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SKA Science Commissioning and Verification Plan

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The Square Kilometre Array (SKA) [1] is a global project to build a next generation multi-purpose radio telescope that will play a major role in answering key questions in modern astrophysics and cosmology. The SKA is composed of two radio telescopes (SKA-Low and SKA-Mid) covering a frequency range from 50 MHz to 15 GHz (initial phase). The first stage of the project (SKA1) officially entered the construction phase in July 2022. SKA-Mid will comprise 197 dishes in South Africa, 64 of which are already in place, forming the MeerKAT precursor telescope. SKA-Low will consist of 131,072 log-periodic antennas distributed across 512 aperture array stations of 256 antennas each in Western Australia. The SKA Global Headquarters (GHQ) is hosted at Jodrell Bank Observatory in the UK.

The Array Assemblies (AA) are subsets of the full array characterized by the number of stations (SKA-Low) and dish systems (SKA-Mid) which will be deployed with an increasing range of observing mode capabilities. The first major milestone, known as AA0.5, requires the completion of six SKA-Low stations and four SKA-Mid dishes and is expected in late 2024. A further four Array Assembly milestones have been defined leading up to the full design baseline. Funding is currently allocated for three of these (AA1, AA2 and AA*), with completion of AA* anticipated in 2027-8.

The SKA System Science team is currently based at the SKA GHQ, with one member in South Africa. Its main current roles are: planning for science commissioning and verification, acting as an interface between science and engineering, supporting requirements analysis and verification and participating in project reviews and providing expertise and training in radio astronomical techniques within the SKA project. During SKA construction, commissioning will be the main focus of the team's activity and it will expand to include groups located in Perth (SKA-Low) and Cape Town (SKA-Mid), working very closely with the co-located Assembly, Integration and Verification (engineering) teams. Commissioning involves the testing and optimization of all elements of both SKA-Low and SKA-Mid telescopes to ensure that they meet the scientific requirements. It is a collaborative, interdisciplinary activity, requiring skills in astronomy/interferometry, signal processing, control and data analysis software, as well as hardware engineering and the science. It is a highly iterative process, usually involving several repetitions of each test. The specific role of the science commissioning team will be to plan, perform and analyse astronomical tests of the SKA prior to the start of scheduled observations.

In the very early phases of science commissioning, a subset of tests will be carried out to confirm fundamental array performance (basic interferometry, spectroscopic verification and tied-array beamforming), together with dish (SKA-Mid) and aperture-array station (SKA-Low) verification. By the end of AA0.5, the arrays will be capable of calibrated interferometry (and very rudimentary imaging of simple fields) with a goal of tied-array beamforming for early pulsar observing tests. All of the standard calibrations will be exercised using single subarrays for both SKA-Low and SKA-Mid. Science Verification (SV) will be executed by the Science Operations team with support from Science Commissioning. It will be implemented as a set of end-to-end tests of the system from the proposal submission process to delivery of the data. There also will be a range of targets, with an emphasis on comparison with results from other telescopes. The SV process also provides access to SKA data for the community during construction, enabling data quality to be assessed by a wider group of astronomers outside the immediate commissioning team. Valid Science Verification data will be released publicly.

References

[1] J. McMullin, P. Diamond, A. McPherson, R. Laing, P. Dewdney, A. Casson, L. Stringhetti, N. Rees, T. Stevenson, M. Lilley, A. van Es, M. G. Labate, G. Swart, A. Schinckel, T. Cheetham, M. Caiazzo, M. Austin, L. Ball, S. Berry, R. Braun, A. Chrysostomou, "The Square Kilometre Array Project," *Proc. SPIE*, **11445**, 512, December 2020, doi: 10.1117/12.2565117