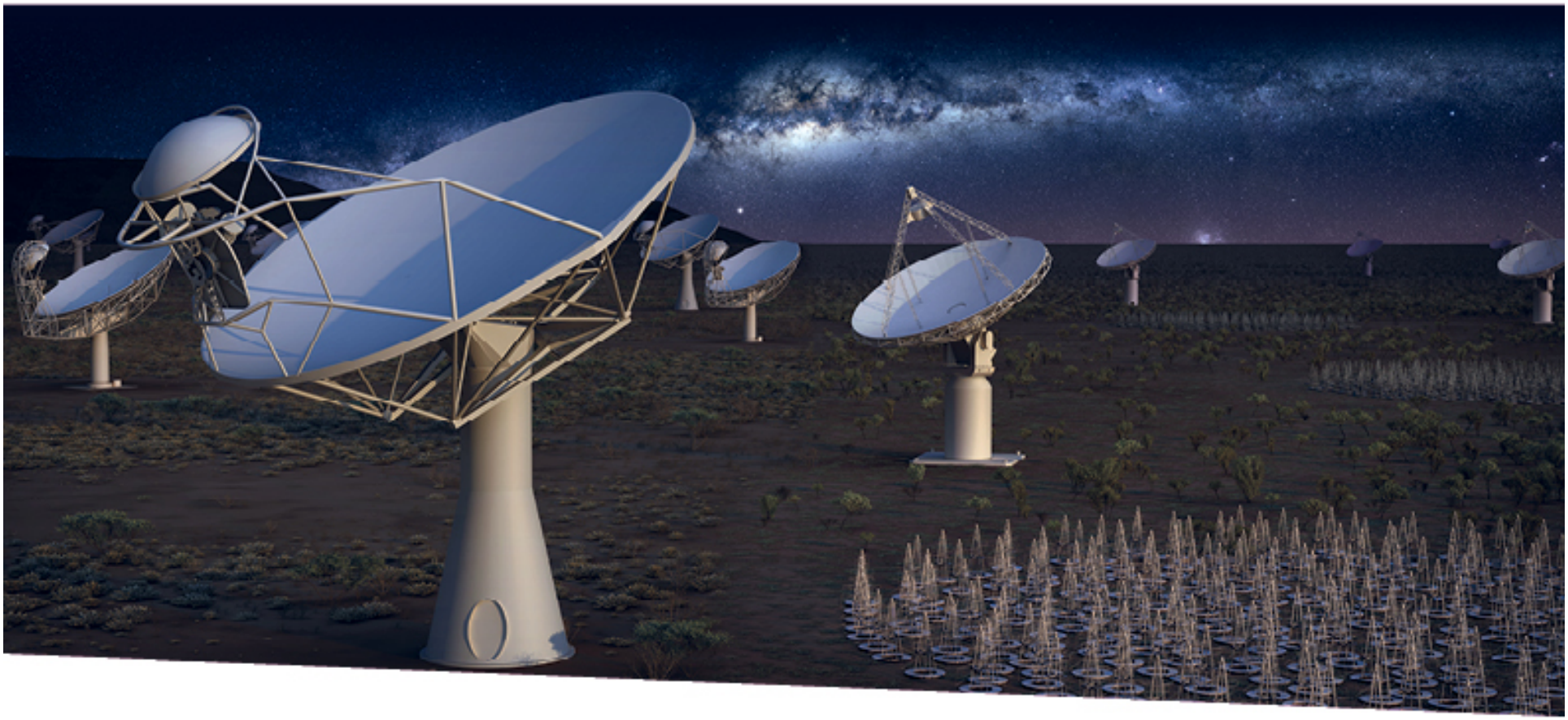
Square Kilometre Array



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Philip Diamond, Director General

Chicago 17th December 2015

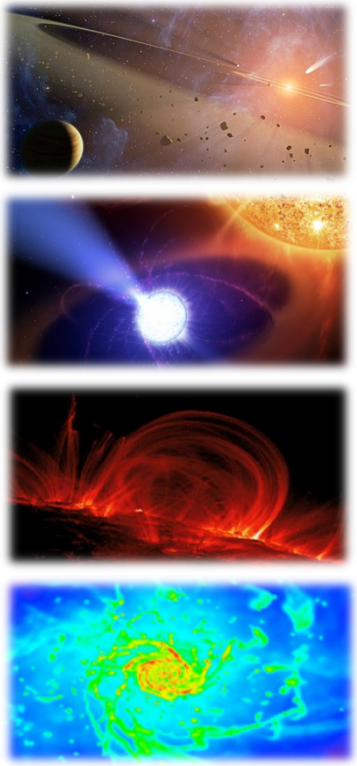
SKA Science

- SKA: will be one of the great physics machines of 21st Century and, when complete, one of the world's engineering marvels.
- Science goals:
  - Fundamental physics: Gravity, Dark Energy, Cosmic Magnetism
  - Astrophysics: Cosmic Dawn, First galaxies, galaxy assembly and evolution; proto-planetary discs, biomolecules, SETI + much more
  - The unknown: transients; +…????
- Broader science range than any other science facility on Earth.

Headline Science with SKA1 and SKA2

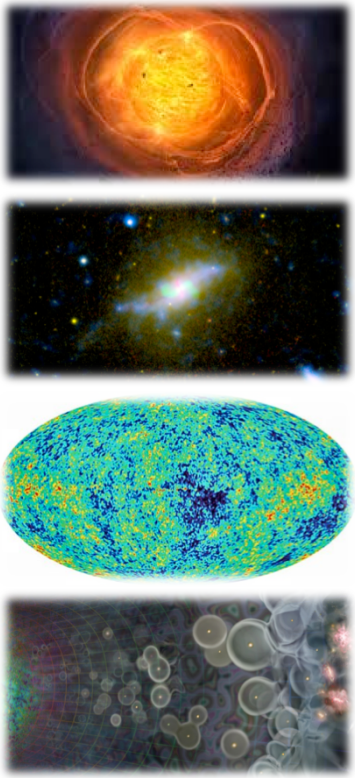
http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=215

	SKA1	SKA2
The Cradle of Life & Astrobiology	Proto-planetary disks; imaging inside the snow/ice line (@ < 100pc), Searches for amino acids.	Proto-planetary disks; sub-AU imaging (@ < 150 pc), Studies of amino acids.
	Targeted SETI: airport radar 10^4 nearby stars.	Ultra-sensitive SETI: airport radar 10^5 nearby star, TV ~10 stars.
Strong-field Tests of Gravity with Pulsars and Black Holes	1st detection of nHz-stochastic gravitational wave background.	Gravitational wave astronomy of discrete sources: constraining galaxy evolution, cosmological GWs and cosmic strings.
	Discover and use NS-NS and PSR-BH binaries to provide the best tests of gravity theories and General Relativity.	Find all ~40,000 visible pulsars in the Galaxy, use the most relativistic systems to test cosmic censorship and the no-hair theorem.
The Origin and Evolution of Cosmic Magnetism	The role of magnetism from sub-galactic to Cosmic Web scales, the RM-grid @ 300/deg2.	The origin and amplification of cosmic magnetic fields, the RM-grid @ 5000/deg2.
	Faraday tomography of extended sources, 100pc resolution at 14Mpc, 1 kpc @ z ≈ 0.04.	Faraday tomography of extended sources, 100pc resolution at 50Mpc, 1 kpc @ z ≈ 0.13.
Galaxy Evolution probed by Neutral Hydrogen	Gas properties of 10^7 galaxies, <z> ≈ 0.3, evolution to z ≈ 1, BAO complement to Euclid.	Gas properties of 10^9 galaxies, <z> ≈ 1, evolution to z ≈ 5, world-class precision cosmology.
	Detailed interstellar medium of nearby galaxies (3 Mpc) at 50pc resolution, diffuse IGM down to N_H < 10^17 at 1 kpc.	Detailed interstellar medium of nearby galaxies (10 Mpc) at 50pc resolution, diffuse IGM down to N_H < 10^17 at 1 kpc.



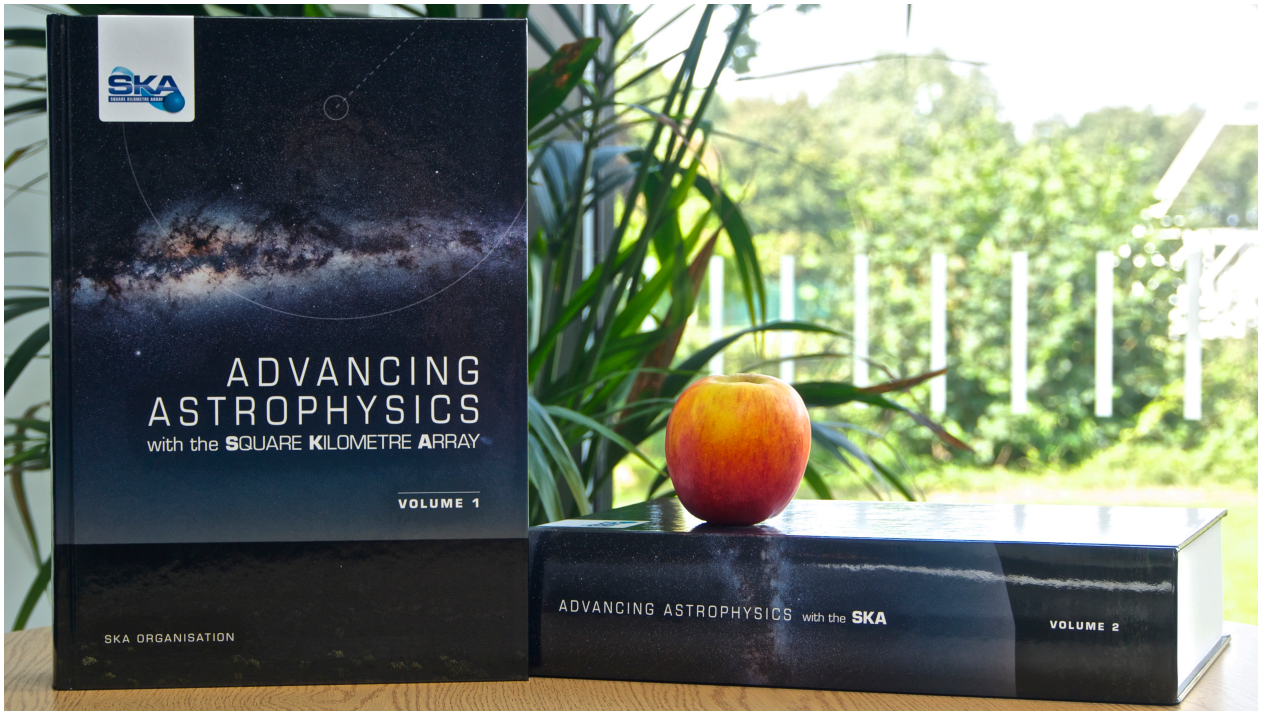
Headline Science with SKA1 and SKA2

	SKA1	SKA2
The Transient Radio Sky	Use fast radio bursts to uncover the missing "normal" matter in the universe.	Fast radio bursts as unique probes of fundamental cosmological parameters and intergalactic magnetic fields.
	Study feedback from the most energetic cosmic explosions and the disruption of stars by super-massive black holes.	Exploring the unknown: new exotic astrophysical phenomena in discovery phase space.
Galaxy Evolution probed in the Radio Continuum	Star formation rates (10 M_Sun/yr to z ~ 4).	Star formation rates (10 M_Sun/yr to z ~ 10).
	Resolved star formation astrophysics (sub-kpc active regions at z ~ 1).	Resolved star formation astrophysics (sub-kpc active regions at z ~ 6).
Cosmology & Dark Energy	Constraints on DE, modified gravity, the distribution & evolution of matter on super-horizon scales: competitive/superior to Euclid.	Constraints on DE, modified gravity, the distribution & evolution of matter on super-horizon scales: redefines state-of-art.
	Primordial non-Gaussianity and the matter dipole: 2x Euclid.	Primordial non-Gaussianity and the matter dipole: 10x Euclid.
Cosmic Dawn and the Epoch of Reionization	Direct imaging of EoR structures (z = 6 - 12).	Direct imaging of Cosmic Dawn structures (z = 12 - 30).
	Power spectra of Cosmic Dawn down to arcmin scales, possible imaging at 10 arcmin.	First glimpse of the Dark Ages (z > 30).



SKA Science Book:

- 135 self-contained chapters; > 1200 authors from 31 countries
- Published electronically in Proceedings of Science, May 2015
- Hardcopy: 2 volumes, total weight 9kg!



The SKA Observatory

Revised project scope: March 2015

3 sites; 2 telescopes; HQ

1 Observatory

Phase 1

Construction: 2018 – 2023

Construction cost: €650M

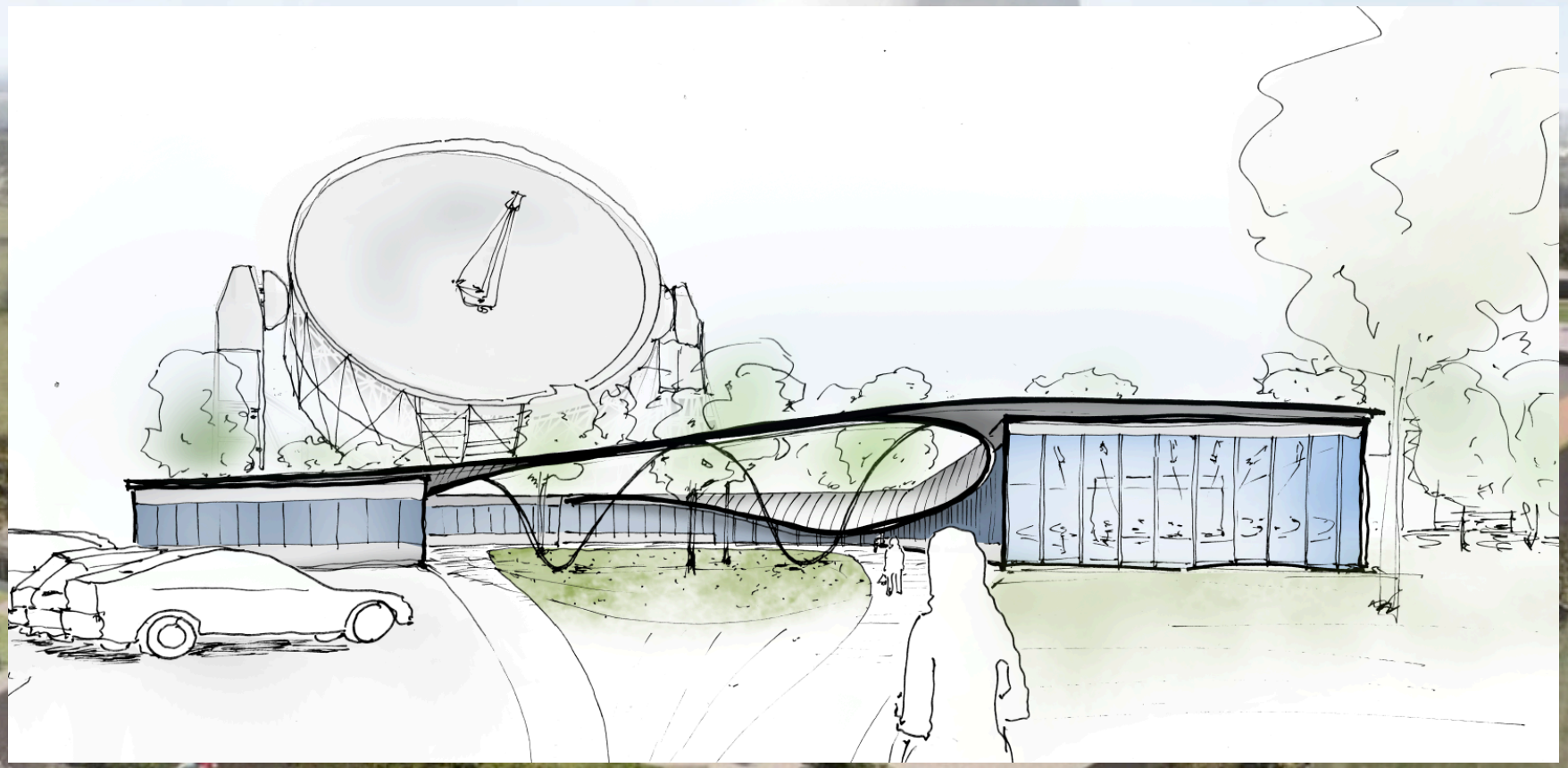
Operations cost: ~€75M/yr, TBD

MeerKat integrated

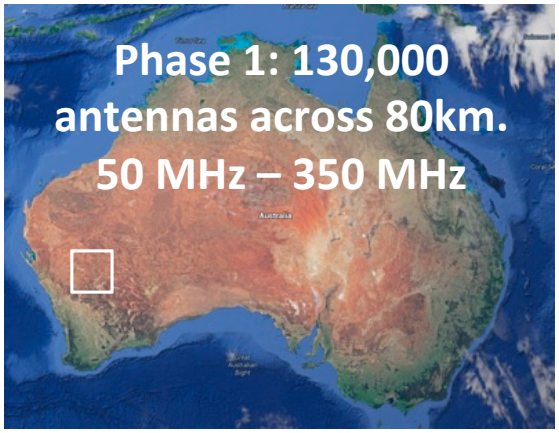
ASKAP incorporated, subject to negotiation

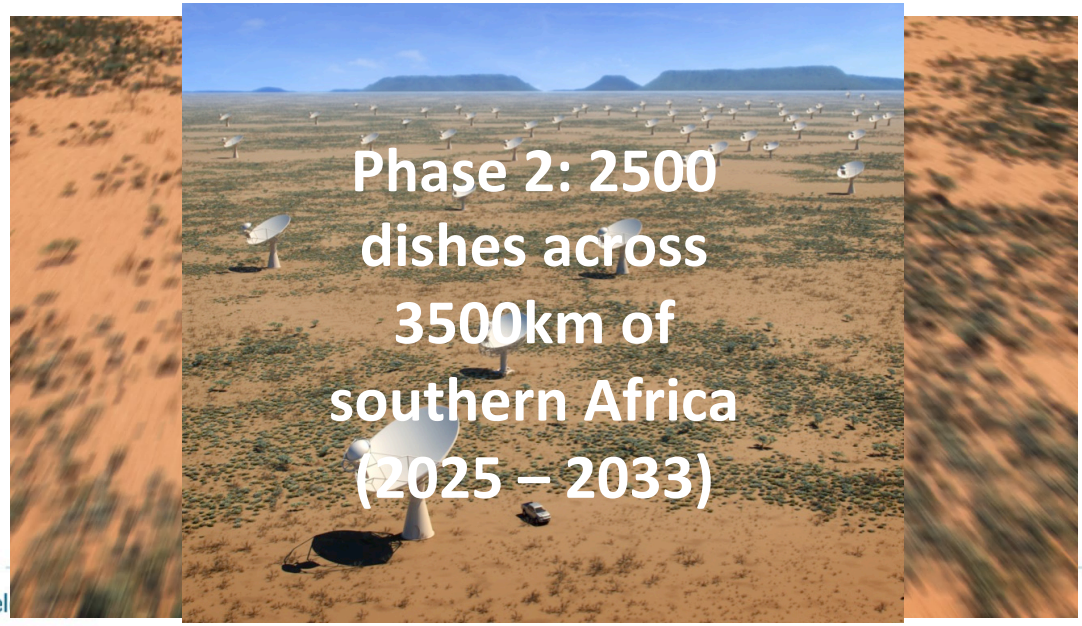
Observatory Development Programme

SKA HQ: Jodrell Bank, UK

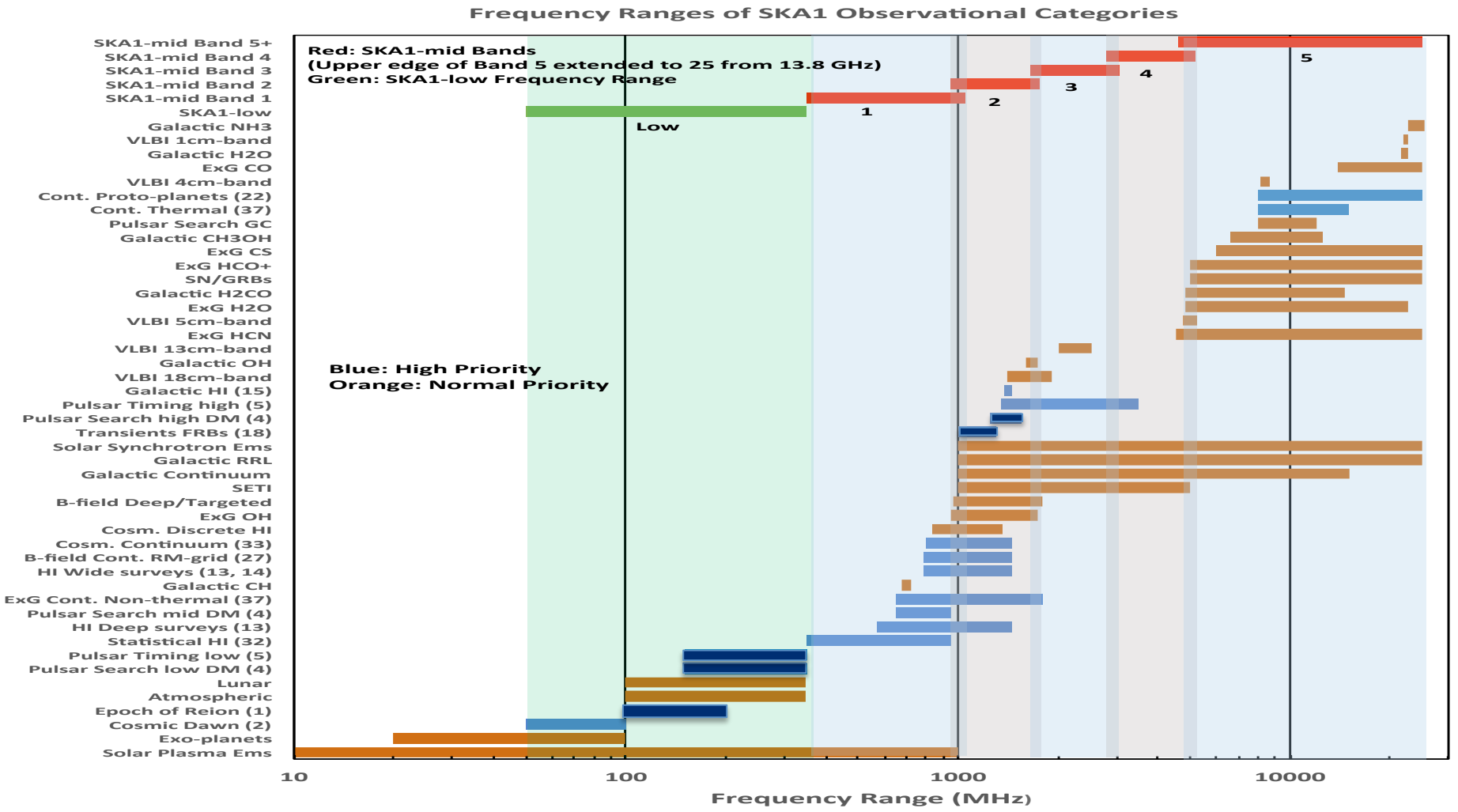


SKA Phase 1: 2018-2023





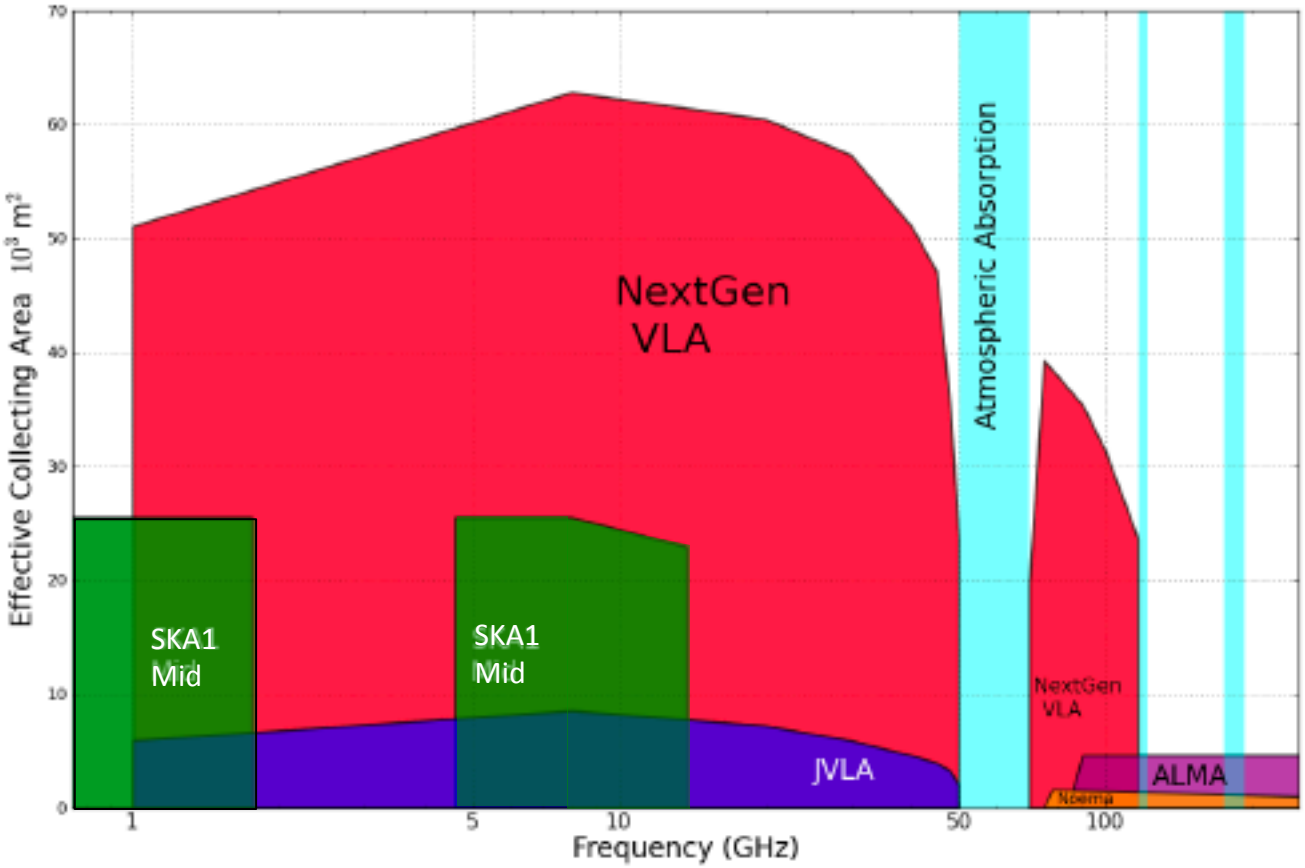
A Package of Notional SKA1 Key Science Projects

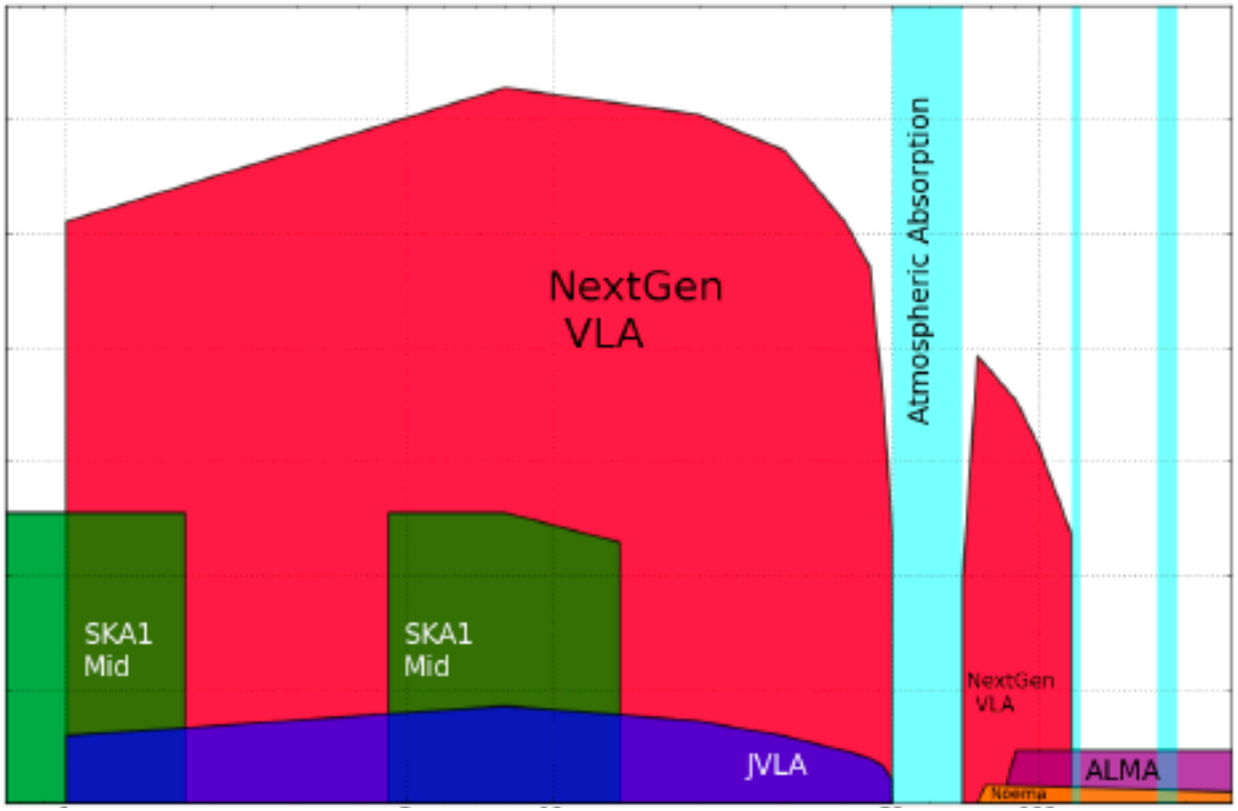


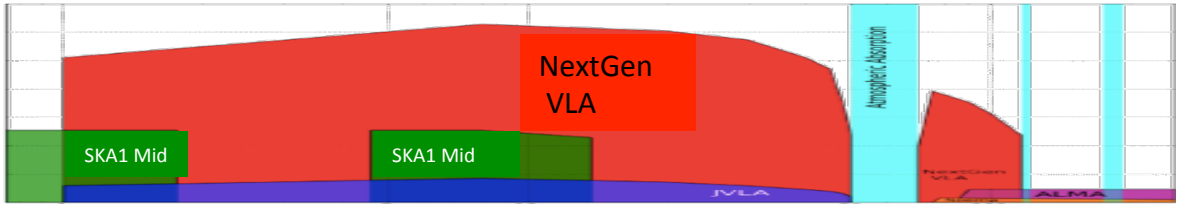
- HPSOs distilled from much broader package of survey ideas and goals

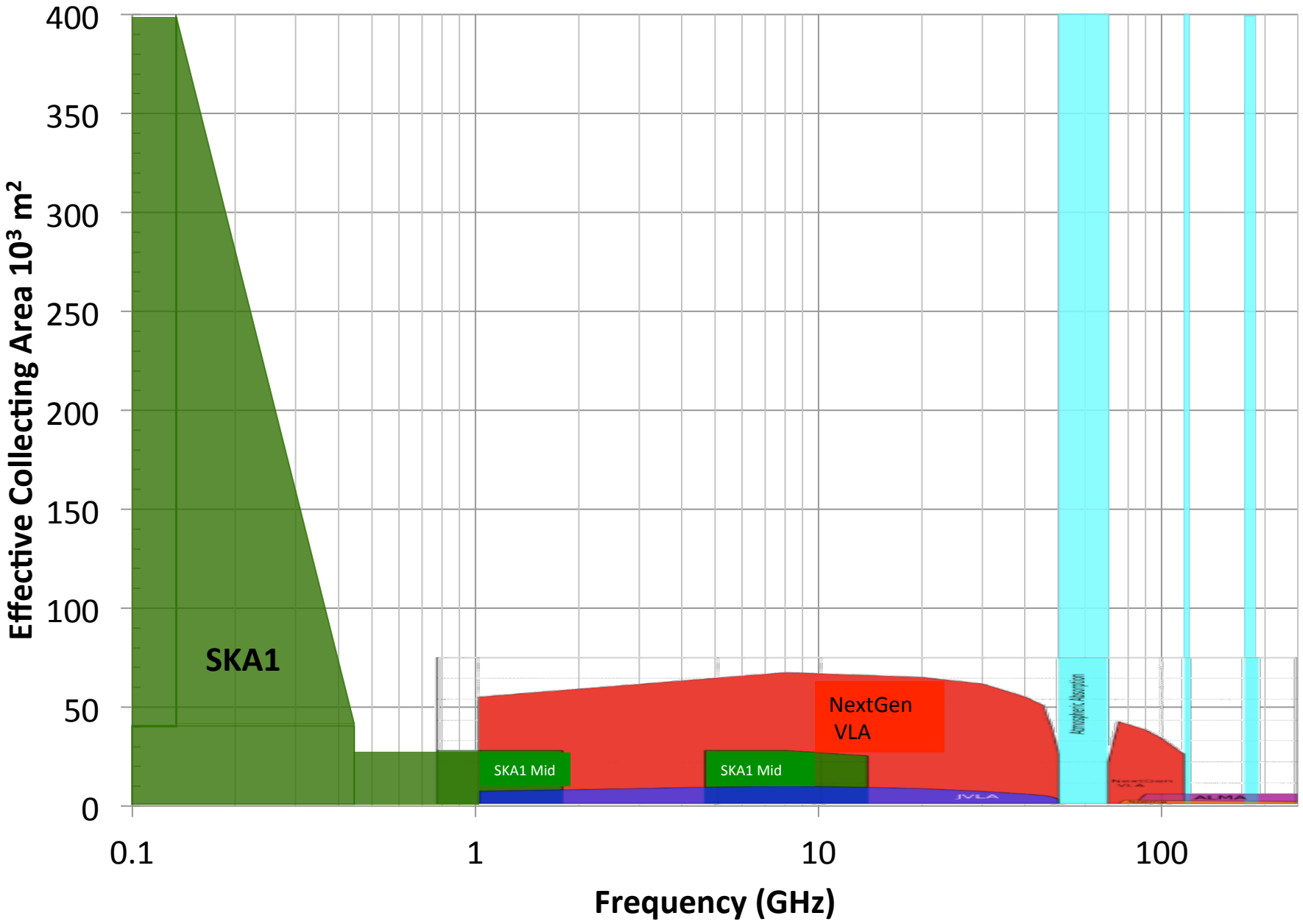
Killer Gap

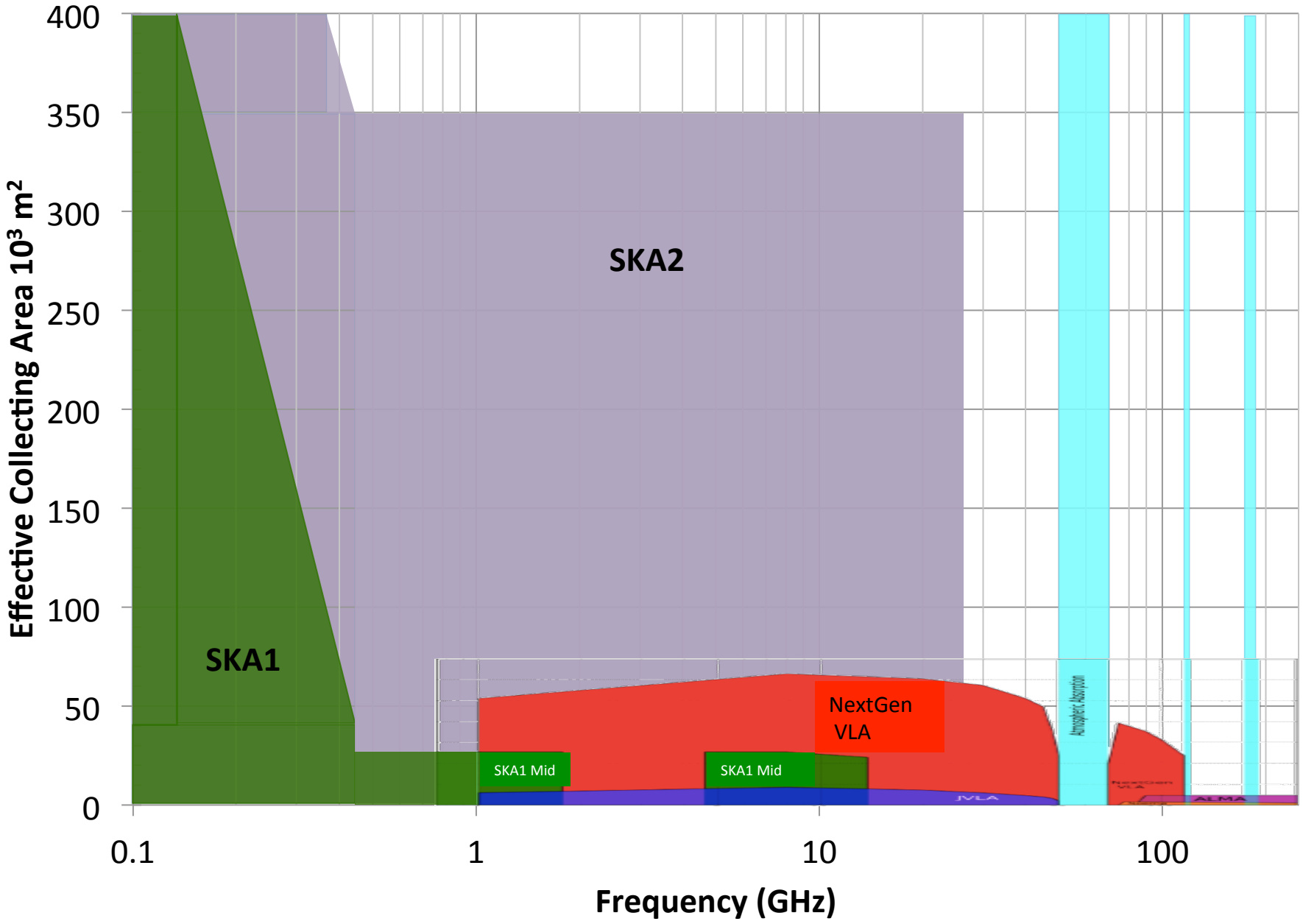
Thermal imaging on mas scales at λ ~ 0.3cm to 3cm




NextGen
VLA
Atmospheric Absorption
SKA1
Mid
SKA1
Mid
JVLA
NextGen
VLA
ALMA


NextGen
VLA
SKA1 Mid
SKA1 Mid
Atmospheric Absorption
JVLA
ALMA


400
350
300
250
200
150
100
50
0
Effective Collecting Area 10³ m²
SKA1
SKA1 Mid
SKA1 Mid
NextGen
VLA
Atmospheric Absorption
JVLA
ALMA
0.1
1
10
100
Frequency (GHz)


Effective Collecting Area 10^3 m^2
400
350
300
250
200
150
100
50
0
0.1
1
10
100
Frequency (GHz)
SKA2
SKA1
SKA1 Mid
SKA1 Mid
NextGen
VLA
JVLA
ALMA
Atmospheric Absorption

Current Status

Project Milestones in 2015

- Prioritisation of the SKA Science goals
- Re-baselining of the SKA project, to fit within the Board's €650M cost-cap
- Selection of Jodrell Bank as the long-term HQ for the SKA
- The UK's commitment of £200M (~€270M)
- 8 of the 9 core design consortia completing PDR; some system-level reviews; sub-system down-selects.
- Stockholm science meeting on future SKA Key Science Projects
- Publication of SKA Science Book
- Department of Atomic Energy take over India's membership of SKAO.
- Start of negotiations to establish the SKA as an InterGovernmental Organisation governed by a Convention
- All-hands engineering meeting in Penticton, Canada
- Begin design of the new SKA HQ building at Jodrell Bank
- Announcement of AUS$293.7M funding for SKA by Australian PM
- Award of €4.95M grant EC H2020 programme funds for infrastructure design

Dish structure down-select

CETC54/MTM design

- Pedestal → Steel
- El Interface → Steel
- BUS → Steel
- Panel → AL
- Subreflector→ CFRP
- Feed Boom→ CFRP

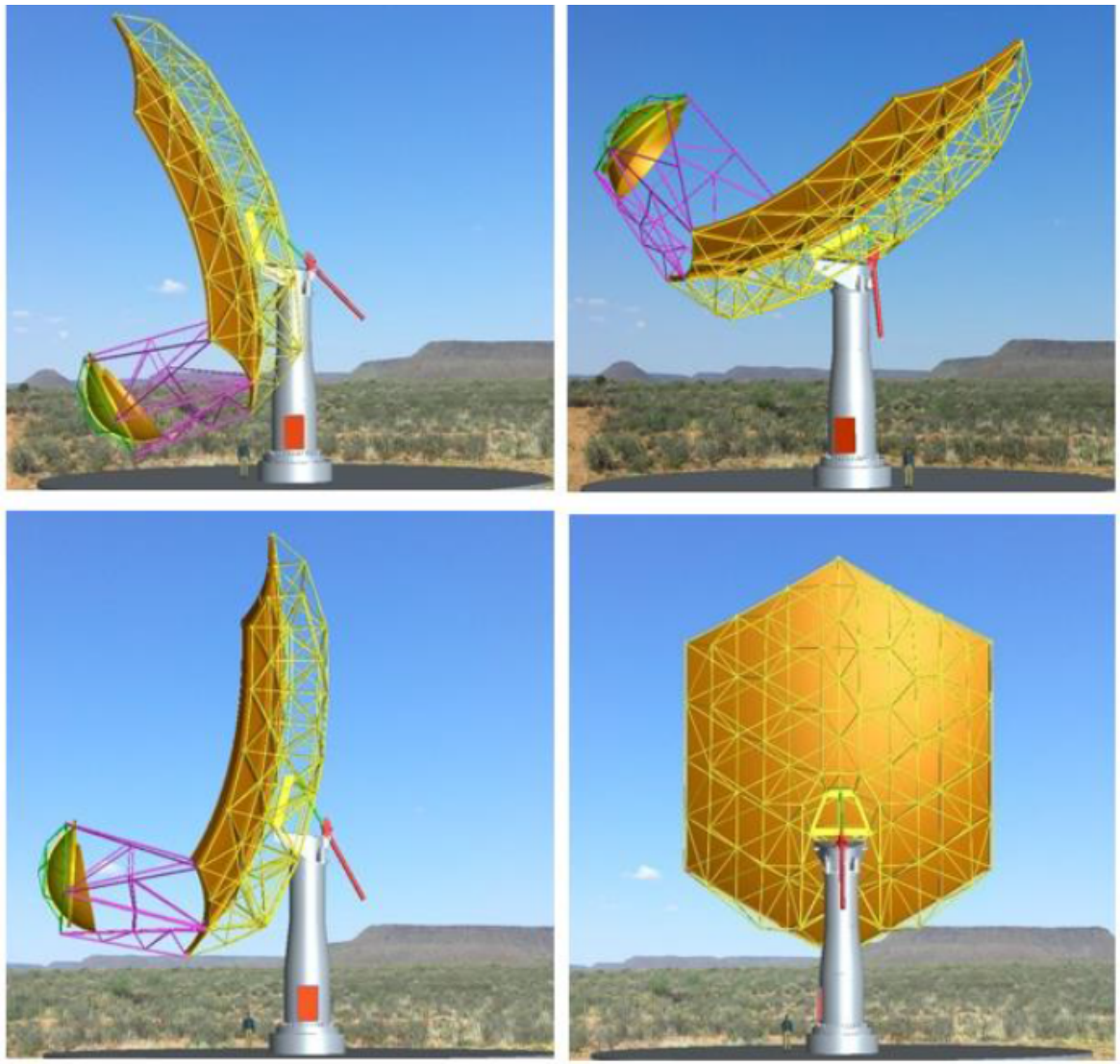
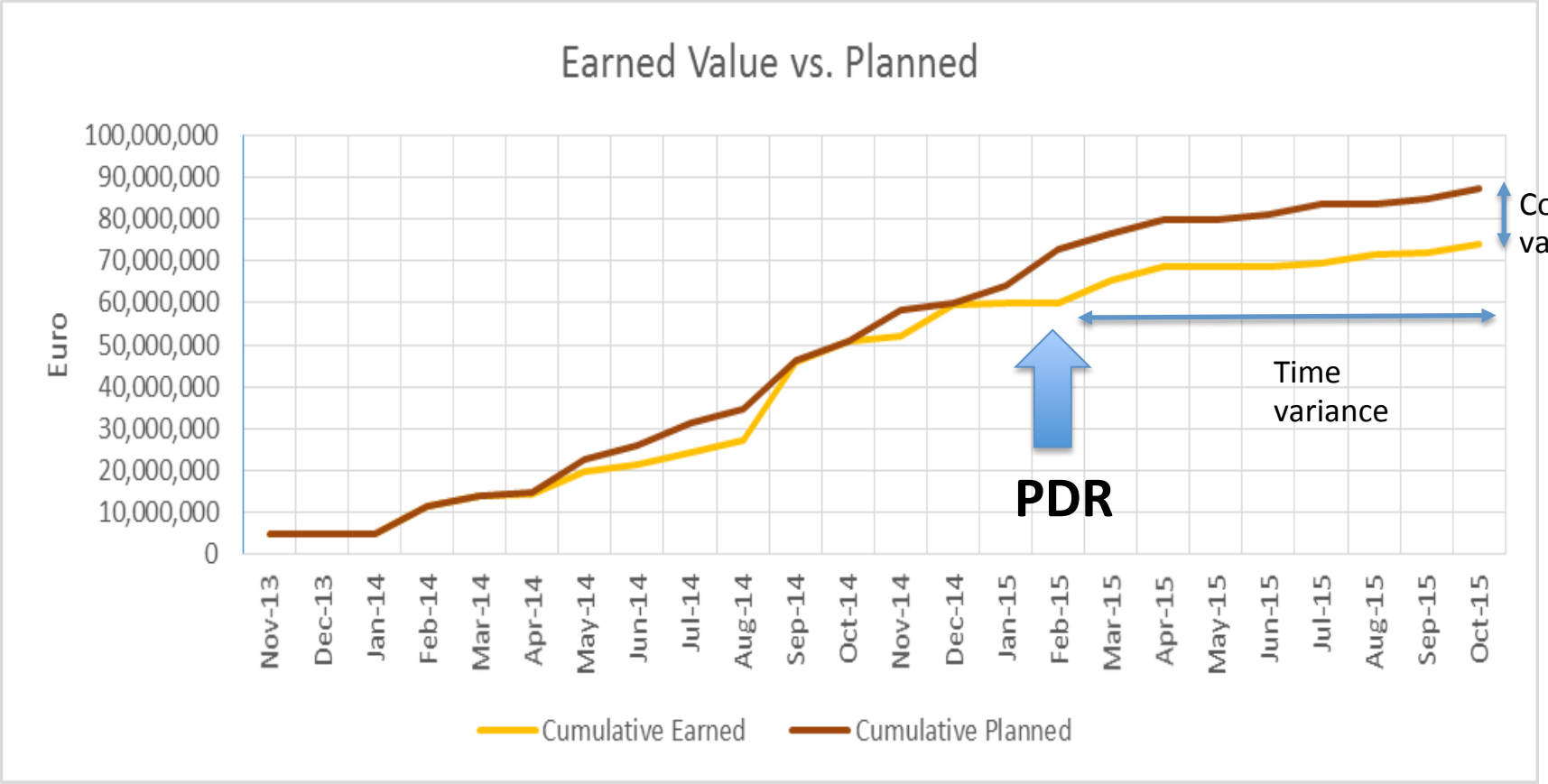


Figure 45: PSM, Artistic Rendering

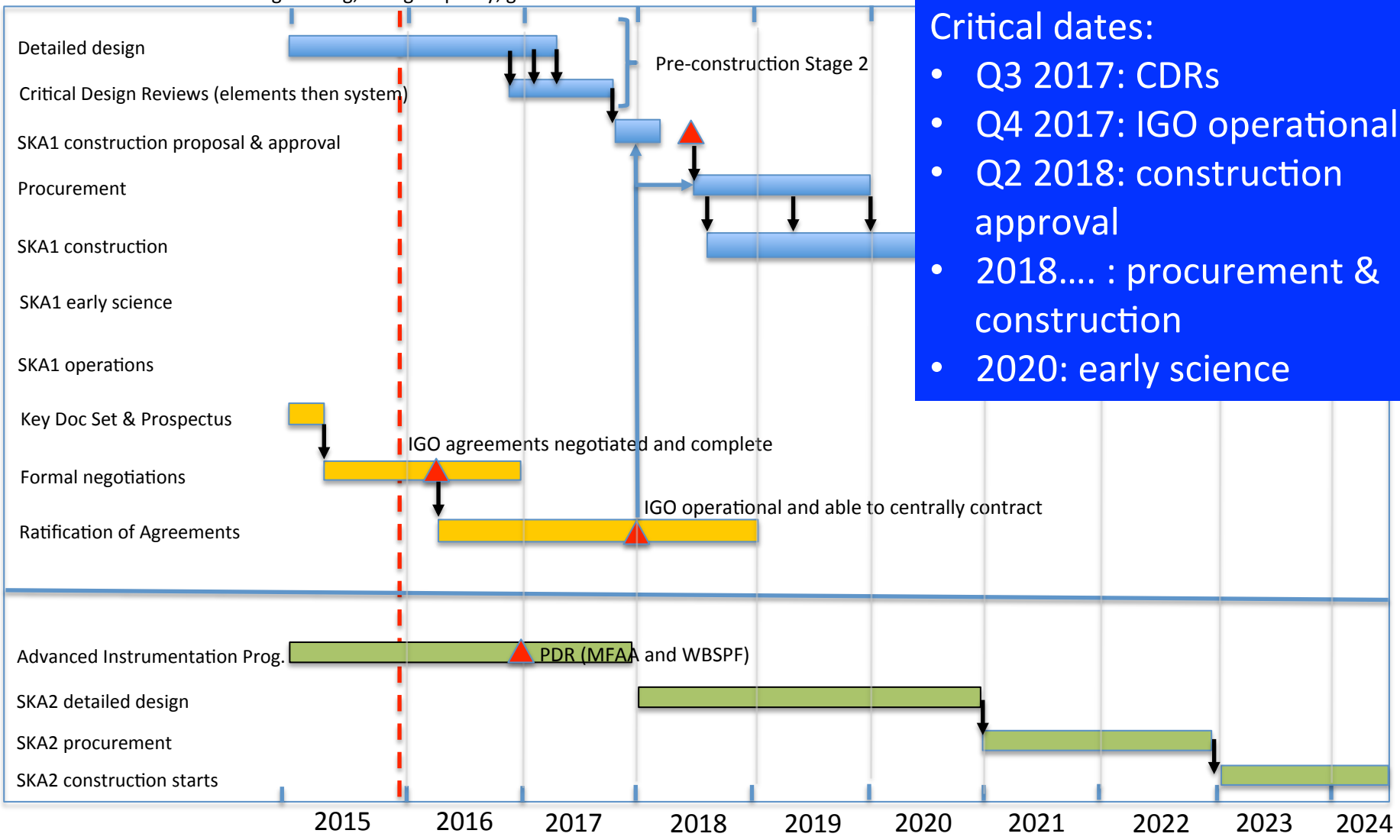
Earned value – end of October



Schedule variance (cost) = -13.3M Euros
Schedule performance index = 85%
Schedule variance (time) = 7 months

High-level SKA Schedule

KEY: Blue = SKA1 science & engineering; orange = policy; green = SKA2



Critical dates:

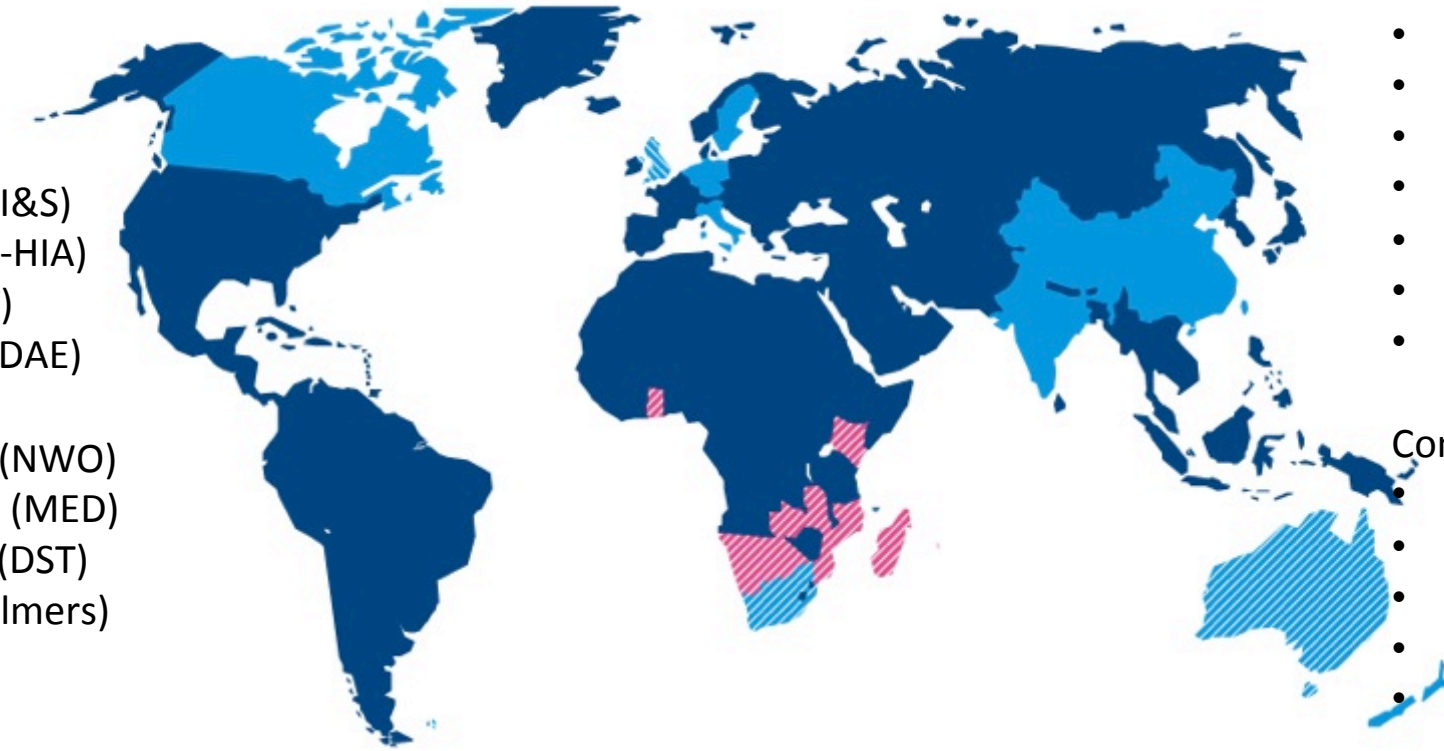
- Q3 2017: CDRs
- Q4 2017: IGO operational
- Q2 2018: construction approval
- 2018…. : procurement & construction
- 2020: early science

SKA structure

Governance

SKA Organisation: 10 countries, more to join

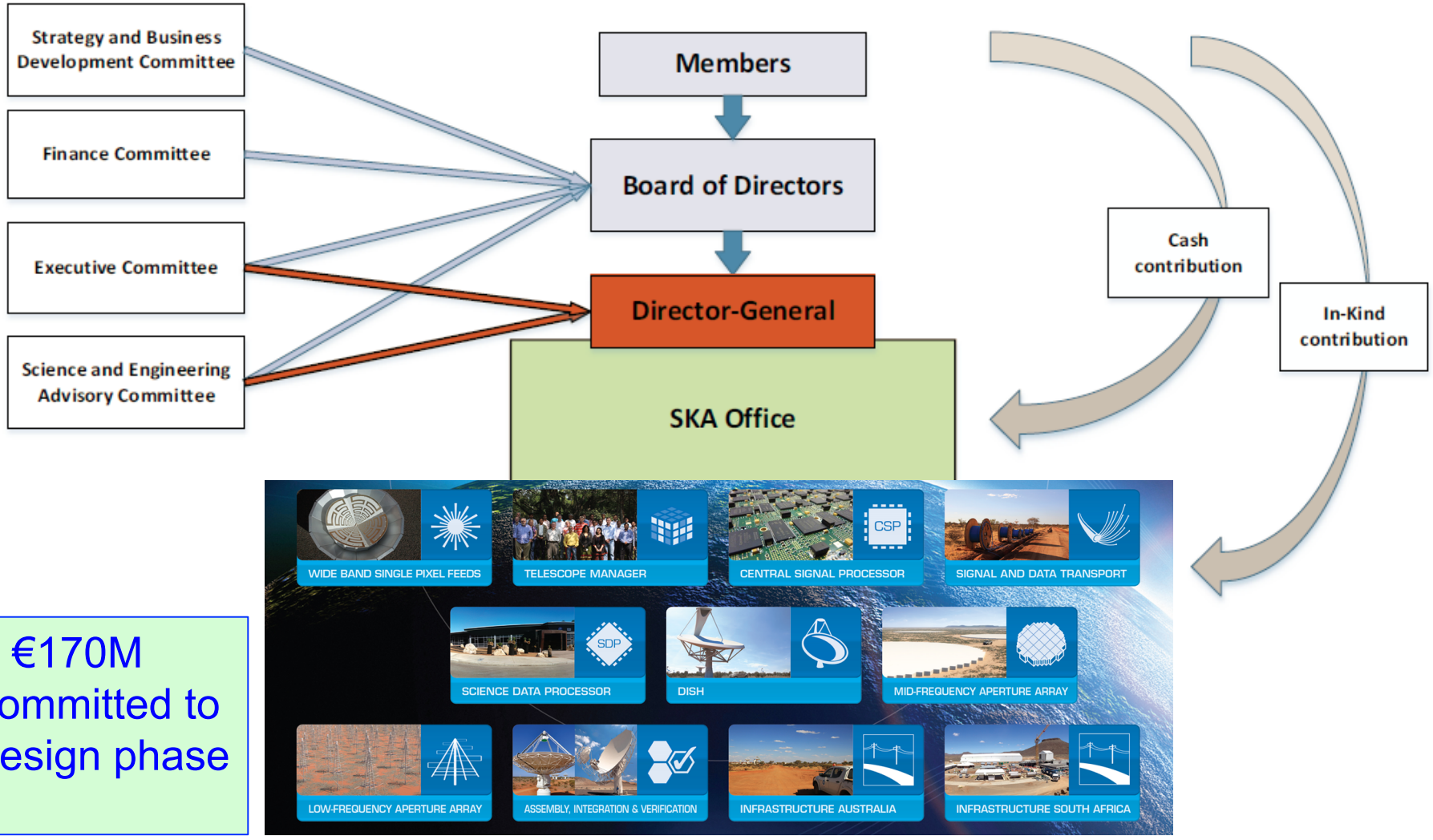
Australia (DoI&S)
Canada (NRC-HIA)
China (MOST)
India (NCRA/DAE)
Italy (INAF)
Netherlands (NWO)
New Zealand (MED)
South Africa (DST)
Sweden (Chalmers)
UK (STFC)



Observers:
- France
- Germany
- Japan
- Malta
- Portugal
- Spain
- USA

Contacts:
- Brazil
- Ireland
- Korea
- Russia
- Switzerland

SKA Ltd structure



~ €170M committed to design phase

Evolve to Inter-governmental Organisation

- SKA Member governments are negotiating the establishment of an intergovernmental organisation (IGO), similar to ESO/CERN/ITER/ESA.
- Will provide:
  - Long-term government commitment and funding stability
  - Availability of Privileges and Immunities from members
  - 'Freedom to operate', specifically through procurement process
- Critical step to allow SKA Observatory to operate as an international scientific facility

IGO: formal negotiations

- Rome: 14-16 October; Minister Vicente (Italy) – Chair.
- All 10 countries present,
- Agenda:
  - Draft text of convention
  - Working groups:
    - Financial Protocol
    - Privileges and Immunities
    - Procurement and IPR
    - Operations and Access
- 2 more meetings scheduled:
  - 26 – 28 January; 19 – 21 April

US engagement in SKA

- US scientists engaged, across the Board, in the definition of SKA Science
- Modest engagement in design effort – but not critical path
- SKA1 can and will be built without US involvement – but US would be most welcome
- SKAO Convention being set up to specifically allow participation by the US – eg CERN-like

US engagement in SKA

- My view:
  - SKA2 can deliver 70% of science I heard discussed, plus more not mentioned.
  - Rest of World will be putting multi-billions into providing massive research infrastructure; US can take advantage of that investment and take a leadership role in its definition.
  - Focus Astro2020 strategy on engagement in SKA2; ngVLA useful vehicle to focus discussions.
  - SKA planning on workshop(s) in 2017 to develop SKA2 science case and to then derive SKA2 design. Join us.

Summary

- Project momentum excellent:
  - ~1/3 construction and operations funds committed;
    - I can see good signs that 75% of funds are within reach.
  - PDRs completing now
  - System review in Q1 2016
  - Work towards CDRs underway
  - IGO formal negotiations in progress
- Challenges are large but not insurmountable
- SKA construction is on the horizon.