The SKA Observatory Development Programme

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What is the SKA Observatory Development Programme (SODP)?

- A programme of upgrades to the SKAO
- Aim is to produce “better” science
  - “Better” may mean qualitatively different, more, cheaper, …
- Technological innovation in the interests of better science
- Continuing funding after the end of SKA construction

History

- Three pre-construction consortia forming the Advanced Instrumentation Programme (AIP)
  - Mid-frequency Aperture Arrays
  - Advanced single-pixel feeds
  - Phased-array feeds
- Current concept is much less restrictive

Why a Development Programme?

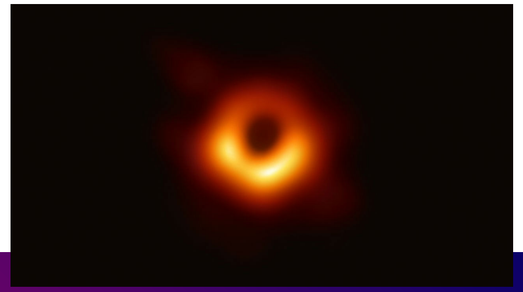
- A Development Programme is essential to the health of any Observatory
  - .. without one, the observatory eventually stagnates
- It allows the Observatory to adapt to changes in scientific priorities and to improvements in technology …
  - … and to fix problems (HST optics)
- There have been many examples of highly successful observatory development programmes in the past:
  - VLA → Jansky VLA
  - HST instrument upgrades (WFC1 → 2 → 3)
  - ALMA VLBI
- … and others are happening now
  - ALMA Wideband Sensitivity Upgrade

What a Development Programme cannot do

- Support blue-sky research and development
  - SKAO is not resourced to be a funding agency for “blue-sky” R&D in the community
    - … but we can support applications for national or trans-national funding
- Completely rebuild an array
  - Some upgrades are just too big to construct without additional funding

Why now?

- It seems strange to be thinking about a development programme when we have only just started construction, but …
  - lead times for technology development are often ~years to decades, particularly when a new idea has to be turned into a robust, mass-produced product
  - we may want to use the initial development programme to restore lost project scope
    - ALMA VLBI



Rationale for the Development Programme

- Enhance SKA science output
  - Adapt to changes in scientific landscape and priorities
  - Enable new science (e.g. a new frequency band)
  - Improve science output (e.g. increased instantaneous bandwidth, faster processing)
  - Reduce operational costs (e.g. power, preventive maintenance)
  - Restore lost capability
- Enabled by:
  - **Projects** to deliver major improvements
  - **Studies** to evaluate new ideas and bring them to a suitable Technology Readiness Level (TRL) to become projects in the future
- Supported by:
  - Prioritisation of research and development in the community
  - Science and Technology Road-maps
  - Development of new ideas to the level that they enable more and better science

Principles

1. SODP projects should aim to offer potentially significant enhancements to the scientific capability of the SKA Observatory.

2. SODP projects should provide a clear path to deployment on or for the SKA. The SKAO is not resourced to support blue-sky R&D.

3. SODP Projects will generally be expected to be undertaken by teams led by an organisation from one of the SKAO Member (or Associate Member) countries. Large projects would be expected to involve international collaborations. Some (usually smaller) projects may be carried out in-house by SKAO staff.

4. SKAO funding of institutes participating in in SODP projects will be limited to institutes from SKAO (Associate) Member countries; organisations from other countries may participate, but using their own resources.

5. When appropriate, industry should be integral to the proposal team; without industry, the SODP project would risk not having access to the necessary expertise to adequately address key areas, e.g. integration, modular design, design for manufacture, cost.

Key Technologies and Upgrades (1)

- Improved frequency coverage
  - Additional receiver bands for SKA-MID
  - Increased RF bandwidth
- Higher sensitivity
  - More dishes/stations
  - Lower noise
- Digital system
  - More bandwidth
  - More channels
  - More bits
  - Integrated receivers
  - RFI resilience

Indicative only

- Spatial multiplexing
  - Phased-array feeds (dishes)
  - More beams (aperture arrays and dishes)
- Higher spatial resolution
  - Longer baselines
  - Higher frequencies
- Better time-domain capabilities
  - Bigger transient buffer

Key Technologies and Upgrades (2)

- Upgraded computing hardware and software
  - Algorithms: RFI excision, direction-dependent calibration …
  - Storage
  - Networks
  - Data processing hardware (in addition to refresh)
  - Lower power consumption
- Environmental monitoring
  - Prediction
  - Better estimates of ionospheric Faraday rotation

Indicative only

- Increased reliability and sustainability
  - Power
  - Remote diagnostics
  - Alarm systems
  - Predictive maintenance
- Access to data at different points in the signal chain
  - “spigots”
  - radio detection of cosmic rays

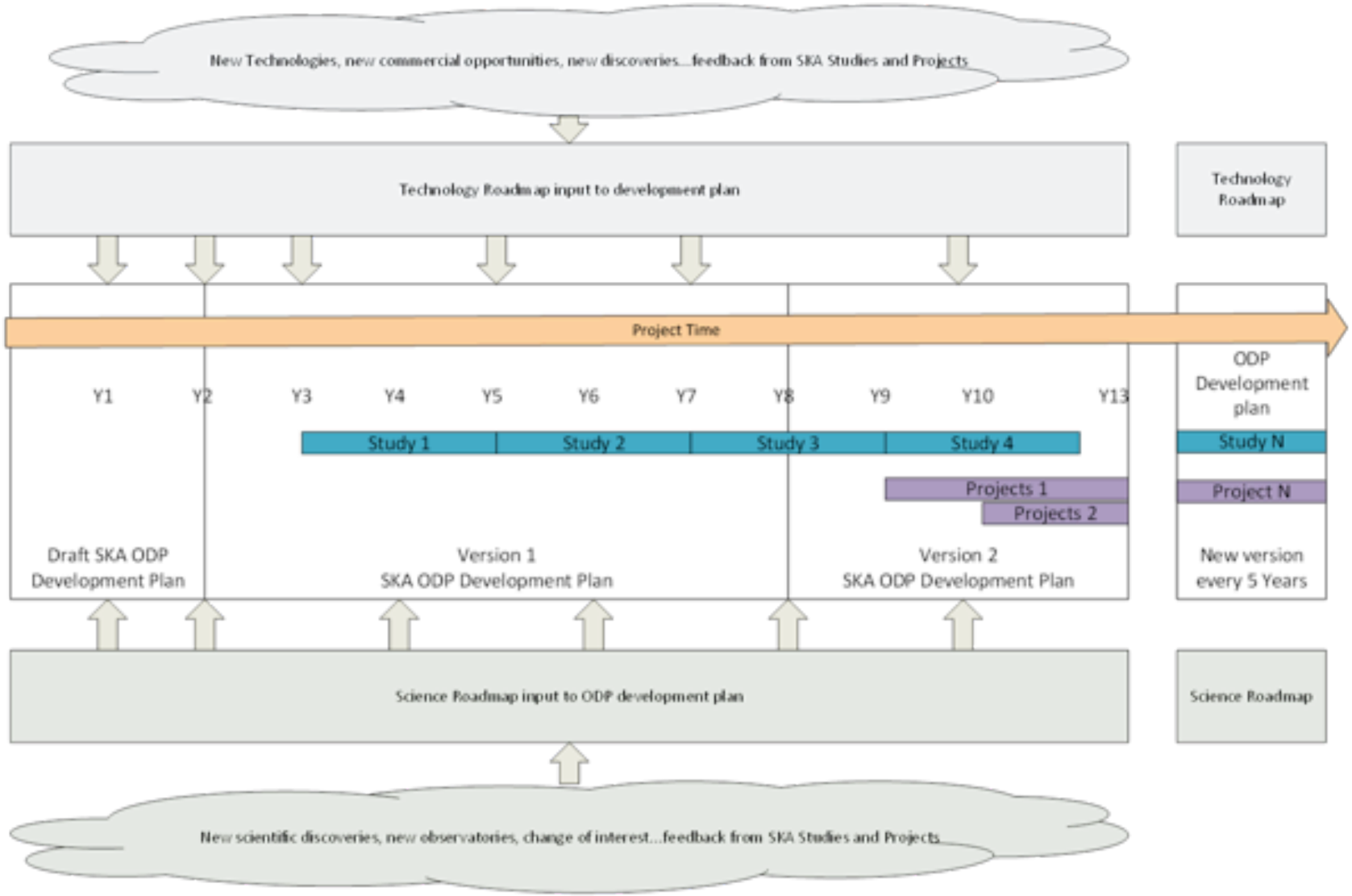
Why do we need a plan when we could just ask for proposals?

- Select the most (scientifically) effective upgrades
- Pick a balanced programme
- Ensure that upgrades work together **as a system**
  - e.g. there is no point in increasing the maximum baseline if the correlator cannot introduce large enough delays
- Implement in a timely way without disruption

Road Maps and Development Plan

- Science Road Map
  - New science enabled by ODP
  - External Advisory Group Chaired by Science Director
  - Maintains a list of science opportunities and priorities
- Technology Road Map
  - Survey of new technology relevant to SKA
  - External Advisory Group Chaired by Project Engineer
  - Surveys new technological opportunities, with a rough assessment of TRL and cost
- Development Plan
  - Evolving Plan for the ODP, informed by the road maps
  - Balances restoration of capability (if required) against new ideas
  - External Advisory Group Chaired by SKAO Senior System Scientist
  - Plan presented to SEAC for approval
  - Circulated to the wider SKA Community

Planning Process



Studies (1)

- Needed to prepare project proposals
  - science case
  - design
  - feasibility and costing
  - improve TRL
- Also small, individual stand-alone developments (e.g. data-processing algorithms)
- 2 or 3-year funding cycle
  - Open call for proposals
  - Fixed-price, with clear deliverables
  - Select by SKAO recommendation (with external input) for review by SEAC
  - Approval by Director General

Studies (2)

- Scope
  - Maximum ≈ €300k?
  - Cofunding (national, EU, etc.) encouraged
- Management within SKAO
  - Light touch
  - Some or all of Project Manager + domain specialist + astronomer (as appropriate)

Projects (1)

- Deliver a major increment in capability
  - Duration 1 – 5 years
  - Budget up to ~€20M (e.g. receiver band)
  - Small projects (€0.3 – 1M) also supported
  - Must budget for operational support as well as construction
  - Avoid spreading budget thinly over many projects just to provide work for more groups
- Project proposals in response to a directed call
  - Expected to be on the road-map
  - Adequate TRL
  - Likely to be linked to the output of an earlier study
  - Unsolicited proposals not ruled out, but probably a minority
  - Balance of size, new science, efficiency improvement, restoration of descoped capability and new opportunities
  - Mandatory science case; project management, systems engineering, test, Quality Assurance plans
  - Co-funding except in special cases

Projects (2)

- Selection
  - Rigorous management
  - Science + Technical + Programmatic assessments by SKAO
  - SEAC review
  - Approval by DG (Council for large projects)
  - Eligibility to be discussed: opportunity for engagement across the SKA partnership

Initial Budget Profile

- Current baseline (direction from Council)
  - €40M over 10 years from Construction start
  - €20M per annum in steady state
- Rationale for funding profile
  - Long lead times and maintaining momentum in the community both argue for an early start to studies
  - Need to manage the study programme during construction
    - Keep things simple – everyone is busy!
  - Major projects not feasible until after the end of construction
  - Phased to restore capability as necessary

Timetable (from construction start 2021 July 1)

Year	Cost (M€)	Activity
1	0	
2	0	Initial draft road maps and development plan. Deadline for Study Cycle 1 proposals
3	1	Study cycle 1
4	1	Study cycle 1 (continued); Deadline for Study cycle 2 proposals
5	1.5	Study cycle 2
6	1.5	Study cycle 2 (continued); Deadline for Study cycle 3 proposals
7	1.5	Study cycle 3 (project preparation)
8	1.5	Study cycle 3 (continued); Approved Development Plan available. Deadlines for Study cycle 4 and Project cycle 1
9	12	Project Cycle 1
	1	Study cycle 4
10	18	Project Cycle 1 (continued)
	1	Study Cycle 4 (continued)
11+ (steady state)	18.5	Projects
	1.5	Studies

Any questions?

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

SKAO

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