Industrial Commissioning of the SKA: Learning from the ALMA, EVLA and MeerKAT Experiences

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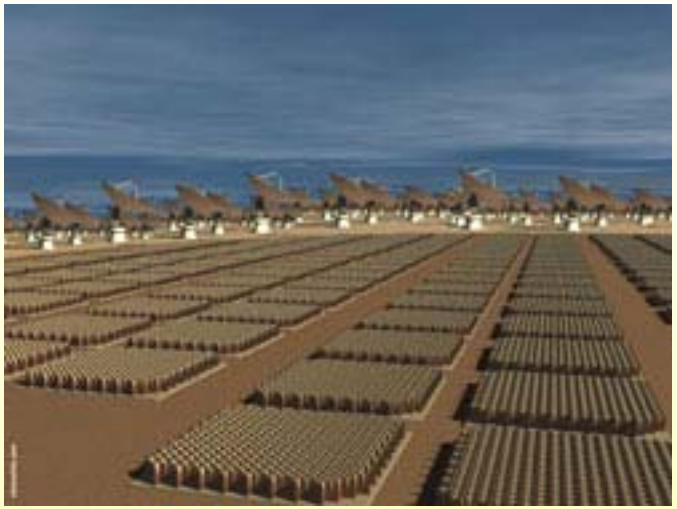
Commissioning the SKA

The Commissioning Challenge

- Four separate array/feed configurations under consideration each with different commissioning requirements and staged, but interdependent construction:
  - Aperture Arrays (AAs):
    - Sparse Aperture, 70 - 300 MHz
    - Dense Aperture, 300 - 700 MHz
  - Dish+Phased Array Feed (PAF), ~ 500 MHz - 3 GHz, large surveys
  - Dishes+Wide Band Feed (WBF) arrays, 500 MHz - 35 GHz



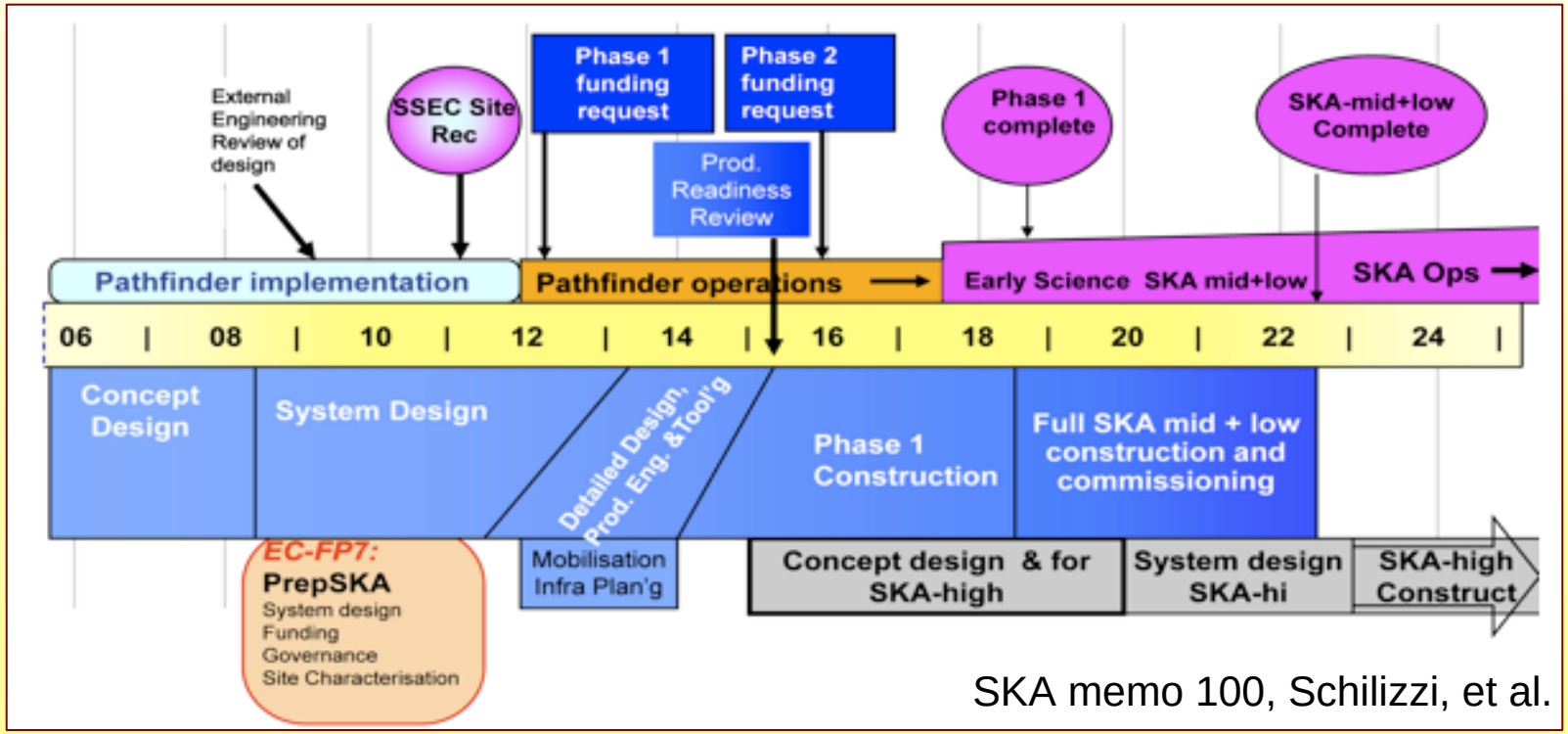
15/11/07 (v2.3)		First Stage		Full SKA			
Parameter		**Phase 1** ***Mid-band*** *– inc. dense AA*		**Phase 2 scenarios** ***Low & mid-bands*** *– all inc. AAs to 500MHz*			**Phase 3** ***High band***
		WBF only	**WBF+PAF***	**WBF only**	**WBF+PAF***	**WBF+dense AA**	
Frequency Range:	Low	500 MHz	500 MHz	70 MHz	70 MHz	70 MHz	10 GHz
	High	10 GHz	10 GHz	10 GHz	10 GHz	10 GHz	35 GHz

Commissioning the SKA

- **Separate** hardware, software & operations, e.g.:
  - Antennas, backend/RF hardware (signal chain), correlators (?)
  - Antenna Control & monitoring, post-processing software components
  - Environment (RFI, atmospheric response)
  - Maintenance tasks, LRUs
  - Commissioning problems can be very different
  - Sub-array operations, pipeline process control
- **Shared** infrastructure, software and operations, e.g.:
  - Fibre routing & patch panels, data transfer, archive, computing hardware, correlator
  - Operations interface, array scheduling software
  - Distributed cooling & power, control & correlator buildings, water, communications links
  - Post-processing software infrastructure & pipeline operations
  - Maintenance management and personnel

Commissioning the SKA

- SKA Phase I antenna roll-out (2013-2018)
  - If infrastructure completed by 2014, assume 300-400 dishes with at least 90% rolled out in last 3 years (2016-2018). *One dish commissioned every 3 days.*



SKA memo 100, Schilizzi, et al.

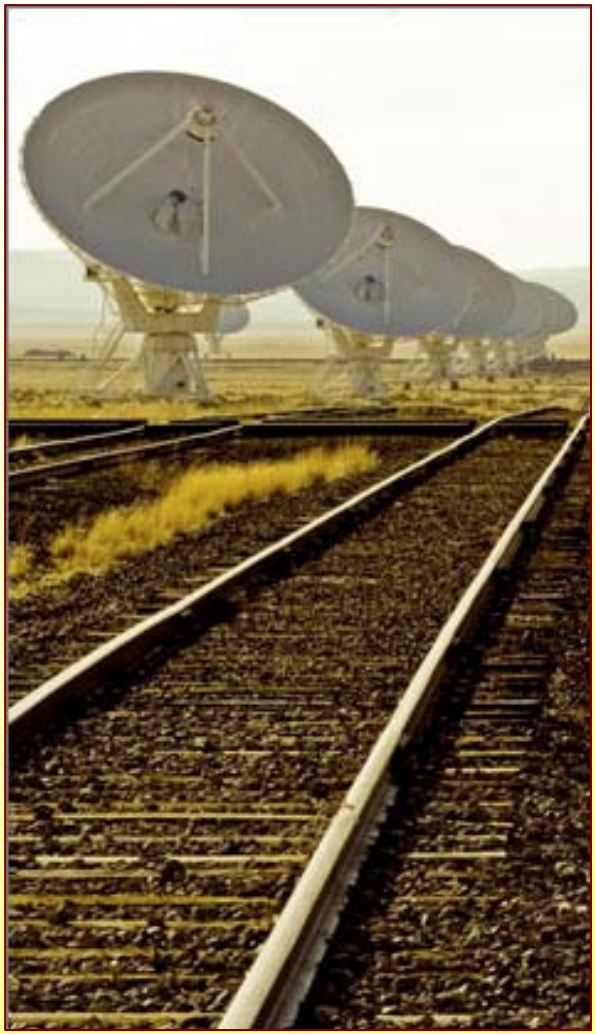
What can help to get ready for this process?

- EVLA - Expanded Very Large Array, 1-50 GHz
  - Mechanical retrofit of 28 antennas, 8 new receivers, new infrastructure (fiber optics, correlator room, power plant improvements), new WIDAR correlator, some new software (e.g. correlator controller, operator interface, post-processing)
  - ~ 0.5 antennas commissioned/months, individual attention
- ALMA - Atacama Large Millimeter Array, 30 - 950 GHz
  - 66 antennas: 50-12m dishes, 12-7m dishes & 4 single dishes
  - Infrastructure, receivers, and correlator built at the same time as antennas. All new software (control, operator interface, archive, obs-prep, post-processing)
  - ~ 1 antenna commissioned/month
- MeerKAT - Karoo Array Telescope
  - 80 antennas, about 1% of the collecting area of SKA. New infrastructure, receivers, expandable correlator, software.
  - ~ 3.5 antennas commissioned/month, focus on industrial commissioning methods

Commissioning Scope for SKA

- Commission a major instrument: 24hrs/day with turno shifts
  4 full shifts of people = 1 'team'
  - Minimum team members: 1-2 astronomers, 1 SW developer, 1 systems engineer, 1 technician
  - 4 shifts = 20 person/'team' (vacation, etc…not included here)
- SKA 'scatter gun' approach has multiple technologies that must be commissioned in parallel, each requires separate 'teams' for:
  - Single antenna integration and commissioning
  - Ph I/II - dish WBF / PAF core & system (backend, correlator, operations software)
  - Ph I/II - dish WBF / PAF core evolving to first station deployment
  - Ph I/II - dense aperture array
  - Science Verification team - post processing, archive/VO, RFI excision, ionospheric modeling, early science results
  - Ph II - Sparse aperture Array
  - 20 people/team = 100 people (minimum)
- Not included: software development, maintenance, systems engineering, infrastructure, archive
- Add operations: effectively double number of people needed (more for multiple points of contact for user community)

EVLA - what we can learn



- Understand how to merge newly commissioned antennas into an existing array producing science.
- Large data rates and volumes
- Quantify issues limiting high dynamic range & fidelity
- Balance engineering, commissioning and operations priorities and resources.
- Dual operations: supporting an established user community (radio black-belts and novices) while commissioning antennas, sub-arrays and integrated functionality of the merged array.

Steve Myers' talk on Monday

ALMA - what we can learn

- Largest ground-based radio astronomy project
- International collaboration with multiple antenna contractors & distributed development
- Large data rates and volumes
- Quantify issues limiting high dynamic range & fidelity
- Distributed science operations and wide user-base
- Power and infrastructure challenges in remote site
- International commissioning team drawn from diverse member countries with different political motivations

See Jeff Kern's talk later this afternoon

MeerKAT - what we can learn

- Starting from scratch as an SKA precursor

  → develop procedures and infrastructure geared to solve anticipated SKA problems
- Scalability key design requirement (EVLA and ALMA have finite size, SKA can almost be considered to be infinite because it will be commissioned for so many years).
- Industrialized Commissioning:
  - Rapid commissioning model can be developed, honed and then lessons learned applied to SKA.

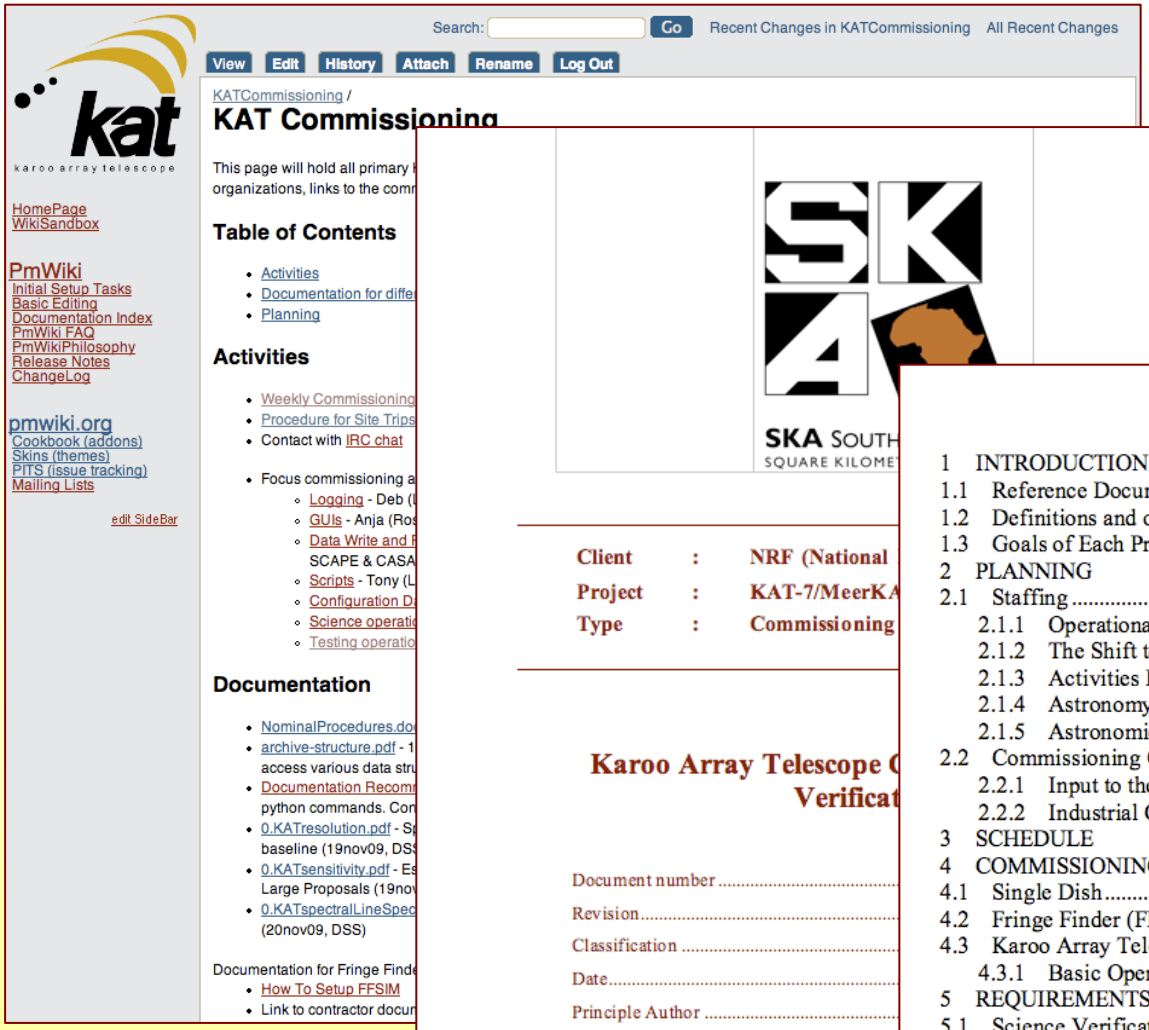
Industrialized Commissioning

- MeerKAT industrial commissioning model includes:
  - Heavy reliance on fully functional hardware and software delivered by contractors
  - Thorough verification by systems engineering and software teams before hand over to commissioning
  - High priority to document often repeated procedures.
  - Build verification procedures upon foundations of previous procedures (single dish → single baseline → antenna batches)
  - Multiple, parallel commissioning teams.
  - Shift to remote operations as soon as possible
  - Sustain test efficiency for years
  - Commissioning teams responsible for training the first operations personnel so there is a smooth transition between commissioning and operations activities.
- Commissioning model being vetted for KAT-7

KAT-7 Commissioning

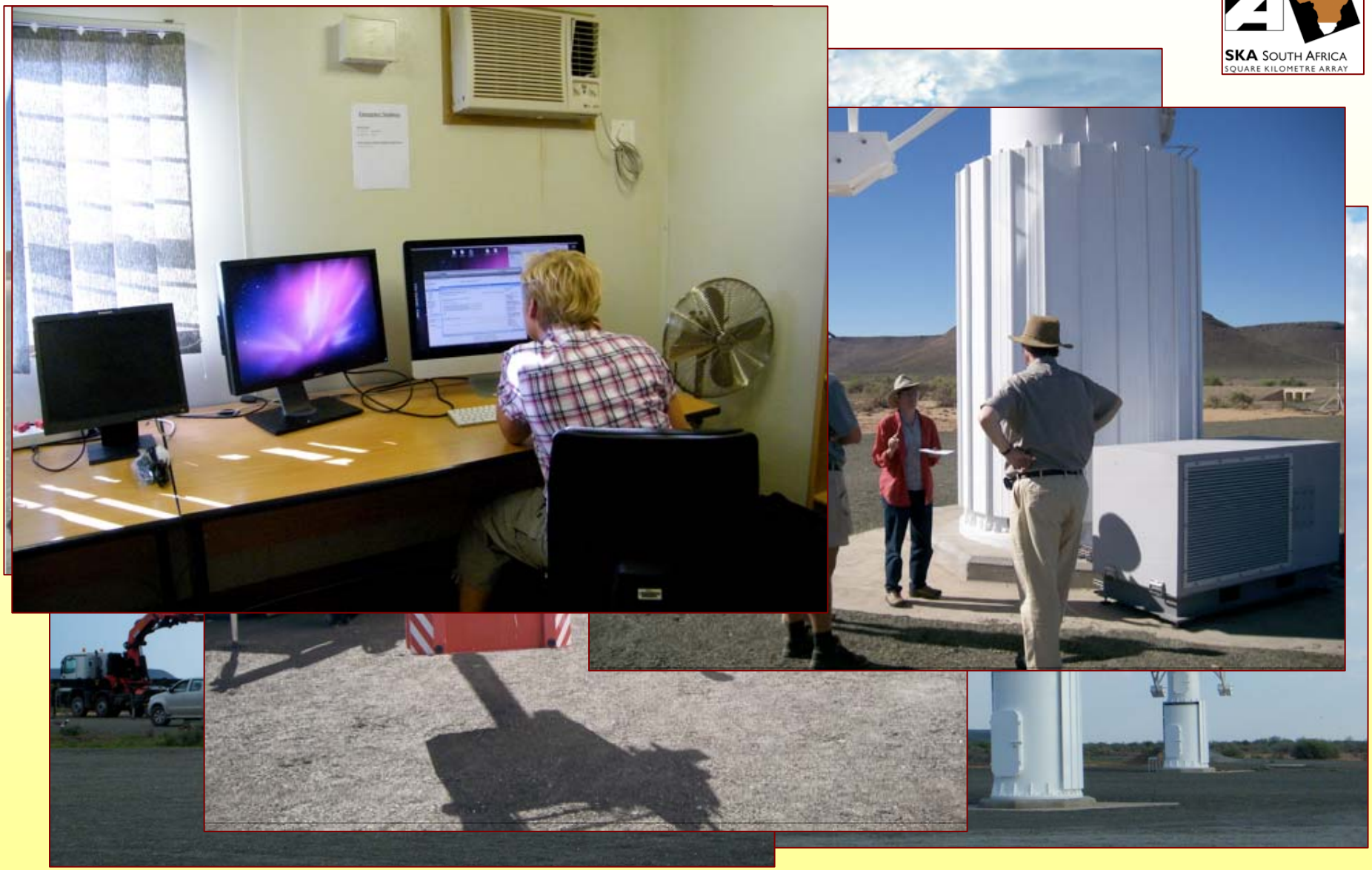
- KAT-7 commissioning is the time to transition to an industrial model of commissioning in which high priority is given to documentation, training, and plug-and-play verification.
- Process defined and initially tested during KAT-7 and then modified as needed for MeerKAT.
- Commissioning with weekly, on-site presence began 3 weeks ago.
- ***Already can do tipping scans, pointing, gain curve, raster scans …***

KAT-7



SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

Commissioning started



Questions?