PAF*	WBF only	WBF+PAF*	WBF+dense AA	
Frequency Range: Low	500 MHz	500 MHz	70 MHz	70 MHz	70 MHz	10 GHz
Range: High	10 GHz	10 GHz	10 GHz	10 GHz	10 GHz	35 GHz
Survey speed ($m^4K^{-2}deg^2$)						
70 - 200 MHz			3×10^9	3×10^9	3×10^9	
200 - 500 MHz	1×10^7	1×10^7	2×10^{10}	2×10^{10}	2×10^{10}	
0.7 GHz	1×10^7	3×10^7	3×10^8	1×10^9	2×10^{10}	
1.4 GHz	2×10^6	3×10^7	6×10^7	1×10^9	4×10^7	
3 GHz	5×10^5	1×10^5	1×10^7	5×10^8	1×10^7	
10 GHz	2×10^4	5×10^3	5×10^5	2×10^5	4×10^5	
25 GHz						4.6×10^4
35 GHz						2.4×10^4
Min. sensitivity at 45° A_{eff}/T_{sys} (m^2K^{-1})						
70 - 200 MHz			4,000	4,000	4,000	
200 - 500 MHz	200	200	10,000	10,000	10,000	
700 MHz	2,000	1,100	12,000	7,000	10,000	
1.4 GHz	2,000	1,100	12,000	7,000	10,000	
3 GHz	2,000	1,100	12,000	7,000	10,000	
10 GHz	1,300	700	8,000	5,000	7,000	5,000
25 GHz						5,000
35 GHz						5,000
Configuration:						
core: < 1 km	50 %	50 %	20 %	20 %	20 %	20 %
inner: < 5 km	75 %	75 %	50 %	50 %	50 %	50 %
mid†: < 180 km	100 %	100 %	75 %	75 %	75 %	75 %
outer: <~3,000 km			100 %	100 %	100 %	100 %

SKA Specifications Status: Dec 2007

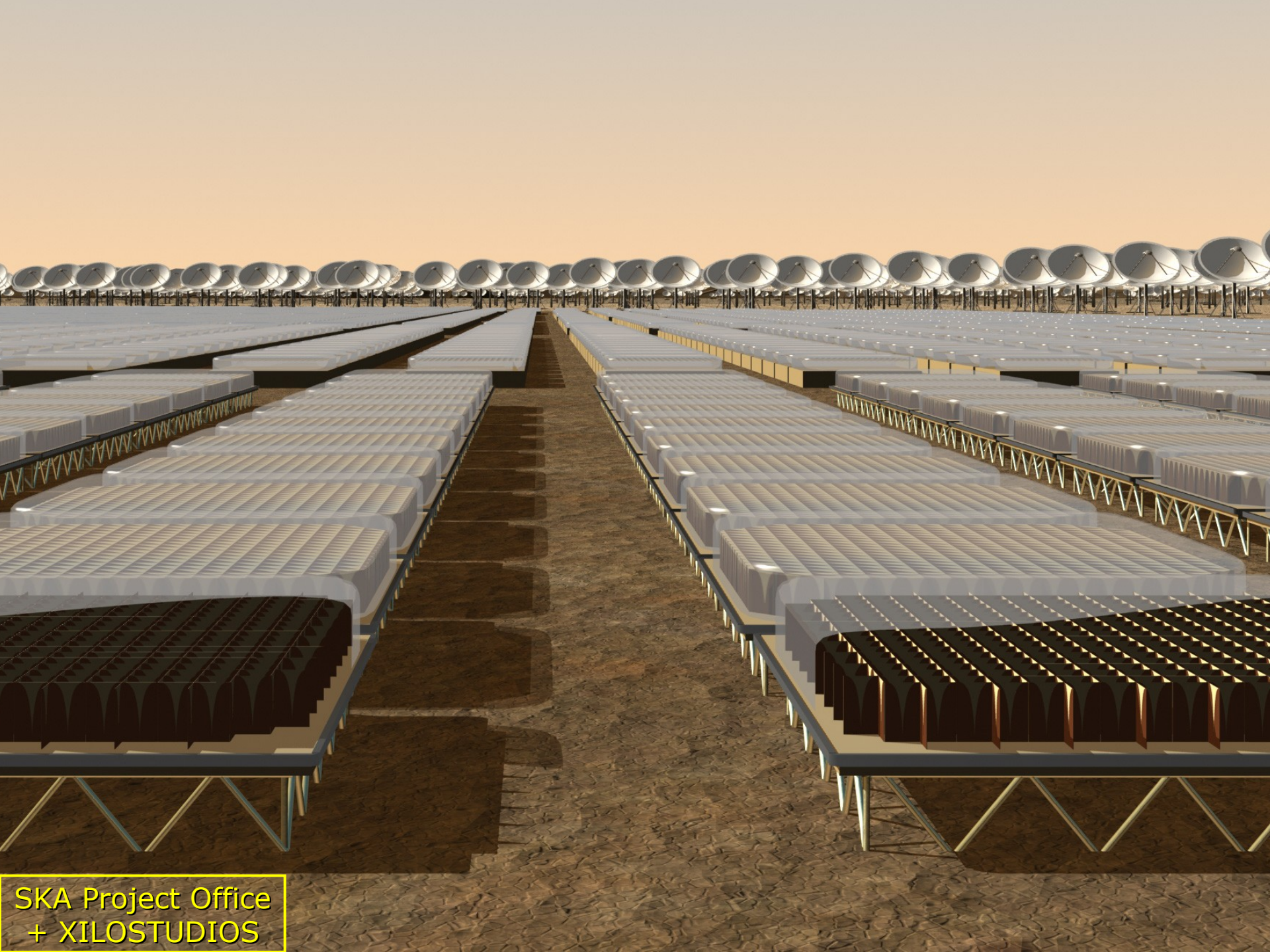
Table 2. Phase 1 technology combinations in the frequency range 500 MHz to 10 GHz. that are projected to cost 200 M€ for components. Note that 2a and 2b are alternative implementations of dish-based systems at the extreme ends of the spectrum of possibilities. 30 M€ is also needed for deployment of an aperture array - sparse or dense to be determined during the course of the PrepSKA Design Study from science and technical readiness considerations.

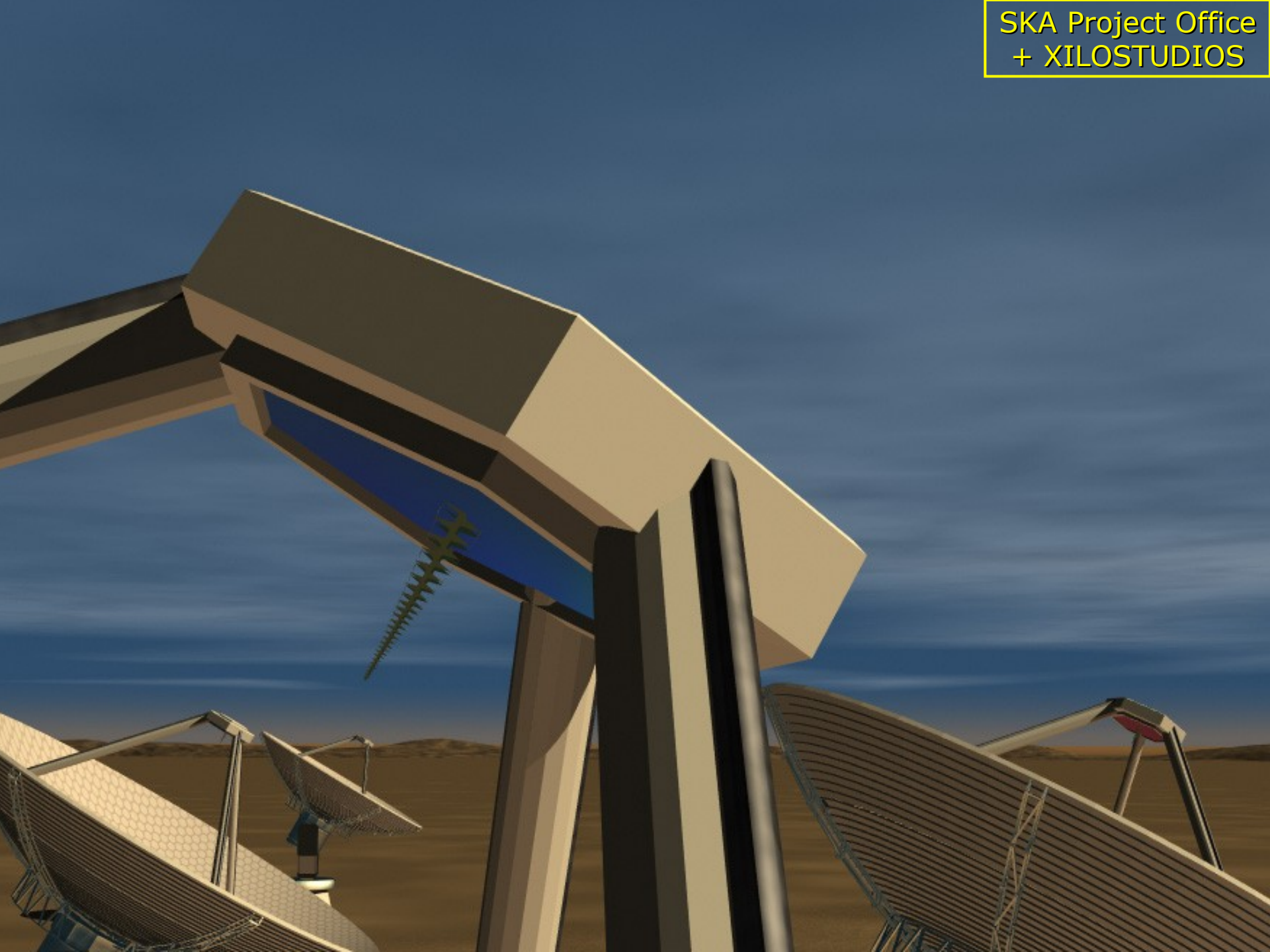
Frequency Range	Sensor	A_{eff}/T_{sys} m^2K^{-1}	Survey speed $m^4K^{-2}deg^2$	Cost
1) 500-800 MHz*	Dense Aperture Array	200	$1x10^7$	30 M€
2a) 0.5-10 GHz	490 15m dishes with PAFs (0.5-1.5 GHz) T_{sys}=50K effic=70%, FoV=20 deg^2 +WBSPF (1.5-10GHz) T_{sys}=35K, effic=65%	1200	$3x10^7$	170 M€
2b) 0.5-10 GHz	620 15m dishes with WBSPFs (0.5-10 GHz) T_{sys}=35K, effic=65%	2,000	$2x10^8$	170 M€

* or 100 – 500 MHz using sparse aperture arrays if science and technical considerations so dictate

Table 3. Three possible combinations of technologies for Phase 2 implementation in the frequency range 70 MHz to 10 GHz that are projected to cost 1,000 M€ for components. (Note that 3a to 3c are three alternative mid-band implementations)

Frequency Range	Sensor	A_{eff}/T_{sys} m^2K^{-1}	Survey speed $m^4K^{-2}deg^2$	Cost
1) 70-200 MHz	Sparse aperture array composed of tiled dipole arrays	4,000-10,000	$3x10^9$	125 M€
2) 200-500 MHz	Sparse aperture array composed of tiled dipole arrays	10,000	$2x10^{10}$	125 M€
3a) <500 MHz - 10 GHz	3,000 15m dishes/WBSPF T_{sys}=30K, effic=70%	12,000	$6x10^7$ at 1.4 GHz	750 M€
3b) 500 MHz - 10 GHz	2,000 15m dishes with PAFs (500 MHz-1.5 GHz) T_{sys}=35K effic=70%, FoV=20 deg^2 + WBSPF (1.5-10 GHz) T_{sys}=30K	7,000	$1x10^9$ $5x10^8$ at 3 GHz	750 M€
3c) 500 MHz - 10 GHz	Dense aperture array (500-800 MHz) + 2,400 15m dishes/WBSPF (800 MHz - 10 GHz), T_{sys}=30K, effic=70%	10,000 10,000	$2x10^{10}$ (500-800 MHz) $4x10^7$ at 1.4 GHz	150 M€ (AA) 600 M€ (dishes / WBSPF) total=750 M€


SKA Project Office
+ XILOSTUDIOS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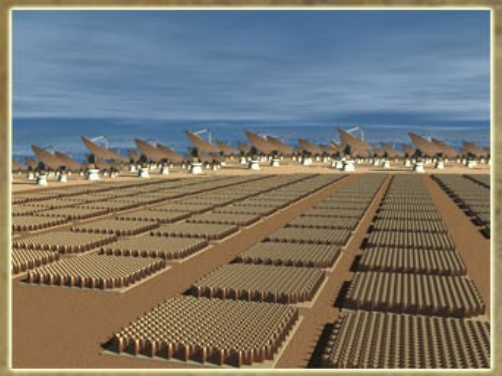
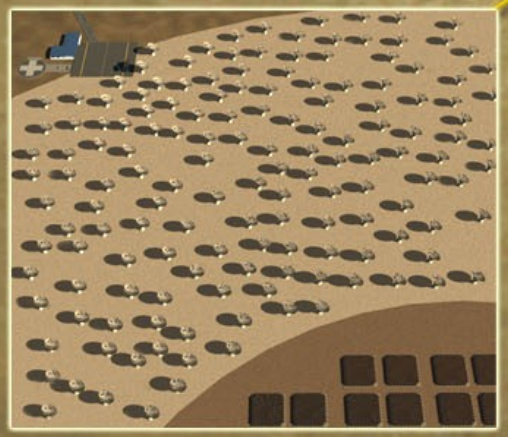
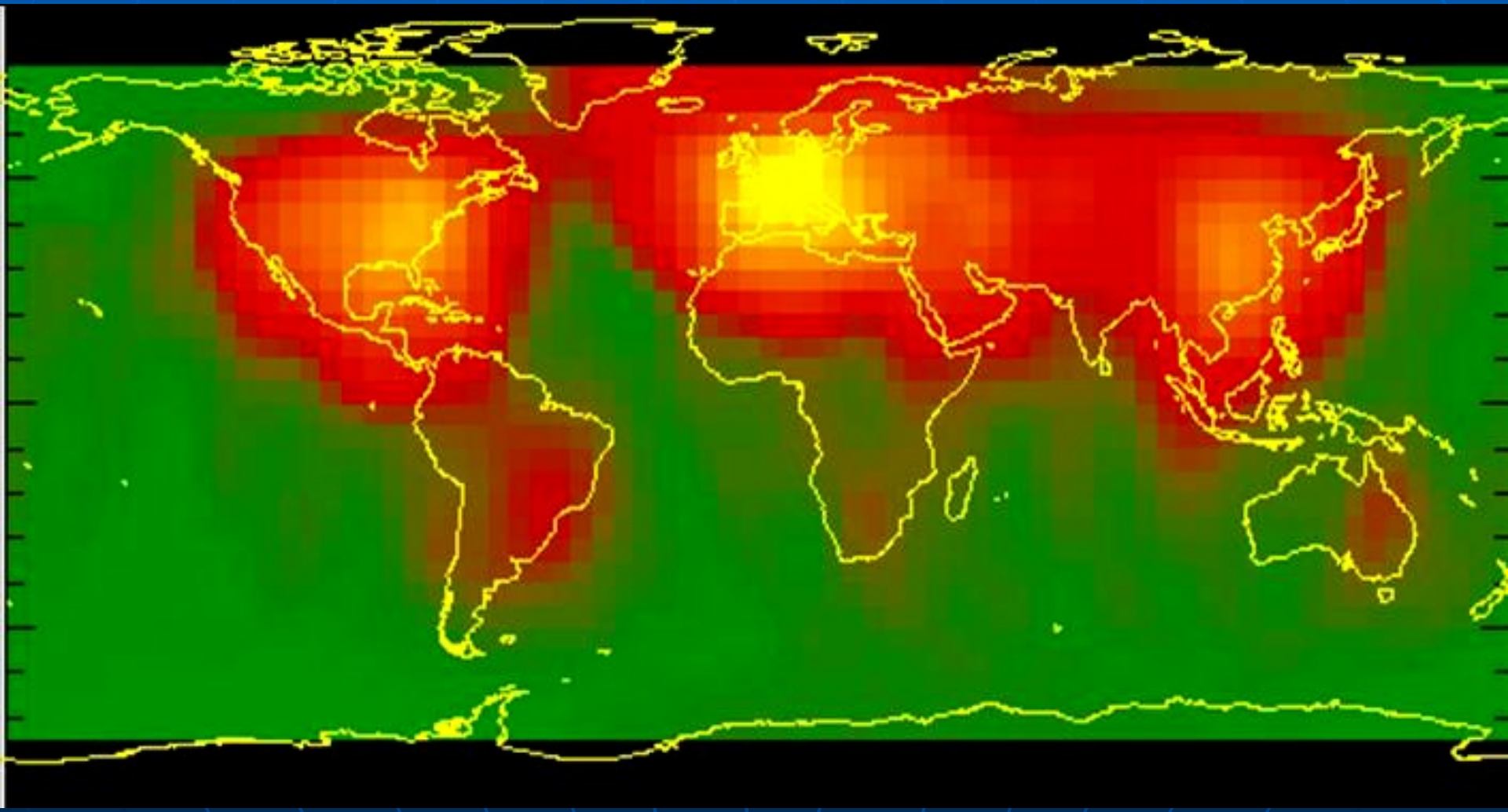




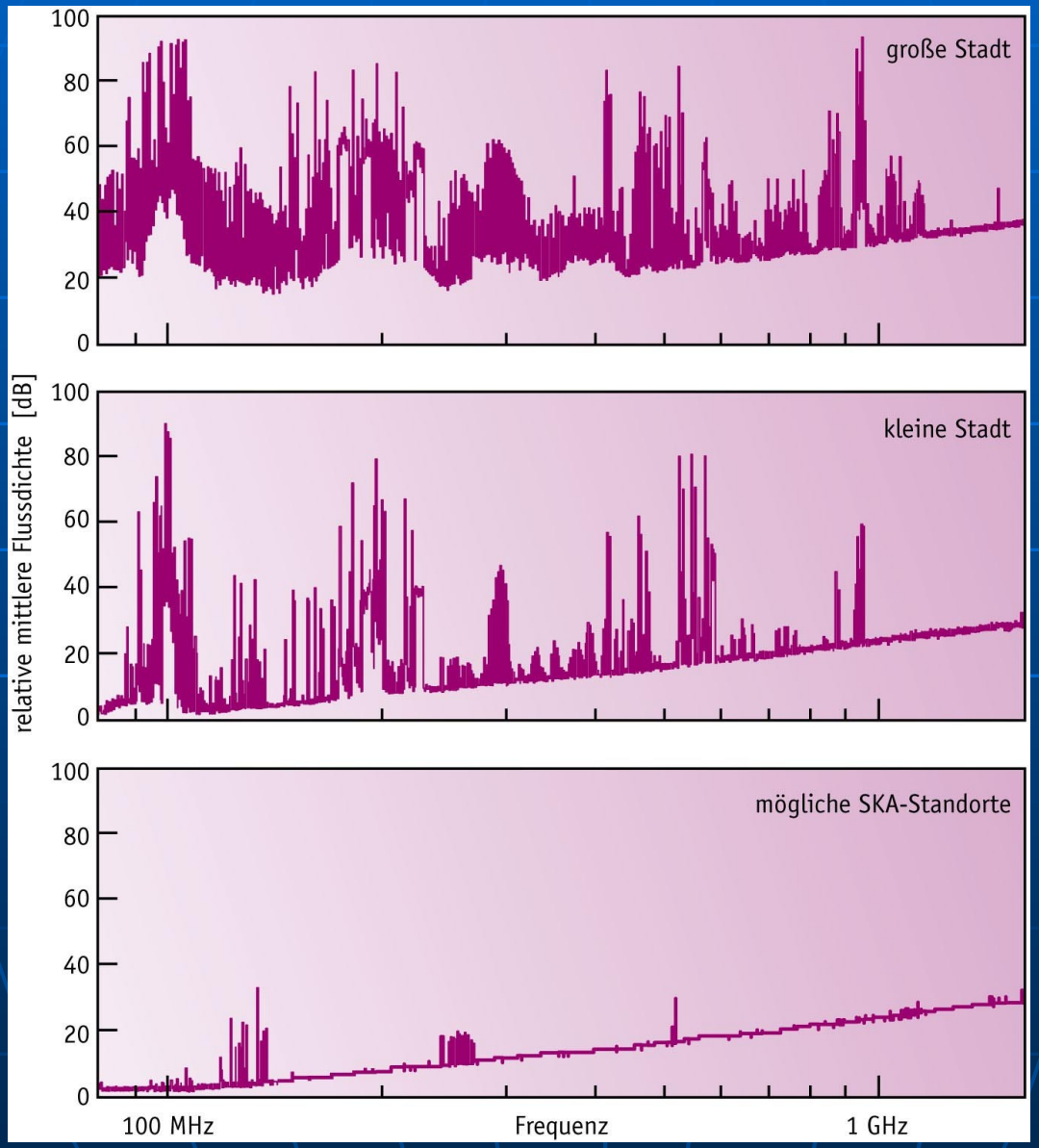
Inner core

Station

Radio interference
(FORS satellite, 131 MHz)



Radio interference



large city

Small city

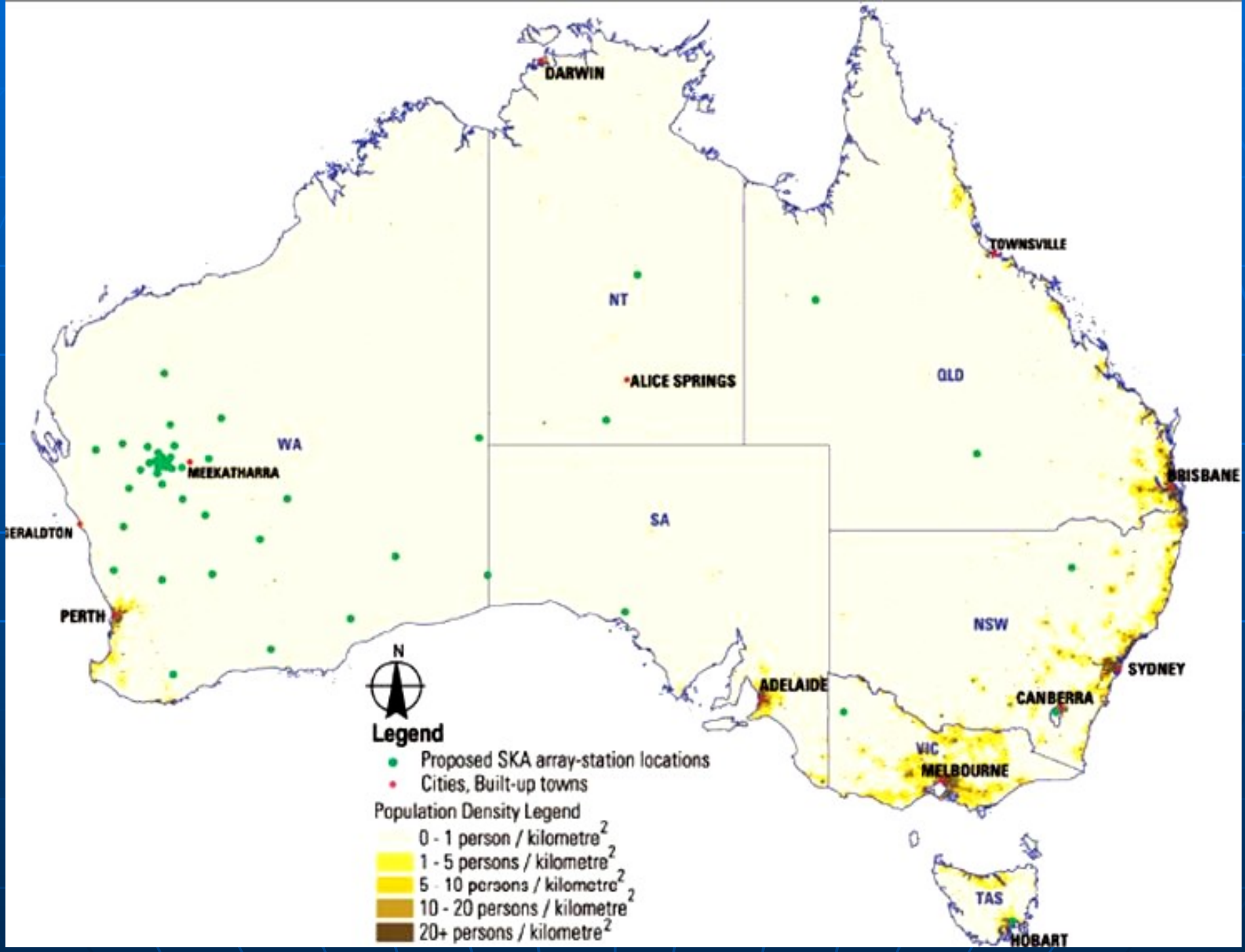
SKA suited

Proposed SKA sites

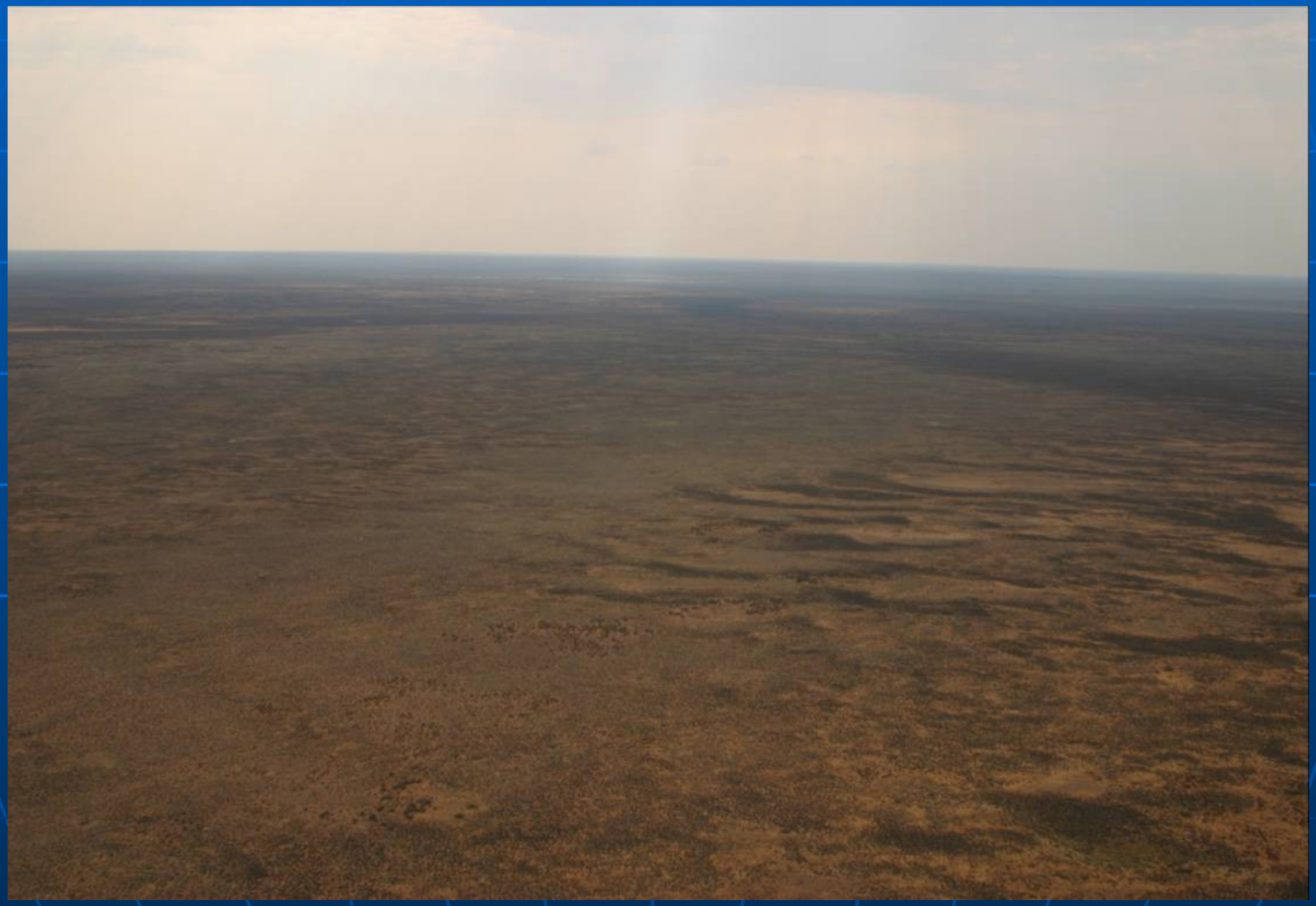
- Western Australia
- South Africa (+ Mozambique + …)

SKA site

Western Australia


DARWIN
TOWNSVILLE
NT
ALICE SPRINGS
QLD
WA
MEEKATHARRA
BRISBANE
SA
PERTH
NSW
N
ADELAIDE
SYDNEY
CANBERRA
VIC
MELBOURNE
TAS
HOBART
Legend
Proposed SKA array-station locations
Cities, Built-up towns
Population Density Legend
0 - 1 person / kilometre2
1 - 5 persons / kilometre2
5 - 10 persons / kilometre2
10 - 20 persons / kilometre2
20+ persons / kilometre2

SKA site



South Africa

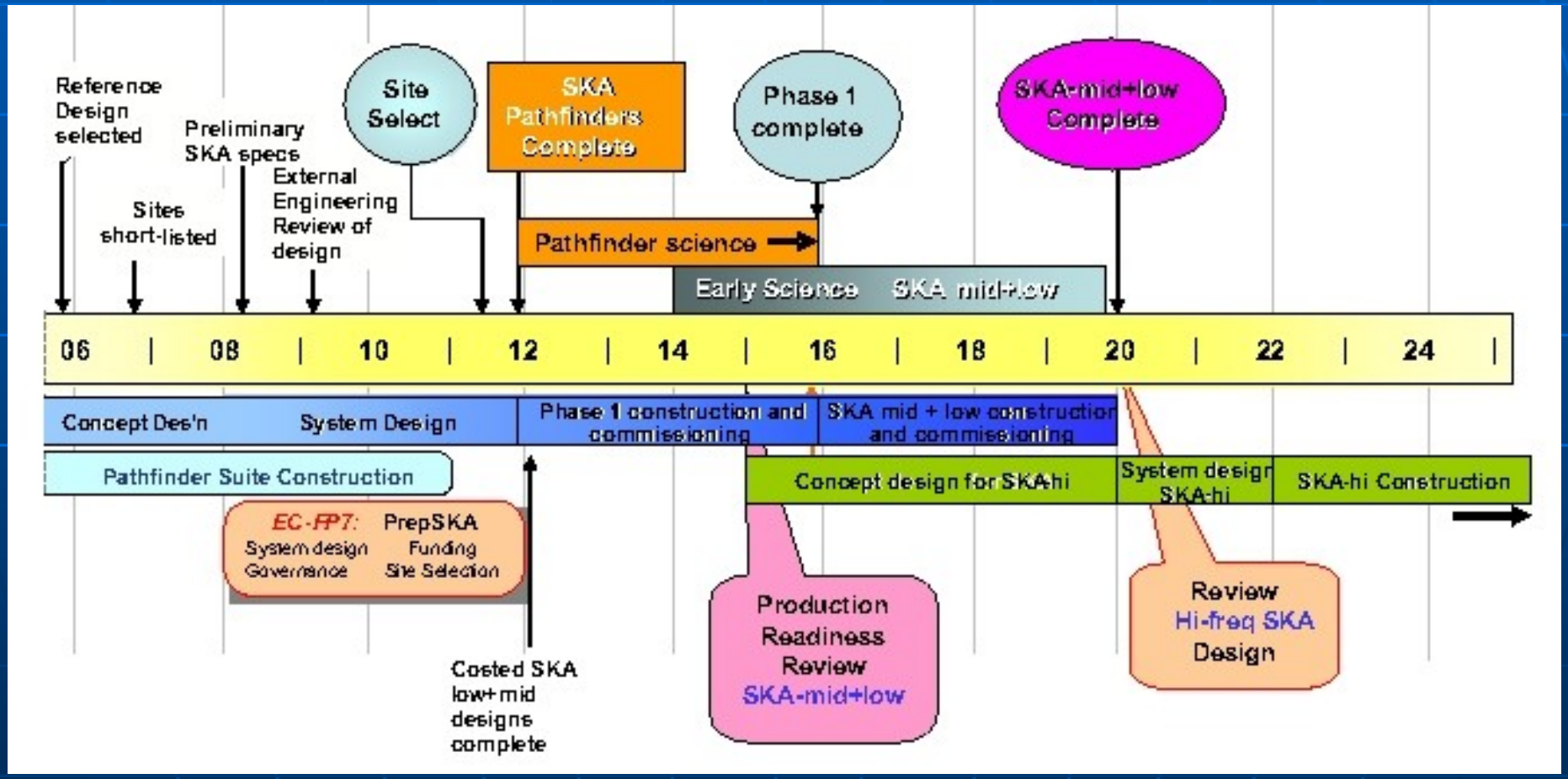

Rotes Meer
Golf von Aden
Niger
Mali
Mauretanien
Senegal
Burkina Faso
Nigeria
Tschad
Sudan
Äthiopien
Somalia
Sierra Leone
Liberia
Guinea
Elfen-bein-küste
Ghana
Togo
Benin
Kamerun
Zentralafrika-nische Republik
Gabun
Republik Kongo
Demokratische Republik Kongo
Uganda
Kenia
Ruanda
Burundi
Tansania
Atlantischer Ozean
Angola
Sambia
Malawi
Zimbabwe
Namibia
Botswana
Mosambik
Madagaskar
Mauritius
Südafrika
Indischer Ozean
0
1000
2000
3000 km

SKA schedule

- 2010: Selection of design
- 2011: Selection of site
- 2012-16: Phase 1 (≈10% of full array)
- 2016-20: Phase 2 (full array, ≤ 10 GHz)
- > 2020: Phase 3 (10-35 GHz)

SKA Timeline

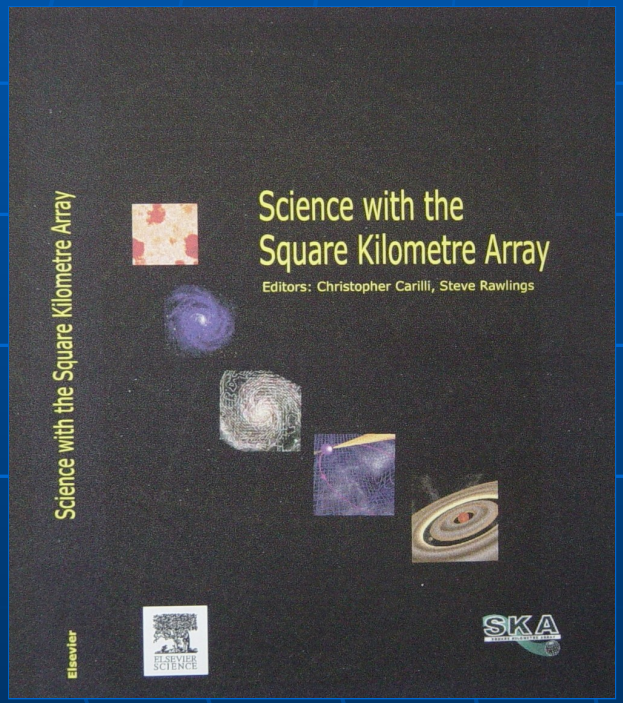
Status: Dec 2007



SKA Key Science

- The Dark Ages & Dark Energy
- Galaxy evolution & large-scale structures
- Testing theories of gravitation
- Cosmic magnetism
- The Cradle of Life
- Exploration of the Unknown

SKA science book



Science with the Square Kilometre Array

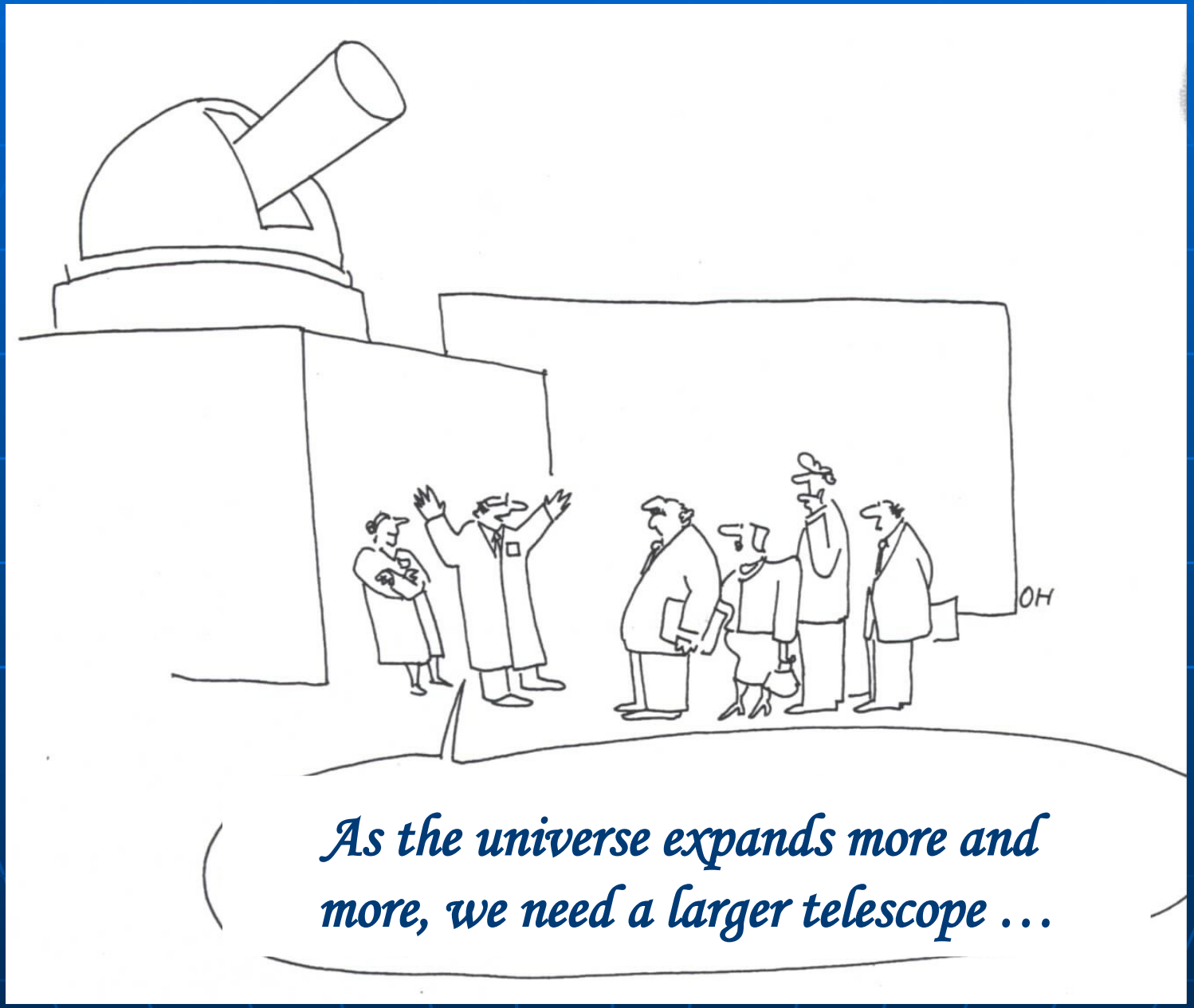
Eds: C.Carilli & S.Rawlings,
New Astronomy Reviews,
Vol.48, Elsevier, Dec. 2004

www.skatelescope.org

Funded SKA Prototypes

- Europe: LOFAR (30-240 MHz)
- Europe: *SKA Design Study* (SKADS), with *Electronic Multi-Beam Radio Astronomy Concept* (EMBRACE) (0.6-1.7 GHz)
- Europe: PREPSKA (from 2009)
- Australia: *Australian SKA Pathfinder* (ASKAP) (0.8-2GHz)
- China: *Five hundred meter Aperture Spherical Telescope* (FAST) (0.3-2 GHz)
- South Africa: *Karoo Array Telescope* (MeerKAT) (0.2-2.5 GHz)
- USA: *Long Wavelength Array* (LWA) (10-88 MHz), *Allan Telescope Array* (ATA) (1-10 GHz)


2 10⁹ €
SKA


OH
As the universe expands more and more, we need a larger telescope …