



# Square Kilometre Array Observatory

Current status

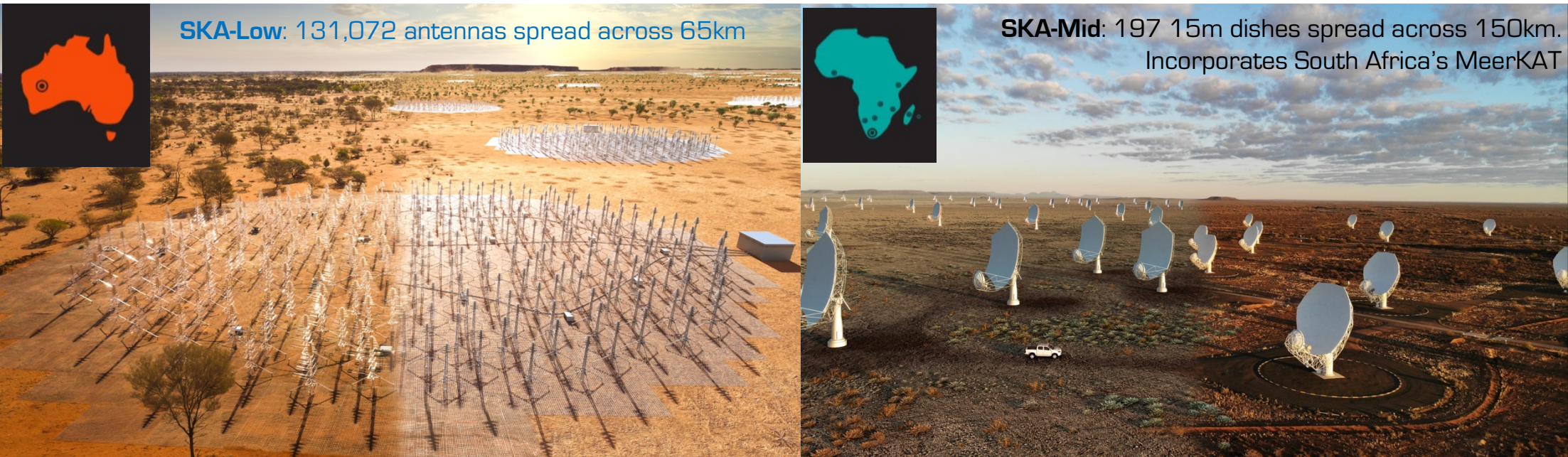
Philip Diamond, Director-General

4<sup>th</sup> October 2021



# SKAO

- A global collaboration of 16 countries which is building and will operate the next-generation radio astronomy observatory
- SKA Observatory (SKAO), a new Inter-Governmental Organisation governed by a treaty, was born on 4 February 2021.
- Headquartered at Jodrell Bank (nr Manchester) in the United Kingdom
- Will be supported by a global network of SKA Regional Centres providing access to SKAO data
- 7-8 year construction schedule. Cost ~€2B (2020 euros) for first 10 years



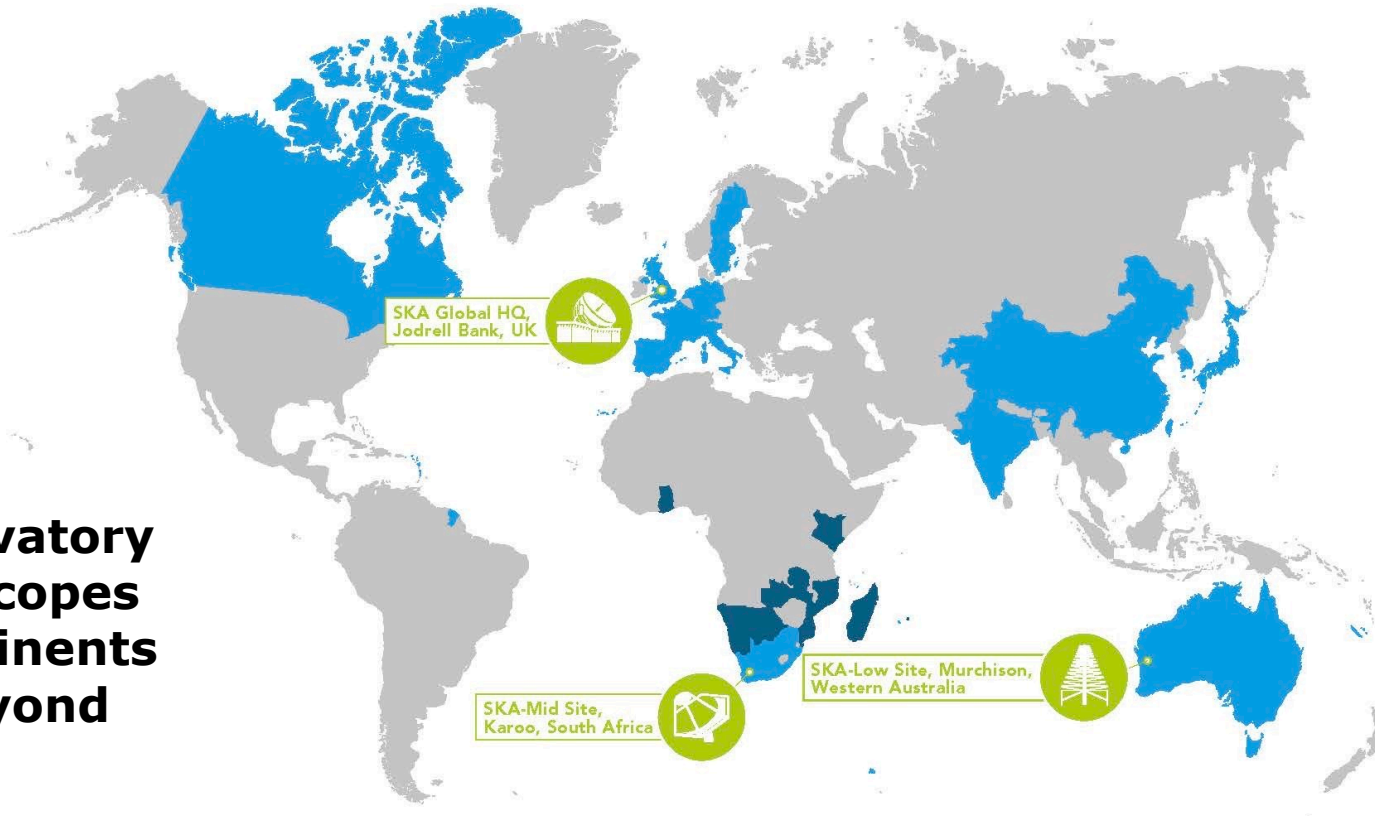
**SKA Phase 2: 2500 dishes across Africa; 1,000,000 antennas across Australia**



# SKAO HQ: Jodrell Bank, UK



# One Observatory Two Telescopes Three Continents ...and beyond



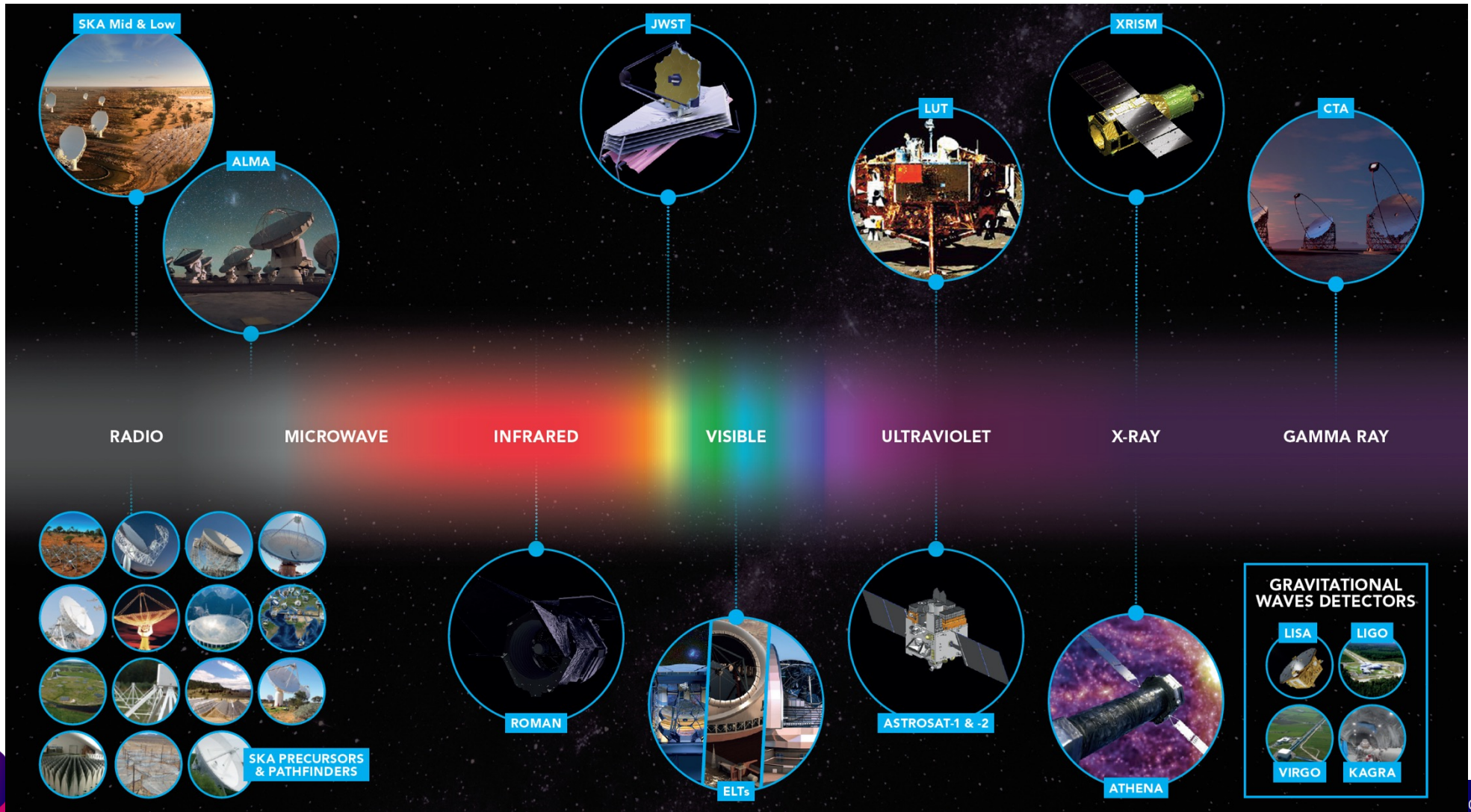
 SKA Partners – includes Members of the SKA Organisation – precursor to the SKAO –, current SKAO Member States\*, and SKAO Observers (as of June 2021)



 African Partner



# 21<sup>st</sup> Century Astronomy



# SKA– Key Science Drivers: The history of the Universe

Testing General Relativity  
(Strong Regime, Gravitational Waves)

Cradle of Life  
(Planets, Molecules, SETI)

Cosmic Magnetism  
(Origin, Evolution)

Exploration of the Unknown

Huge range of science enabled by SKAO

Cosmic Dawn  
(First Stars and Galaxies)

Galaxy Evolution  
(Normal Galaxies  $z \sim 2-3$ )

Cosmology  
(Dark Matter, Large Scale Structure)



# A short history of SKA

Rome: 12 March 2019  
Treaty signed



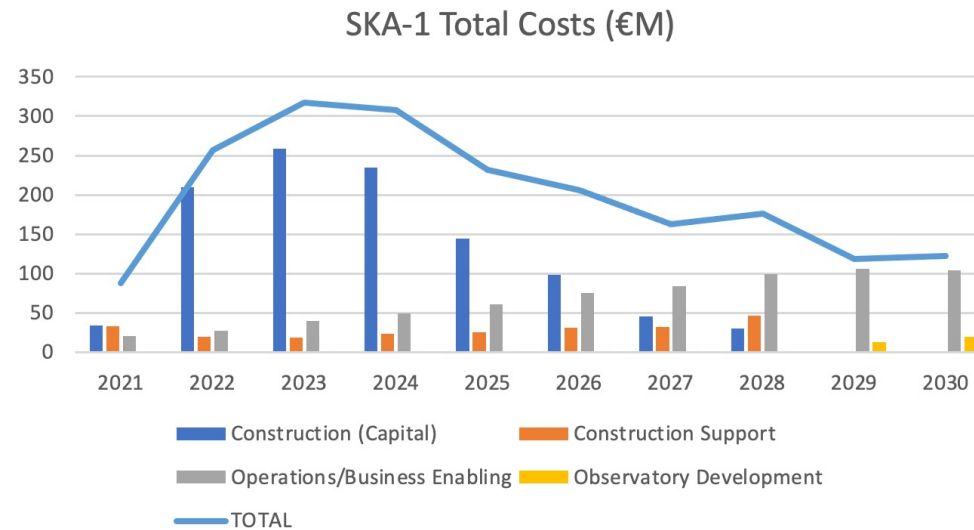
Green Light Given For Construction Of World's  
Largest Radio Telescope Arrays

29<sup>th</sup> June 2021



# Cost Estimate

Design Baseline	Sept 2020 submitted	Provided through annual contributions			
Total Value (€M) (Aug 2020)	Capital cost of construction (€M)	Construction Support Budget (€M)	Observatory Operations & Business-Enabling Functions (€M)	Observatory Development Programme (€M)	Funding Period
1986	1054	228	664	40	2021-2030
	1282				





# Construction timeline: underway

- First contracts (software) have been let
- ITTs for construction camps about to be issued
- Good progress on heritage & ecological surveys; permitting underway.

	SKA-Low	SKA-Mid
Start of construction (T0)	1ST JULY 2021	1ST JULY 2021
Earliest start of major contracts (C0)	AUGUST 2021	AUGUST 2021
Array Assembly 0.5 finish (AA0.5) SKA-Low = 6-station array SKA-Mid = 4-dish array	FEBRUARY 2024	MARCH 2024
Array Assembly 1 finish (AA1) SKA-Low = 18-station array SKA-Mid = 8-dish array	FEBRUARY 2025	FEBRUARY 2025
Array Assembly 2 finish (AA2) SKA-Low = 64-station array SKA-Mid = 64-dish array, baselines mostly <20km	FEBRUARY 2026	DECEMBER 2025
Array Assembly 3 finish (AA3) SKA-Low = 256-station array, including long baselines SKA-Mid = 133-dish array, including long baselines	JANUARY 2027	SEPTEMBER 2026
Array Assembly 4 finish (AA4) SKA-Low = full Low array SKA-Mid = full Mid array, including MeerKAT dishes	NOVEMBER 2027	JUNE 2027
Operations Readiness Review (ORR)	JANUARY 2028	DECEMBER 2027
End of construction	JULY 2029	JULY 2029



# Transition from Planning to Building

## Planning stage

- Integrating designs from pre-construction consortia
- Aligning budgets & schedules
- Understanding risks
- Developing our people

## Now

- Market surveys, ITTs, preparing contracts
- Awarding & managing contracts
- Finalising areas of design
- Assemble, integrate verify
- Operate for the community as a transformational facility

Must recognise that every issue encountered in the planning or execution must be paid for from a fixed budget and timeline



## Some key technical challenges (not exhaustive list)

- Power
- Data handling and processing
- Satellite mega-constellations



- SKAO does not intend to operate power stations
- Preparing Request for Proposals for industry to build and operate
- Electrical and spatial design complete
- EMC design in progress



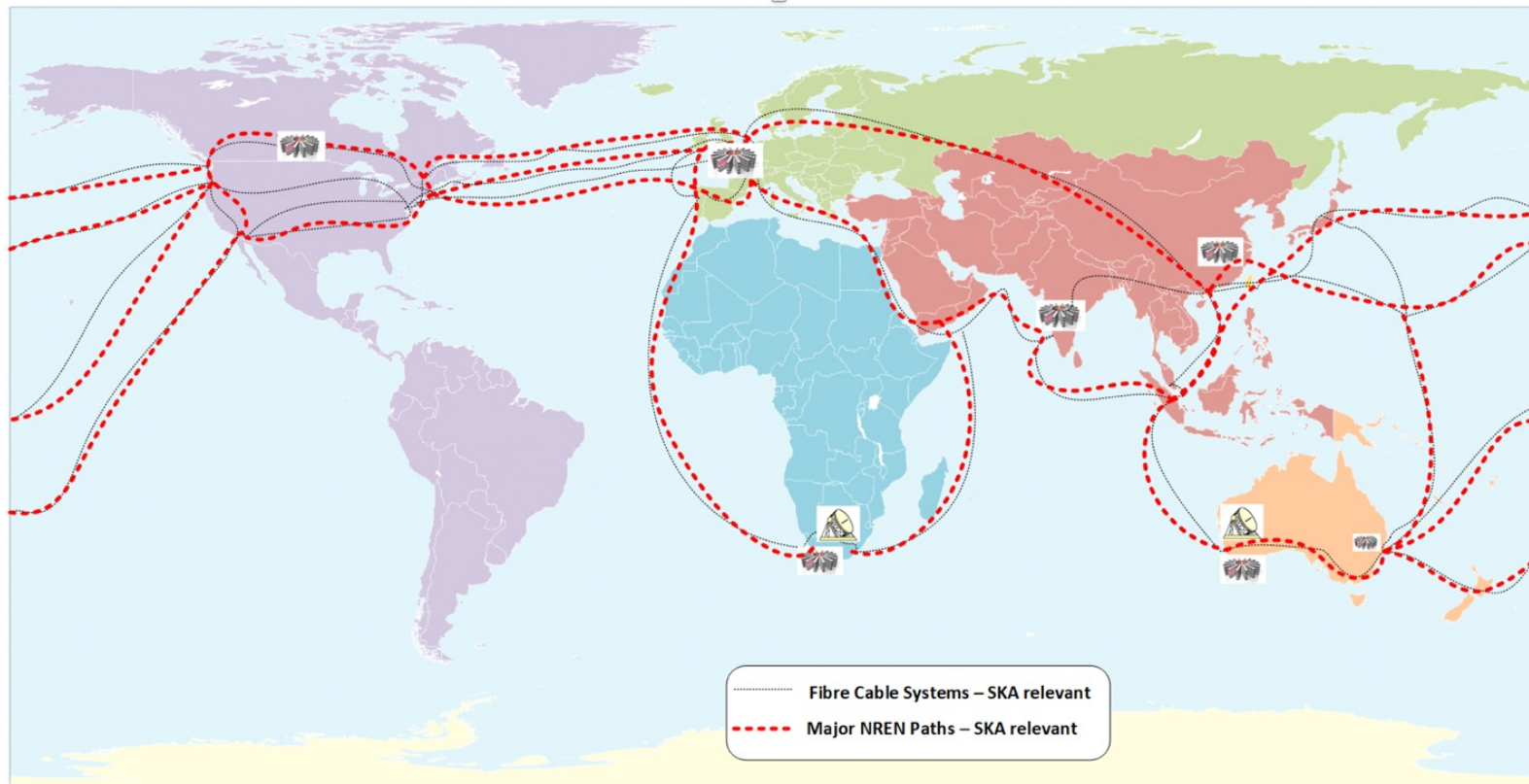
# SKA Observatory Data Flow



SKA output Data rates are vast - approximately 50-70 times higher output than LSST, or CTAO. In line with "High Luminosity" LHC at CERN

\* Data rates approximate, 100 Gb/s is maximum possible

# SKA Regional Centres (SRCs)

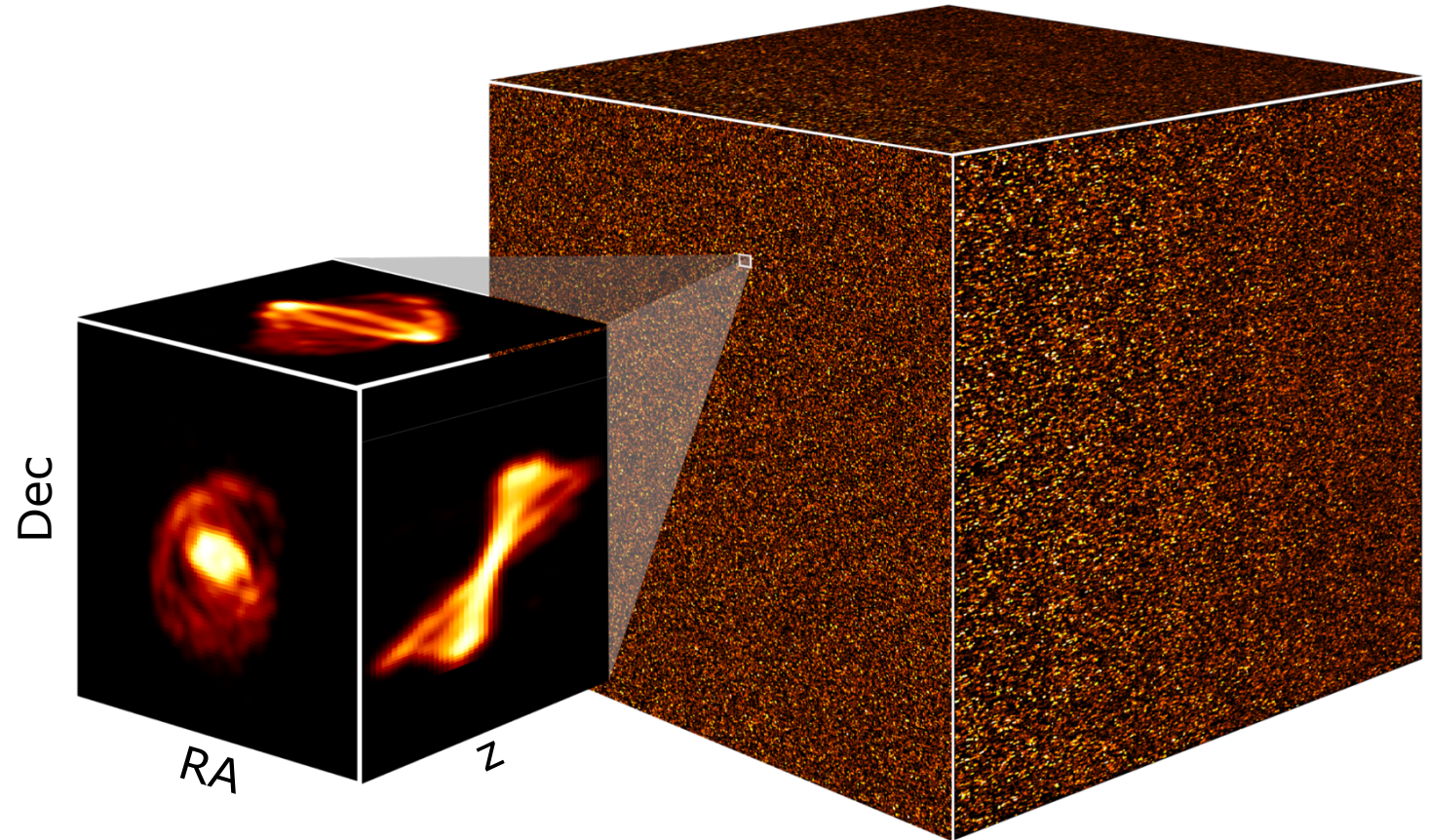


- Planning a network of SRCs around globe hosting SKA Science Archive
- Users may access SKA Science Archive via SRC network
- SRCs will provide resources for further processing and analysis
- Working groups developing SRC network design



# Science Data Challenge 2 (SDC2)

- Simulated HI Survey
  - $z = 0.24 - 0.5$
  - $20 \text{ deg}^2$  FoV
  - $7 \text{ arcsec} / 30 \text{ kHz}$  resolution
  - $2000^{\text{h}}$  simulated integration
  - 1 TB Data Product size
  - Source finding & characterization



- Illustration of cube (above) is prior to sampling with telescope beam and inclusion of noise
- Almost  $10^6$  simulated neutral hydrogen galaxies and  $10^7$  continuum sources (not shown)
- Expect up to  $10^5$  HI detections with more than  $10^3$  well-resolved



# SKAO Science Data Challenge 2

MAP OF WORLDWIDE PARTICIPATION



- SDC2 finished 31 July
- 12 teams submitted
- Winning team to be announced shortly
- Paper in preparation



## THE CHALLENGE IN NUMBERS

Teams analysing **1TB** of astronomical data

**280** registered participants in **22** countries

**8** supercomputing centres

**15 million** CPU core hours\* and 15 TB RAM available for teams



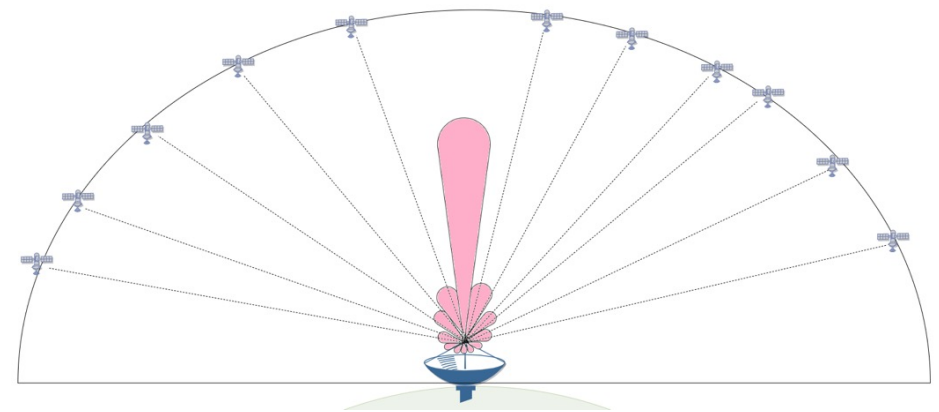
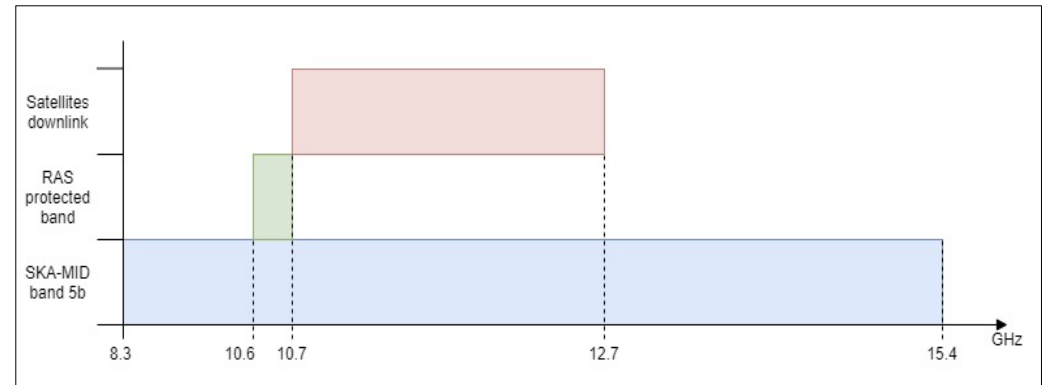
The challenge's 3D data cube is a series of stacked radio images, each reflecting a different frequency. It shows galaxies across a distance of 4 billion light years.

\*A core hour refers to the number of processor units (cores) used, multiplied by the duration of the job in hours.



# Satellite mega-constellations

- SKAO telescopes are sited in Radio Quiet Zones (national regulations) to avoid RFI as much as possible, but spaceborne transmissions **are not covered by national RQZ regulations!**
- New “mega-constellations” are a significant change in the satellite situation in the sky
- SKA-Mid can be impacted **in a portion** of Band 5b by downlinks in 10.7-12.7 GHz.
- Radio telescopes ‘see’ the satellites through main beam and sidelobes





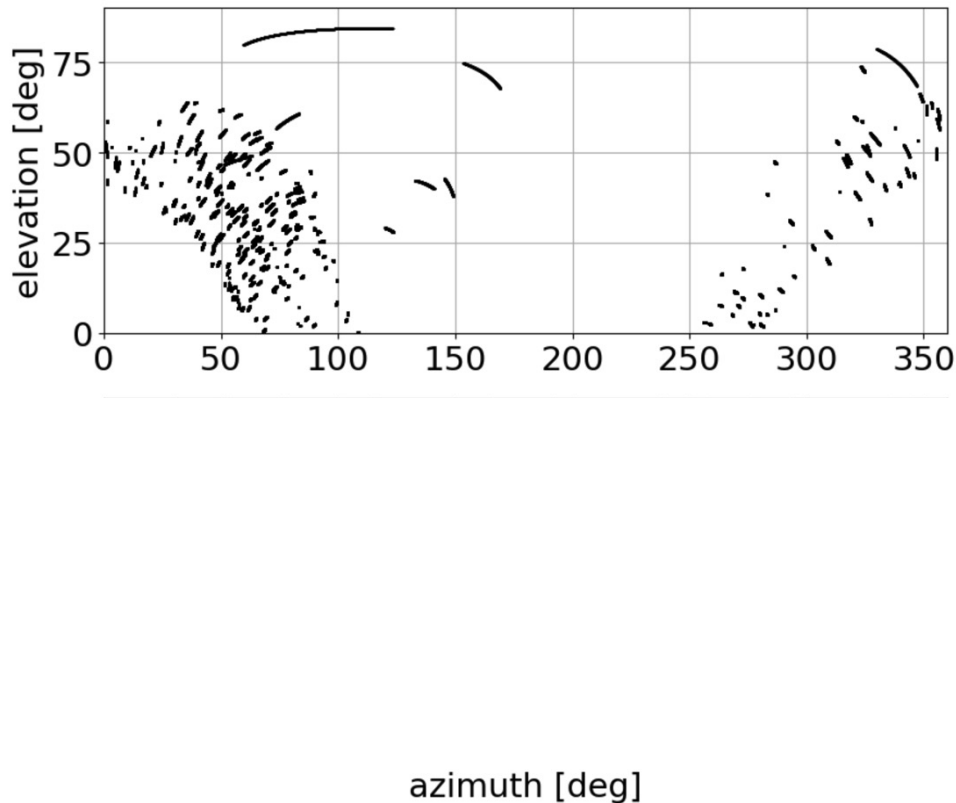
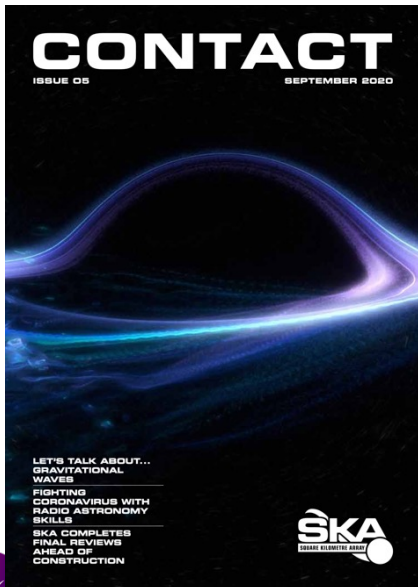
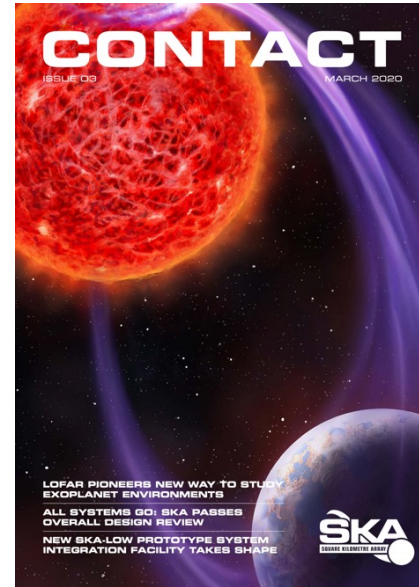
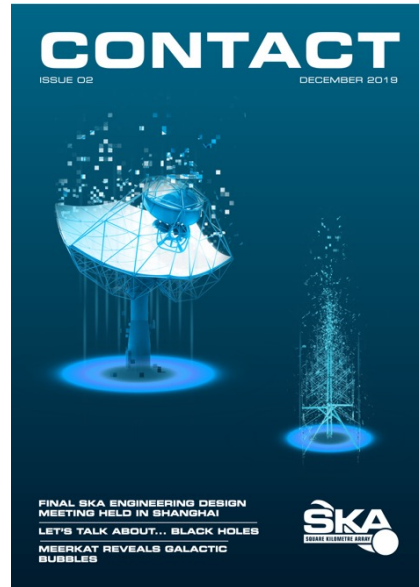


Figure 3. Escalation of satellites above the horizon as seen from the SKA-Mid site in South Africa. Top figure shows the movement of all currently active geosynchronous satellites in 2000 seconds, bottom figure shows movement of OneWeb and Starlink phase 1 for the same time period.

- Mitigation possible, but requires cooperation with industry and regulatory improvements.
- SKAO is a sector member of the ITU and, as of August, a permanent observer at UN COPUOS





## Summary

- SKAO is now an operational inter-governmental organisation, only the second in astronomy
- SKAO's mission is to build and operate the two largest and best radio telescopes on earth
- The scientific capability of SKAO will cover a huge range from the dawn of the Universe to the origins of life.
- SKAO Council approved the start of construction:  $T_0$  was 1<sup>st</sup> July 2021; procurement is now underway



Thank you

*We recognise and acknowledge the  
Indigenous peoples and cultures that have  
traditionally lived on the lands on which  
our facilities are located.*

**SKAO**

[www.skao.int](http://www.skao.int)