MANCHESTER 1824

The University of Manchester

SKA Technical developments relevant to the National Facility

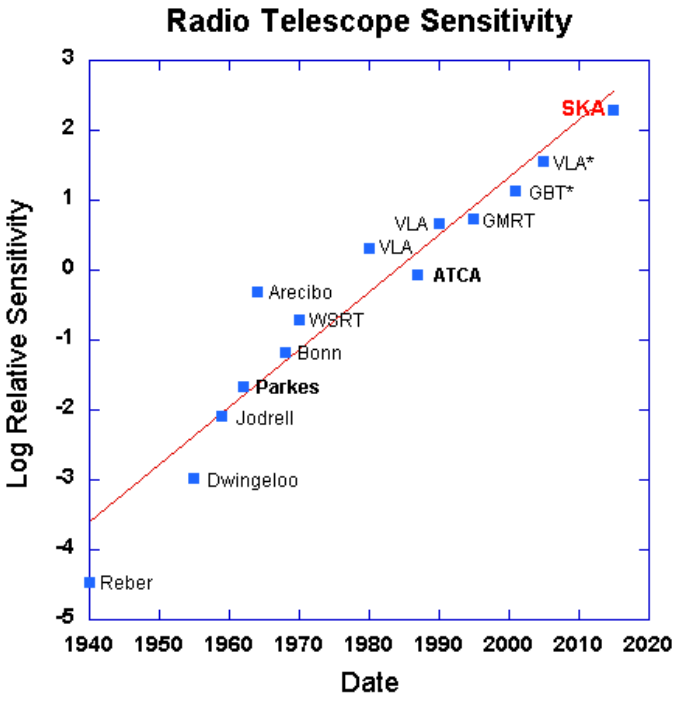
Keith Grainge
University of Manchester

Talk Overview

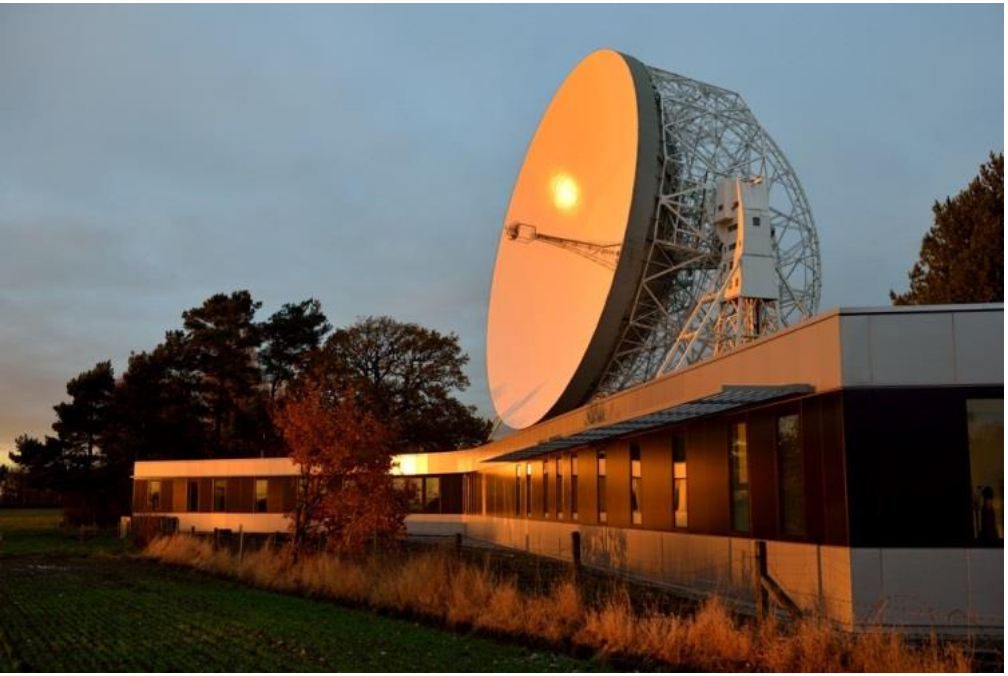
- SKA overview
- Receptors
- Data transport and network management
- Synchronisation and timing
- Correlator and beamforming
- Pulsar search
- (Anna speaking about SDP)

The SKA

- Large radio telescope for transformational science
- > 1 million m^2 collecting area
- Baselines 3000+ km
- Wide-field interferometer
- Frequencies from 50 MHz to 15 GHz
- Aperture Arrays and 15m Dishes
- High performance correlator(s)
- HPC Science Data Processor
- Optical fibre network
- 2 Phases; SKA1 cost cap €650M
- 100 time survey speed increase
- 2 Continents; 2 telescopes



International SKA Headquarters

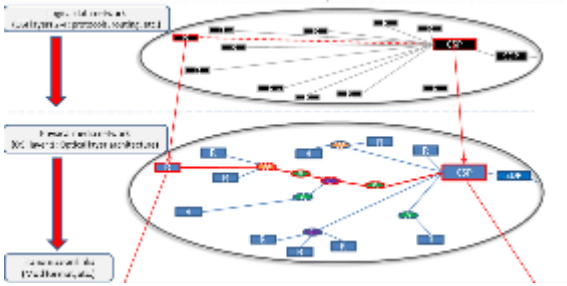


Jodrell Bank has been selected as the permanent SKA HQ location

- Phase 1 €650M cost cap
- HQ at Jodrell Bank
- 9 international consortia
- All passed PDR
- €120M for 4-year design
- SKA to be industry built
- Too large for universities and research institutes
- IGO to be formed end 2017
- Construction to start 2018
- First science 2020
- Construction complete 2023

SKA Design Elements

Low frequency aperture array



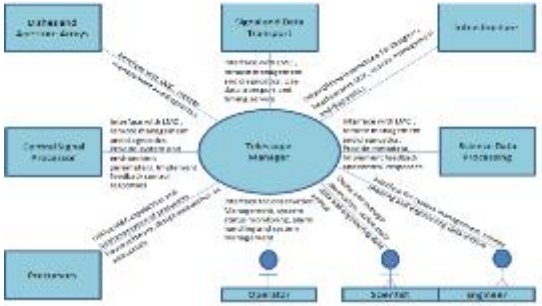
Signal & Data Transport

Central Signal Processor

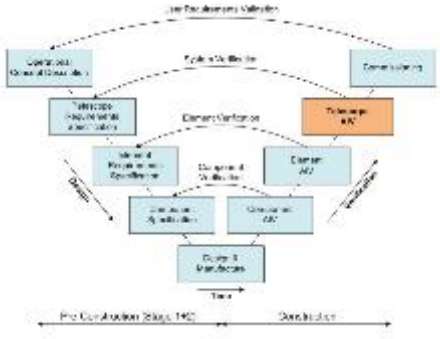
Science Data Processor

Dish

Infrastructure



Telescope Manager



Assembly, Integration Verification

SKA Global Design Consortia

SKA Global Consortia

SKA Phase 1

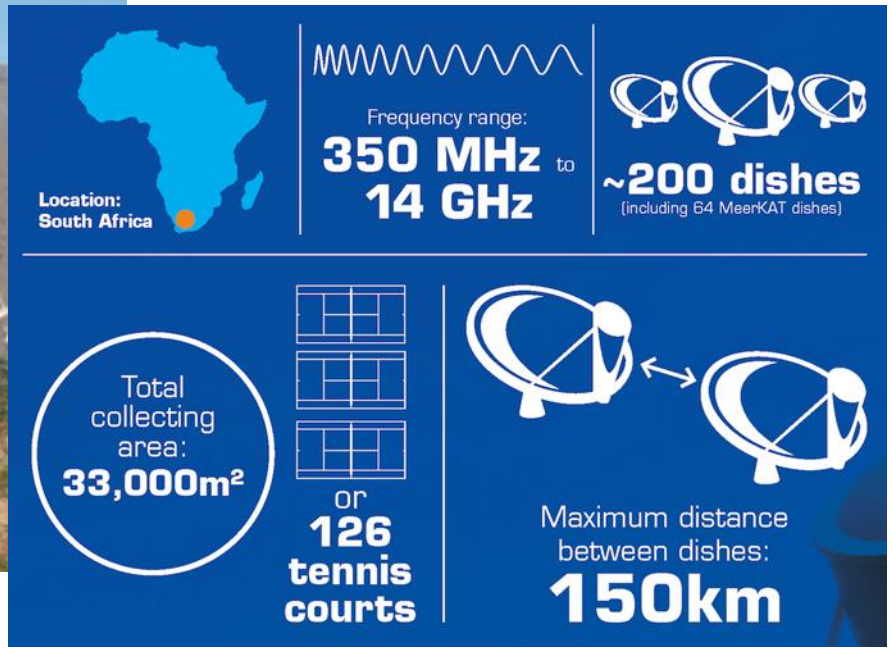
South Africa

SKA1_Mid 350 MHz – 14 GHz
64 MeerKAT dishes
133 SKA1 dishes.

Australia

SKA1_Low 50 – 350 MHz
131,000 aperture array dipole
512 stations of 256 antennas

Design: SKA-Mid



Mid Observing Bands

- Single Pixel Feed Bands
  - 1: 350 – 1050 MHz
  - 2: 950 – 1760 MHz
  - (3: 1.65 – 3.05 GHz)
  - (4: 2.8 – 5.2 GHz)
  - 5: 4.6 – 13.8 GHz (only two 2.5 GHz processed)
- Ongoing ECP to break Band 5 into 2 octaves
  - 4.6 – 8.5 and 8.3 – 15.5 GHz
  - Increased sensitivity and polarisation purity
- For future, Advanced Instrumentation Programme
  - Wide Band Single Pixel Feeds
  - Phased Array Feeds

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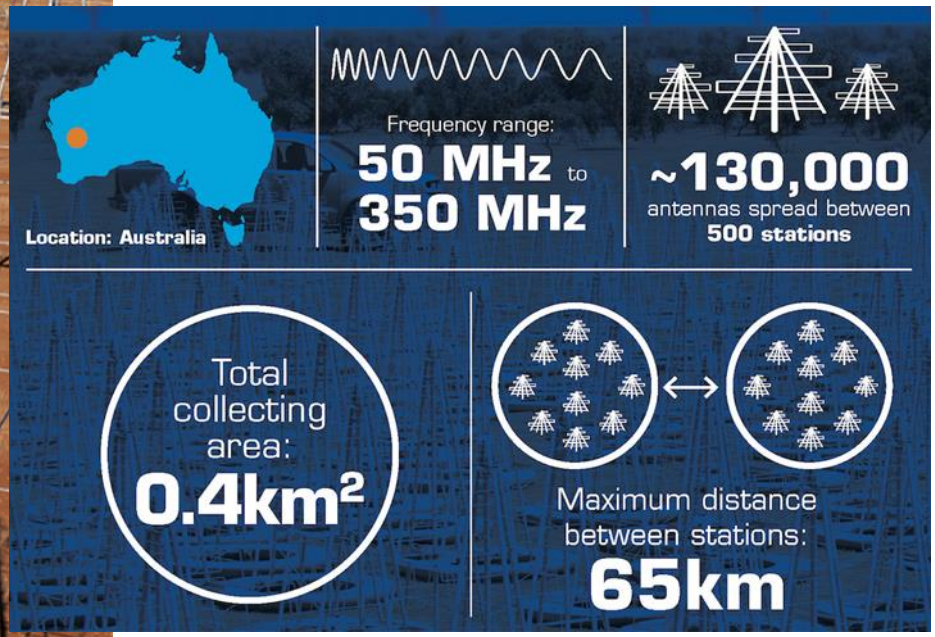
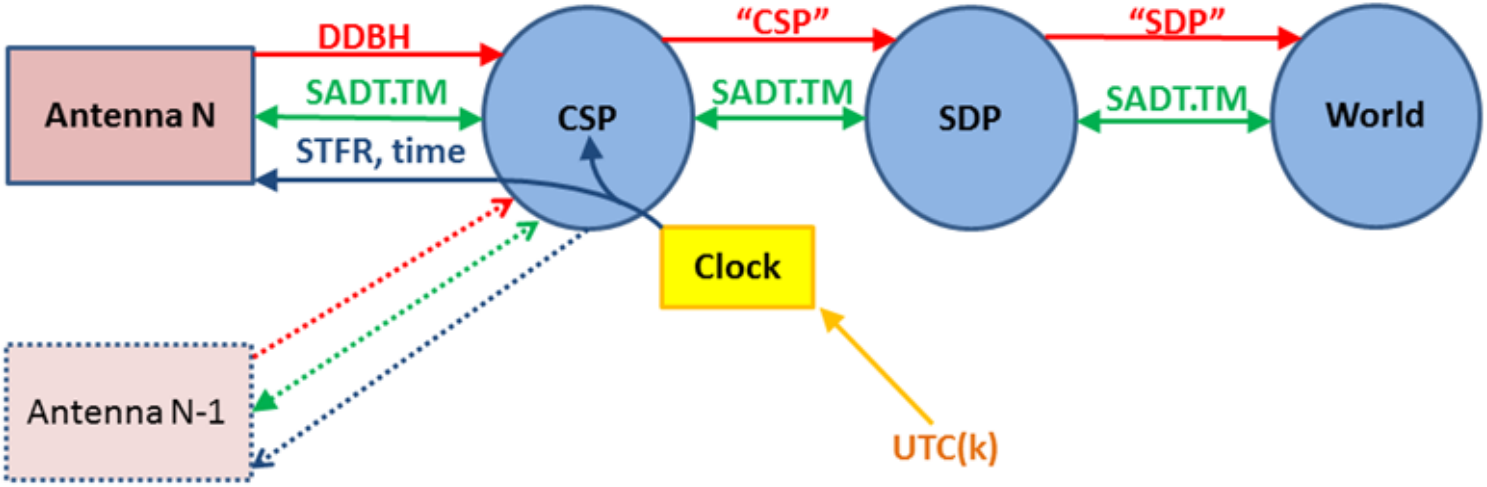
Design: SKA-Low

SKA SQUARE KILOMETRE ARRAY

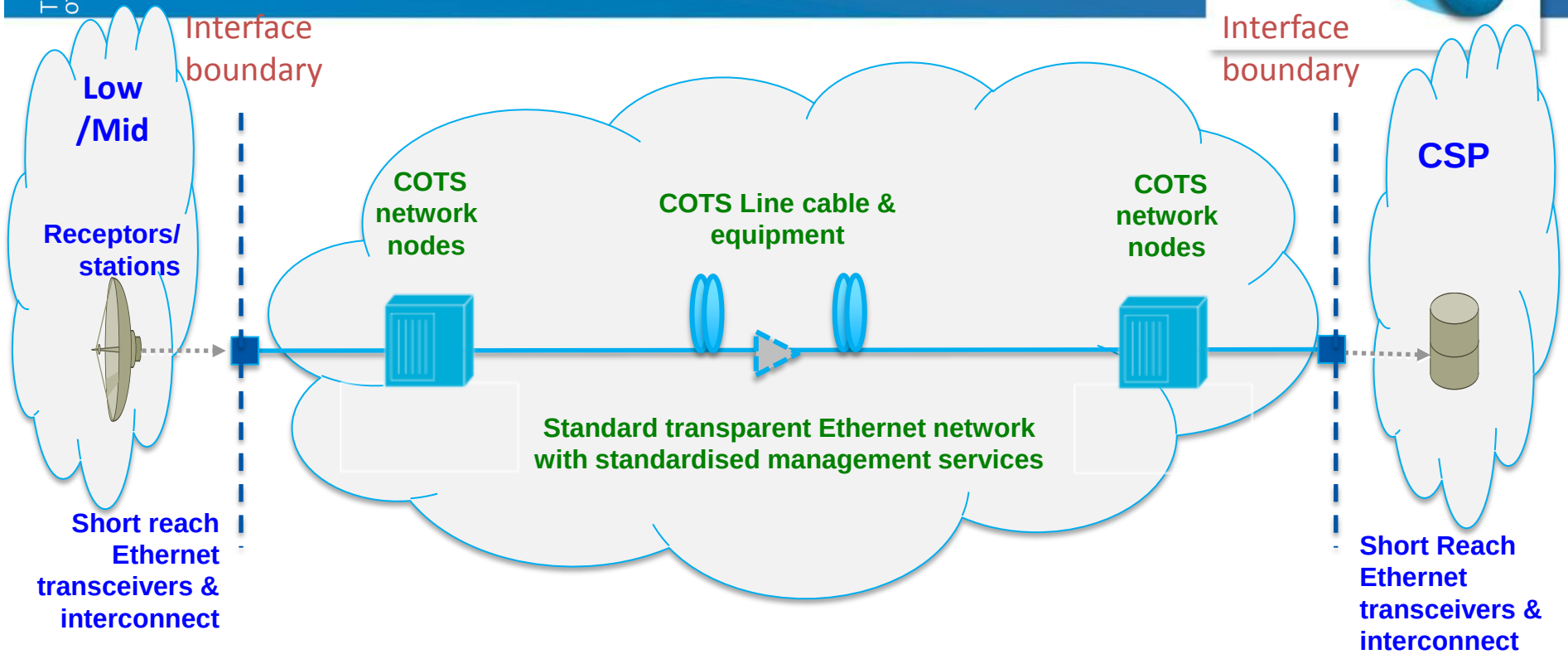


SADT – 3 Networks

- The astronomy data network (DDBH)
- The synchronisation and timing network (SAT)
- The general purpose network (NSDN)
- Each has its own set of challenges



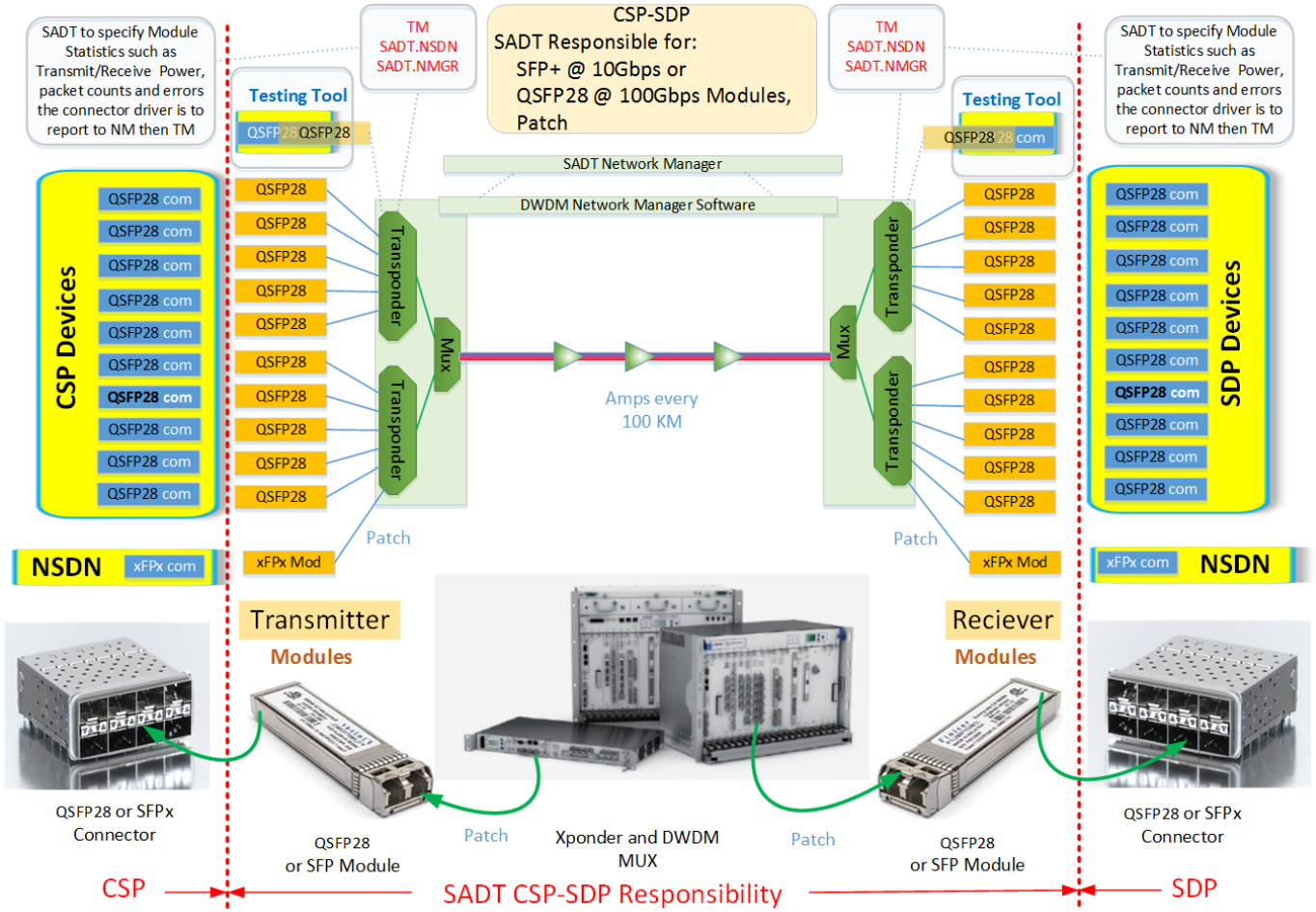
DDBH design concept



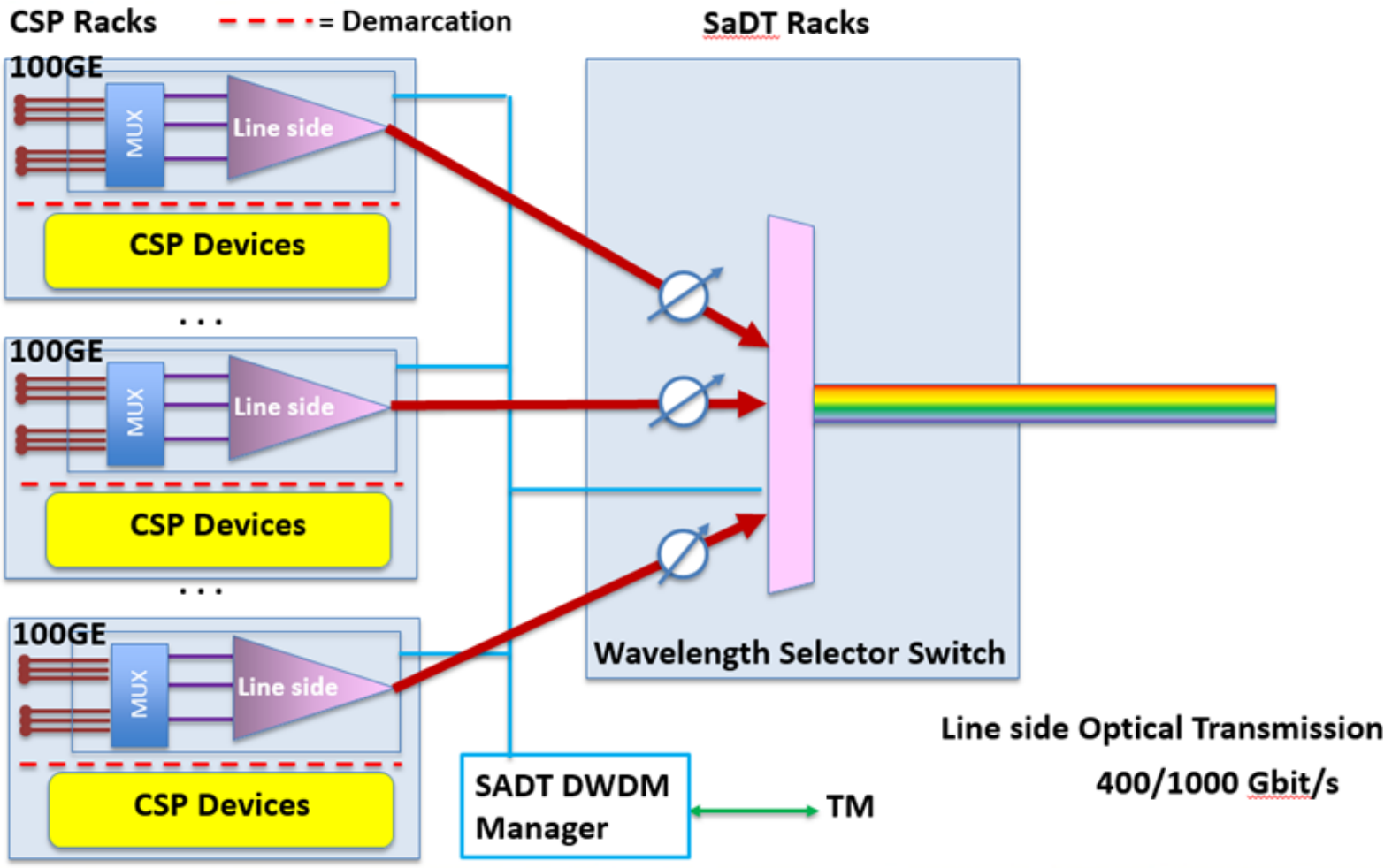
- Fully managed COTS solution – vendor agnostic design
- SKA-Mid; 133 dish antennas, 1x100GE transport lanes
  - Passive spans with LR4/ER4 grey optics or amplified/regen spans with DD/Coherent DWDM
- SKA-Low; 36 remote beam formed super-stations, 2 x 100GE transport lanes (3x 40GE clients)
  - Passive spans with DWDM optics

CSP-SDP design concept

- Provides a high bandwidth path from the Correlator to the HPC
- Carries the following on 10/100 Gigabit Ethernet channels from CPF to SPF:
  - Visibility
  - Pulsar
  - VLBI
  - NSDN
- COTS



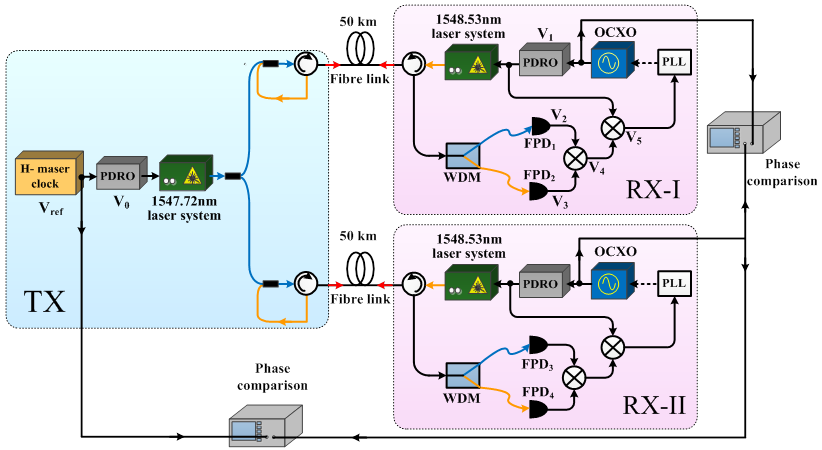
CSP Egress: Visibility Data



Network Manager functionality

- **Fault Management**
  - Reception and processing of SNMP traps, Syslog messages, ICMP pings, etc.
  - Performing diagnostics
  - Performing monitoring for network devices, servers and applications.
- **Performance Management**
  - Polling regularly by SNMP (or other standard protocol) for performance counters.
  - Rolling up counters at predefined intervals
  - Storage of performance counters
- **Configuration Management**
  - Inventory management
  - Network maps
  - Configuration backup and restore
  - Configuration audits & compliance reports
  - Configuration templates & bulk configuration
  - Change automation
  - Change notifications
  - Scheduled tasks
  - Power cycle network element
  - Startup / shutdown card / port
  - Image file management
  - Software / firmware upgrade
- **Other Requirements for NMGR**
- Interfacing between SADT network and Telescope Manager in accordance with the SADT TM ICD & the LMC Common Interface Guidelines
- Performance requirement as per the L1 alarm latency requirement
- L1 availability requirement for SADT and the Telescope

Clock and frequency reference



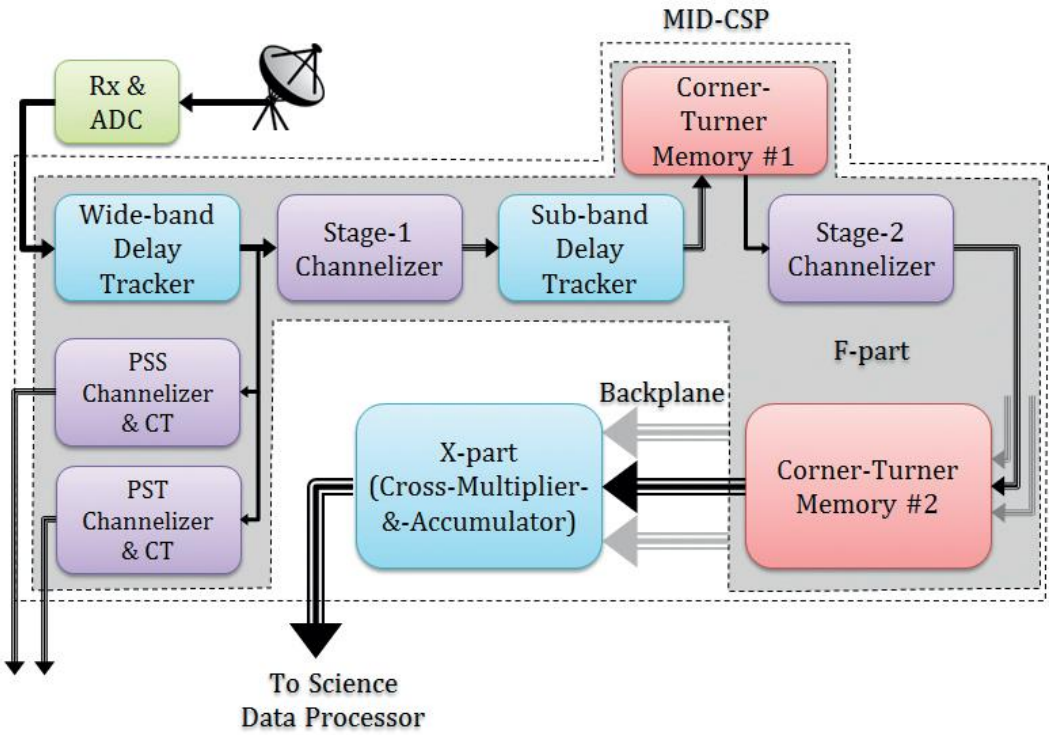
H-maser clock at NPL UK

- Requirements:
  - Phase coherence of array
    - → accuracy = 1ps
  - Long-term timing for pulsars
    - → 10ns over 10 years
- "3 cornered hat" H-masers
- Active go-and-return frequency reference transfer

E-MERLIN experience

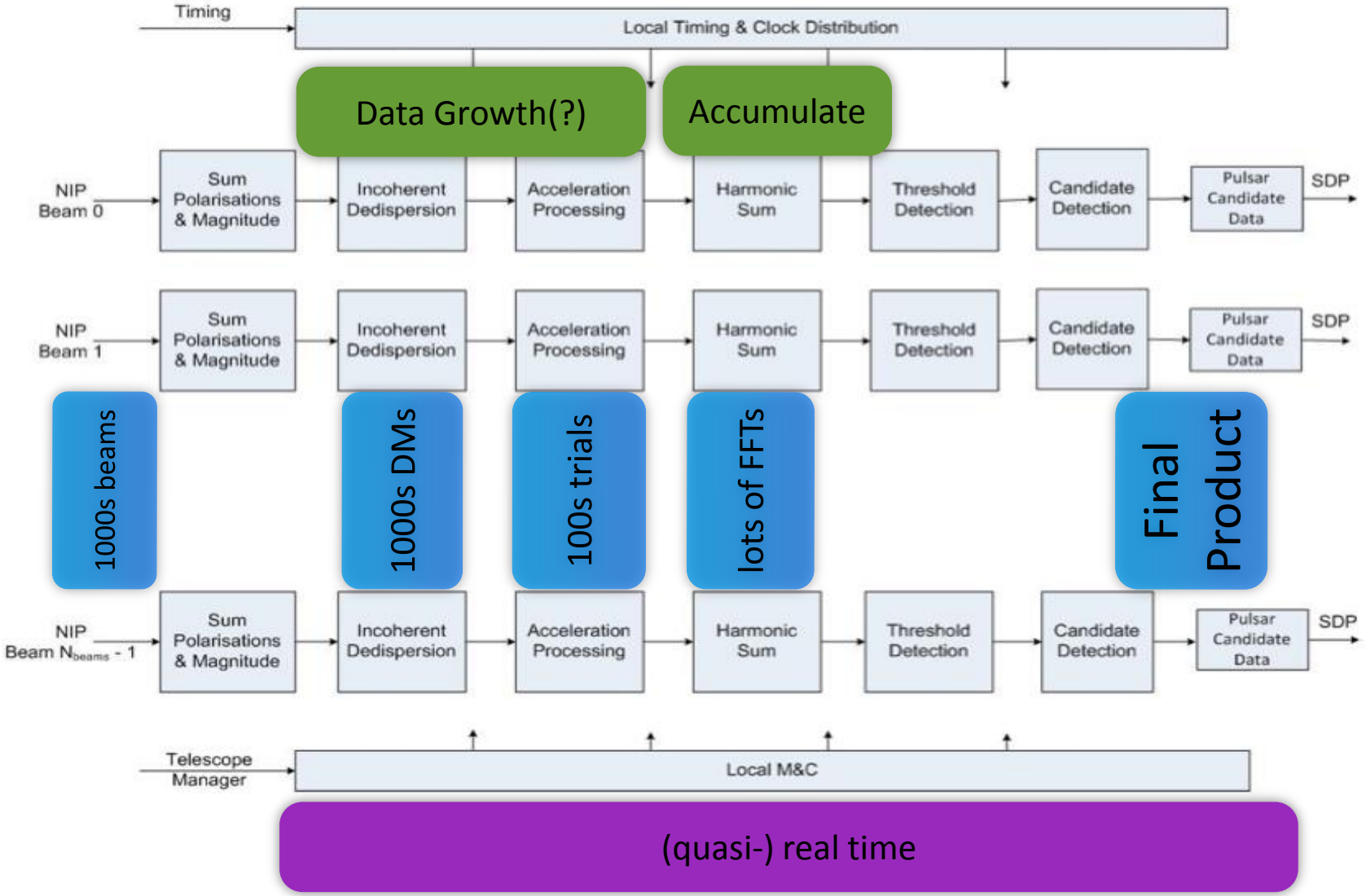
- Very few issues with fibre infrastructure – even for rural, shallow buried sections where we are single occupier; GX/L3 response excellent
- No major problems with optical performance
- Data Tx equipment has been quite reliable
- Co-lo access is a pain
- Lack of network management is a nightmare
- ADSL NSDN is free but flaky
- Synchronisation network runs on same fibre – very reliable; copes with very large temperature changes, vibration due to trains etc

CSP – Correlator/beamformer



- Several concepts taken to PDR
- Down-selected solutions:
  - PowerMX Altera-focused FPGA approach for Mid
  - Perentie Xilinx-focused FPGA approach for Low

Non-Imaging Processing



Accelerators

Prototype solutions

- UK leading “Non-imaging” design
- ~10 Pflop
- A Big Data problem
- Requirements:
  - Real-time processing
  - High flops/watt required
- Problem suitable for accelerators
  - FPGAs
  - GPUs

Summary

- Opportunity areas:
- Receivers
- Data transport
  - COTS high bandwidth Digital Data Backhaul
  - COTS Monitor, Control, Auxiliary services
  - Network management
- Correlators, DSP
- Pulsar back-ends