Status Update

2021 Tango Community Meeting

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- SKA Telescope Control System
  - What do we need to monitor and control
  - Requirements, challenges
  - Design patterns
  - Status

Project Status - Lots to celebrate !

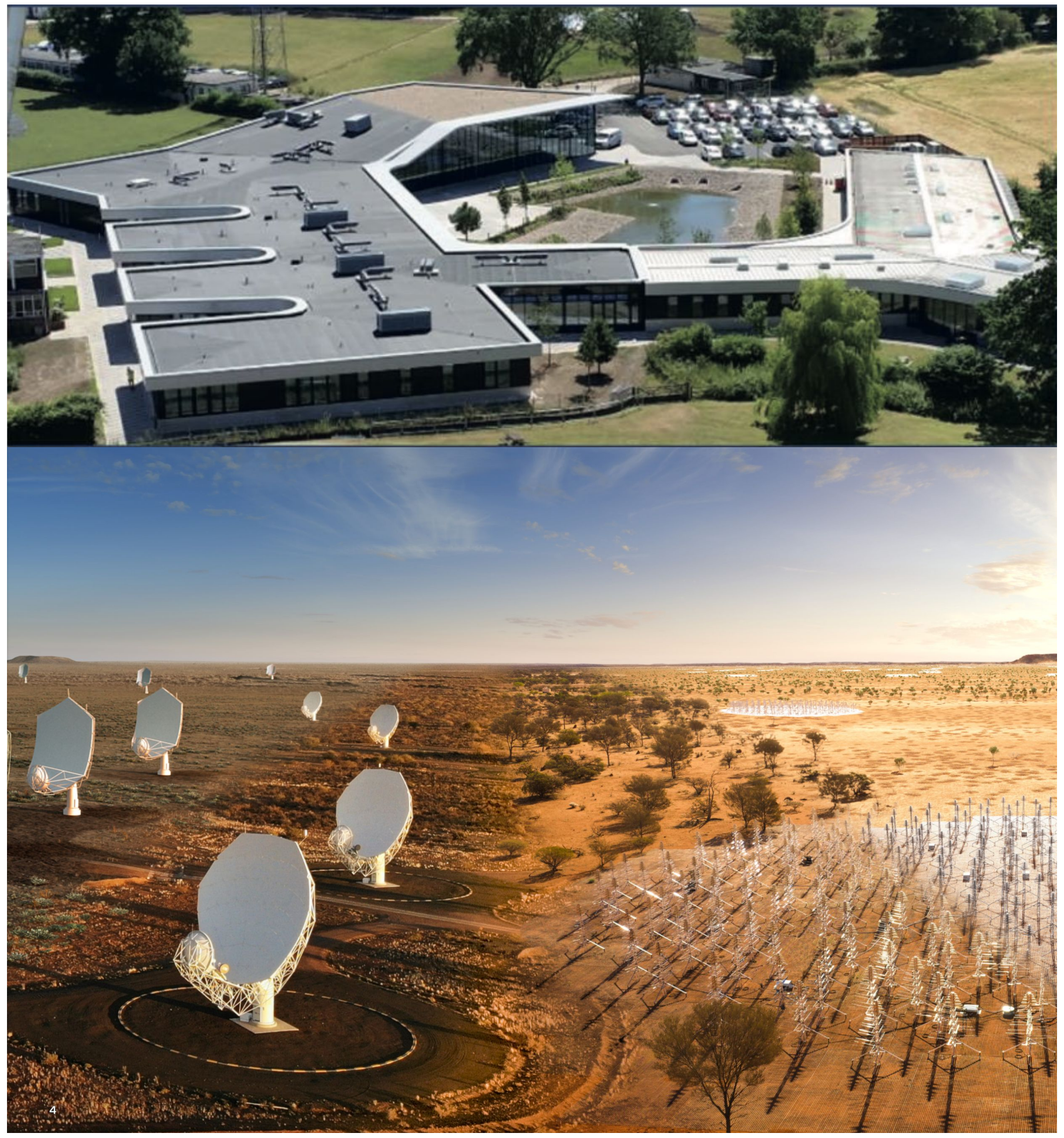
- ★ Early 2020: passed Critical Design Review.
- ★ So far seven member countries signed the agreement.
- ★ Spring 2021: formed **International Organisation SKA Observatory**
- ★ Spring 2021: passed Construction Readiness Review.
- ★ <u>1. July 2021: Construction started !</u>
  - Contracts being awarded.
  - Team is growing.
  - Transition to construction is gradual.
  - More member countries expected to join the construction team.

Mission

The SKAO’s mission is
to build and operate
cutting-edge radio telescopes
to transform our
understanding of the Universe,
and
deliver benefits to society
through
global collaboration and innovation.

Vision

The SKAO is one observatory
with two telescopes,
on three continents;
a 21st century observatory
and
an inter-governmental organization with
sustainability and respect
to all our communities at its heart,
driven by a commitment
to fundamental science and technology.



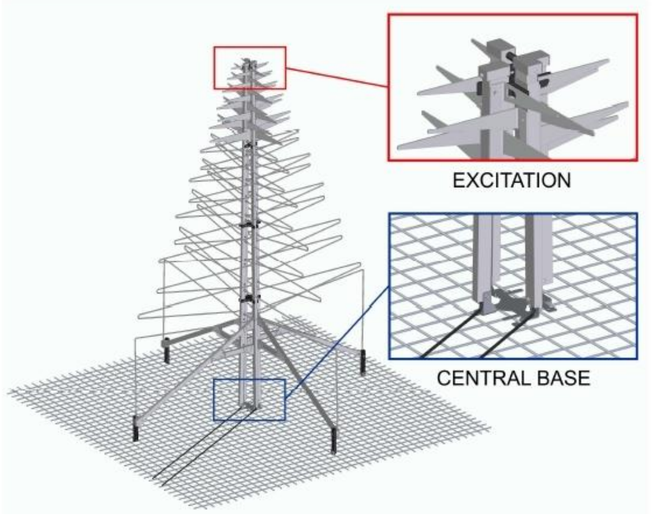
SKAO - SKA Observatory

- Square Kilometre Array
  - a goal to build a radio-telescope with a collecting area of ~1km^2
- 1 observatory, 2 telescopes, 3 continents

★ **Global HQ** - Jodrell Bank, Manchester, UK

★ **Low Frequency Array Telescope**
- Murchison region, Western Australia
- Observing range: 50 - 350 MHz
- 131,072 (512 x 256) log periodic antennas

★ **Mid Frequency Array Telescope**
- Karoo region, South Africa
- Observing range 350MHz - 15GHz
- ~200 x 15m diameter dishes



Strategy

Develop the earliest possible working demonstration of the architecture and supply chain (AA0.5).

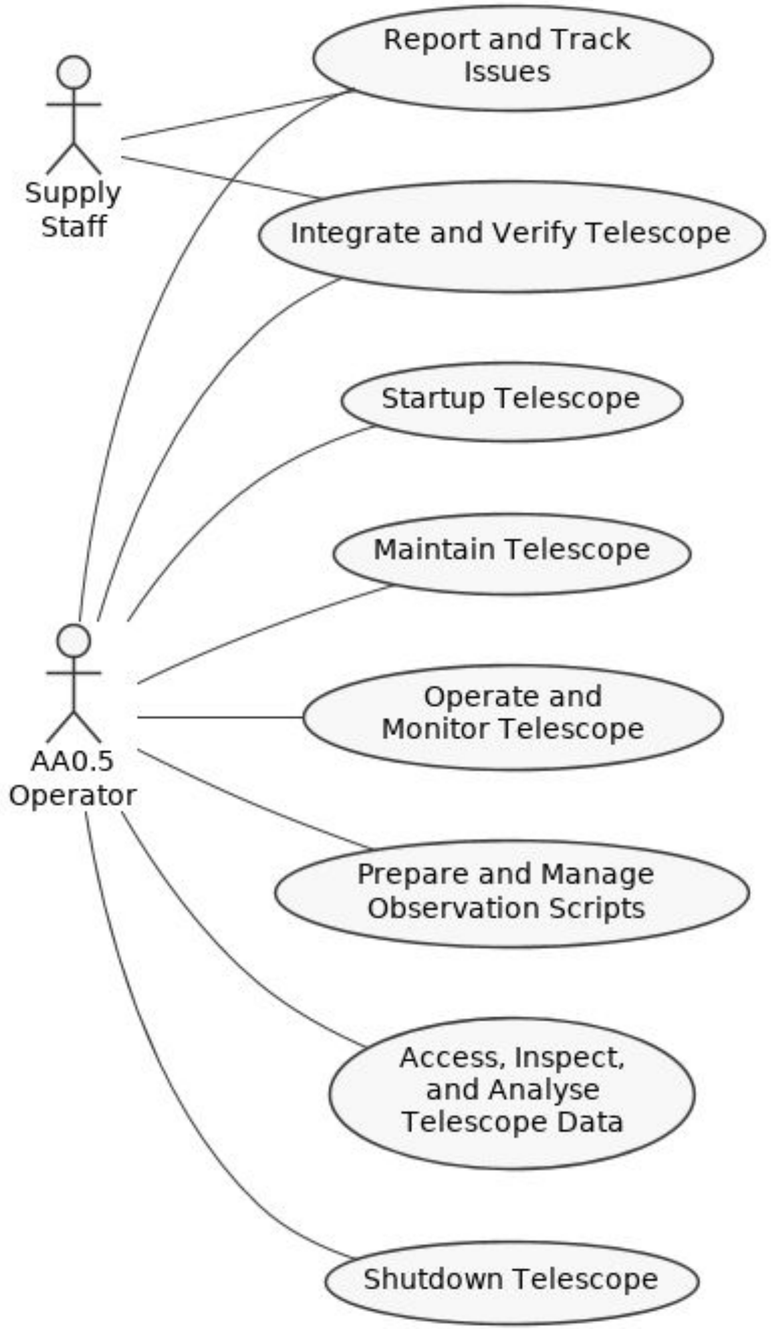
Then maintain a continuously working and expanding facility that demonstrates the full performance capabilities of the SKA design.

	SKA Low	SKA Mid
Start of Construction (TO)	1 July 2021	1 July 2021
Earliest Major Construction Contracts (C0)	July 2021	July 2021
Array Assembly 0.5 Finish	Feb 2024	June 2024
Array Assembly 1 Finish	Feb 2025	Sep 2025
Array Assembly 2 Finish	Feb 2026	July 2026
Array Assembly AA* Finish	Feb 2027	June 2027
Operations Readiness Review	May 2027	August 2027
End of Construction	July 2028	July 2028

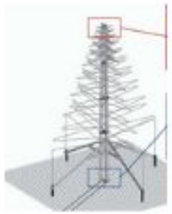
AA 0.5 What does it do ?

Quite a lot, actually:

- **Startup** and **shutdown** telescopes (and/or ITF/PSI equipment)
- **Integrate and verify** telescope equipment
- **Reporting and tracking** of issues
- **Prepare and manage observation scripts**
- **Operate and monitor** the **telescope**, enable data gathering
- **Access, inspect, and analyse** astronomical and engineering data
- **Maintain telescope equipment**



Radio-Telescope - an overview



electromagnetic vawes

Receptors

Collect and digitise band of interest

packetised and timestamped data samples

Digital Signal Processing

Real-time processing
correlation
beam-forming

visibilities and beamformed data

Data Processing

Near real-time processing
pulsar search & timing
calibration
creating data-sets

data sets corrections pulsar candidates

Batch Processing

Batch processing
imaging

image cubes pulsar data

Mid Dishes:
servo motors
Low and Mid:
analog and digital hardware
(PLC / FPGA / CPU)

digital hardware
COTS and custom
FPGA / CPU / GPU
network switches

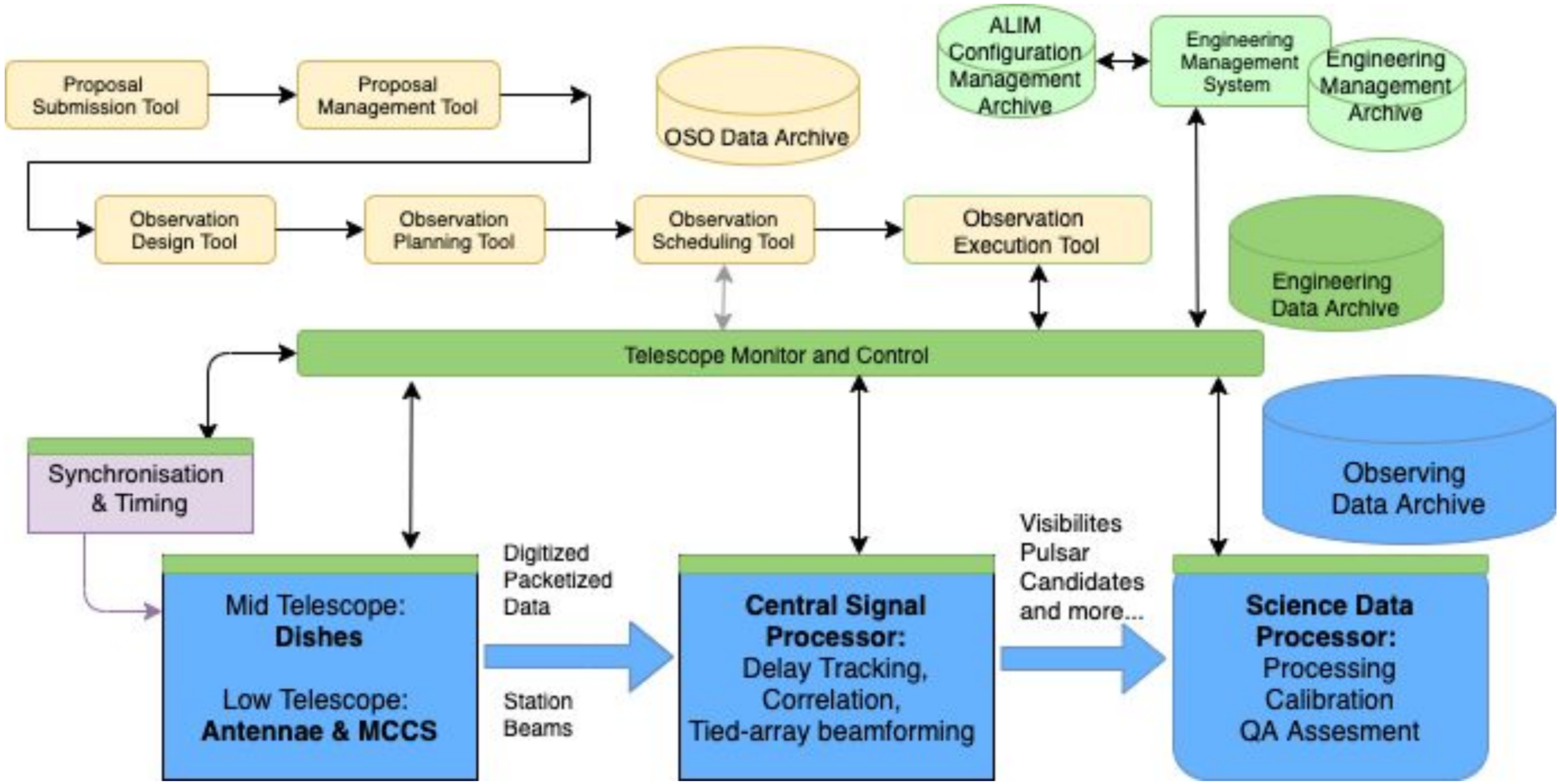
high-performance computing platform

FPGA / CPU / GPU
COTS and custom

high-performance computing platform

Infrastructure: facilities, roads, lending strips, power, water, networks, masers, IT...
Data Archives: Observing Data, Scientific Data, Engineering Data, Project Data...

Radio-Telescope - a software overview

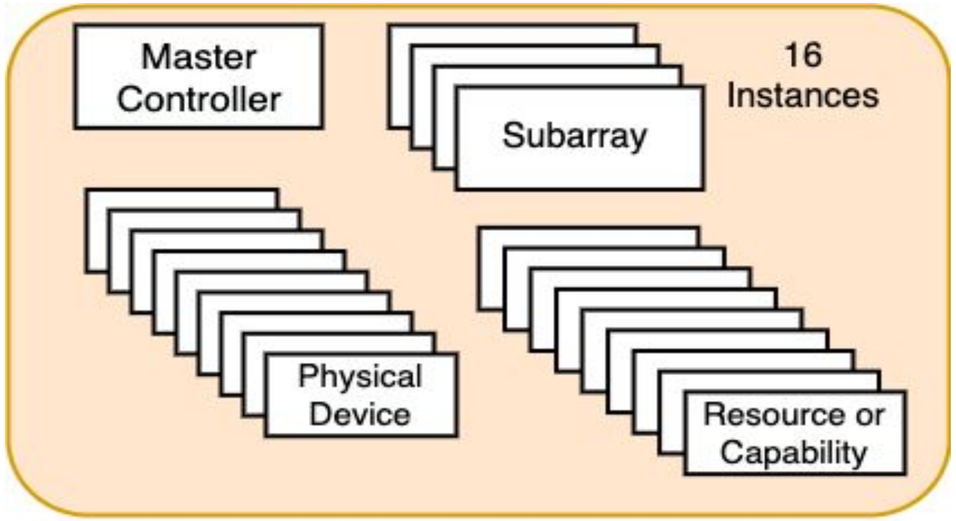


SKA Telescope Control System Architecture

- Each sub-system implements internal M&C, exposes:
  - Attributes that report status and configuration
  - Commands to trigger configuration, mode and state transitions.
- In an interferometer, the functional view does not always directly map to the physical view.
- A requirement to be able sub-divide the array, and operate each sub-array as an independent telescope further complicates the ‘mapping’ of functionality to physical equipment.
- CS provides two views:
  - Physical (equipment and components).
  - Functional (subarrays, capabilities).

SKA Telescope Control System Architecture

- Master Controller
- Physical devices
- Subarray
- Capability



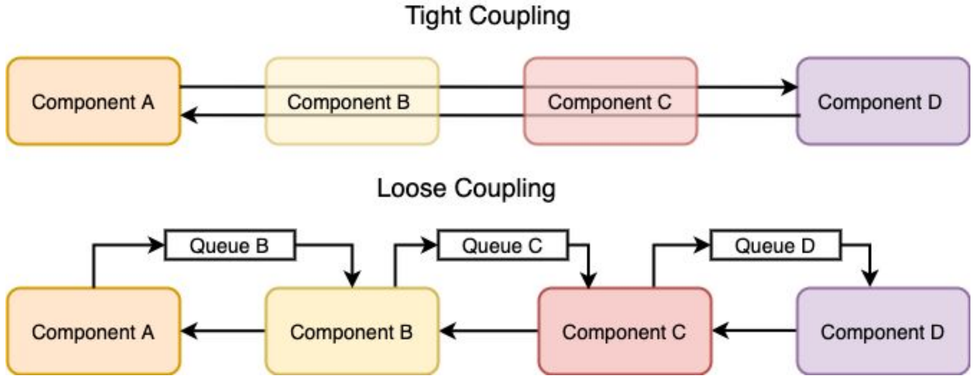
- Sub-systems consists of hundreds of components and are organised hierarchically.
- Each sub-system replicates this design pattern.
- Each ‘level’ performs aggregation and reports overall status of all subordinate components.
- Using commands to pass the observing mode configuration from top to bottom.
- At each ‘level’ the higher-level parameters are translated into detailed configuration of the subordinate components.

SKA Telescope CS - Design Patterns

- ➔ Hierarchical organisation
- ➔ “Deep adoption of TANGO” - provides TANGO API:
  - Top-level view (overall status of the telescope).
  - All low level components
  - And also for the ‘middle’ i.e. all the sub-systems
  - In short: everywhere!
- ➔ Unwanted consequences:
  - The framework (TANGO) becomes entangled into every aspect of the control system logic; overly dependent on TANGO.
  - Confusion regarding what is ‘the device’ (i.e. system being controlled).
- ➔ Solution: Decouple the TANGO API (layer) from the ‘business logic’.

SKA Telescope CS - Design Patterns

- Loose coupling of components achieved using the following techniques:
  - Asynchronous communications
  - Components implement input queue (optional)
  - Use of JSON



- Overview of the command implementation:
  - Before issuing a command a client registers to receive events.
  - When a command is received, the server adds the commands to the queue (FIFO).
  - Control is immediately returned to the caller.
  - A worker thread, when idle, removes the command form the queue and executes.

Status of the Control System development (1 of 2)

- Software organisation following https://www.scaledagileframework.com/
- Planning and tracking work: JIRA and Miro.
- Development environment and processes (recently improved and re-organised)

  https://developer.skatelescope.org/en/latest/
- Solution Intent (specifications, intended and emerging design) are documented in Confluence (not publicly available).
- Bug/issue reporting and tracking: JIRA.

➔ Busily improving and refining processes and documentation to facilitate onboarding of new team members.

➔ Applying what we learned so far, and adjusting processes to accommodate larger team.

Status of the Control System development (2 of 2)

https://gitlab.com/ska-telescope

What we developed so far:

- Rudimentary monitor and control functionality for the key sub-systems.
  - State machine, commands that trigger state/mode transitions.
- Embedded software to supports testing of firmware.
- SKA TANGO Base Classes
- In collaboration with MaxIV improved WebJive/Taranta.

Thank you !

Questions ?