MeerKAT Status Update

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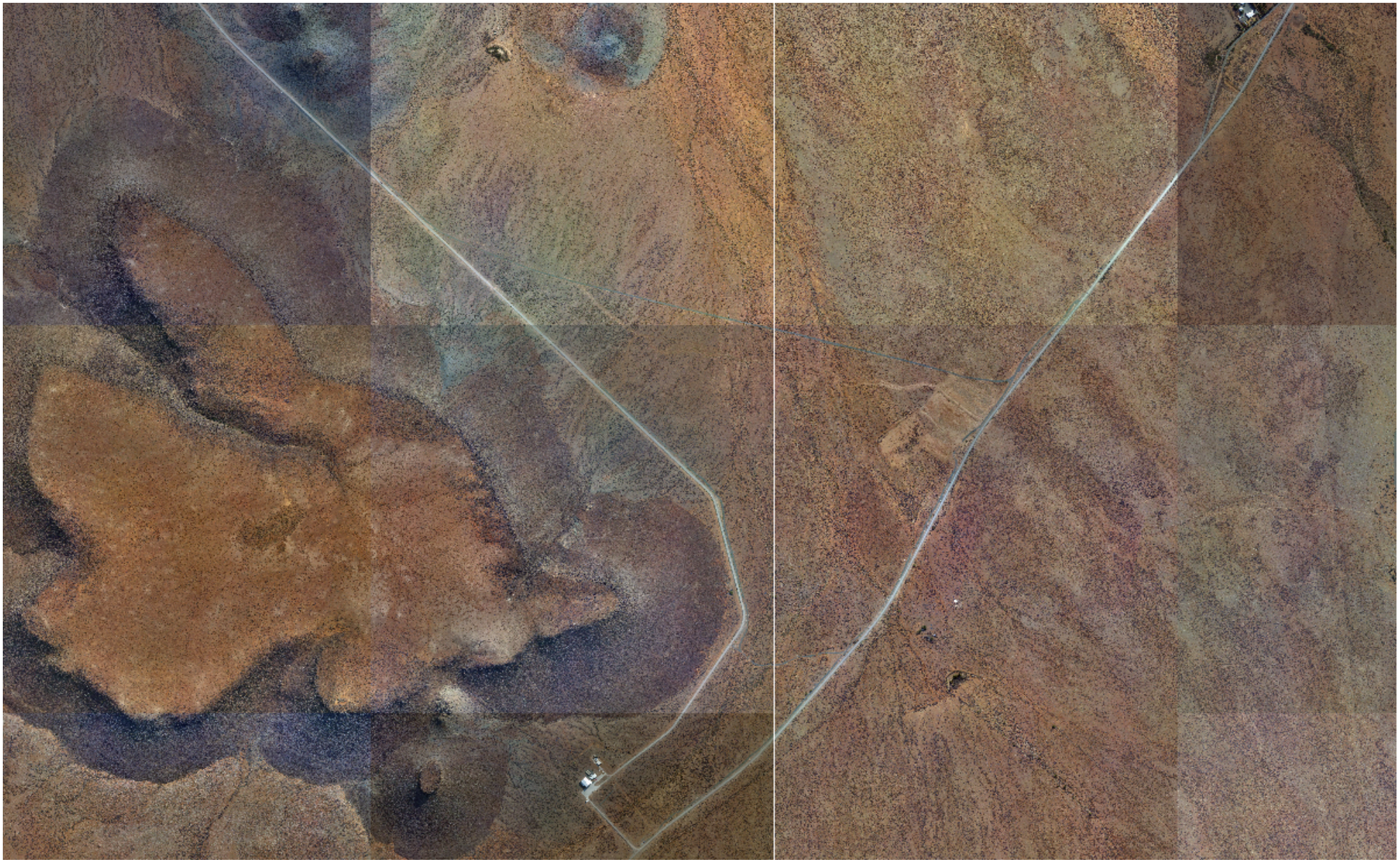
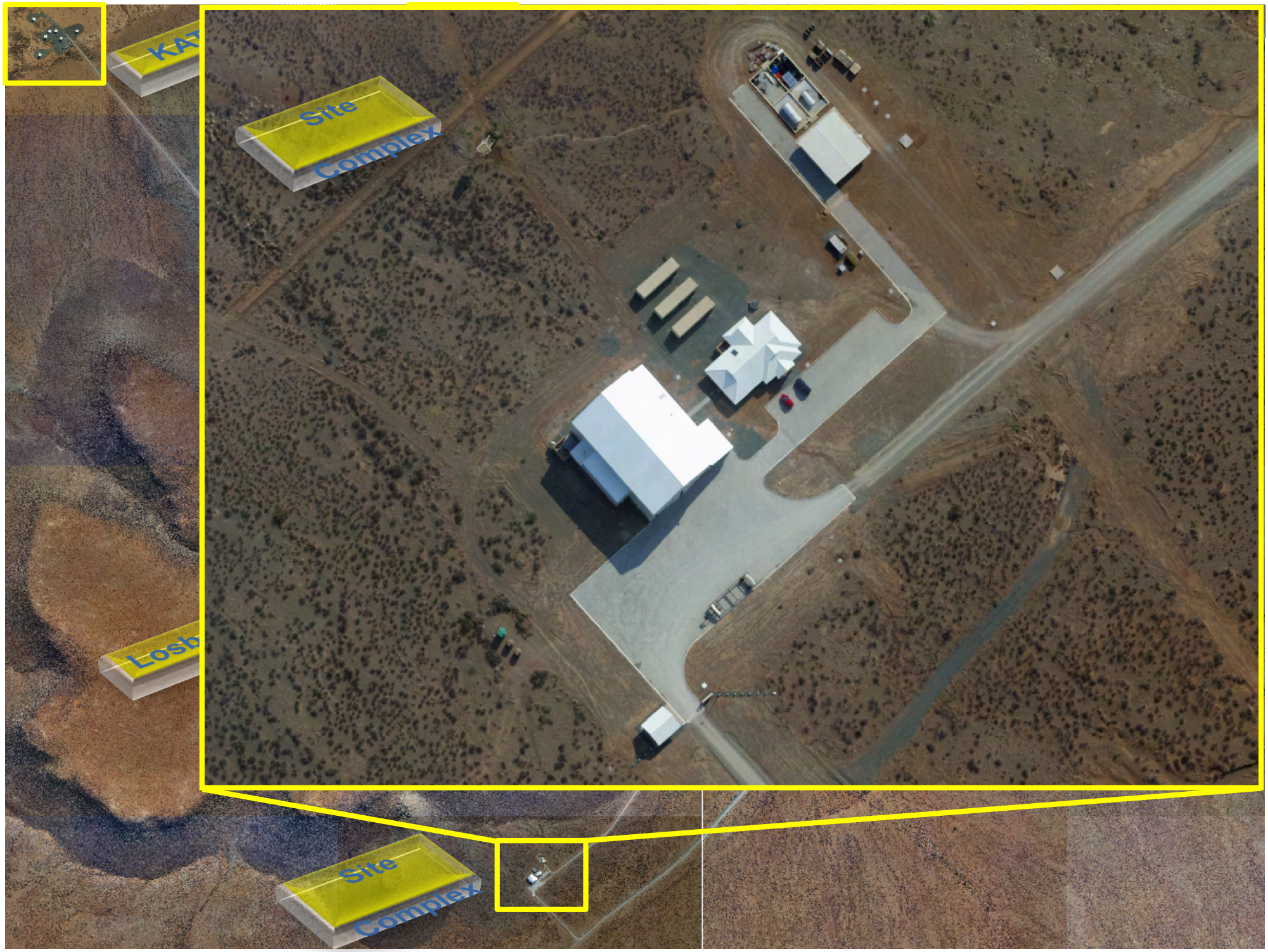
Overview

- Our site
- KAT-7 status
- KAT-7 voltage capture and VLBI experiment
- MeerKAT timeline & specs
- MeerKAT proposed site
- MeerKAT science processing
  - Architecture
  - Software pipelines
  - Next steps

Our Site




KAT7
PAPER
Meysdam
Access Road
Losberg
Site Complex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KAT7
PAPER
Meysdam
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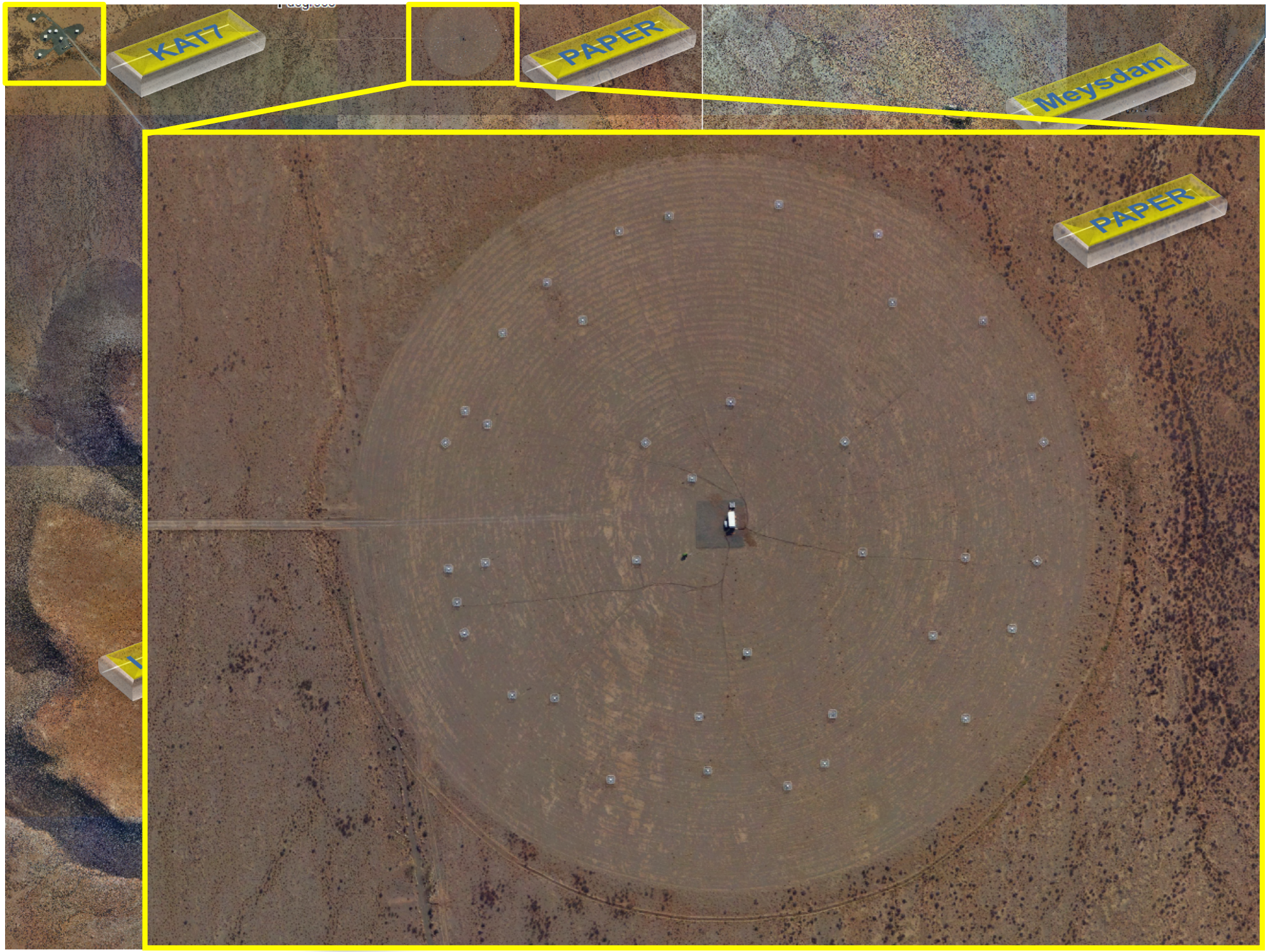
KAT7
PAPER
Meysdam


KAT7
PAPER
Meysdam
PAPER


KAT7
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Meysdam
PAPER

KAT-7: Our Playground

KAT-7 Status

- End July 2011: Complete with 7 cold feeds, full ROACH correlator
- All supporting infrastructure in place (grid and back-up power, 10 Mbps fibre, roads, buildings, water)
- Hardware and software systems in place and supporting routine data collection from Cape Town and on site (CAM, Scripting, Data Capture, Archive, Post-Processing)
- Commissioning well advanced, entering early science operations phase
- Excellent test bed for site readiness, telescope technology and operations. Great test-bed for MeerKAT software development!

Site Transport

Intel Collaboration

"Partnership with Intel South Africa Corporation to evaluate the highest Intel® technologies in processing the enormous data rates produced by radio telescopes."

SKA AFRICA
SQUARE KILOMETRE ARRAY

Voltage Capture Device

- First Intel collaboration produced voltage capture device for VLBI and pulsar observations
- Single node processes 2 x 400 MHz bandwidth voltage streams
- Uses latest generation Intel Core i7 and Solid State Disk technology
- GPU used for PFB, DDC and coherent de-dispersion
- Low power consumption and form factor
- Can store 4 hours of dual polarisation VLBI data
- Extremely cost effective

Prototype machine

3 x 300 GB SSD
Dual GPU
Dual 10 GbE
Core i7 2600

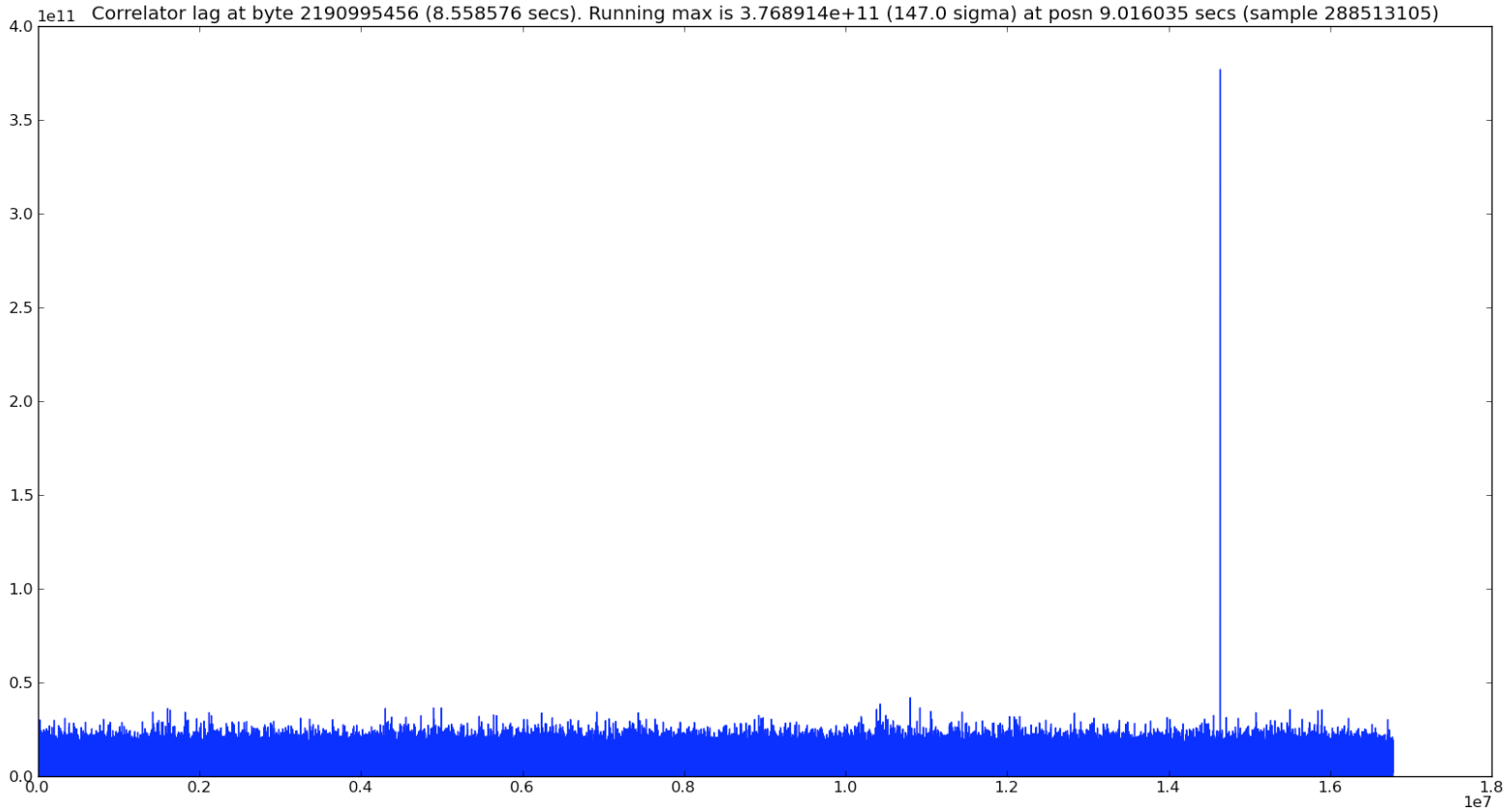
KAT-7 – HartRAO VLBI

- L-band observation of 3C273 (Nov 2010)
- HartRAO used Mark5A VLBI recorder (16x16 MHz sub-bands)
- KAT-7 recorded full-band (400 MHz) to disk
- 1696-1712 MHz used as fringe test
- Data extracted from HartRAO recording using DiFX utilities and custom code
- Data extracted from KAT recording using custom software DDC
- Two correlation approaches (for safety):
  - Custom python correlator
  - DiFX correlator

Spike in lag plots would indicate success ….

KAT-7 – HartRAO Baseline

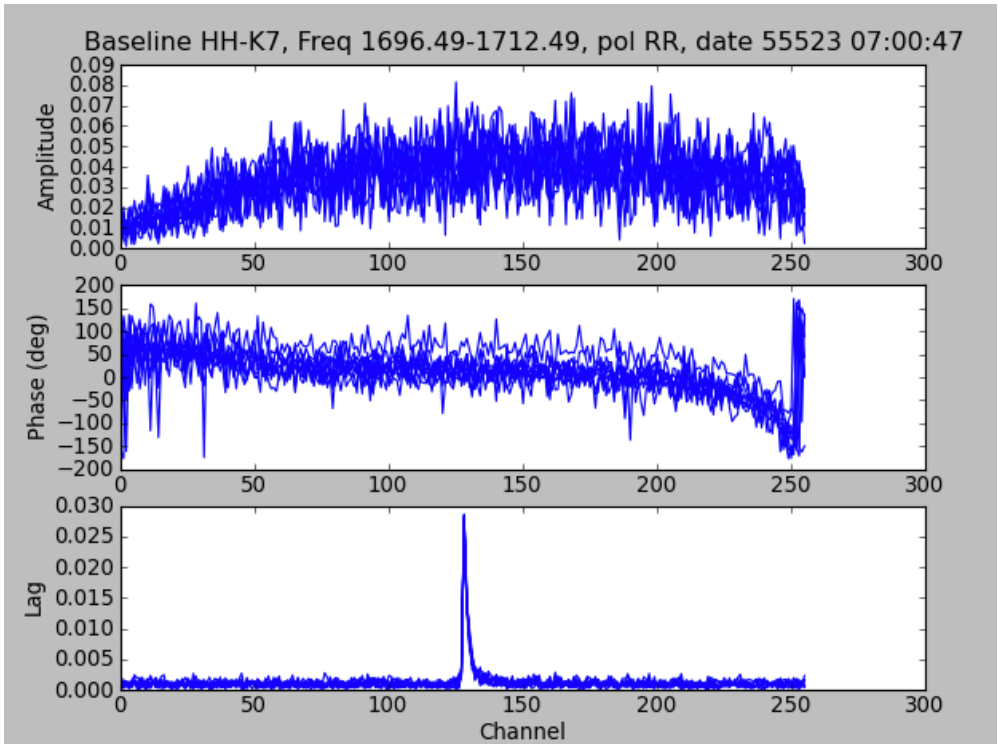
VLBI Lag Plot (Python correlator)



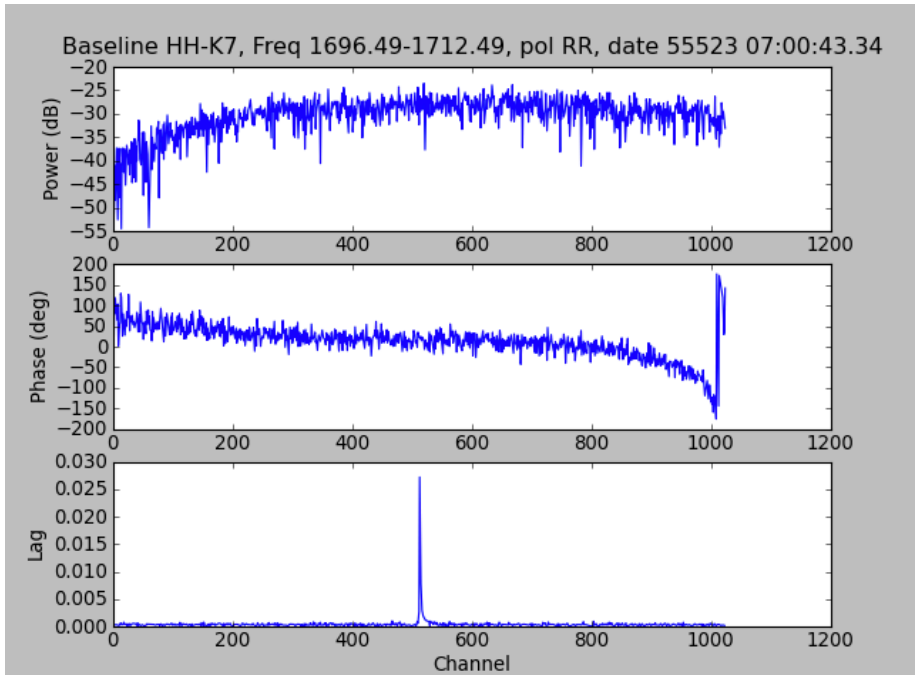
Spike where correlated signals correctly time aligned

…. work, more work … SUCCESS!!

VLBI Lag Plot (DiFX correlator)



9 x 1 sec integration



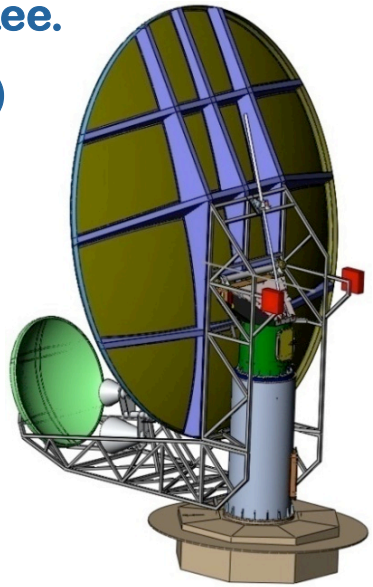
9 sec integration

work, more work, …. SUCCESS AGAIN!!

MeerKAT ...

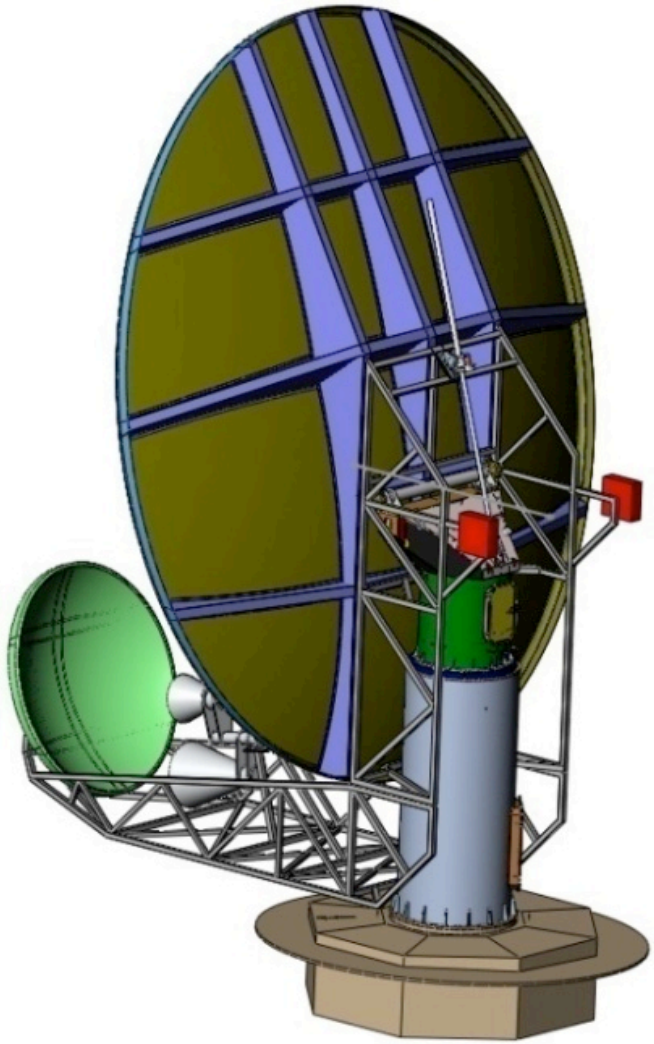
MeerKAT – 2010/2011

- **March 2010:** Science Proposals received
- **July 2010:** CoDR (options for MeerKAT with performance, budget, schedule implications on system level for each option) presented to and reviewed by international panel who are experts in their fields. Feedback from CoDR panel on the quality of the documentation (i.e. technical work) very positive.
  - Resulted in change to 64 x 13.5m offset antennas recommended to steering committee
- **Sept 2010:** Change (schedule, budget) approved by steering committee.
- **Oct 2010:** TAC input to finalize URS (evaluation of science proposals)
- **Jan 2011:** System Spec version 1, URS version 2
- **Mar 2011:** Operational URS
- **July 2011 (last week!):** System PDR successfully passed
- **Sept 2011:** Antenna Tender
- **Dec 2011:** Antenna Contract award



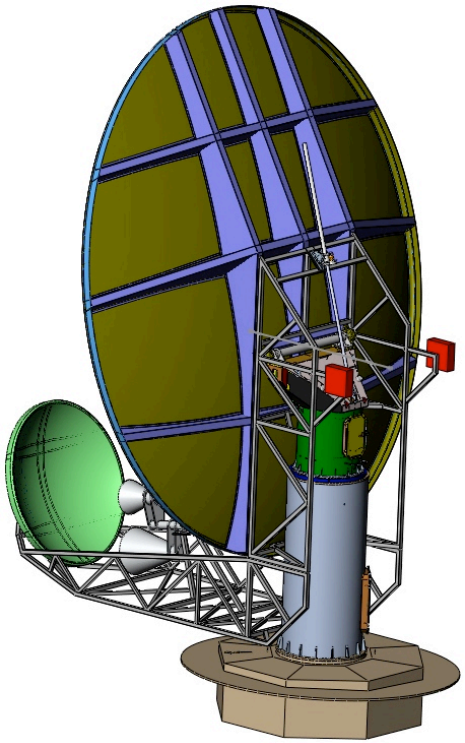
MeerKAT – Main Specs

SYSTEM	
Sensitivity (m^2/K)	223 (Phase 1)
Tsys (K)	27
ARRAY	
# antennas	64
Minimum / maximum baseline	29 m – 7.7 km
ANTENNA	
Diameter (m) – effective	13.5
Optics	Offset Gregorian
Surface Accuracy (mm RMS)	1
Pointing Accuracy (“)	9” (mosaicing), 20” (other)
FOV (degrees)	1
RECEIVER	
# Feeds	4
Frequency range (Phase 1)	0.9 – 1.75 GHz
Frequency range (Phase 2)	0.58 – 1.015 GHz 8 – 14.5 GHz



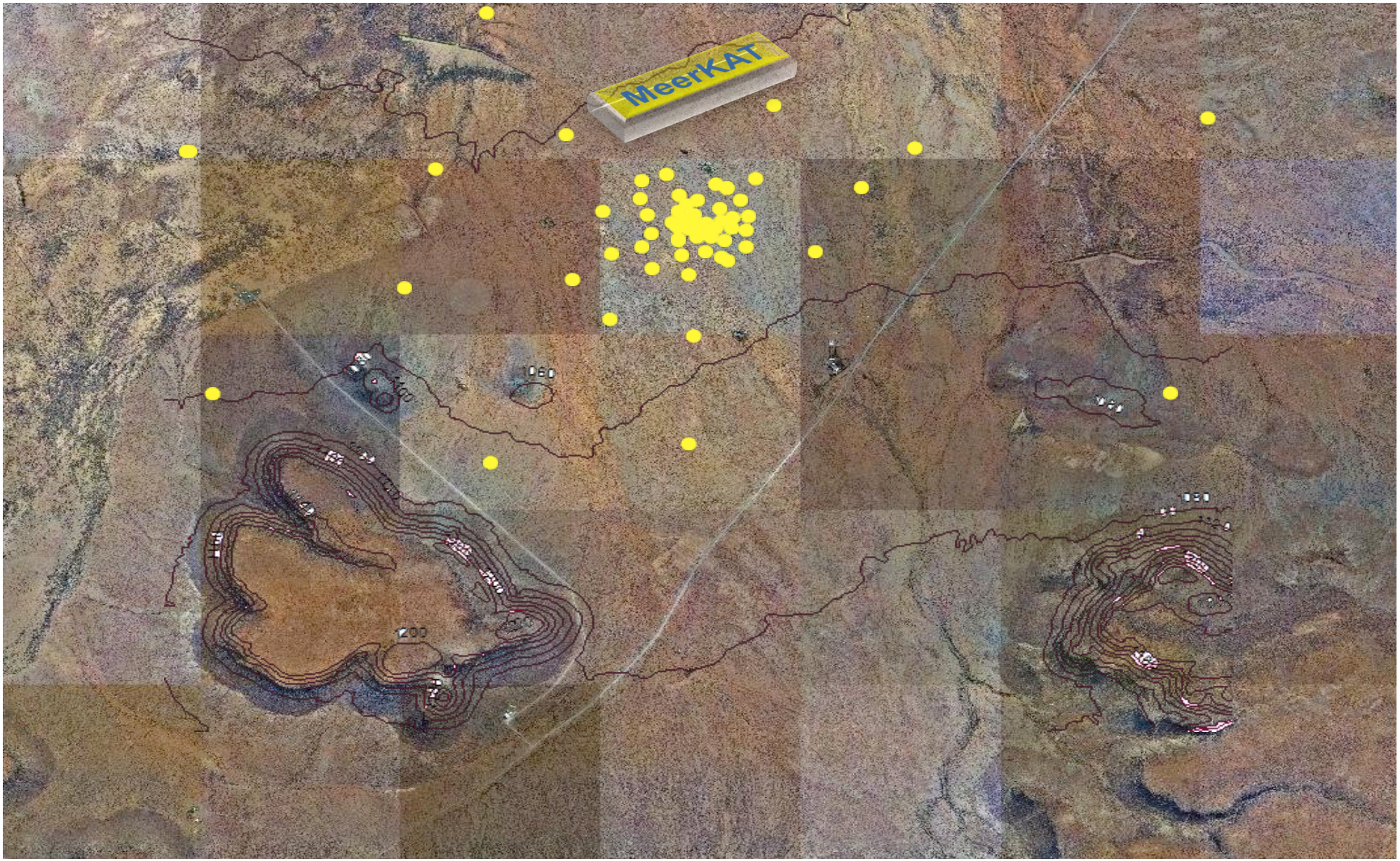
MeerKAT – Phases

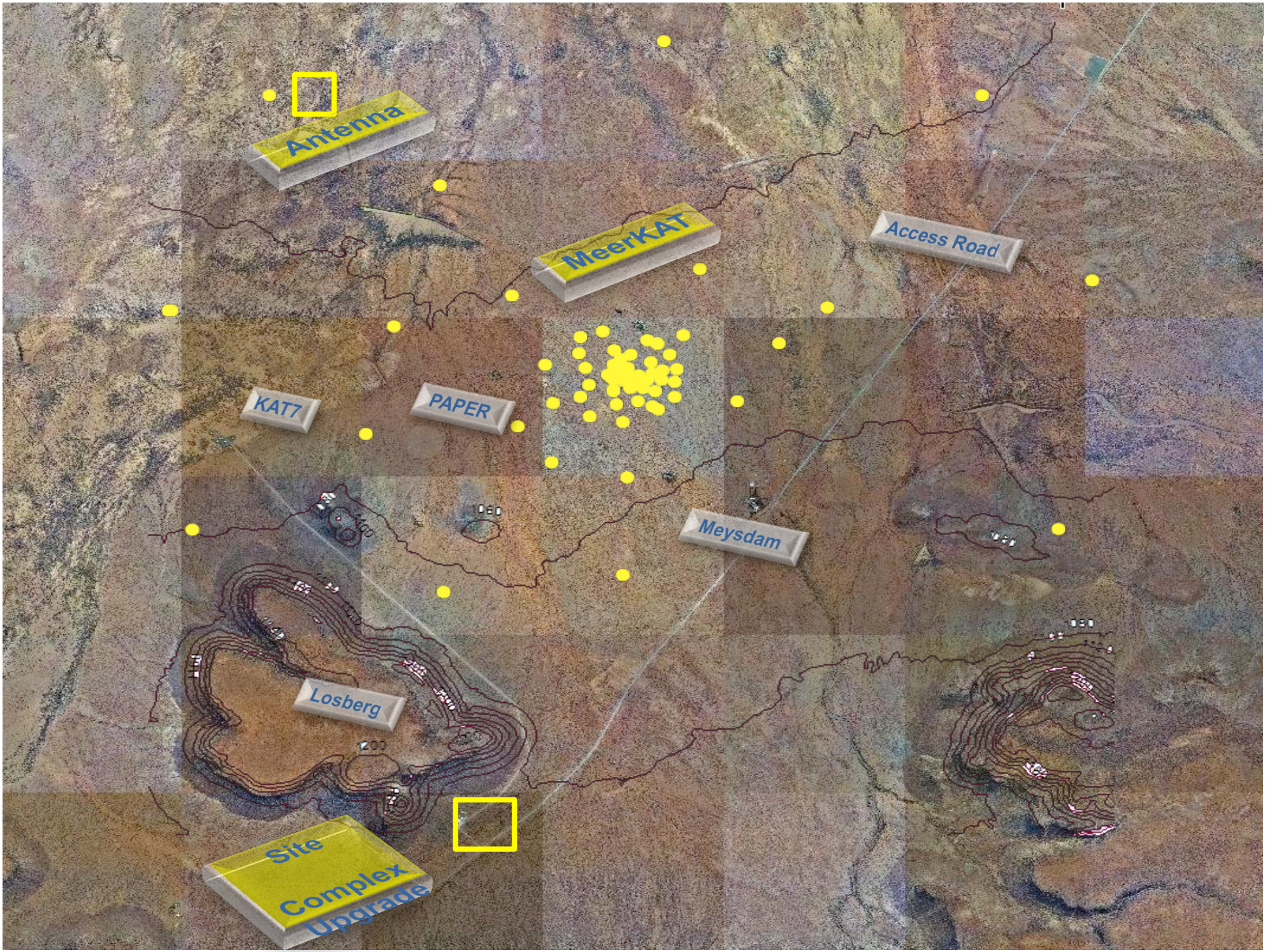
	Phase 1 (current planning)	Phase 2
Estimated completion date	2016	2018
Frequency bands (GHz)	1 – 1.75 (ECP: 0.9 – 1.75)	0.58 – 1.015 8 – 14.5
RF bandwidth (MHz)	850	6500
Sampling frequency (GSPS)	5	30
Processed bandwidth (MHz)	850	6500
Max baseline (km)	10	10

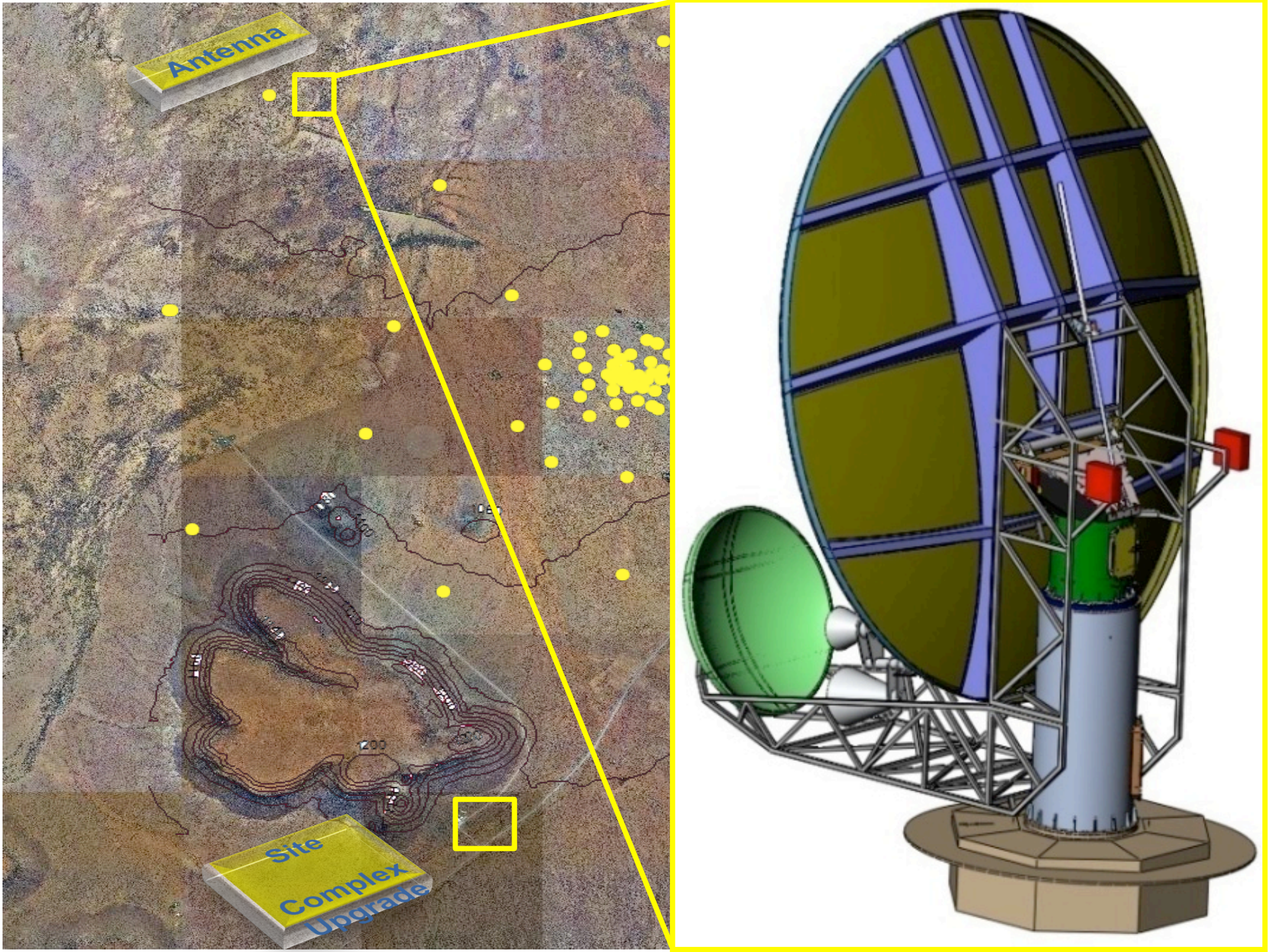


- All current planning for phase 1 – need to know where you are going
- Phases not finalised (phase 1 is firm)
- Phase 2
  - Added Receivers (frequency upgrade)
  - Correlator upgrade (replacement)

The Proposed MeerKAT Site




Antenna
MeerKAT
Access Road
KAT7
PAPER
Meysdam
Losberg
Site Complex Upgrade


Antenna
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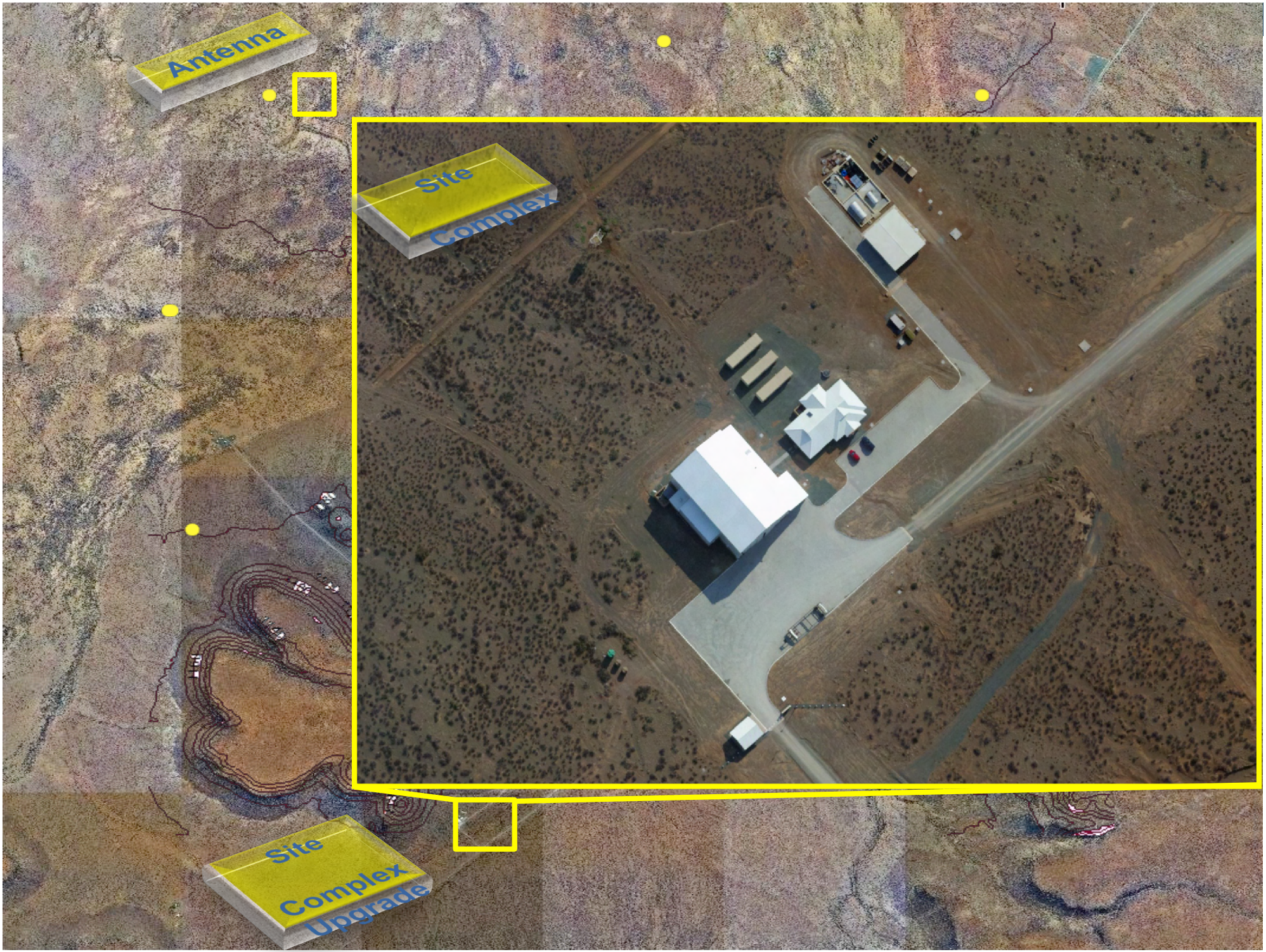
Upgrade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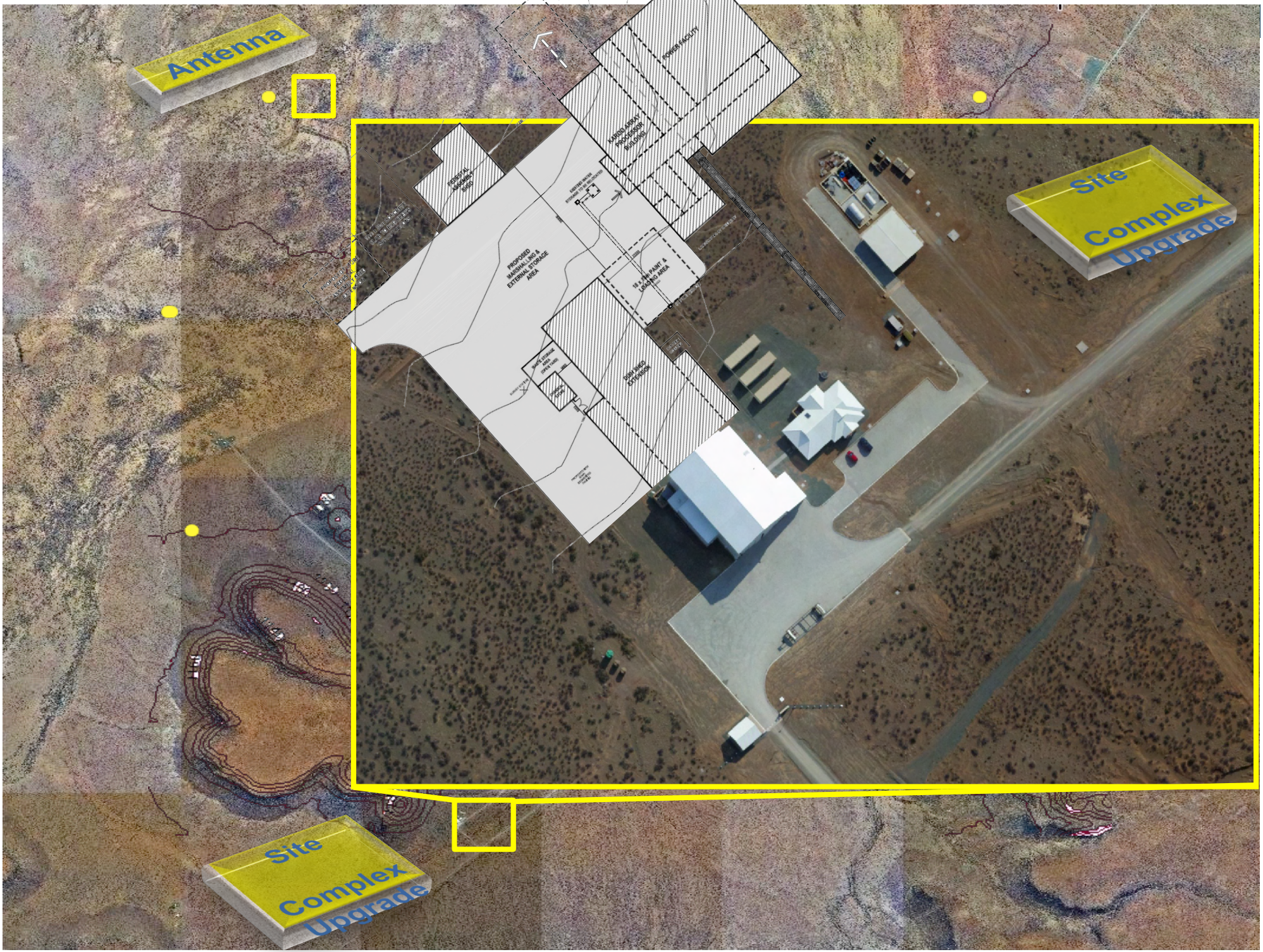
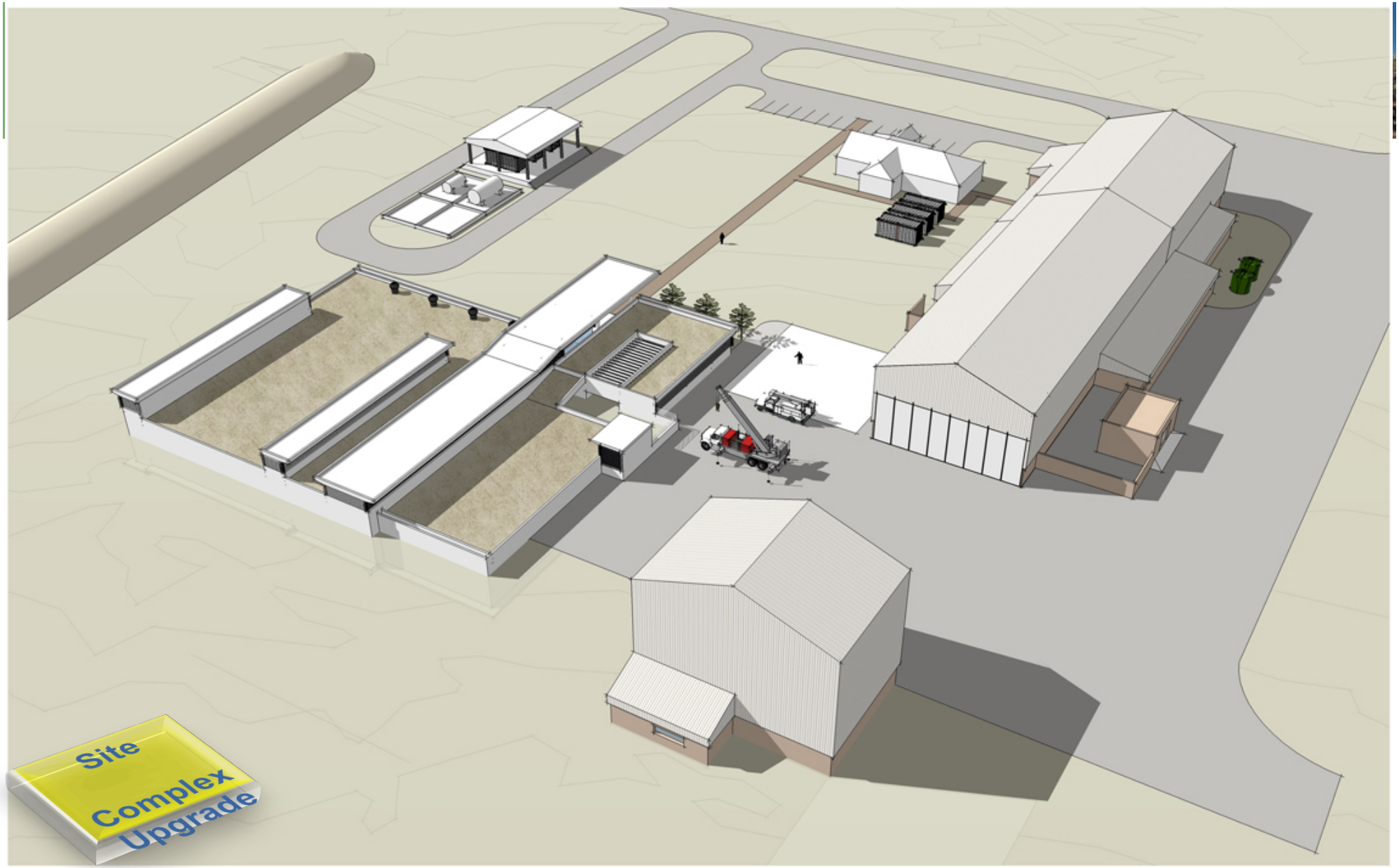

Antenna
Site
Complex
Upgrade
Site
Complex
Upgrade
POWER FACILITY
PROPOSED MARSHALLING & EXTERNAL STORAGE AREA
DUO SHED EXTENSION



View from West

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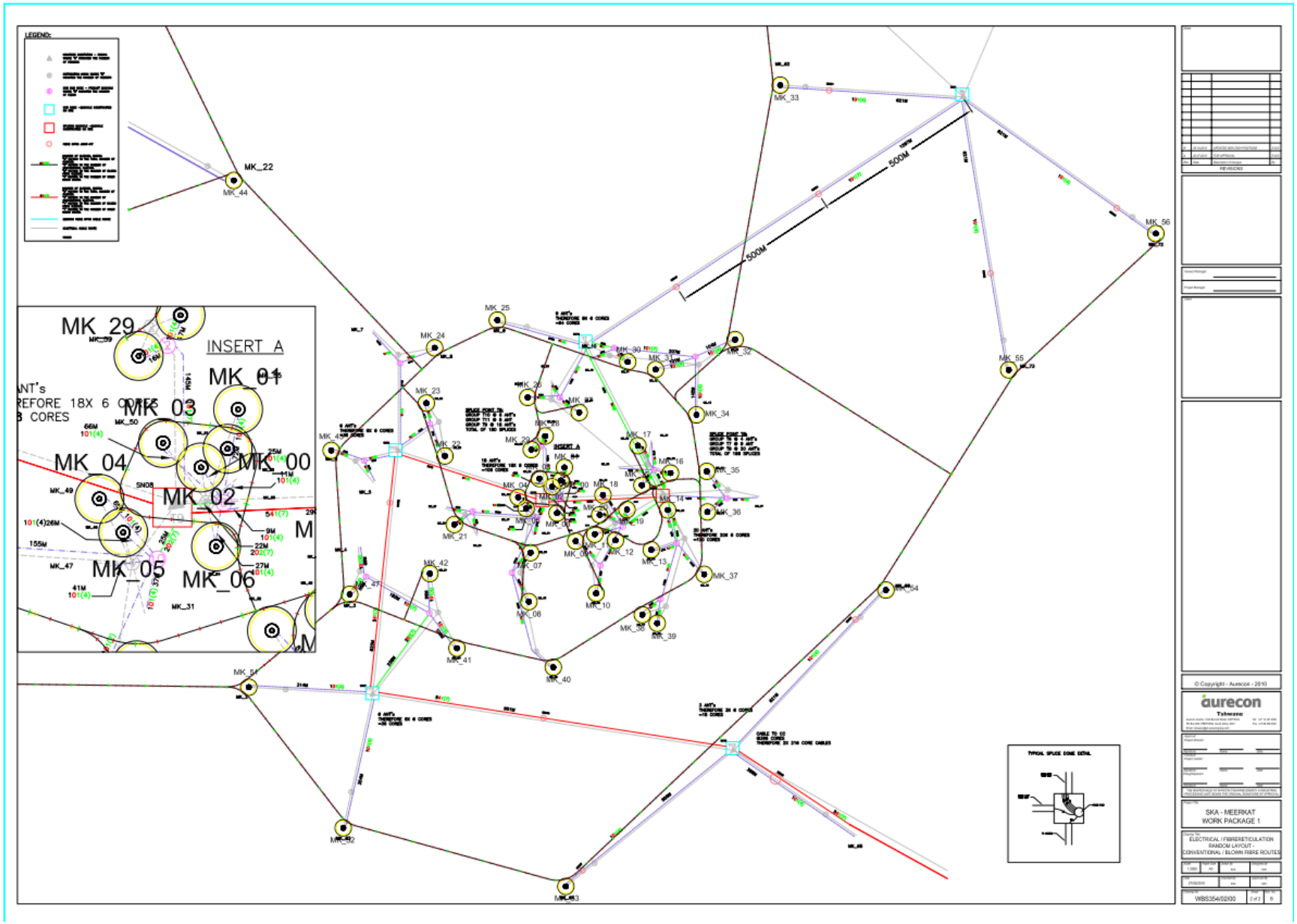
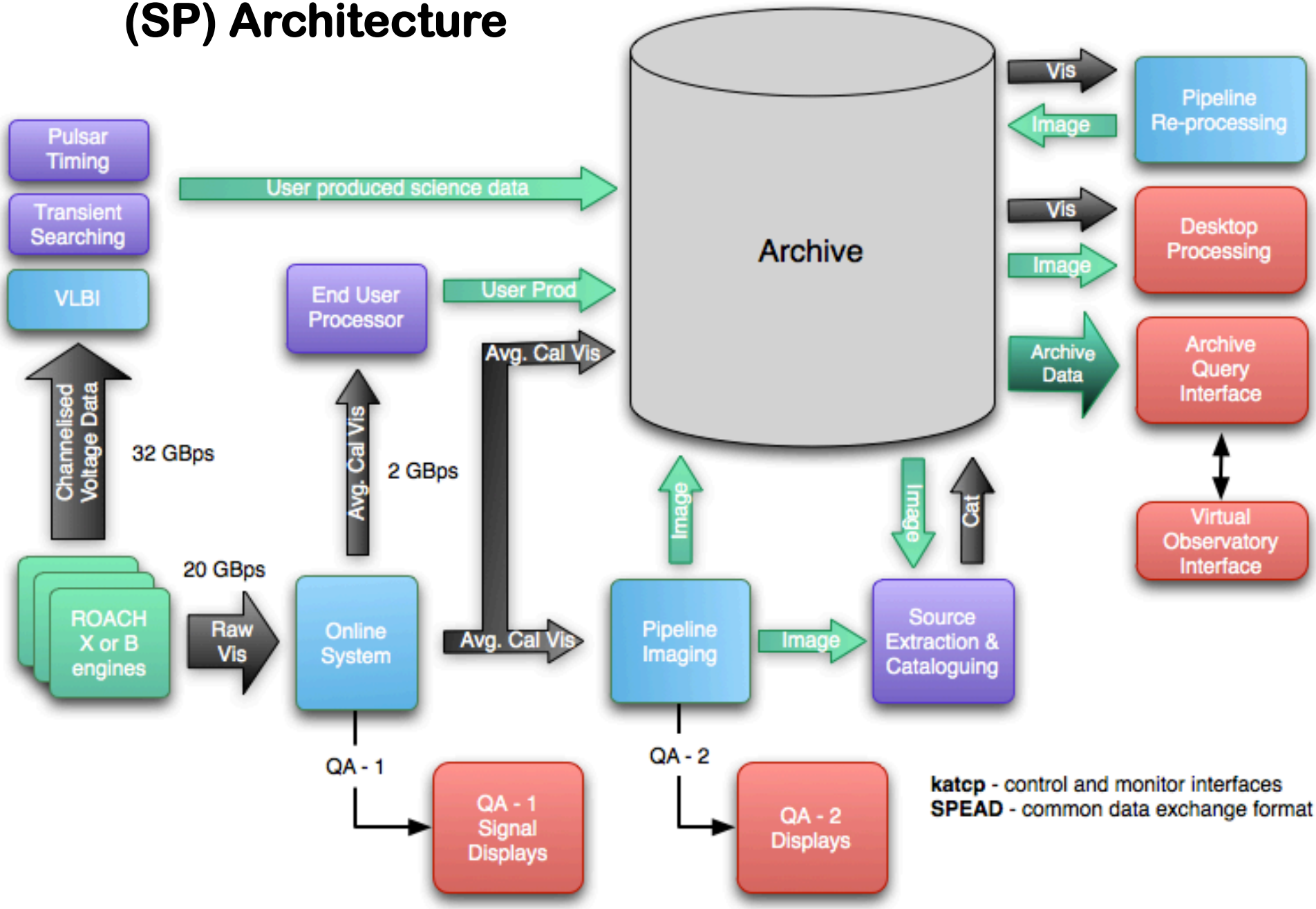
SQUARE KILOMETRE ARRAY

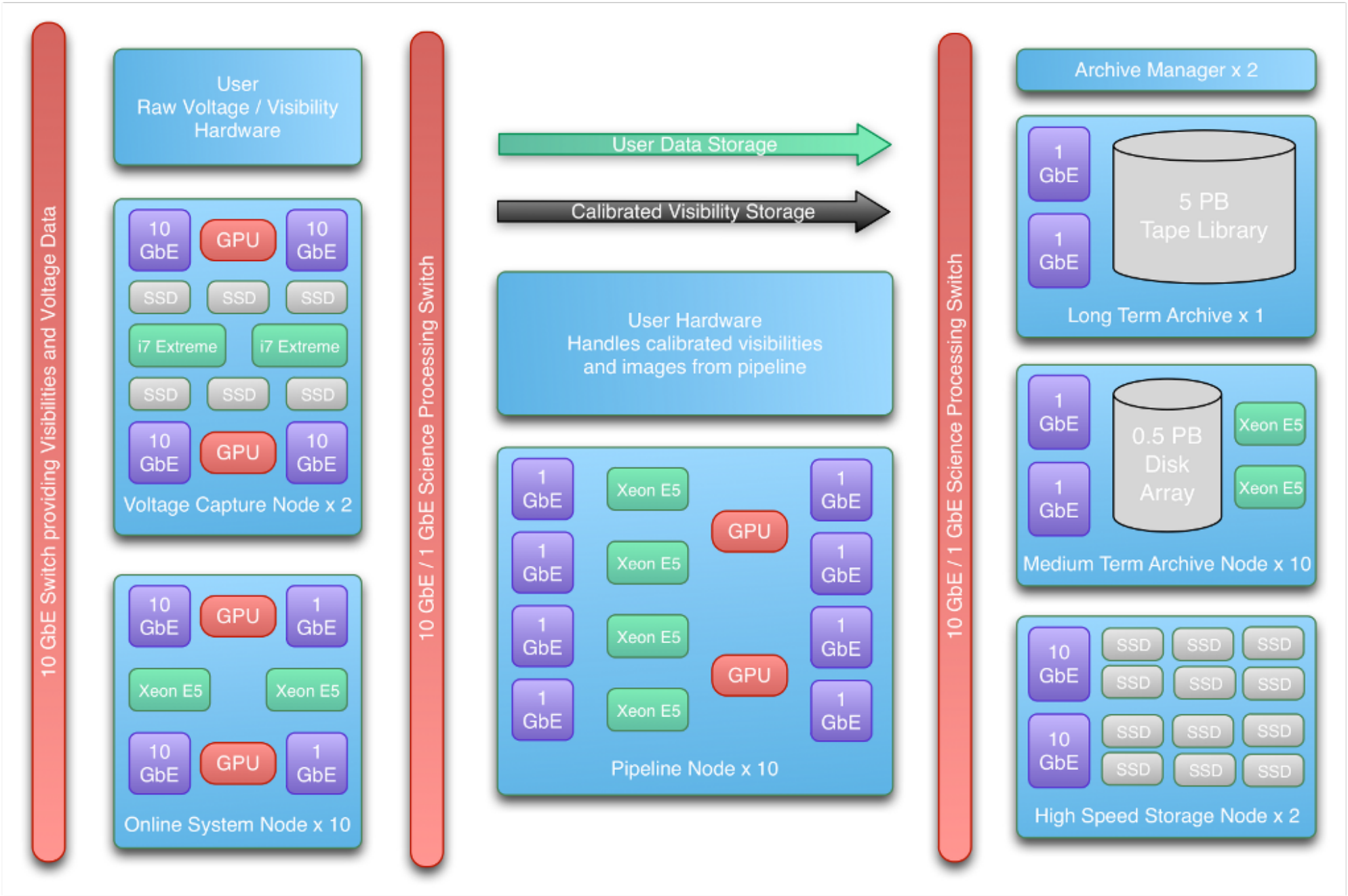
MeerKAT Reticulation



MeerKAT Science Processing (SP) Architecture



MeerKAT SP Hardware (if 2012)



MeerKAT To Provide

- Calibrated visibilities
- Certain standard pipelines (spectral line image cubes, continuum images)
- Storage for visibility data (project disk quotas?)
- A 10 PB archive on site plus 3 PB in CT, plus likely overseas mirror
- Archive access and facilities to reprocess from archive
- Flexible architecture for “black belt” users plus space and power in the Array Processor Data Centre for additional user-supplied equipment
- Support for some re-use of existing mature packages where possible (support CASA, MeqTrees)

Pipelines

- Non-trivial…
- One pipeline to rule them all? – almost certainly not.
- A few pipelines to cover the common cases? – perhaps.
- Science quality pipeline output? – with time and experience… perhaps.

photo: Mike Slagter

photo: darthdowney

photo: surfglassy

Pipeline “algorithm”

Approach to software pipelines development:

- Start with CASA and MeqTrees KAT-7 reductions
- Script and apply to new observations
- Evaluate and improve
- Iterate
- …
- Think MeerKAT size and science. Interact with science teams. Simulate and reduce. Expect quality and performance bottlenecks. Re-evaluate technology choices.
- Apply to emerging MeerKAT
- Rework and refine
- Iterate

MeerKAT SP – Next Steps

- Imaging on KAT-7:
  - 4 dish single pol (done, using FF correlator)
  - 7 dish dual pol (this month using KAT-7 correlator)
- Imaging data reduction (important to have more than one package for testing):
  - CASA
  - MeqTrees
  - custom python (exploratory)
- Spectral line imaging (Q4 2011 – correlator mode dependent)
- Engineering imaging pipelines development starting now

MeerKAT SP – Other Collaborations

- Working with NRAO on GPU speed-ups in CASA [Sanjay] and testing of parallel CASA deployments in large cluster environments (CHPC in Cape Town).
- Working with ASTRON on modelling of beams and investigations into unmodelled beam effects in high dynamic range imaging [Oleg].
- Investigating the use of Apache OODT (ex NASA earth sciences) for data archive toolset [Chris Mattmann, JPL].
- IBM InfoSphere Streams collaborative work on RFI flagging (poster by Thomas Bennett)


Questions…
http://www.ska.ac.za