



SKA Project Status Update

ICALEPCS 2023

Nick Rees

on behalf of the SKA Software Collaboration





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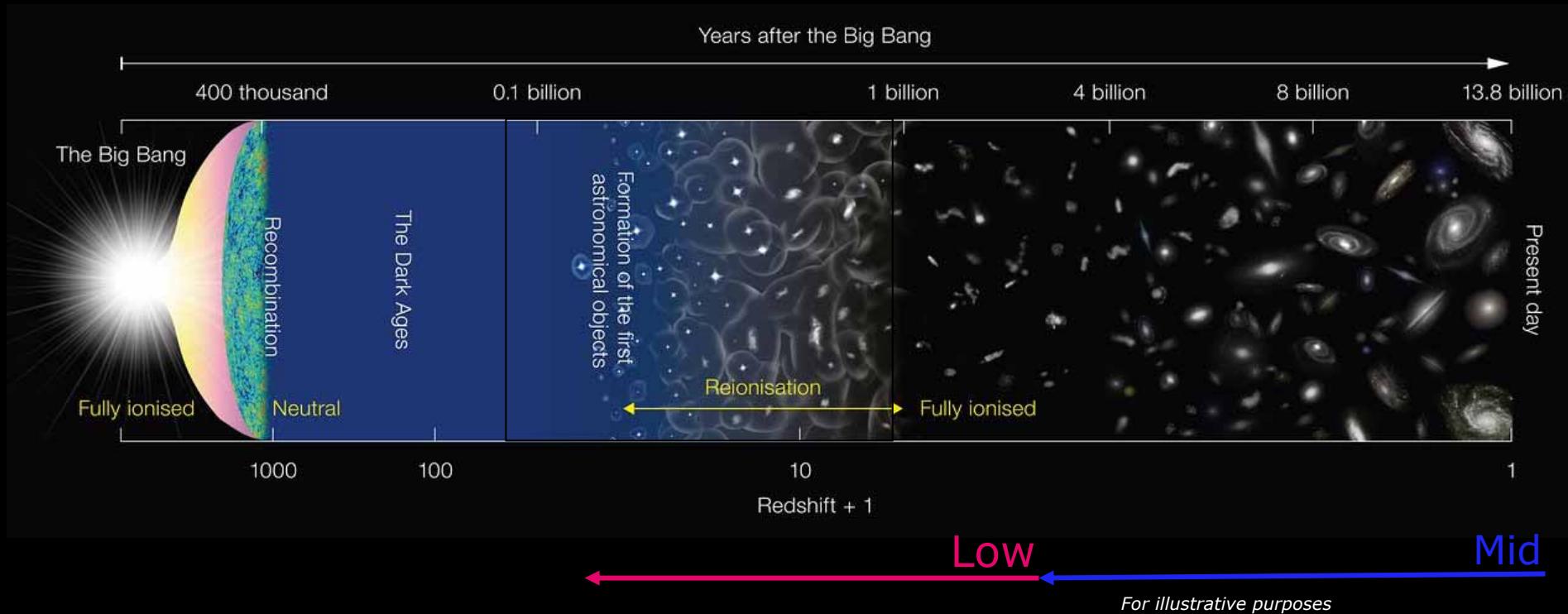
The M81 group

Credit: Keesscherer; NRAO



The M81 group

Credit: Keesscher; NRAO



Tracing neutral hydrogen right back to *Cosmic Dawn and the Epoch of Reionisation*

Science Working Groups cover the science areas that will be addressed with the SKA telescopes

HI Galaxy Science Science Working Group

The Square Kilometer Array (SKA) is a global enterprise to build the largest scientific instrument on Earth, both in physical size and in scientific reach. The SKA will revolutionize our understanding of the universe by exploring the fundamental processes that govern the evolution of galaxies and the large-scale structure of the universe. The SKA will also enable us to better understand the origin and evolution of life, the formation of stars and planets, and the search for extraterrestrial intelligence. The SKA will be built in two phases: Phase One (SKA1) will begin construction in 2024 and Phase Two (SKA2) will begin construction in 2030. The SKA1 will consist of over 100,000 individual dish antennas and the SKA2 will consist of over 1 million dish antennas.

The HI Galaxy Science Working Group (SGWG) is focused on studying the formation and evolution of galaxies by mapping the HI spectral line of neutral hydrogen (H₂) absorption/emission, the reservoir of cold gas in galaxies. Our primary goals are to investigate the physical properties of galaxies, such as their mass, age, and chemical composition, and to study the interaction between galaxies and their environment. Our findings will help us understand how galaxies replenish their gas.

How do galaxies replenish their gas?

Galaxy formation and evolution is a process that involves the interaction between galaxies and their environment. One of the most important ways that galaxies replenish their gas is through the accretion of gas from the intergalactic medium. This process is driven by the gravitational pull of the galaxy, which attracts gas from the surrounding environment. As the gas falls towards the galaxy, it forms a dense, luminous filament known as a "gas accretion filament". The gas then falls onto the galaxy's disk, where it is converted into new stars and planets. This process is called "star formation".

How are gas accretion, star formation & feedback related?

The relationship between gas accretion, star formation, and feedback is complex and still not fully understood. However, it is clear that these three processes are closely linked. For example, the rate of gas accretion into a galaxy is often limited by the amount of feedback energy released by the galaxy's star-forming regions. This feedback energy can come from supernovae, black hole accretion, or other sources. The feedback energy can heat the surrounding intergalactic medium, which can then cool and collapse to form new galaxies. The interaction between these processes is key to understanding the evolution of galaxies and the formation of the large-scale structure of the universe.

How is HI linked to galaxy formation?

Associated to absorption around a radio source host galaxies, the HI SFGWG will study the formation and evolution of galaxies and their environment. The SKA will enable a detailed study of the physical properties of galaxies and their environment, including the formation and evolution of galaxies and their environment. The SKA will also enable a detailed study of the physical properties of galaxies and their environment, including the formation and evolution of galaxies and their environment.

How is HI affected by galaxy interactions, environment & feedback?

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SKAO

www.skao.int

Epoch of Reionization Science Working Group

SKAC

www.sksas.org

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SKAO

www.skaeo.int

SKAC

SKAO

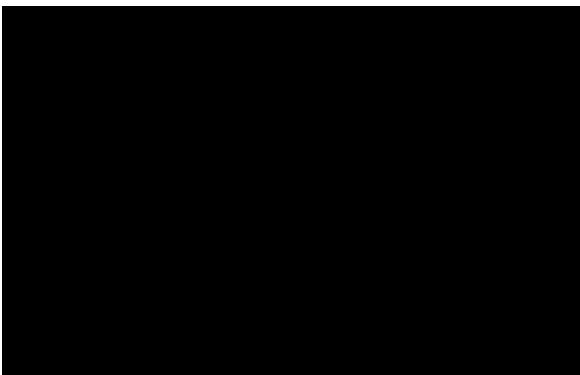
www.skoal.com



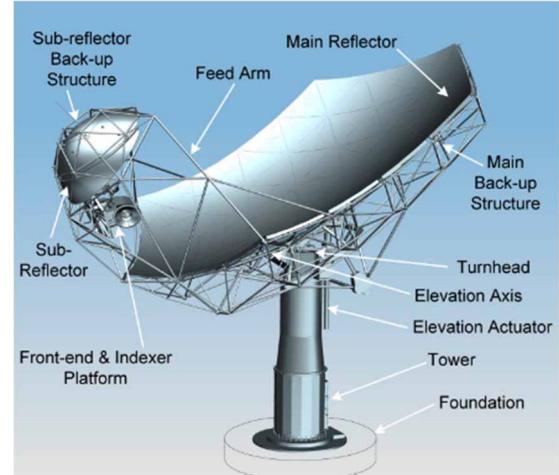
SKA MID Telescope



- 133 SKA 15m dishes
- 64 MeerKAT 13.5m dishes
- Maximum baseline 150 km
- 3 logarithmic spiral arms
- ~ 50% within ~2 km randomly distributed

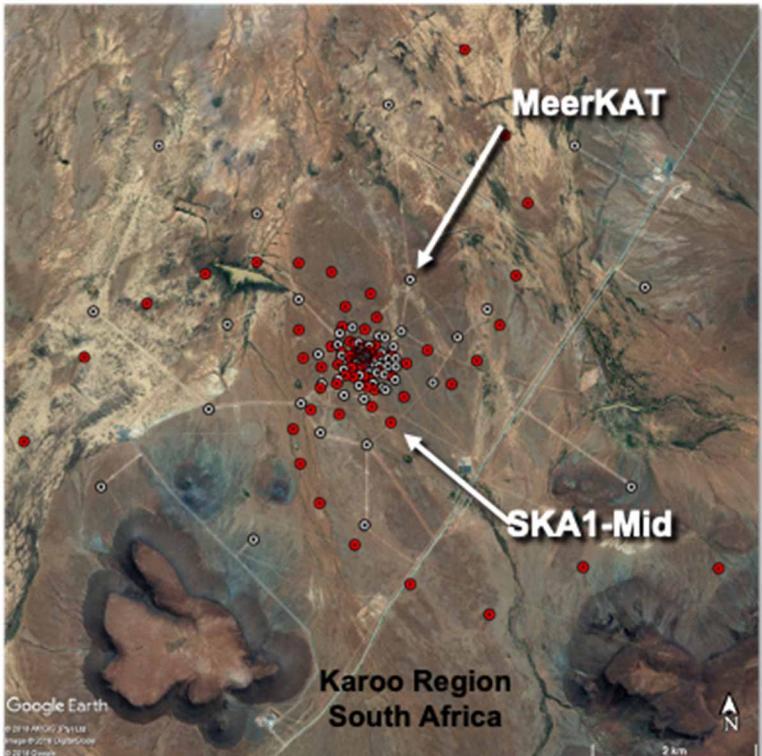


First on-site dish prototype April 2019

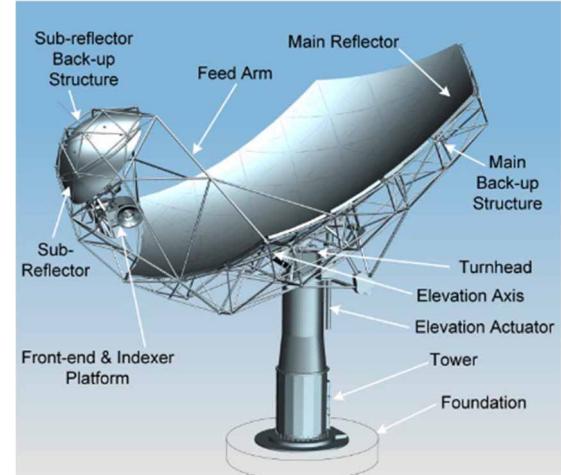


MeerKAT antennas in the Karoo

SKA MID Telescope



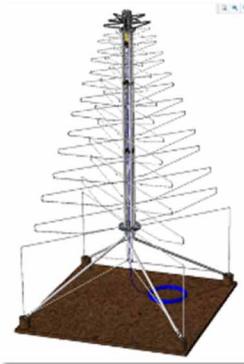
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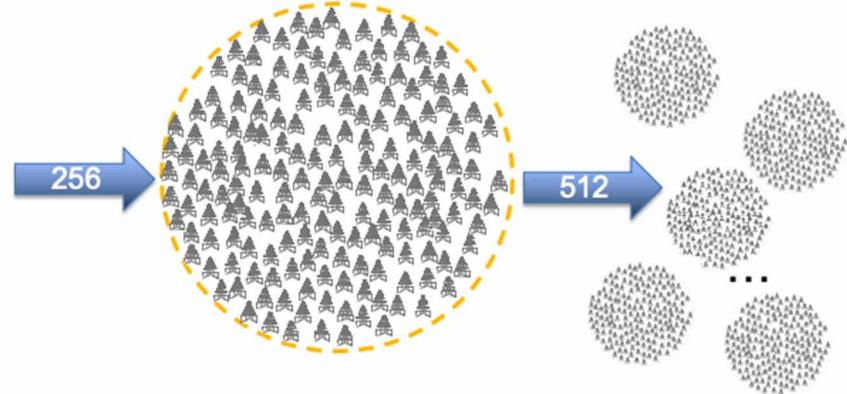
SKA LOW Telescope



SKA1-Low
Antenna/Receptor

Antenna Beam

512 aperture array stations
Maximum baseline 65 km
3 modified spiral arms
~ 50% within ~1 km
randomly distributed
Others in clusters of 6
stations arranged randomly
over an area 100 to 150 m in
diameter



SKA1-Low
“Station”

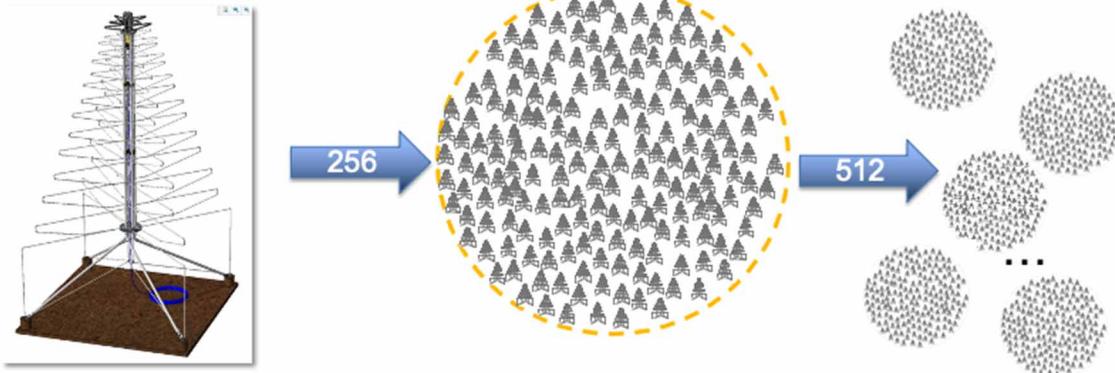
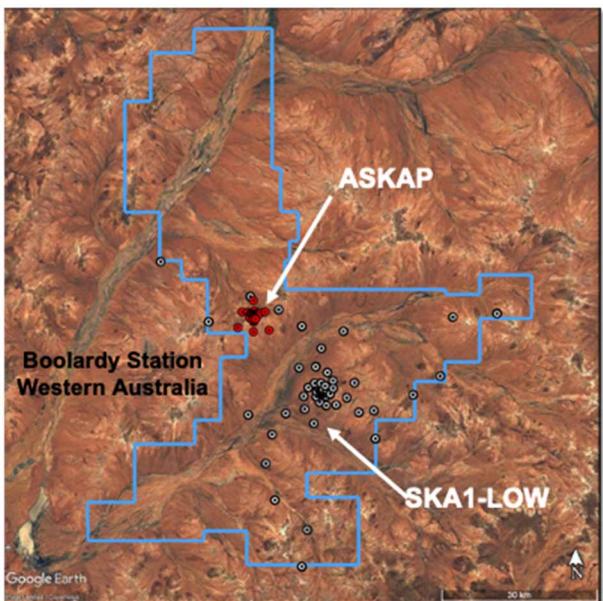
Station Beam

SKA1-Low
“Array”

Correlation and
Tied-array Beams

- 256 antennas per station
- 38m station diameter

SKA LOW Telescope



SKA1-Low
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Correlation and
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- 512 aperture array stations
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Construction Strategy

- **Target:** To build the SKA Baseline Design (197 Mid dishes; 512 Low stations: AA4)
- Not all funding yet secured, therefore following Staged Delivery Plan (AA*)
- Develop the earliest possible working demonstration of the architecture and supply chain (AA0.5).
- Then maintain a continuously working and expanding facility that demonstrates the full performance capabilities of the SKA Design.

Milestone Event (earliest)		SKA-Mid (end date)	SKA-Low (end date)
Construction Approval		2021 Jul site access AA0.5 xxx 2022	2021 Jul site access AA0.5 Dec 2022
AA0.5	4 dishes 6 stations	2025 Jan begin: 2024 xxx	2024 Nov Begin: 2024 xxx
AA1	8 dishes 18 stations	2026 Jan Begin 2025 xxx	2025 Nov Begin 2024 xxx
AA2	64 dishes 64 stations	2027 Jan Begin 2025 xxx	2026 Oct Begin 2025 xxx
AA*	144 dishes 307 stations	2027 Oct Begin 2025 xxx	2028 Jan Begin 2025 xxx
Operations Readiness Review		2028 Jan	2028 Apr
End of Staged Delivery programme		2028 Jul	2028 Jul
AA4	197 dishes 512 stations	TBD	TBD

Dates from Integrated Project Schedule Version July 2023;
schedule modelling projects ~2 months per year shift in schedule for the project execution

First data release to the community
expected in 2026/27 (for science verification)



Current Status – SKA-Low



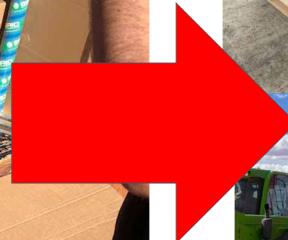
Current Status – SKA-Low



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Environmental impact and cost reductions



AAVS2 Antenna delivered on site in 2019. Fit for purpose, but room for improvement.

AAVS3 Antenna delivered on site in 2023.
Elimination of zip ties, expanded polystyrene,
reduction in cardboard



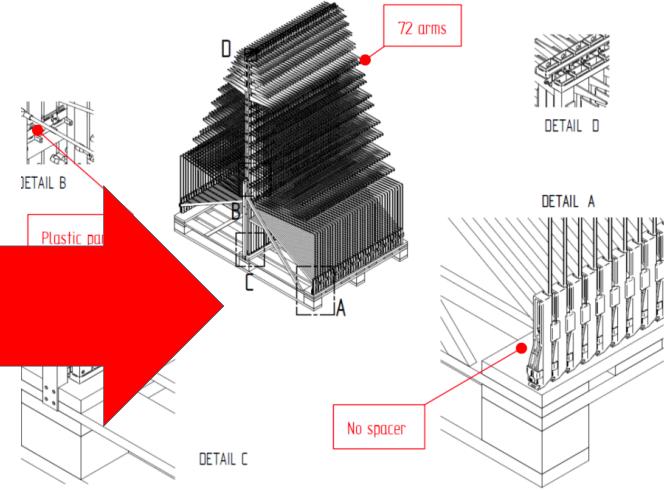
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Future improvements in packing density and durability:

- From 40 Antennas/pallet to 72
- Reduction of ~250 containers (from over 600 to under 400)
- Zero cardboard waste

Current Status – SKA-Mid



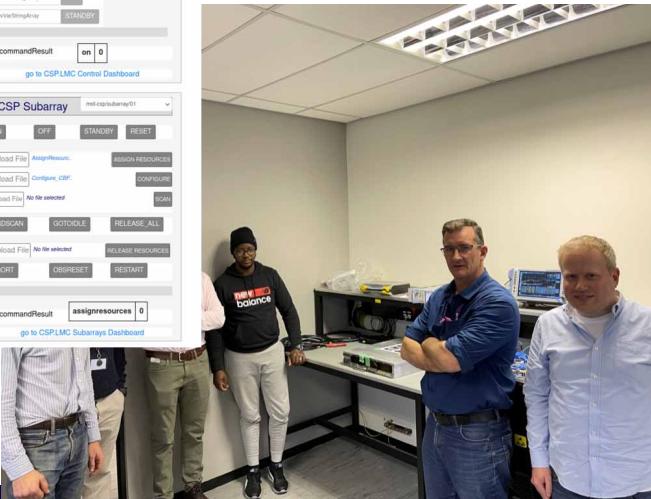
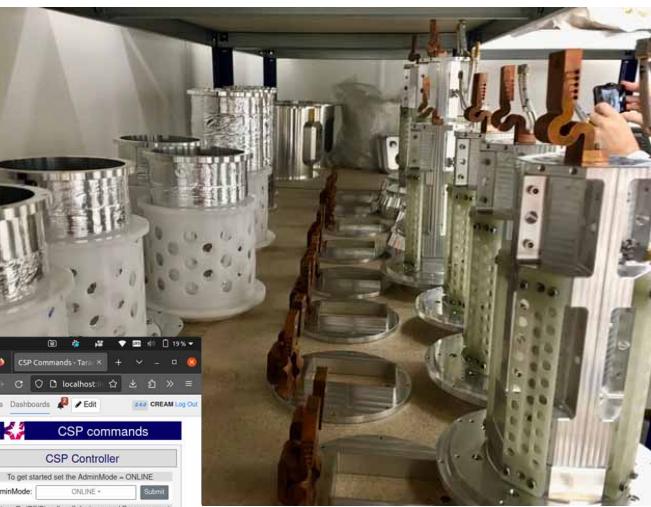
Current Status – SKA-Mid



Current Status – SKA-Mid

The collage includes:

- A photograph of the SKA-Mid construction site with several white shipping container-like buildings under construction on a dry, brown landscape.
- A close-up photograph of a geological outcrop showing layered rock formations.
- A screenshot of the "SKAO Mid Telescope - CSP Local Monitoring and Control - Monitor Panel". It displays two main sections: "CSPLMC" and "Correlator and Beam Former (CBF)".
 - CSPLMC:** Shows device status for mid_csp/control/0 through mid_csp/capability-vcc/0, all marked as ONLINE with OK healthstate and obsstate.
 - Correlator and Beam Former (CBF):** Shows device status for mid_csp.cbf/sub_elt/controller and mid_csp.cbf/sub_elt/subarray_01 through mid_csp.cbf/sub_elt/subarray_03, all marked as ONLINE with OK healthstate and obsstate.
- A screenshot of the "CSP commands" interface, specifically the "CSP Controller" section. It includes fields for "adminMode" (set to ONLINE), "Device Standby", and "Device StandbyAll". A "commandResult" field shows "on 0".
- A screenshot of the "CSP Subarray" interface, showing controls for "ON", "OFF", "STANDBY", and "RESET", along with "Upload File" and "ENDSCAN" buttons.
- A screenshot of the "CSPLMC Subarrays" interface, featuring a graph of "mid_csp/subarray/0/lobestate" over time (0 to 200 seconds). The state transitions from EMPTY to IDLE, then SCANNING, then CONFIGURING, and finally READY.
- A photograph of a large industrial building complex with multiple white structures and parking areas.



SKAO Software status

What can the SKAO Software do today:

- Preliminary end-to-end software for both SKA-Mid and SKA-Low
- Execute operational modes of both telescopes, including set up and run a simple (simulated) observation
- Handle (simulated) real time data ingest and some pointing calibration
- Run a simple pipeline to process simulated imaging
- Support future observation through sensitivity calculator
- Run in the various environment needed (hardware and software test facilities) using a common platform
- Pulsar Search Software and other Data Processing pipelines are being prepared but will be integrated at a later stage.

SKA Software Current Focus

- Working with the assembly, integration and Verification (AIV) teams to deliver suitable monitoring and control systems for AA0.5 needs. AA0.5 is a very limited interferometer (4 SKA-Mid Dishes and 6 SKA-Low stations), with no scaling issues. We have working examples of most code components, but still struggle with system level integration.
- Supporting the rollout of a new test station for SKA-Low (known as AAVS3).
- Supporting the installation and testing of the first dishes for SKA-Mid.
- Developing the scaled processing needed for later Array Releases (AA2 and AA*)
- Developing the basic observing modes needed - such as interferometric pointing calibration for the SKA-Mid dishes.
- Integrating the signal chains from digitization through to science data processing.
- Improving the team's ability to deliver software efficiently.

Where to find more information

- MO2BC001 - Driving Behavioural Change of Software Developers in a Global Organisation Assisted by a Paranoid Android
- MO2BC003 - Strategy and tools to test software in the SKA project: the CSP-LMC case
- MO2BC005 - Enabling Transformational Science through Global Collaboration and Innovation using the Scaled Agile Framework
- MO4BC001 - Using BDD Testing in SKAO: Challenges and Opportunities - see Giorgio and Verity paper
- TUMBCMO09 - Front-End Monitor and Control Web Application for large telescope infrastructures: a comparative analysis
- TH1BC003 - The Tango Controls Collaboration Status in 2023
- TH1BC004 - Asynchronous Execution of Tango Commands in the SKA Telescope Control System
- TH2AO06 - SKA Tango Operator
- THMBCMO14 - Development of the SKA control system, progress and challenges
- THSDSC05 - The SKAO Engineering Data Archive: From basic design to prototype deployments in Kubernetes
- FR2BC002 - A Lean UX approach for developing effective monitoring and control UIs: a case study for the SKA CSP.LMC subsystem
- FR2BC003 - Taranta project - Update and current status

Finally.... We are hiring

United Kingdom:

- <https://recruitment.skao.int/vacancies.html>
 - Software Product Manager
 - Release Train Engineer
 - Graduate Software Engineer (Multiple roles)

Australia:

- <https://jobs.csiro.au/search/?createNewAlert=false&q=ska>
 - Control Software Manager (open until filled)
 - Controls Software Engineer
 - Computing and Software Engineers and Developers (Multiple roles)
 - DevOps Engineer
 - Platform Engineer

South Africa:

- <https://www.sarao.ac.za/vacancies/>
 - Senior Control Software Engineer
 - Control Software Engineer
 - Senior Network Engineer
 - Network Engineer
 - Senior Pipeline Engineer
 - Pipeline Engineer
 - Senior Signal Processing Engineer
 - Signal Processing Engineer



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