ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

SKA Project

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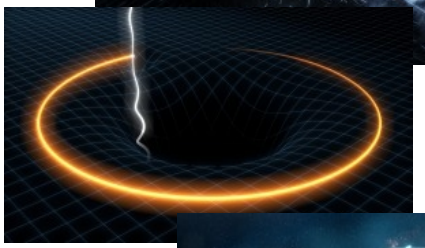
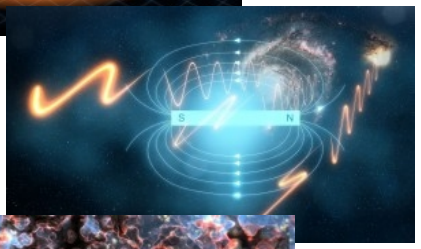
in behalf of
SKA – IT Team

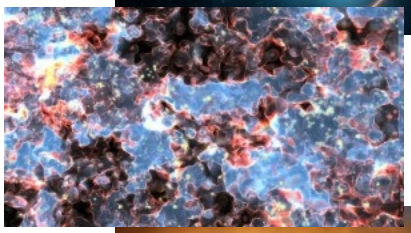
SKA Science

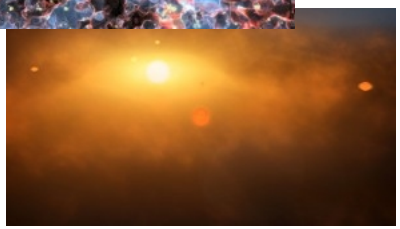
The SKA aims to solve some of the biggest questions in the field of astronomy.

The unprecedented sensitivity of the thousands of individual radio receivers, combining to create the world's largest radio telescope will give astronomers insight into the









- **Cosmology, dark energy**

  (the acceleration in the expansion of the Universe has been attributed to a mysterious dark energy.

  The SKA will investigate this expansion after the Big Bang by mapping the cosmic distribution of hydrogen)

- **Formation and evolution of the first stars and galaxies after the Big Bang**

  (SKA will look back to the Dark Ages to discover how the earliest black holes and stars were formed)

- **Cosmic magnetism**

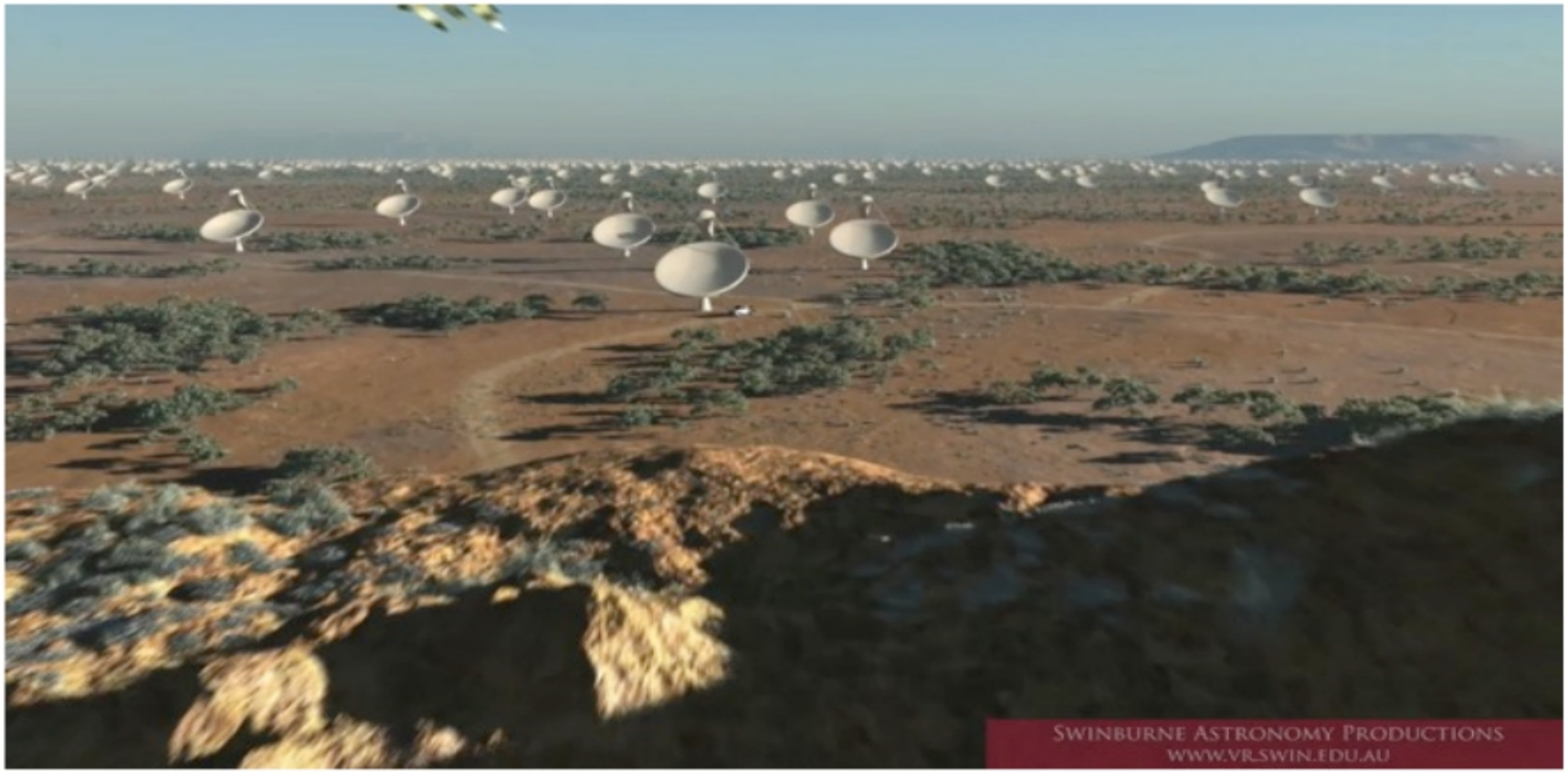
  SKA will create three-dimensional maps of cosmic magnets to understand how they stabilize galaxies, influence the formation of stars and planets, and regulate solar and stellar activity)

- **Nature of gravity**

  (Strong field tests of gravity using Pulsars and black-holes: the collapsed spinning cores of dead stars will be monitored to search for gravitational waves and to test general relativity in extreme conditions, like close to black holes)

- **Life beyond Earth**

  (detect very weak extraterrestrial signals and will search for complex molecules, the building blocks of life, in space)



- 2020 era radio telescope
- Very large collecting area (km^2)
- Very large field of view
- Wide frequency range (70MHz - 25 GHz)
- Large physical extent (3000+ km)

- International project
- Telescope sited in Australia and/or South Africa
- Headquarters at Jodrell Bank, UK
- Multiple pathfinders and precursors now being built around the world

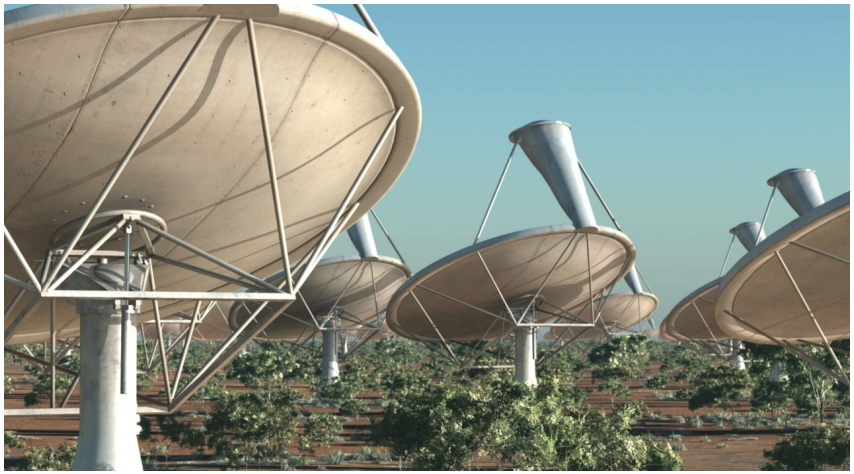
SKA Technology

Two types of radio telescopes will be used by the SKA to provide continuous frequency coverage from 50 MHz (6 m wavelength) to 20 GHz (1.5 cm wavelength):

- **Dishes (surveys)**

  15m diam. / hundred

  - imaging dynamic range
  - Design for mass manufacture
  - Low operating cost per dish
  - Rapid installation with minimum manpower and equipment
  - Feed flexibility
  - Maximum sensitivity per dish



- **low frequency aperture arrays**

  several thousand

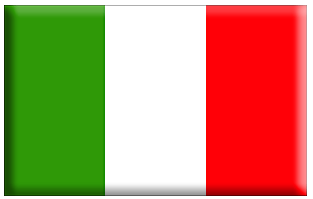
  An aperture array is a large number of small, fixed antenna elements coupled to appropriate receiver systems which can be arranged in a regular or random pattern on the ground. A signal “beam” is formed and steered by combining all the received signals after appropriate time delays have been introduced to align the phases of the signals coming from a particular direction.

SKA pre-construction program

1. SKA.SCI Project Science
2. SKA.OPS Site Operations
3. SKA.SCIOPS Science Operations
4. SKA.TEL Telescope

SKA WBS - Level 2

1. SKA.TEL.OFF SKA Office
2. SKA.TEL.SE System Engineering
3. SKA.TEL.DSH Dish
4. SKA.TEL.LFAA Low Frequency array
5. SKA.TEL.SADT Signal and data transport
6. SKA.TEL.CSP Central signal processor
7. SKA.TEL.SDP Science Data Processor
8. **SKA.TEL.MGR Telescope Manager**
9. SKA.TEL.INFRA Infrastructure
10. SKA.TEL.AIV Assembly Integration and Verification
11. SKA.TEL.WBSPF Wideband single pixel feeds

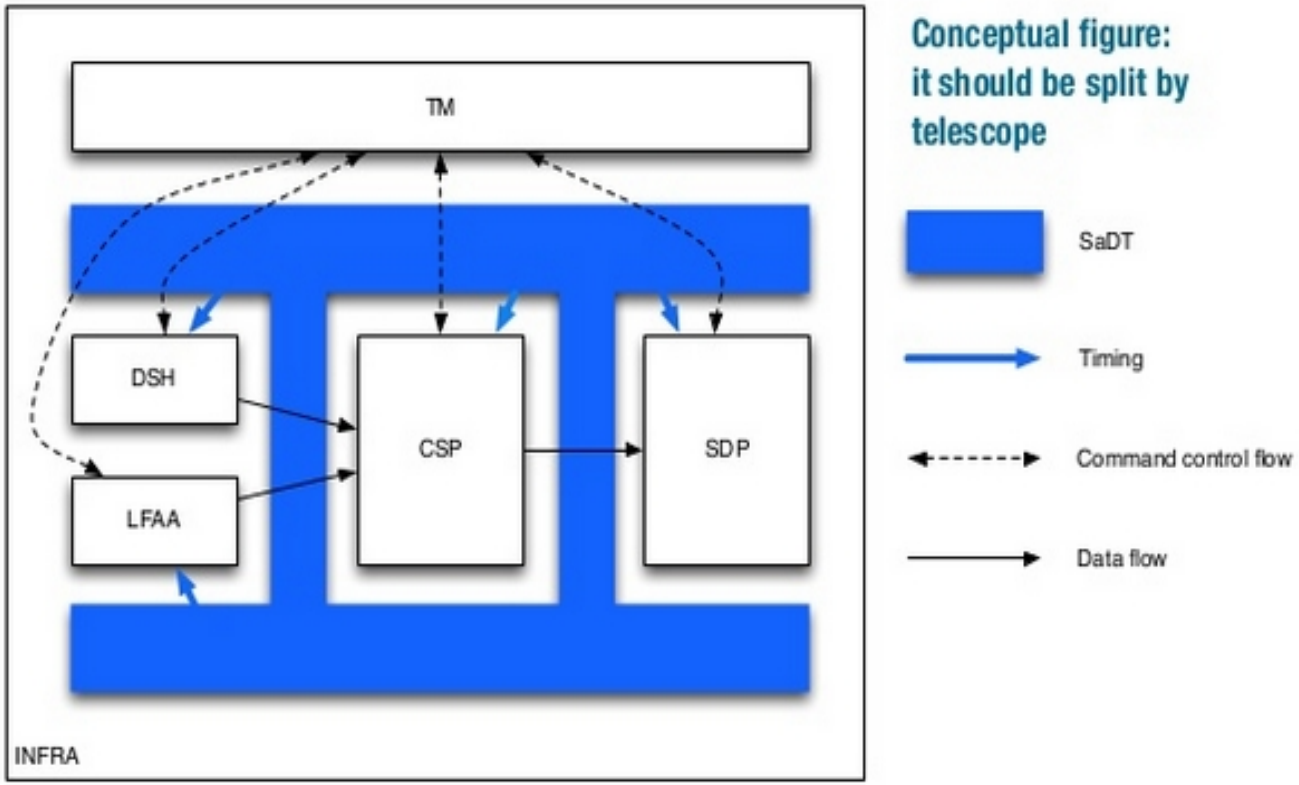




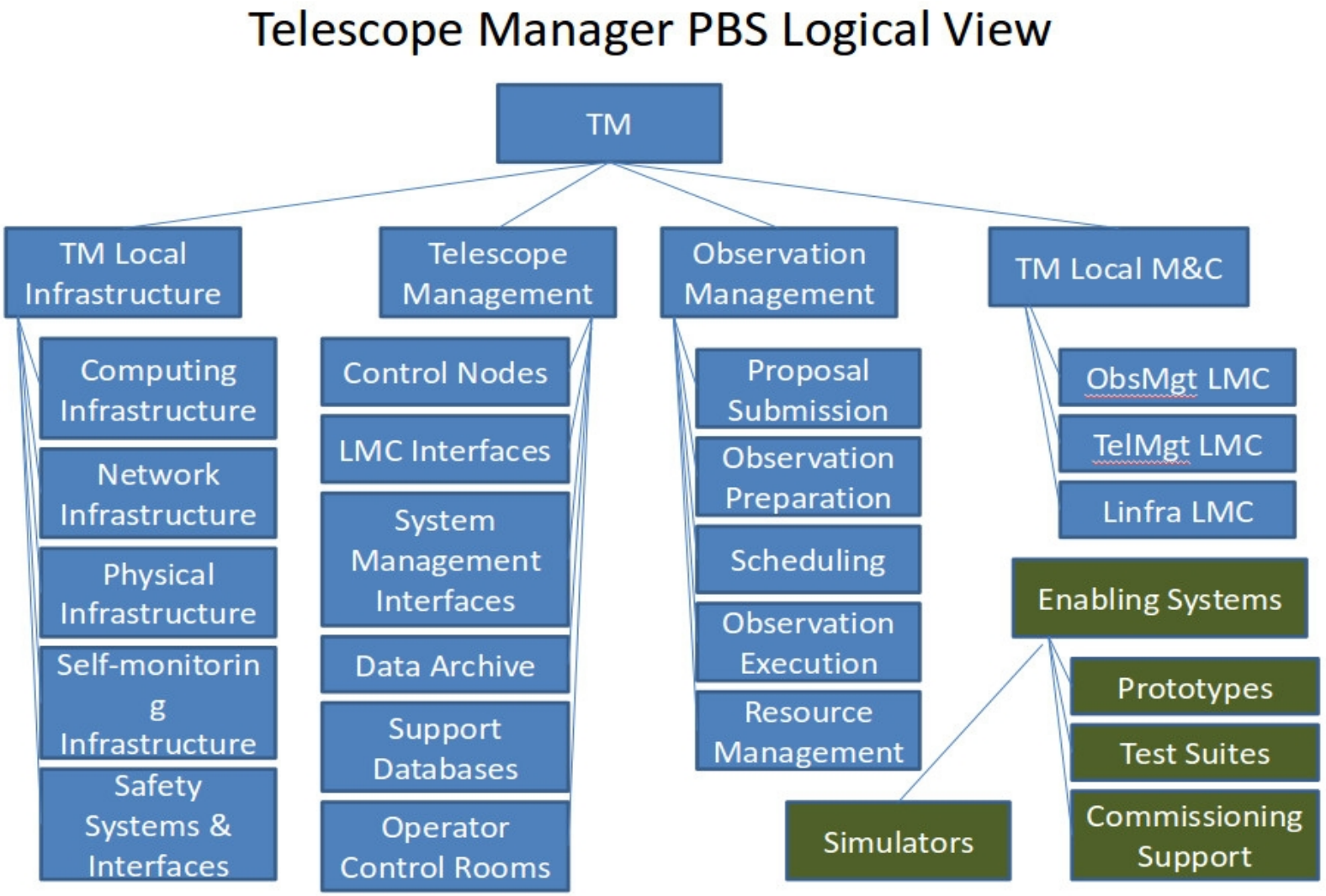


SKA - ELEMENTS

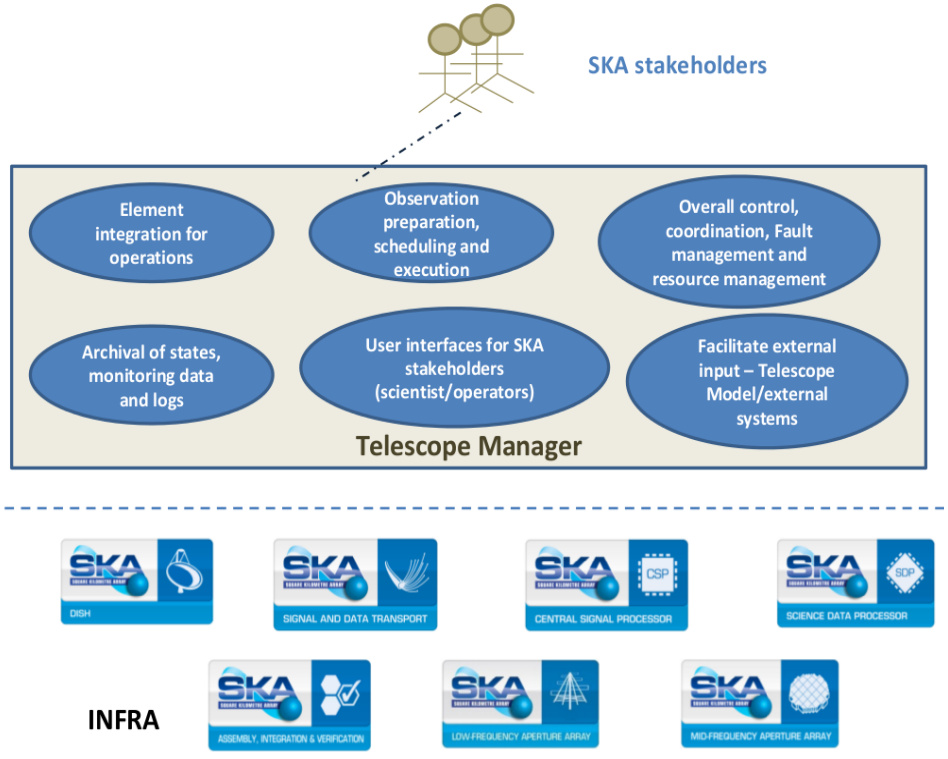
SKA - Elements Interfaces

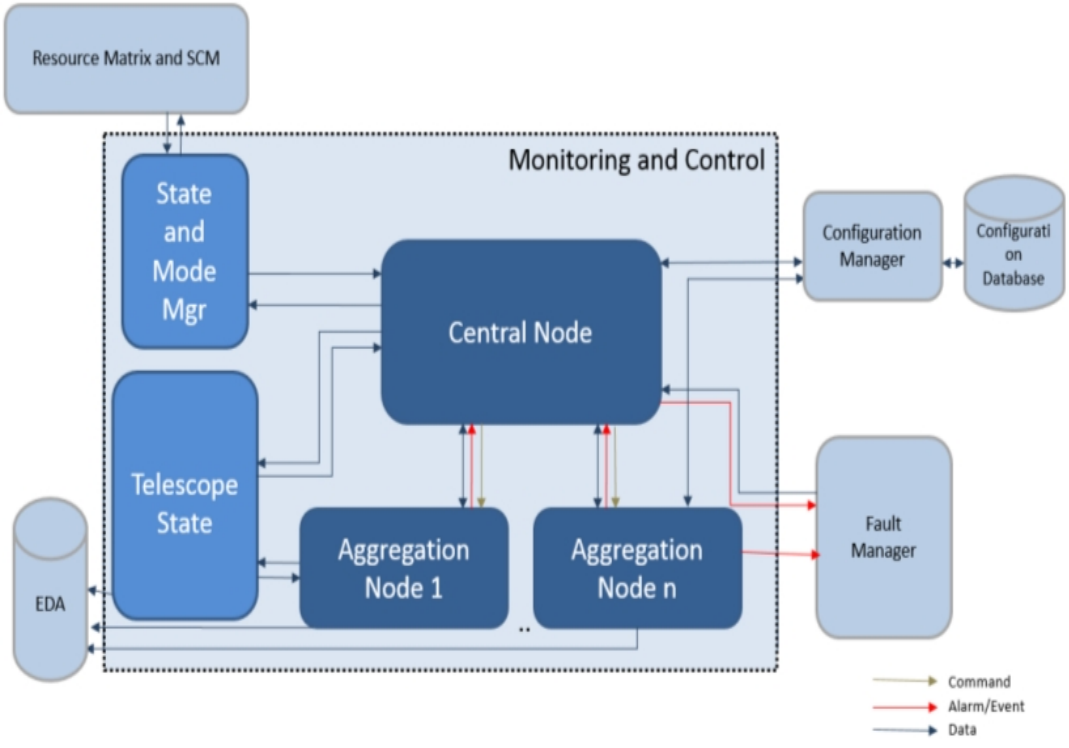


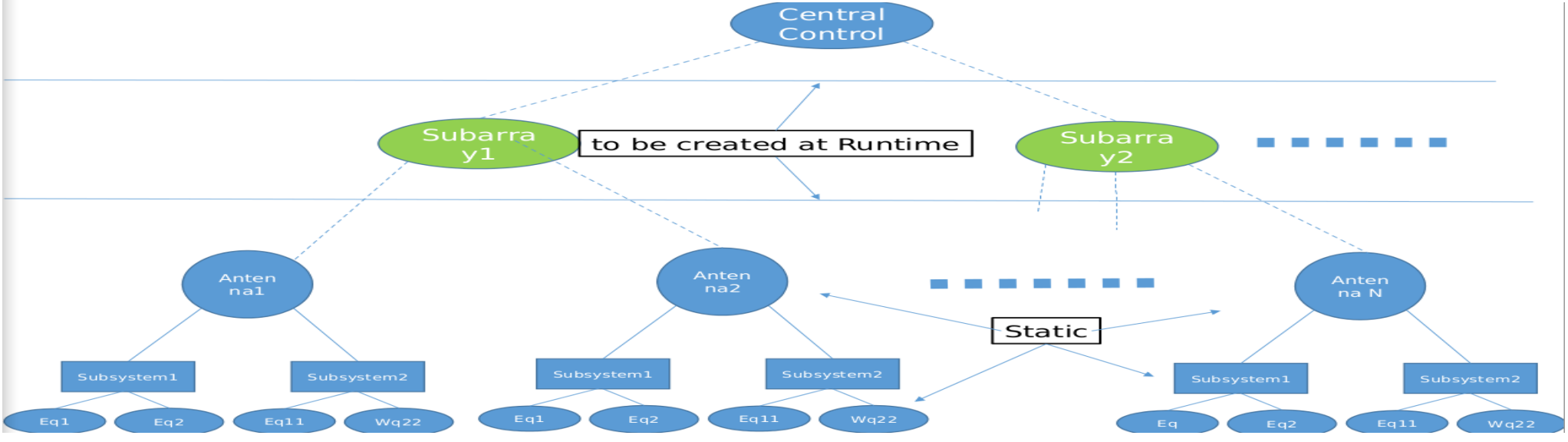
SKA TM Level 3 PBS



SKA TM Telescope Management







SKA TM Local Monitoring and Control

Local monitoring and control includes all software and hardware that are required to support the operation of the telescope manager system in a distributed environment. This includes dedicated software that monitors the performance of the system and ensures that remote diagnostics can be performed.

Duties:

- activation (o re-activation, e.g. after a forced shut-down)
- initialization
- monitoring health of TM: hw, processes, communications
- detection of problems (fault conditions), alarms handling
- failure diagnostics
- control health of TM: hw, sw and communications
- software and firmware upgrade
- shut-down of the system

Additional "special" features:

- avoiding common point failures with TM
- interacting with external operators in case of TM failure
- keeping alive communication with SKA Elements while recovering TM after a failure – acting as a "degraded performance TM"

SKA – CSP LMC

- Dishes
  - Depends on feeds, but illustrate by 2 GHz bandwidth at 8-bits
  - **64 Gb/s from each dish**
- For Phased Array feeds increased by number of beams (~20)
  - **~ 1 Tb/s**
- For Low frequency Aperture Arrays :
  - Bandwidth is 380 MHz
  - **240 Gb/s**
- These are from each collector into the correlator or beam former
  - **2700 dishes**
  - **~ 600 Tb/s**

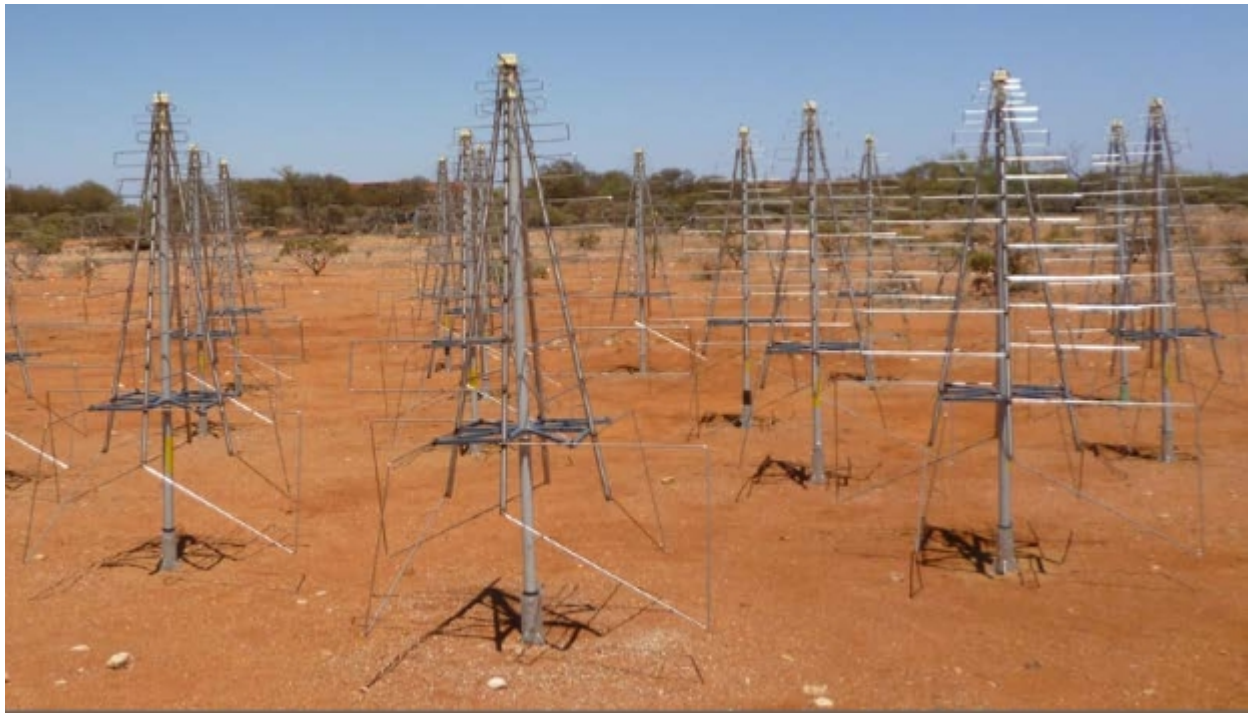
SKA computational requirements CSP LMC

- SKA correlator in case of Pulsar search (PPS):
  - data rate of the pulsar search engine is expected to reach 0.6TeraSamples/sec (1sample = 4*8 bit)
  - SKA Pulsar Search input is approximately **1PetaBytes** on each cycle of observation which lasts up to 600s
  - It is expected to observe in pulsar surveys for 1 day → **144 PB** of raw data
  - No possibility to handle with this amount: from 1 PB raw → some hundreds MB of correlated data for each cycle → **14 TB/day**
  - Particular case of massive objects:pipeline performances required → **10 PetaOps/s** for acceleration process

SKA SAT LMC

- Part of Signal and Data Transport (SaDT) Element
- NCRA-India and University of Manchester-UK jointly working.
- Monitors and Controls the Synchronization and Timing (SAT) system (UTC accuracy of 10ns over 10 years, Frequency drift of less than 10ns / day).
- Orchestrates the working of the SAT system between Clocks (containing Masers) and Time and Frequency Distribution sub-systems distributed across the telescope site.
- Monitors approximately 1500 monitoring points
- Software a major component and not Hardware

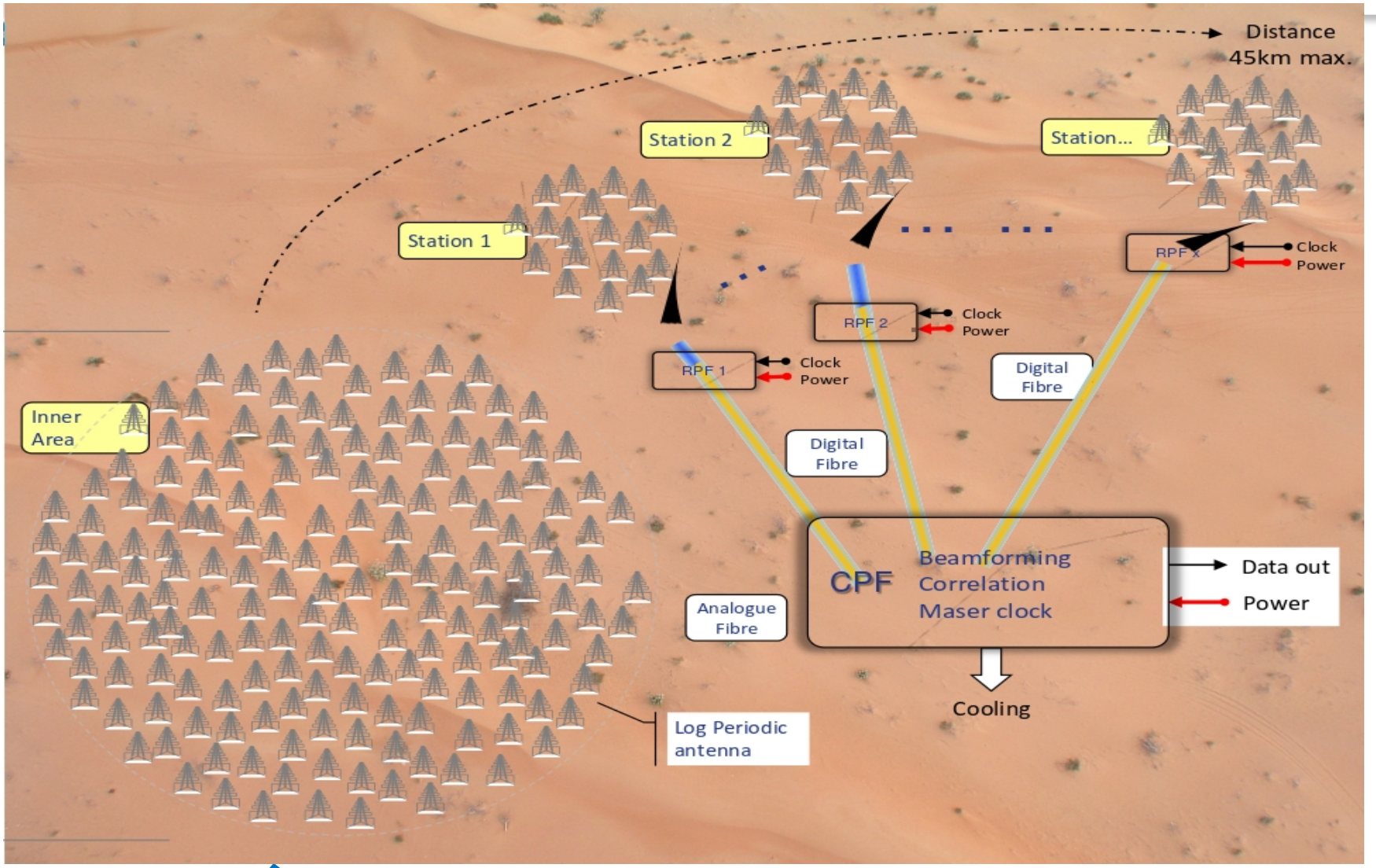
SKA LFAA LMC



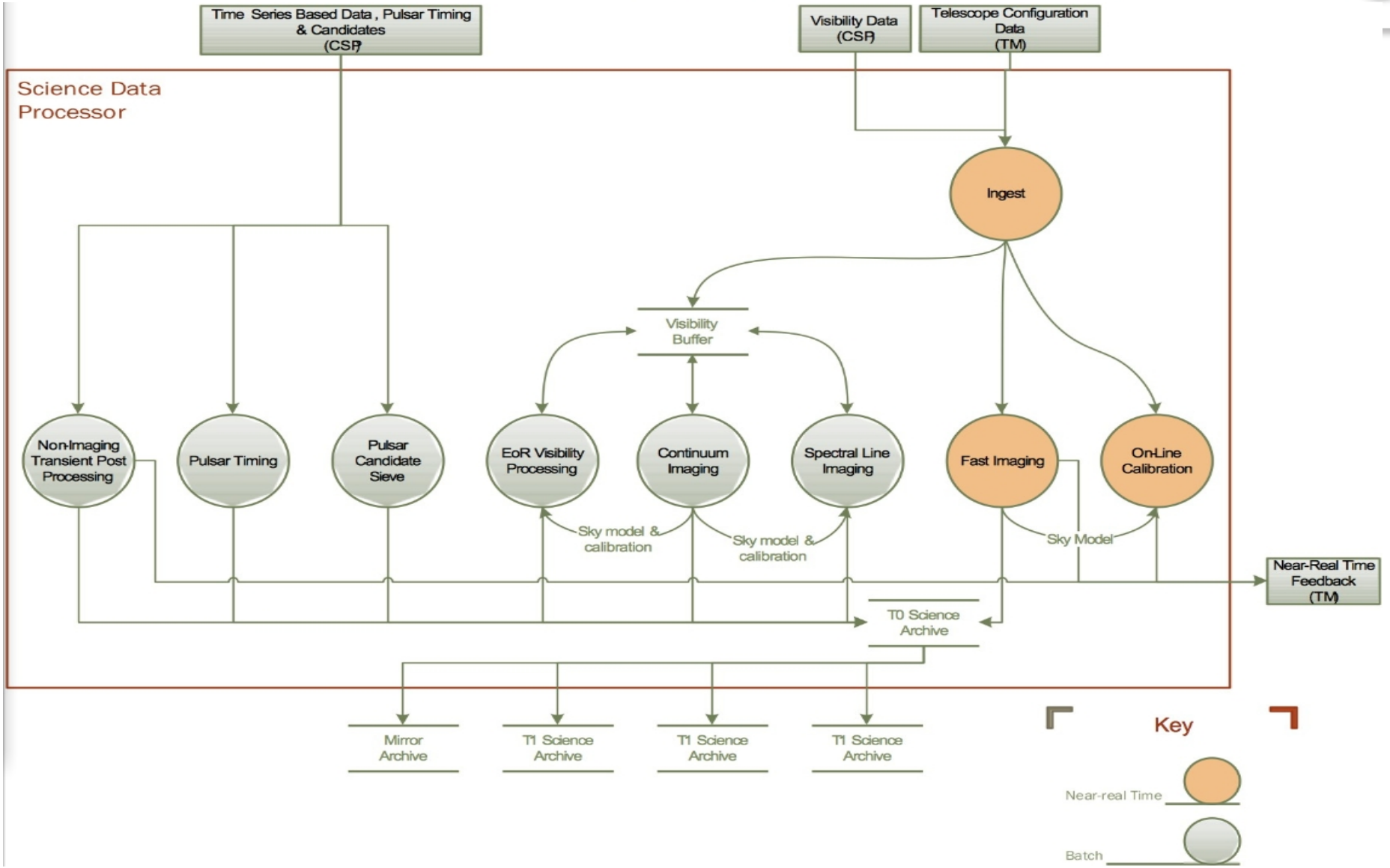
Frequency:	50MHz – 350MHz
Bandwidth:	300MHz
Sensitivity :	500m^2/K (110–350MHz)
Polarisation:	Dual (of good quality)
Beam size:	>5° (no beam stitching)
Stations:	512

Scan angle:	>45°
# of beams:	>5
Configuration: (TBC)	50% <600m radius 75% <1km radius 95% <3km radius 3 spiral arms of 40km
Data rate:	~7.5Tb/s (total)

SKA LFAA LMC


Distance
45km max.
Station 2
Station...
Station 1
RPF x
Clock
Power
RPF 2
Clock
Power
RPF 1
Clock
Power
Digital
Fibre
Inner
Area
Digital
Fibre
CPF
Beamforming
Correlation
Maser clock
Data out
Power
Analogue
Fibre
Cooling
Log Periodic
antenna

SKA SDP LMC


Time Series Based Data , Pulsar Timing & Candidates (CSP)
Visibility Data (CSP)
Telescope Configuration Data (TM)
Science Data Processor
Ingest
Visibility Buffer
Non-Imaging Transient Post Processing
Pulsar Timing
Pulsar Candidate Sieve
EoR Visibility Processing
Continuum Imaging
Spectral Line Imaging
Fast Imaging
On-Line Calibration
Sky model & calibration
Sky model & calibration
Sky Model
Near-Real Time Feedback (TM)
T0 Science Archive
Mirror Archive
T1 Science Archive
T1 Science Archive
T1 Science Archive
Key
Near-real Time
Batch

SKA LMCs – Common Framework

Since the huge amount of devices to control and monitor, LMC of the different sub-systems should have a “common framework” in order to simplify the complexity of interfacing them. A set of well known and mature solutions were investigated. They are all based on the concept of distributed control system.

During the three days LMC common framework meeting held in Trieste on 20th – 22nd of March 2015

TANGO was chosen!

Thank you for your attention!