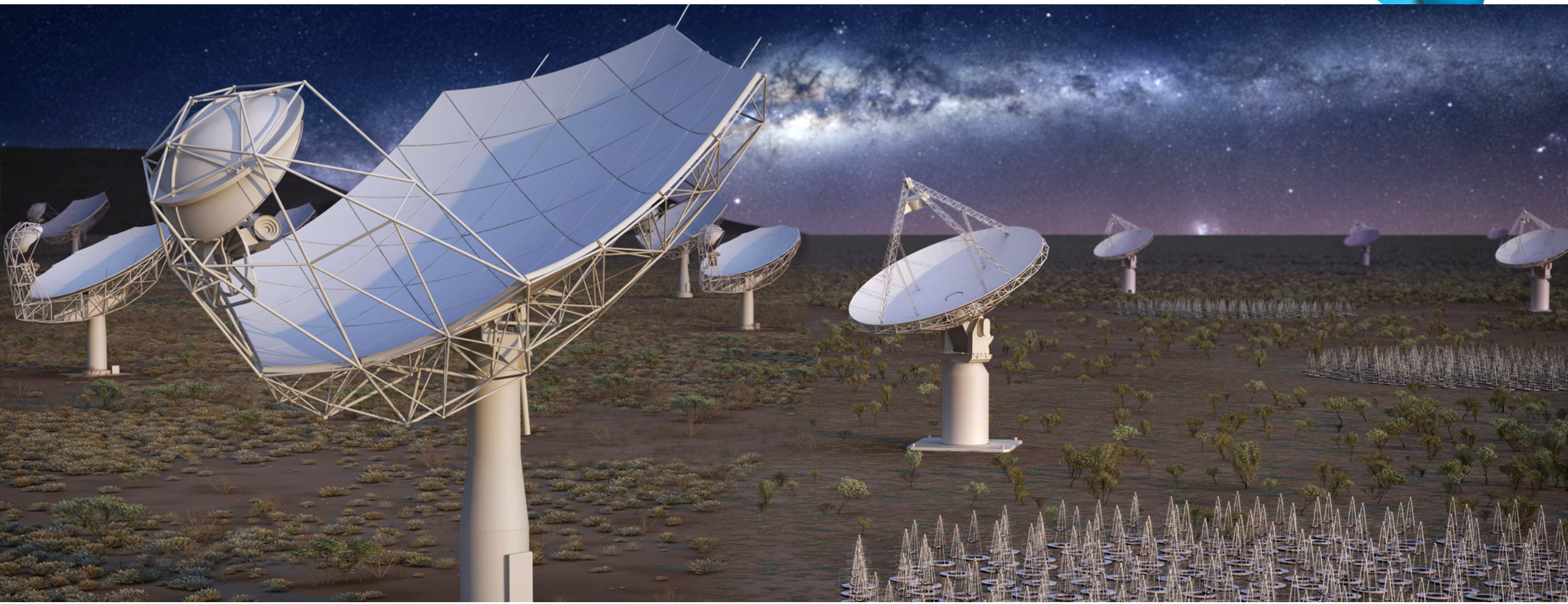
AIV and Prototypes



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

L. Stringhetti (SKA1 Project Engineer)

25th November 2019

Summary

- Part 1
  - AIV definition for SKA
    - Definitions and their references in System CDR data Package
    - AIV is present at different level of the WBS and of the Project
  - System AIV
    - Current preparation status update (for System CDR), including the AIV management approach in SKAO
- Part 2
  - Status of verification through prototypes
    - Current status update (for System CDR)

AIV Definition (SKAO)

- **A**ssembly
  - The activities required to physically establish a product of the SKA1 Telescope System on-site. [..] The installed product may be verified against simulators and/or emulators.

- **I**ntegration
  - The activities required to incorporate a product into the SKA1 Telescope System. Any simulators and/or emulators that might have been used during the installation process are replaced with real hardware and/or software, and the associated tests repeated, perhaps in abbreviated form.

- **V**erification
  - All activities that are executed to formally verify the Telescope system against its Level-1 Requirements.
    - Achieved by performing astronomical observations and/or dedicated engineering tests.
    - Successful commissioning is a necessary pre-condition.
    - It will be necessary to define test criteria for intermediate configurations (e.g. the achievable noise level scales with the number of array elements).

From:
SKA-TEL-SKO-0000315 Science Commissioning and Verification Plan
SKA-TEL-SKO-0000739, SKA Product Quality Assurance Plan
SKA-TEL-SKO-0000475, SKA integration and verification policy
SKA-TEL-SKO-0001201, Engineering management plan

V in SKA…..

Verification : Confirmation, through the provision of objective evidence, that a Product of the SKA1 Telescope System meets its specified requirements. Verification is performed at each level of the system hierarchy. It answers the question: “Was the system built right?”

- **The preferable verification methodology is test**

(This means that we want to test early).

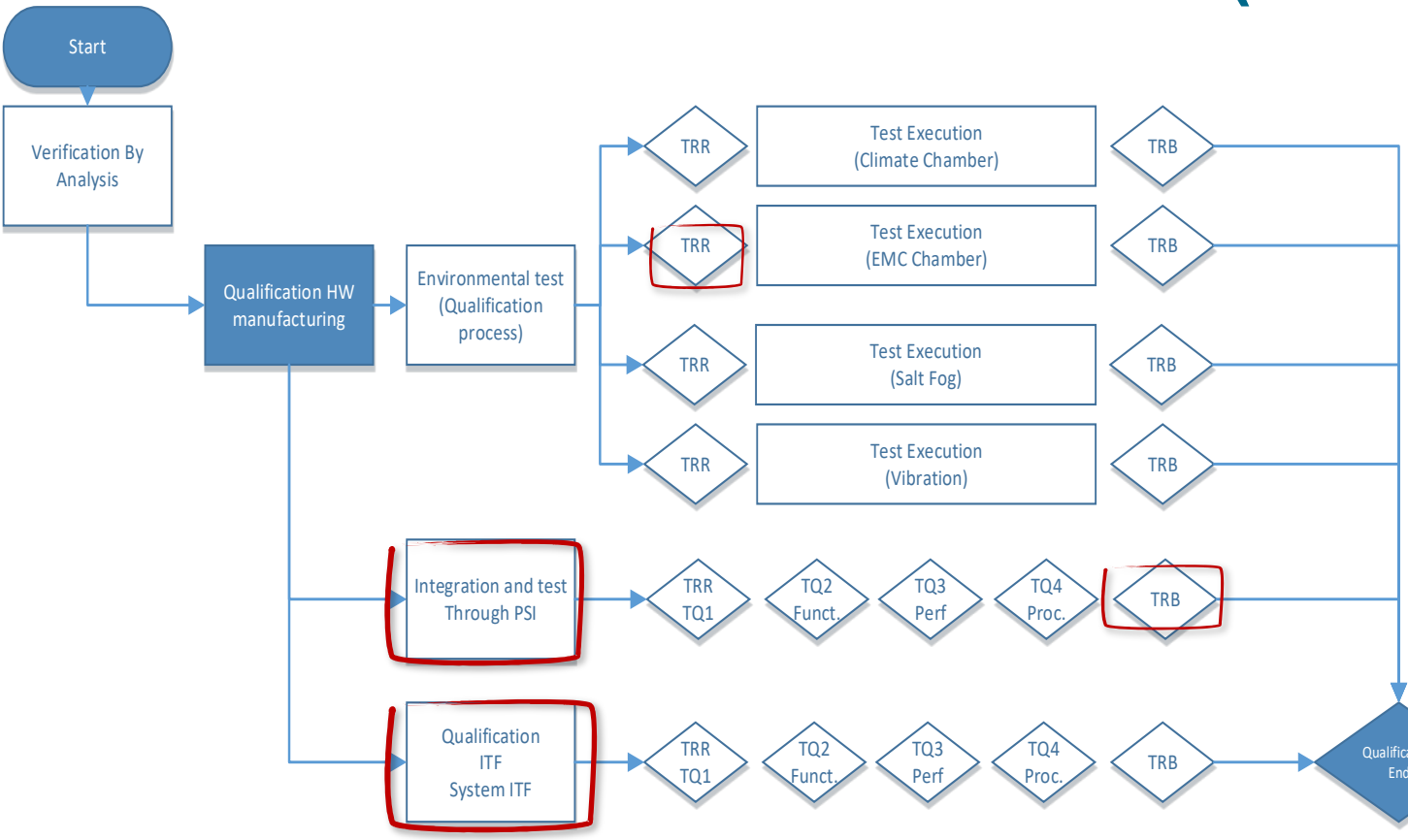
- **The test shall be performed as soon as possible**.

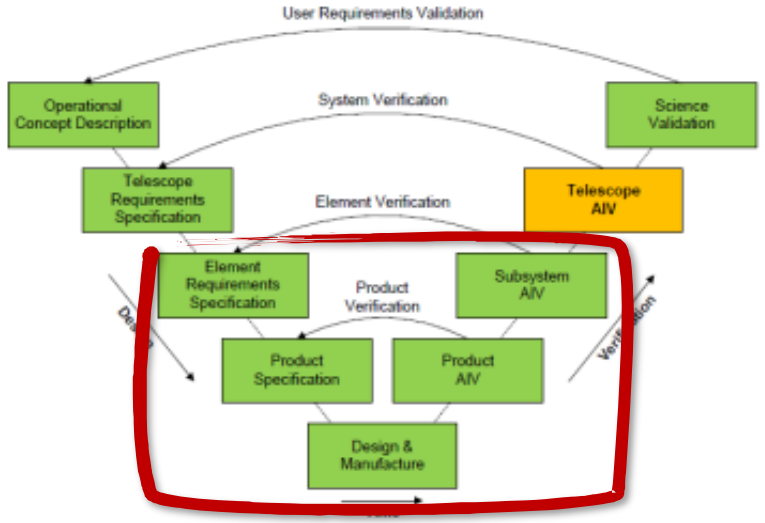
(This means we want to test often).

From the EMP (SKA-TEL-SKO-0001201)

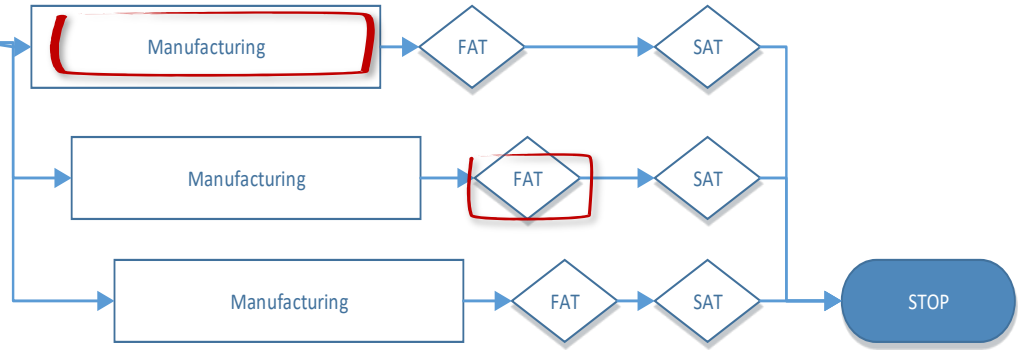
The SKAO will be involved (through the SKA-TE and QA office) during all the processes where verification is needed including the “Qualification” stage. Responsibility of SKAO staff will be tailored respect the level of the product in the hierarchy. System Level is full responsibility of the SKAO.

Verification at Product level (example)





Key points for SKA AIV/QA personnel

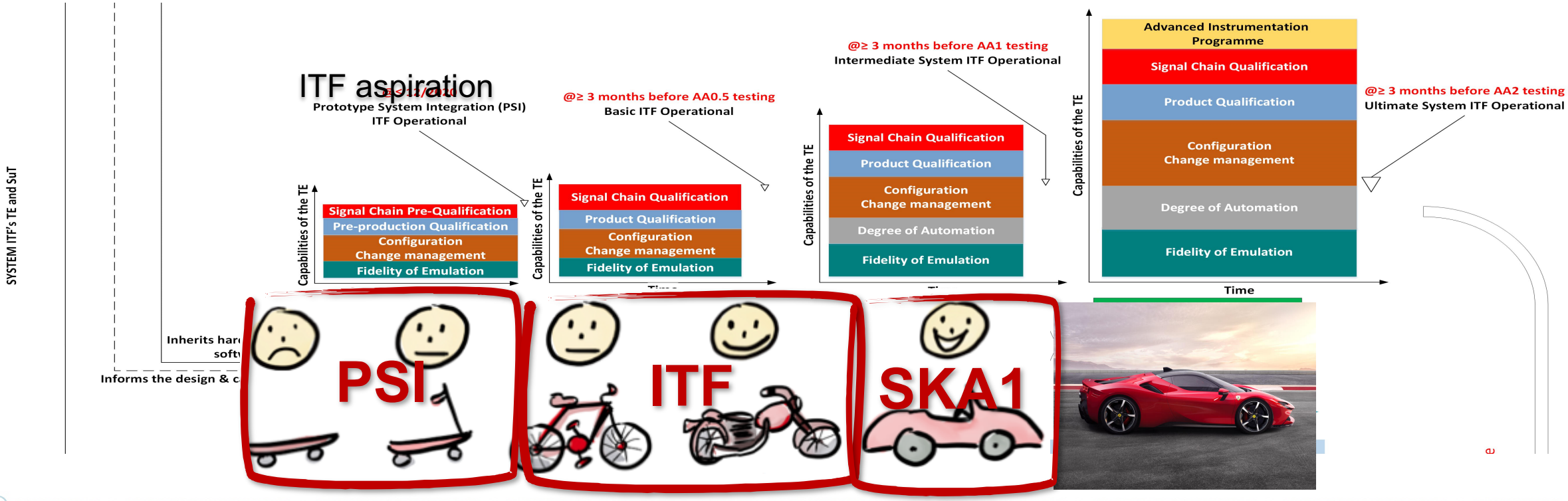


TRR : Test Readiness Review
PSI: Prototype System Integration
SAT: Site Acceptance Test

FAT: Factory acceptance Test
TRB: Test Review Board (or Meeting)
ITF: Integrated Test Facility

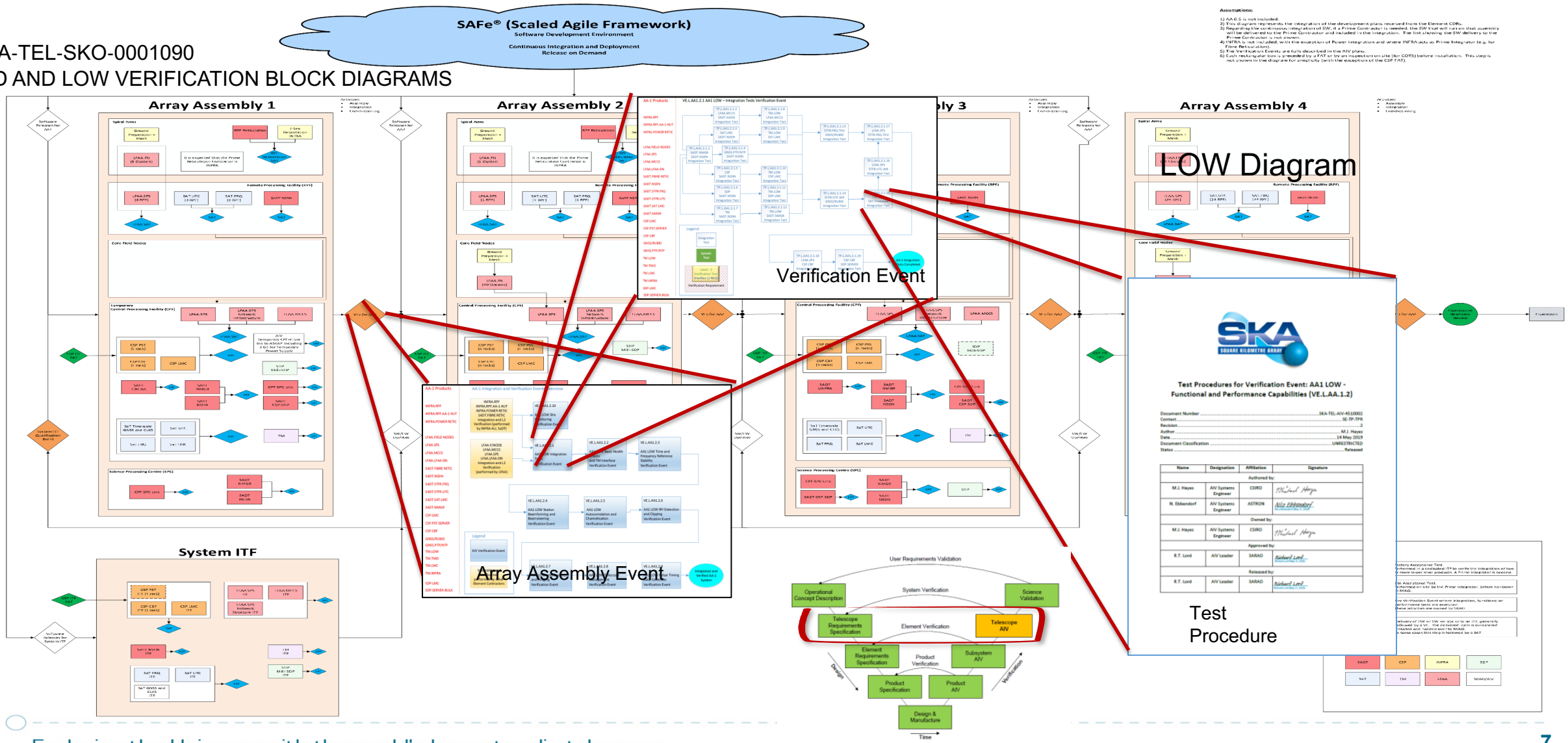
Verification before Site

- SKA has adopted two programs to minimise risks of the Site integration
  - PSI Verification program: can happen in any part of the world with pre-construction SW/HW
  - ITF Verification program: Will happen in Host countries facility with construction SW/HW.

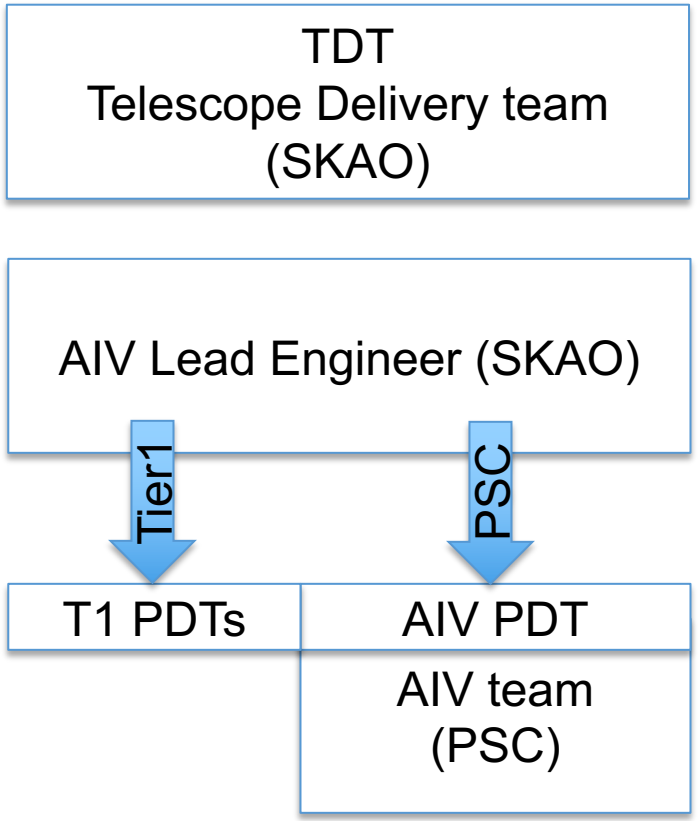


System Level AIV

SKA-TEL-SKO-0001090
MID AND LOW VERIFICATION BLOCK DIAGRAMS



AIV management in SKAO



Telescope Delivery Team (TDT, one for each telescope

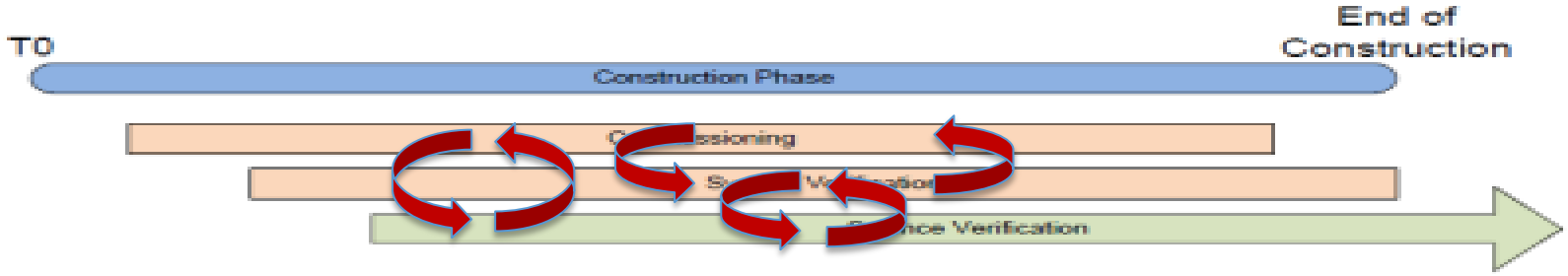
AIV Lead Engineer, one for each Telescope, will lead all the AIV activities crosscutting the Telescope

AIV Team will be base on the host country on the base of a Professional Service contract.

PDT= Product Delivery Team

SKA-TEL-SKO-0001201, Engineering management plan
SKA-TEL-SKO-0001100-01_SKA1ProjectExecutionPlansigned

Is that all?



Commissioning

- All activities necessary to arrive at a working end-to-end system that can be used to perform system verification. These include:
  - setting-to-work
  - integration testing
  - system testing
  - execution and analysis of test science observations, with the aim of debugging the system.

Science Commissioning

The subset of commissioning which requires specification, execution and analysis of astronomical observations. This is separated out, since it will be primarily performed by a different group from that responsible for engineering commissioning and is a principal concern of this document.

Science **V**erification

All activities that are executed to verify the Telescope system against its Level-0 Requirements, i.e. to ensure that the Telescope system meets the needs of the science and operational users.

SCIENCE COMMISSIONING AND VERIFICATION PLAN

Document Number SKA-TEL-SKO-0000315
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Author ..... R.A. Laing
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Status ..... Released

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Conclusion (Part1)

- AIV is an iterative and recursive process at all stages of the project from part to the full system.
- System AIV is managed by SKAO
- In order to minimise risk from the ***I*** (following the second AIV principle: test as soon as you can!) PSI program planning is starting, and ITF planning is continuing.
- Integrated teams will work together through the project stages (AIV, SME, Comm. Scientists, Operation)

Status of verification through prototypes

SKA1 PROTOTYPING REPORT

Document number	SKA-TEL-SKO-0001631
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Author	R. Brederode, A. Pellegrini, L. Stringhetti,
Date	2019-10-16
Document Classification	FOR PROJECT USE ONLY
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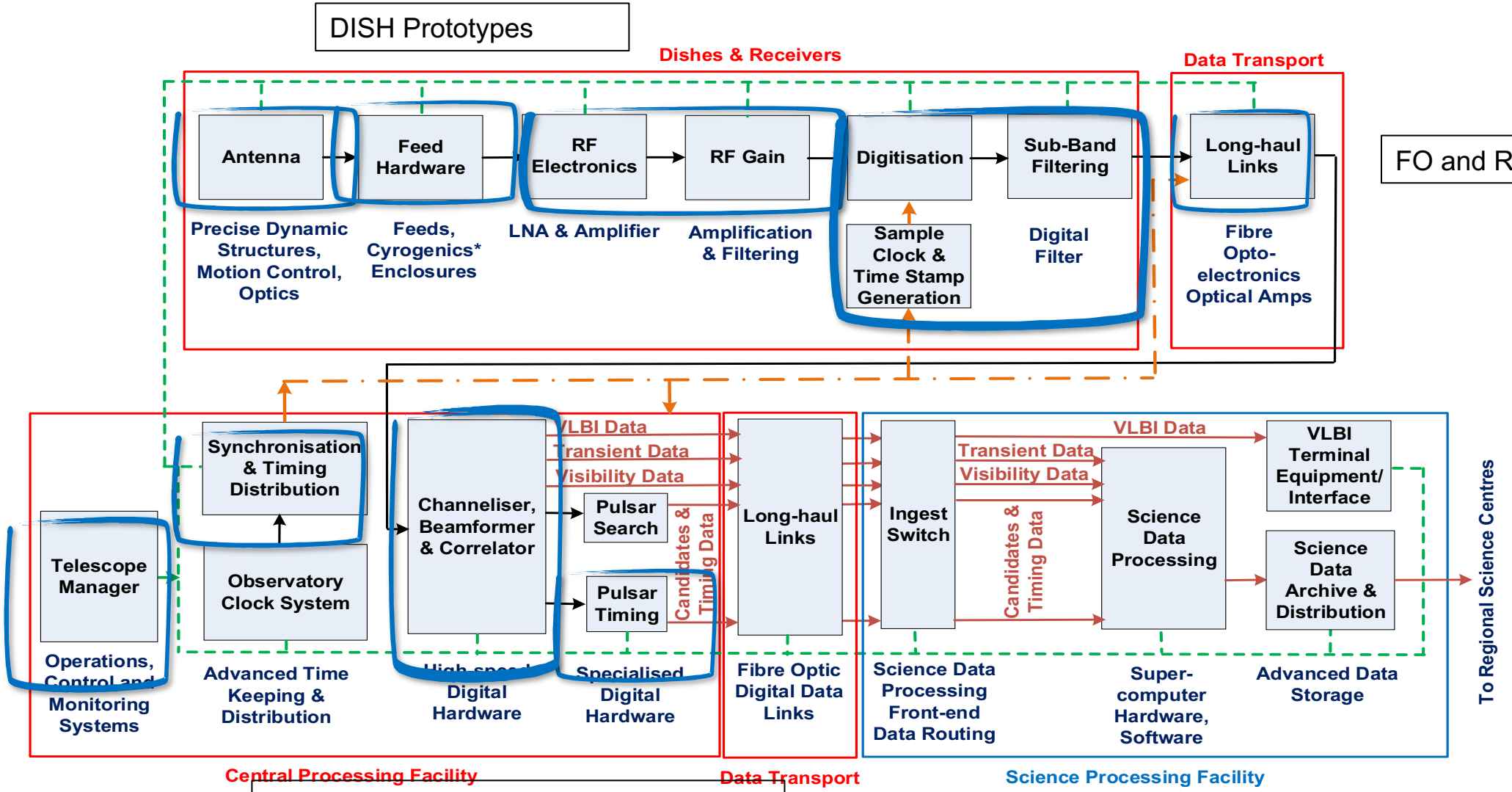
The Prototype work done is presented in
SKA-TEL-SKO-0001631 SKA1 Prototyping Report

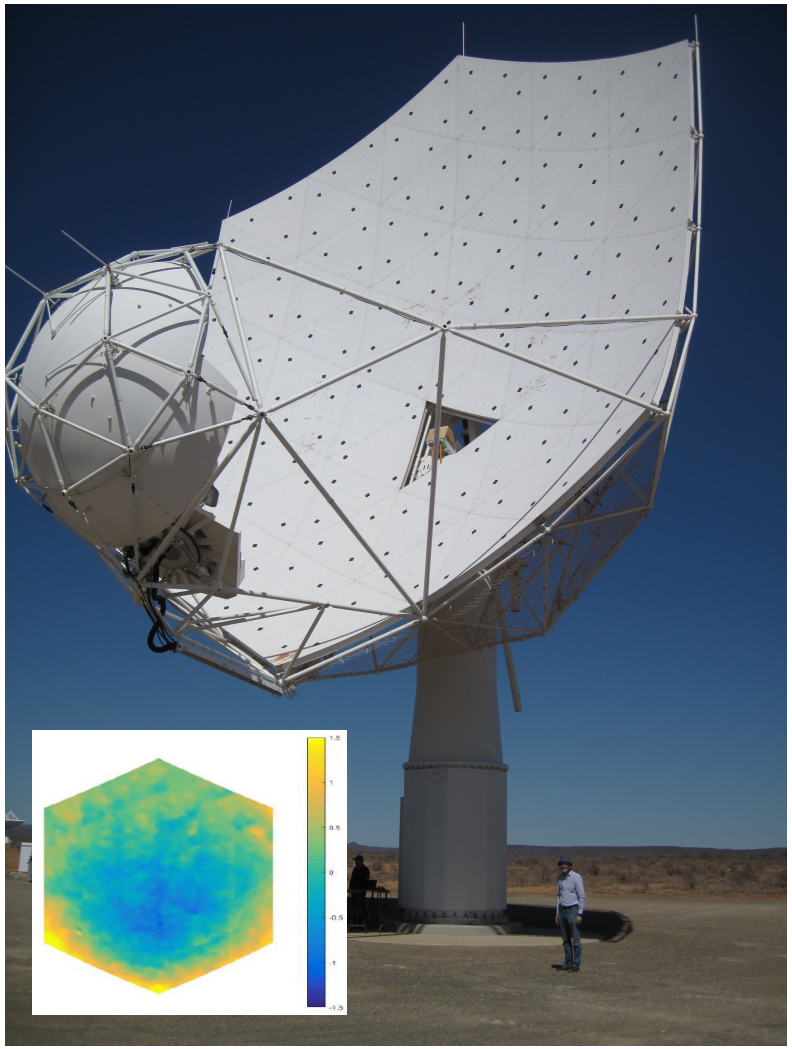
This is an “incomplete” collection of the work done in the last years. It covers the HW and the SW effort and present testing results.

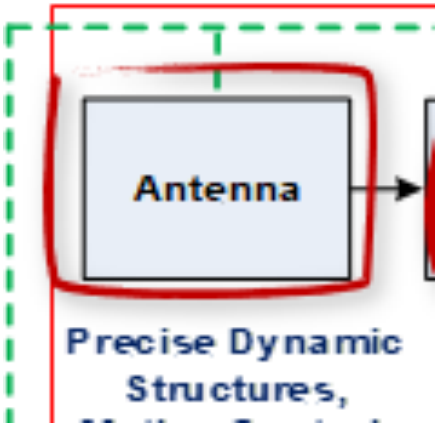
The Scope of this presentation is to report a summary of this document with the most updated results of some of the prototyping work still happening now.

MID Prototyping program

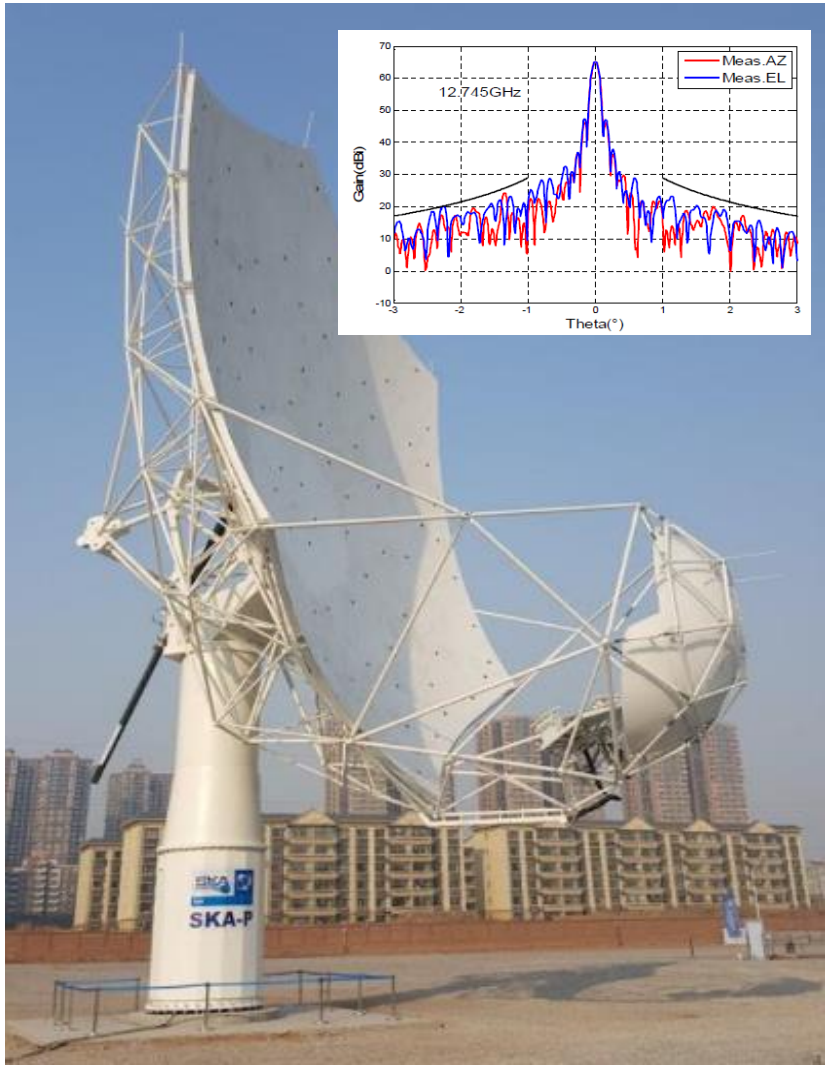


MID Prototype

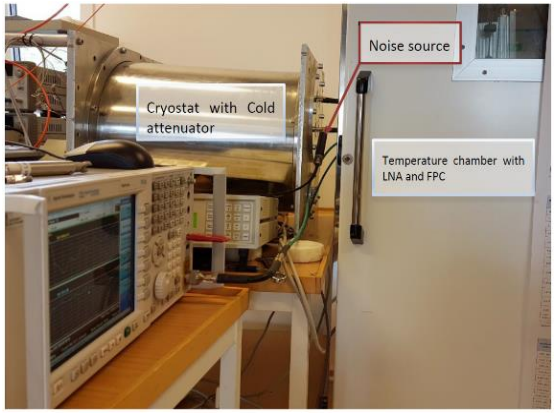


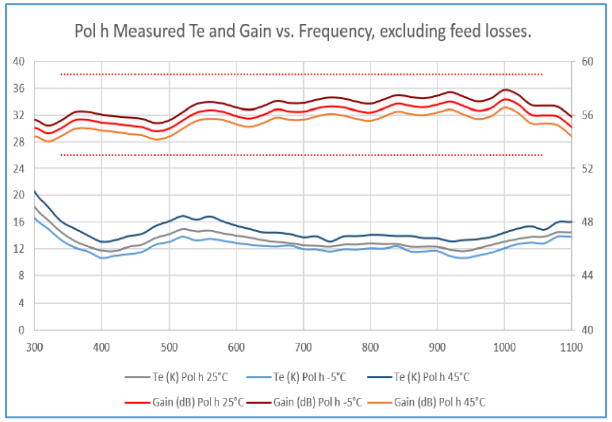


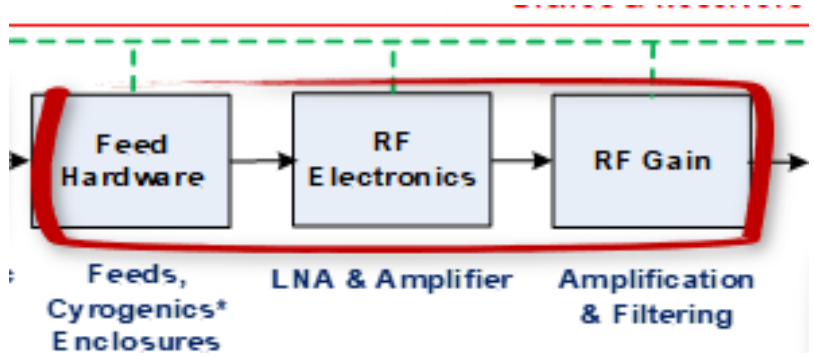
Two structure prototype available to test manufacturing, and basic mechatronic performance. Used to test surface accuracy (photogrammetry) and pointing performance. Test still happening.



MID Prototype



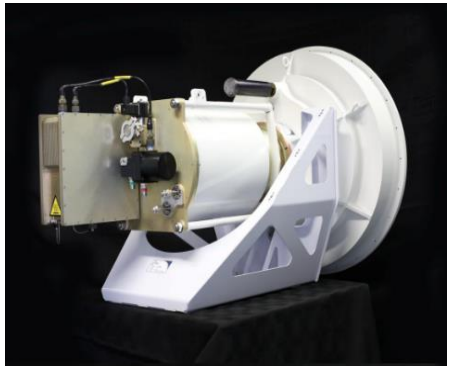


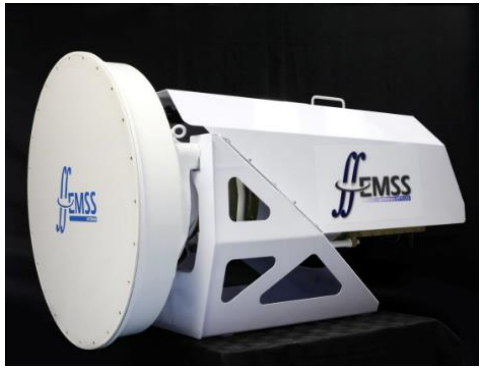


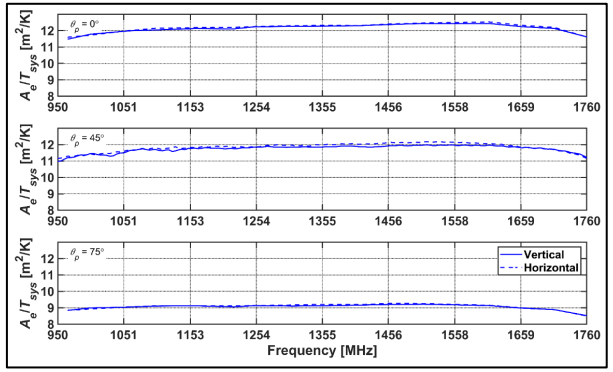
BAND 1 Assembly test campaign included:

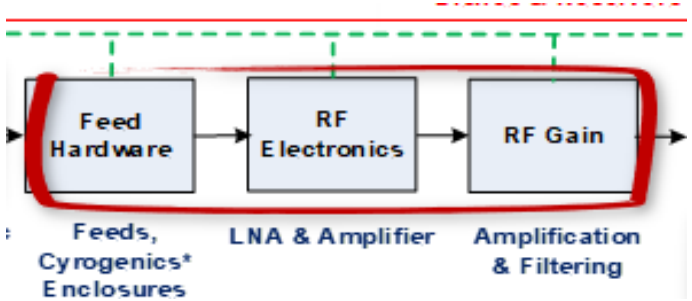
- Performance and temperature cycling tests that require standard laboratory microwave measurement equipment.
- Humidity and Vibration tests.
- Hail tests.
- Band 1 feed sensitivity and beam patterns were performed on a MeerKAT dish (South Africa).
- RFI tests

MID Prototype







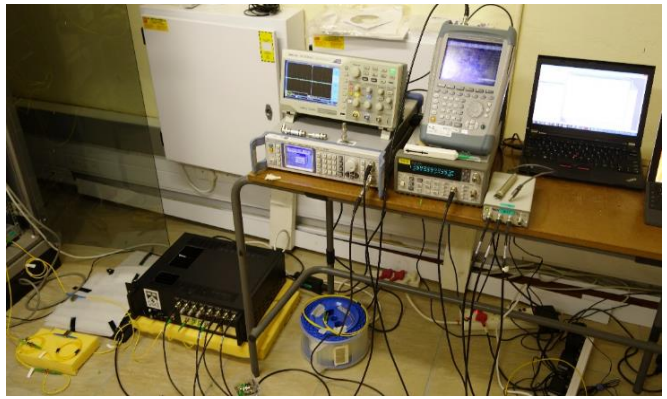


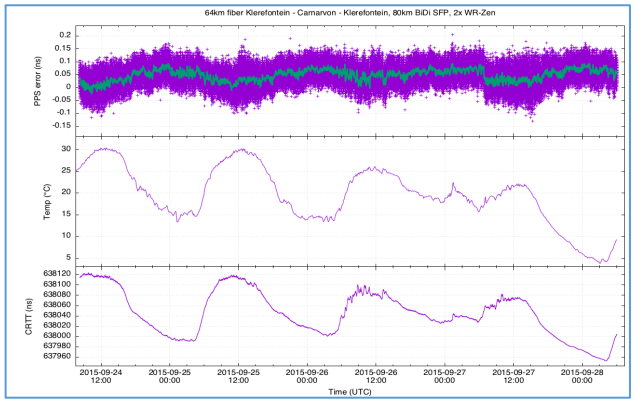
BAND 2 Assembly test campaign:

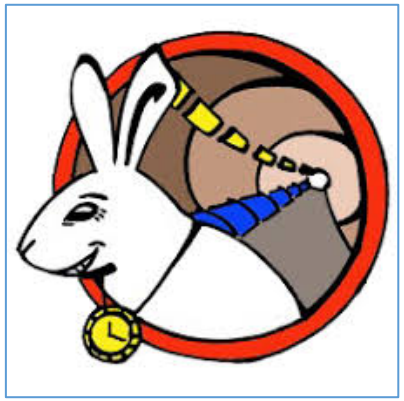
- Performance and temperature cycling tests that require standard laboratory microwave measurement equipment.
- Hail tests.
- Band 2 feed sensitivity and beam patterns were performed on a MeerKAT dish (South Africa).
- RFI tests

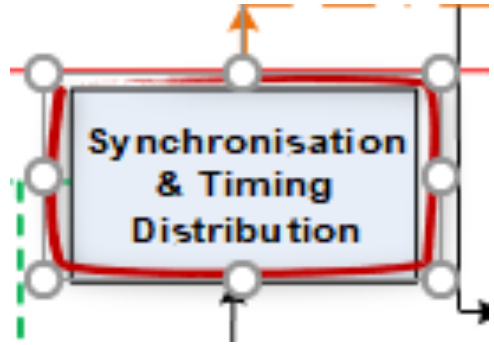
MID Prototype

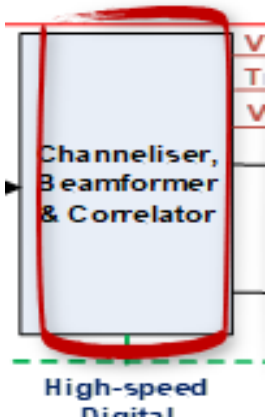
T&F UWA solution has been tested in real condition (South Africa) on a long baseline (~64 km)

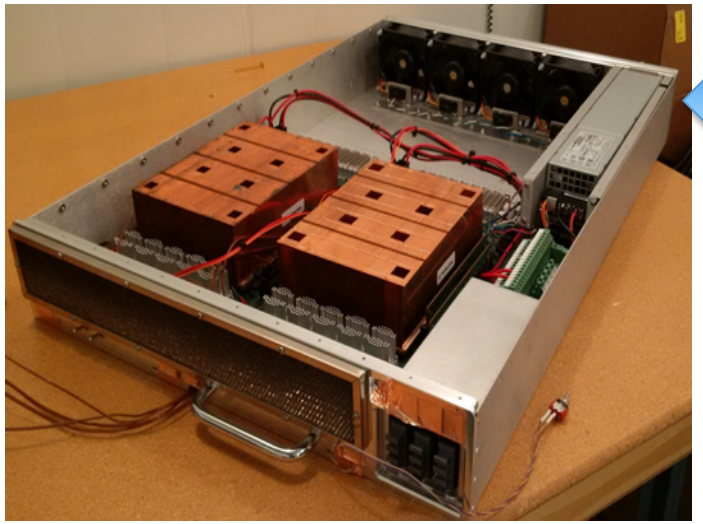






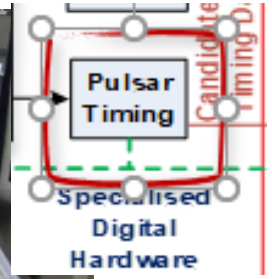






TALON board implementation has been manufactured and tested for the CBF application and same board is now used in the digitizer assembly.

PST Hw is currently installed in MeerKAT delivering real scientific data



LOW Prototyping Program

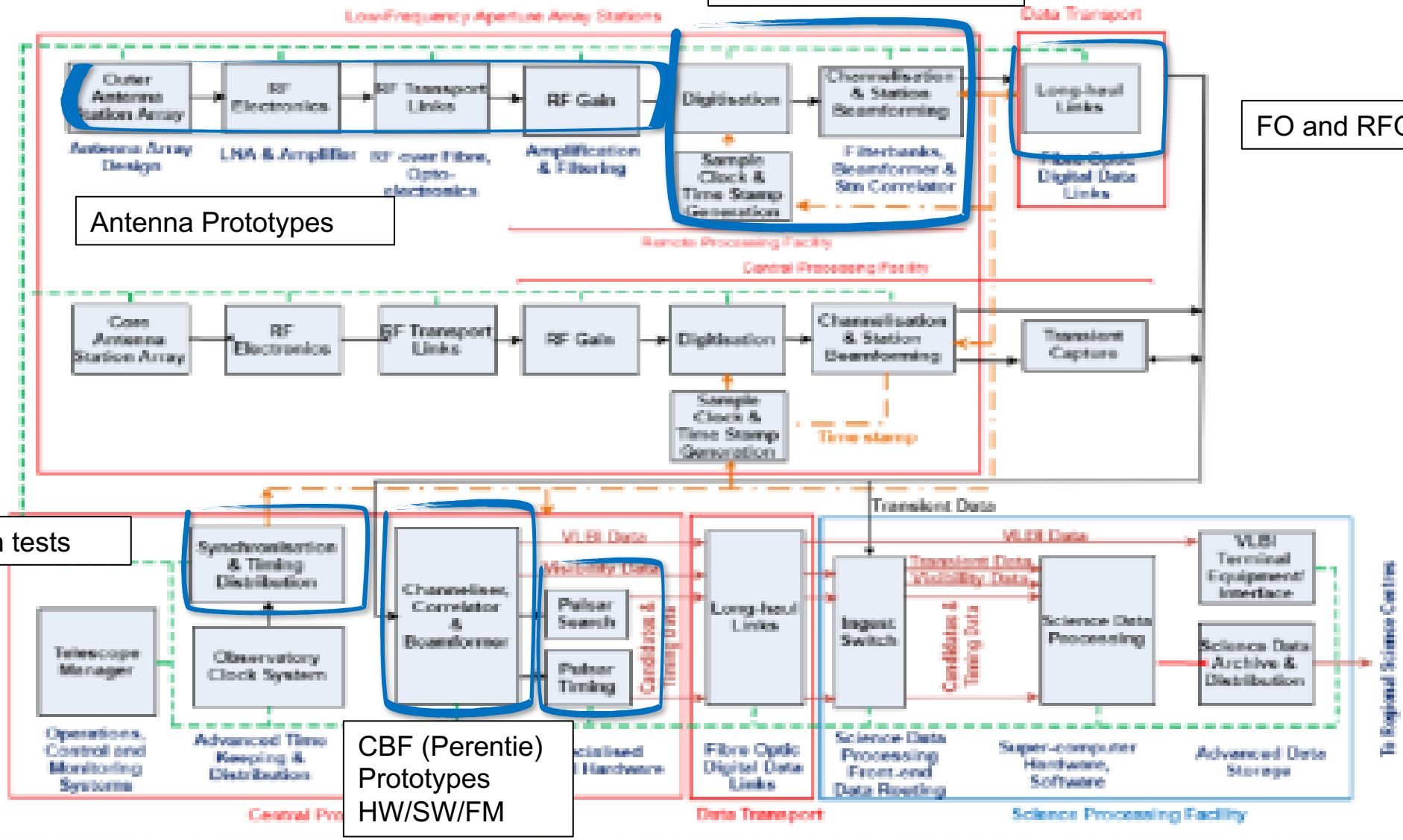
SPS (TPM) and MCCS
Including FW/SW

FO and RFOF tests

Antenna Prototypes

T&F Distribution tests

CBF (Perentie)
Prototypes
HW/SW/FM

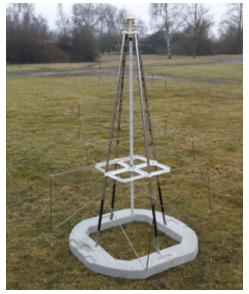
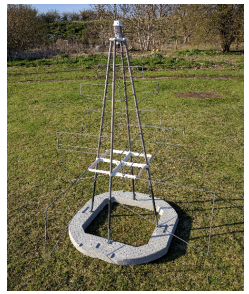
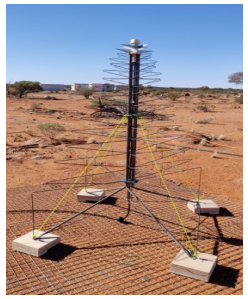


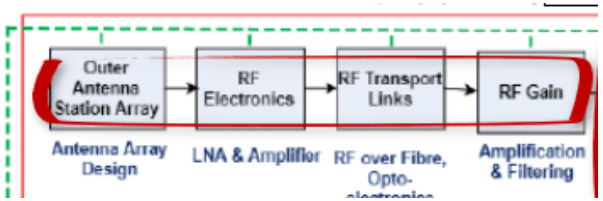
LOW Prototyping Program

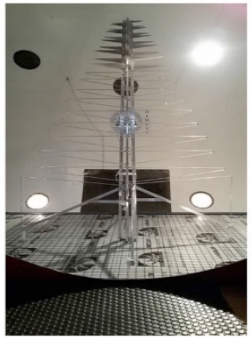
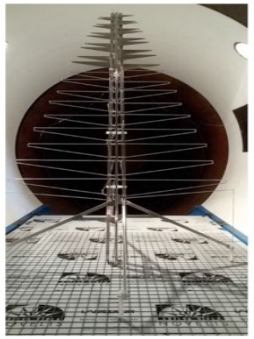
During the last years, a quite intense prototyping effort has been spent in the community.

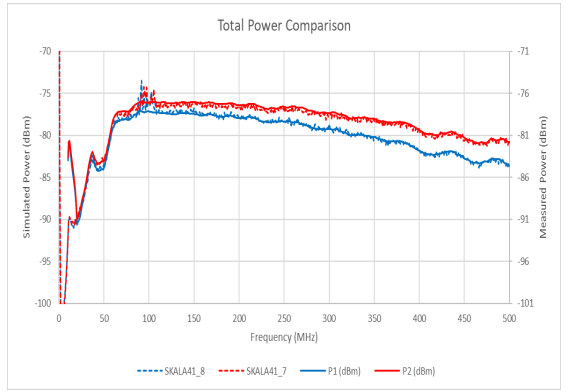
From SKALA 0 to SKALA4.1

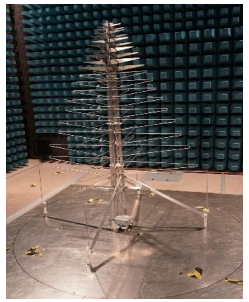
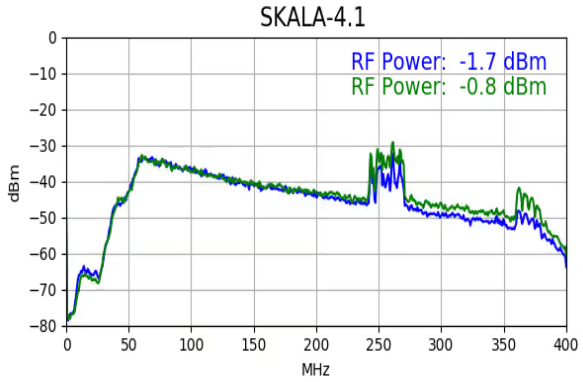






Mechanical Prototype

- Informed non functional requirements as: Reliability, Accessibility, Maintainability, Integrability

Electrical prototype

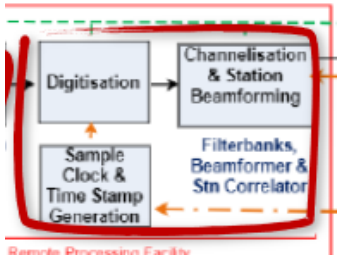
- Confirm Performance Requirements: Return loss, Transducer gain, Bandpass

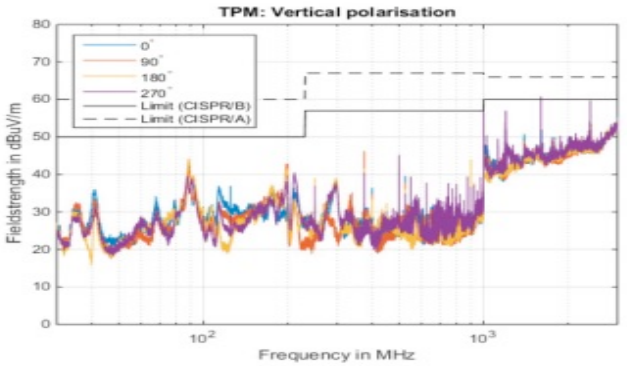
LOW Prototyping Program

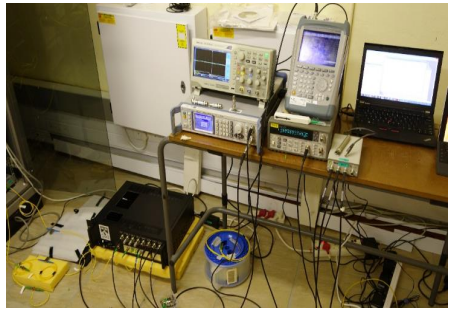
A prototype of the SPS (Signal Processing System) has been developed, deployed, integrated and used through the AAVS1.0 campaign and currently for AAVS2.0.

Firmware and SW development test bed.
Performance of a full station (AAVS1, EDA2, AAVS2.0)
Non-functional requirement (Reliability, Maintenability)

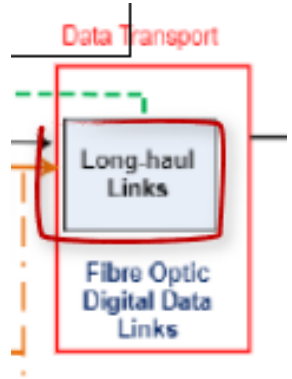
Further prototypes are planned in Bridging Phase

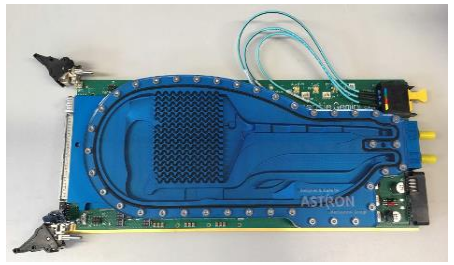


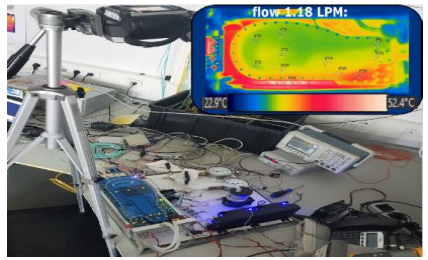




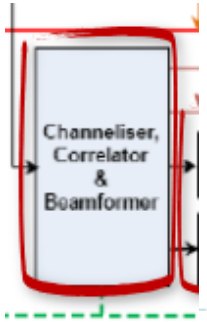
A test run in SA using long FO showed fully compliance of the T&F distribution system in term of stability (Allan Deviation)



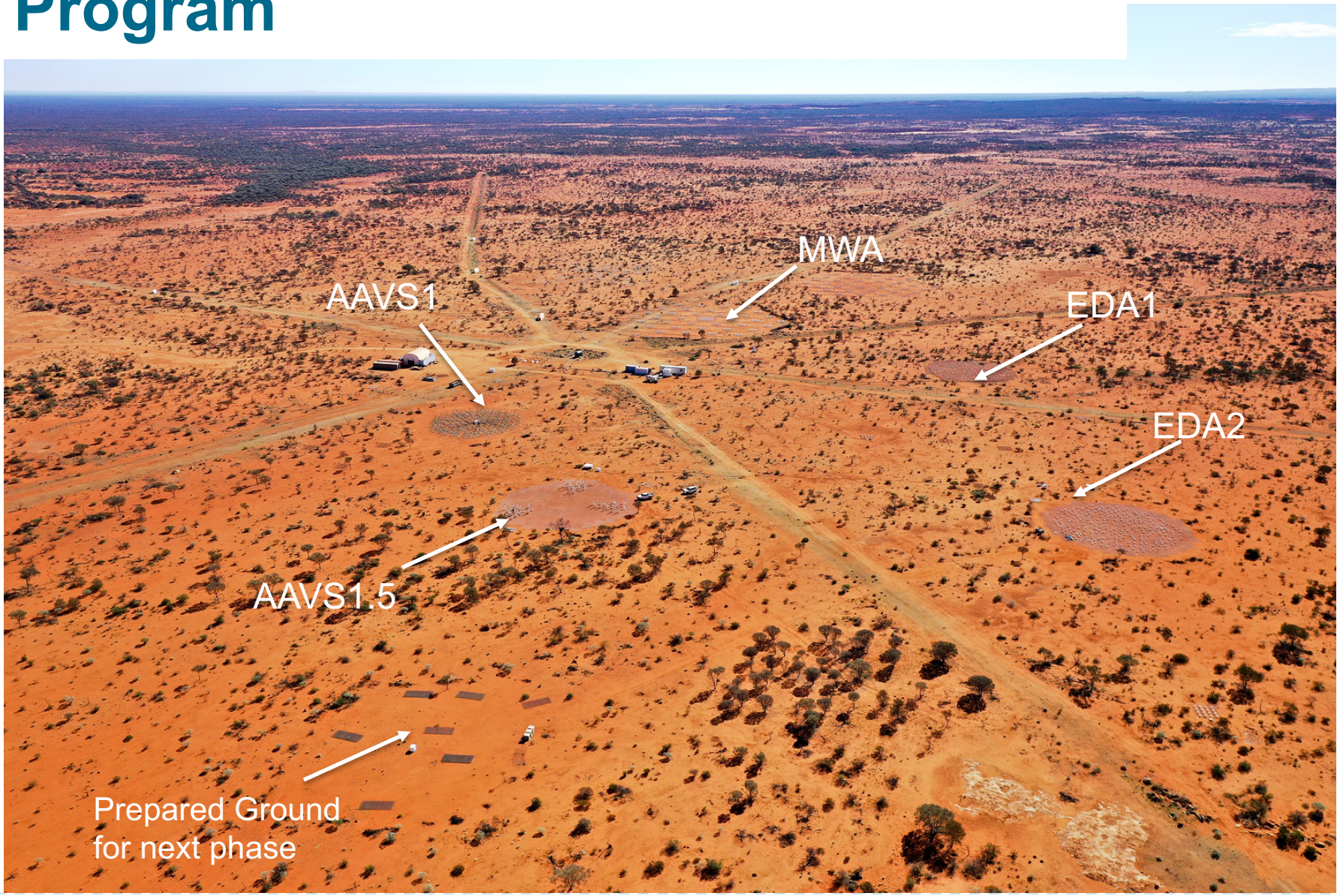




Perentie boards have been manufactured and tested against non-functional requirements and used as FW/SW test beds. We tested feasibility and manufacturability of the boards.



AAVS Program



AAVS1

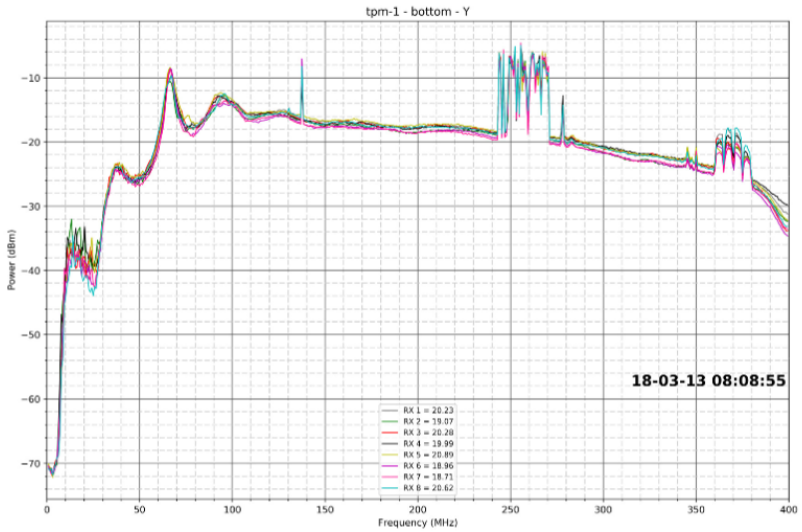
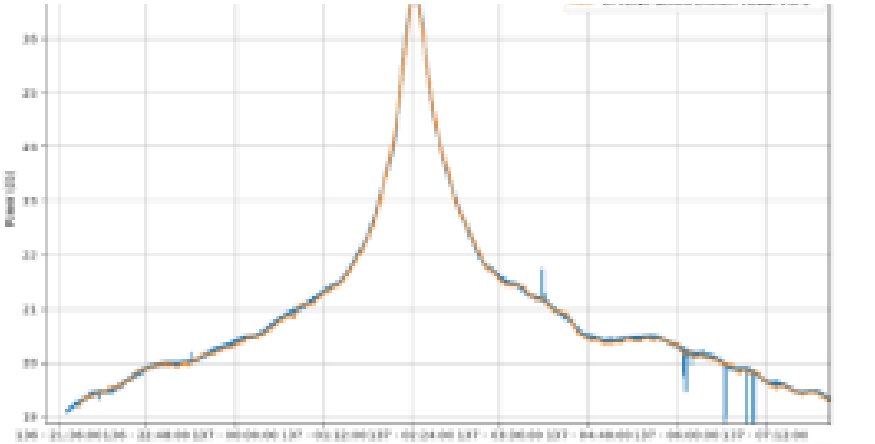


Figure 6-2. Integrated bandpass from one TPM, showing inputs from a single PREADU/polarisation. RMS level of ADC input is shown in legend



For zenith drift scans we can assume that online == offline

LOW-FREQUENCY APERTURE ARRAY

AAVS1 SOFTWARE DEMONSTRATOR DESIGN REPORT

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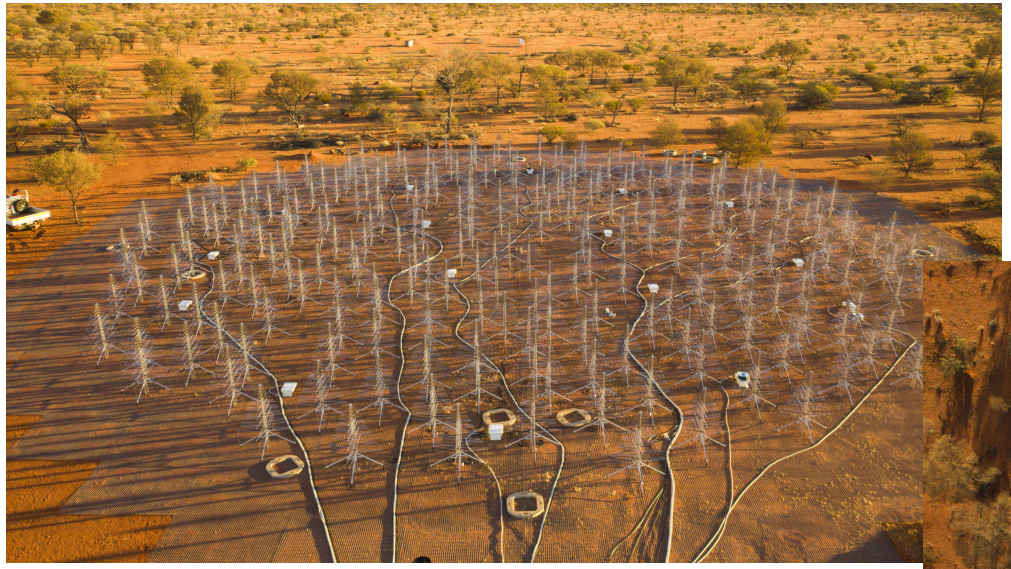
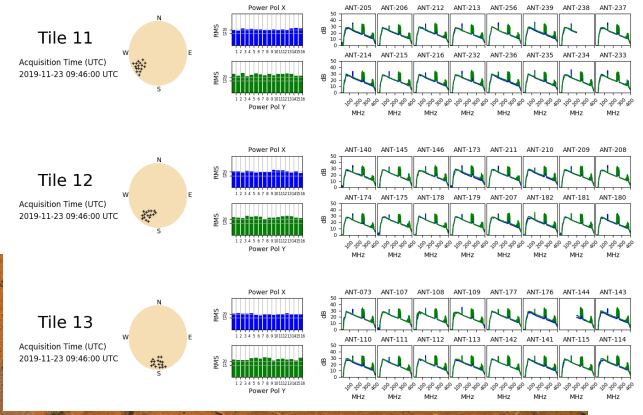
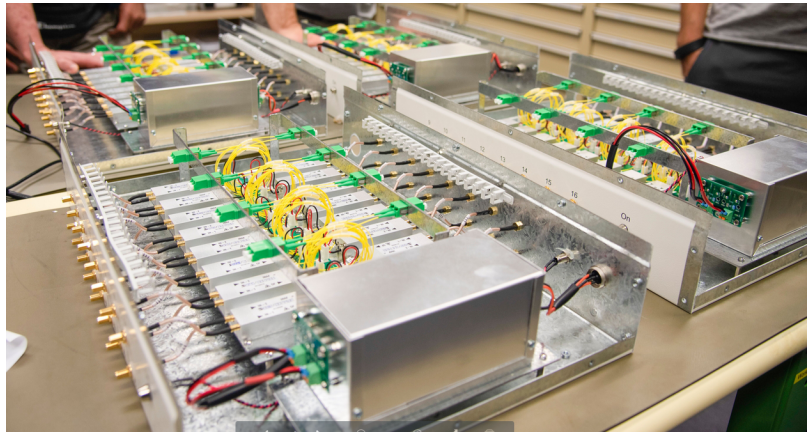
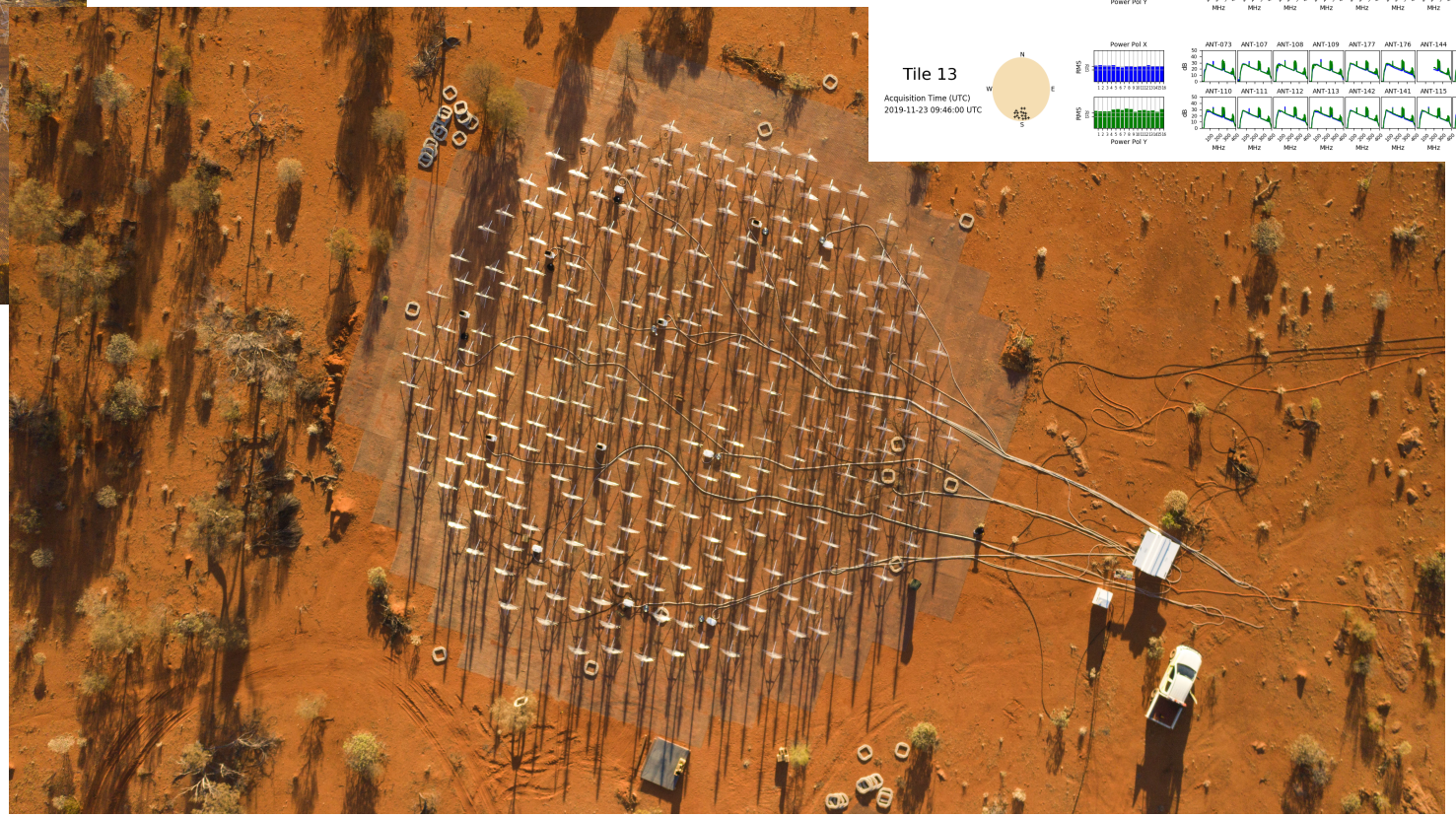
AAVS Program



Testing configuration is under completion. Commissioning is about to start.





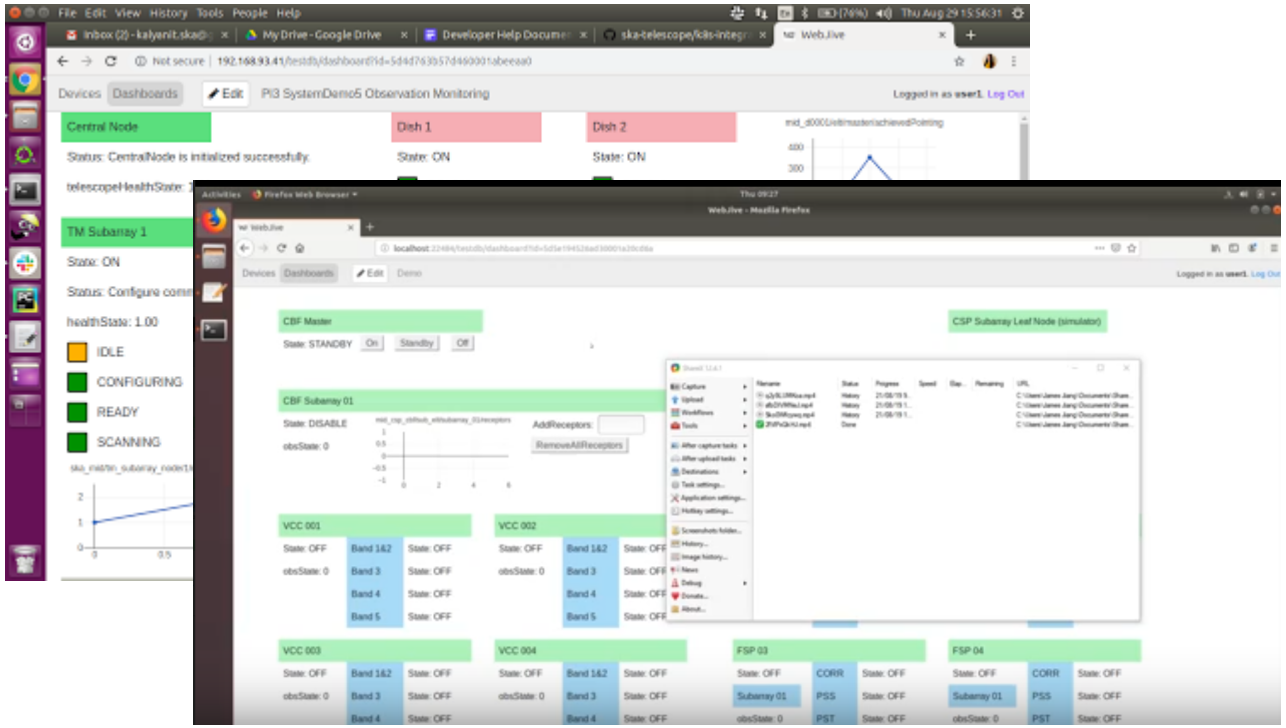


SW prototyping

- Telescope Monitoring and Control (TMC)
  - M&C Engine
  - Engineering Data Archive
  - Development Environment
  - Data Driven and Simulation Framework
  - LMC Interface Simulator Framework
- Local Infrastructure
  - Local Infrastructure Prototype
- User Interface Prototypes
  - GUI Prototype
- Observatory Science Operations (OSO)
  - Scripting layer and OSO-TMC Interface
  - Observation Planning Tool and Observation Scheduling Tool
  - Proposal Handling Tool
  - Authentication and Authorisation
  - Observation Data Archive
- Local Monitoring and Control (LMC)
  - LMC Monitoring Prototype
  - LMC Lifecycle Manager

Quite a lot of work has been done (and it is continuing) within the bridging phase and in the SAFE program.

PI#5 Next week in SKA HQ (System DEMO)



Conclusion (Part2)

- Prototyping is a normal process used in SKA following the main principles:
  - **The preferable verification methodology is test** (This means that we want to test early).
  - **The test shall be performed as soon as possible**. (This means we want to test often).
- There is still quite some work to be done in prototyping elements and sub-elements.
- Even more interesting to see how the elements/sub-element can come together in assemblies closer to the system.

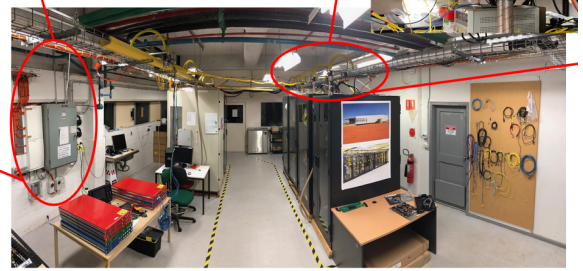
Prototyping System Integration

Facilities 2/2

NRC DRAO (Penticton)

- Used if more complex environments needed
- Computing and office space
- Basic Mid.CBF (TDC) equipment
- Room for additional servers, timing equipment, PSI workers
- Co-located with NRC Team/Talon HW

3-Phase Power



~180 Square Metre

Industrial Heat Exchanger

No need to start from scratch

Opportunity to test “closer to system” interfaces using pre-construction HW. Discussion is happening…SKAO is 100% supporting these proposals.

SKA1 Multinational Project

SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope