SADT update

SKA Engineering Meeting, Rotterdam

13th June 2017

Jill Hammond, SADT PM
University of Manchester

The SADT Consortium

- **This morning I will be covering:**
- **A quick overview of the consortium structure, organisation and participating institutes.**
- **An update on the progress of the Consortium since the last engineering meeting.**
- **An outline of the work still to do before CDR and outstanding issues.**

The SADT Consortium

- **A quick overview of the consortium structure, organisation and participating institutes.**
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The SADT Consortium

SIGNAL AND DATA TRANSPORT

SQUARE KILOMETRE ARRAY

CSIRO

The University of Manchester

SKA AFRICA
SQUARE KILOMETRE ARRAY

NCRA • TIFR

JIVE
JOINT INSTITUTE FOR VLBI IN EUROPE

NPL
National Physical Laboratory

ugr Universidad de Granada

GÉANT

Tsinghua University

THE UNIVERSITY OF WESTERN AUSTRALIA

aarnet
Australia's Academic and Research Network

SANReN
South African National Research Network

nmisa
National Metrology Institute of South Africa

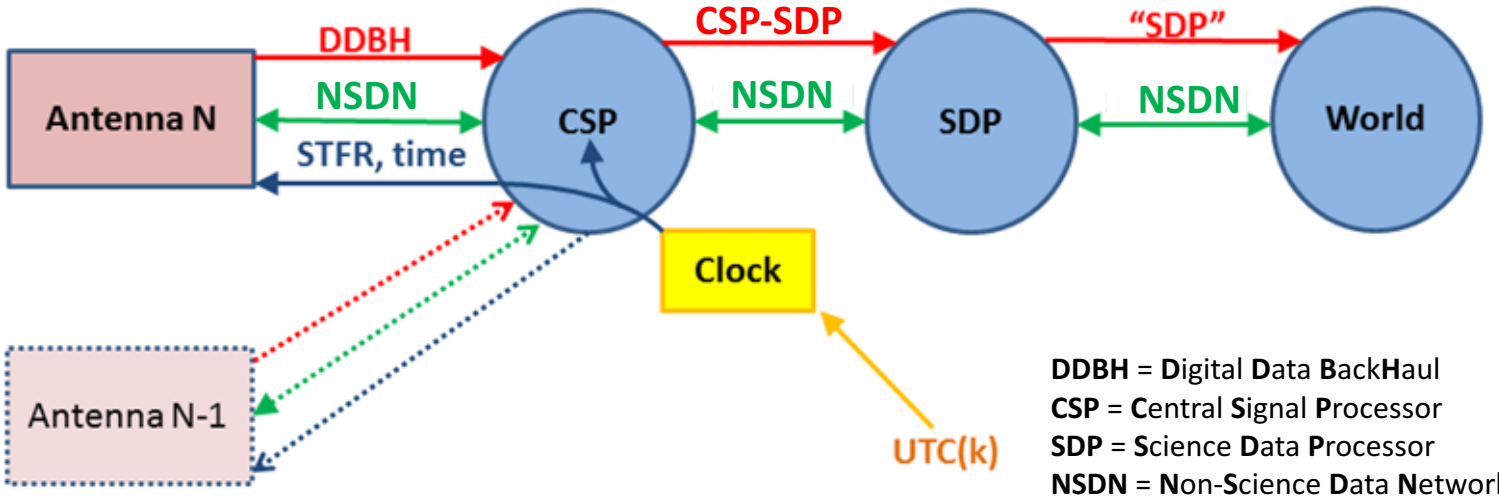
SADT Summary

Science Data
- DDBH
- CSP-SDP
- SDP to world

Sync & Timing
- Clock ensemble
- Freq. & Phase
- UTC time

Non-Science Data
- Control & Monitor
- Alarms
- Internet, VoIP

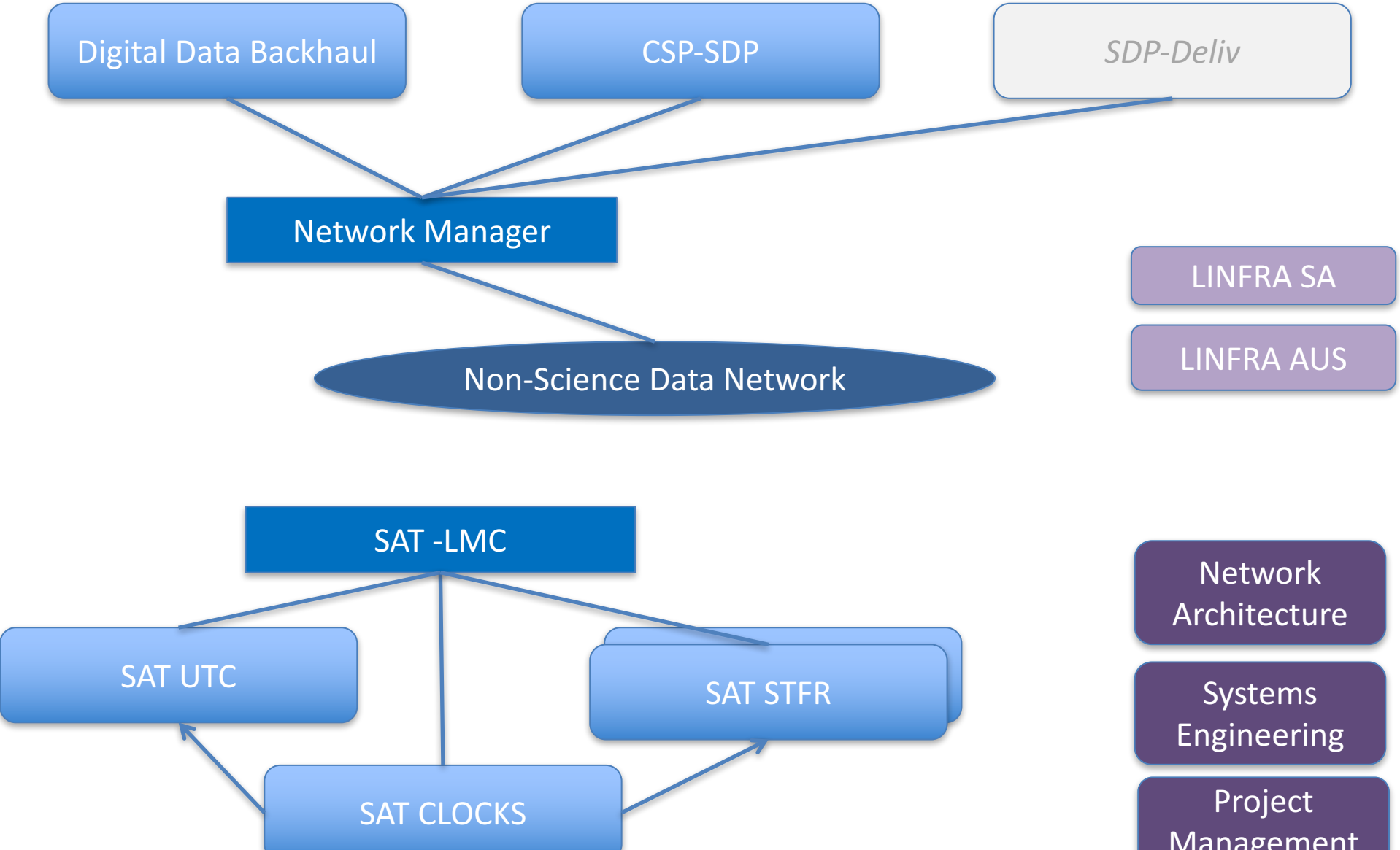
"Spanning" Tasks: Network Architecture; Network Manager; Local Infrastructure



DDBH = **D**igital **D**ata **B**ack**H**aul
CSP = **C**entral **S**ignal **P**rocessor
SDP = **S**cience **D**ata **P**rocessor
NSDN = **N**on-**S**cience **D**ata **N**etwork
STFR = **S**ystem for **T**ime and **F**requency **R**eference
UTC = **C**oordinated **U**niversal **T**ime

SADT Work Packages

SIGNAL AND DATA TRANSPORT



The SADT Consortium

- A quick overview of the consortium structure, organisation and participating institutes.
- **An update on the progress of the Consortium since the last engineering meeting.**
- An outline of the work still to do before CDR and outstanding issues.

The SADT Consortium

The changes introduced by L1 requirements version 10 +

- **A delayed downselect for the solution for Frequency Distibution**
- **Meerkat integration**

Updating and consolidation of our costs

The Cost Control Exercise

External change/Internal change

Testing

Fibre Gap

June construction cost estimate reduced by almost €10 million

SIGNAL AND DATA TRANSPORT

- €57m total construction cost (includes additional allocated costs)
  - €52.9m net of 10% central contingency
- €37.7m versus €36.2m budget (+4% budget challenge)

- June savings include:
  - Least cost DDBH solution (-€3.1m)
  - Least cost FRQ solution (-€3.1m)
  - Optimum re-use of Meerkat timescale (-€3.2m)
  - Updated CSP-SDP cost benchmarks (-€1.5)
  - Remodelled LMC costs (-€0.5m)
- June additional costs include:
  - Increased Project Management overhead (+€0.8m)
  - Increased NSDN costs (+€0.9m)
  - Miscellaneous (+€0.1m)
- Net construction cost reduction of €9.6m

- Operational costs remain steady at €3.3m p.a.

Progress

Network Architecture, NWA, model is completed
SADT End-to-End Diagrams – All telescope locations, all network connectivity

Please visit posters on Wed 12-13 & 14 -15 PLATE ROOM (20) to review, discuss, and add comments

Updated Fibre reticulation (using model developed in house, allows us to 'quickly' recalculate fibre requirements when route for fibre changes)
Power consumption budget updated – very **mature** wrt being vendor agnostic
SADT Rack Diagrams – All telescope locations, all active SADT equipment
Significant prototype testing undertaken in several work packages.

Document set of:

8 External ICDs (CSP LOW, CSP MID, LFAA, DSH, SDP LOW, SDP MID, INAU, INSA) Lead and written- submitted to SKAO for next round of System Engineering and SKAO signatures

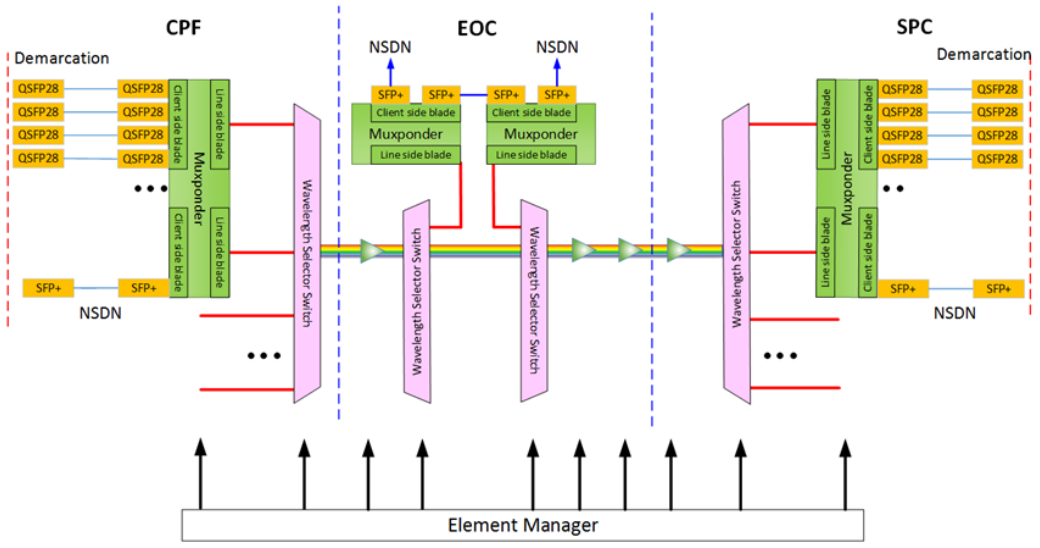
4 External ICDs (SADT-TM, CSP to SDP, SDP-TM , TM-INFRA) which SADT are signatory to.

14 Detailed design documents written avarage 80% complete - Ready for internal SADT review?

42 Internal ICDs (NMGR, NSDN, LINFRA) - all baselined and signed

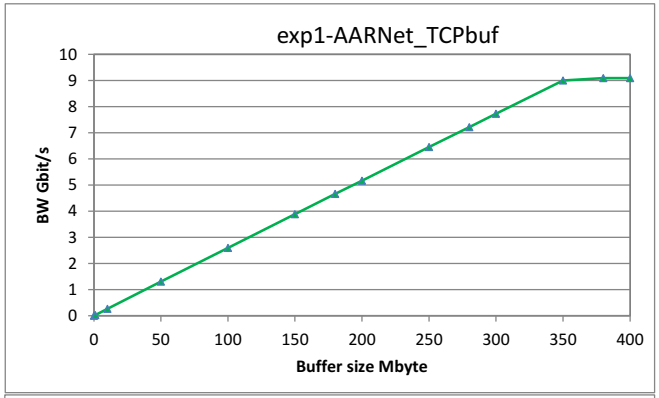
CSP-SDP: Status for Low and Mid

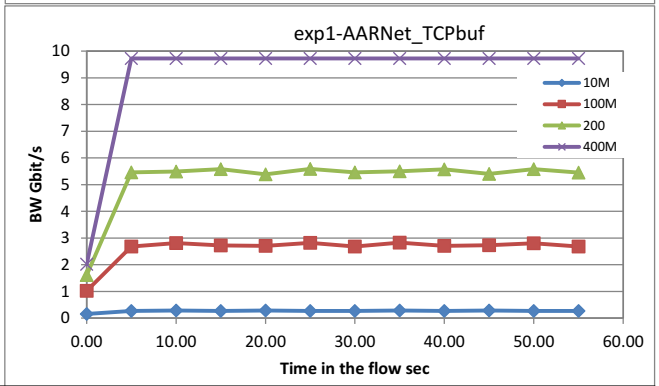
- Long-Haul from CSP to SDP
  - SKA1-Low 7.5Tbit/s 912km
  - SKA1-Mid 5.4Tbit/s 820km
- Technology demonstrations
  - 200 Gigabit/s per wavelength line-side operational MRO-Perth
  - 96 Gigabit/s for one UDP flow from SaDT Test Box PC

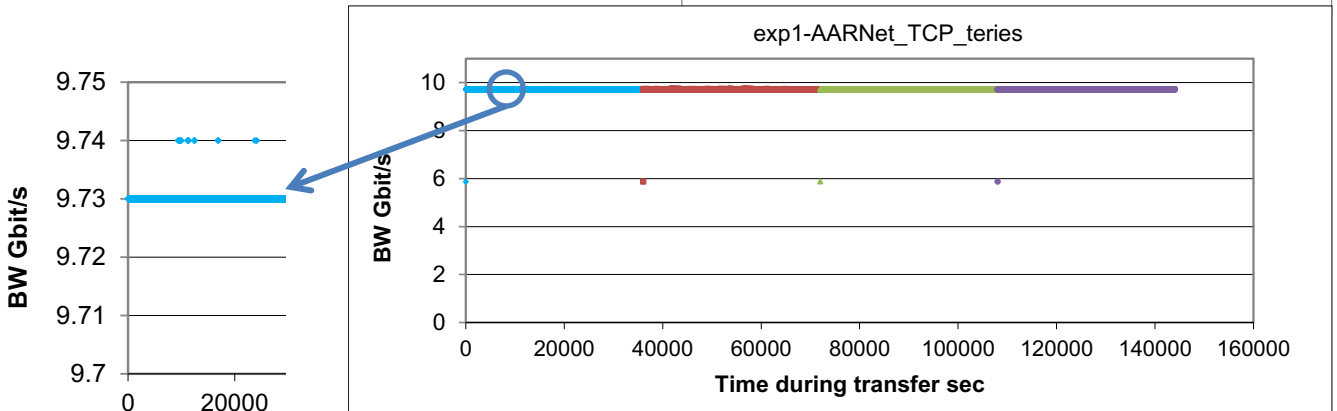


SDP-Deliv: 10 Gigabit TCP GÉANT London to AARNet Canberra

- Route using GÉANT ANA300, Internet2 & AARNet 100Gig path was: London-Washington-LosAngeles-Sydney-Canberra
- 10GE NIC, TCP offload on, TCP cubic stack
- RTT 304 ms, Delay Bandwidth Product 280 MB.
- One TCP flow rises smoothly to the plateau at 350 MBytes.
- Throughput of 9.73 Gbit/s after TCP Slow start
- Stable throughput as recorded every 10s for 40 hours.
- NO TCP re-transmitted segments during the tests.
- Next tests: 100Gigabits SuperComputing17.



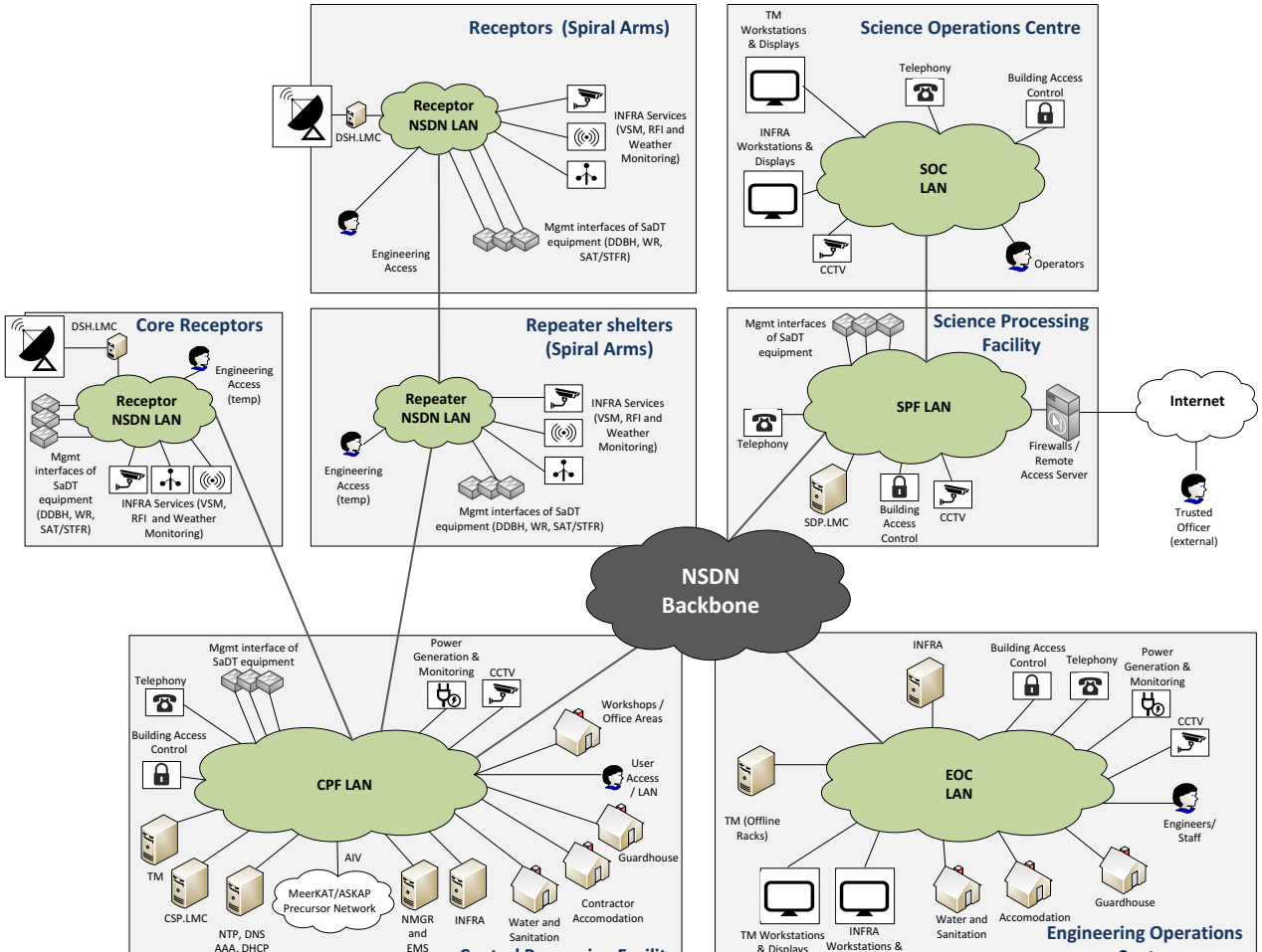




Non-Science Data Network

SIGNAL AND DATA TRANSPORT

- No changes to the conceptual design for NSDN:
- Detailed Design now mature:
  - Quantity of switches and locations refined
  - Incorporated LFAA requirements for SKA1-LOW



SAT.Clocks Activities

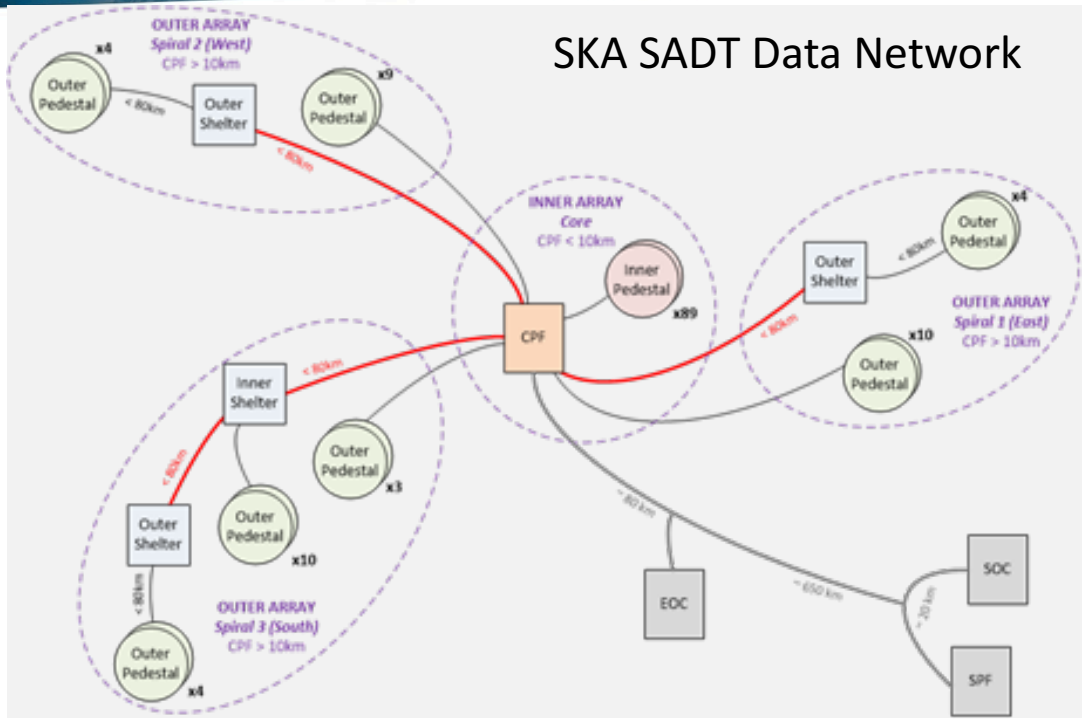
- Re-design of the 1 PPS, 10 MHz and 100 MHz outputs has been undertaken to account for a requirement for considerably increased numbers of outputs.for LOW telescope..

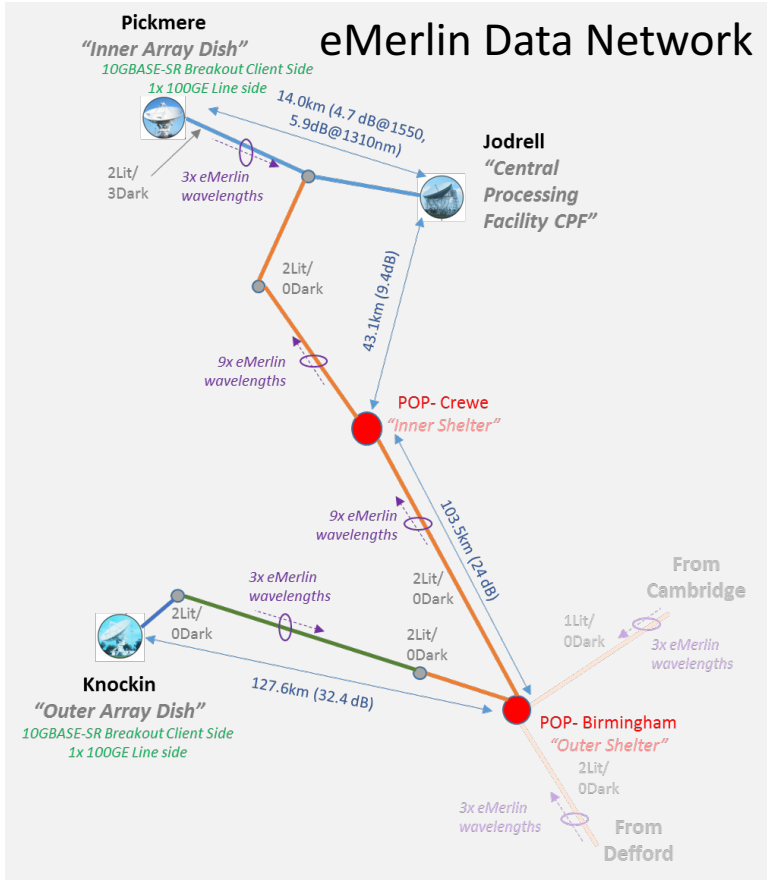
- Test planning and procurement of equipment completed, and work has now started on the testing of a experimental solution to the problem of passing GNSS signals through double layer shielding, present at the Low telescope.

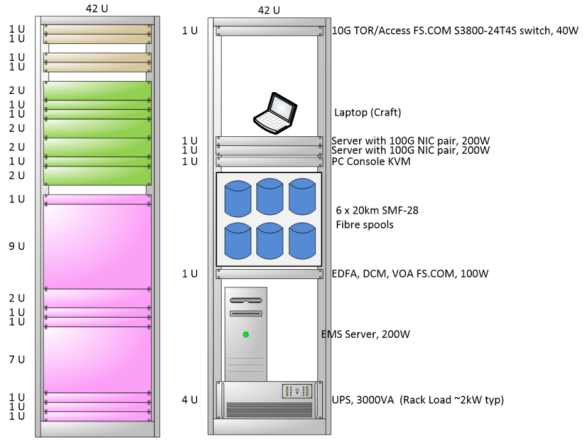
- Revisions of SAT.Clocks construction costings for both Low and Mid telescopes. This has resulted in a significant reduction in the cost estimates. In particular considering re-use of Meerkat equipment over the full roll out period

SADT (DDBH) data network testbed at Jodrell Bank Observatory

SIGNAL AND DATA TRANSPORT

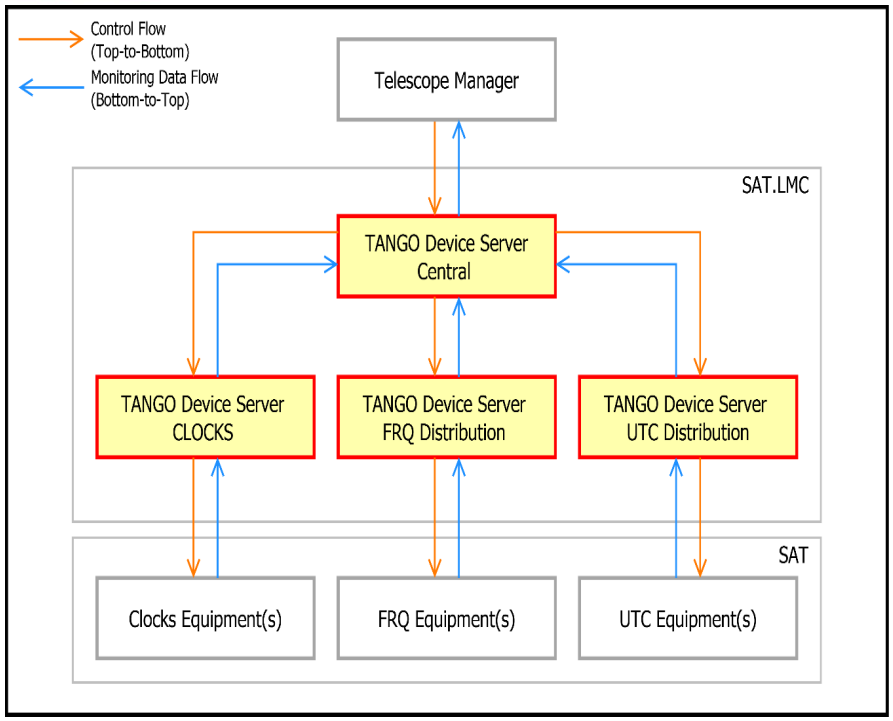






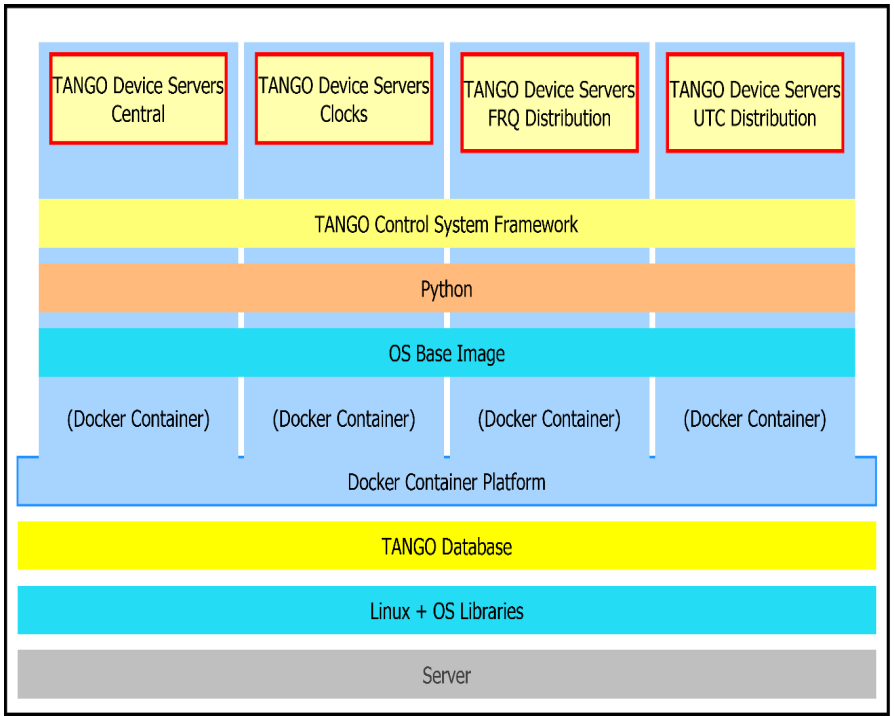
- 100GE network switch and transmission equipment purchased to replicate Inner and Outer array links on SKA1-MID
- Equipment also suitable to demonstrate 100GE data transport on several eMerlin telescope links longer term

SAT.LMC – Redesign for cost efficiency.



- Connects to SAT and TM through NSDN
- Monitors ~450 SAT equipment for SKA1-Mid and ~80 for SKA1-Low
- TANGO + Docker + Python + Linux stack

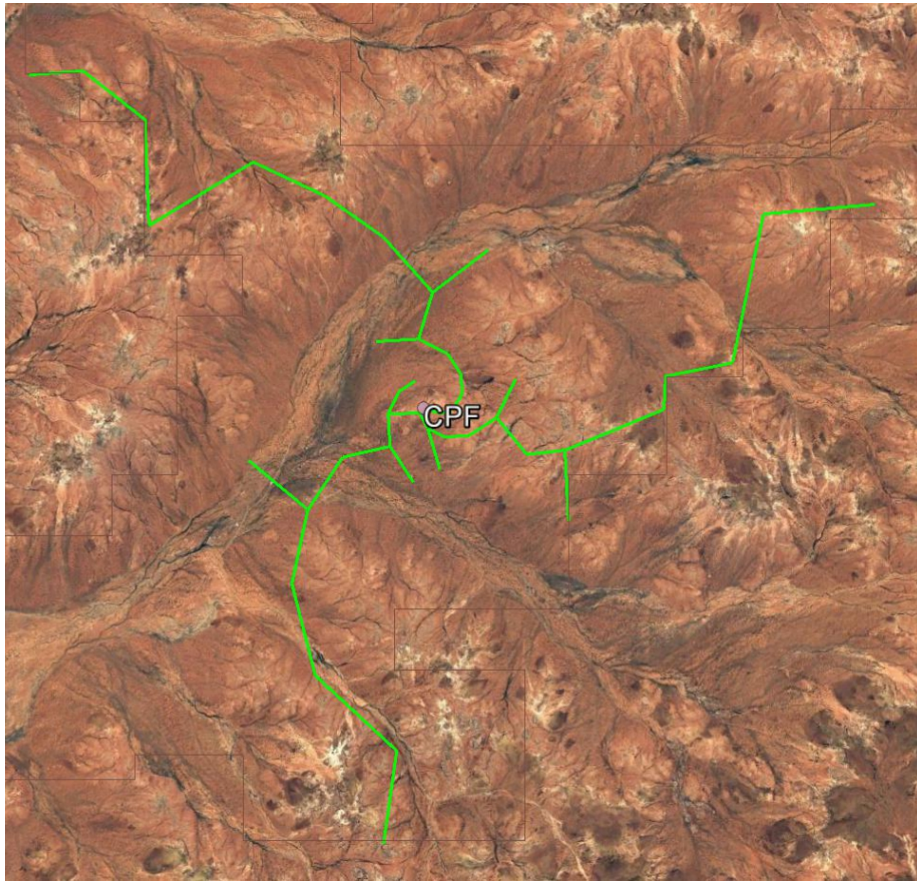
- 2-tier Hierarchical structure
- Monitors, Controls and orchestrates SAT
- Predominantly Software
- Single hardware server



SAT.LMC – Changes since Stellenbosch

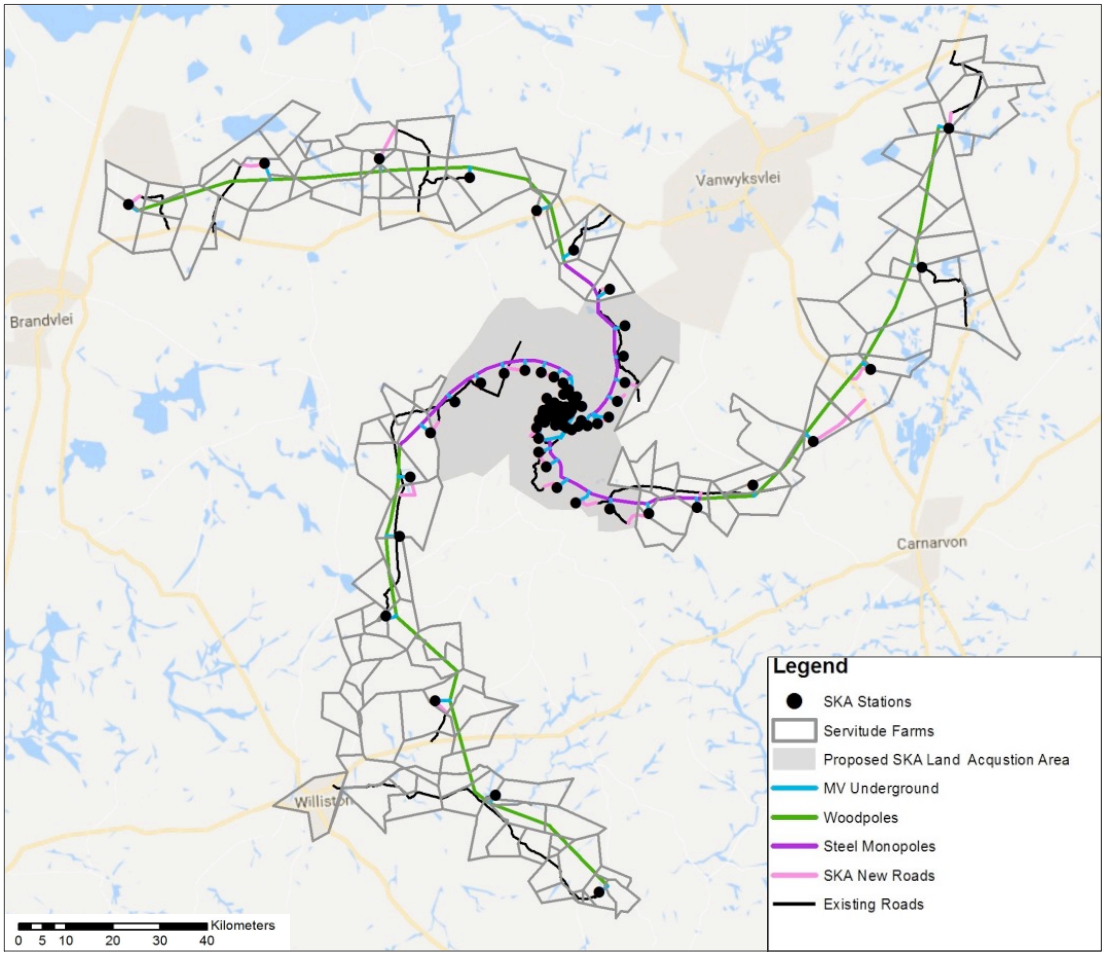
- Server consolidation and cost savings made by replacing 4 PC104 boards with a single industry server. Application isolation achieved through use of Dockers.
- Dockers with TANGO technology verified.
- Architecture and Design documented as per SKAO standards document. At 80% completion

LINFRA LOW



- Overview
  - Three spirals <60km
  - No Repeater locations needed
  - Within optical loss parameters for equipment
- Activities
  - FMECA, RAMS and Security assessments undertaken
  - Input into CCP
- Documentation Status
  - Mostly complete and awaiting internal review
    - Local Infrastructure and Fibre Design
    - IICD (9x)

LINFRA MID



SKA1 MID – fibre route attached to the overhead powerline

- Overview
  - Three spirals ±160km
  - 4 Repeater locations needed
  - Final section on southern spiral requires low loss fibre to meet optical loss parameters for equipment
- Activities
  - FMECA, RAMS and Security assessments undertaken
  - Input into CCP
- Documentation Status
  - Mostly complete and awaiting internal review
    - Local Infrastructure and Fibre Design – cost update in progress
    - IICD (9x)

The SADT Consortium

- A quick overview of the consortium structure, organisation and participating institutes.
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- **An outline of the work still to do before CDR and outstanding issues.**

Future Work &Issues

- Formal Internal Document review
- Lack of end-element and system level network architecture definition
- L1 Requirements changes – ECPs causing detailed design impacts
- MeerKAT integration/retro-fit impacts
- Telescope roll-out plan into detailed design implementation
- Cost Control Project – ECPs causing detailed design impacts
- >2020 deployment dates – Telecom market changes, power/cost forecast uncertainty
- Lack of end-element interface testing – Pedestal EMC and thermals, DSH-CSP data interface
  - NSDN to other elements (TM, SDP, CSP, INFRA) still largely based on assumptions. Requires detail in EICDs.
  - Refinement of optical transceiver selection based on final fibre distances.
  - MeerKAT integration
  - ITF equipment requirements
- Fibre Gap design incorporated into doc set
- Assesment of impact and then updating of SAT-LMC and NMGR with latest LMC CS Guidelines.

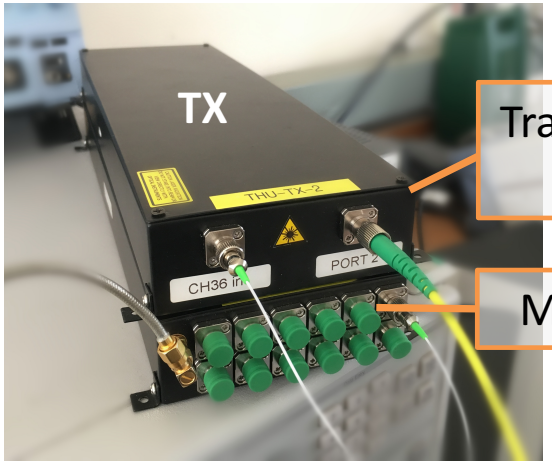
STFR.FRQ-Tsinghua Solution Ongoing Testing

SIGNAL AND DATA TRANSPORT

Tsynchronisation system:

Capacity for mass production

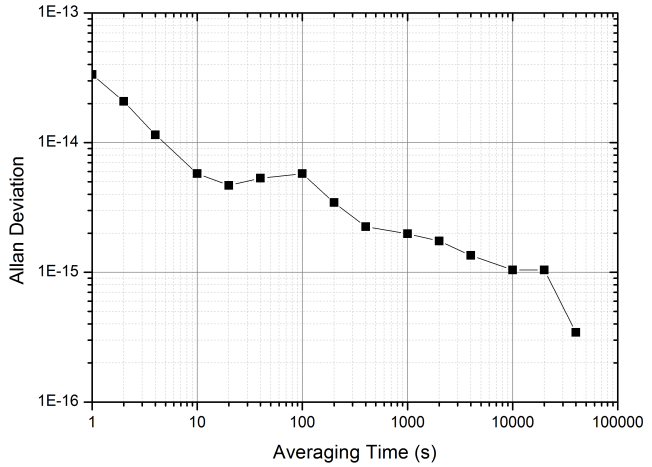
Modular Design
Automatic
Robust
Cheap



Reliability test under large temperature fluctuation:

Temperature:
6℃/10min

Stability:
3E-14@1s
5E-15@1min
2E-15@10min



STFR.FRQ-THU：Tsinghua Solution Ongoing Testing

Various reliability tests passed Some tests still outstanding.

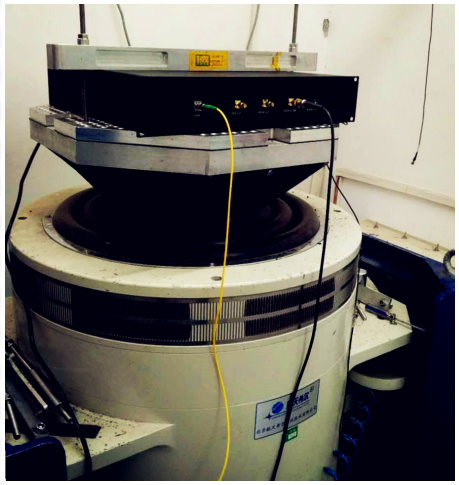
Temperature

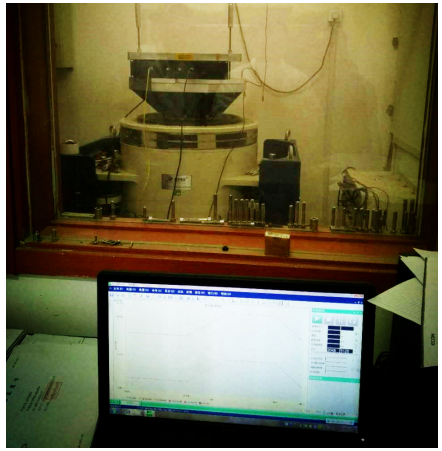
-5℃~50 ℃

±3 ℃/10min

Humidity

40%~60%



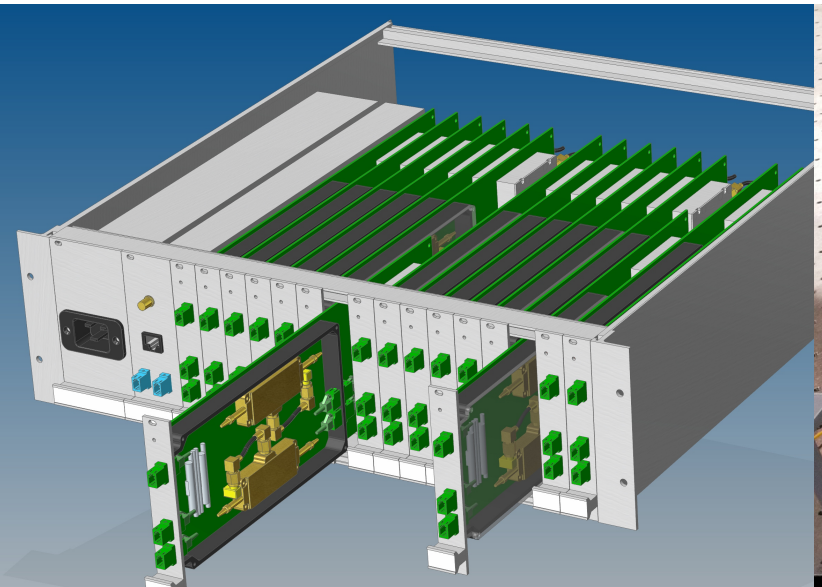


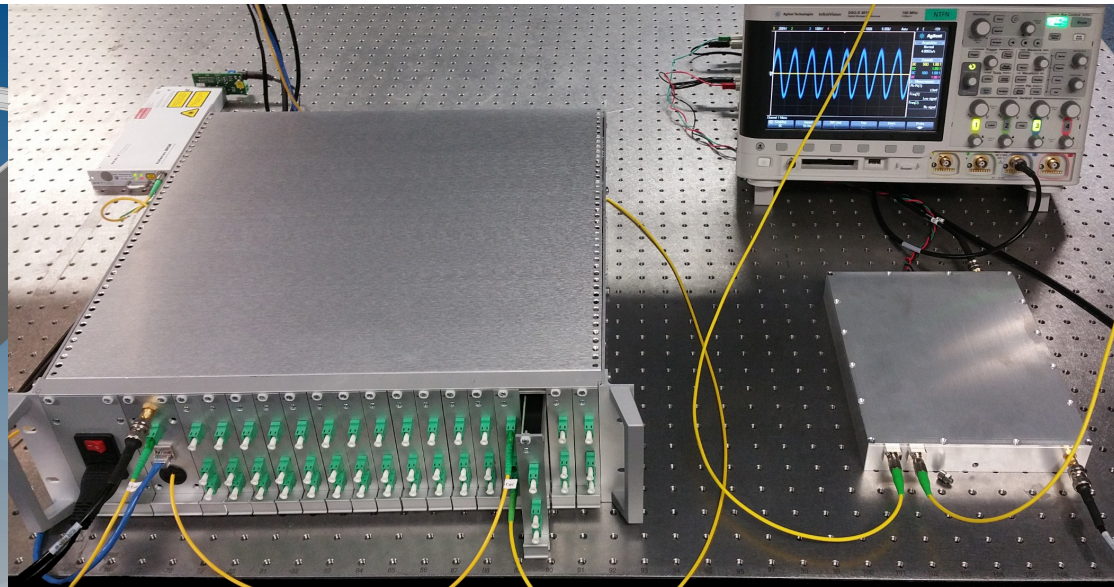
Seismic Resilience

1m/s^2

STFR.FREQ.University of Western Australia Solution Ongoing Testing

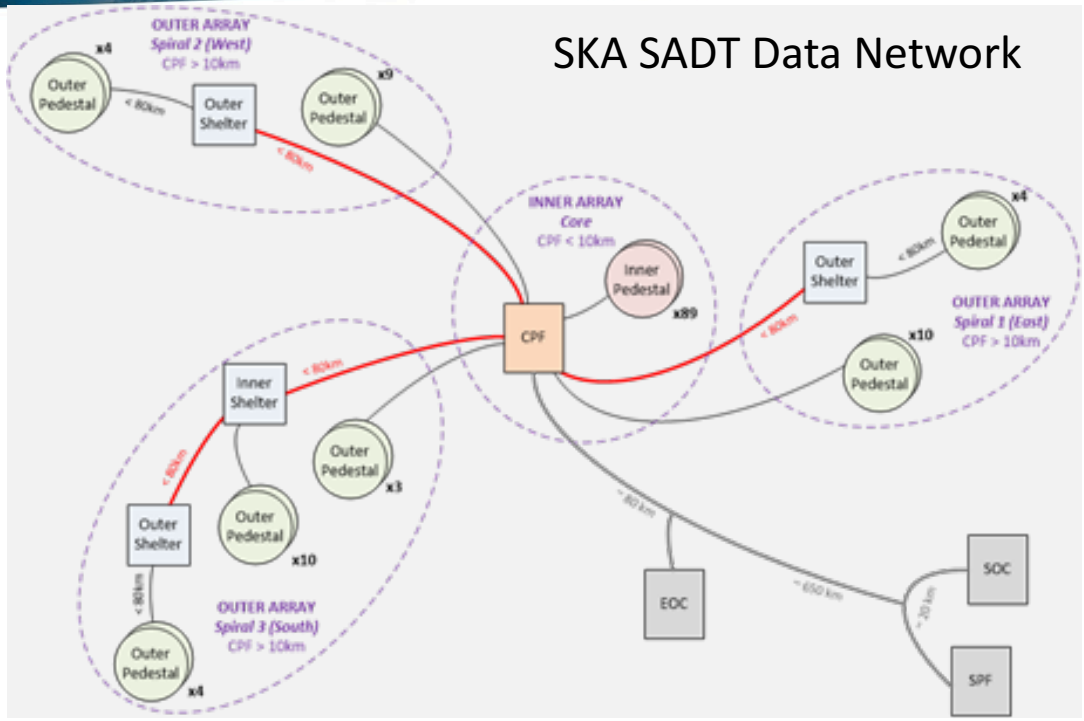
- Optimised designs for low and mid
  - Both use optical phase sensing and actuation
- Successful astronomical verification tests
- Work progressing on mass manufacture design

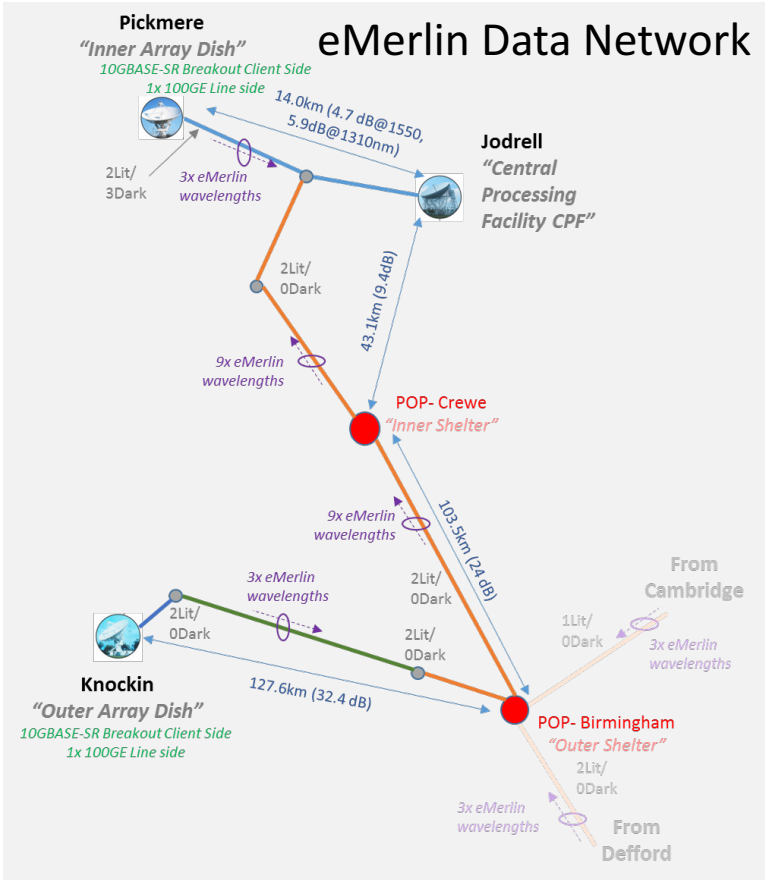


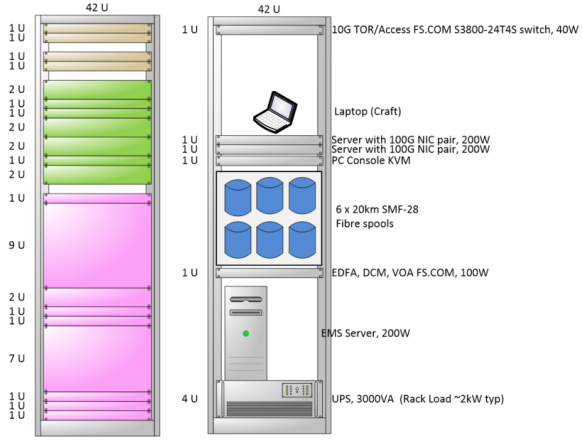


SADT data network testbed at Jodrell Bank Observatory

SIGNAL AND DATA TRANSPORT







- 100GE network switch and transmission equipment purchased to replicate Inner and Outer array links on SKA1-MID
- Equipment also suitable to demonstrate 100GE data transport on several eMerlin telescope links longer term

SADT Consortium

Any Questions

NWA work package progress

SIGNAL AND DATA TRANSPORT

Progress

- NWA model – Rack space budget, Power consumption budget, Spatial maps model
- SADT Rack Diagrams – All telescope locations, all active SADT equipment
- SADT End-to-End Diagrams – All telescope locations, all network connectivity
  - Please visit Posters in PLATE ROOM (20) to review, discuss, and add comments
- All documents under version control
  - SADT ECP process implemented
  - Documentation packs baselined and synchronised across all PBS/Cost model/NWA deliverables

Issues

- Lack of end-element and system level network architecture definition
- L1 Requirements changes – ECPs causing detailed design impacts
- MeerKAT integration/retro-fit impacts
- Telescope roll-out plan into detailed design implementation
- Cost Control Project – ECPs causing detailed design impacts
- SADT detailed design changes and gap analysis delaying NWA CDR deliverables

DDBH work package progress

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Progress

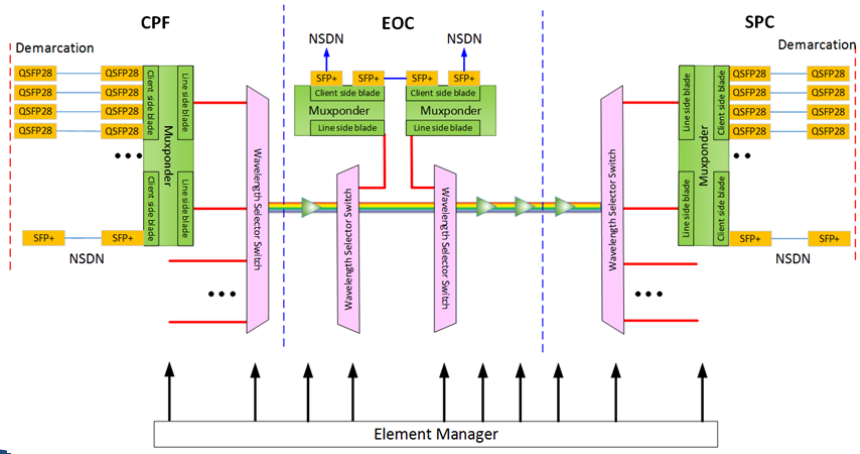
- Detailed design documents 90% complete - Ready for internal SADT review
- Internal ICDs (NMGR, NSDN, LINFRA) - all baselined and signed
- External ICDs (INFRA, LFAA, DSH, CSP) - all OAR comments addressed, out for next round of System Engineering and SKAO signatures
- FMECA, Safety hazard, ILS, and security risk assessments complete
- Cost and Power estimates up to date via multi-vendor Request for Information process
- Market analysis - Ongoing vendor meetings, product demonstrations, roadmap presentations
- SADT data network testbed being constructed at JBO with multi vendor DDBH equipment technologies

Issues

- L1 Requirements changes – ECPs causing detailed design impacts
- MeerKAT integration/retro-fit impacts
- Cost Control Project – ECPs causing detailed design impacts
- >2020 deployment dates – Telecom market changes, power/cost forecast uncertainty
- Lack of end-element interface testing – Pedestal EMC and thermals, DSH-CSP data interface

CSP-SDP: Status for Low and Mid

- Long-Haul from CSP to SDP
  - SKA1-Low 7.5Tbit/s 912km
  - SKA1-Mid 5.4Tbit/s 820km
- DDDs complete
  - Aligned with PBS
- EICDs with CSP and SDP Agreed
- IICDs with LINFRA, NSDN, NMGR
- Costs updated with RFI (Mid) build-out (Low)
- Assumptions & Risks considered
  - Registers being updated
- FMECA & Logistic studies performed
  - Confirmed known points of failure and mitigation.
- Technology demonstrations
  - 200 Gigabit/s per wavelength line-side operational MRO-Perth
  - 96 Gigabit/s for one UDP flow from SaDT Test Box PC



NMGR

- IICD
  - NMGR-DDBH (SKA-LOW and SKA-MID)
    - Reviewed by both NMGR and DDBH team.
    - Under review by SADT System Engineer
  - NMGR-NSDN (SKA-LOW and SKA-MID)
    - Reviewed by both NMGR and NSDN team.
    - Under review by SADT System Engineer
  - NMGR-CSP_SDP (SKA-LOW and SKA-MID)
    - Reviewed by both NMGR and CSP_SDP team.
    - Under review by SADT System Engineer

NMGR

- DDD
  - Completed and Submitted to SADT consortium for review
    - LMC CS Guidelines were not finalized
  - Current Progress
    - Reviewed by SADT consortium
    - Being re-worked with respect to the review comments
    - LMC CS Guidelines are published – DDD is being updated with respect to the latest CS Guidelines.

STFR.FRQ-THU：Tsynchronisation

Cooperating companies and production lines

RF Module

Optical Module

System Assembly

Sampling Master　OPEAK　峻烽光电　SUPLET

SAT.Clocks Activities Since Stellenbosch Engineering Meeting

- Re-design of the 1 PPS, 10 MHz and 100 MHz outputs has been undertaken to account for a requirement for considerably increased numbers of outputs. Different numbers of outputs are required for the Low and Mid telescopes.
- Progress made on advancing the SAT.Clocks Detailed Design Document.
- Work has started on the testing of a experimental solution to the problem of passing GNSS signals through double layer shielding, present at the Low telescope.
- Contributions made to both the internal ICDs and ICDs external to the SADT consortium. In particular detailed contributions have been made to the interface with SAT.LMC.
- Revisions of SAT.Clocks construction costings for both Low and Mid telescopes. This has resulted in a significant reduction in the cost estimates.