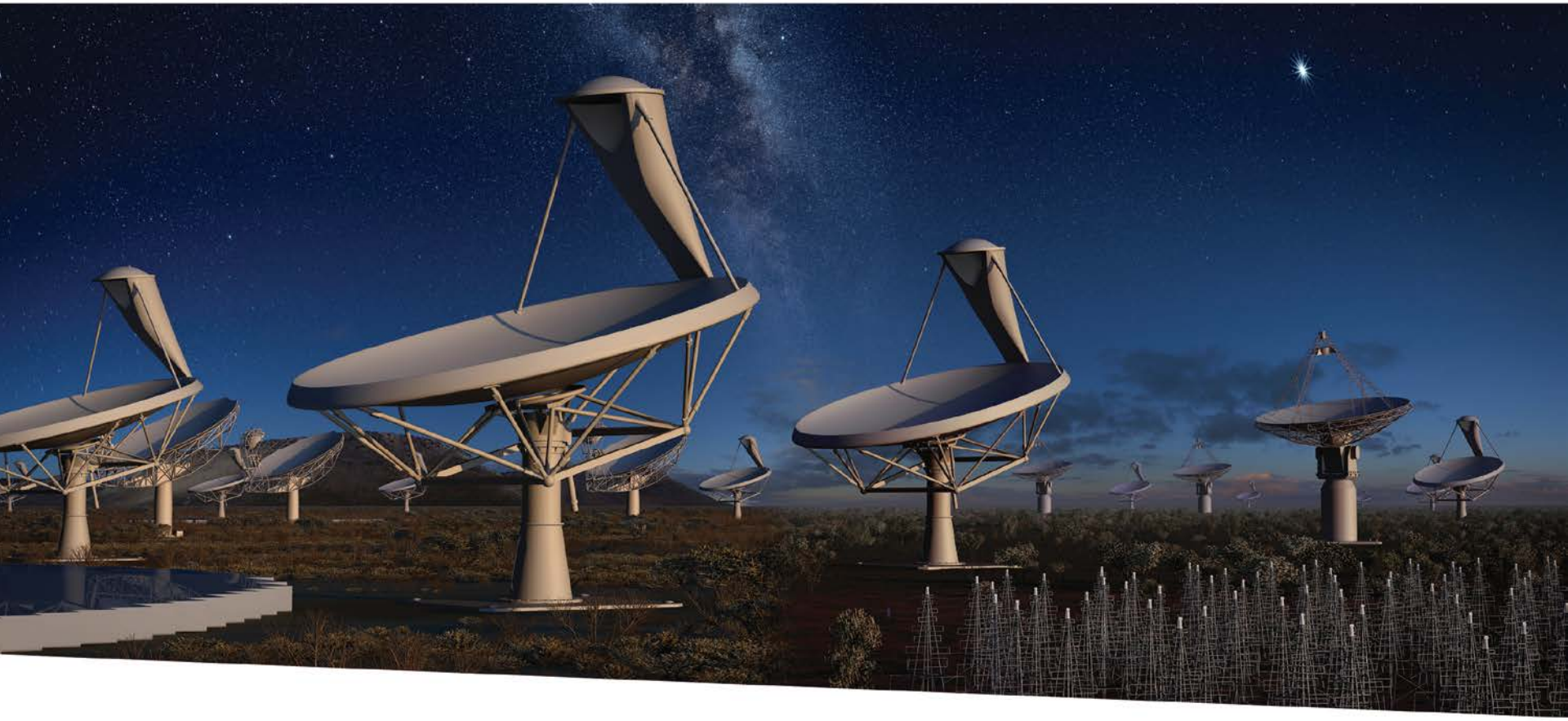
The Square Kilometre Array



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Miles Deegan

Project Manager, Science Data Processor & Telescope Manager

The Square Kilometre Array (SKA)

The SKA is a next-generation radio interferometer:

- 3 telescopes, on 2 sites
- Collecting area > 5 km^2 on baselines up to 3000 km
- Frequency range 50MHz - 14GHz
- Expected cost: >1.5 billion Euros

Compared to current instruments, SKA will be:

- ~100x more sensitive
- ~10^6x faster surveying the sky

Major ICT project

- Distributed Research Infrastructure on ESFRI Roadmap
- Implementation support - INFRA

SKA Phase 1

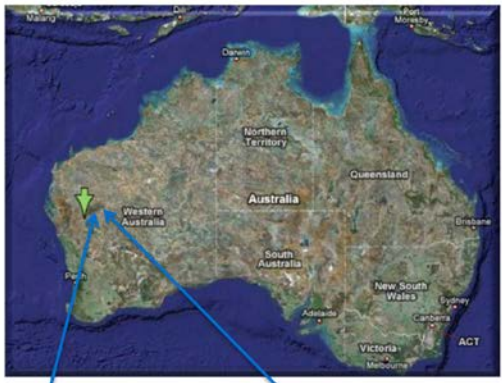
SKA Phase-1 is the first phase of the SKA project:

- builds on technologies of “precursors”, ASKAP, MeerKAT & MWA, along with “pathfinders” such as LOFAR, eMERLIN, eEVN
- construction 2018-2022
- first science ~2020
- fixed budget: €650M

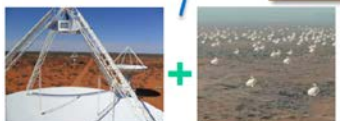
Baseline design:

- 3 telescopes, 2 sites
  - SKA1-Mid (South Africa)
  - SKA1-Low (Australia)
  - SKA1-Survey (Australia)
- 50MHz - 3GHz
- £100M UK commitment
  - UK role ~18-19%

SKA1-Mid: ~190 15m dishes + MeerKAT (~64 dishes)



SKA1-Low: ~250,000 low-freq antennas in ~900 stations of 35m diam.



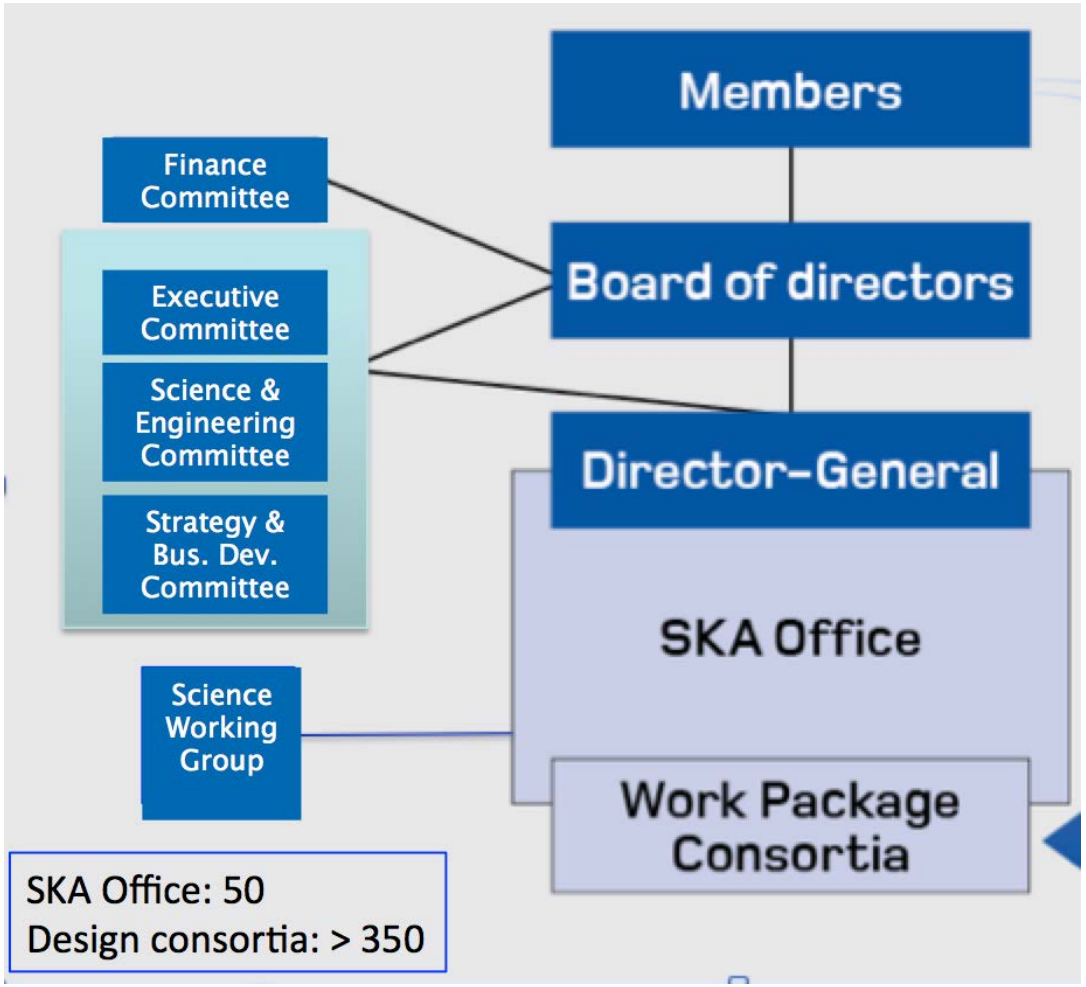
SKA1-Survey: ~60 15m dishes + ASKAP (36)

SKA Science

SKA will tackle a wide range of science:

- Neutral hydrogen in the universe from cosmic dawn until now
- Evolution of galaxies
  - Active Galactic Nuclei
  - dark matter; dark energy
- Star formation and the cradle of life
  - Protoplanetary disks, organic molecules, SETI
- Fundamental forces:
  - pulsars, general relativity, gravitational waves
- Origin and evolution of cosmic magnetism
- Transients: new phenomena

Global SKA Structures



Current country members:

- Australia
- Canada
- China
- Germany (until 06/15)
- India
- Italy
- Netherlands
- New Zealand
- South Africa
- Sweden
- UK
- Others joining soon…

SKA project office for current development phase is at Jodrell Bank.
Location of project office for operations phase to be decided in 2015.

Work packages

- Led by SKA Office
  - Management
  - Science
  - System Design and system engineering
  - Maintenance & Support and Operations
- Carried out by Work Package Consortia (11 work packages)
  - Dish Array
  - Aperture Arrays
  - Signal and Data Transport (including synchronisation and timing)
  - Central Signal Processor
  - Science Data Processor
  - Telescope Manager
  - Infrastructure, including power
  - Assembly, Integration and Verification
  - Advanced Instrumentation Programmes
    - Mid Frequency Aperture Array
    - Wide Band Single Pixel Feeds

Pre-Construction Phase

2013 2017 2021

Preparatory Phase (PrepSKA)	Preconstruction Phase	SKA1 Construction	SKA1 Operations	SKA2 Operations
			SKA2 Construction	

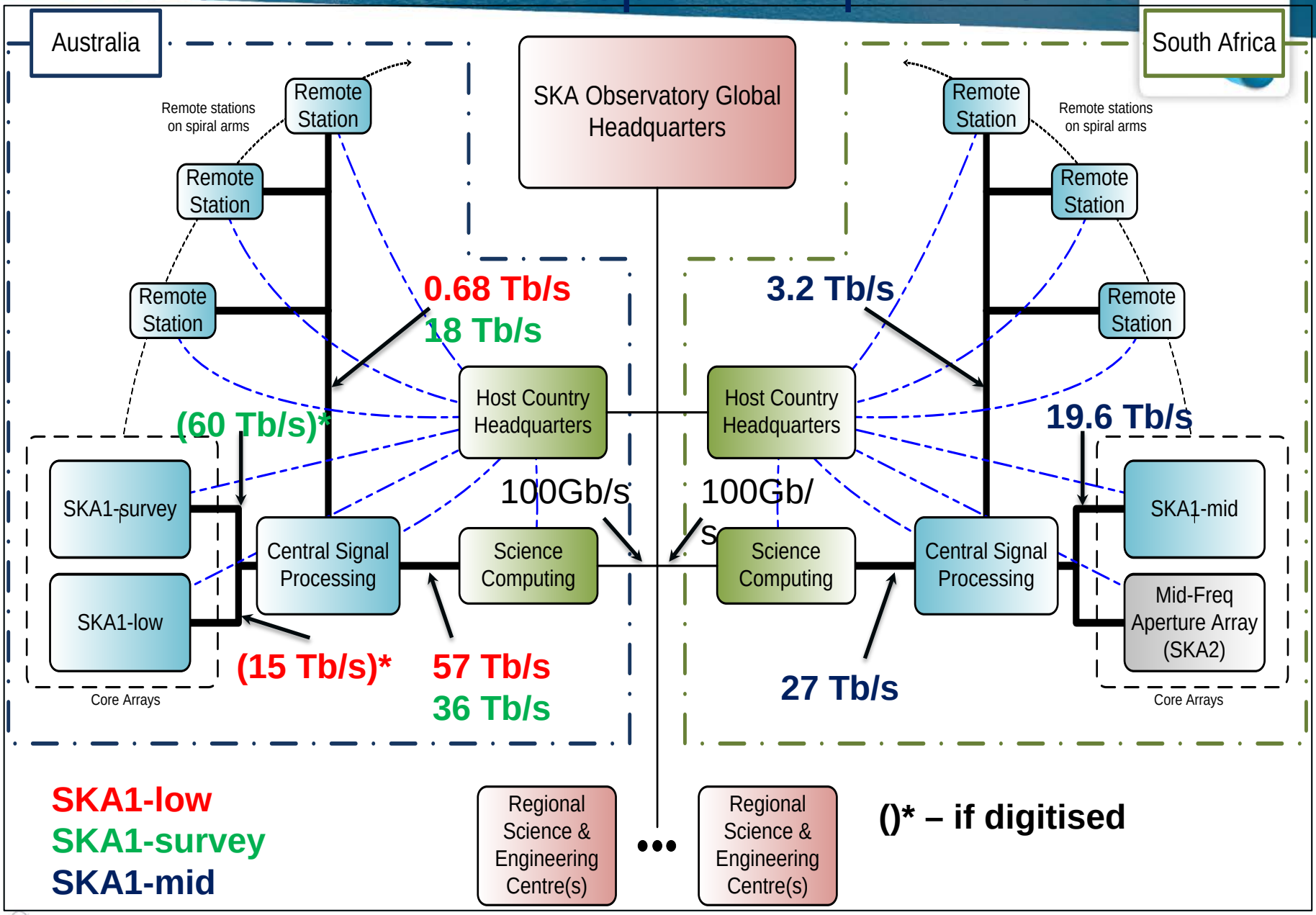
- Move the project through preliminary design to completion of detail design (CDR)
- SKA Office responsible for the system
- All the work at the Element level (major subsystems) will be ‘subcontracted’ to consortia
- Agreements made with Consortia late 2013
- T0 for Pre-Construction passed

2014-15 Workplan

- Develop Designs
- Complete Supporting Documentation
- Re-baselining Exercise
- Preliminary Design Reviews
- Cost Review
- Systems Review
- then sort out the mess!

SKA and e-Infrastructure

SKA Data Transport Requirements



SKA is a BIG data project

- Bleeding edge of e-Infrastructure
- This animation illustrates why…
- Tackling such a big data project will hopefully lead to technological/economic impact
  - Another Wi-Fi perhaps?

Towards Exascale: Science Data Processor Consortium

Led by Cambridge University

- Project Leader is Professor Paul Alexander

– 250+ individuals
– 14 full partners
– 3 associate partners
– 9 countries

- Canada – New Zealand (conference calls a challenge)

– Regional and national supercomputing centres

- Juelich, Barcelona, STFC

– Potential new partners in the pipeline
– IT vendors

SDP Requirements

- Take correlator/beamformer outputs and produce calibrated science data products
  - The stuff that astronomers will then further analyse to produce the science
- Architecture and cost
  - Understand pipeline algorithms, software development effort, hardware choices and data centre requirements
    - A lot can be learned from HPC, Cloud, Web 2.0 and big data developments
    - There will be areas of overlap and collaboration with other HEC initiatives
  - All within cost-cap, power and environmental constraints imposed by the three telescopes
  - Non-trivial!

	Processing Sustained Pflops	Ingest GB/s	Use Cases GB/s
LFAA	50	7200	245
Survey	180	4300	995
Mid	250	3300	255

Power – a big constraint

- A major problem for HPC in the coming years
  - SKA no exception
- Estimated Telescope power consumption approximate, excl. SDP -2MW(SA), 3.5MW(AUS):
  - SKA1_Mid: 5.5 MW
  - SKA1_Survey: 1.6 MW
  - SKA1_Low: 4.7 MW
- Power supply options
  - SA: ESKOM grid using existing infrastructure (power limited)
  - Aus:
    - Diesel generation: low capital cost, high power tariff
    - Gas (LNG) or grid: Very high capital cost, low power tariff
  - Advances in solar could help

Risks

- Managing Distributed Consortia – in-kind contributions
- Management and coordination of a consortium structured this way is a challenge
  - Recruitment lag after funding has been acquired does not help either but has to be dealt with
- Need to keep personnel focused on the engineering task at hand, not blue skies thinking
  - Work within current baseline design, WBS, SoW, etc.
  - Detailed, timely reporting and scheduling
  - Risk registers and management
- Design within Cost Cap
- Management of a project like this is primarily about risk management
  - Technology risk too – TRLs and maturity concerns

SKA2: Issues Driving Development

- Dishes, feeds, receivers (N=250 → 2500)
- Low and mid aperture arrays (n=250k → 1000k)
- Signal transport (10 petabit/s)
- Signal processing (exa-MACs)
- Software engineering and algorithm development
- High performance computing (exa-flop capability)
- Data storage (exa-byte capacity)
- (Distributed) power requirements (10 → 50MW)

Current Status

- March 2013: Baseline Design published
- July 2013: €650M Cost-cap established
- Nov 2013: design consortia kick-off
- Sept 13 – Jan 14: 8 Science Assessment Workshops
- March 2014: UK Science Minister announces £100M commitment for construction/early ops
- June 2014: #skascicon14
- Sept/Oct 2014: all-hands engineering meeting, Fremantle, WA
  - 300 attendees
- Nov 2014 onwards: Element Preliminary Design Reviews
- Oct 2014 – Feb 2015: Re-baselining
- March 2015: Board approves updated Baseline Design

Any questions?

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