Signal Transport & Networks for the SKA

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Contents

- SKA Approach
- Extent of the STaN Domain – System Context
- Groups working within PrepSKA
- Requirements and Functionality
- Working Assumptions
- Gap Analysis
- Interfaces

Phased Approach

- SKA1 – 10% array.
- Studying Neutral Hydrogen in the Universe and Pulsars as probes of fundamental physics.
- Includes 300 dishes to 3 GHz and 50 AA-lo stations.
- 100 km baselines
- Reviewed at a System δCoDR.
- Implemented with extensibility to SKA2 in mind.

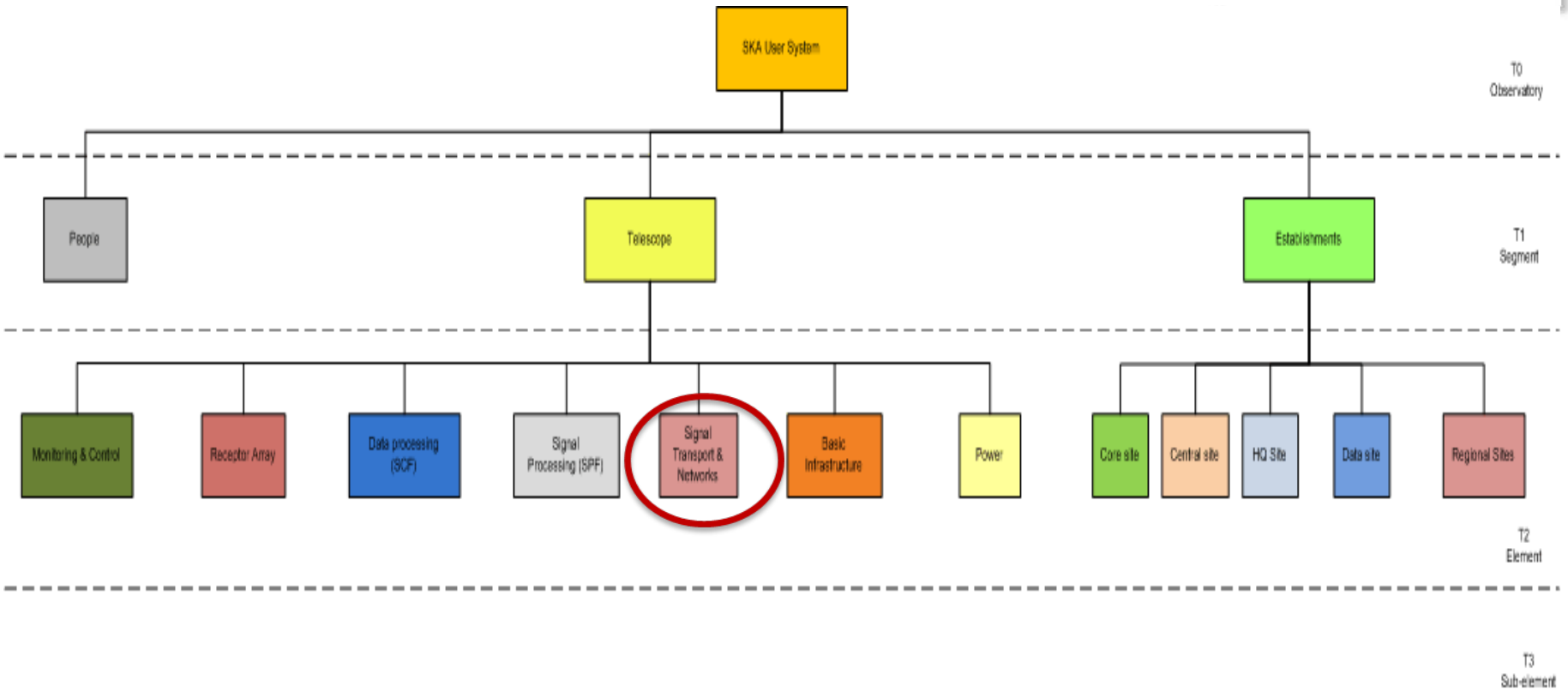
Phased Approach

- SKA2
- Large collecting area
- Long baselines
- 10 GHz top frequency
- Inclusion of advanced instrumentation (AIP)
  - PAFs
  - Dense Aperture Arrays
  - WBSPFs

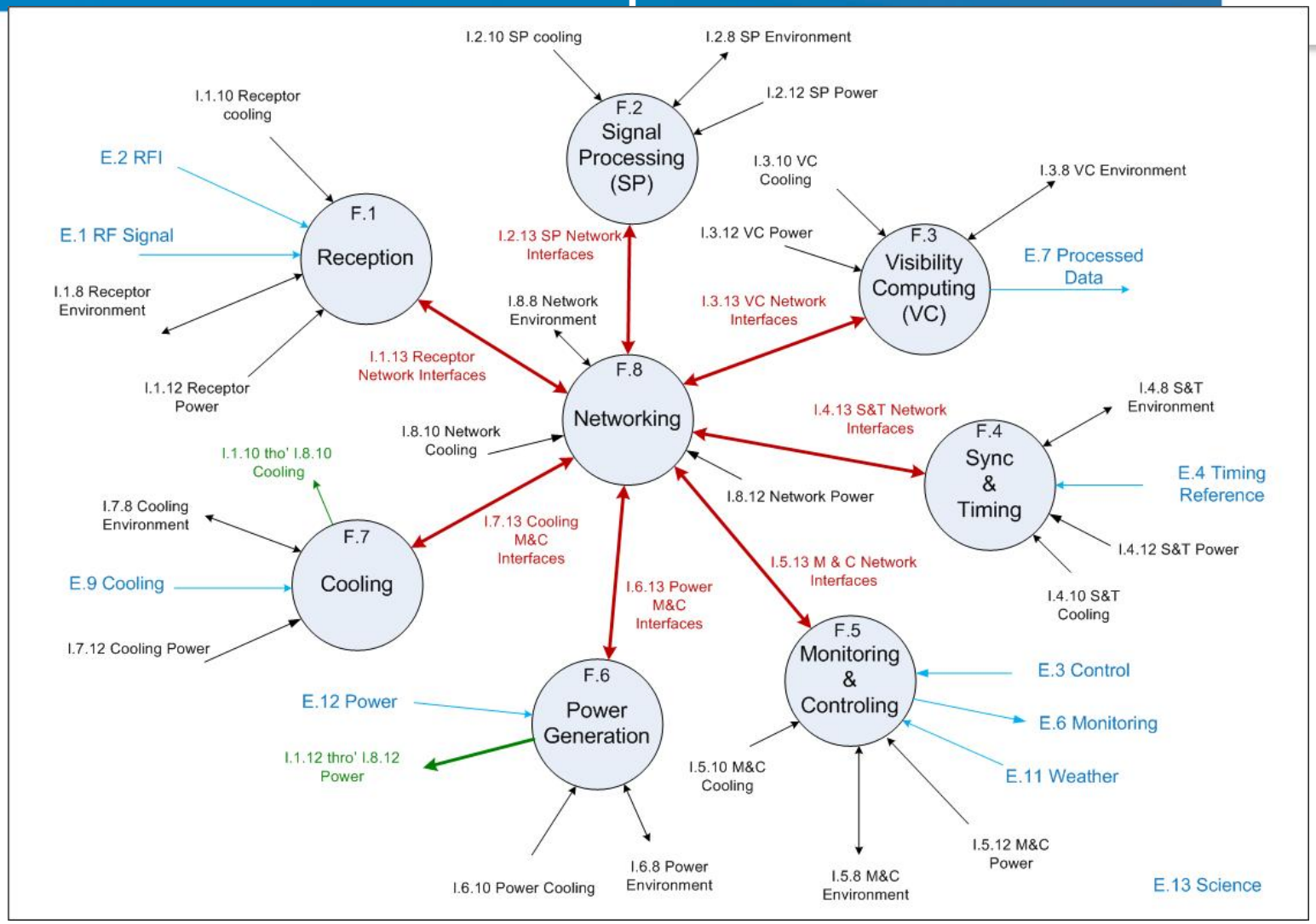
System Engineering

- Defined approach for the project
- Methodical and documented, recognised process for the design and construction of large projects
- Establishing requirements
- Defining interfaces;
  - physical & data exchange
- Application of knowledge and experience within this framework

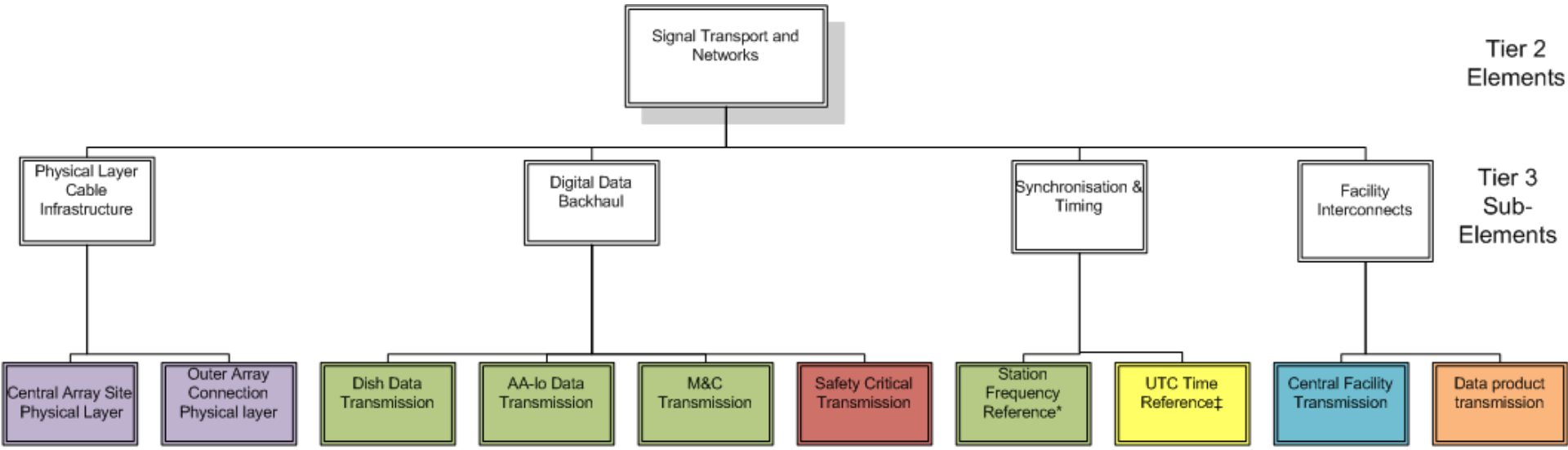
Signal Transport & Networks – SKA Hierarchy

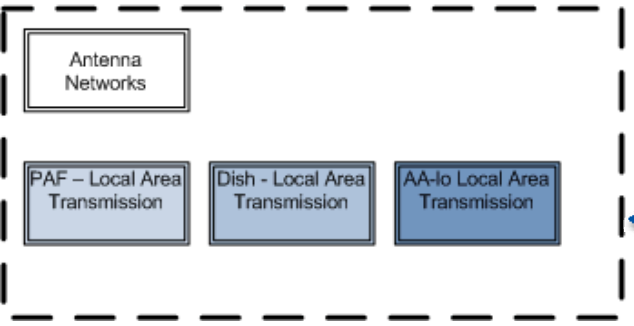


Signal Transport & Network – Functional description



Signal Transport & Networks Product Tree



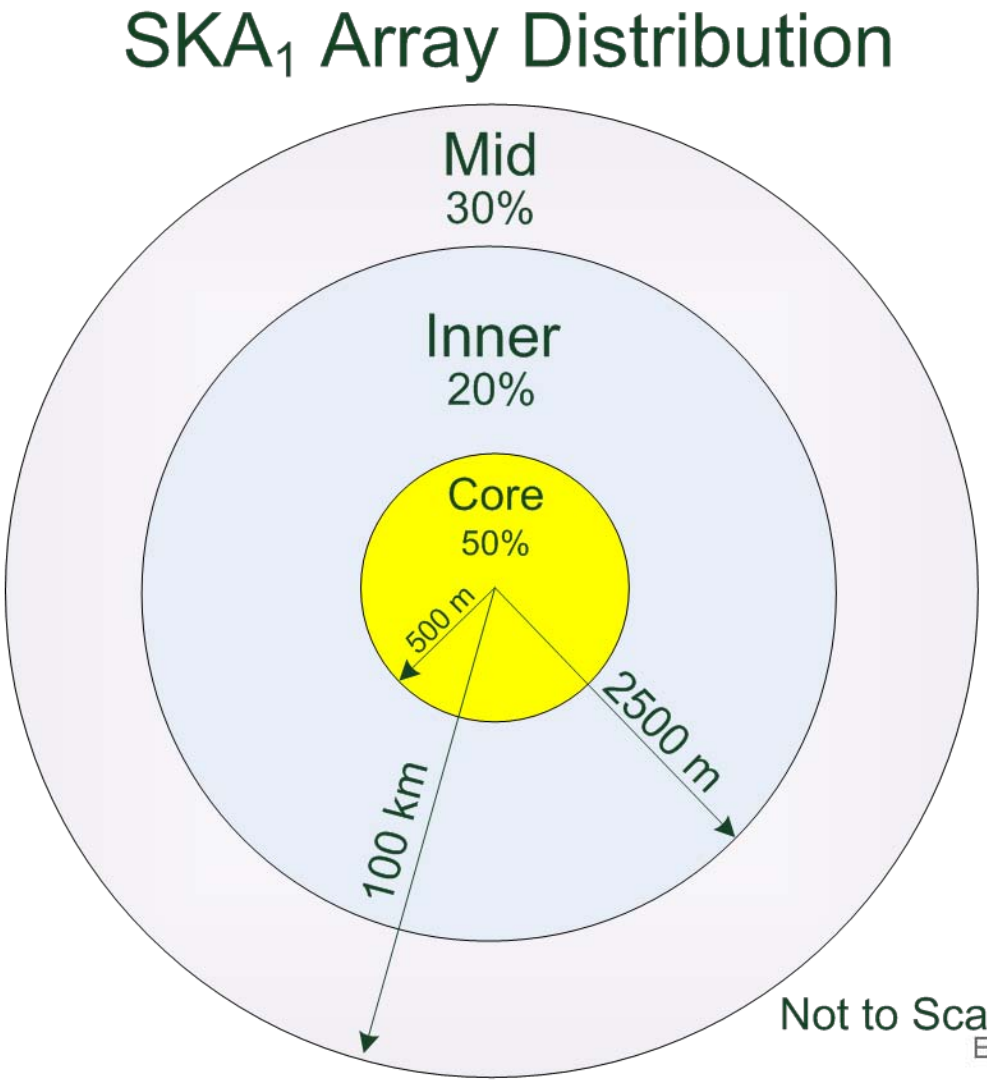


Part of the receiver chain. Covered in the STaN domain in order to pool specialist knowledge and avoid 'silo' designs resulting in inefficient use of system blocks

Signal Transport & Networks for the SKA

Data Network	• For transporting astronomical signals to a central processing facility (CPF)
A Monitor & Control Network (M&C)	• Including comms and required redundancy
Synch & Timing Network	• For the distribution of local oscillator signals for clocks and down converters.
Facility interconnects	• For the distribution data from the CPF to the HPC and of imaging data to regional centres
High Volume, High Speed Interconnects	• Not fully defined but significant data centre style interconnects will be required
Network Infrastructure	• Serves all those services carried over a fibre optic network

Configuration



SKA1:
2 cores
3 spiral arms
250 dishes
50 AA-lo stations

Extensible to .....
SKA2, potentially:
3 cores
3,000 km extent
5 spiral arms
3,000 dishes
500 AA stations

Requirements and Functionality

Antenna Networks

- Part of a receiver chain
- Link between the receiver and a digitising stage
- RF over fibre links
- Imaging Dynamic Range
  - Gain & Phase Stability per pol and across pol

Requirements and Functionality

Antenna Networks

- Working assumptions
- 2 per pol
  - per dish – 250 dishes = ***500***
  - Per AA element – 1 Million elements, 50 stations – ***50 Million***
  - Per PAF element – 64 elements, 220 dishes = ***14,000***
- Resource
  - SPF Antenna Networks, ASTRON
  - AA-lo Antenna Networks, INAF
  - PAF Antenna Networks, CSIRO

Requirements and Functionality

Data Network

- Digitised signals from telescope elements and the output of beamformed stages
- Digital optical transmission
- Point to point links
- Unidirectional transmission
- Bit rate proportional to:
  - Bandwidth, # of bits per sample and # of beams

Requirements and Functionality

Data Network

- Working Assumptions
  - 24 Gbps per dish = **6 Tbps total**
  - 1216 Gbps per AA station = **60.8 Tbps**
  - 929* Gbps per PAF = **204 Tbps**
- Resource
  - COTS implementation, IT
  - Custom design, UMAN
  - Interfaces, CSIRO

Requirements and Functionality

Monitor & Control Network

- Requirements derived from M&C at the system level
- Digital optical transmission
- Bi-directional
- Special case – safety critical networks
- Very likely COTs

Requirements and Functionality

- Working Assumptions
  - **1-10 Gbps** link per dish or station.
  - **300** dish and station locations in SKA1
- Resource
  - Lessons learned review – CSIRO
  - No PrepSKA resource

Requirements and Functionality

Synchronisation & Timing Network

- Fundamental to the operation of the telescope as an interferometer
- Frequency reference for high precision timing ticks.
- Time servers for UT time stamps
- Functional requirements defined by top frequency of operation
- Very likely a distribution system with correction

Requirements & Functionality

Synchronisation & Timing

- Working Assumptions
  - One time server per dish or station location = **300 @ GPS long term accuracy**
  - On frequency reference system per dish or station location = **300**
  - **@ 9 ps short term accuracy in SKA1; 3 ps in SKA2.**
- Resource
  - Work undertaken by UMAN

Requirements and Functionality

Facility Interconnects

- Models to size the problem
- CPF to HPC – point to point link
- HPC – Wider world – international research network links.
- Data Centre Style - high speed, high volume data interconnects

Requirements and Functionality

- Working Assumptions
  - Correlator to HPC = **2.4 Tbps SKA1** (EoR forest optimised output)
  - HPC to Wider world = **10 Gbps SKA1**
- Resource
  - No PrepSKA resource allocated

Requirements and Functionality

Network Infrastructure

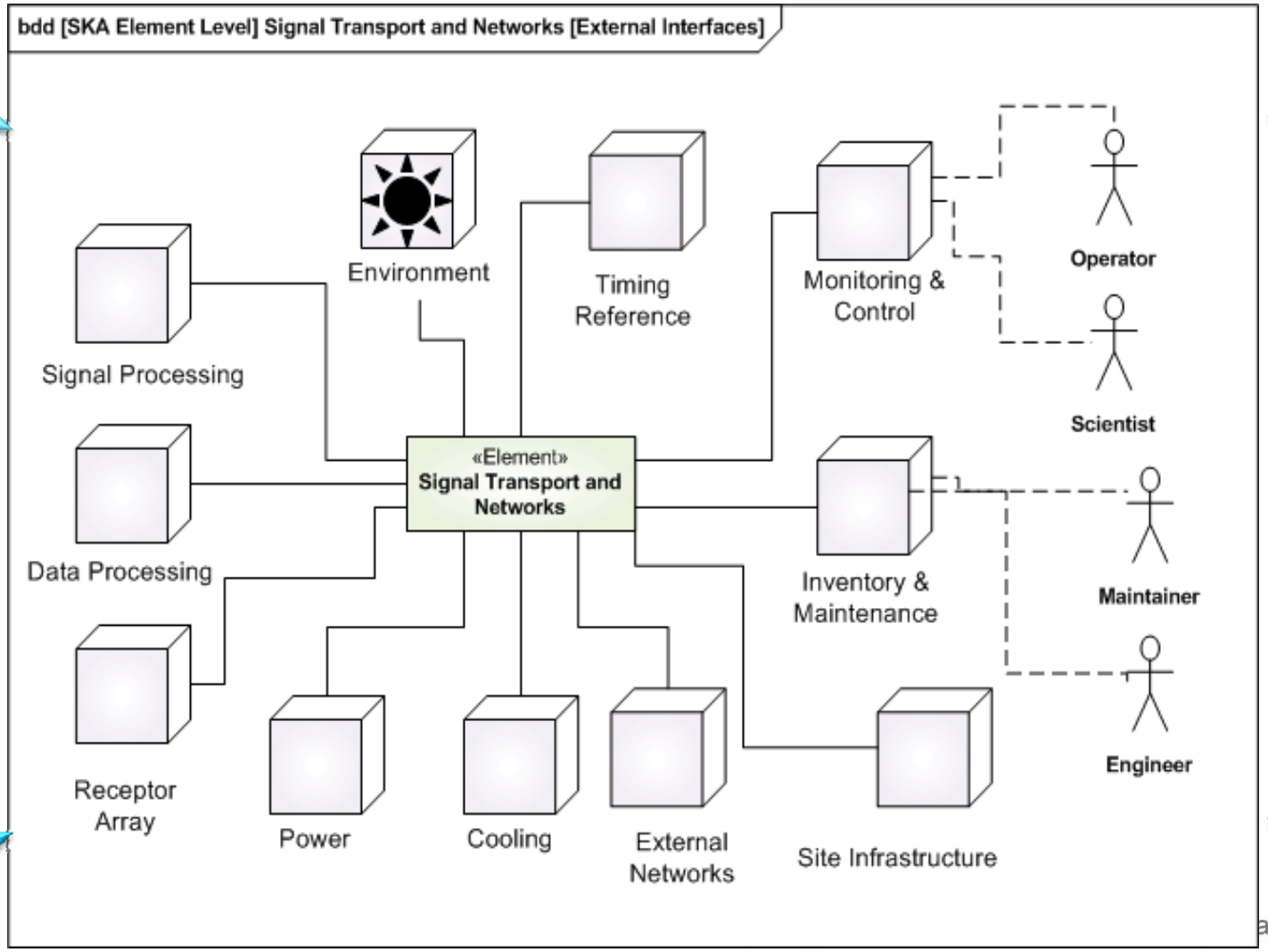
- Reliable
- Maintainable
- Safe
- Cost effective (within budget)
- Fulfil the functional requirements of:
  - M&C,
  - DDBH,
  - Synch & Timing
  - Facility interconnect systems

Requirements and Functionality

Network Infrastructure

- Working Assumptions
  - **100 Gbps** channels
  - **64 channels** per fibre
- Resource
  - No PrepSKA resource allocated

Signal Transport & Networks Interfaces



Physical

Data Exchange

adio telescope

Conclusions

- SKA has a phased approach and system engineering framework for delivery
- STaN sits within this to serve many elements of the observatory
- Description, working assumptions and resource for:
  - Antenna, Data transport, M&C, Synch & Timing, facility interconnect and network infrastructure
- Networks interface to all aspects of the system

Questions