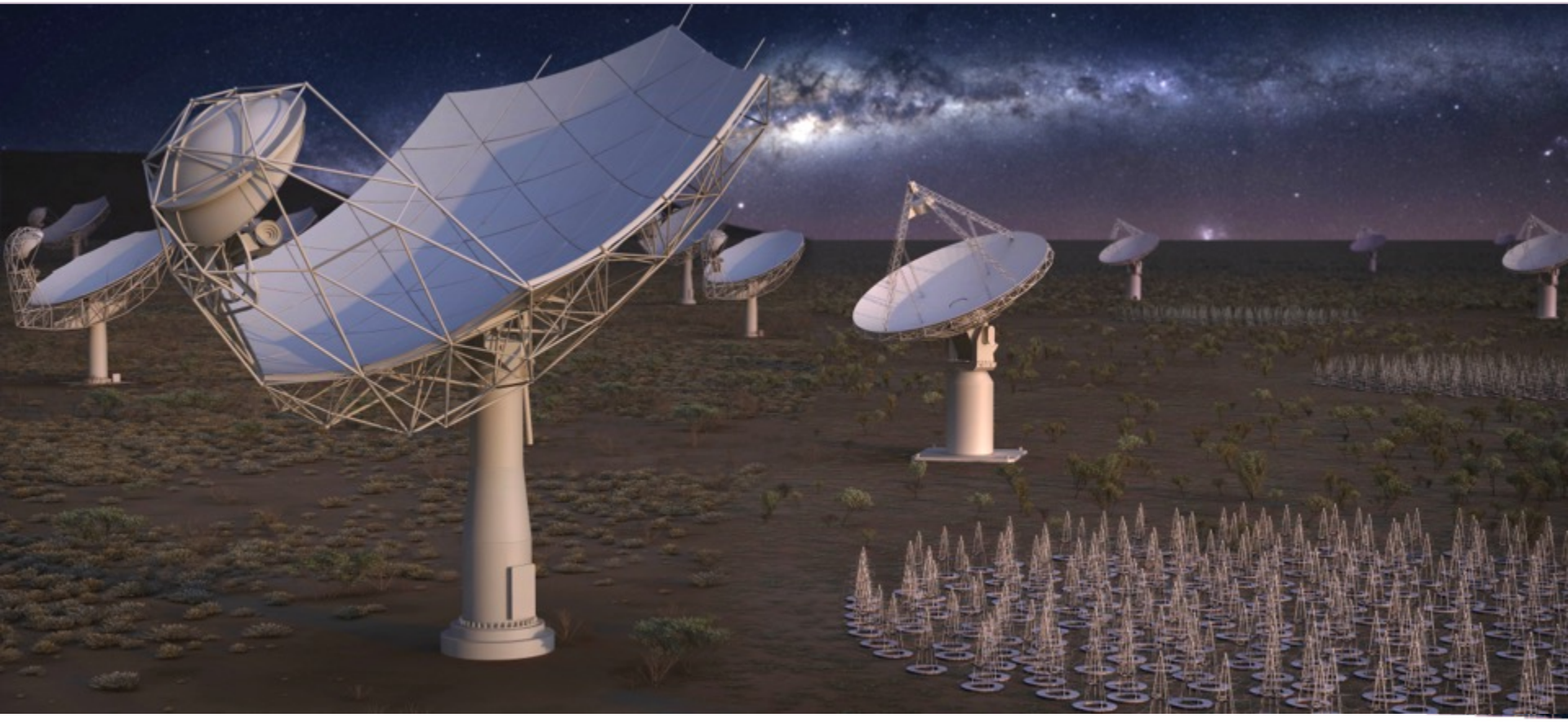
The Square Kilometre Array:
Concluding our past, realising our future

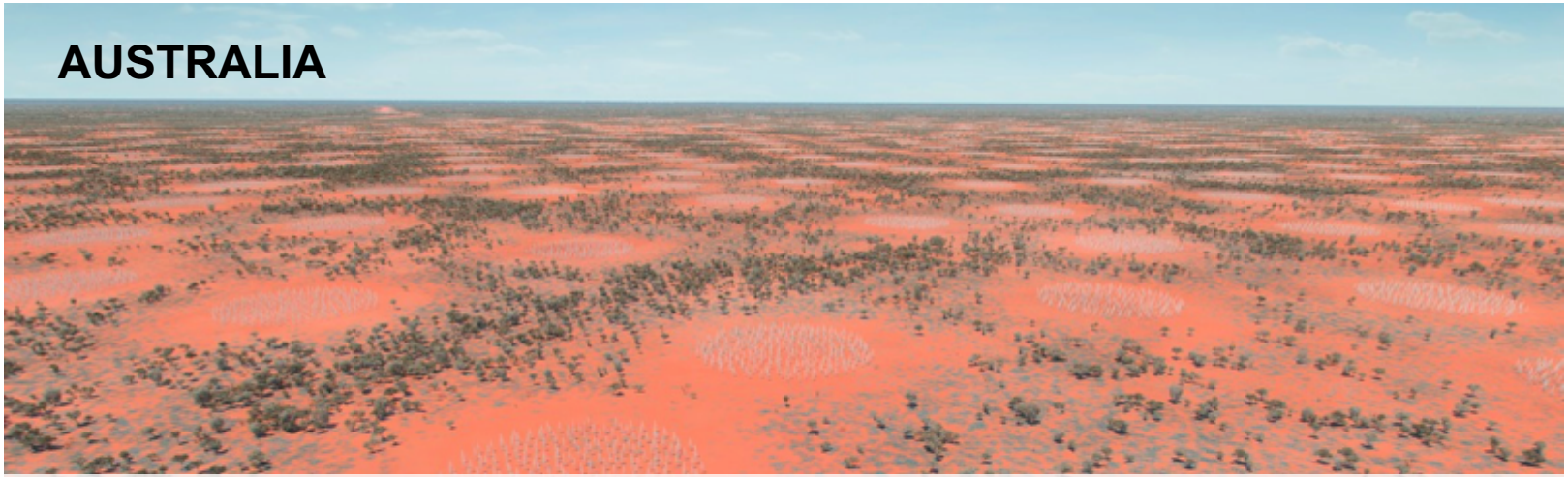


SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Philip Diamond, Director-General

25th November 2019

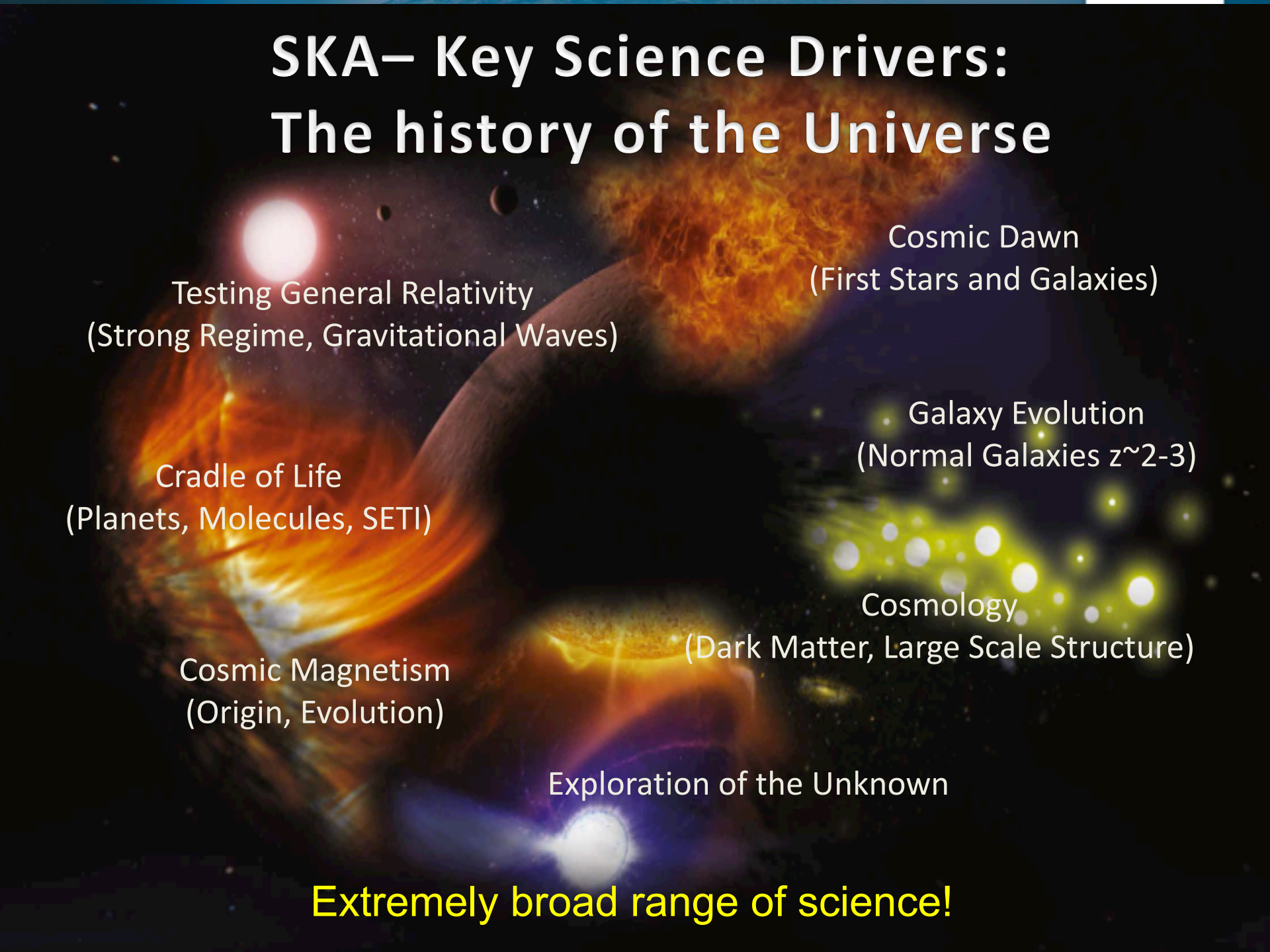


International effort to build the World's largest radio telescope

Prime Motivation: Study the history of the Universe in Hydrogen

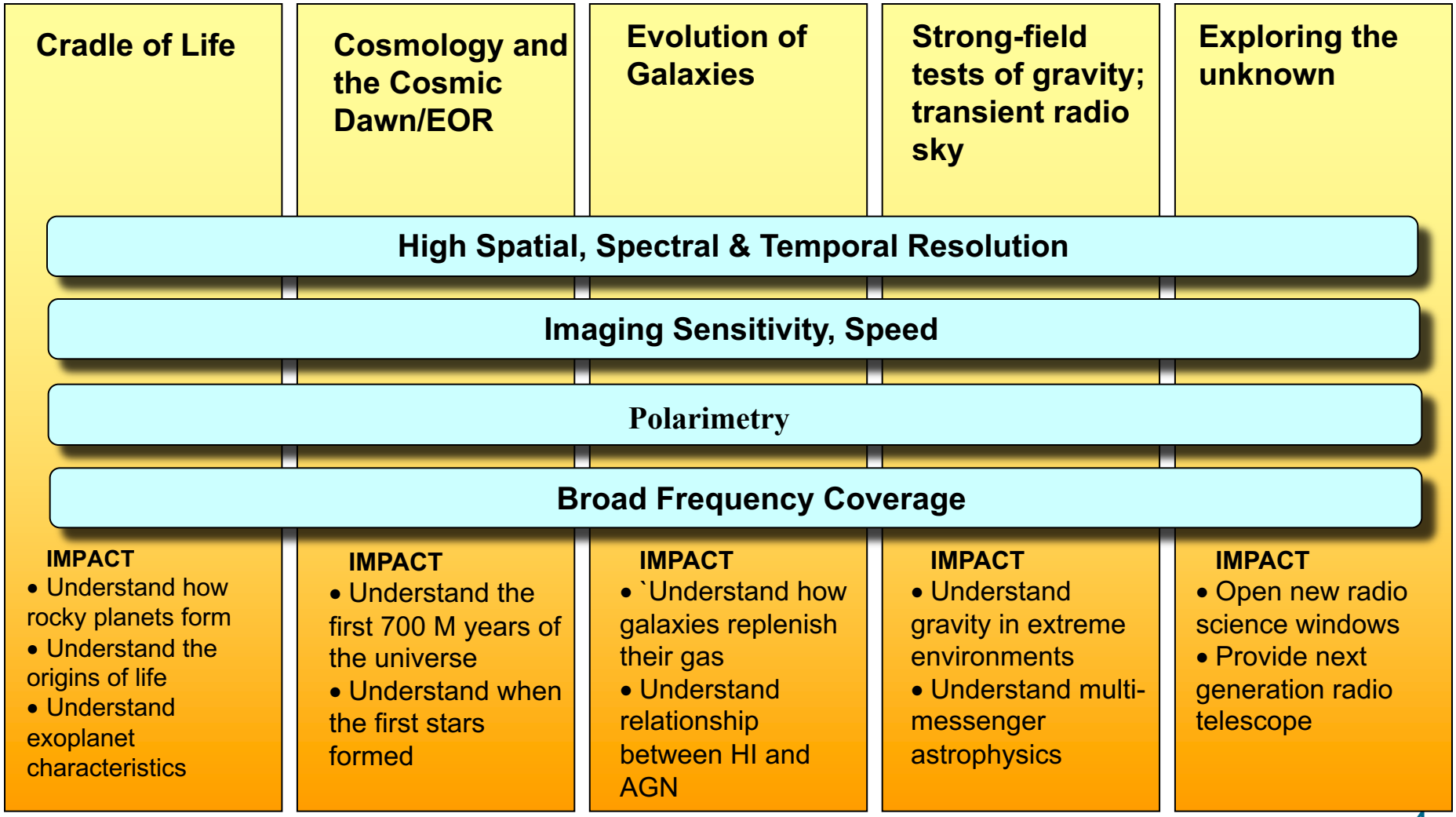
Will enable transformational science in many other areas

SKA– Key Science Drivers: The history of the Universe



Extremely broad range of science!

Science Drivers and Requirements



SKA Phase 1

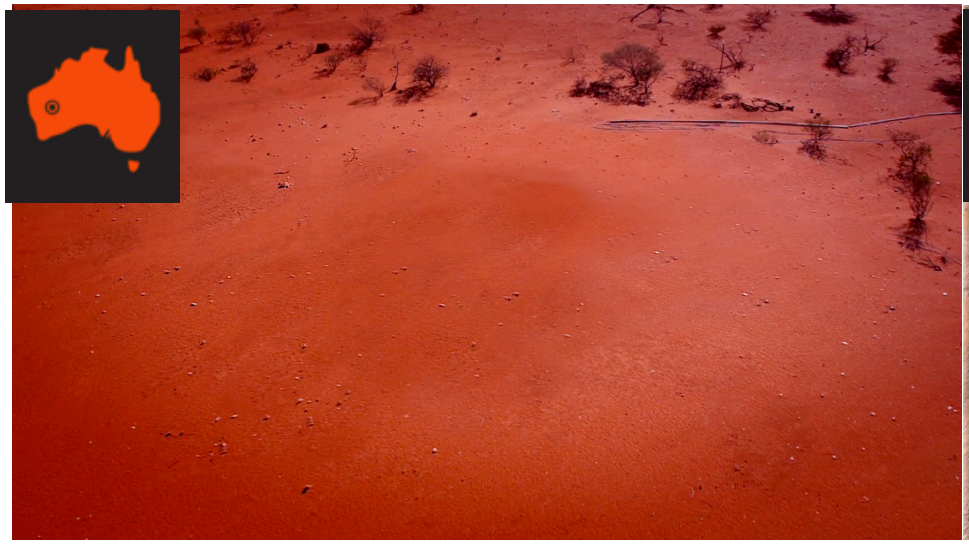
3 sites (AUS, RSA, UK-HQ) **2 telescopes (LOW, MID)** **one Observatory (SKAO)**

Construction: 2021-2027 (Science commissioning 2023+)

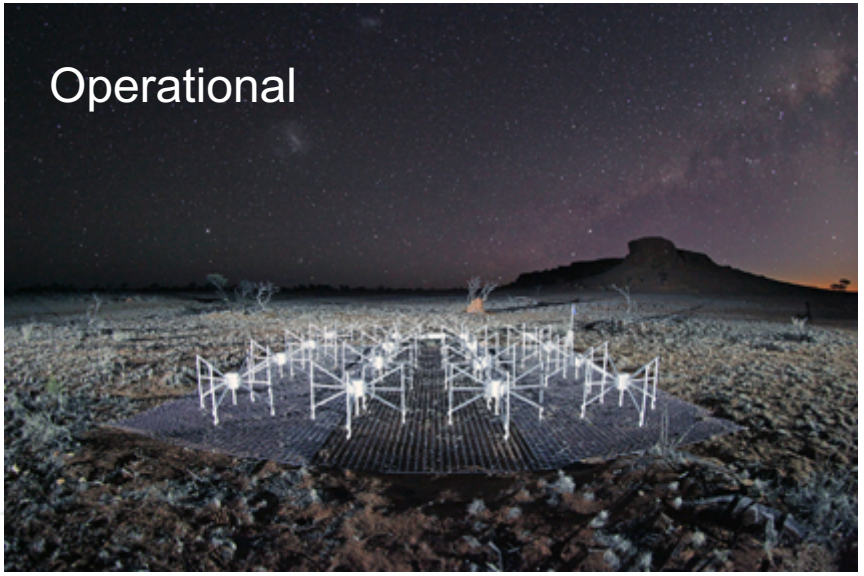
SKA1-Low: 512 x 256 low-freq dipoles,
50 – 350 MHz
65 km baselines (11" @ 110 MHz)
Murchison, Western Australia

SKA1-Mid: 133 x 15m + 64 x 13.5m dishes,
0.35 – 15 GHz
150 km baselines
(0.22" @ 1.7 GHz; 34 mas @ 15 GHz)
Karoo, South Africa

MeerKAT



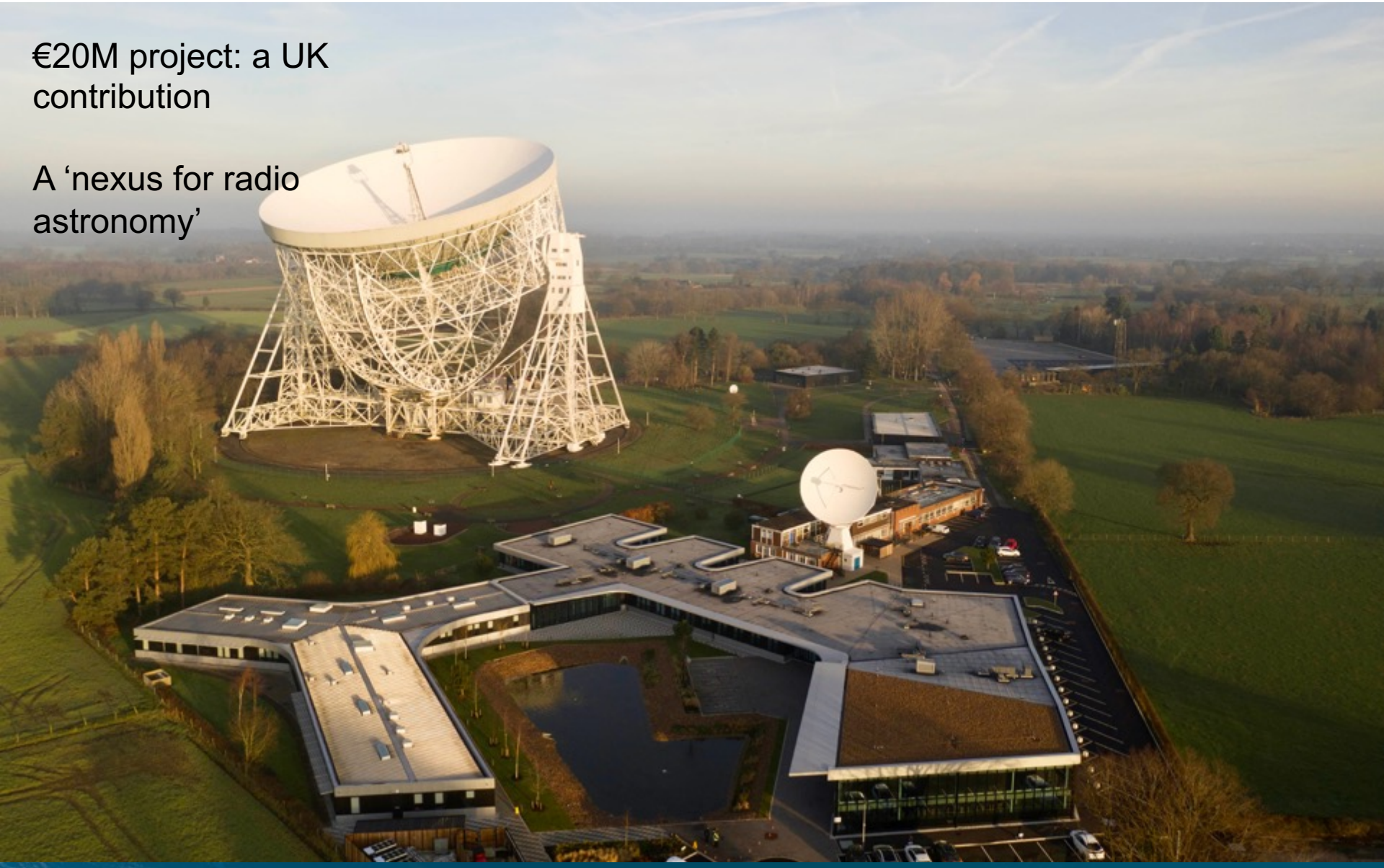
Precursor Telescopes



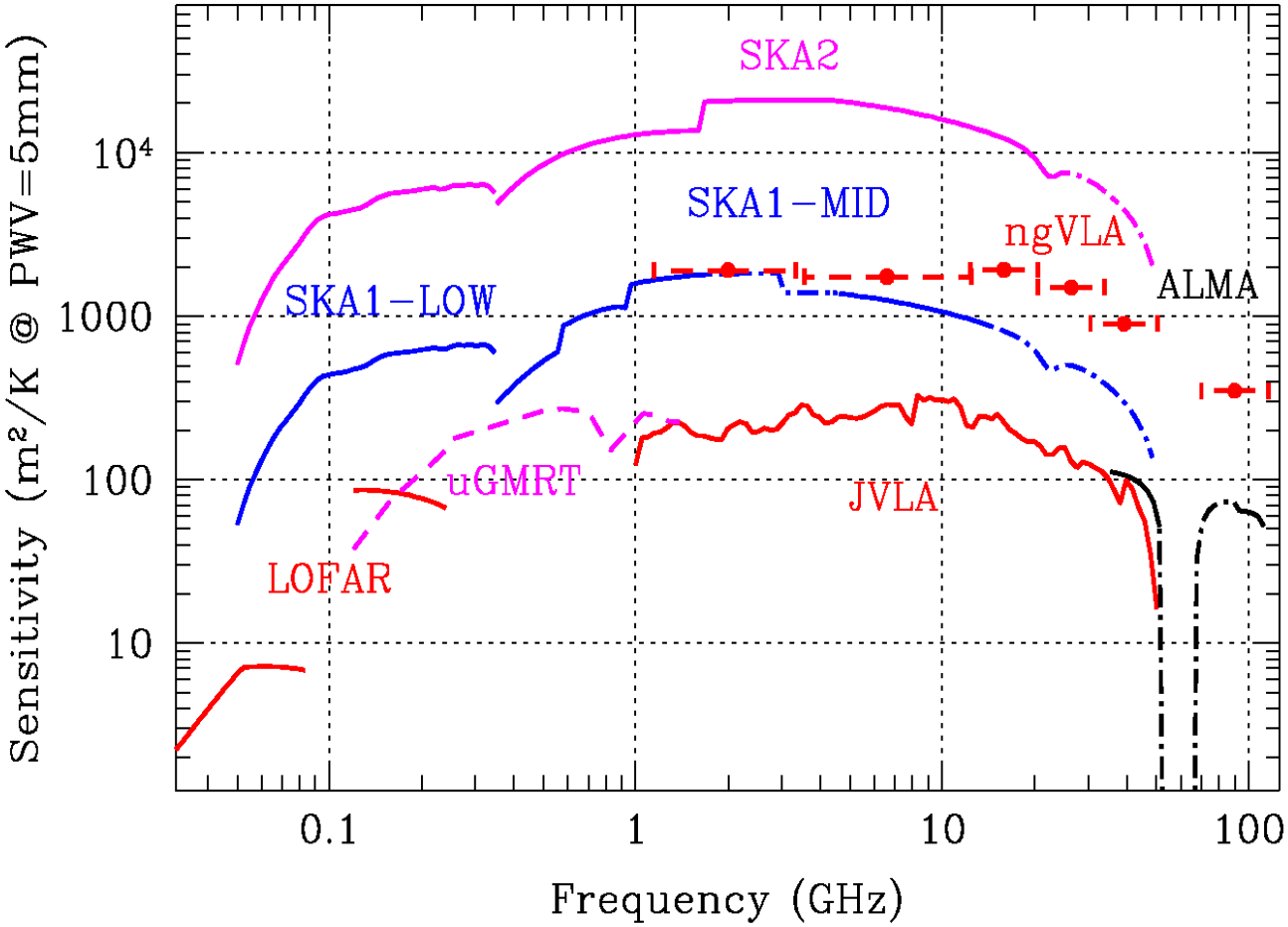
SKA HQ: Jodrell Bank, UK

€20M project: a UK contribution

A ‘nexus for radio astronomy’



SKA1 Anticipated Sensitivity



- Improved performance predictions now available at all frequencies
- Opportunity for seamless interface of SKA to ALMA capabilities

SKA1 Design Baseline Cost

Design Baseline	October 2019 snapshot	Provided through annual contributions			
Total Value (€M) (Dec 2017 euros)	Capital cost of construction (€M)	Construction Support Budget (€M)	Observatory Operations & Business-Enabling Functions (€M)	Observatory Development Programme (€M)	Funding Period
	(760 + 180) = 940	(140 + 26) = 166			
1697	1106		591	(TBD)	2021-2030

A little history

Previous meetings

- Oct 2013: Manchester, UK
- Sept/Oct 2014: Fremantle, AU
- Nov 2015: Penticton, CA
- Oct 2016: Stellenbosch, ZA
- June 2017, Rotterdam, NL
- Nov 2019, Shanghai, CN

- Jul 2013: Cost Cap
- Oct 2013: Consortia kick-off
- Q4 2014/Q1 2015: re-baselining

- PDRs
- Cost Control

- CDRs

- System CDR

Status

Treaty signing: Rome, 12 March 2019

19 August: NL ratified

14 October: AU Joint Standing Committee On Treaties discussing.

12 November: ZA National Assembly approves Convention.

Progressing well in other countries.

Exepcted Entry-into-force: May 2020.

Similar to ESO, CERN, ITER, ESA……

System Critical Design Review

System CDR

Events

- 13 September 2019:
  - Internal publication of CDR documentation
- 21 October 2019:
  - Publication of CDR documentation
  - Kick-off teleconference
- 19 November 2019
  - OAR status update/draft agenda
- 09-12 December 2019:
  - CDR Meeting
- March 2020: Target CDR closeout

SYSTEM CDR PLAN AND PROCEDURE

Document number	SKA-TEL-SKO-0001022
Document Type	PLN
Revision	01
Author	L Stringhetti
Date	2019-03-15
Document Classification	FOR PROJECT USE ONLY
Status	Released

Name	Designation	Affiliation	Signature	
Authored by:				
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Owned by:				
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			Date:	2019-03-16
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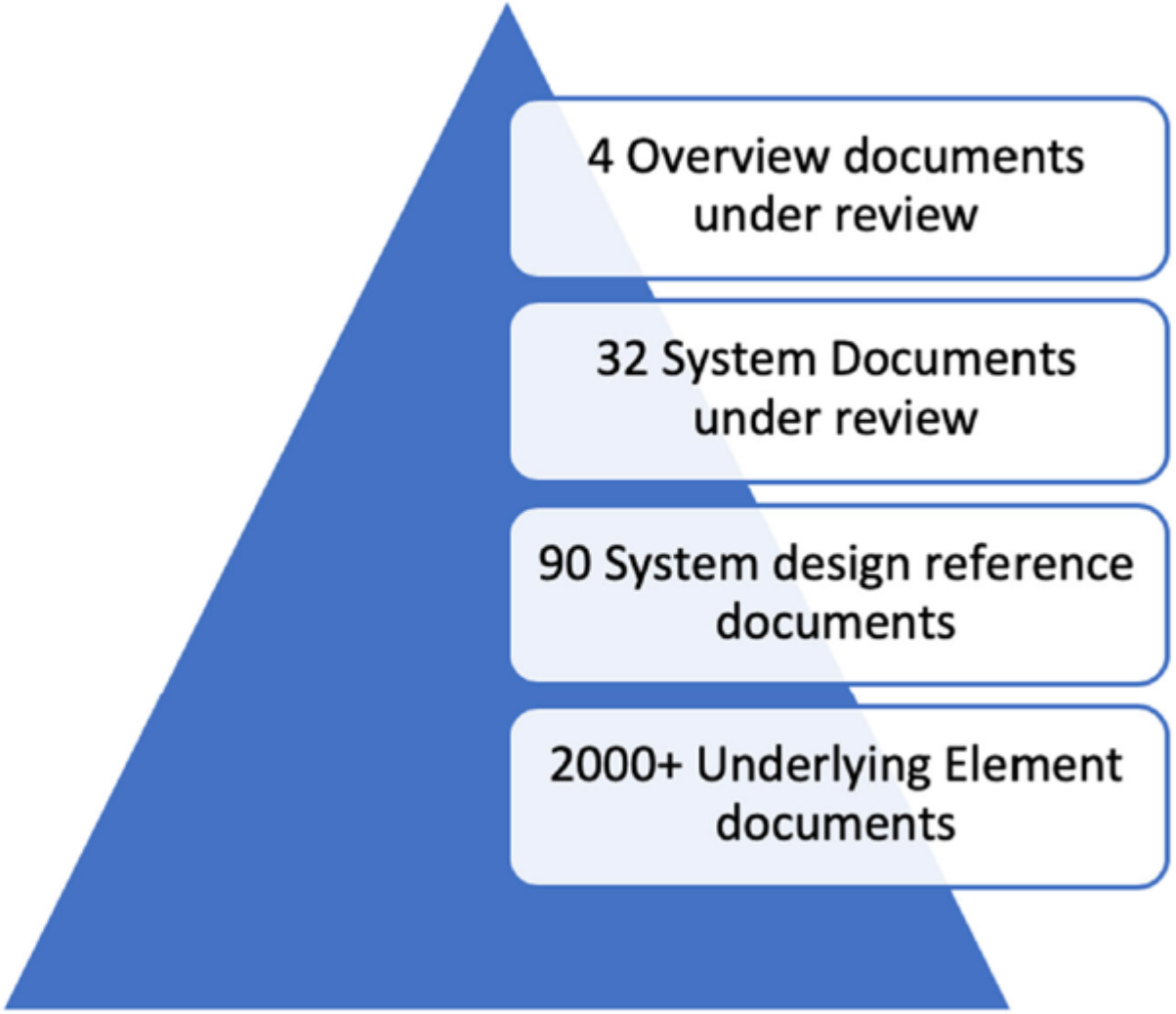
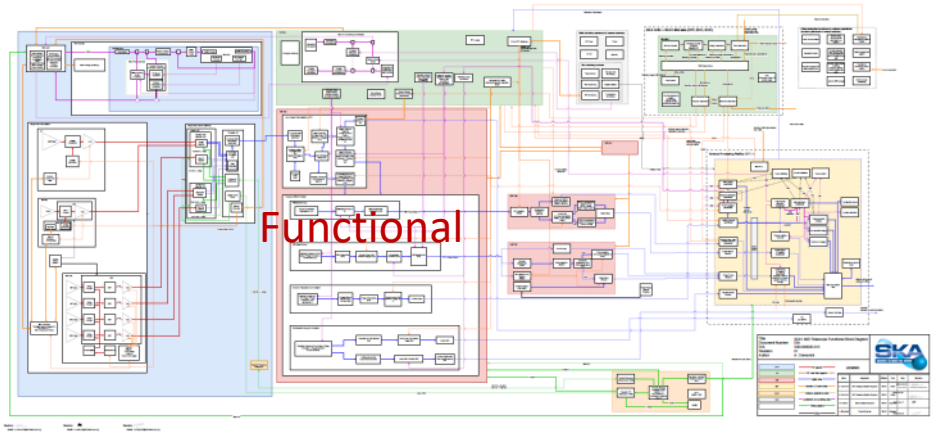
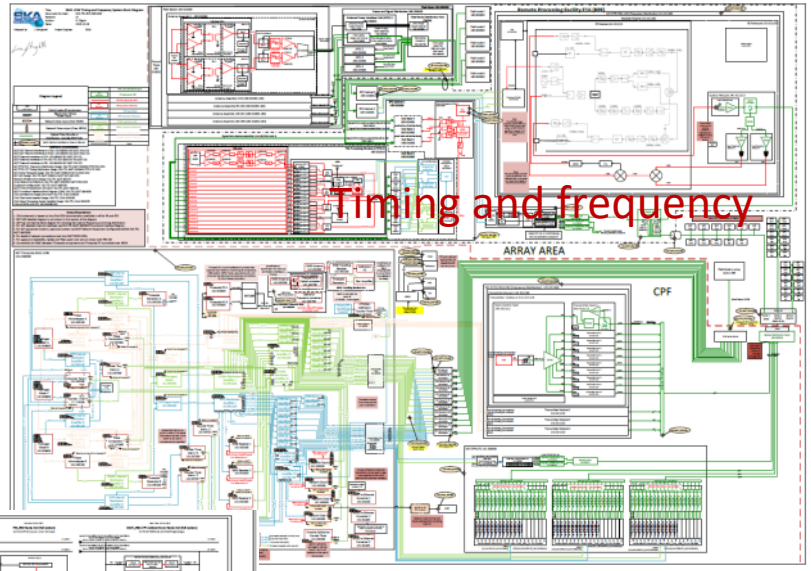
Tim Stevenson	Head of Mission Assurance	SKAO		
			Date:	2019-03-18
Released by:				
Joe McMullin	Programme Director	SKAO	J P McMullin	
			Date:	2019-03-18

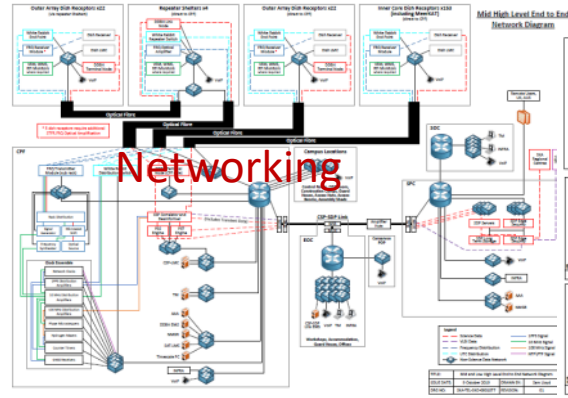
Document Tree (CDR Reading Guide)

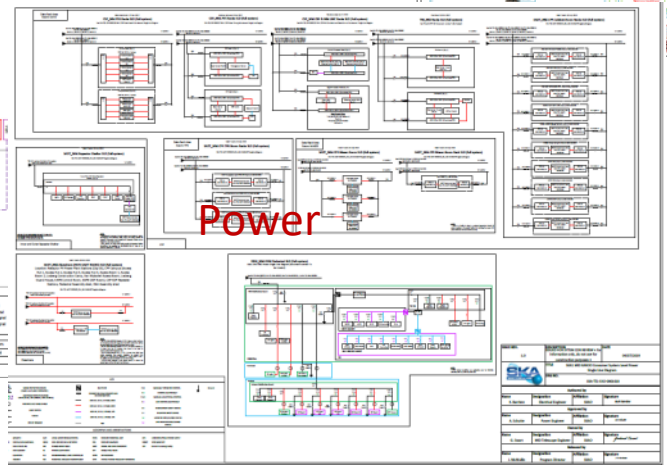


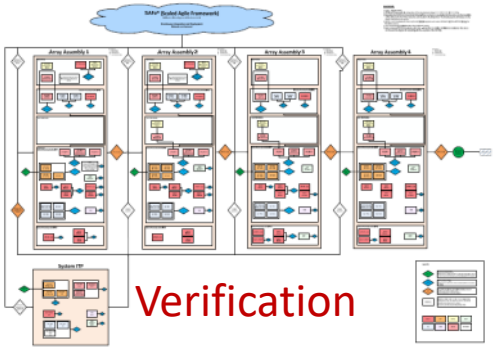
Examples of System Artefacts



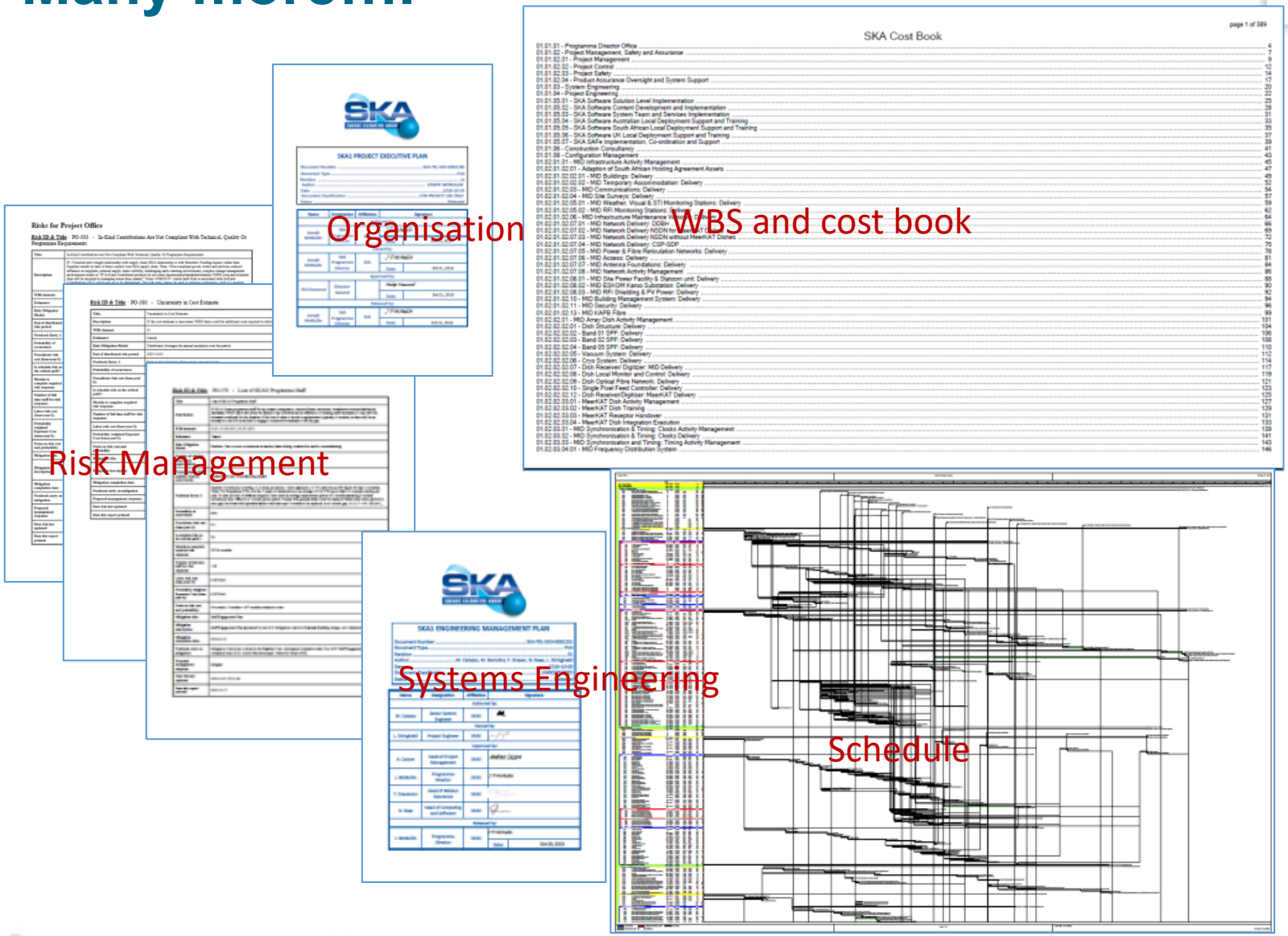








Many more….


Organisation
WBS and cost book
Risk Management
Systems Engineering
Schedule
SKA Cost Book

Construction Schedule

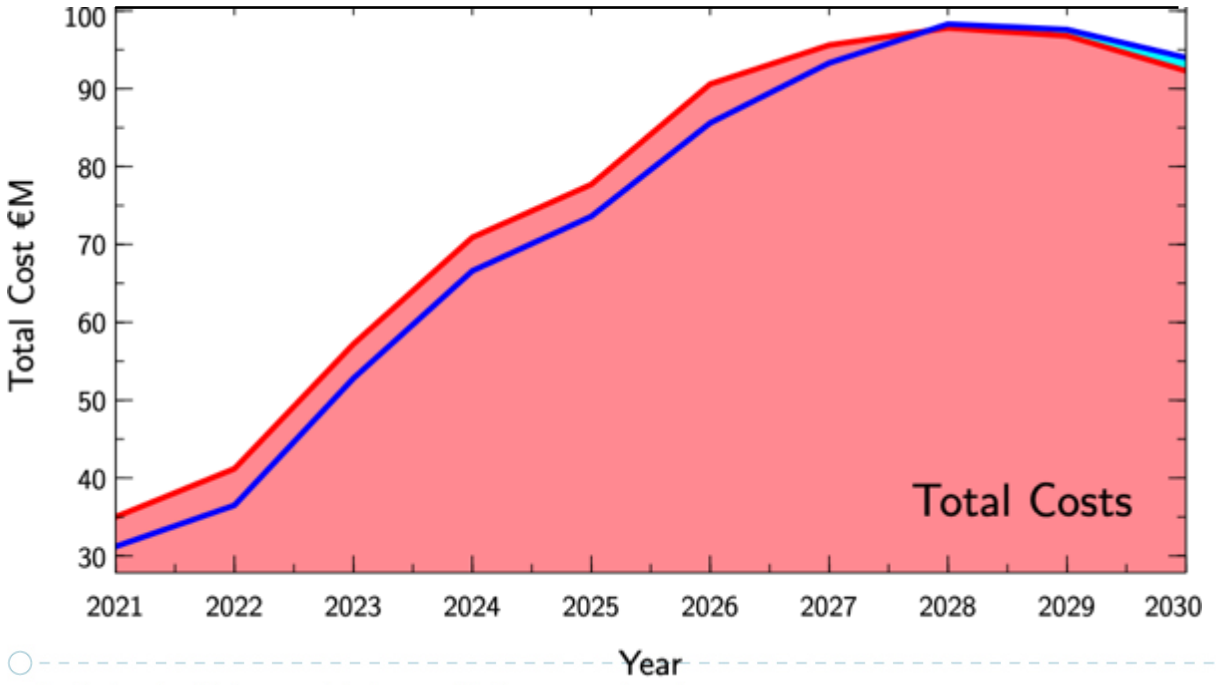
Key project milestone	Designation	LOW Telescope	MID Telescope
Start of construction	T0	1st January 2021	1st January 2021
Earliest start of major contracts	C0	1st July 2021	1st July 2021
Integrated Test Facility Qualification Event finish	ITF-QE Fin	January 2024	December 2023
Array Assembly 1 finish	AA1	September 2024	December 2024
Array Assembly 2 finish	AA2	October 2025	January 2026
Array Assembly 3 finish	AA3	September 2026	October 2026
Array Assembly 4 finish	AA4	July 2027	July 2027
Operations Acceptance Review	OAR	September 2027	September 2027
End of Construction		September 2028	September 2028

Planning for Operations

Summary

- Staffing profile projected for 10-year period from 2021-2030 from Construction and into the Operations phase

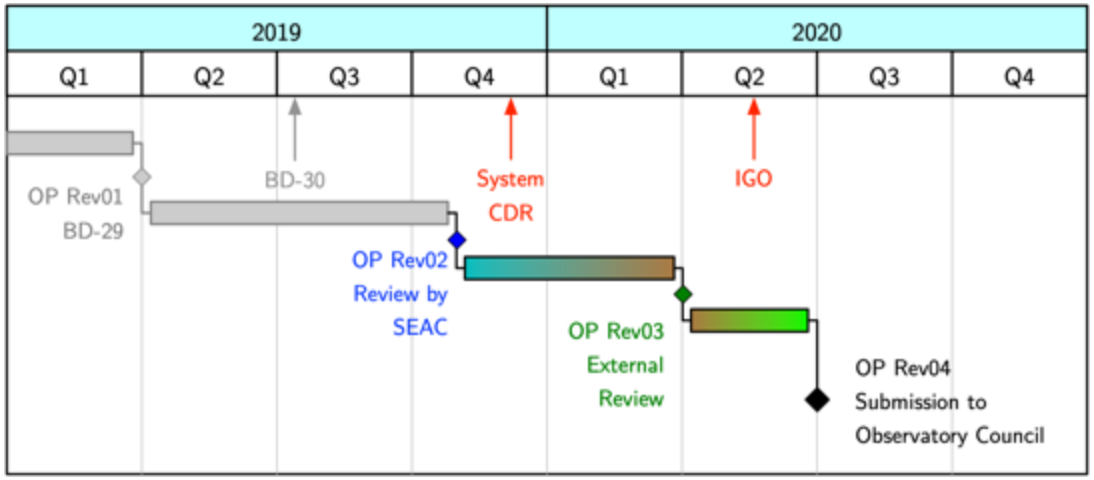
Location	CONSTRUCTION PHASE							OPERATIONS PHASE		
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GHQ	141.1	145.6	153.1	160.6	169.6	174.1	177.1	147.1	143.6	142.6
AUS	21	35	69	97	106	121	136	126.5	126.5	112
RSA	20.5	39.5	70.5	96.5	110.5	121.5	134.5	124	124	112
TOTAL	**182.6**	**220.1**	**292.6**	**354.1**	**386.1**	**416.6**	**447.6**	**397.6**	**394.1**	**366.6**



Item	Total (€M)
LOW Power	11.8
MID Power	6.3
Data Transport	6.2
Mid O&M	6.1
LOW O&M	6.0
Staff travel	4.2
DG Contingency	2.5
MID Running	2.5
LOW Running	2.2

Review process

- Review timetable for further revisions of the Operations Plan



- External review panel:
  - Andreas Kaufer (ESO, Chair)
  - Stuartt Corder (ALMA)
  - Claire Chandler (NRAO)
  - Doug Simons (CFHT)

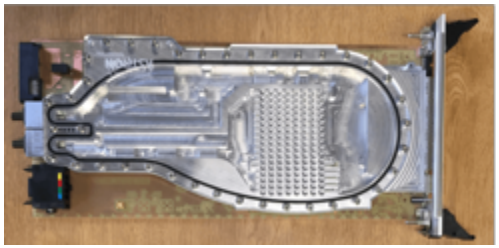
SKA Data

SKA Data Flow Challenge

Few km

~7 Tb/s

Low Central Signal Processor



~5 Tb/s

800 km

Perth Supercomputer

130 Pflops

600 PB/yr

~8 Tb/s

Mid Central Signal Processor

Few km

~5 Tb/s

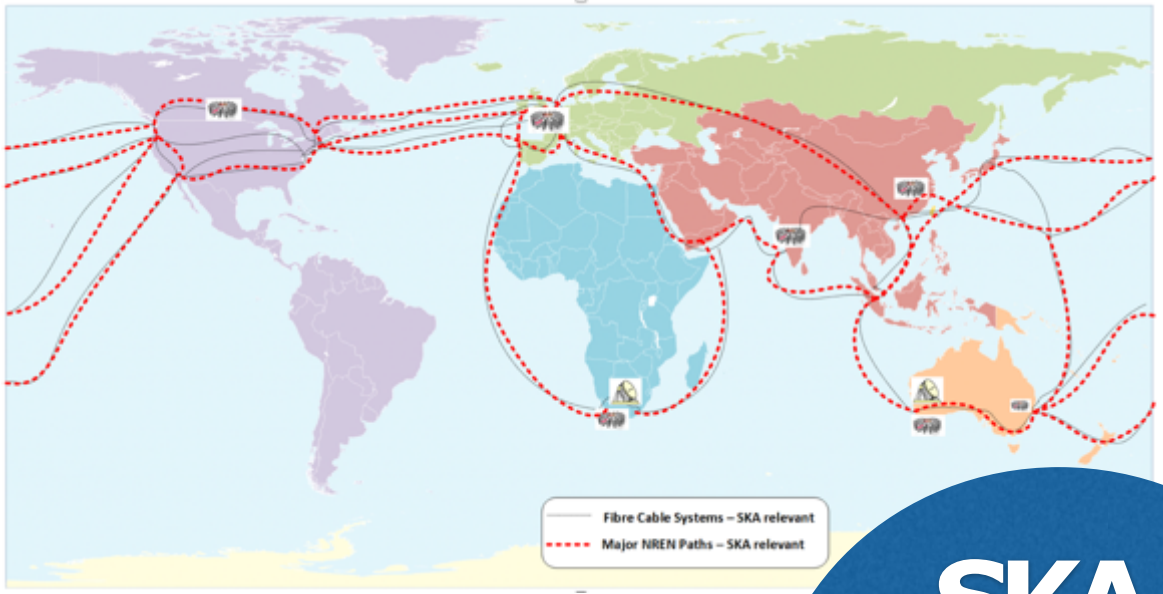
130 Pflops

Cape Town Supercomputer

600 km

SKA Data Flow Challenge: SKA Regional Centres

600 PB/yr



LOFAR 23PB

Uploads to Google 100PB

Uploads to Facebook 180PB

SKA Phase1 Science Archive 600PB

Deployment Baseline Definition

Current cost estimate: €940M

Cost cap: €691M

Funding available: under discussion

Process of Definition

- Build on 2017 community endorsed Cost Control Process
- Now: updating cost estimates for elements in 'descope ladder'
- Now: explore other options for potential savings
  - (e.g. SKALA4.1 antennas 20% better than requirement; explore consortia cost-saving ideas; further explore phasing options, …..)
- Dec/Jan: engagement with SWGs
- February: Board meeting to establish single cost goal for deployment baseline and 'appetite for risk'
- April: definition of deployment baseline, communication with Board
- Late April: three Information sessions with science community
- May: Gateway Cost Audit using engineering consultants
- May: Advanced drafts of construction proposal, operations plan etc shared with the Board (BD-32)

Next Science Meeting

- 2020 SKA Science Meeting and KSP Workshop, 7 – 11 September
  - Stellenbosch University
  - Up to 350 participants
  - Title: "The Precursor View of the SKA Sky"

Photo Credit: Jefri Tamba 2018

Timeline

- Q1 2019: Treaty signing
- Q4 2019: System CDR (Dec 9-12)
- Q2 2020: SKA Observatory exists, post ratification
  - 1st SKA Observatory Council Meeting (23-24 June 2020)
- Q3 2020: Construction and operations proposal submitted to SKAO Council, after approval by the SKA Board
- November 2020: SKA Observatory Council to approve start of construction
- December 2020: formal transition of staff from SKA Org to SKA Obs
- Q1 2021: Construction activity begins
- Q3 2024/5: Science Commissioning starts, community involved
- 2027/8: SKA1 construction complete

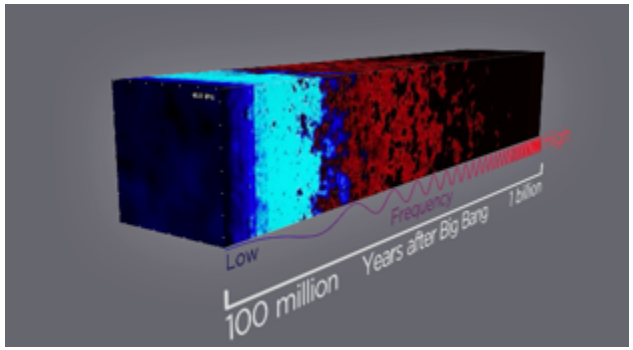
This meeting

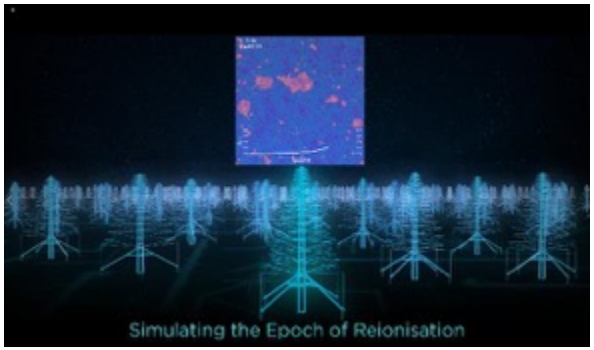
- Presenting SKA System Design
- First community view on SKA Operations, Commissioning Plan and SKA Regional Centres
  - Seeking your input on how we can improve our plans
  - Seeking your input on how the community will be access SKA data through the SRCs

- Momentum in SKA excellent
- Schedule has accelerated
- Excellent mood emerging from Board/CPTF meetings last week

SKA shakes hands with SUMMIT (200 Pflops)

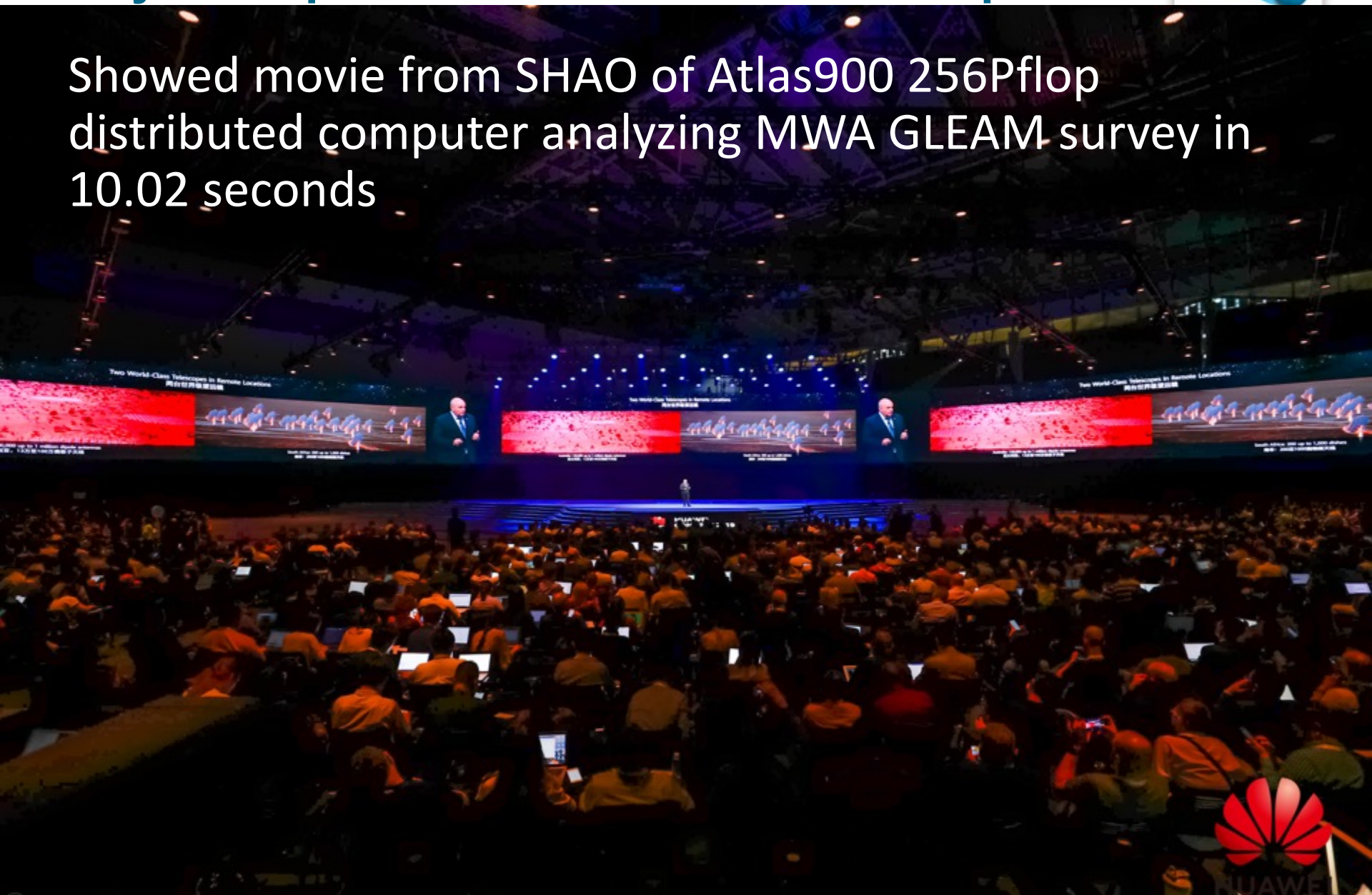
- The largest workflow of the SKA, even astronomy, successfully executed on the fastest supercomputer SUMMIT, simulating the EoR using the SKA1-low configuration
- The peak ingest data rate 400Gbps is on the same scale of the SDP, which will have a peak of 5 Tbps
  - This is a single observation of 6 hours; compared with multiple tasks streaming into the SDP
- A maximum of 4560 compute nodes (98% of SUMMIT) was used – SKA big data challenge!
- This experiment shows astronomers can handle SKA data processing (see demonstration in the afternoon coffee time)





Keynote speech at Huawei Connect Sept 2019

Showed movie from SHAO of Atlas900 256Pflop distributed computer analyzing MWA GLEAM survey in 10.02 seconds



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Credits: Jader Monari and INAF team