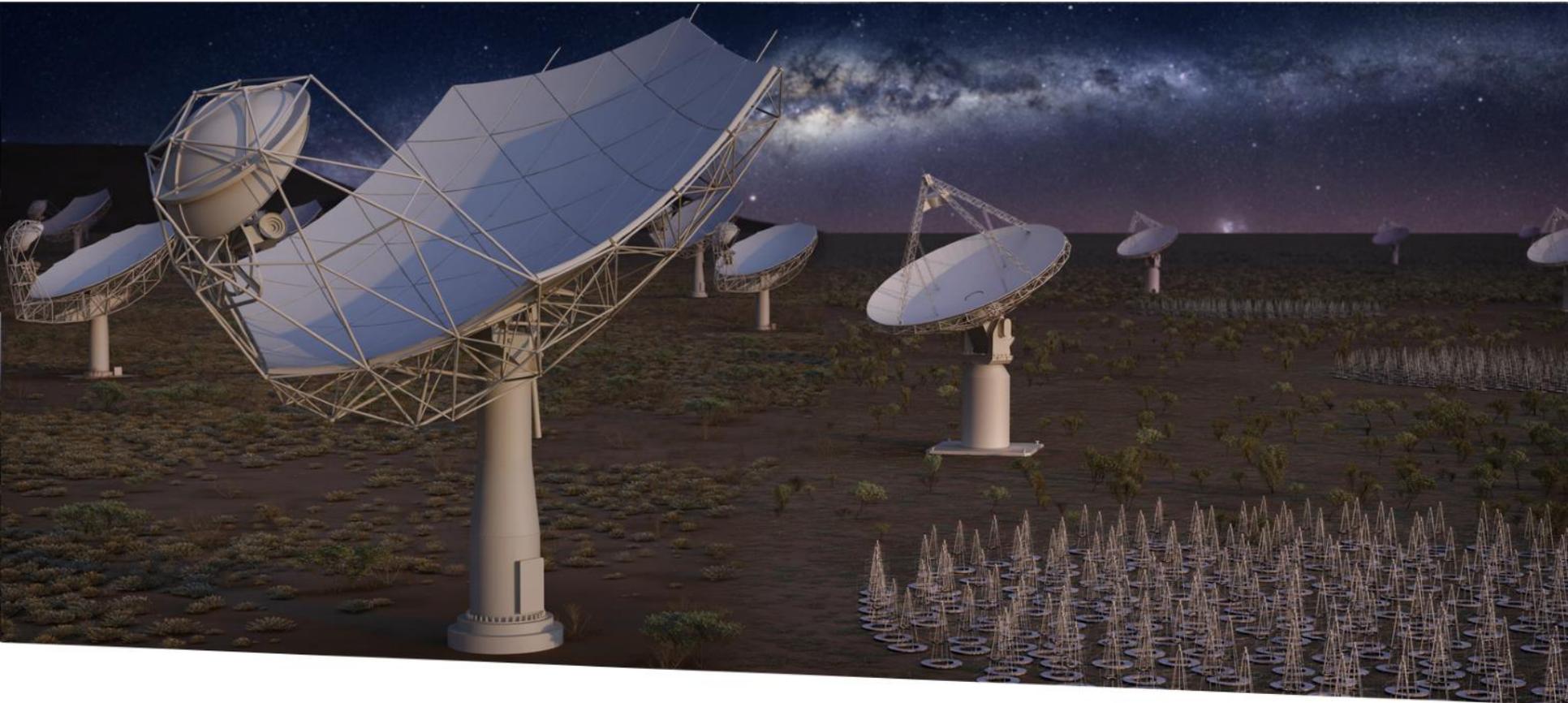


# The SKA approach to sustainable research



**SQUARE KILOMETRE ARRAY**

Exploring the Universe with the world's largest radio telescope

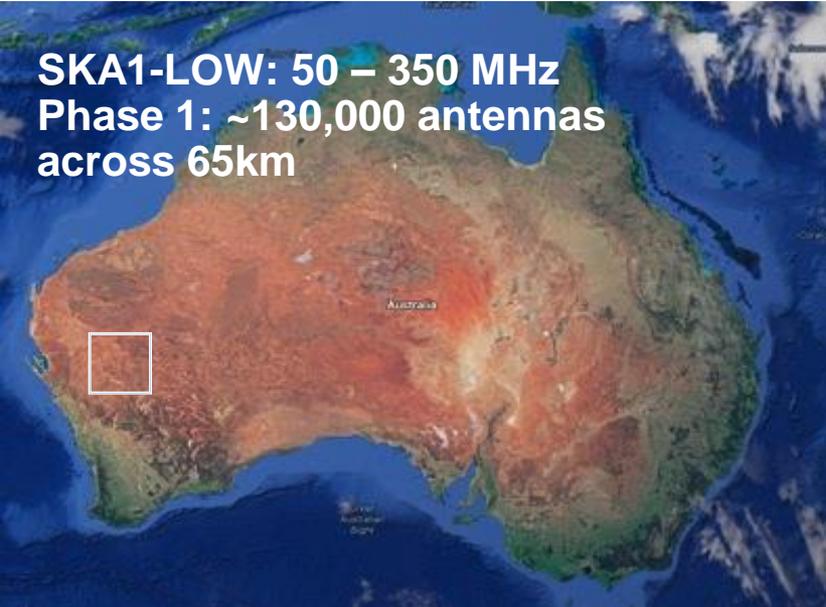
**Simon Berry, SKA Organisation**

25<sup>th</sup> June 2019

# SKA: HQ in UK; telescopes in AUS & RSA



**SKA1-LOW: 50 – 350 MHz**  
**Phase 1: ~130,000 antennas**  
**across 65km**



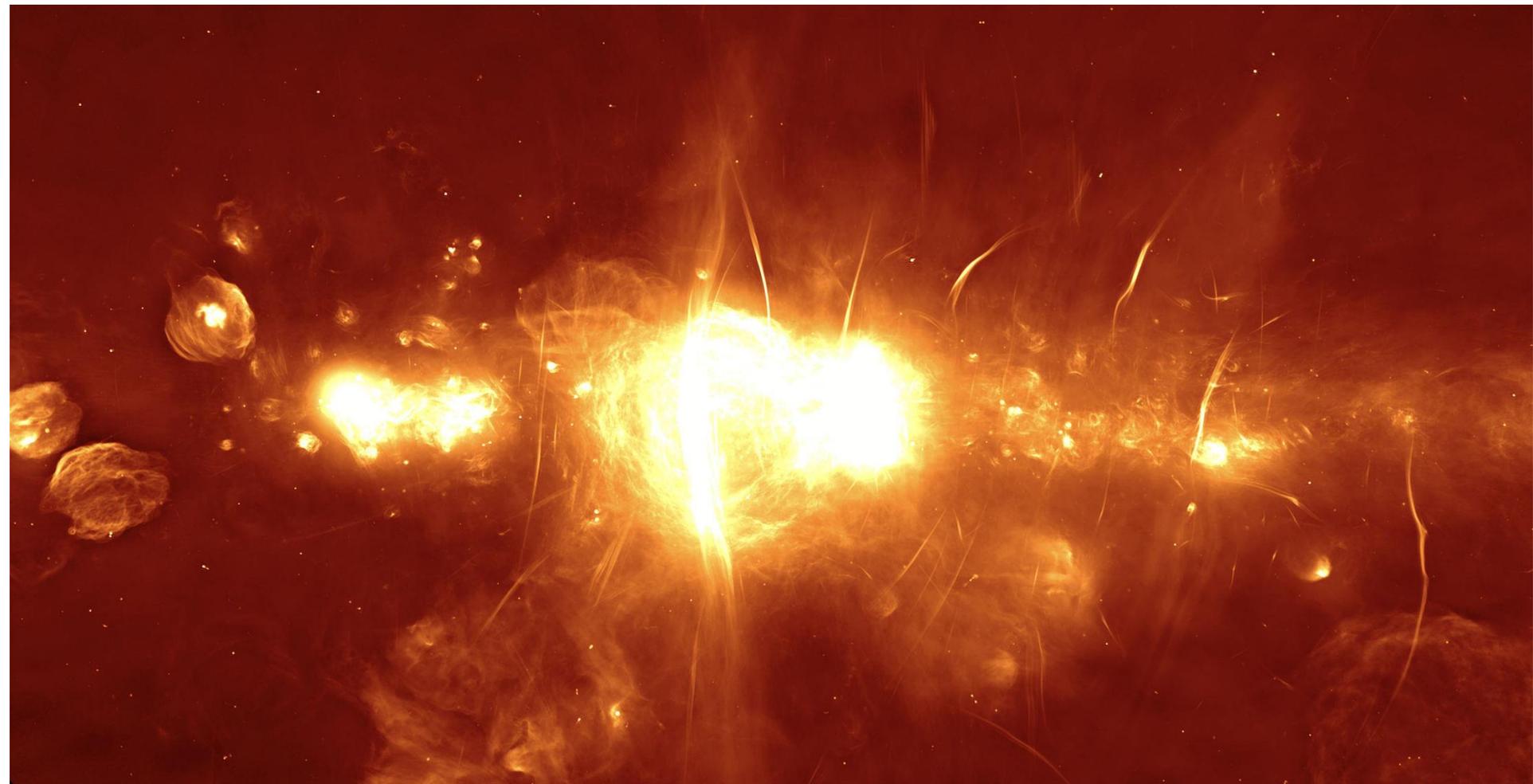
**SKA1-Mid: 350 MHz – 24 GHz**  
**Phase 1: 200 15-m dishes**  
**across 150 km**



# SKA Precursor: MeerKAT



Exploring the Universe with the world's largest radio telescope

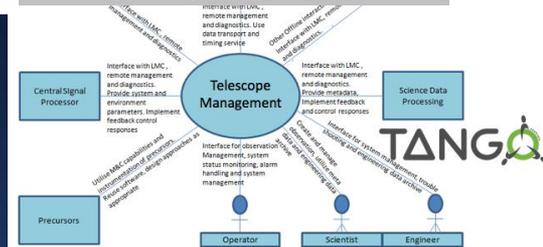


# Hardware in South Africa

SKA-P2: Karoo (China/Germany/Italy), 24 April 2019



India/UK/South Africa



# Hardware in Australia

AAVS1: AU/IT/NL/UK

NL/Aus/NZ



1.6MW solar/battery power station: operational



# SKA HQ: Jodrell Bank, UK



Exploring the Universe with the world's largest radio telescope



# SKA: A global Research Infrastructure



## Potential Future Members



+.....



 **Members of the SKA Organisation**  
Host Countries: Australia, South Africa, United Kingdom



 **African Partner Countries**

SKA Observatory will be established as an Intergovernmental Organisation in 2020, taking over from the SKA Organisation. It will undertake the construction and operation of the telescope.

As of March 2019, confirmed SKA Observatory members are



# Timeline

## Key dates:

- **Q1 2019: Convention signing** ✓
- **Q4 2020: Construction activity begins**
- **Q3 2023: Science Commissioning starts, community involved**
- **2027/8: SKA1 construction complete**
- **2028 onwards – full science operations**
- **2030's: construction upgrade to SKA2**
- **.....science and operations ongoing**

# Long term Sustainability

- Multi-decade lifetime
- Encompassing national facilities
- Multi-phased construction
  - Ongoing upgrades
- Periods of construction, operation and overlapping construction and operation
- Host countries as partners not 'landlords'

## MAIN RECOMMENDATIONS

- 1 **Establish and maintain excellence** through the entire lifecycle of RIs by all appropriate means, by securing adequate framework conditions, and by opening the RIs up to the world.
- 2 **Ensure that RIs have the right people in the right place at the right time** by strengthening and harmonising national research and educational systems to make sure that all essential skills are available.
- 3 Harmonise and **integrate a vision for convergent operation of RIs and e-Infrastructures** in Europe to ensure cost-effective service provision to the user communities.
- 4 **Fully exploit the potential of RIs as innovation hubs** by incorporating strategies for their development into national and European innovation policies.
- 5 Set up effective means of **determining the economic and wider social value of RIs**, and incorporate these benefits into science-policy-society dialogues.
- 6 Establish adequate framework conditions **for effective governance and sustainable long-term funding for RIs at every stage in their lifecycle**, together with effective management.
- 7 Foster broader **coordination at National and European levels** when designing processes for planning and supporting national and pan European RIs and so enhance their strategic value.

# Sustainable governance



- SKA Organisation member governments agreed to develop an Intergovernmental Organisation in 2015
- Rationale:
  - Appropriate for a genuinely global research infrastructure of SKA's scale
  - Government commitment: political stability, funding stability
  - A level of independence in structure
  - 'Freedom to operate', specifically through procurement process, employment rules etc
- Building an organisation based on successful IGOs such as CERN, ESO, ESA etc
- Negotiations started October 2015 – led by Italian government.



# Convention signing – 12<sup>th</sup> March



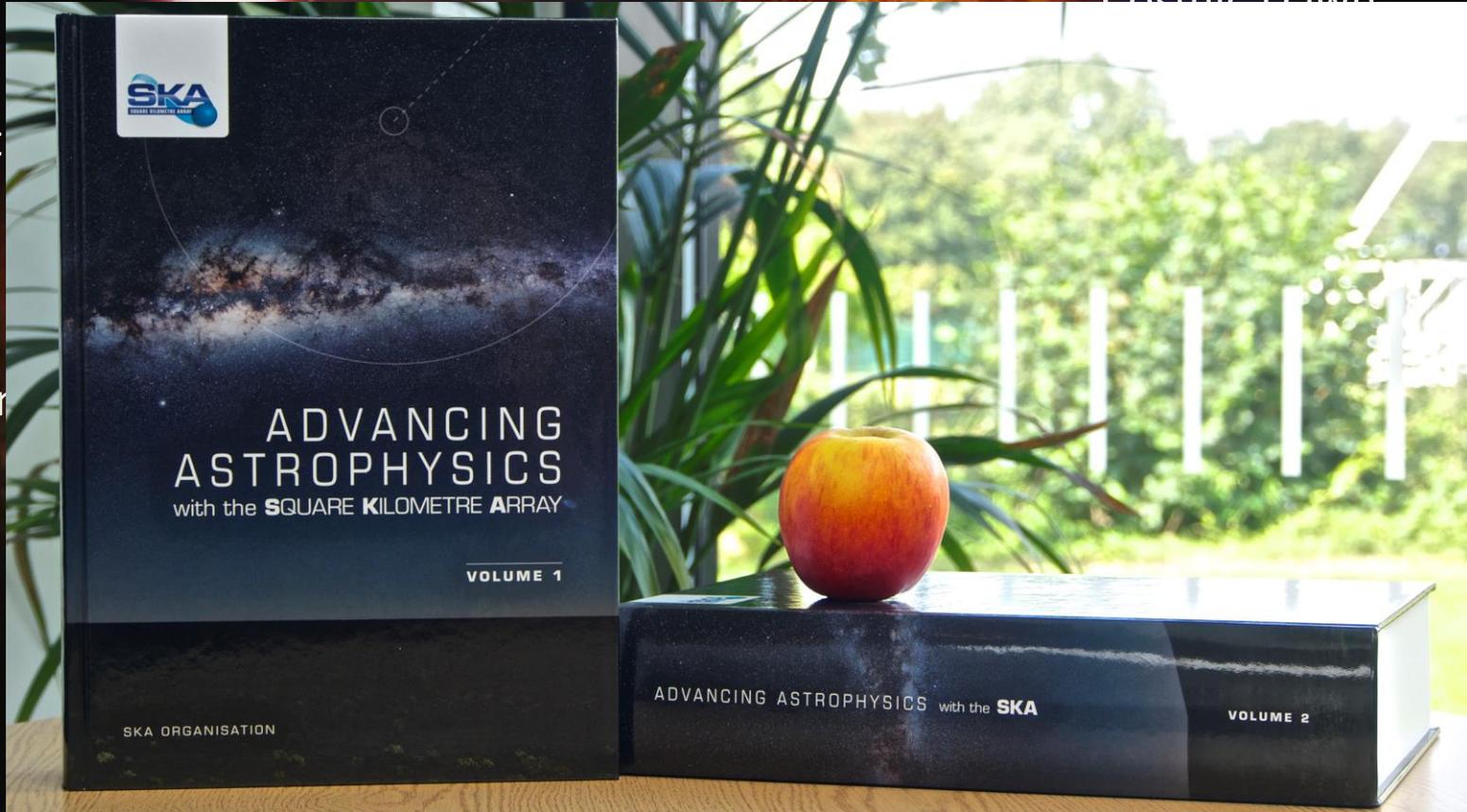


# Science excellence

Cosmic Dawn

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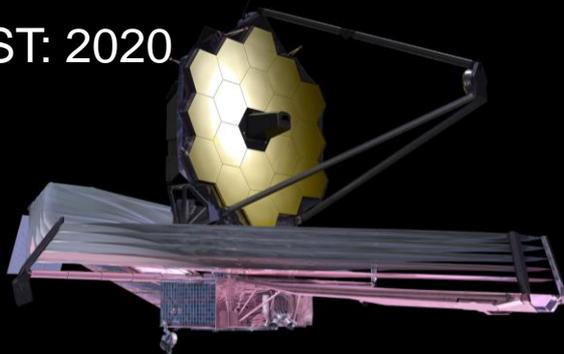


# 21<sup>st</sup> Century Observatories

LIGO: operational



JWST: 2020



ATHENA:  
2028



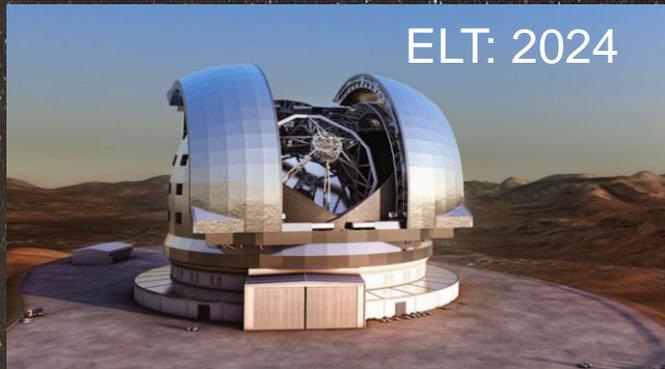
ALMA: operational



SKA: 2028



ELT: 2024



CTA: 2024



Radio waves

Microwaves

Infrared



Ultraviolet

X-rays

Gamma



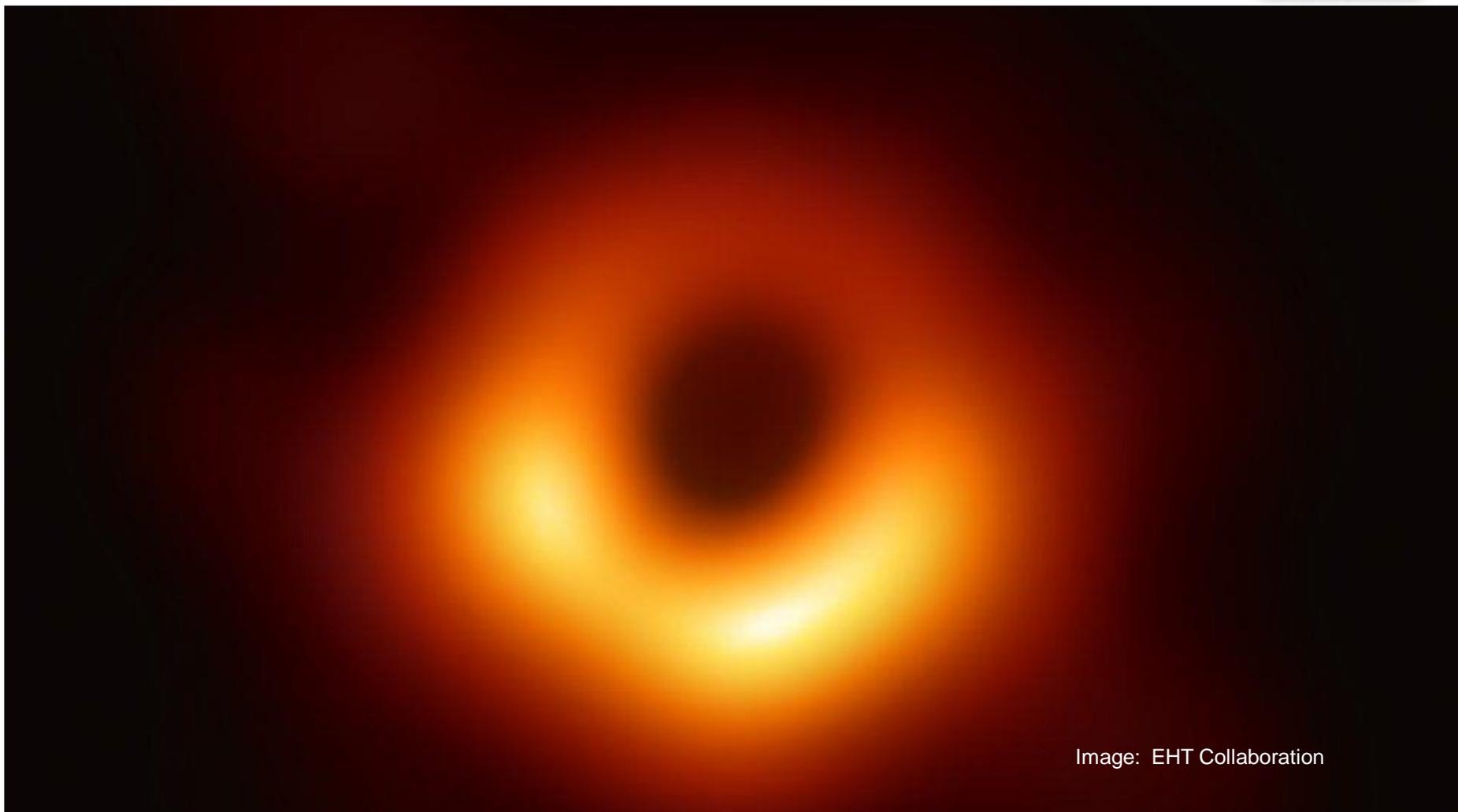


Image: EHT Collaboration



# Computing Challenges (SKA1)



## SKA-LOW



~2 Pb/s



7.2 Tb/s



8.8 Tb/s



## SKA-MID

Global Traffic in 2020 ~500 Tb/s



~50 PFlops

~5 Tb/s (over 600 km)



@Perth  
~250 PFlops  
@Cape Town

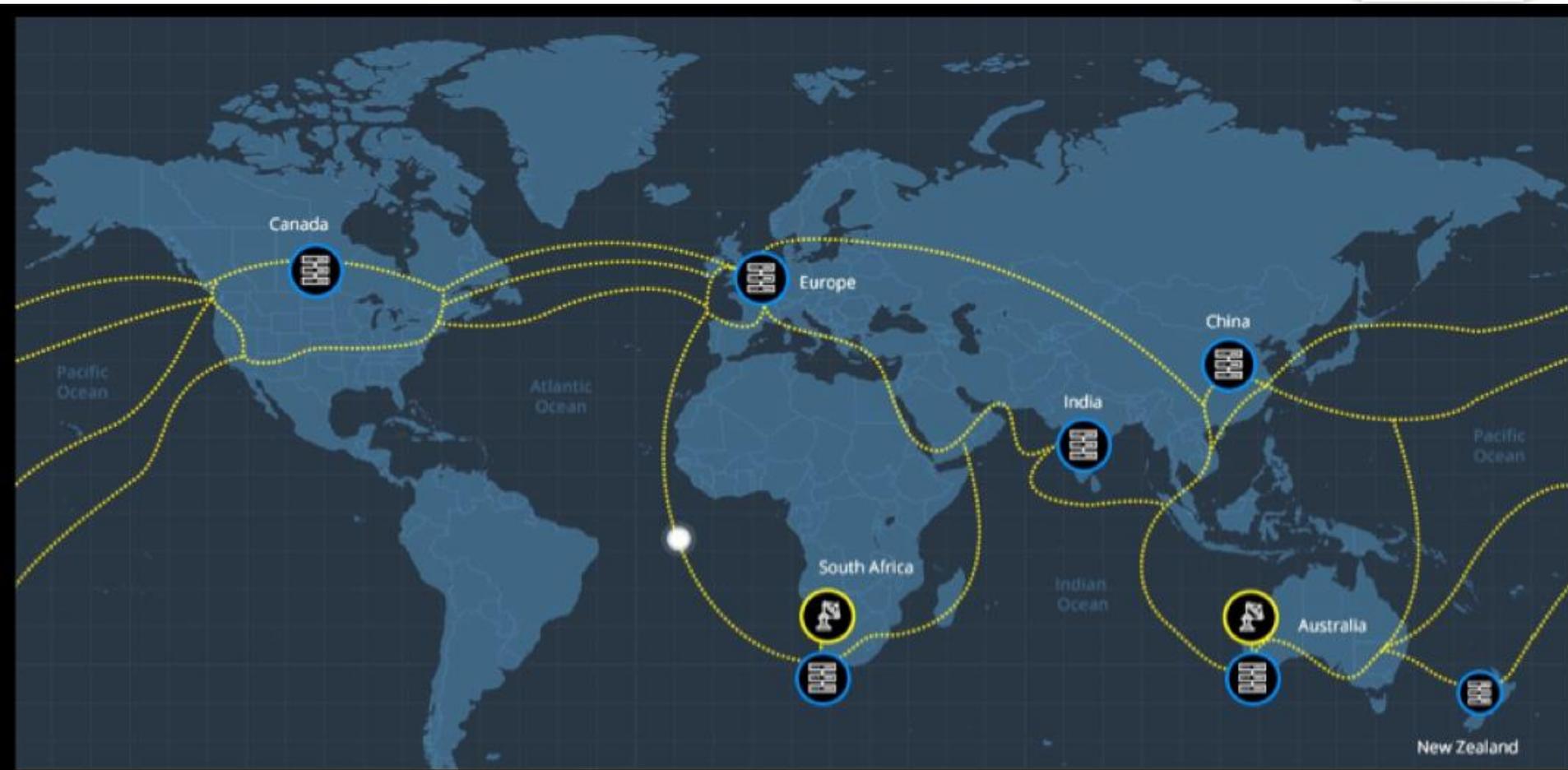
~600 PB/yr

SKA Regional Centres

AWS, IBM,  
Google,  
Nvidia  
SGI, Intel,



# SKA Regional Centres (c.f. CERN Computing Grid)



Observatory Data Products flow from the Science Data Processors in Perth and Cape Town to SRCs around the globe

# Socio-economic impact and innovation

- **Now:**

- Already ‘local’ impacts (on sites and in hosting countries) happening and evidence there: **real economic and other factors being tracked now**
- Looking ahead to ‘real direct’ impacts: industrial contracts and IP in construction

- **Soon:**

- Construction phase activities: ‘juste retour’, innovation impacts, policy impacts
- Continuation of hosting country impacts, and broader global involvement/outcomes
- Science preparation

- **Later:**

- Science impacts and returns
- Operations phase ‘juste retour’?

- **Later still:**

- Subsequent construction phases.....
- Subsequent operations phases.....
- Science.... etc



Innovation, generation of new IP  
Economic return from innovation



US005487069A

**United States Patent** [19] [11] **Patent Number:** **5,487,069**  
**O'Sullivan et al.** [45] **Date of Patent:** **Jan. 23, 1996**

[54] **WIRELESS LAN** 26—line 35.

[75] **Inventors:** John D. O'Sullivan, Ermington; Graham R. Daniels, Willoughby; Terence M. P. Percival, Lane Cove; Diethelm I. Ostry, Petersham; John F. Deane, Eastwood, all of Australia

[73] **Assignee:** Commonwealth Scientific and Industrial Research Organisation, Australia

[21] **Appl. No.:** 157,375

[22] **Filed:** Nov. 23, 1993

[30] **Foreign Application Priority Data**  
 Nov. 27, 1992 [AU] Australia ..... PL6069

[51] **Int. Cl.<sup>6</sup>** ..... **H04B 7/01**

[52] **U.S. Cl.** ..... **370/94.3; 375/284; 375/348; 455/52.3; 455/65**

[58] **Field of Search** ..... 375/34, 39, 51, 375/57, 58, 99, 101, 254, 261, 279, 284, 285, 346, 348; 370/95.3; 455/56.1, 54.1, 63, 65, 52.3

[56] **References Cited**

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5,283,780	2/1994	Schuchman et al.	455/65

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Supercomm/ICC'92 vol. 2, Jun. 1992, Chicago US pp. 1025-1031 D. Buchholz et al. 'Wireless In-Building Network Architecture and Protocols' p. 1029, left col., line

IEEE Transactions on Communications, vol. 39, No. 5, May 1991, New York US pp. 783-793 E. F. Casas et al. 'OFDM for Data Communication over Mobile Radio FM Channels—Part I: Analysis and Experimental Results' p. 784, left col., line 1—right col., line 2; FIG. 1 p. 790, right col., line 18—line 22.

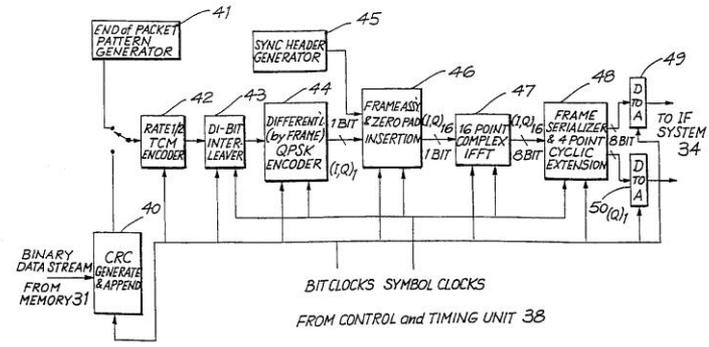
42nd VTS Conference vol. 2, May 1992, Denver US pp. 819-822 T. Le-Ngoc 'A CSMA/CD Portable Data System Using Adaptive Reed-Solomon Coding' p. 820, left col., line 2—line 9.

IEEE Transactions on Communications, vol. 33, No. 7, Jul. 1985, New York US pp. 665-675 L. J. Cimini Jr. 'Analysis and Simulation of a Digital Mobile Channel Using Orthogonal Frequency Division Multiplexing' par. I-par. II. Par IV.

[57] **ABSTRACT**

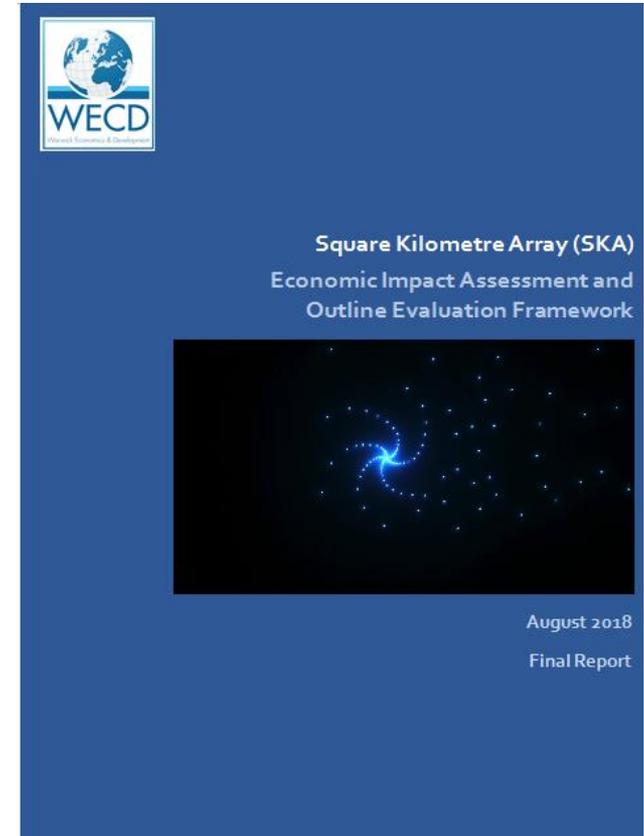
The present invention discloses a wireless LAN, a peer-to-peer wireless LAN, a wireless transceiver and a method of transmitting data, all of which are capable of operating at frequencies in excess of 10 GHz and in multipath transmission environments. This is achieved by a combination of techniques which enable adequate performance in the presence of multipath transmission paths where the reciprocal of the information bit rate of the transmission is short relative to the time delay differences between significant ones of the multipath transmission paths. In the LANs the mobile transceivers are each connected to, and powered by, a corresponding portable electronic device with computational ability.

72 Claims, 8 Drawing Sheets



# Tracking impact

- SKAO involved in OECD, ESFRI, RI-PATHS and other discussions on impact:
  - Aim to have central reporting framework in place
  - Resource base for stakeholders to access relevant impact information
- STFC report on UK-SKA impacts and economic benefits – August 2018



# Local impacts: South Africa



Industry activity  
Contracts  
Labour and employment



# SKA SA's investment impact on the Northern Cape



**R220 MILLION**



The total amount of money spent in the Northern Cape through KAT-7 and MeerKAT

this includes:

This information includes figures up until November 2016.

**R134 MILLION**



Amount spent at local suppliers for the construction of MeerKAT and other related projects

**R1 MILLION**



The amount spent on training 351 people from Northern Cape communities

**R1.7 MILLION**



Amount spent on material sourced from local suppliers for equipment for the building of the Hydrogen Epoch of Reionisation Array (HERA)

**7284**



Total number of employment opportunities created through the construction of KAT-7, MeerKAT and other related projects

**72**



The number of FET students funded by SKA in the Northern Cape since 2011

**9**



Number of SKA funded students from local communities enrolled at universities

**8**



Number of schools where structured Human Capital Development programmes are conducted. These include Carnarvon High School, Carnarvon Primary School, Williston High School, Nico Bekker Primary School, Loxton Primary School, Vosburg Primary School, Brandvlei Primary School and Brandvlei High School, involving more than 4 000 learners

**120 000 HA**



Nature reserve to be declared and protected for future generations

**219**



Farmers and farmworkers provided with fixed broadband connectivity via satellite (V-SAT) since December 2015



The SKA SA project has invested heavily in the Northern Cape province, from upgrading knowledge centres to creating jobs and providing deserving students with much-needed academic funding. With its partners, SKA SA has contributed towards social and technological development in areas such as Carnarvon, Vosburg, Williston, Van Wyksvlei and Brandvlei.

SKA SA has five focus investment areas in the Northern Cape:



Investing in the youth



Supporting community upliftment programmes



Developing small to medium enterprises



Nurturing learners' talent



Ensuring communication connectivity

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[www.ska.ac.za](http://www.ska.ac.za)



**CONTACT US:**  
SKA SA, 3rd Floor, The Park, Park Road  
Pinelands, Cape Town, 7405  
Tel: +27 (0) 21 506-7300  
[www.ska.ac.za](http://www.ska.ac.za)



# Site activities: Australia

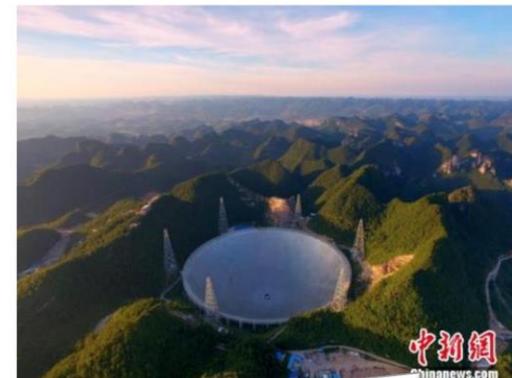
- Indigenous Land Use Agreement (ILUA) with the Wajarri aboriginal group of the region required
- Scope includes direct monetary benefits to a trust fund managed by them
- Indirect monetary benefits includes:
  - Employment and contracting opportunities
  - Liaison and business development officers
  - Education : cadetships, apprenticeships, mentoring, school visits
  - Support for art programmes
  - Cultural: support for Wajarri cultural displays for interpretive centres
  - Value ~€10'sM

# Societal impact



FAST项目是中国重大科技项目，系目前世界上口径最大的单天线射电望远镜，是人类直接观测遥远星系行星、寻找类似太阳系或地球的宇宙环境，以及潜在智慧生命的重要设施。其科学目标主要是巡视宇宙中的中性氢、发现新脉冲星、主导国际甚长基线网、探测星际分子、寻找地外文明等，在航天工程及其他领域具有广泛用途。

平塘县旅游事业管理中心负责人介绍，目前造访“天眼”的游客以周末、节假日来的占大多数，2016年国庆黄金周期间，每天造访“中国天眼”景区的游客最高达万人。由于要保障“天眼”的正常运行，平塘县在旅游开发中，将观景台址5公里范围设为“静默区”，不得使用任何电子设备，每天控制2000人次的最大承载量。尽管如此，“天眼”还是吸引了越来越多远道而来的游客。



## Support

- 125k Euro work package within the Jumping JIVE H2020 project
- Funds trainers from EU radio observatories to help with the DARA basic training
- Funds a seminar series to advertise DARA programme
- Funds African students to attend EU radio astronomy training events
- Funds staff exchanges between EU and AVN countries



# Public appeal...



- SETI: huge public interest
- Significant private investment already
- Careful balance needed in future – science priorities vs other agendas

## PUBLIC WEBSITE

### SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

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Home » Latest News » New partnership between SKA precursor telescope MeerKAT & SETI programme Breakthrough Listen

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## New Partnership Between SKA Precursor Telescope MeerKAT & SETI Programme Breakthrough Listen



**Bremen, Germany – October 2, 2018** – Breakthrough Listen, the global initiative to seek signs of intelligent life in the universe – announced today at the International Astronautical Congress the commencement of a major new programme with the MeerKAT telescope in partnership with the South African Radio Astronomy Observatory (SARAO).

*Breakthrough Listen's* MeerKAT survey will examine a million individual stars – 1,000 times the number of

targets in any previous search – in the quietest part of the radio spectrum, monitoring for signs of extraterrestrial technology. With the addition of MeerKAT's observations to its existing surveys, *Listen* will operate 24 hours a day, seven days a week, in parallel with other surveys.

Observations will occur in a *commensal mode* – at the same time as other astrophysics programs. Using sophisticated processing, *Breakthrough Listen* scientists will digitally point the telescope at targets of interest. This means that the *Breakthrough Listen* instrument at MeerKAT will be operating almost continuously, scanning the skies for signs of intelligent life.

"Collaborating with MeerKAT will significantly enhance the capabilities of *Breakthrough Listen*", said Yuri Milner, founder of the Breakthrough Initiatives.

<https://www.skatelescope.org/news/meerkat-breakthrough-partnership/>

1/2

# Conclusions

- SKA at critical point:
  - Design activities moving towards construction readiness
  - Poised for new organization being established
  - Huge national momentum and visibility already in South Africa and Australia
  - SKA Observatory will create global entity
  - Science primary driver, but careful planning already underway for ongoing sustainability through project lifetime



# SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope



Thank you

[www.skatelescope.org](http://www.skatelescope.org)