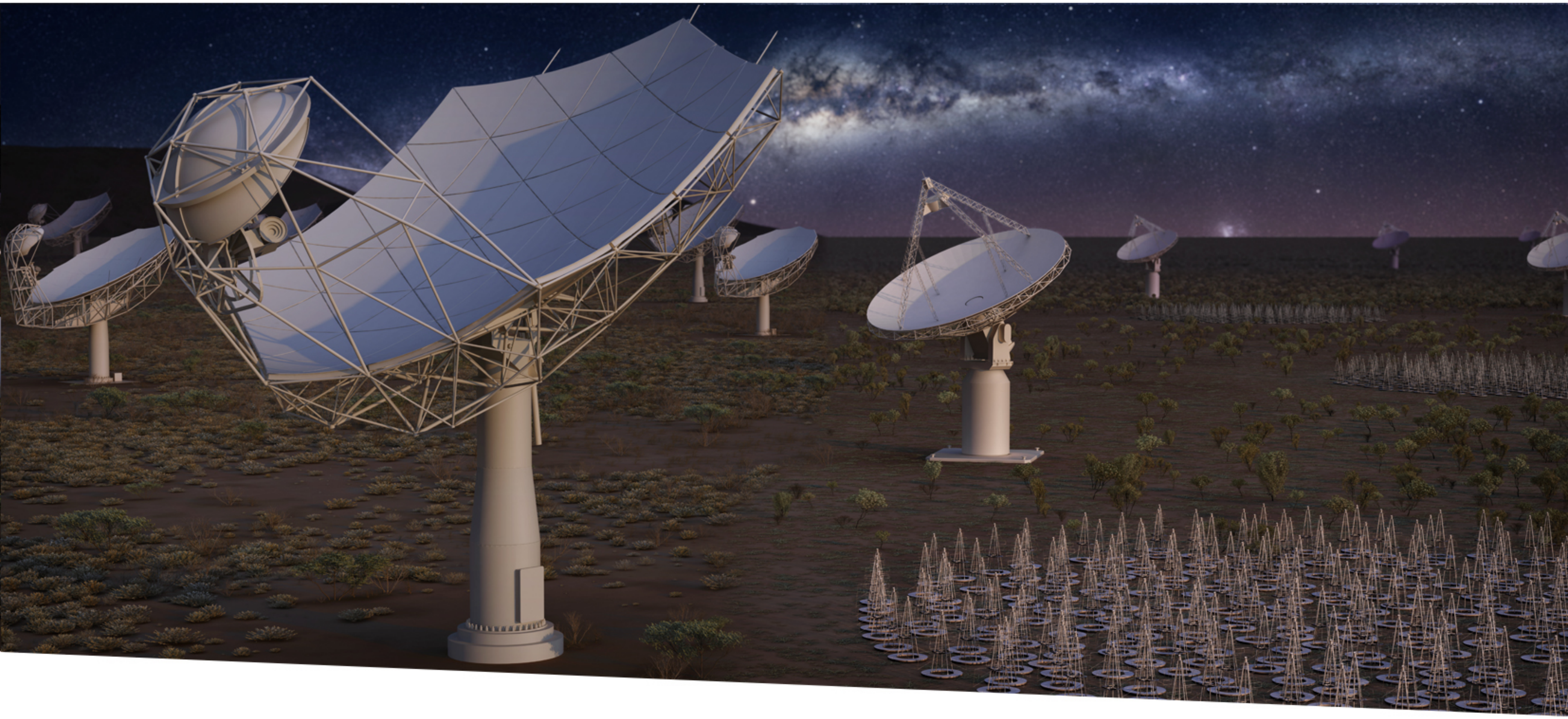
Low Early Production Array

(EPA)



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

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2018-03-07

EPA-Low

- Motivation for EPA-Low
- High Level Plan
- Proposed Configuration
- Contributions
- Project Plan
- High Level Risks

Why Early Production Arrays

The Early Production Array is intended to be a representative end-to-end system based on the SKA reference design, that is the result of system CDR. The EPA will be a prototype integrated system built on a realistic infrastructure.

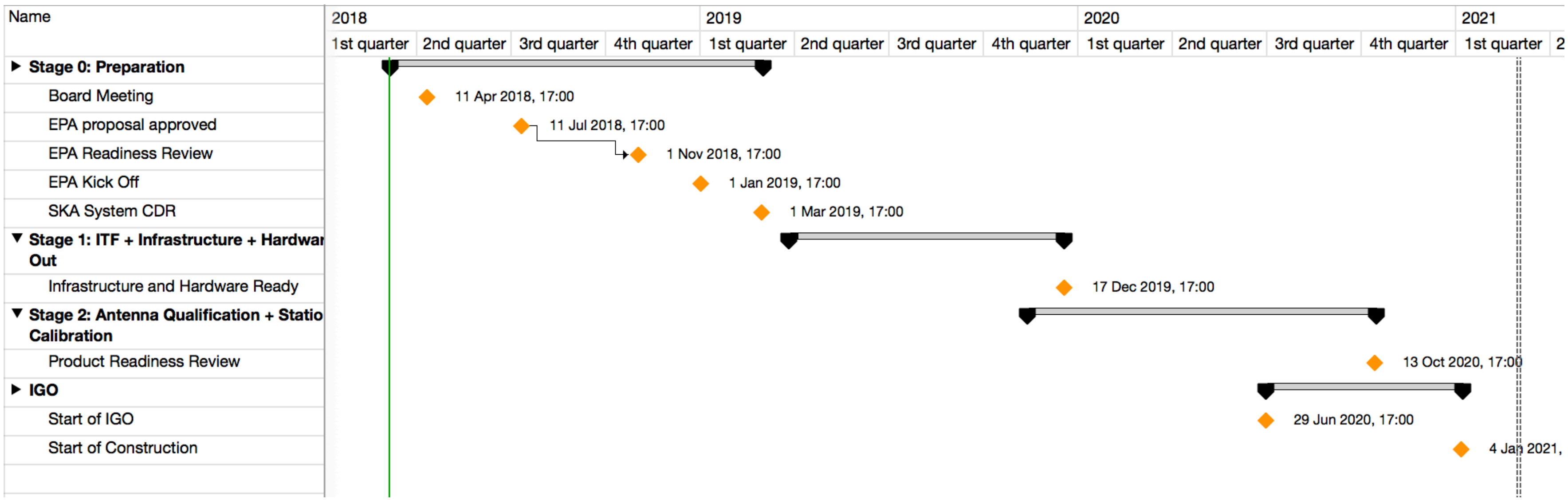
The objective of the EPA is to reduce the risks associated with the roll-out of the telescope in terms of process, cost, design and performance.

The impact of the EPA will increase when as many sub-systems as possible (hardware and software) are available for integration into the Early Production Array, even if in rudimentary or prototype form.

Result of Low Early Production Array

- Verify subsystem interfaces and subsystem functionality
- Characterise the SKA1 telescope on essential requirements such as antenna performance, calibratability and monitoring and control
- Finalise the design for procurement of the complete system, in particular by qualifying components for series production
- Improve and optimise roll-out procedures in terms of integration, verification and acceptance
- Prepare the SKAO for the roll-out of the telescopes

EPA-LOW in the overall SKA-Plan



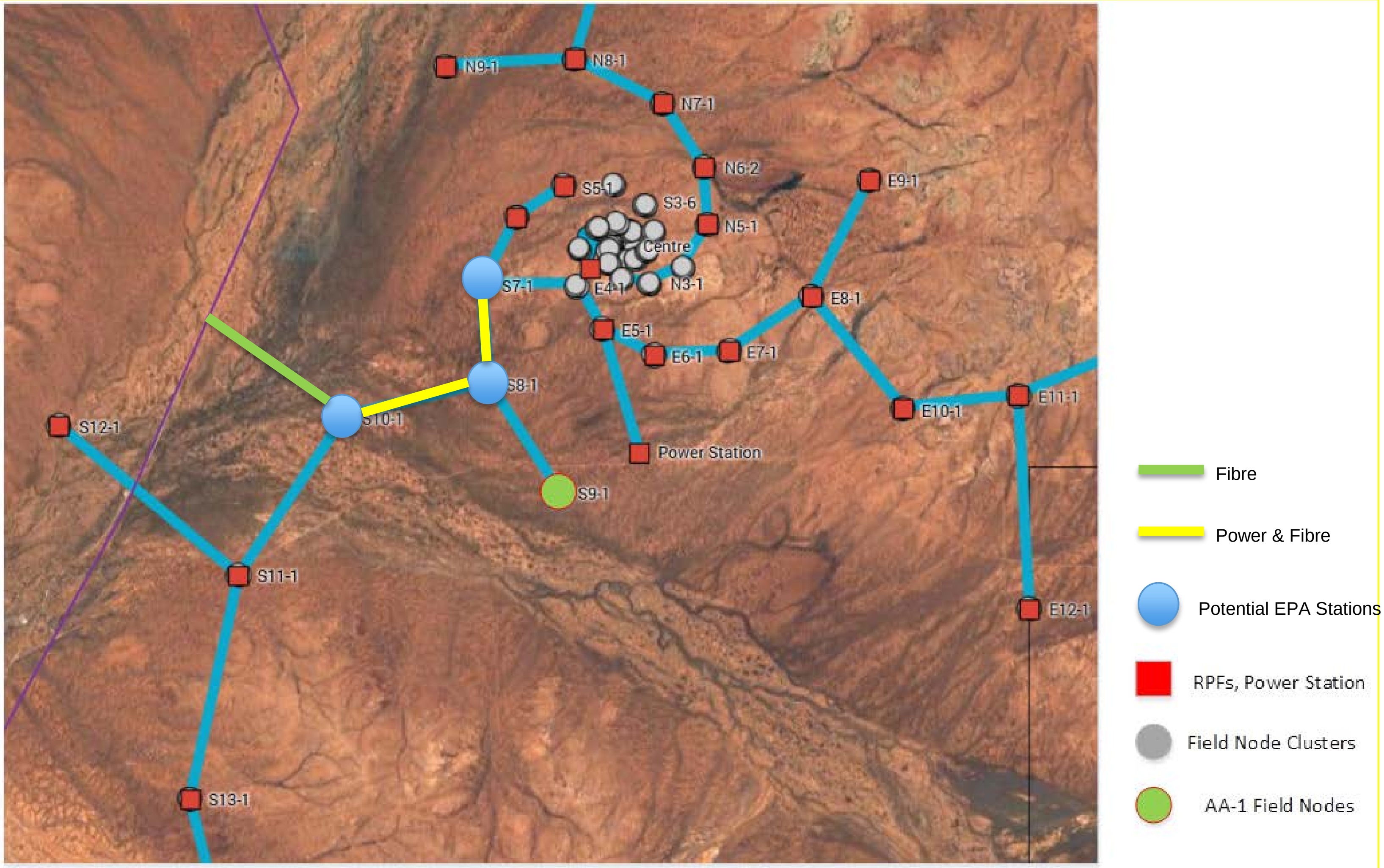
The EPA is pre-ceding the AIV project as it is:

- Planned before project construction starts
- Is used for **hardware qualification** before procurement starts
- Is used for verification purposes to reduce procurement and construction risks

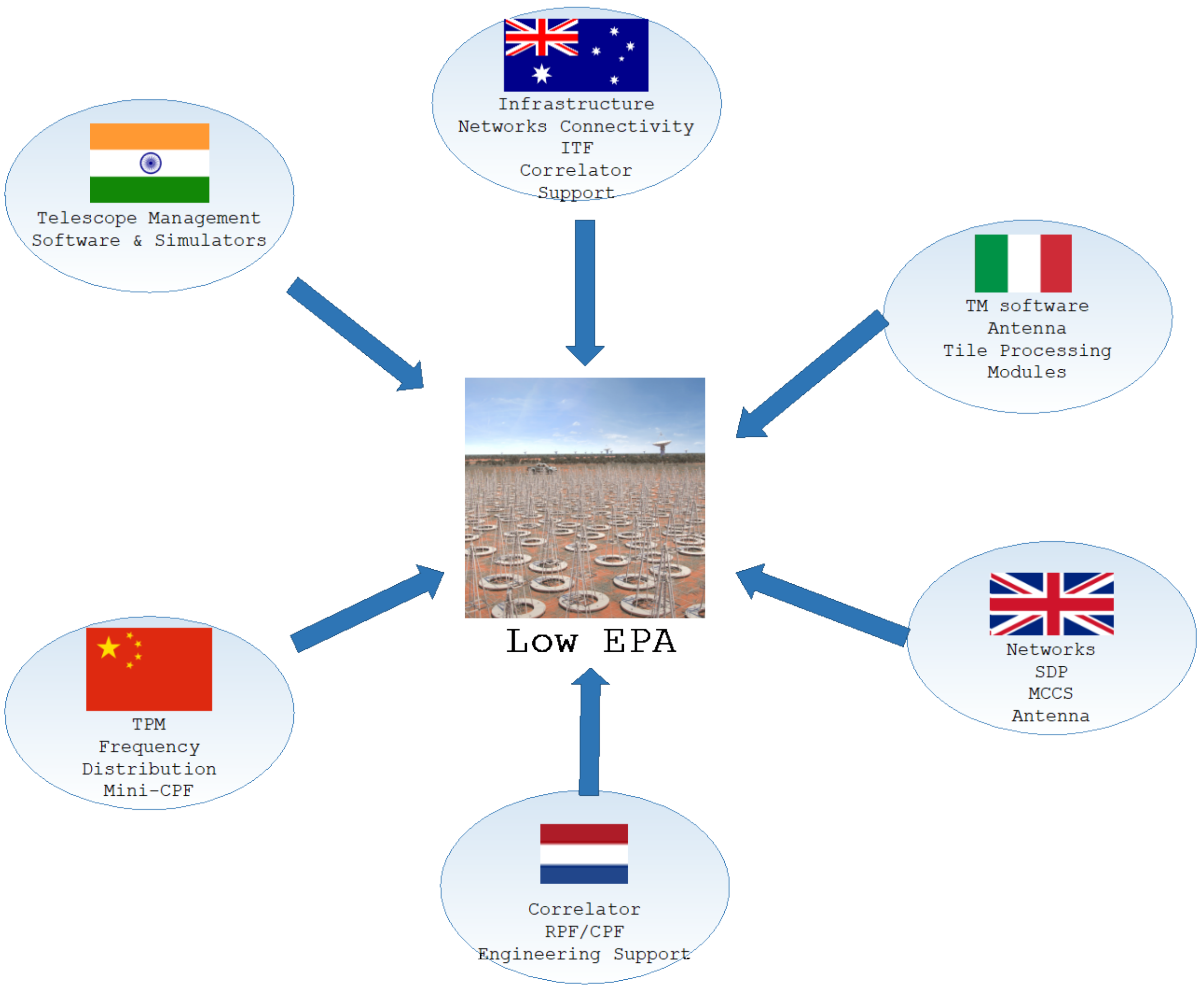
EPA Qualification + Verification (subset of AA1)

- Qualification of Antenna design
- Qualification of TPM design
- Qualification of RPF
- Qualification of Frequency Distribution
- Correct operation of POST (Power On Start-up Test), BIT (Built In Test) and alarm handling
- Fine tuning beam steering on the sky
- Manual calibration and beam steering (requires a basic correlator)
- Basic test of beam shape and beam stability (Raster or drift scan)
- Phase closure
- Amplitude closure
- Fringes
- Absolute & relative timing models (SaDT: 1PPS and synchronisation tone)
- Band pass characterisation and calibration (gain flatness over frequency and spurious signals)
- Early performance comparisons against simulations
- Development of methods for managing beam shapes, pointing models, beam rotation
- Basic operational Interface (TM)
- Ability to reliably conduct long observing runs (beam shape, beam stability over seconds, minutes and hours including operational interface stability)
- Interferometric pointing
- Fringe rotation and delay compensation models.
- Basic continuum image
- Basic spectral line Image
- Frequency agility
- Do comparison observations with MWA.

Proposed locations for EPA



Possible Contributors



Construction Costs

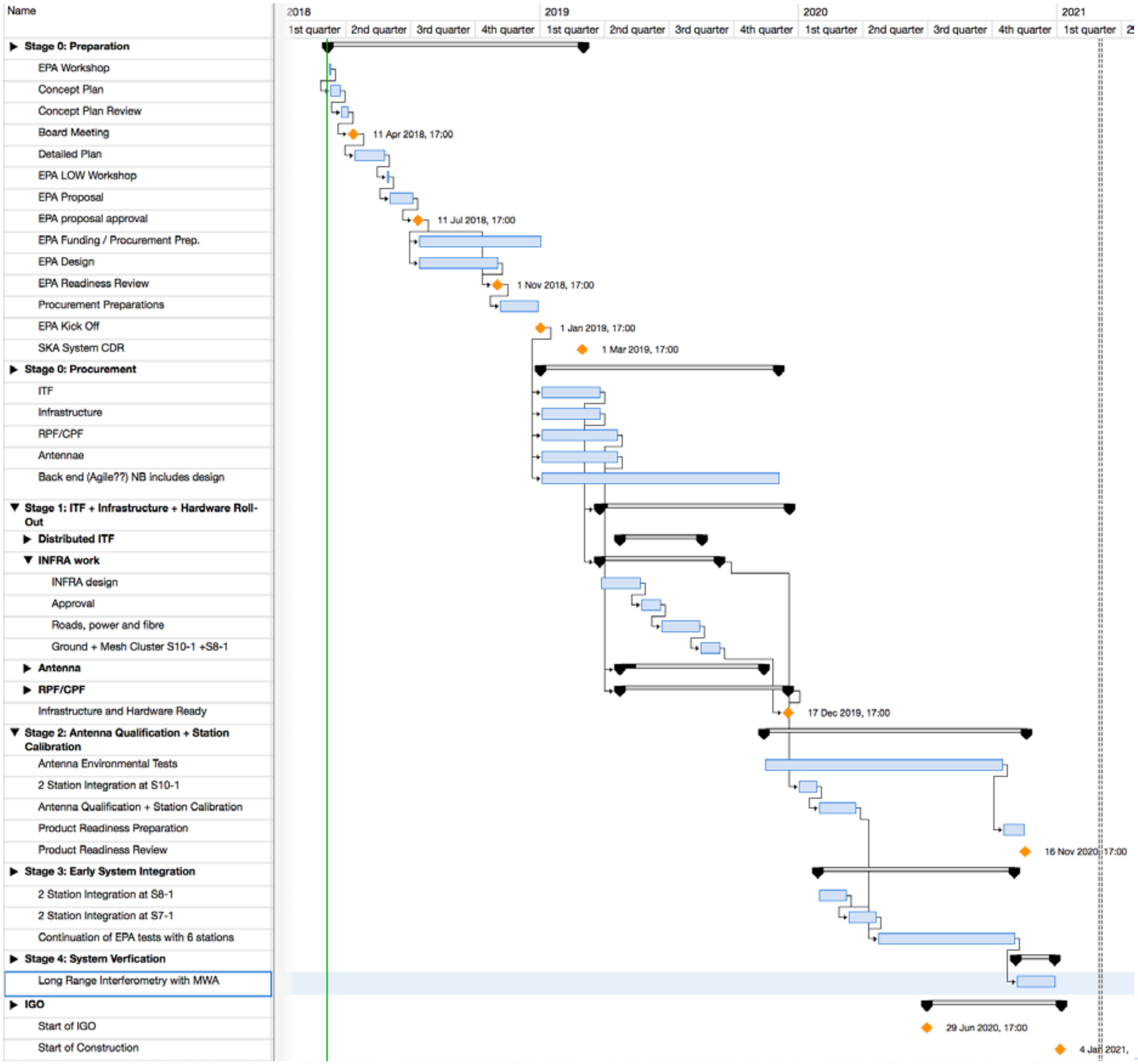
Part name	Construction Cost
Field node	470,000
Tile Processing Module	465,000
TPM Chassis	52,000
LFAA Data Network (LFAA-DN)	70,000
Monitoring and Calibration Sub-system (MCCS)	35,000
Power Distribution	1,650,000
Secondary Access Tracks	330,000
RPF	565,000
LOW Ground Preparation (6 stations)	40,000
Frequency Distribution	30,000
Fibre Infrastructure	640,000
White Rabbit	25,000
NSDN	35,000
Total construction cost with contingency	4,407,000
Scaling correction 20%	**5,288,400**
Infrastructure	**2,290,000**
Risk to be reduced	**2,998,400**

Disclaimer:
Based on 3 clusters with 2 stations
Hardware construction cost, no software, indication only
Not based on March 2017 cost submission
Workforce for site maintenance / system integration and evaluation not budgetted

5 Staged Plan

Stage	Name	Goal
0	Preparation	Detailed Project Plan and Detailed Design of EPA
1	ITF, Infrastructure and Hardware Procurement and Roll-Out	Agreements on EPA EPA hardware ready for use on site
2	Antenna Qualification and Station Calibration	Qualification of Products in EPA resulting in Product Readiness Review
3	Early System Integration	Short baseline interferometry tests with 4 or 6 stations
4	Long baseline tests with MWA	Long baseline interferometry Assessment of ionospheric calibration on long baselines

Current Plan



Start date from Stage 0 indicative

High Level Risks

- The scope of the work should be within the planned construction work, but limited additional cost is imposed on the project.
- Costs agreed in the EPA are considered as credits to SKA construction contributions once the IGO is enabled.
- May limit the advantages of open tender for WBS elements.
- Development maybe extended delaying construction.

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Detailed EPA Objectives

- Technical Objectives
  - Hardware Qualification in the actual environment: antenna, TPM, Tim/Freq, RPF

  => **completion by Product Readiness Review**

- Design Validation by connecting subsystems
  - Testing Analog/Digital signal chain
  - Testing Networks
  - Testing Correlator
  - Testing Early Telescope Control & Monitoring Functionality
  - Testing Early Imaging Software
- Project Objectives
  - Risk Reduction by connecting subsystems even at prototype maturity
  - Complete product qualification to a level ready for industrial procurement by a Product Readiness Review of antenna, TPM, Frequency distribution and RPF at the end of Stage 2
  - Reducing costing uncertainty of antenna, TPM and RPF procurement
  - Demonstrate management, project and procurement processes from SKAO, between HQ, site and supplliers
  - Improvement and optimisation of the roll-out and test-procedures in terms of integration verification and acceptance.
- Science Objectives
  - Completing and testing calibration scheme for the Low telescope
  - Perform early imaging observations to verify system functionality
  - Investigating ionospheric calibration on longer baselines performing interferometry with MWA

EPA Hardware Needed +

Country	Possibility of Contributions
Australia	**Support:** - Site Management - Manpower for installation and integration - Engineering Support for Evaluation of the Results - Logistics Support
	Provide Temporary ITF
	Infrastructure works: - Trenching (power/fibre) - Cluster site preparation including mesh - RPF container - Power - APIU
	Networking: - NSDN network + equipment + supporting computers - External Connectivity: network + storage
	Contribution to correlator hardware / software (joint NL/AUS)
Italy	Provide TPM-system (rack+boards+firmware) Measurement equipment for station beamforming TM software
UK	Commercial procurement of 4 x 256 antennas (LNA+fibre to APIU) SDP hardware + software + storage Network equipment for CSP-SDP MCCS Hardware + Software (with Malta) Rubidium clock + White Rabbit equipment
China	Provide Container for mini-RPF Provide TPM-system (rack+boards+firmware) Provide Frequency Distribution (Tsinghua design)
Netherlands	Contribution to correlator hardware / software (joint NL/AUS) Engineering Support for Evaluation of the Results
India	TM software (joint contribution with Italy)
SKAO	Project Management Procurement Support Engineering /Science Support for evaluation of the results