WP2.2 CoDR
PAF Sub-system
Requirements, Risks & Logistics

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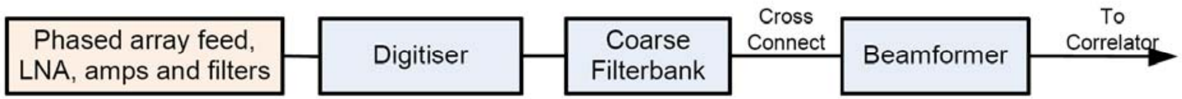
WP2.2.3

PAF sub-system overview

PAF presentations at CoDR



PAF SKA Context, addressing SKA requirements	Carole
PAF concept – PAF Feed payload assembly & LNA (PINK)	Stuart, Bruce
PAF Concept PAF Receiver systems (BLUE)	Russell, Bruce, Grant
PAF Requirements, Risks and Logistics at the SKA scale	This Presentation
PAF Costs & plans for next phase	Carole

PAF Sub-system Requirements

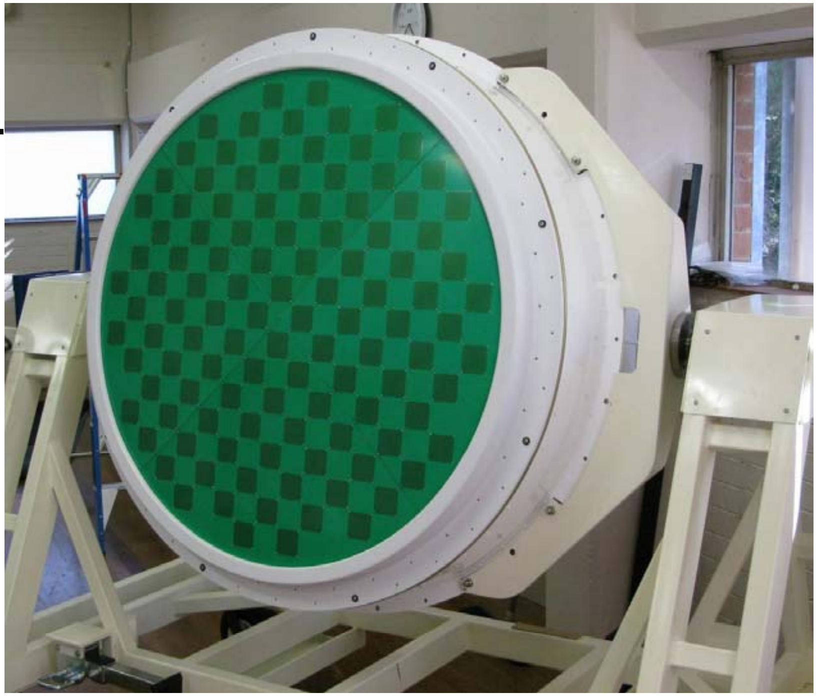
- Derived from the System Requirements and Dish Array Requirements.
- Full PAF sub-system requirements in WP2-025.030-RS-001-A
- Quantitative limits on most requirements are currently not defined at system level.
- Functional Requirements – Direct impact upon astronomy
  - Small sub-set of overall requirements
  - Need to be ranked to allow design trade-offs
- Non - functional Requirements
  - Operational and Maintenance Requirements
  - Environmental Requirements

PAF Sub-system Requirements

SKA PAF (Chequerboard) Array Non-Functional Requirements

Physical parameters (PAF SKA1)

- **Size:** ~900 – 1400mm Dia x 500mm Deep.
- **Weight:** ~200kg (80 + 0.6kg per chan).
- **Power Consumption:** 700W (3W per chan).
- **Monitor and control:** Temp, humidity, voltages and currents.
- **Cooling:** Chilled water 700W + (700W environmental load).
- **Cost at 2014:** 100 - 200k Euro per system (including signal transport and beamformer).



PAF Sub-system – Top 5 Risks

PAF Sub-system Risks

- Generic risks common to all PAF options
- Full risk register and mitigation strategies in WP2-025.030-RE-001-A

Risk	Description
PAF System Performance	The performance of the PAF system may not meet the imaging dynamic range, spectral dynamic range, bandwidth or other functional requirements of the SKA.
Weight and Volume	A PAF system that meets the performance requirements will not fit within the weight limit and space available on the antenna.
Power Consumption	The power consumption of the PAF system is so high that the system cannot be operated within the assigned power requirements.
EMC and RFI Compliance	The SKA site radio quiet zone may be compromised by RFI generated by the PAF receiver system.
Development Timeline	Satisfactory PAF systems cannot be developed and manufactured in the time allocated in the project delivery schedule, PEP, SKA1 and SKA2.

PAF Feed Payload - Top 5 Risks

Risk	Description	Chequer	Dipole	Active Vivaldi
Performance	The array performance of the candidate PAF feed payload designs is unproven for the dish optics and bandwidths expected for the SKA.	X	X	X
LNA Noise Performance	The requirement for high-impedance balanced LNAs for the PAF Chequerboard Array with low-noise performance comparable to 50Ohm LNAs may not possible.	X		
Maintainability	The requirement for high vacuum and cryogenic systems results in greater maintenance requirements, significantly increasing maintenance and operational costs.		X	
Cost	The high fabrication/manufacturing and operating cost associated with high vacuum and cryogenic systems significantly increases the cost of implementing PAF systems.		X	
Oscillation	Active antennas place large amounts of gain at the feed point of an antenna. If there is insufficient shielding and the amplifier output couples to the input, it is possible for oscillation to occur.			X

PAF Receiver Assy – Top 5 Risks

Risk	Description	RFoF	I/Q	Direct Sample
Gain/Phase Stability	The PAF receiver system gain and phase are not stable enough to allow calibration on an suitable calibration cycle time.	X	X	X
Technology Maturity	The receiver technologies have been demonstrated to various degrees but integration on a scale necessary for the SKA is yet to be achieved.	X	X	X
Dynamic Range	The dynamic range of the RF over Fibre receiver system is not sufficient to meet the system requirement.	X		
Technology Maturity	The I/Q mixer receiver has been demonstrated but integration on a scale necessary for the SKA is yet to be achieved.		X	
Oscillation	The direct sampling receiver architecture requires high gain in the receiver, this may result in receiver system instability and oscillation.			X

PAF Receiver Assembly Risks

- Different options presented for:
  - PAF Feed Payload
  - PAF Receiver
- Risks common to all PAF options.
- PAF Feed Payload technological risks mitigated by use of different element options:
  - Vivaldi (APERTIF, AFAD)
  - Chequerboard (ASKAP)
  - Fat Dipole (Cornell, BYU, NRAO)
- PAF Receiver timeline and technological risks shared by use of several receiver options:
  - RF over Fibre (SKA1)
  - I/Q Mixer (SKA1, SKA2)
  - Direct Sampling (SKA2)

Logistical Engineering - SKA

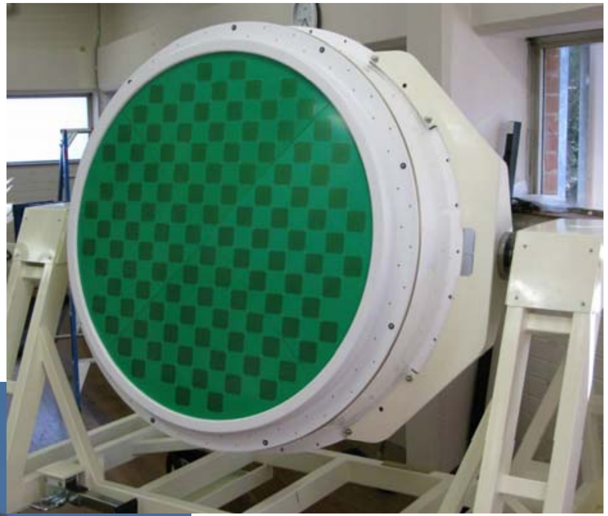
- SKA Logistic Engineering Management Plan
  WP2-005.010.030-MP-002-C
- Replaceable assemblies
  - Line Replaceable Unit (LRU)
  - Shop Replaceable Unit (SRU)
  - Component
- Maintenance levels, facilities and support
  - Organisational Level Maintenance (O-Level or OLM)
  - Intermediate Level Maintenance (I-Level or ILM)
  - Depot Level Maintenance (D-Level of DLM)
  - Supplier Level Maintenance (S-Level or SLM)

PAF Logistical Engineering

- Focus elements of PAF system incorporated as one LRU replaceable on-site (O-Level).
  - PAF Feed Payload (Feed element, LNAs)
  - PAF Receiver (RF electronics and RFoF, I/Q or Digitiser)
- Consumables replaceable at O-Level (filter elements, radome).
- Remaining PAF receiver elements divided up as LRUs based on location and function.
  - Antenna pedestal, node or central site (~10km)
  - PAF Receiver (RF electronics and RFoF Tx, I/Q or Digitiser)
  - SRUs may be replaceable O-Level
- PAF System LRUs and SRUs repaired at an I-Level or D-Level facility.

PAF Logistical Engineering

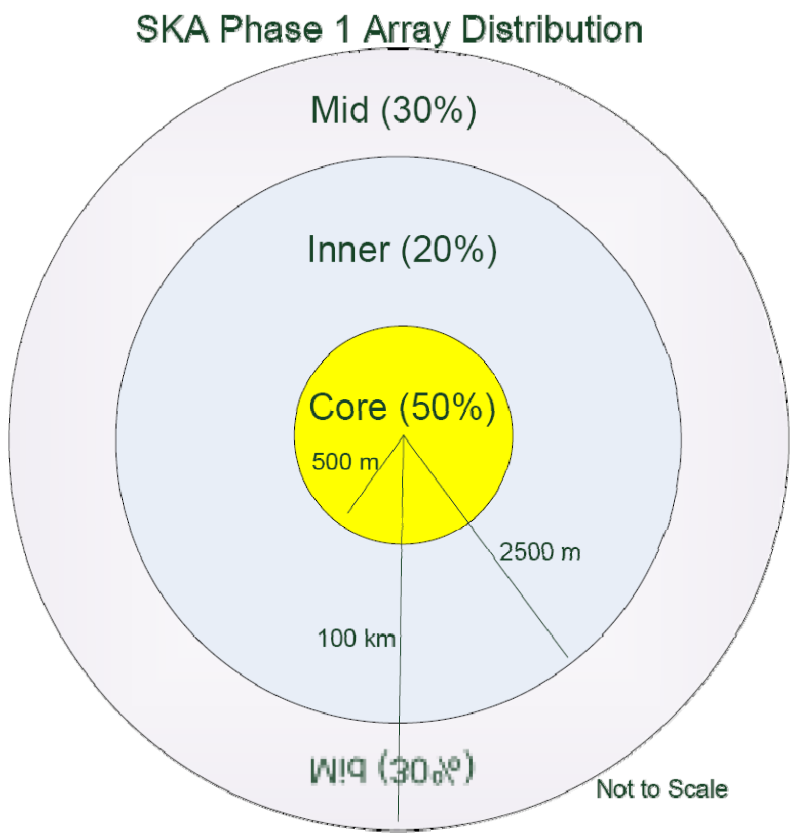
SKA PAF LRU Replacement – ASKAP as an example



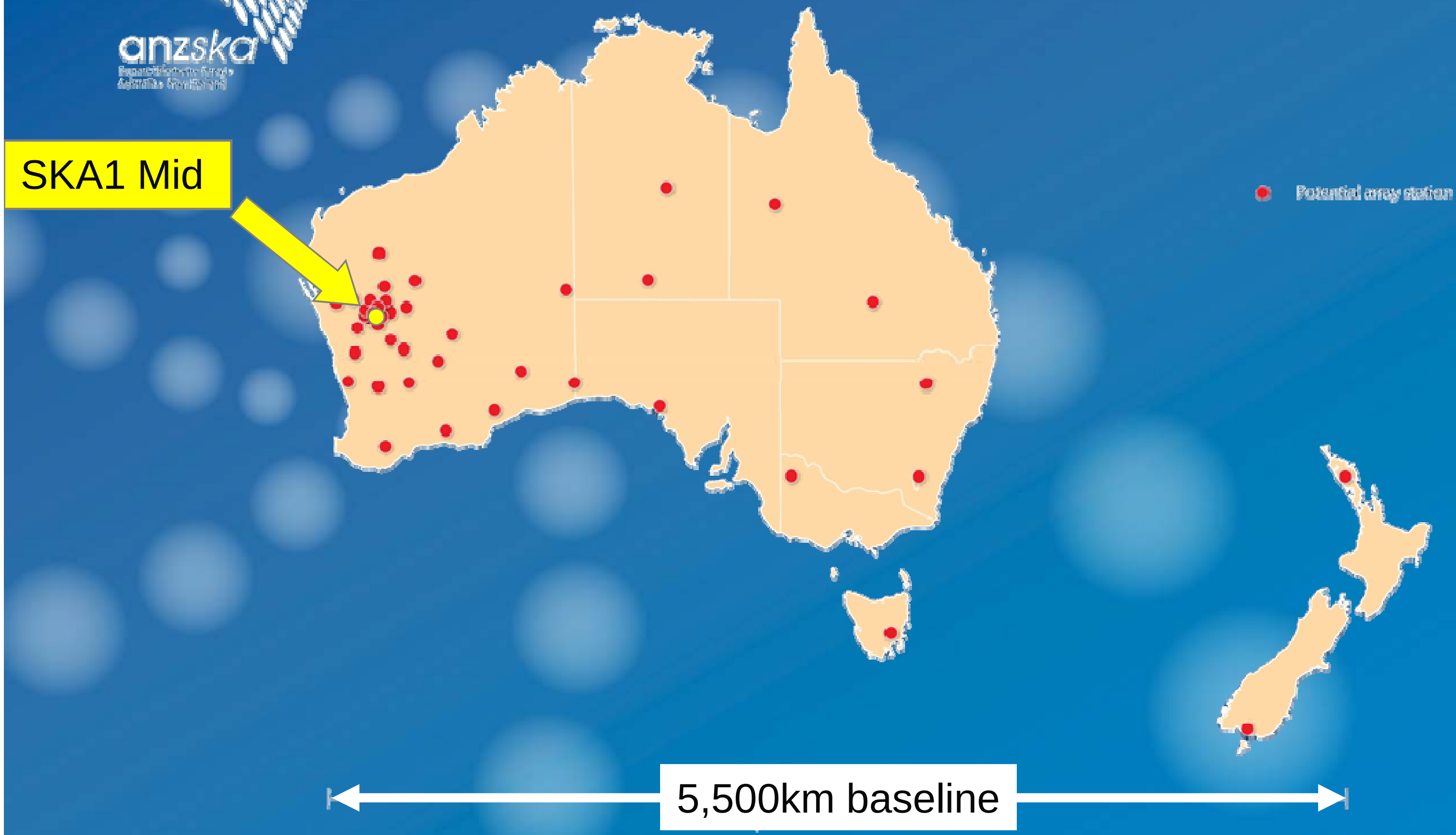
Logistical Engineering - SKA1

SKA1 Array Distribution (Memo 130)

- 250 dishes in total
  - 175 in the core and inner regions,
  - 75 in the mid region.
- In the core and inner regions
  - All dishes are < 2.5 km from centre
- In the mid region
  - 3 spiral arms extending 100km,
  - 5 clusters per arm,
  - 5 dishes per cluster.



Logistical Engineering – SKA2



Logistical Engineering – SKA2

- Scale of SKA2 larger than anything attempted by the radio astronomy community thus far. (LOFAR)
- An operational plan needs to be developed at the top level.
- Experience from precursor facilities needs to be incorporated (LOFAR, ASKAP and MeerKAT).
- Analysis of the operational plan and its impact upon PAFs.
- Sufficient monitor and control must be implemented to enable diagnosis to LRU, SRU level remotely (Operational plan).
- O-Level, I-Level and D-Level facilities need to be located appropriately (multiple facilities, cross-national boundaries).
- Any supplier support contracts need to be negotiated as part of construction.

Critical Points

An SKA operational plan is essential for the PEP.

- Define PAF system operational requirements:
  - Control and monitor
  - Mean Time Between Failure (MTBF) of equipment
  - Maintenance strategy
  - Operational lifetime
- Flow through to PAF non-functional requirements:
  - Size of maintenance pipeline and spares inventory
  - Location, number and type of support facilities
  - Cost (operational and construction)
  - Telescope availability
- Concrete requirements required in time to allow cost and risk reduction for the PEP and SKA1.