SKA SWG Update

Robert Braun, SKAO Science Director

21 March 2023

SKA Science Update

- Commissioning and Science Verification (Robert Laing)
- Proposal Planning (Tyler)
- Science Meetings
- AOB


SKAO
Plans for SKA Commissioning
and Science Verification
Robert Laing
SWG, March 21 2023

Key Dates (as of 2023 January report)

Event	MID	LOW
Integration Test Facility start	2023 Jan	2023 Feb
AA0.5 Integration and Verification start	**2024 Jun**	**2024 Apr**
AA0.5 end	**2024 Dec**	**2024 Aug**
AA1 end	2025 Nov	2025 Oct
AA2 end	2026 Oct	2026 Sep
AA* end	2027 Aug	2028 Jan
Operations Readiness Review (handover to Operations)	2027 Nov	2028 Apr
End of construction (including contingency)	2028 Jul	2028 Jul

Dates are earliest possible, except for the end of construction, which includes contingency. End dates are milestones from the Integrated Project Schedule (IPS).

Brief Definitions

- **Observing Mode:** *A distinct type of observation applicable to a range of astronomical targets.*
- **Assembly (A):** *The activities required to physically establish a product of the SKA Telescope System on-site.*
- **Integration (I):** *The activities required to incorporate a product into the SKA Telescope System*
- **Commissioning (C):** *All activities necessary to arrive at a working end-to-end system that can be used to perform system verification*
- **Science Commissioning (SC):** *The subset of commissioning which requires specification, execution and analysis of astronomical observations.*
- **Verification (V):** *All activities that are executed to formally verify the Telescope system against its Level-1 Requirements.*
- **Science Verification (SV):** *All activities that are executed to verify the Telescope system against its Level-0 Requirements, i.e. to ensure that the Telescope system meets the needs of the science and operational user*

(Science) Commissioning

- **Commissioning**
  - *All activities necessary to arrive at a working end-to-end system that can be used to perform system verification.* These include:
    - setting-to-work
    - integration testing
    - system testing
    - execution and analysis of test science observations, with the aim of debugging the system.
  - Commissioning is a collaborative, interdisciplinary activity, requiring skills in astronomy / interferometry, signal processing, control and data-analysis software, as well as hardware engineering. It is a highly iterative process, usually involving several repetitions of each test.
  - Boundaries between AIV (hardware and software), Commissioning and Operations are fundamentally blurred
- **Science Commissioning**
  - *The subset of commissioning which requires specification, execution and analysis of astronomical observations.*
  - This is separated out, since it will be primarily performed by a different group from that responsible for engineering commissioning.

Science Commissioning Test Groups

- Basic functionality (AA0.5)
- Dish (MID) and Station (LOW) Calibration
- Array Calibration
- Interferometric Imaging
- Beamforming and non-imaging modes
- Regression and integration tests
- Calibrator and Global Sky models

- Repeat single-dish/station tests
- Single-baseline interferometry ("first fringes")
- Basic multi-element interferometry using point-source calibrators/simple fields
  - Calibrate flux, complex gain, bandpass, delay, leakage, ….
  - Array calibration and stability (dish/station locations, cable delays, ..)
- Rudimentary imaging
- Dish/station characterisation with interferometry/holography
- Single tied-array beam for pulsar timing

Commissioning Scientist Skills

- Understand the system as a whole and be able to diagnose (possibly complex) faults in collaboration with hardware and software engineers
- Collectively be able to cover all of the key test group areas
- Have experience with technically similar projects
- Have data reduction and scripting skills
- Collaborate effectively with other disciplines
- Know what the science users expect

Recruitment and retention is a concern

Intend to enable transition from commissioning to operations at the end of construction, both to provide a career path and to ensure knowledge transfer

Opportunity for early hires in South Africa → Training/experience on MeerKAT (SEAC recommendation)

Support Assumptions

- Science Commissioning and Verification Teams are based primarily at Perth and Cape Town
  - Very limited travel to array sites: requires good communications with site staff
  - Co-located with AIV (computing, correlator)
- Access to the Array
  - LOW: Assume contractors working 0700-1700, 7 days/week
  - MID: Assume contractors working 0700-1900, weekdays
  - Cannot guarantee RFI levels during these times
  - Primary science commissioning/verification periods at night
    - What fraction of night-time will be available in practice? Current assumption is 50%
    - Will need daytime access for some tests: live with RFI or negotiate access
- Operator and on-call technical support consistent with this assumption
  - Array Operator executes observations
  - Science Commissioning Team plans observations; reduces data (again, some special cases)

Science Verification

All activities that are executed to verify the Telescope system against its Level-0 Requirements, i.e. to ensure that the Telescope system meets the needs of the science and operational users.

- Science verification will be implemented as a set of end-to-end tests of the system from proposal submission to data delivery.
  - Each test verifies one or more *observing modes.*
  - There will be a range of targets, with an emphasis on comparison with results from other telescopes.
  - Modes may be verified periodically as array capabilities mature.
- The Science Operations Team performs Science Verification supported by the Commissioning and AIV teams.
  - Science Verification is used to test reduction tools as well as observational procedures.
  - SV provides feedback to the Commissioning and Operations teams.

Science Verification Process

- Based on ALMA/ESO model
- Announcement to the Community inviting short proposals to utilise specific modes and capabilities of the SKA.
- Internal technical appraisal of the proposals received by the Observatory to ensure that they meet the stated objectives.
- Light-touch priority assessment, which could be by external group (SEAC?) or internal to the Observatory.
  - Pool of suitable proposals, not a scientific ranking
  - Comparison with observations of the same targets with other arrays if sensible
- Execution of a full end-to-end test, starting with a mock proposal and ending with Quality Assurance and data delivery.
  - Partial in early phases
- Data releases will be public and announced in advance.
  - Made by the Regional Centres.
  - Fully processed data products (e.g. image cubes, averaged visibilities)
  - Visibility data in earlier phases
- Each SV observation generates a report which can be used to assess the status of the associated observing mode.

Stages of Science Verification

- Early
  - Worthwhile from later phases of AA2, when capabilities become comparable with existing arrays.
  - Interspersed with science commissioning; no long, dedicated SV blocks
  - ~200 hr for each array in AA2, ~Q3-4 2026 on the current schedule
- Preparation for Cycle 0: first open call, shared risk
  - Observing Modes Review to decide what to offer in Cycle 0
  - Dedicated block of SV observations scheduled to inform this review (~9 months before end AA*)
- Handover to Operations
  - The formal end of construction is signified by a successful Operations Readiness Review (ORR). This will demonstrate the ability of the Observatory to execute a set of key observing modes, illustrated by end-to-end tests of representative Science Verification projects from proposal preparation to (public) data delivery.
  - Requires a second dedicated SV block (“Dress Rehearsal”) at the end of AA*
  - Also acts as the Observing Modes Review for Cycle 1

How do the parts fit together?

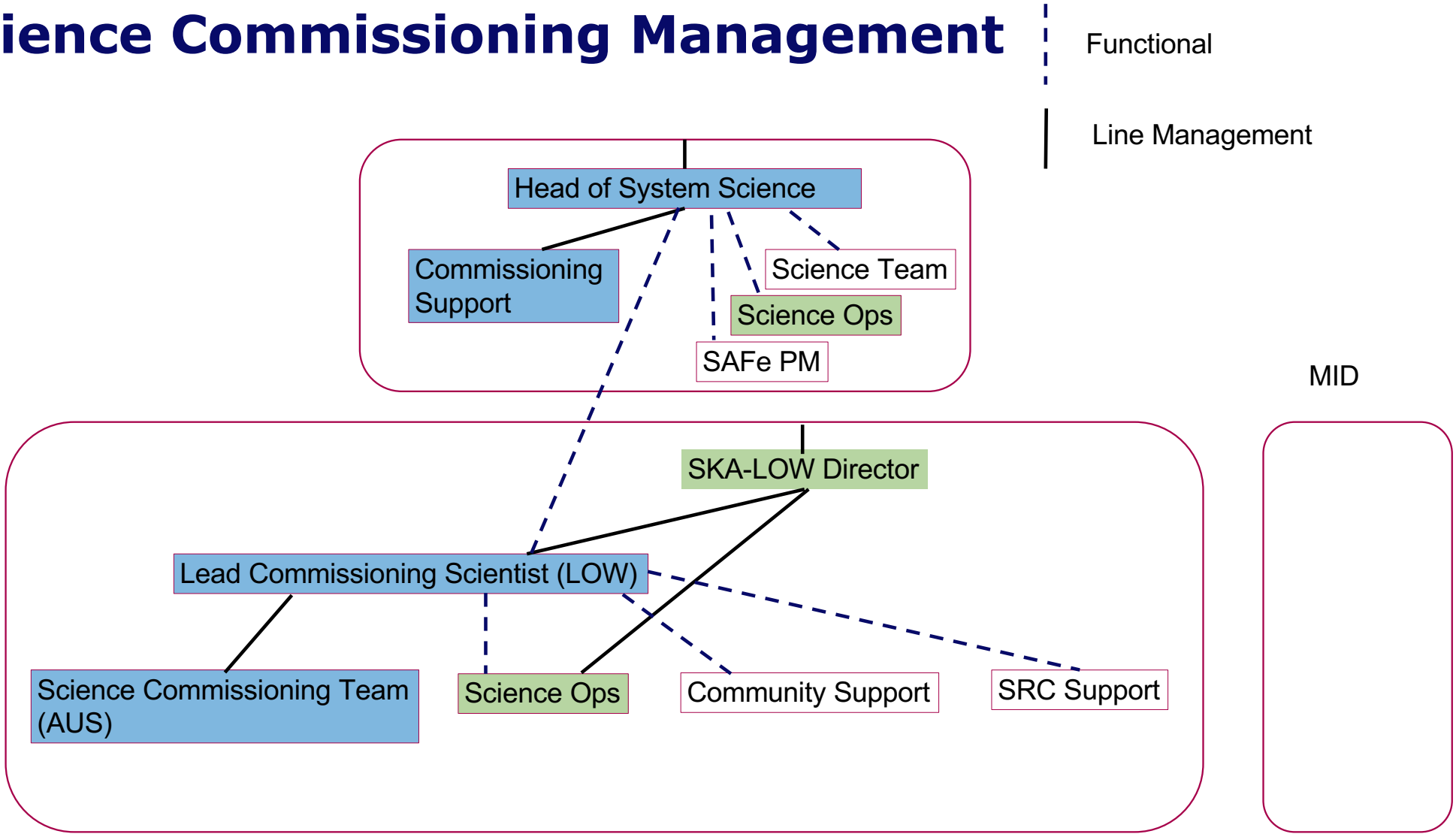
Integrated Engineering + Science Teams for MID and LOW

For a given observing mode:

- AI → C → fix problems → C → V → SV → additional IV, C, SV → Operations
  - with iteration until the performance is good enough to meet user expectations.
  - Overall balance of activities tends to change between AIV and science commissioning as the array develops, with the latter increasing in importance as the system matures.
  - Similarly with science commissioning and verification
  - Flexible work assignments: ”all hands to the pumps”
  - Not the classical “V diagram”

- **Planning Cadence**
  - Longer-term planning on a three-monthly cycle, synchronised with SAFe programme increments.
  - Group leaders meet weekly (chaired by the Engineering Lead) to coordinate work on site
  - Daily planning/fault triage meetings with delegated responsibilities.

Science Commissioning Management



Hiring

- Plan is to have the first Commissioning Scientists in post 3-6 months before the start of AA0.5 tests on the sky.
  - Advertise ~June 2023 for LOW and ~August 2023 for MID
  - SEAC recommendation to hire junior commissioning scientists early to work on precursors – currently under discussion

Community Involvement in Commissioning

- Experienced commissioning astronomers from the community contribute a **huge** amount, but are very rare.
  - SKA needs to attract them
- Degree of involvement in hands-on commissioning varies a lot between sub-fields
- Not usually effective to offer observing time in exchange for commissioning effort, but motivating/rewarding commissioning scientists with access to the array is beneficial.
- Substantial commitments of time are needed (usually >3 months) with at least some f2f contact with the core commissioning team initially.
  - Involving outside people/groups can be a major effort for the core team
  - "No Astro-tourists"
  - Structured training and management of community effort is essential.
- SKAO will be flexible in supporting community engagement in commissioning

SKA Time Allocation Process: Access, Proposals, Review, & Allocation

- Principles of Access to SKA Resources
- Proposal Types
  - KSPs …
- Telescope Access
- Proposal submission & review
- Extras
  - Policy/regulation documents
  - Definitions
  - Member share accounting
  - Road to science (indicative timeline)

Guiding Principles

- Access is proportional to Member share
- Allocation is based on science merit and technical feasibility
- Access and allocation of SKA “Schedulable Resources”
  - Schedulable Resources include:
    - telescope time on sky (traditional resource)
    - associated computing resources needed to process the data, for example the Science Data Processor (SDP)

Access to SKA Resources

- SKAO resources are made available to scientists from Member and non-Member states
  - For members, allocation is proportion to their share in the project
  - For non-members, allocation is capped at a percentage defined as Open Time
  - Time allocation for all is based on scientific merit and technical feasibility, evaluated by a common proposal review process
- Calibrated data will be automatically generated by SKAO, these are called Observatory Data Products (ODPs) ✗ **Raw Data**, ✓ **See next page**
- Scientists will access ODPs via SKA Regional Centres (SRCs)
  - may require further processing (e.g., co-adding) to produce Advanced Data Products (ADPs) for analysis

SKA Observatory Data Products

- Currently foreseen Data Products that can be produced by SDP at both single observation and project level

Image Cubes	**Calibrated restored images, residuals, etc**
uv Grids	**Calibrated gridded visibilities**
Calibrated Visibilities	**With time and frequency averaging**
LSM Catalogue	**Sky Model of FoV**
Imaging Transient Source Catalogue	**Alerts from fast imaging pipeline**
Pulsar Timing Solutions	**ToA and timing model residuals**
Transient Buffer Data	**Voltage data following trigger**
Pulsar and Transient Candidates	**Output of search pipeline**
Science Alerts Catalogue	**Searchable IVOA record of alerts**
Science Product Catalogue	**Searchable record of data products**

Proposal Types

Key Science Projects (KSPs)

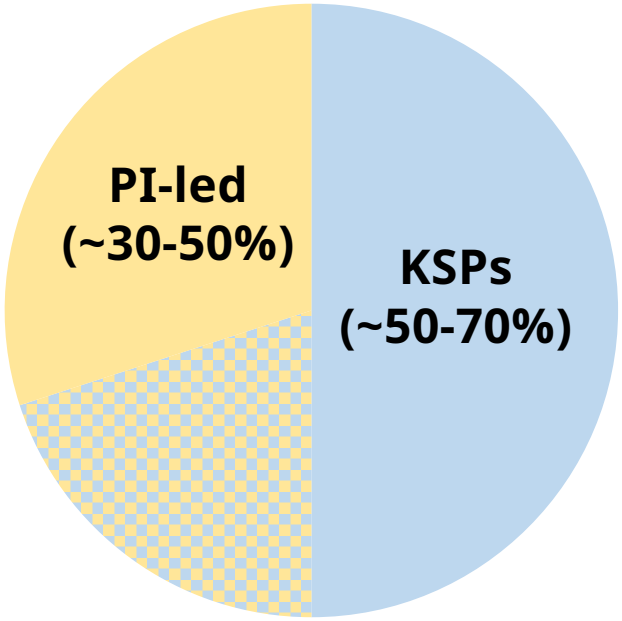
- Large programs that require the allocation of significant observing time (a few x 100h ? - TBC) and resources, performed over multiple cycles (nominally 1 cycle = 1 year)
- PI & leadership team from SKA-member countries; co-Is from any country (latter may be limited)
- Expected to provide added-value data products and tools back to SKAO
- Regular reviews to track progress toward goals

Principal Investigator (PI) Projects

- Smaller programs (< KSP) performed within a single cycle

Director-General's Discretionary Time

- Time allocated by the D-G outside of the normal TAC process



Indicative allocation split over first 5 years of normal operations

Possible Proposal Attributes

Target of Opportunity (ToO)

- rapid response triggered internally or externally
- may override currently executed observations
- may be awarded by normal review process, or by D-G as a DDT proposal outside of this process

Long Term Projects (LTP)

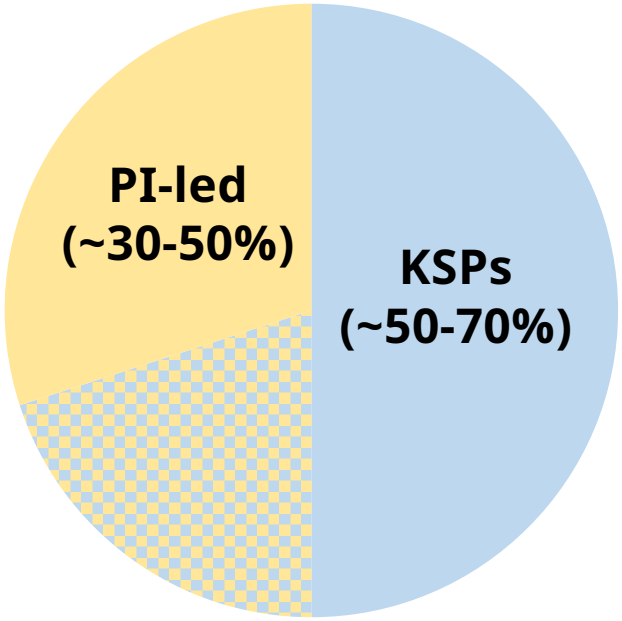
- requires more than one proposal cycle, but don't qualify as a KSPs

Joint SKA Project (JSP)

- requires both SKA-Mid and SKA-Low, and may require simultaneous observations (or very near in time)

Coordinated Project

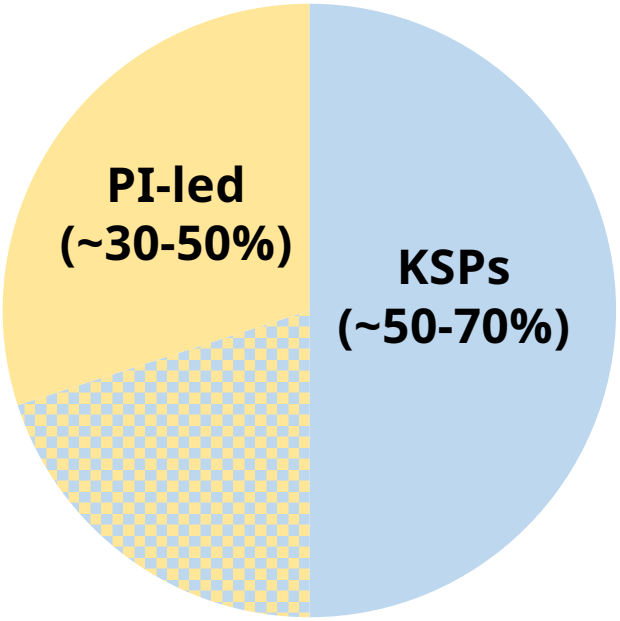
- of SKA observations with other facilities (ground or space based). Example is VLBI



Indicative allocation split over first 5 years of normal operations

Key Science Projects (KSPs)

- must demonstrate they address **extremely compelling science questions**
- may take up to 5 proposal cycles to complete (nominally 1 cycle = 1 year)
- requires a **Leadership Team** to oversee the delivery of the scientific outcomes
- Leadership Team will normally be no more than 10 individuals (one member will be the main contact for communications with SKAO, in place of a PI)
- Leadership roles are only **open to scientists from Member countries**; co-Investigators may come from any country
- Progress will be reviewed regularly by an expert panel; if the science goals are unlikely to be achieve the D-G may terminate or reduce the project

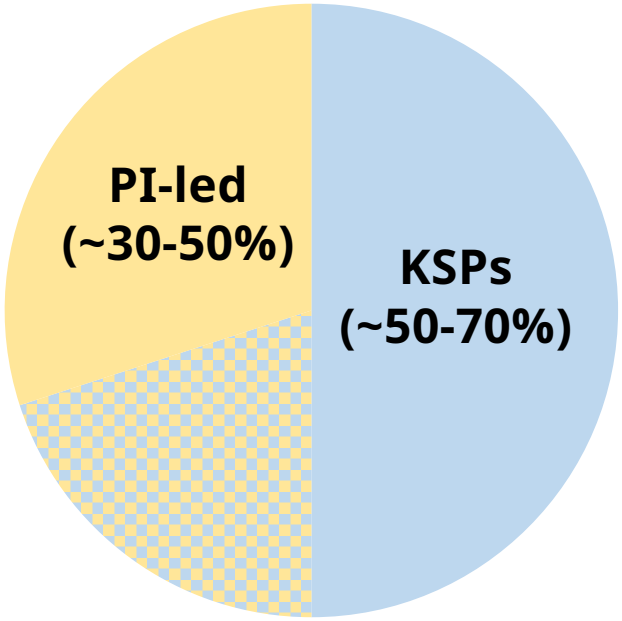


Indicative allocation split over first 5 years of normal operations

Key Science Projects (KSPs)

Each KSP proposal will be required to include:

- a detailed management plan describing the roles and responsibilities of each member of the KSP Leadership Team and the qualities they bring to the proposed science
- a plan for the reduction and analysis of Observatory Data Products (giving details of any secured resources at SRCs)
- a plan for the dissemination of scientific results to emerge from the project
- a justification for any investigators on the KSP proposal from non-Member countries[1]
- a plan for the submission of ADPs into the SKAO Science Archive.



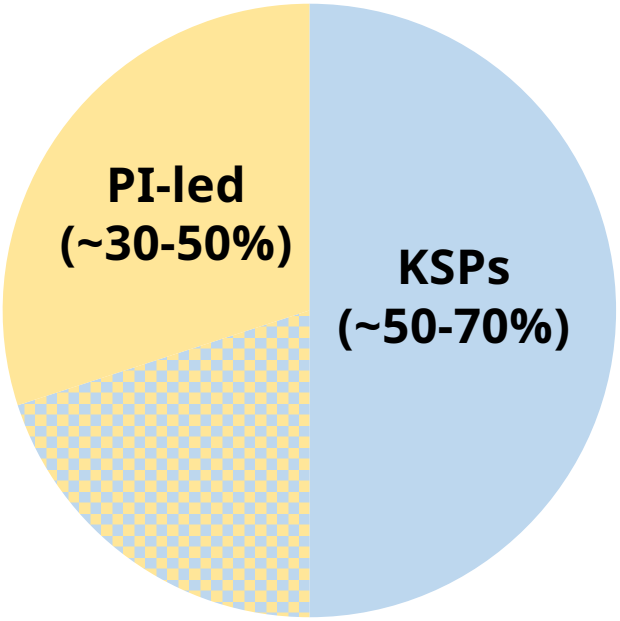
Indicative allocation split over first 5 years of normal operations

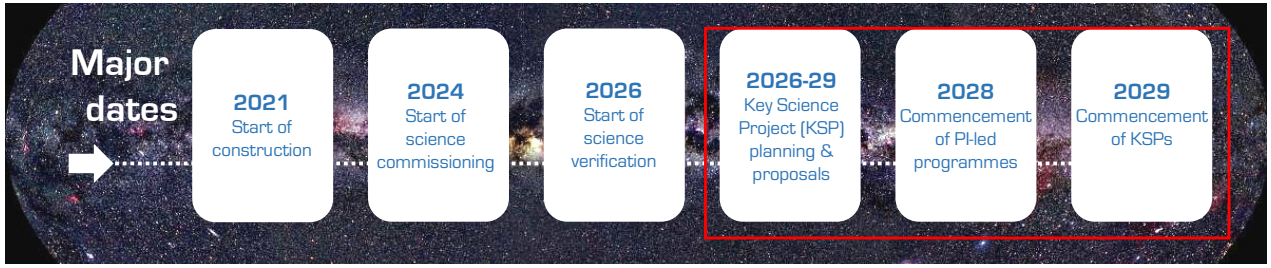
[1]a limit may be set on the fraction of investigators from non-Member countries.

Key Science Projects (KSPs)

Planning for KSPs:

- SKAO will run at least one planning workshop and issue a call for Letters of Intent (preliminary co-ordination), starting > 2 years before first KSP observations
- Workshops provide a forum for co-ordination and perhaps collaboration of proposals with similar science goals and technical needs
- Data Challenges, to help the community get used to working with SKA sized data





Telescope Access

Commensal Science

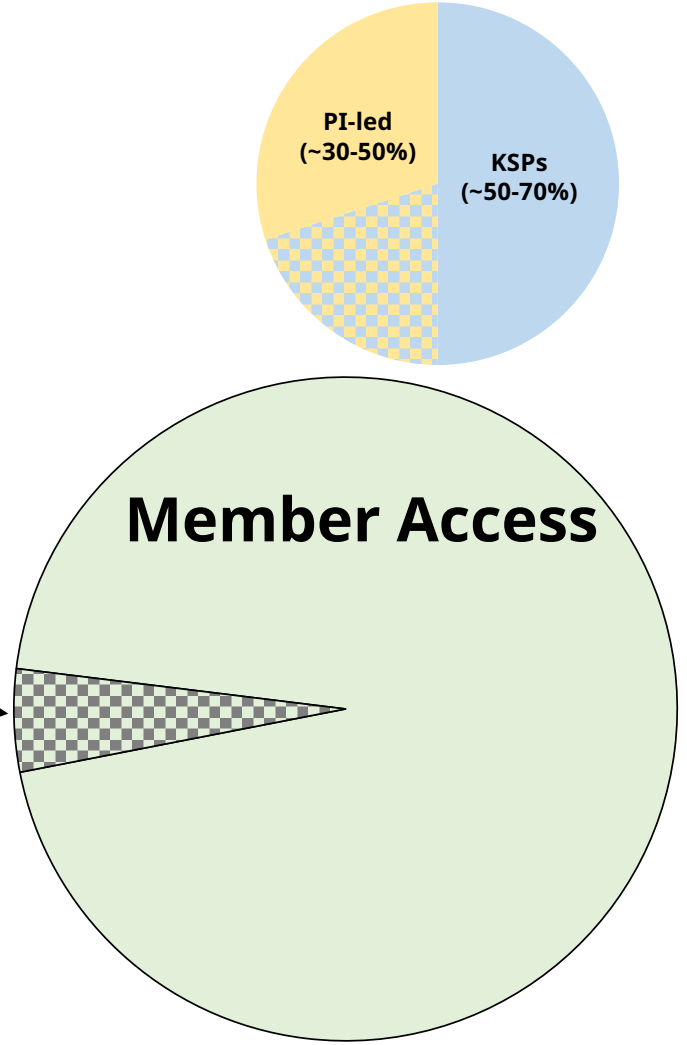
- Maximizes the use of SKA resources
- Commensal science is not ”free”, will be counted against member share
  - Data: different projects use same data products for different science goals
  - Observing: difference projects use same signal/data for different data products (e.g., cont., line)
  - Multiplex: different subarrays observing at the same time

Members (and Associate Members)

- Can lead any program (KSP, PI)
- Can be part of KSP leadership teams
- Access in proportion to member share

Non-Members

- Can lead PI programs
- Can be team members of KSPs, but not part of leadership team
- Access capped at **5% (”Open Time”;** TBC by Council)
- Access to any individual non-member entity may be capped



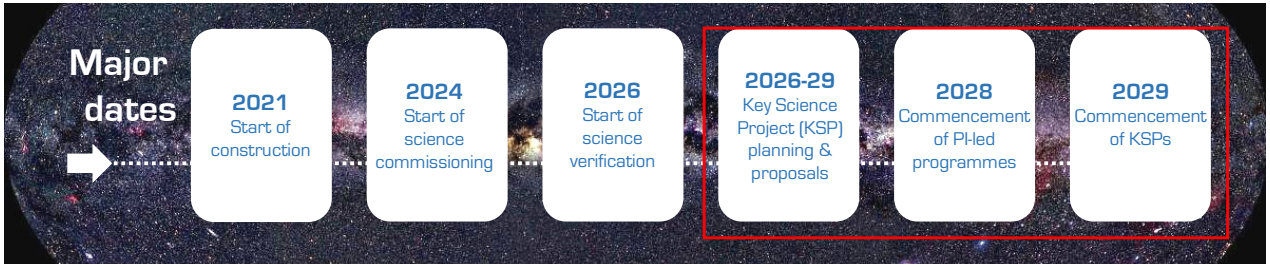
Telescope Access

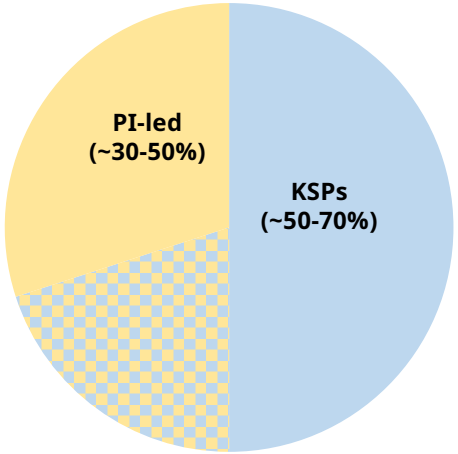
NO time has been allocated for ANY project

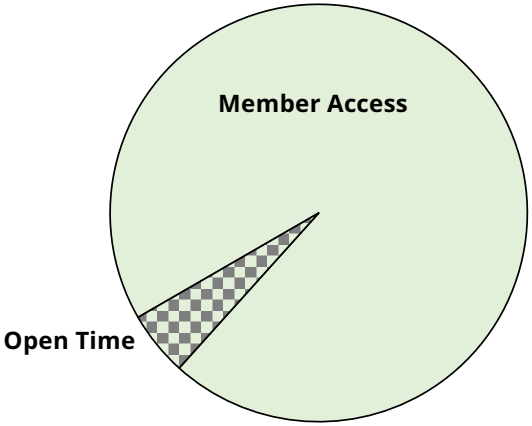
SWGs are NOT proto-KSPs, although they are intended to be a forum for KSP planning

There are NO guaranteed KSPs

Time allocation will be based on
SCIENTIFIC MERIT
and technical feasibility
through a common proposal review process
(while accounting for member share)



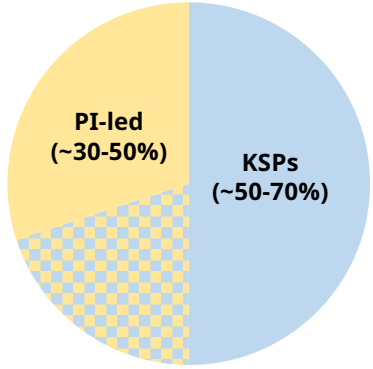


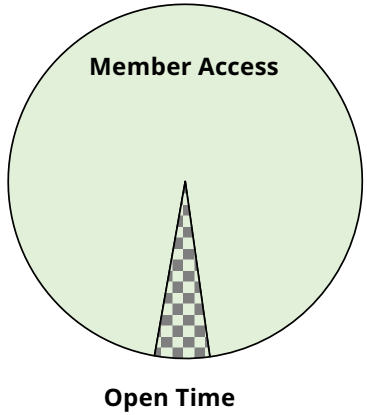


Proposal Submission & Review

Proposal Review

- All proposed reviewed and assessed by a Time Allocation Committee (TAC)
- SKAO will undertake a technical feasibility review, including evaluation of SRC resources that will be required
- TAC members appointed by D-G with advice from SKAO staff
- Proposal assessment shall be:
  - driven by scientific merit and technical feasibility
  - be fair and transparent, informed by peer review
  - be able to resolve conflicts of interest
- The TAC shall:
  - rank each proposal according to scientific merit and technical feasibility
  - provide a recommendation of telescope time and resources for each proposal
  - present a ranked list of proposals to the D-G
- The SKAO shall construct the science program, considering:
  - sky coverage
  - scheduling feasibility
  - observatory resources
  - opportunities for commensality
  - members' share of the project





Science Meetings

- Joint ESO/SKAO meeting "Coordinated Surveys of the Southern Sky", in Garching: week of 27 February 2023 https://www.eso.org/sci/meetings/2023/CSSS.html
  - White paper now being written, draft by July
- PHISCC 2023 – "HI surveys in full swing", Cape Town, 27 – 31 March 2023 http://www.astro.rug.nl/phiscc2023
- Joint SKAO/ngVLA Science Conference, Vancouver, 1 – 5 May 2023, (see next slide), http://go.nrao.edu/ngVLASKA
- Timing and Imaging of compact sources with SKA pathfinders and precursors, Kerastari, 12 – 18 June, https://www.atnf.csiro.au/research/conferences/2023/Kerastari2023/index.html
- Community of European Solar Radio Astronomers (CESRA) Workshop, 3 – 7 July 2023, https://star.herts.ac.uk/cesra/
- EAS 2023, Krakow, 10 – 14 July 2023, SKAO Lunch Session (1.5 hour) approved, now being planned
- URSI GASS 2023, Sapporo, 19 – 26 August, New Facilities session, 41 abstract submissions received

New Eyes on the Universe: SKA & ngVLA
Vancouver 1 – 5 May 2023

Important Dates:

Abstracts
Dec 2, 2022 – Abstract submission open
Feb 10, 2023 – Abstract submission deadline (Oral)

Registration
Jan 16, 2023 – Opens
Apr 7, 2023 – Closes
**** If planning to attend in person, please check if you need a Canadian visa, and the processing time in your country ****

Programme
Mar 13, 2023 – Announced

Hotel
Apr 7, 2023 – cutoff for conference rate. Please stay at the hotel if you can.

http://go.nrao.edu/ngVLASKA

Any Other Business

- News from SWG Chairs?
- …

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

www.skao.int