From eVLBI to the SKA

Roshene McCool
SKA Domain Specialist
Signal Transport & Networks

Objectives

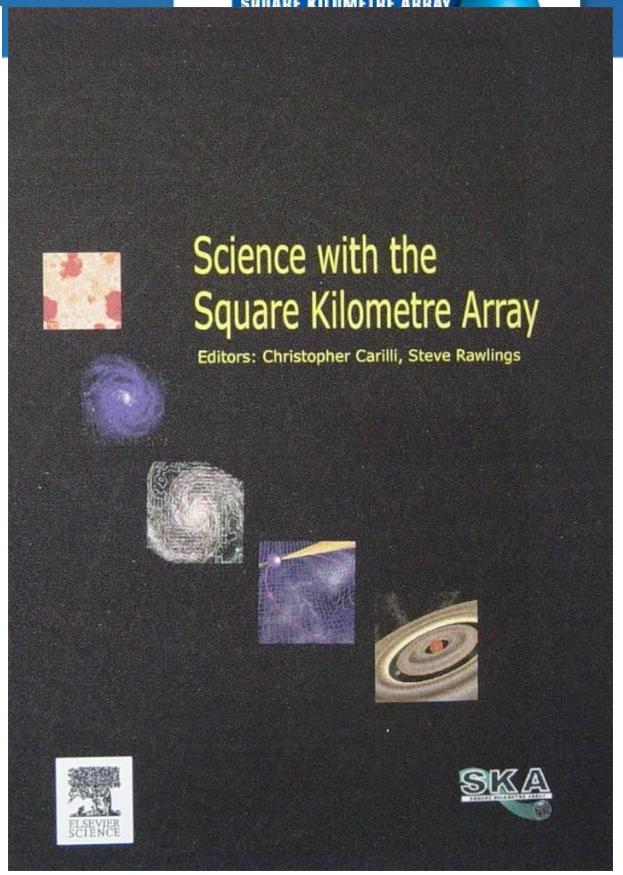
- What is the SKA?
- How is it similar to eVLBI and, therefore what techniques and developments can be shared?
- How is it different from eVLBI and, therefore what needs to be considered in the development of solutions?

What is the SKA?

Five Key Science Projects (KSPs)

1. **Probing the Dark Ages**
2. **Galaxy Evolution, Cosmology, & Dark Energy**
3. **The Origin & Evolution of Cosmic Magnetism**
4. **Strong Field Tests of Gravity Using Pulsars and Black Holes**
5. **The Cradle of Life/Astrobiology**

… plus The Exploration of the Unknown as an underlying philosophy for design of the instrument

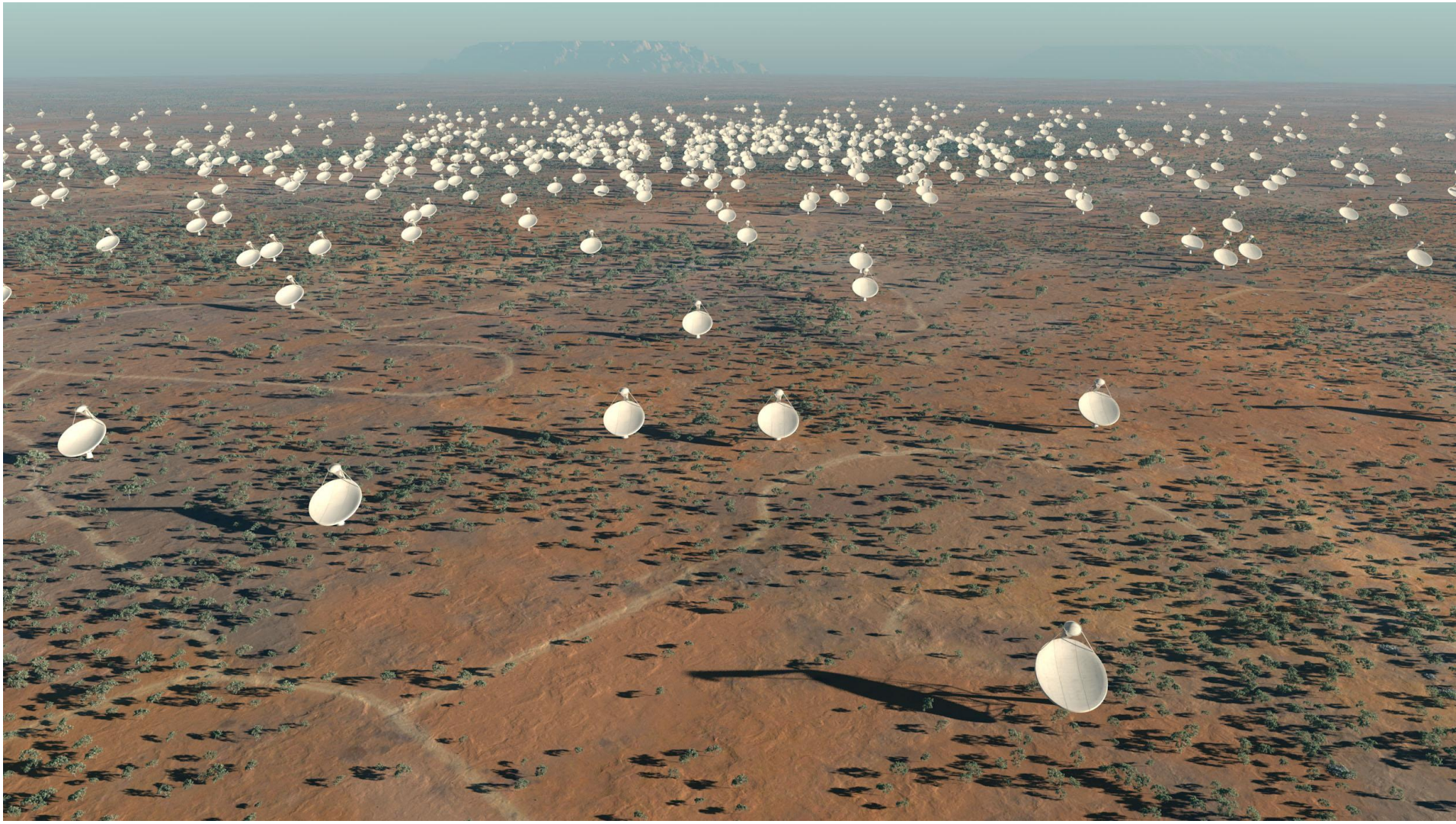


The Square Kilometre Array

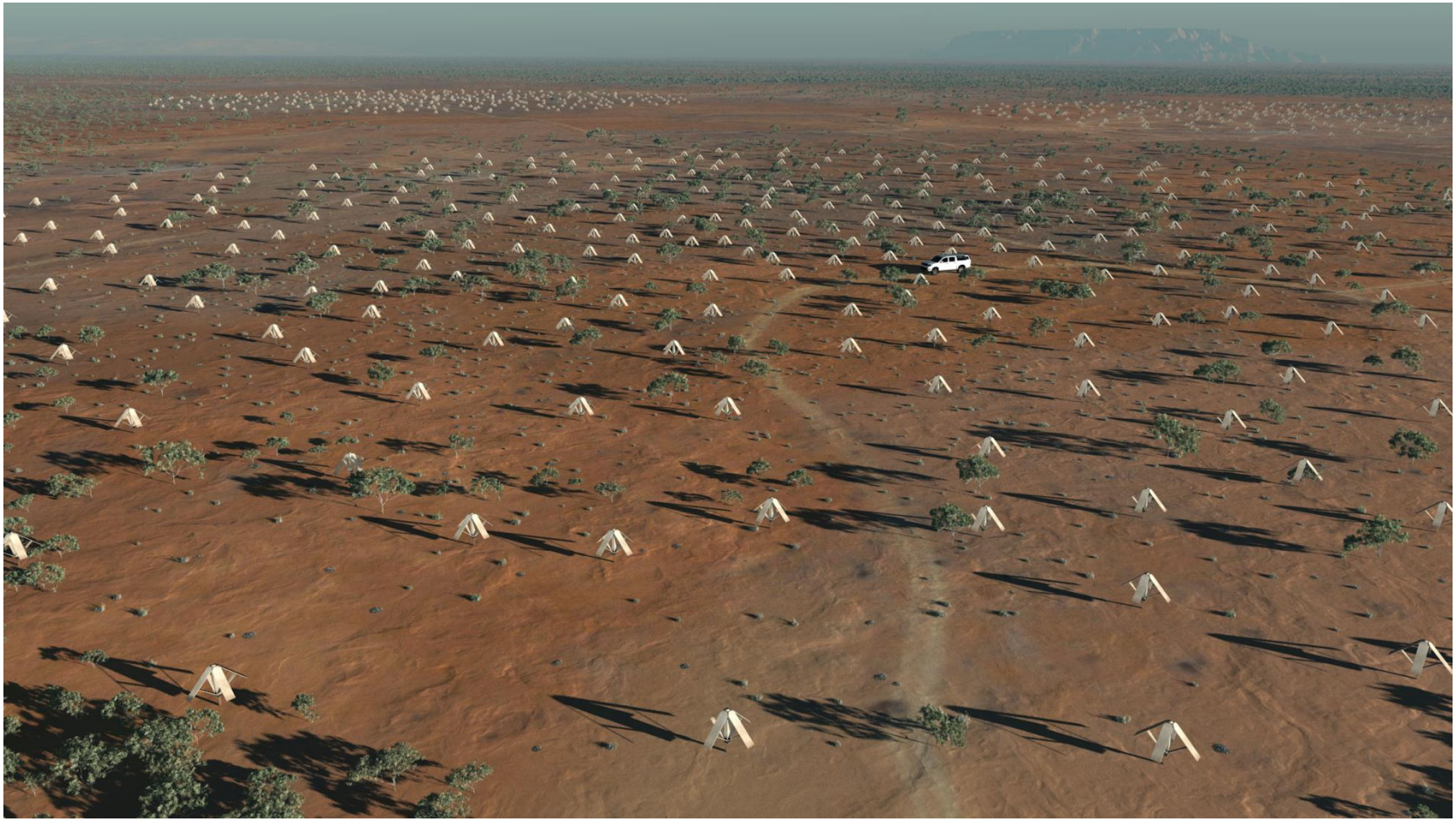
4 prime characteristics

- **very large collecting area (km^2)** → sensitivity to detect and image hydrogen in the early universe
- **very-large-angle field of view** → fast surveying capability over the whole sky
- **wide frequency range required for the Science Reference Mission**
  - **low : 70-300 MHz**
  - **mid: 300 MHz-10 GHz**
- **large physical extent (3000+ km)** → capability for detailed imaging of compact objects and astrometry with milli-arcsec resolution

The SKA



The SKA



Exploring the Universe with the world's largest radio telescope

Implementing the SKA

- Many elements
  - Mass manufacturing
  - Installation techniques
  - Operational considerations
- High speed, long distance data transfer
- High Performance Computing
- Low cost, low power, low RFI
- Developed & funded by a global community

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

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 AA-lo stations.
- 100 km baselines
- Described in SKA memos 125 and 130.
- Implemented with extensibility to SKA2 in mind.

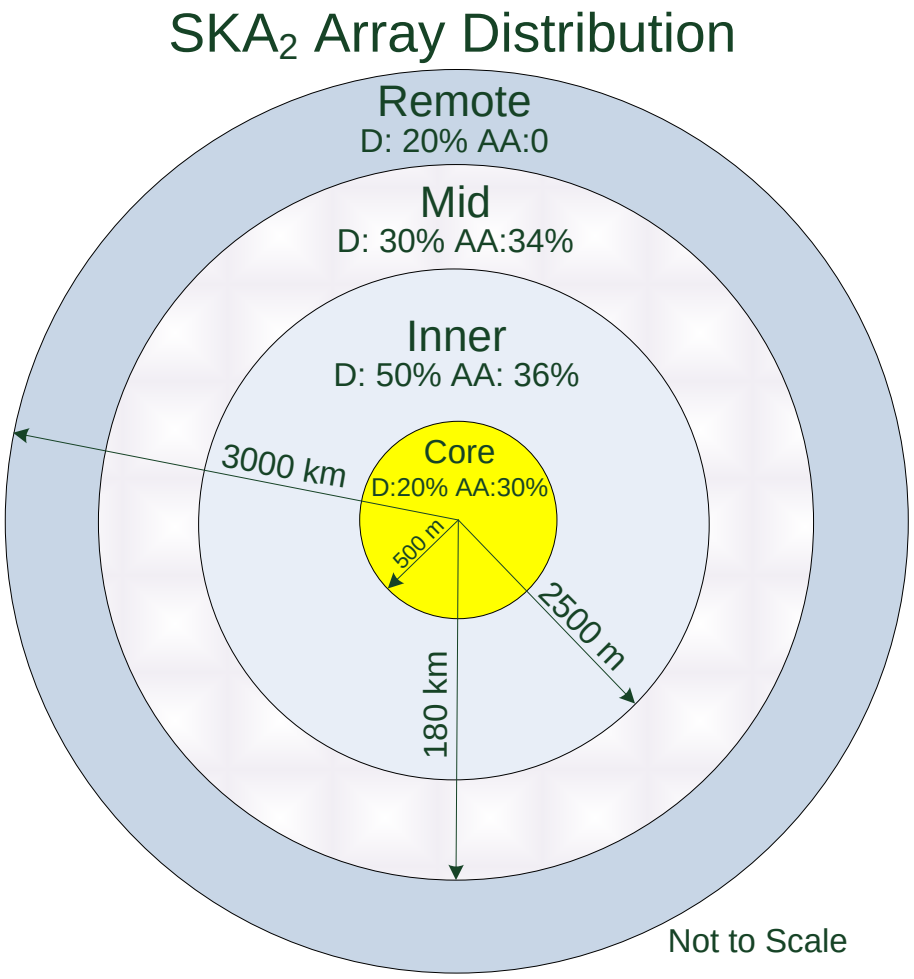
Phased Approach

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

Visualising SKA2 Baseline Requirements

Tour de France is the 3,000 km race.
SKA will transmit data along many 3,000 km arms!

Array Configuration SKA2

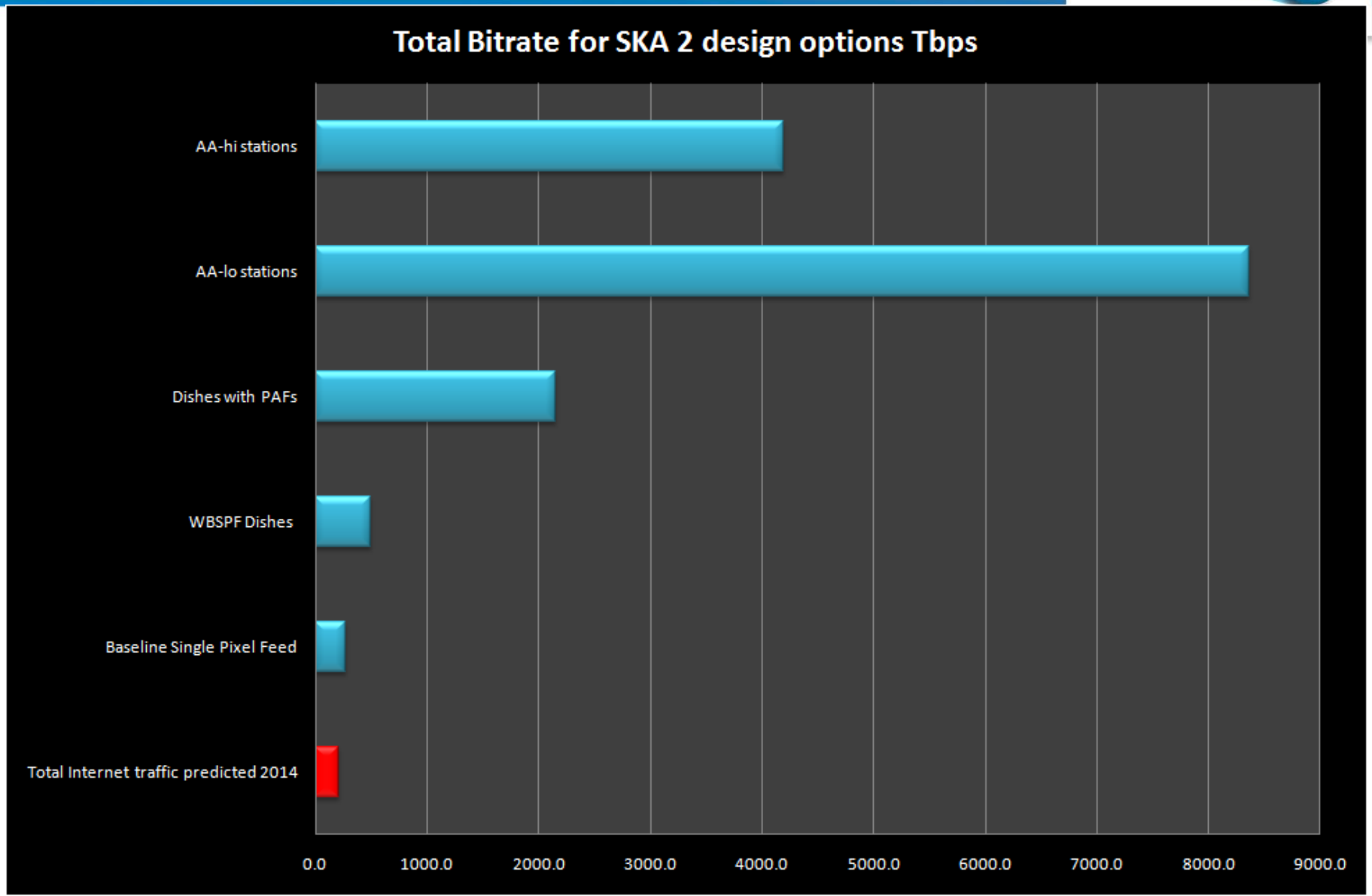


Collecting area will be concentrated in an inner 2.5 km radius. With Outer stations, over 3,000km from the core.

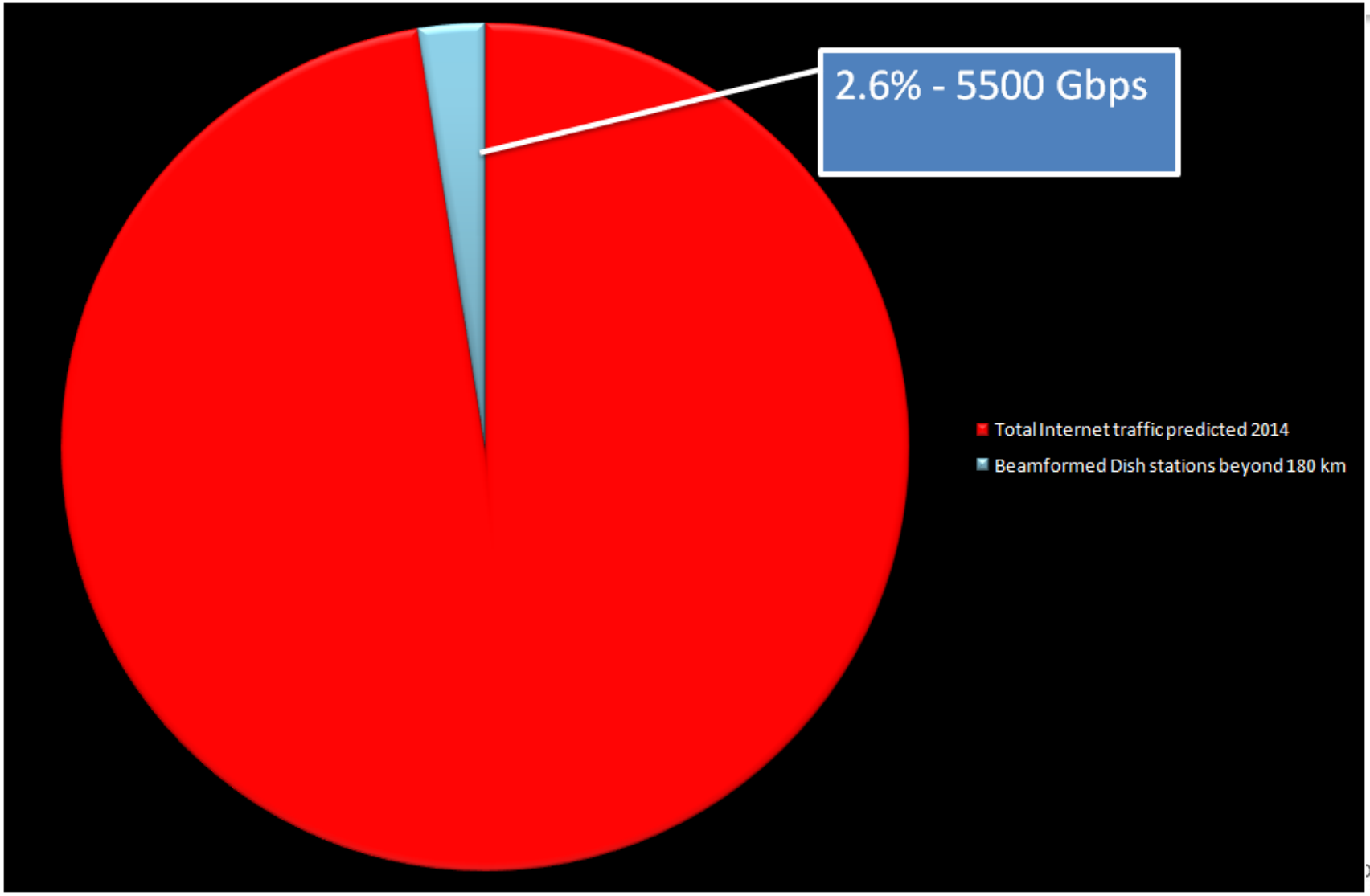
Signal Transport & Networks for the SKA

Data Network	• For transporting astronomical signals to a central processing facility (CPF)
Timing Network	• For the distribution of local oscillator signals for clocks and down converters.
A Monitor & Control Network (M&C)	• Including comms and required redundancy
Connections from the HPC to the outside world	• For the distribution of imaging data to regional centres
High Volume, High Speed Interconnects	• Not fully defined but significant data centre style interconnects will be required

Data Network Requirements



Beamformed stations on long baselines



The nature of the SKA Data Transport networks

- A radio telescope can accept a lower availability than a commercial network.
- The data is not, in its own right, valuable.
- The network is deterministic.
  - That is to say the data always flows from one known location to another. The data rate and the routing remain constant.
- The data traffic is unidirectional
  - (this excludes, of course, the clock and M&C functions)

eVLBI

The nature of the SKA data transport requirements

- The data rates are large
- The network does not produce revenue.
- Timing is critical
- The removal of a dish, or station from a radio telescope array will not prevent observations from taking place.
- Observatory, station and dish system environment has particular and peculiar requirements

Lessons to be learnt from eVLBI

- Protocols
  - Transport of large datasets
  - Applicable metadata
- Recording and streaming data
  - I/O considerations & techniques
- Operating widely spaced antenna
  - Timing
  - Control
- Technical demonstrator

Lessons to be learnt from eVLBI

- Standardisation across institutions
  - Interfaces
  - Equipment
  - Language & Definitions
- Use of commercial networks & NRENS
  - Operational models
  - Technical Challenges
- Other ...

What is different?

SKA	eVLBI
Always on production traffic	Experimental 'best efforts' service
Exceeding capacity of existing networks	Stress testing capacity of existing networks
SKA billed for service?	"free" to the user in many cases
Could utilise existing NREN or might not ...	Utilising existing NREN networks.*(Facilitated by DANTE in Europe)*

Conclusions

- SKA is a large and exciting project
- Conduct transformational science
- SKA2 signal transport & networks represents the biggest (and most exciting!) network in science.
- The eVLBI community has a lot to contribute in experience and techniques
- SKA is like eVLBI, but it is not the same as eVLBI

Engaging with the project

- International groups of collaborators
- System engineering approach
- Central Project Office – SPDO UMAN >> SPO based at Jodrell Bank, UK.
- Domain Specialist – mccool@skatelescope.org
- Industrial liaison officer – crosby@skatelescope.org
- http://www.ska2011.org

Questions