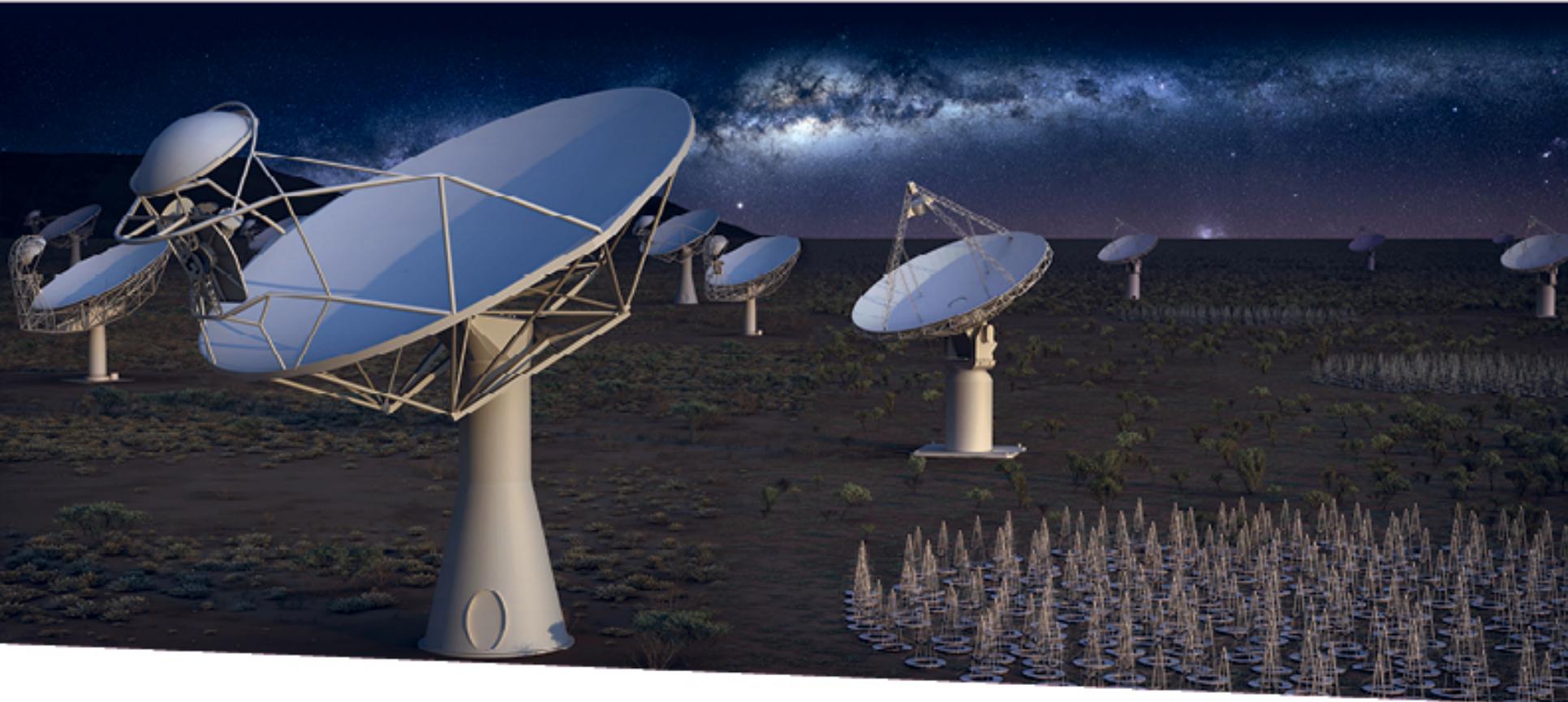


# The SKA Project: Status

## An experiment of social science



**SQUARE KILOMETRE ARRAY**

Exploring the Universe with the world's largest radio telescope

Luca Stringhetti SKA Project Engineer

Milano IASF Milano 6<sup>th</sup> April 2017

# Trafford Centre: #scienceX (24<sup>th</sup> 25<sup>th</sup> April 2016)



- What it is going to see?
- Who is going to build so many antennas, and is it even possible?
- How so many different people can work together?
- Are you going to find aliens?



# Agenda

- First Part
  - Science objectives
  - SKA Organization:
    - The Consortia
  - SKA system
  - SKA Solutions
    - Internal Organization
    - IGO
    - Reviews
  - Current status and future

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

(what is going to see?)

Testing General Relativity  
(Strong Regime, Gravitational Waves)

Cosmic Dawn  
(First Stars and Galaxies)

Cradle of Life  
(Planets, Molecules, SETI)

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

Cosmic Magnetism  
(Origin, Evolution)

Cosmology  
(Dark Energy, Large Scale Structure)

Exploration of the Unknown

**Extremely broad range of science!**

# SKA Science Working Groups

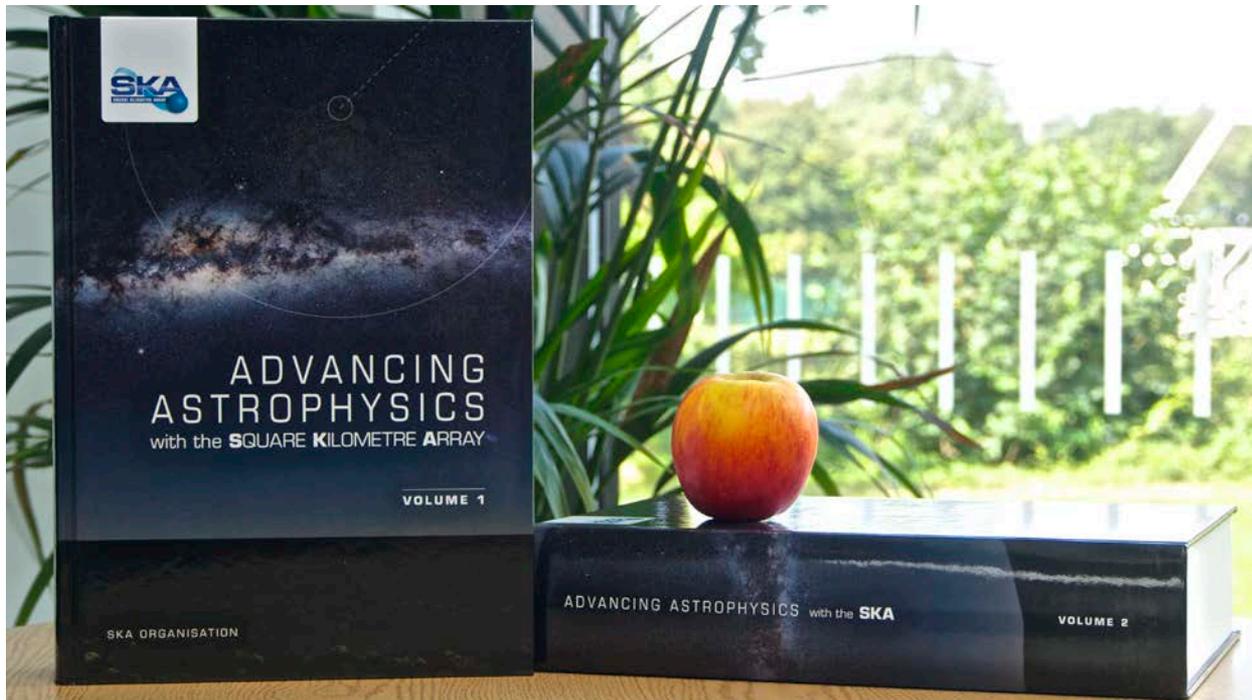
- Current SWGs represent a wide range of scientific areas:
  - Extragalactic Spectral Line (non-HI)
  - Our Galaxy
  - Solar, Heliospheric & Ionospheric Physics
  - Epoch of Reionization
  - Cosmology
  - Extragalactic Continuum (galaxies/AGN, galaxy clusters)
  - Cradle of Life
  - HI galaxy science
  - Magnetism
  - Pulsars
  - Transients
- Technique focused Working Group:
  - VLBI
- Topical Focus Group:
  - High Energy Cosmic Particles

Membership open to any active researcher with willingness to contribute at appropriate level

Anyone can nominate themselves by contacting the current SWG Chairperson (per web site) or SKA Project Scientist/Science Director

# 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!



# SKA Organization: Consortia (1/2)

Who is going to build so many antennas?



10 Consortia are working in the SKA.

DSH – Dish

LFAA – Low Frequency Aperture Array

CSP – Central Signal Processor

SDP – Science Data Processing

SADT – Signal And Data Transport

INFRA – Infrastructure (SA and AU)

TM – Telescope Manager

MFAA – Mid Frequency Aperture array

WBSP – Wide Band Single Pixel Feed

PAF – Phase Array Feed

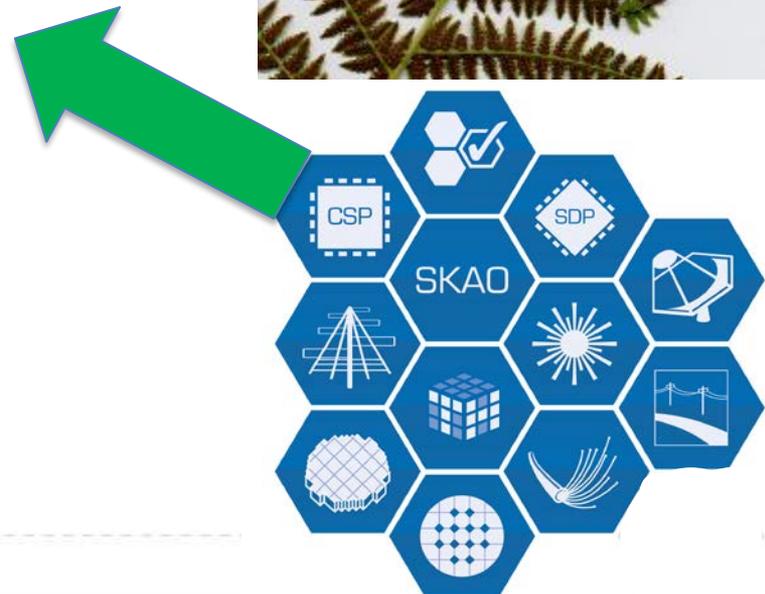


The design consortia were selected following a Call for Proposals issued by SKAO in March 2013.

<https://skatelescope.org/project/>

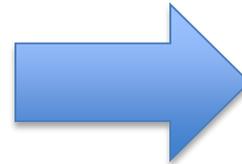
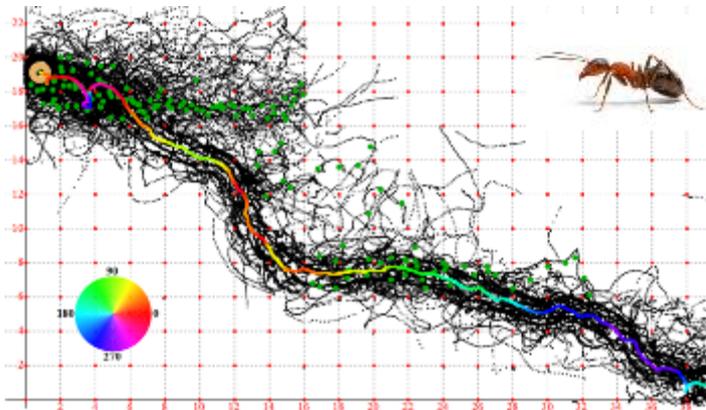
# SKA Organization: Consortia (2/2)

- [Commonwealth Scientific and Industrial Research Organisation \(CSIRO\)](#), Australia
- [International Centre for Radio Astronomy Research \(ICRAR\)](#), Australia
- [Swinburne University of Technology](#), Australia
- [CISCO](#), Australia
- [National Research Council of Canada \(NRC\)](#), **Canada**
- [Canadian Institute of Theoretical Astrophysics \(CITA\)](#), Canada
- [MDA Systems Ltd](#), Canada
- [Key Lab of Aperture Array and Space Application \(KLAASA\)](#), **China**
- [Max Plank Institute for Radio Astronomy \(MPIfRA\)](#), **Germany**
- [National Centre for Radio Astrophysics \(NCRA\)](#), **India**
- [National Institute for Astrophysics \(INAF\)](#), **Italy**
- [SELEX Electronic Systems](#), Italy
- [University of Malta](#), **Malta**
- [Netherlands Institute for Radio Astronomy \(ASTRON\)](#), **The Netherlands**
- [Joint Institute for VLBI in Europe \(JIVE\)](#), The Netherlands
- [Netherlands eScience Center \(NLeSC\)](#), The Netherlands
- [AUT University](#), **New Zealand**
- [Massey University](#), New Zealand
- [University of Auckland](#), New Zealand
- [Compucon New Zealand](#), New Zealand
- [Open Parallel Ltd](#), New Zealand
- [SKA South Africa](#), **South Africa**
- [Reutech Radar Systems](#) (A Division of Reutech Limited), South Africa
- [Ingeniería de Sistemas para la Defensa de España \(ISDEFE\)](#), **Spain**
- [Universidad Politécnica de Madrid \(UPM\)](#), Spain
- [IBM Zurich](#), **Switzerland**
- [Science and Technology Facilities Council \(STFC\)](#), **UK**
- [University of Manchester](#), UK
- [University of Oxford](#), UK
- [Adaptative Array Systems Limited](#), UK
- [NVIDIA](#), **USA**
- [JPL](#), **USA**



# SKA Organization

- Consortia are needed (is where the how know-how can be find) but it is complex for them to keep the same pace.

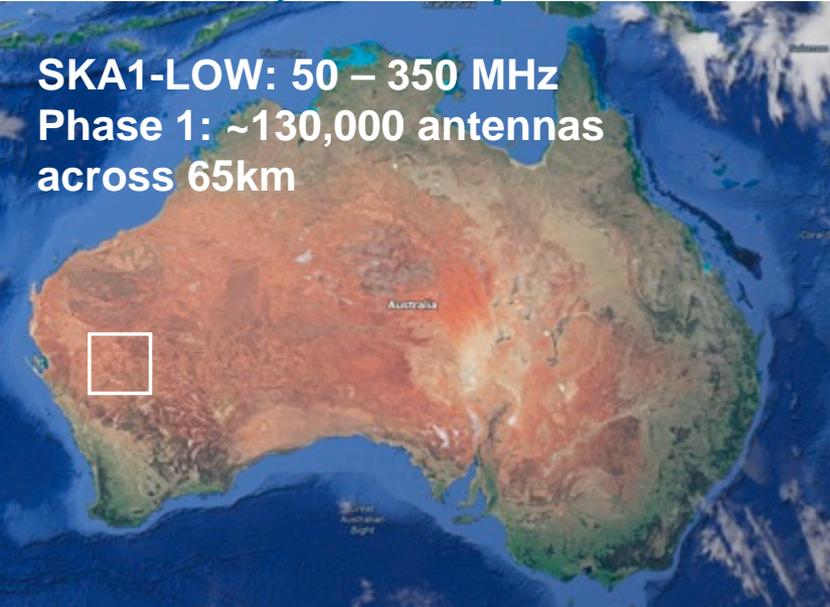


# SKA: 1 Observatory – 2 Telescopes

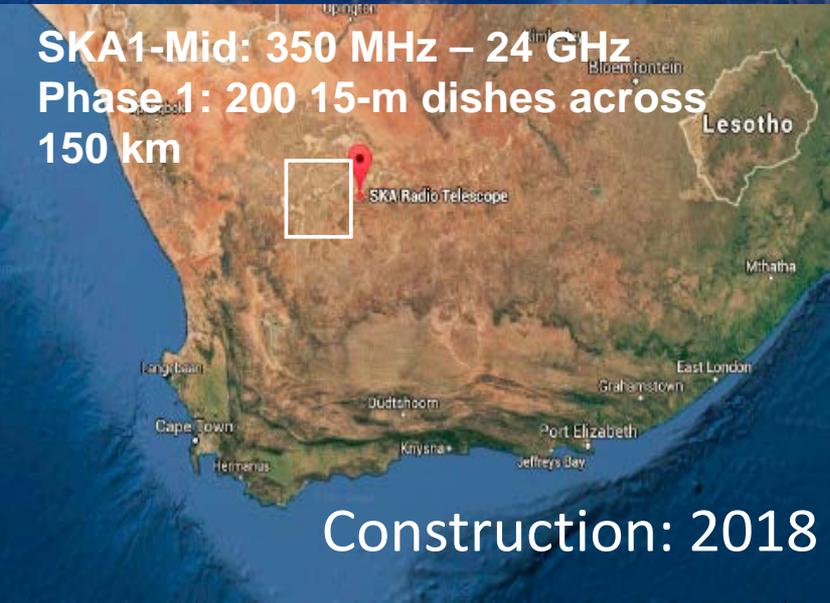
## HQ in UK; telescopes in AUS & RSA



**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**



**Construction: 2018**



## SKA System: Are we building the thing right?



**SKA-LOW: Australia**  
**~130,000 antennas then**

**500 stations over 80 km**  
**Raw data output: Tb/sec, ZB/yr**  
**Huge engineering, computational and science challenge**

**SKA-MID: Africa**

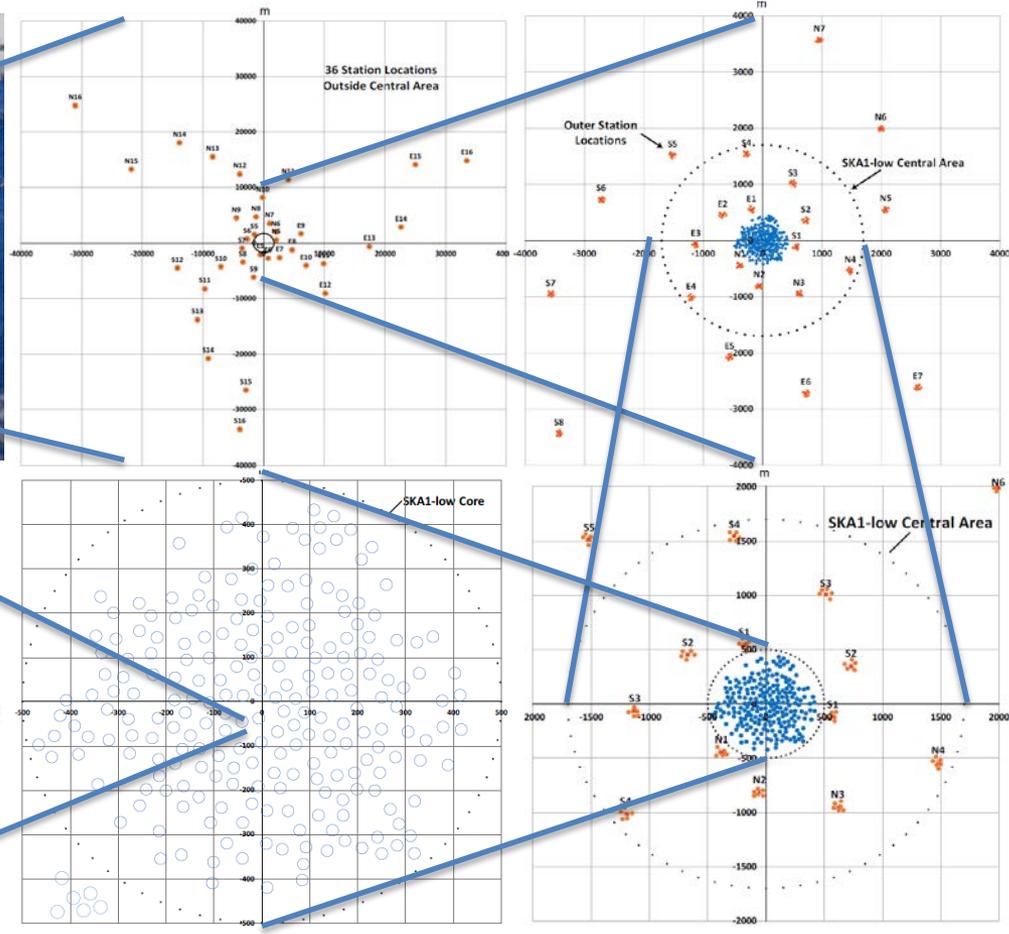
**200 15-m dishes across 150 km**

**Massive increase in capability over current facilities**

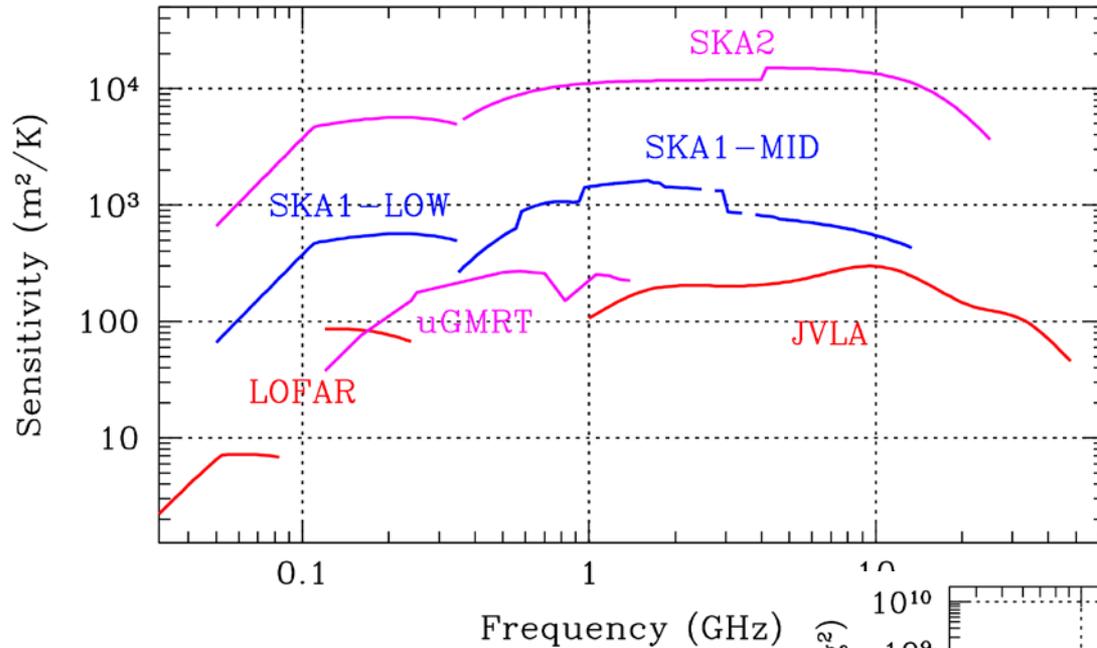
**Huge data rates and infrastructure challenge**



# SKA1 Configuration

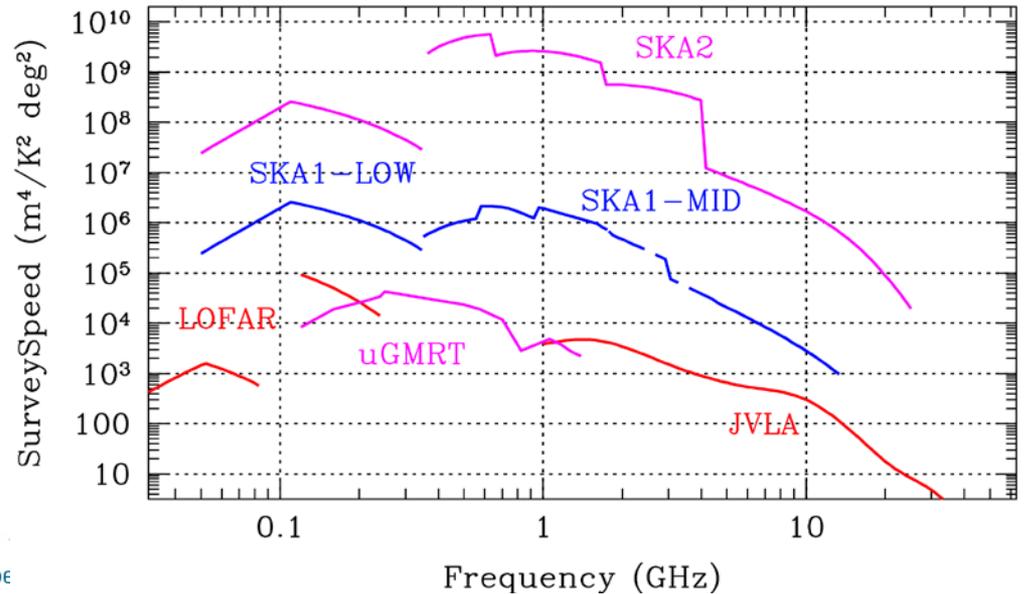


# SKA1 capability vs state-of-the-art

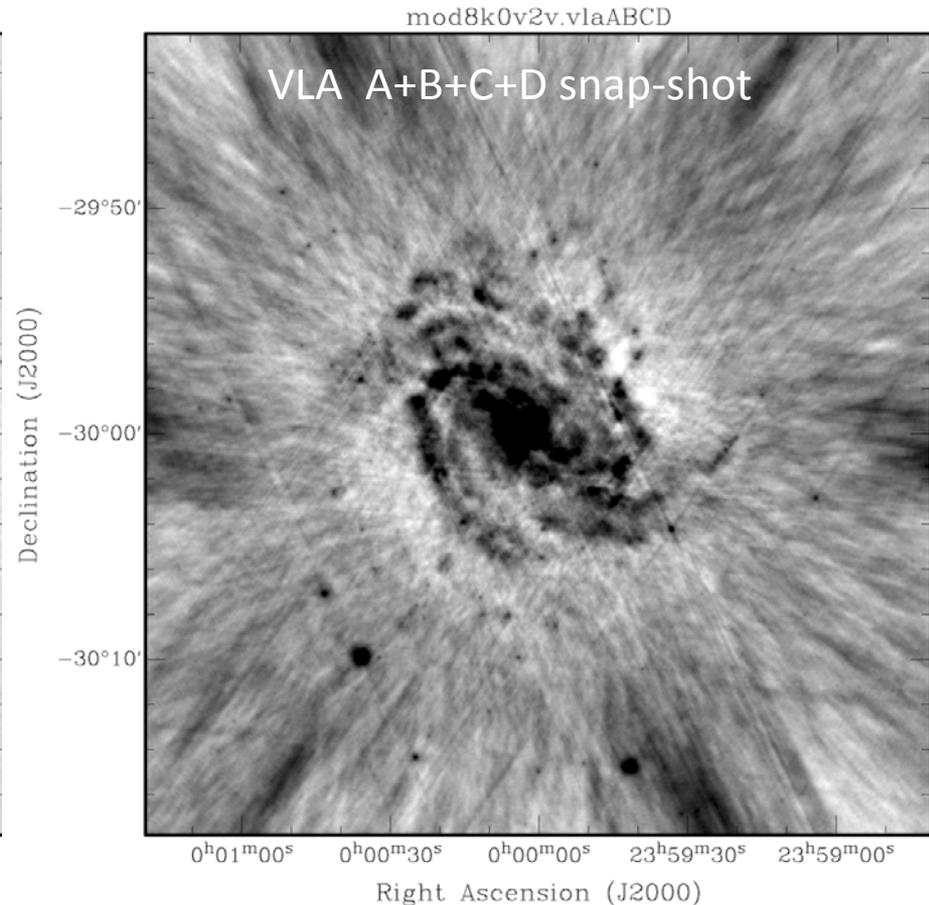
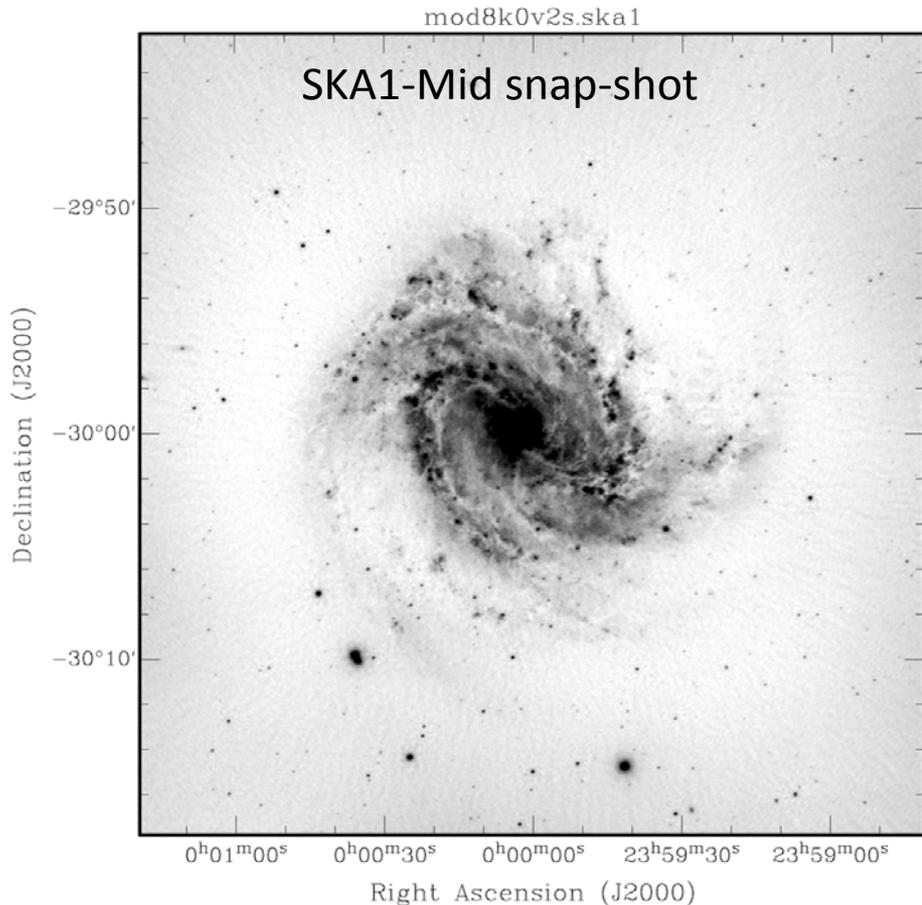


Point-source sensitivity:  
 $\sim 4 - 20$  times state-of-the-art

Survey speed:  
 $\sim 10 - 100$  times state-of-the-art

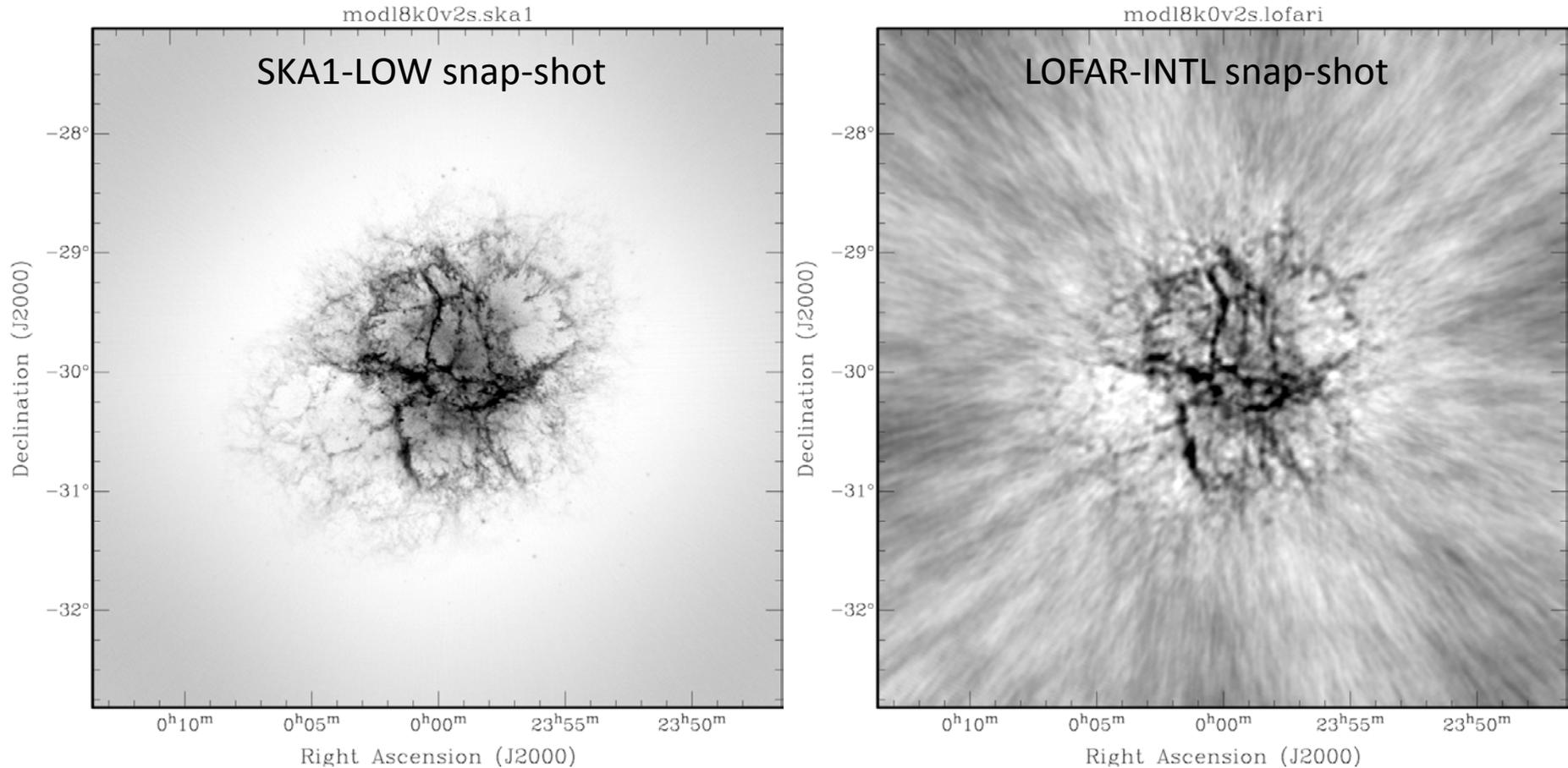


# Image Quality Comparison



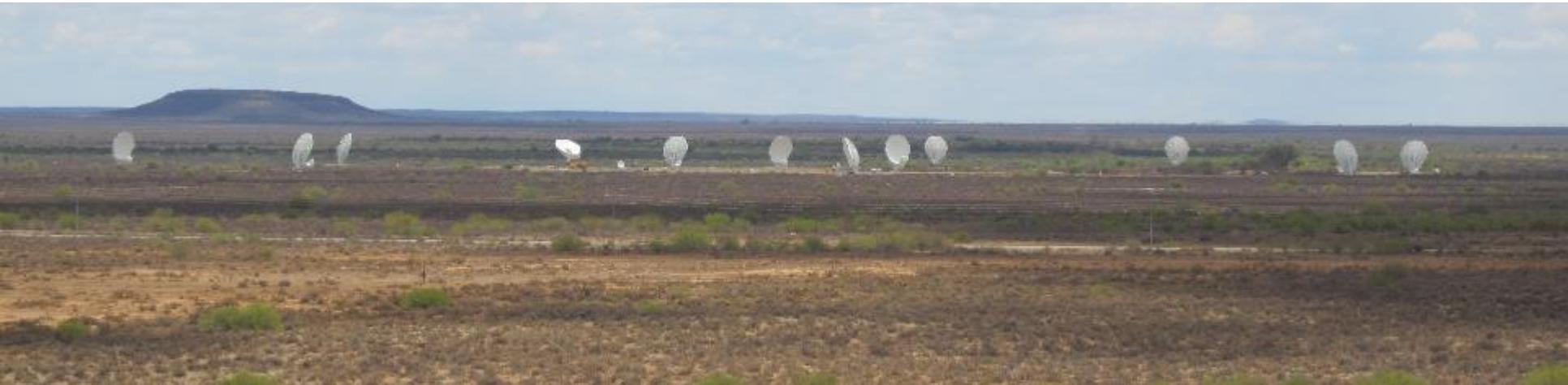
- Single SKA1-Mid snap-shot compared to combination of snap-shots in each of VLA A+B+C+D

# Image Quality Comparison



- Single SKA1-Low snap-shot compared to LOFAR-INTL snap-shot

## Construction stage: Are we building the thing right?



The main difficulty are:  
to guarantee same quality and results for such a big number of  
elements  
**and**  
To guarantee it for a life cycle of 50 years  
**And..**

## Construction stage: Challenges (3/3) Are we building the thing right?



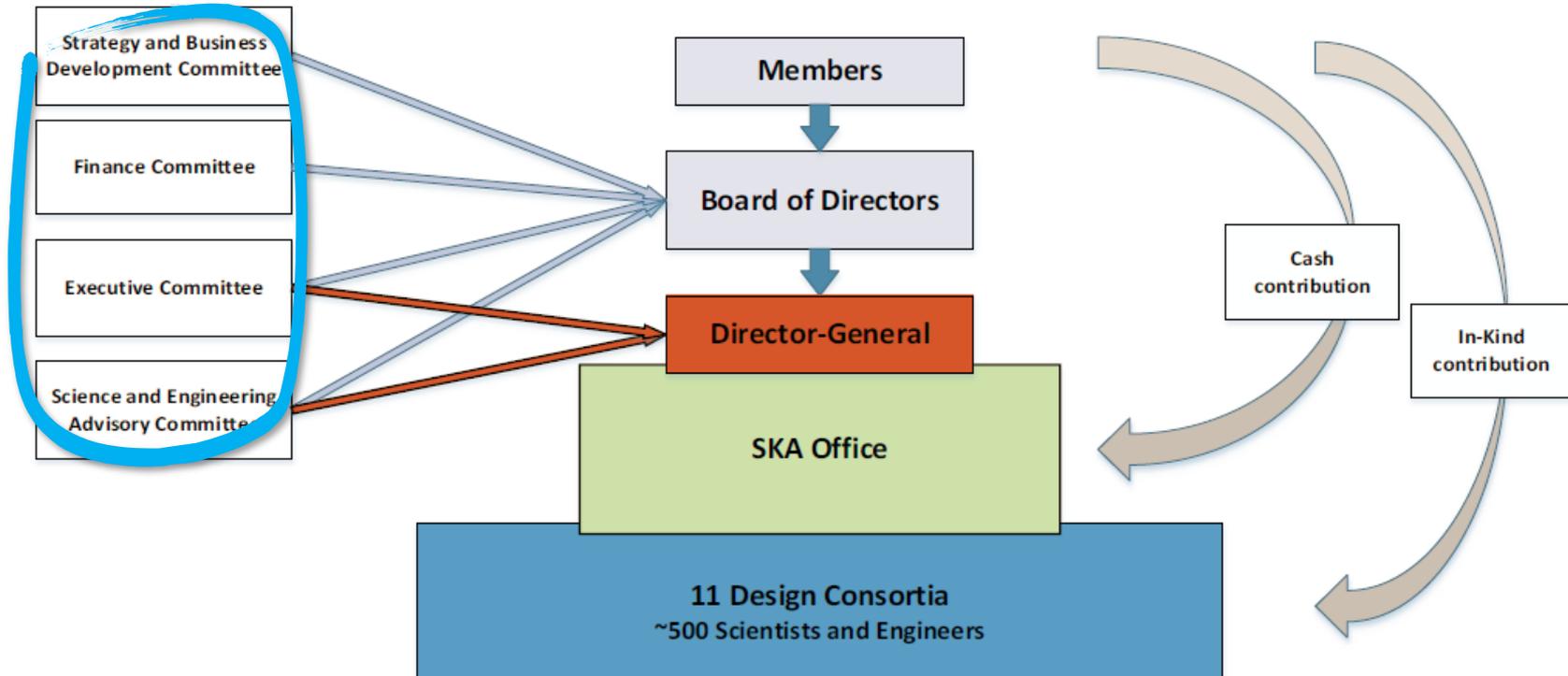
**And..**

To stay within the cost cap  
(Construction Cost: 674Meuro  
Operation cost: underway)

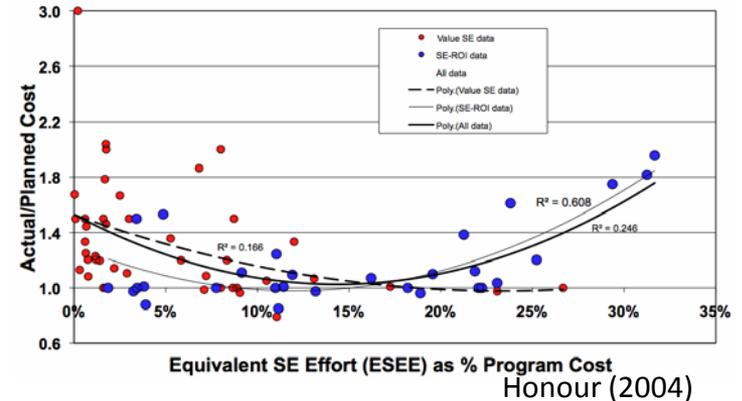
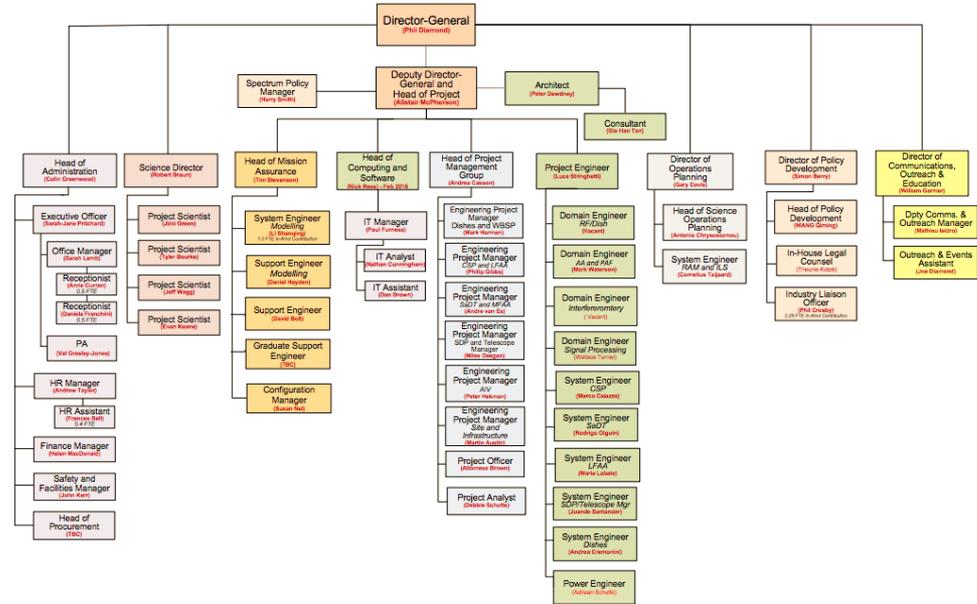
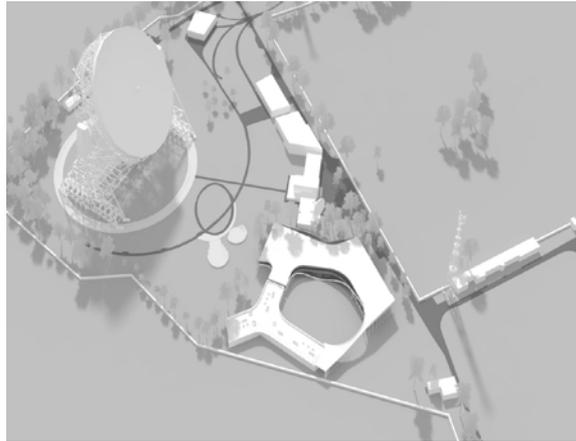
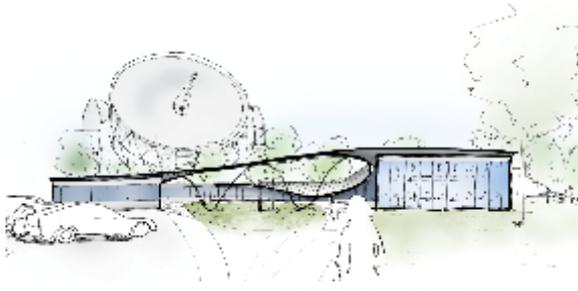
**Descoping is not an  
option!**



# SKA Solution space: Organiz. (1/2)



# SKA Solution space: Organiz. (2/2)



Currently, there are 53 FTE within the SKA Office from.

- UK, USA, South Africa, Australia, Canada, Japan, China, France, Spain, Chile, Netherland, Germany, and Italy

# SKA Solution Space: 10 countries, more to join



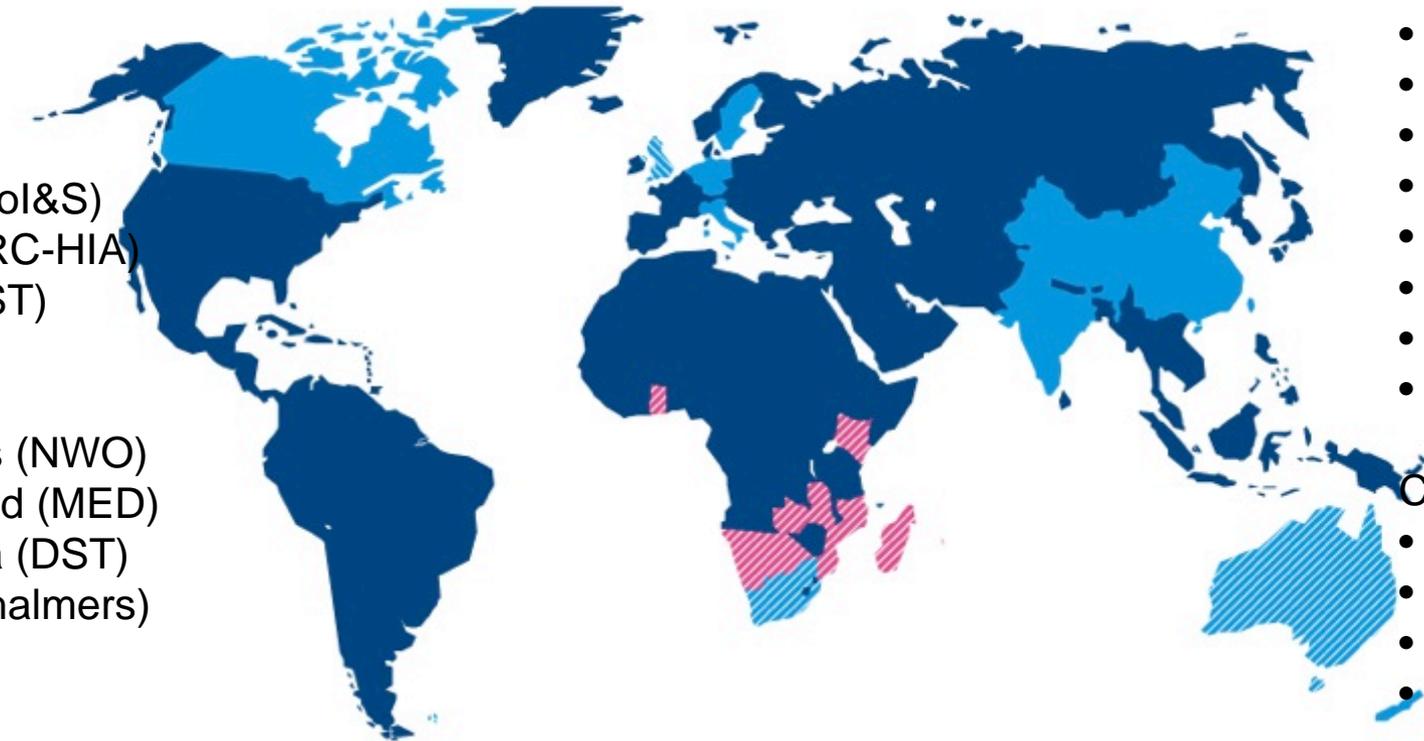
Australia (DoI&S)  
 Canada (NRC-HIA)  
 China (MOST)  
 India (DAE)  
 Italy (INAF)  
 Netherlands (NWO)  
 New Zealand (MED)  
 South Africa (DST)  
 Sweden (Chalmers)  
 UK (STFC)

## Observers:

- France
- Germany
- Japan
- Malta
- Portugal
- Spain
- Korea
- USA

## Contacts:

- Brazil
- Ireland
- Russia
- Switzerland



- Full members
- ▨ SKA Headquarters host country
- ▨ SKA Phase 1 and Phase 2 host countries



- ▨ African partner countries (non-member SKA Phase 2 host countries)

This map is intended for reference only and is not meant to represent legal borders

# SKA Solution Space: IGO

- Will evolve to an SKA IGO, similar to ESO/ESA/ITER/EMBL/
- Rationale:
  - Government commitment: Long-term political stability, funding stability
  - Availability of Privileges and Immunities from members
  - ‘Freedom to operate’, specifically through procurement process
- **IGO Formal Negotiations**
- Rome: Minister Enrico Vicente (Italy) – Chair.
- All 10 countries present: 9 with negotiating mandate





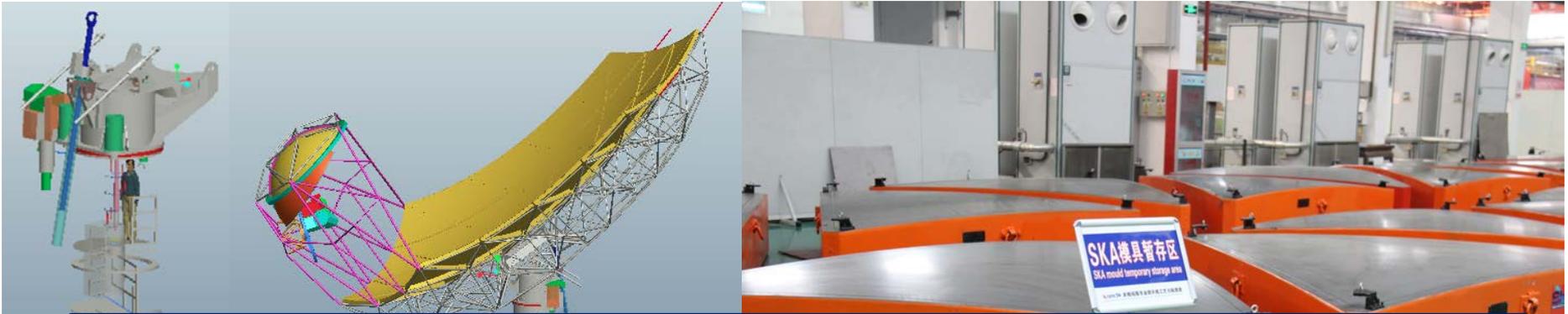
Exploring the Universe with the world's largest radio telescope

# SKA Solution: Keep the pace

- SKAO is continuously under review from external players
  - System Review (April 2016)
  - Management Review (May 2016)
  - System PDR Review (Dec 2017)
  - More to come....
- Reviewers
  - ALMA
  - TMT
  - CERN
  - ESOC
  - STFC
  - ESO
  - ...



# Technical Progress



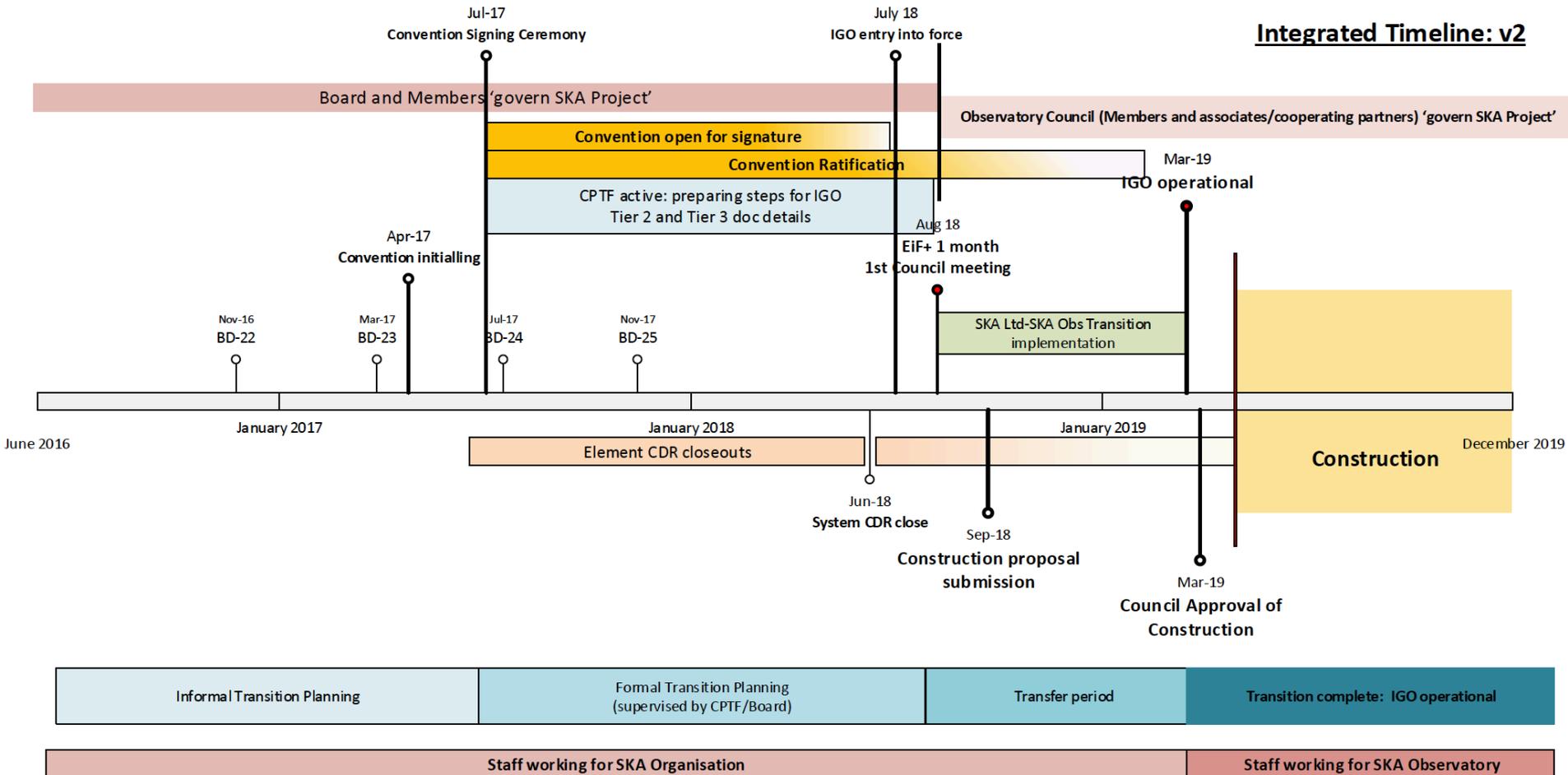
Headline: SKA System PDR passed in December, subject to some work now underway.



# Overall project timeline – to be confirmed.



## Integrated Timeline: v2



### Key dates:

- Convention signing July 2017
- CDRs Q4 2017 – Q2 2018
- IGO enter into force July 2018
- SKA1 Construction approval early 2019



## 2017 SKA Engineering Meeting

12–16 June 2017

Rotterdam, the Netherlands

[#SKAengcon17](#)

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