Progress with the Construction of the SKA Observatory

NREN

J. McMullin

26 Feb 2024

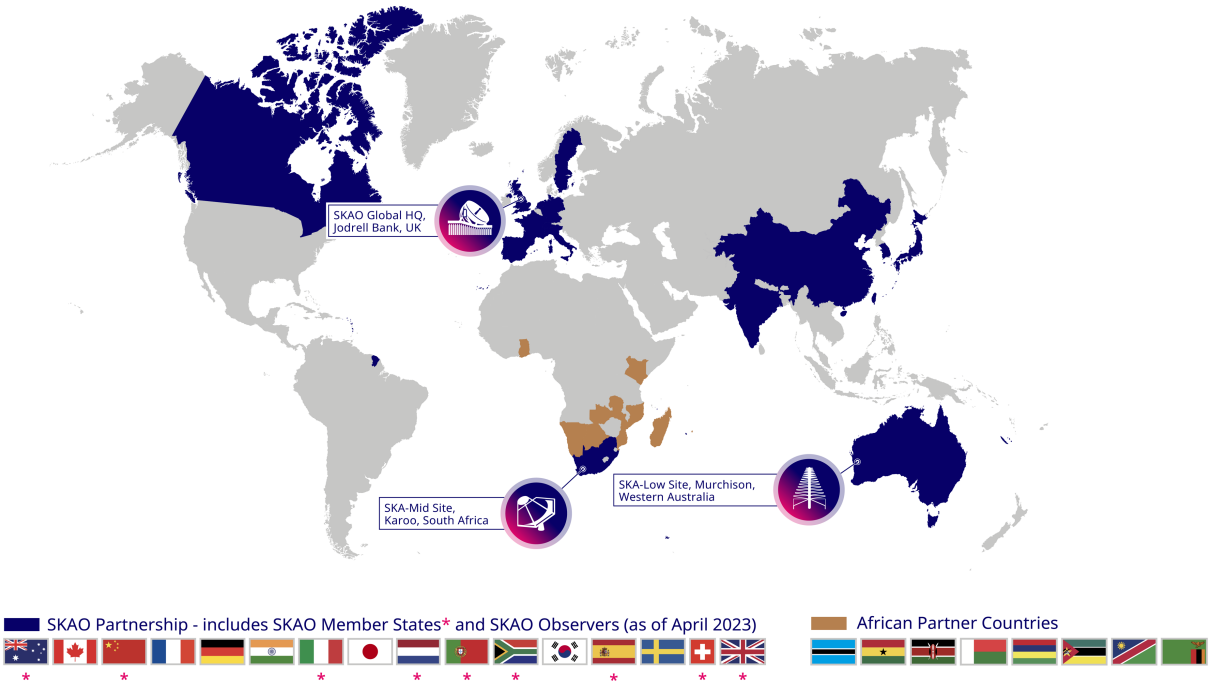
SKAO, an IGO since January 2021

Full members:
Australia, China, Italy, Netherlands, Portugal, South Africa, Spain, Switzerland, UK

Accession stage:
India, Canada, France, Germany

Awaiting government decision:
Sweden

Early stages:
South Korea, (Poland, Ireland Japan, Thailand)



SKA Construction Update

- 30 months of Construction Execution
  - Projected End of Construction Q1 2029
  - ~8 months later than End of Construction at start/July 2021
  - Earned Value Management reflects delayed schedule, under budget
  - 22% Project Contingency remaining

    *assuming availability of Additional Funds
- 77 contracts awarded with a total budgeted value of €677M
- 2024 Pivotal Year in Delivery Planning – AA0.5
  - SKA-Low AA0.5 – currently projecting to be demonstrated by EOY
  - SKA-Mid AA0.5 - challenges from high frequency aspects (Band 5, SPFRx45) to meet schedule

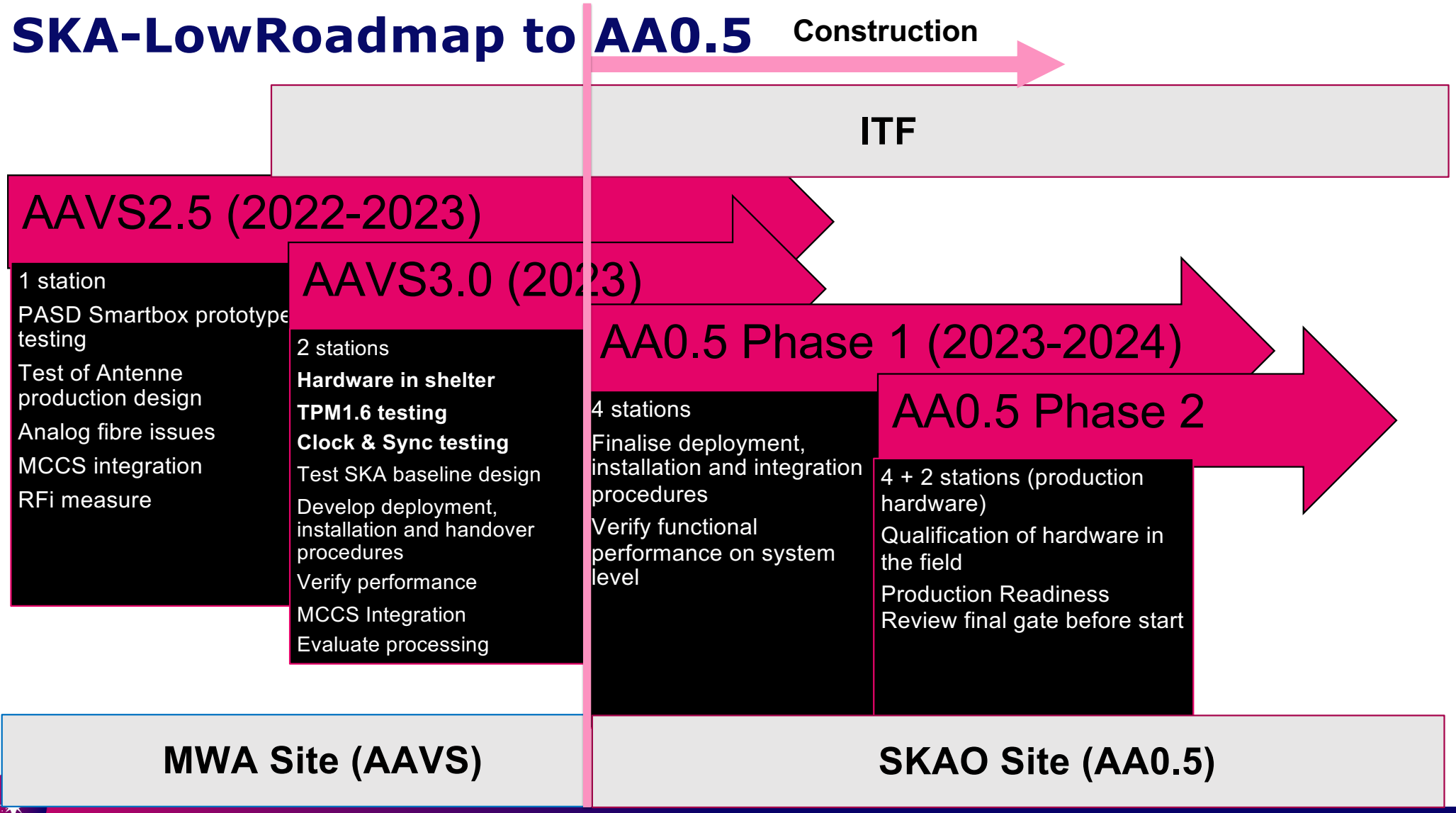
Construction Strategy

- **Target**: 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.
- AA0.5 remains critical; it has slipped in time by approximately 10 months to enable preservation of the planned scope.

Event	MID	LOW
Construction Approval	2021 Jul	2021 Jul
Integration Test Facility start	2023 Jan	2023 Feb
AA0.5 Integration and Verification start	**2024 Jul**	**2024 Jul**
AA0.5 end	**2025 May**	**2024 Nov**
AA1 end	2026 May	2025 Nov
AA2 end	2027 Apr	2026 Oct
AA* end	2028 Jan	2028 Jan
Operations Readiness Review (handover to Operations)	2028 Apr	2028 Apr
End of construction (including contingency)	2029 Mar	2029 Mar

First data release to the community expected around AA2 (currently 2026/27) for science verification
Planned project schedule contingency has also been used to manage global and observatory impacts.

SKA-LowRoadmap to AA0.5



2024 SKA Mid AA0.5 Program Highlights

ITF **Q1**

- - band 2
- Including minimal software - SUT definition

Site

- Assembly of first dish
- Start assembly of second dish
- Installation of networks, interim T&F, compute stack

ITF **Q2**

- Complete 4 channel signal chain
- Fully tested software with AA0.5 functionality

Site

- Extended commissioning of first dish
- Complete assembly of second dish
- Installation and standalone commissioning CBF

ITF **Q3**

- Complete 4 channel signal chain
- Upgraded (final) T&F system

Site

- Assembly of third dish
- First test of interferometry (two dishes)**
- Initial high frequency testing (band 5 cooled receiver, downconverter)

ITF **Q4**

- Complete 4 channel signal chain
- Fully tested software with AA0.5 functionality
- Preliminary testing of boresight PST beamforming

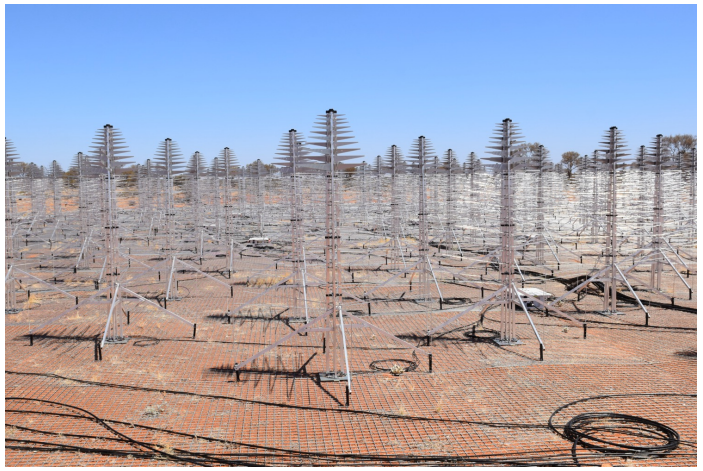
Site

- Assembly of fourth dish
- Interferometry (three then four dishes)
- Formal AA0.5 testing

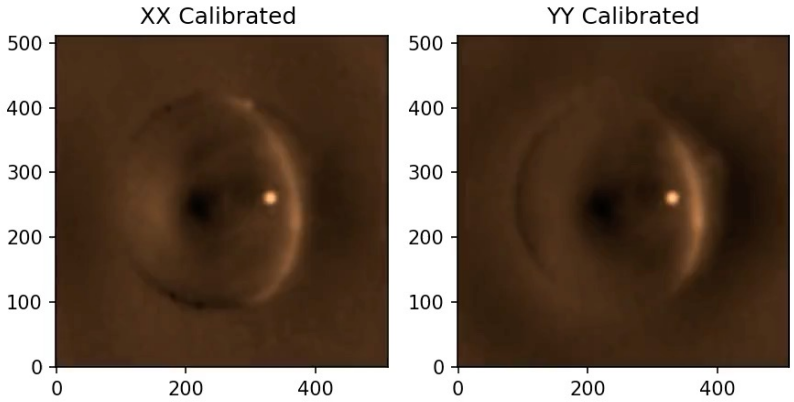
SKA LOW Construction Update

- AAVS3 Low Prototype Station operational in October 2023
- Observations with AAVS3 started
- Station hardware for AA0.5 has arrived and is ready for installation: Antennas, SPS available, Smartboxes due late Feb
- AA0.5 Site S8, S9 and S10, mesh is laid down and ready for handover
- First RPF for AA0.5 installed 25 Feb
- First Antenna to be placed on site

  March 7th



110MHz AAVS3 2024-01-09 14:19:17 (AWST)



SKA LOW Construction Update

Left to Right: RPF Arriving Freemantle, Laydown of the mesh at S9, Power Switches for SKA-Low at SCG Belgium

Left: Visit of Elemaster, company delivering SPS systems at SKAO

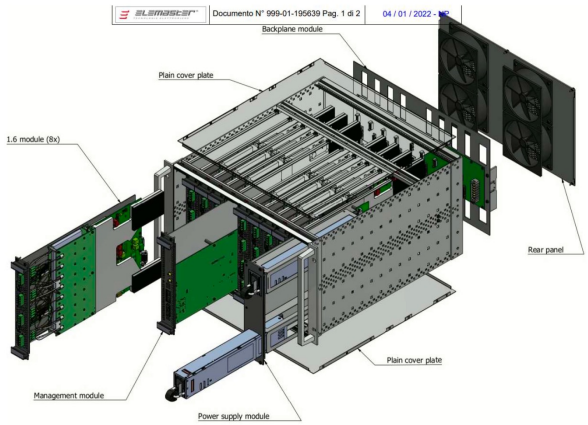
Right: 1050 km of power cable, stored at site

Below: Low PSI Marsfield

Contract	Status	Notes
LOW Infra PSC	Ongoing	Established early. Team involving Aurecon and RLB, lead by CSIRO
LOW Infra 1 & 3: Access roads, site preparation , power and fibre networks, buildings	Ongoing	Materials procured by observatory and provided (Free Issue Materials; steel, cable, etc)) Designing RPF and CPF Final Design of Infrastructure Currently South Arm Complete, core cleaned RPF for AA0.5 arrived and in preparation
LOW Infra 5	In preparation	Camp monitoring, pre-design ready. TSC in Feb
Low Infra 6 Temporary Accommodation	Ongoing	Includes: • Design • Fly Camp (Executed through Infra 1&3 vendor) • Camp hire • Camp Infrastructure & Build (executed through Infra 1&3 vendor) • Camp operations, negotiations ongoing. TSC Feb 2024
Low Infra 7 Main Road and Emergency Airstrip	Ongoing	Work began October 2023
LOW Infra 8 AARNET fibre	Ongoing	Work started, first links between site and SOC operational

Top to Bottom LR:
Core cleared, SIRIO Antenna at MRO
Fly Camp Unit

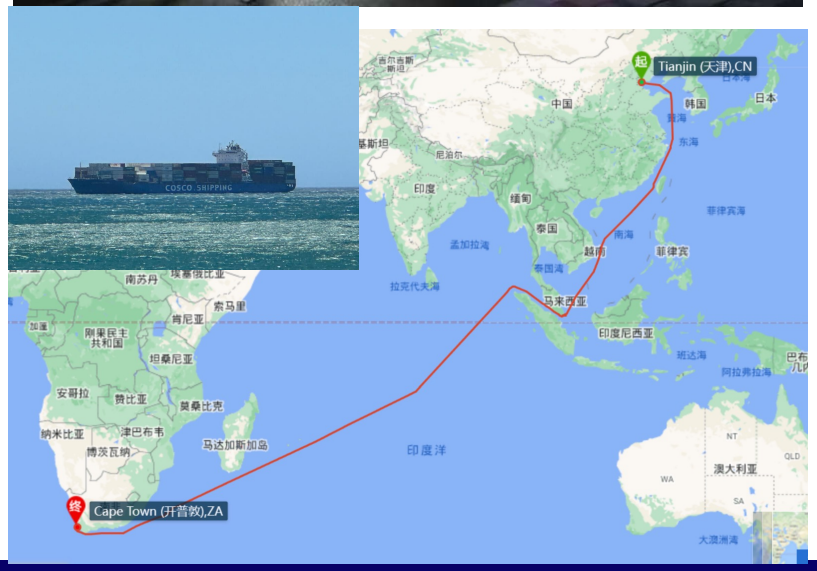
Contract	Status	Notes
Antenna Manufacturing	Ongoing	SIRIO Italy Antenna for AA0.5 delivered Manufacturing in preparation, Production Readiness Review Feb 24
Power and Signal Distribution	Ongoing	AA0.5 secured production started Series design in preparation, cost engineering phase ongoing
SPS Production	Ongoing	Elemaster, Italy FEM design optimization ongoing SPS production in preparation, qualified design expected Feb 2025 Pre-deliveries for AA0.5 and AA1.0
SPS MCCS & Cabinet Integration	Ongoing	Oxord/RAL Working on firmware development and cabinet integration & installation
LOW Correlator Beamformer	Ongoing	CSIRO Marsfieild Hardware design COTS Alveo boards. New Generation planned for AA1.0 onwards Design finalized AA0.5 FAT
LOW CSP	Ongoing	TOPIC Dutch Host CSP integration PSI In preparation for AA0.5 FAT
LOW Network	Ongoing	Framework contracts in preparation for switches+servers Installation done by SKA-Low OPS team
Low & Mid Synchronisation and Timing	Ongoing	Economies developed in management of component deliveries. Split across multiple systems as initial Tier 1 procurement failed to produce a viable bid. Final design and deployment underway for all the systems. Tsinghua procurement for LOW Freq distribution in preparation Currently WR used for UTC + Freq Distribution
LOW Station Deployment	Ongoing	SKAO team deploying Field Nodes Installing SPS Integrating Stations Labour hire for extended roll out at AA2.0
LOW INAF Station Services Contract	Ongoing	INAF Provides consultancy on Station Design finalization and SPS to Elemaster
LOW Curtin Station Services Contract	TSC Feb 24	Curtin University: Providing consultancy on Station Roll Out, support on AAVS3 operations and Antenna/PaSD Design
Low Science Processing Centre	TBD	
Low Central Processing Facility	TBD	



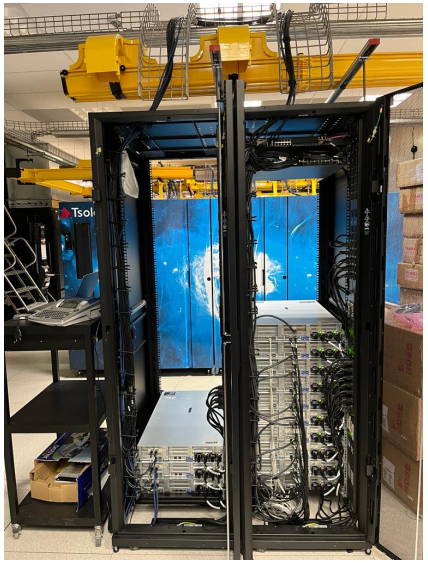
ELEMASTER SpA
Tecnologie Elettroniche

SKA Mid Construction Update

- First SKA Mid Dish shipped from China to South Africa late in Nov 23
- Ship docked on 28 Jan 23 having travelled 16,156.72 km (delays in Cape Town harbour). After customs clearing, first dish was transported to site; assembly begins this week!
- 2nd Dish structure arrived and on site.
- Servo system being air-freighted to RSA in the next week
- Active engagement with CETC54 to ensure health, safety, environmental management plans in place prior to start of construction
- Feed Indexer shipped from Italy and ship awaits docking in Cape Town harbour



SKA Mid Construction Update



Above & Right: Successful installation & configuration of the AA0.5 servers in the Karoo Array Processor Building on site

Left: Minimum Viable Product (MVP): Prototype for standalone photovoltaic plants in spiral arms (RFI-shielded container being manufactured in Gauteng generator delivered to factory
Right: Power Adenco Learnership Programme on-site experience

Contract	Status	Notes
Mid Infra PSC	Ongoing	Established early. Split between two providers (Zutari/SARAO); resourcing challenges has pushed work to SKAO; some conflict in resources with MK+
Mid Infra 1 **Access roads, foundations, power and fibre networks, security**	Ongoing	Managing final design details. Difficulties due to delayed handover of Construction camp infrastructure from the MK+ Security management review underway.
Mid Infra 2 **Building management system, power facility/UPS**	TBD	A supplier is being pre-qualified to tender for the design and supply of the building management system (BMS). The design of the power facility/UPS is under assessment and will be tendered once the design concept is complete.
Mid Infra 4 **Digital Mobile Radio Communication System**	Ongoing	Contracted for consolidated needs of Host Country with SKAO to provide economies.
Mid Infra MK+ **Camp, 24 foundations along with power/fibre network**	Ongoing SARAO IK	**MK+ non-compliances (foundations & fibre), delays (camp and as-builts/completion in general) are driving costs (compensation events and ECP's) on the SKA project**
Mid Dish Structure	Ongoing	Dishes 1 and 2 shipped from China in November Strong technical collaboration on RFI and testing on dish assembled in China. Conflicts with simultaneous MK+ manufacture; final qualification at AA0.5
Mid Dish Structure, Subreflector	TBD	AA0.5 secured. AA* Subreflector tender to commence in Spain shortly
Mid Dish Structure, Cabinets	PO	
Mid Dish Structure, Indexer	Ongoing TSC-18	AA0.5 secured. Indications of escalated costs for full manufacture.

Contract	Status	Notes
Mid Correlator Beam Former	Ongoing IKRC	MID CBF development underway, first modules deployed to ITF and under test
Mid System Assembly, Integration and Verification	Ongoing TSC-15	Team integrating into broader AIV.
Mid Dish Element **AIV of Dish subsystems**	Ongoing TSC-31	Contract kickoff in January
Low & Mid Synchronisation and Timing	Ongoing Mgmt: IKRC-03, TSC-20 Mid Freq Distn:TSC-14 Masers: TSC-27 UTC: TSC-XX Timescale: TSC-31	Economies developed in management of component deliveries. Split across multiple systems as initial Tier 1 procurement failed to produce a viable bid. Final design and deployment underway for all eky systems.
Mid Band 1	Ongoing TSC-31	In negotiation on received tender.
Mid Band 2 & Mid SPF Services	Ongoing TSC-27	Strong collaboration with RSA partner enabled consolidation (!) of contracts and budget savings.
Mid Band 5	Ongoing TSC-17	AA0.5 pre-production manufacture secured; temporary downconverter. Qualification Dec 23 CDR
Mid Cryo	Ongoing TSC-30	Qualification of coldhead at band 5 Dec 23 CDR. Awaiting panel report
Mid SPF Rx 123	Ongoing TSC-27	Secured. High cost beyond budget projections.
Mid SPF Rx 45	TBD	Redesign effort underway; projected delay to SKA-Mid. Alternative solutions being investigated
Mid Central Signal Processor	Ongoing	Not formally contracted but work underway
Mid Science Processing Centre	TBD	
Mid Central Processing Facility	TBD	
Mid Network	TBD/Ongoing	Initial COTS procurement for early AA underway

Key Challenges

- Budgetary Pressures from changed global economy (post-2019 when the SKA Cost Book was fixed except for member-averaged inflation)
  - C.f. Funding Strategy discussion
    - Constant stress on procurements from the splits in allocation
  - Project efforts to manage to within that communicated value; the majority of procurements have concluded; actively managing contracts; residual exposure looks approximately equal to communicated projections.
  - Without additional funding (management reserve), low probability of success indicates that scope will be lost.
- Corresponding Schedule pressures; to date have compressed margins but not reduced planned scope; that will be under increasing tension.
  - Key risks in supply, assembly and integration being managed.
- Technical
  - c.f. SEAC-09.09 Programme Technical Risk
  - Engineering Change Proposals (next slide)

Key Challenges

- Identified risks in the management of the existing contracts
- Cost uncertainty in remaining procurements for SKA Mid & SKA Low
- Schedule uncertainties in the execution of the SKA Mid & SKA Low programme
- Requirement gaps, incomplete interfaces
- Data Software/HPC scaling risks

- Outside of the Project Management: Host Country Deliverables not being available

SKA Regional Centres: SKAO data ingest

SKA Construction Update

- 30 months of Construction Execution
  - Projected End of Construction Q1 2029
  - ~8 months later than End of Construction at start/July 2021
  - Earned Value Management reflects delayed schedule, under budget
  - 22% Project Contingency remaining

    *assuming availability of Additional Funds
- 77 contracts awarded with a total budgeted value of €677M
- 2024 Pivotal Year in Delivery Planning – AA0.5
  - SKA-Low AA0.5 – currently projecting to be demonstrated by EOY
  - SKA-Mid AA0.5 - challenges from high frequency aspects (Band 5, SPFRx45) to meet schedule

Questions?

Technical Engineering Change Proposals

- Class 1
  - ECP-230067 Rotation of Ground Planes
  - ECP-230163 WR based Low SAT.STFR.FRQ system for AA0.5 up to AA1
  - ECP-230184 Antenna Assembly LNA design rectification
  - ECP-240008 Modified Approach for Low AA0.5: 4 Stations
  - ECP-210113 Perturbed Vogel Station Layout
  - ECP-230228 Update Verification Milestone Allocation for Requirements at Low ITF

- Class 2
  - ECP-230031 Timestamp from UTC to TAI
  - ECP-230178 Antenna Assembly Plastic foot design change for improved shipping density and mesh mating.
  - ECP-230181 Chamfering of Antenna Assembly booms
  - ECP-220073 DSH Mass Budget
  - ECP-230089 Cabinets with Integral Fire Suppression
  - ECP-230198 Adding duplex fibre between CPF and Inner Repeater Shelter for UTC distribution
  - ECP-2300199 Update power arrangement and consumption of Mid SAT.STFR.UTC in CPF
  - ECP-210100 Change of Connector Type for Low Antenna to PaSD Smartbox
  - ECP-230220 Update to Low & Mid SAT STFR UTC Requirement specification
  - ECP-230203 Update the CBF-PSR ICD Low PSS Bandwidth/Channel Definitions
  - ECP-230170 Change the baseline of the Tropospheric Monitoring receivers to 300m from 500m