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SKA Low CBF Requirements Verification & Factory Acceptance Testing

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The Square Kilometre Array (SKA) LOW Correlator and BeamFormer (CBF) [1] is governed by high quality SKA system requirements covering criteria from equipment documentation to interface definitions, motivated by specific science requirements. The LOW CBF team (aka Perentie) has a contractual obligation to demonstrate that the system meets requirements for the final SKA LOW telescope. To ensure continuous delivery of a functional product, the LOW CBF team goes through periodic compliance assessments called Factory Acceptance Tests (FAT) that follow the same incremental Array Assembly (AA) roll-out stages as the overall telescope (AA0.5,1,2,*). Therefore, the LOW CBF team plans to perform as many FAT as there are AAs. To date we have successfully completed FATs for AA0.5 and 1, with AA2 and * remaining.

While SKA and LOW CBF requirements are defined and recorded with a system engineering approach [2] in *Jama Connect*, the LOW CBF team opted for a more software engineering approach to interpretation and verification. We have thus defined a series of tests called "Perentie Test Cases" (PTCs) to verify the technical requirements. We have identified four broad categories of test cases associated with the requirements: visual inspection, interface, functional, and performance. The visual inspection test cases are performed manually, and include checks of equipment models, datasheet parameters, and some basic protocol checks using an open source packet analyzer such as Wireshark. The other categories are fully automated.

The interface category of PTCs aim to verify the various interfaces between LOW CBF and other components of the telescope such as protocol definitions between LOW CBF and scientific data consumers. The functional category of PTCs aim to verify the functional requirements of LOW CBF, such as being able to track multiple station beams, having coherent noise from multiple stations added linearly in the various beamformers, and having the required control features. The last type of PTC relates to performance, scaling, precision, and system reliability. These performance tests are defined to verify the requirements associated with the expectations of a science operator/user of the telescope, for example that the correlator does not introduce any bias, or that channelisation results in acceptably low leakage between adjacent frequency channels.

As of November 2024, the Perentie team have successfully passed the AA1 FAT and delivered a LOW CBF system that can support the AA1 SKA LOW configuration, through the implementation of nearly 40 PTCs that verify more than 269 of the 438 final system requirements.

PTCs are implemented in Python code using the *pytest* framework to allow test automation and repeatability. Test execution is automated via a *GitLab* Continuous Integration (CI) pipeline [3]. The CI pipeline can be triggered when changes are made to any Low CBF sub-component for regression testing of changes, using filters to select only the relevant tests. The tests are also scheduled to run periodically, out of working hours, when there is less contention for resources in the test facility. This allows better usage of scarce hardware resources during development periods by avoiding long-duration tests, while ensuring all tests will still be executed occasionally to demonstrate ongoing compliance with requirements as the system evolves.

The conference presentation will present some of the key requirements, tests and results, including more details on the testing infrastructure and processes.

1. Grant A. Hampson et al., "Square Kilometre Array Low Atomic commercial off-the-shelf correlator and beamformer," Journal of Astronomical Telescopes, Instruments, and Systems, vol. 8, no. 1, p. 011018, Feb. 2022, doi: 10.1117/1.JATIS.8.1.011018
2. NASA Fundamentals of System Engineering https://www.nasa.gov/reference/2-0-fundamentals-of-systems-engineering/
3. A. B. Bolin et al., "Continuous Integration Testing of Real-time Signal Processing and Control for the SKA Low Correlator and Beamformer," presented at URSI GASS 2023, Sapporo, Japan, 19-26 Aug., 2023