

The African VLBI Network (AVN) – current status & an exciting journey

21 April 2015



international relations
& cooperation

Department:
International Relations and Cooperation
REPUBLIC OF SOUTH AFRICA



science and technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA



Overview

- Context and background;
- Some (very little) technical stuff;
- A lot of pictures to show you a possible future!
- Summary and Closure.

What is the AVN and why are we doing it?

- Develop a network of VLBI-capable radio telescopes on the African continent;
- Africa (led by South Africa) will co-host the Square Kilometre Array telescope with Australia, 9 African countries to host stations in SKA2 (including SA):
 - Develop the skills, regulations and institutional capacity needed in SKA partner countries to optimise African participation in SKA2 and enable participation in SKA pathfinder technology development and science;
 - Skills and knowledge transfer in African partner countries to build, maintain and operate radio telescopes independently;
 - Bring new science opportunities to Africa on a relatively short time scale and develop strong RA science communities.

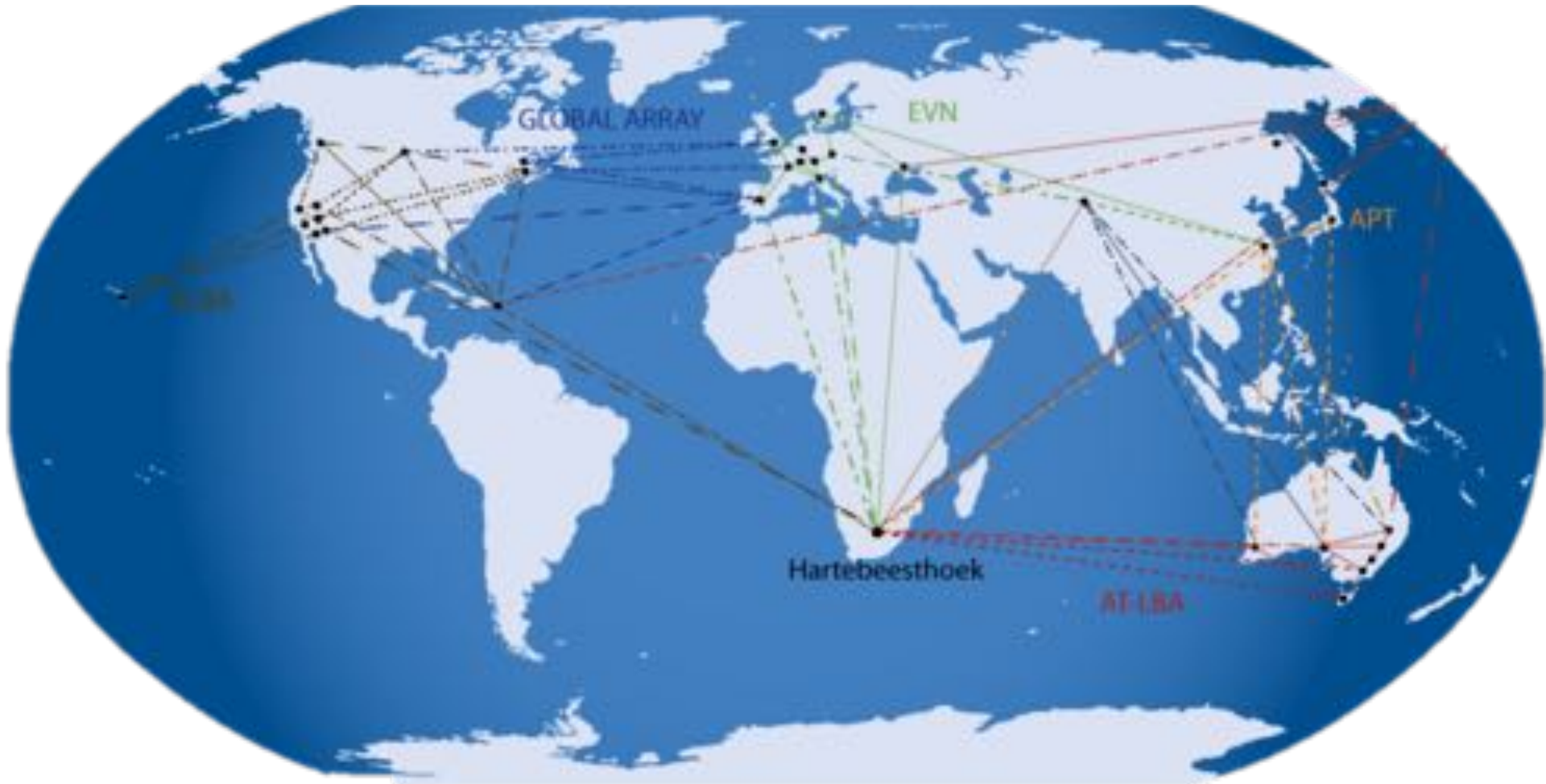
Funding and focus areas

- Not all areas of the envisaged AVN are funded:
 - Antenna conversion projects;
 - Development of requirements, specifications for new-build telescope systems, source funding;
 - Phased training interventions for “core essential observatory skills”;
 - Grow the capacity building initiatives – especially robust user groups, Big Data;
 - Develop model for operations (establish the AVN Operations Team, Data Center and correlator) for the established observatories in SA and partner countries.

AVN main considerations

- What science case? How many telescopes? Where (which countries?);
- Compatibility with other VLBI networks;
- Telescope sensitivity target / System Equivalent Flux Density (SEFD) target;
- Antenna optical design;
- Required antenna diameter to achieve targeted sensitivity;
- Number and type of receivers and feeds.

“Filling the gap” with the AVN



- International VLBI science community wants better “UV coverage” i.e. more telescopes on the African continent;
- HartRAO extends the north-south array size but the large gap between Europe and South Africa leads to missing information, poor image quality, difficulty in calibrating HartRAO data.

Currently the only VLBI telescope on the African continent - HartRAO



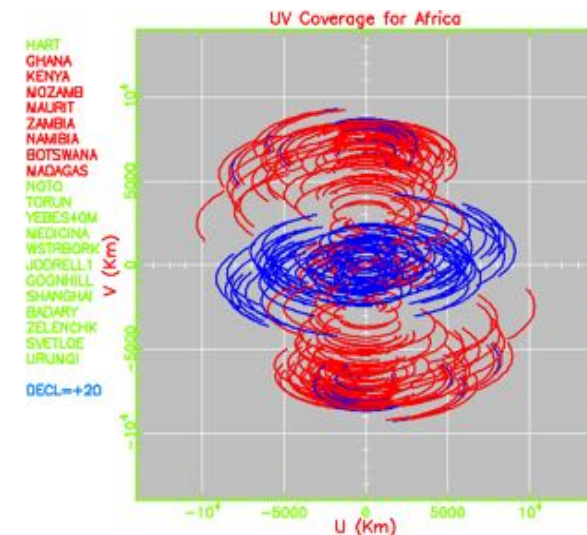
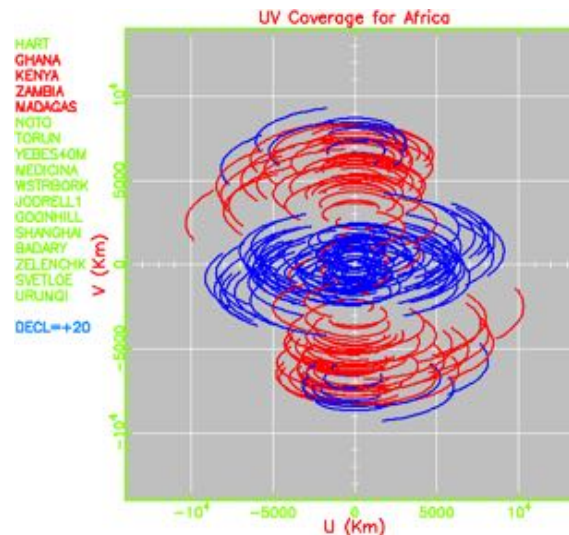
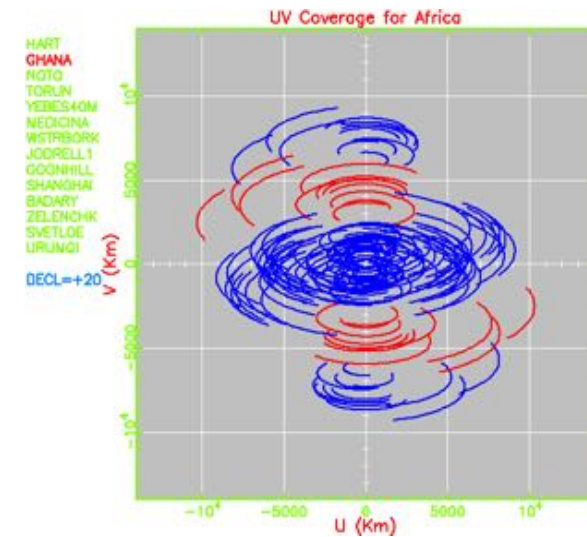
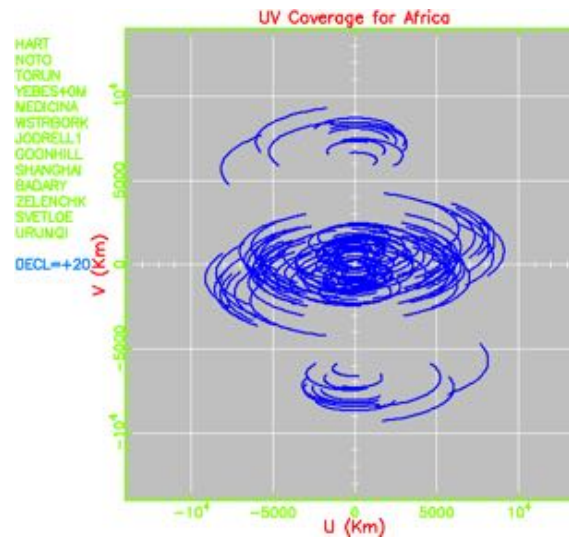
Africa & the SKA



- South Africa,
- Botswana,
- Ghana,
- Kenya,
- Madagascar,
- Mauritius,
- Mozambique,
- Namibia, and
- Zambia

Can (this) AVN make a real difference?

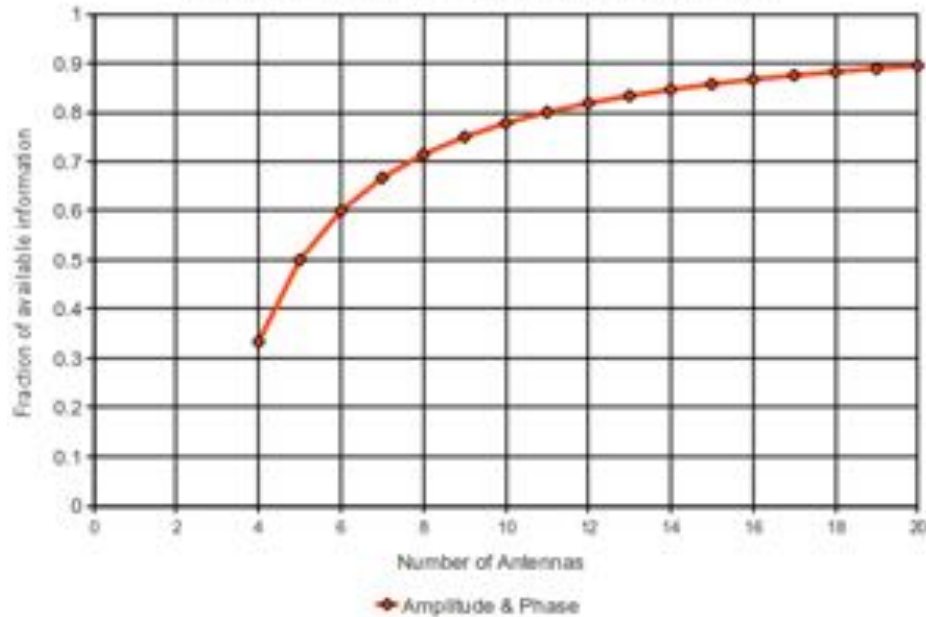
- The quality of a VLBI image is usually determined by the density and distribution of UV tracks in the UV-plane. These tracks are formed by the 2-D projection of the various interferometer baselines on a plane (the so-called "uv-plane") which is perpendicular to the source direction.
- Every pair of antennas makes a contribution to filling the UV-plane, and the design of a synthesis array is aimed at filling the UV-plane as completely as possible (**An Introduction to Radio Astronomy** by Bernard F. Burke, Francis Graham-Smith)
- Better UV coverage enables high dynamic range, milli-arcsecond resolution images of complex radio sources. "Snap-shot" observations of many sources can also take advantage of the dense UV coverage.



UV+20 = +20° declination (source 20° north of the Equator)

AVN - how many telescopes and what frequencies?

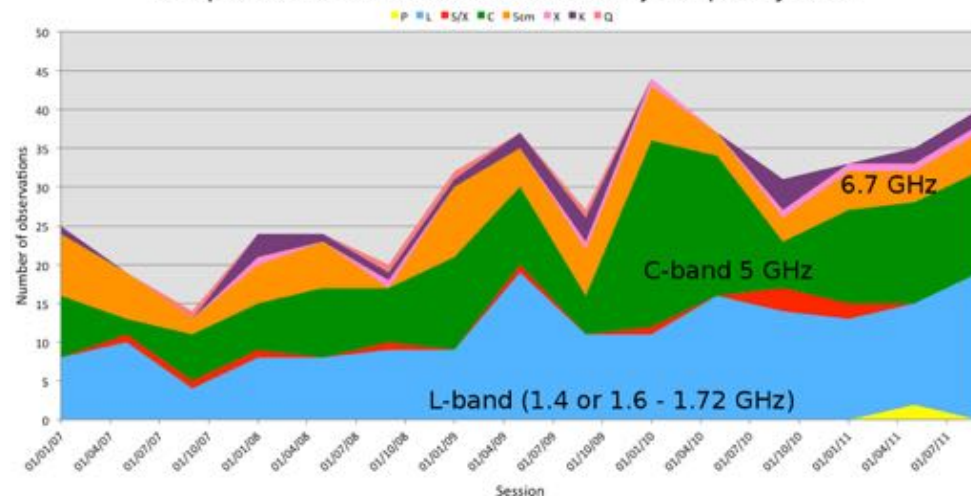
Fraction of available information versus number of antennas



No of tele-scopes	Relative Recovery
4	1.0
5	1.5
6	1.8
7	2.0
8	2.13
9	2.25

- Four telescopes - minimum VLBI network size able to do imaging;
 - Currently have funds for 3 conversions;
 - 8 telescopes recover just over 2x more data than 4.
- (Reference: Thompson, Moran & Swenson 1986 P360 Fig 11.4 eqn 11.22)

European VLBI Network Observations by Frequency Band



Equipment at each AVN VLBI radio telescope

- **Receiver** covering at least one standard VLBI band;
- **Hydrogen maser frequency standard** providing frequency standard and reference frequencies for the receiver / signal chain;
- **GPS receiver** providing time standard for recording systems;
- **Internet connection** (10 Mbps min bandwidth) for: receiving VLBI test and science schedules, liaising with operators at other telescopes in the schedule and at the correlator that is processing the data, sending VLBI test data samples to the correlator to check for fringes;
- **Wideband internet connection** for: sending science data by e-shipment after the VLBI to the correlator – 128 Mbps min bandwidth, real-time e-VLBI transmission of narrowband spectroscopy data to the correlator – 128 Mbps min bandwidth, real-time e-VLBI transmission of wideband continuum and pulsar data to the correlator – 1 Gbps – 1024 Mbps min bandwidth;
- **Reliable continuous power and other infrastructure.**

**Policy Environment
& Governance**

(government level policy,
Institutions, etc.)

**Science
Infrastructure**

(including radio
observatories, high
performance
computing facilities,
etc.)

(Skilled) people

(academics / researchers /
scientists, engineers,
technicians, artisans)

**Physical
Infrastructure**

(including data
transport networks,
power, roads, etc.)



But this is a celebration of the past and a look at
an exciting future..
please allow me to give you a glimpse into that
future!

4th European VLBI meeting at Jodrell Bank, September 1977







Deputy Minister Masutha launches AVN Technical Training Programme in Cape Town - Ghanaian core essential observatory staff training



“Baby telescope” key training tool as part of knowledge transfer and hands-on immersive learning

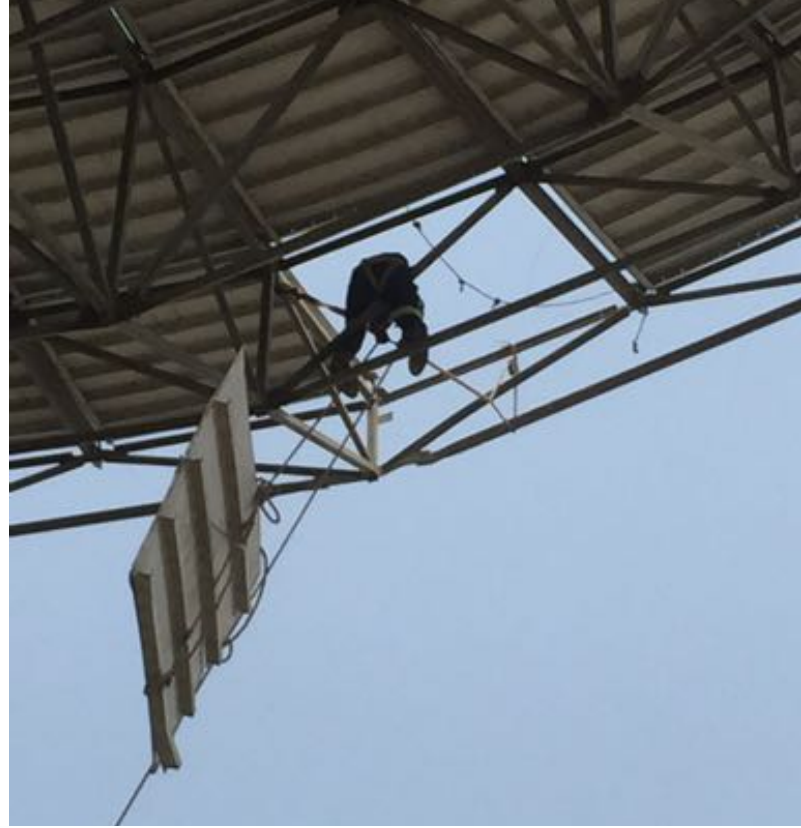


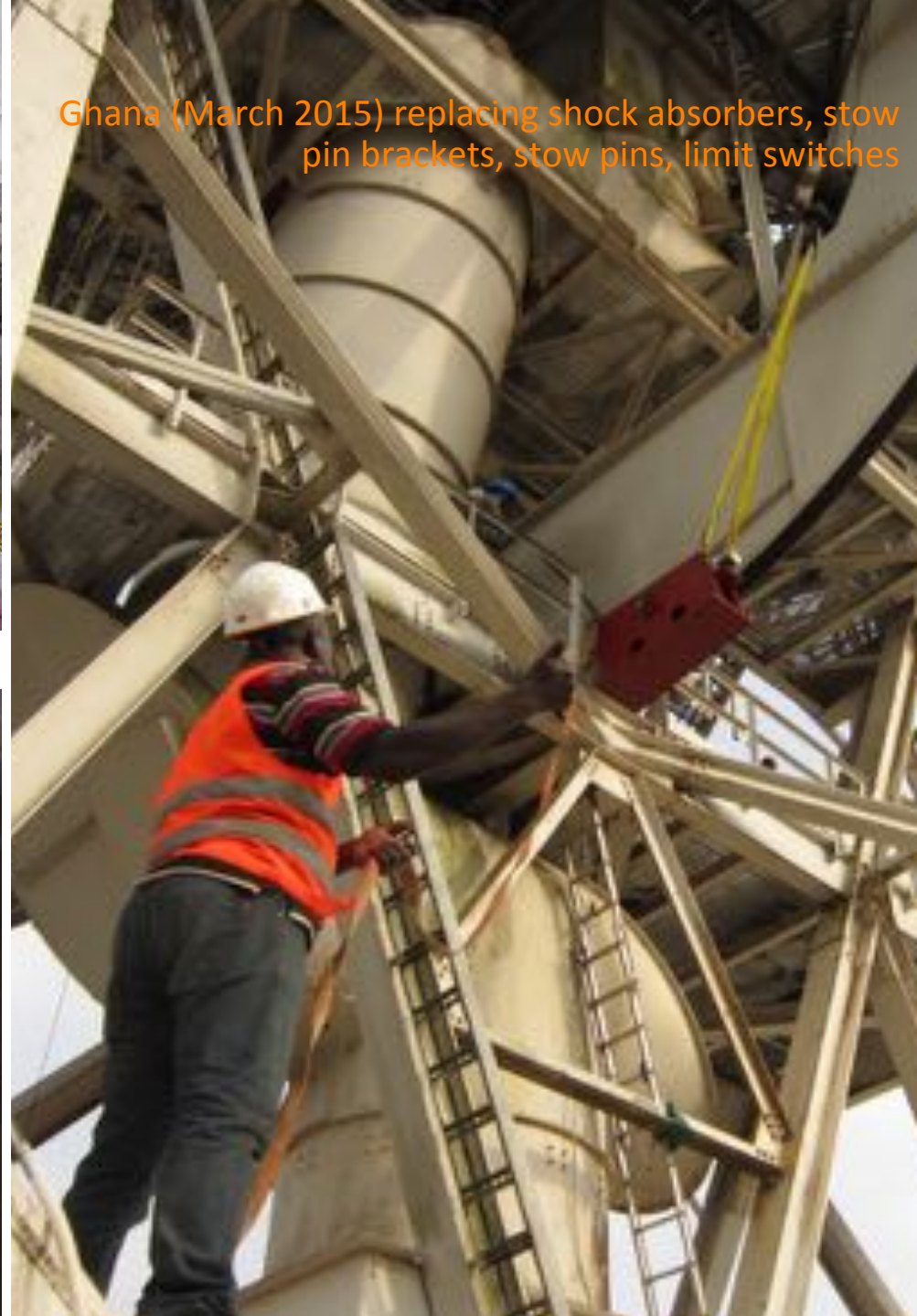
Laboratory, handskills and IPC soldering course and certificate





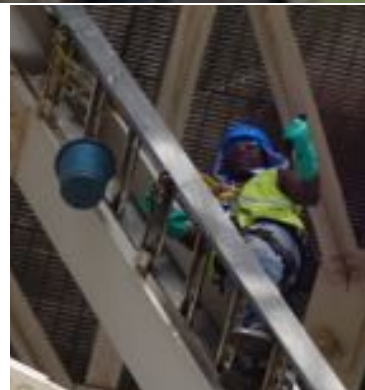
Graduation 30 May 2014: Ghanaian core essential observatory staff





Ghana (March 2015) replacing shock absorbers, stow pin brackets, stow pins, limit switches







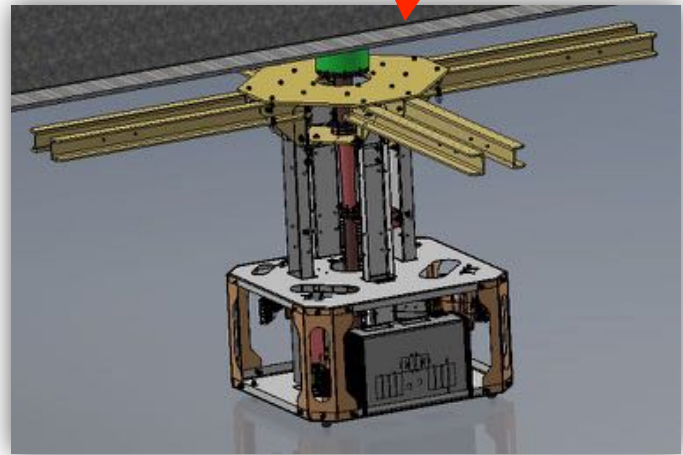
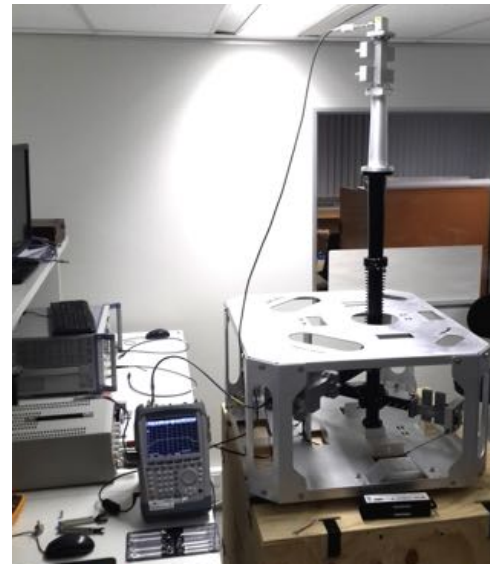
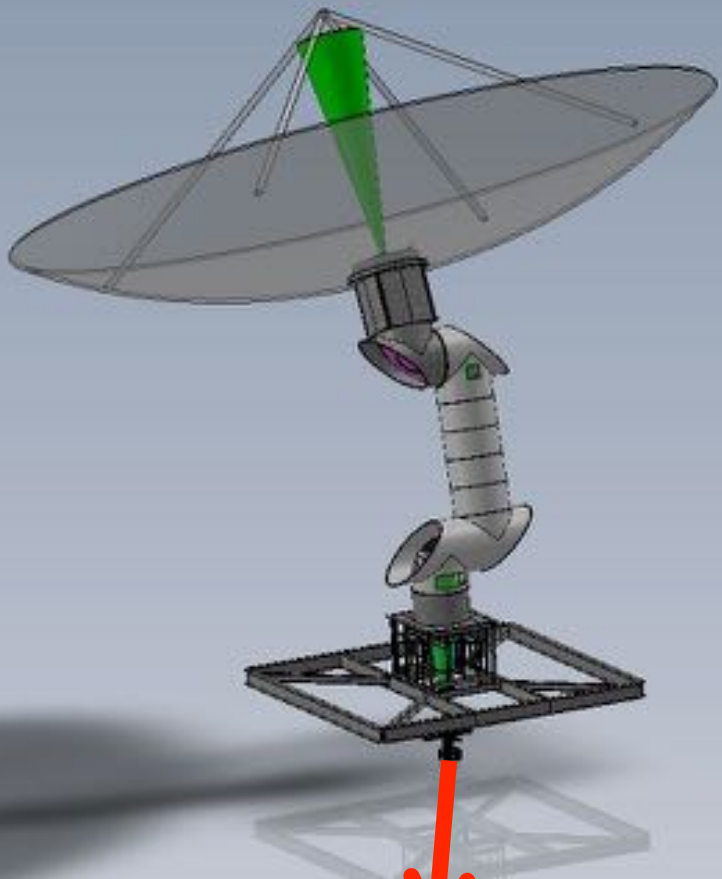
Removal of both elevation and azimuth motors and recording of interface dimensions for MOOG plate design, removal of clutch plates from all 4 motors, temporary protection of interface for gearbox (longer term protection will be required, "grease cakes" in azimuth axle bearing housings (found in all bearings – poor maintenance during operational life).

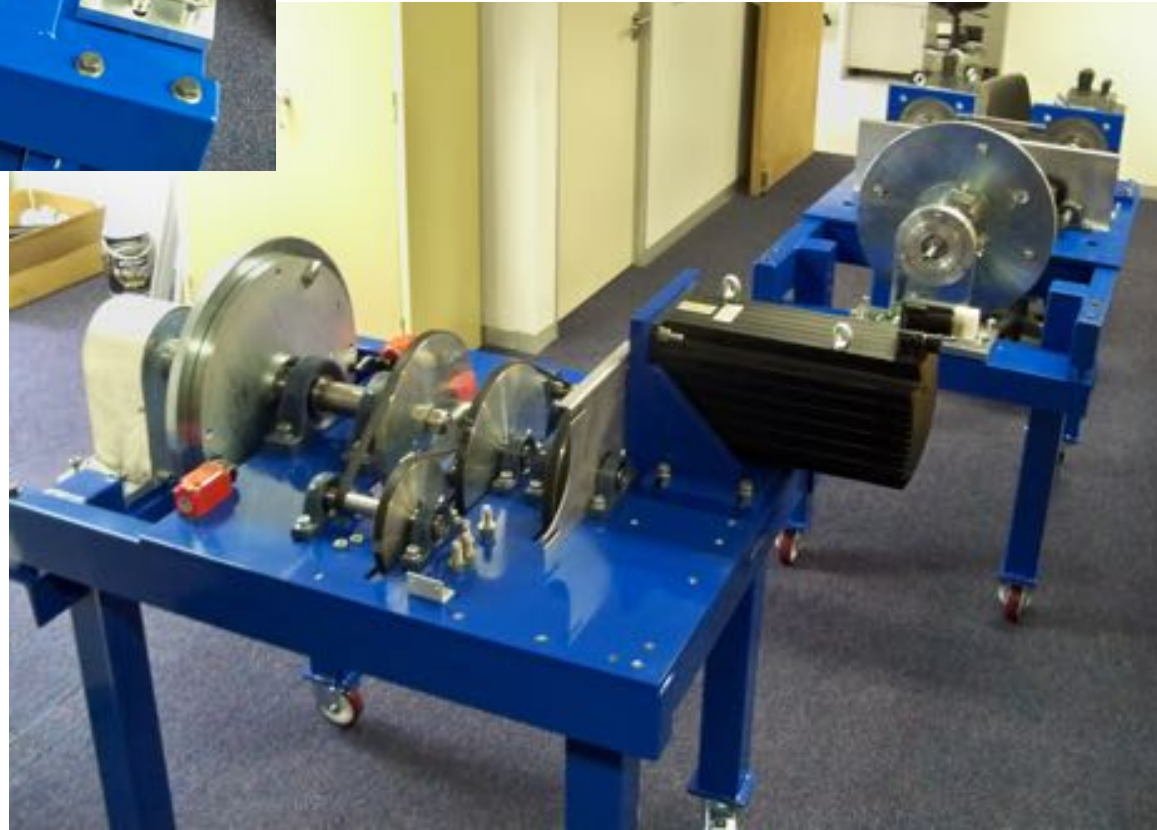




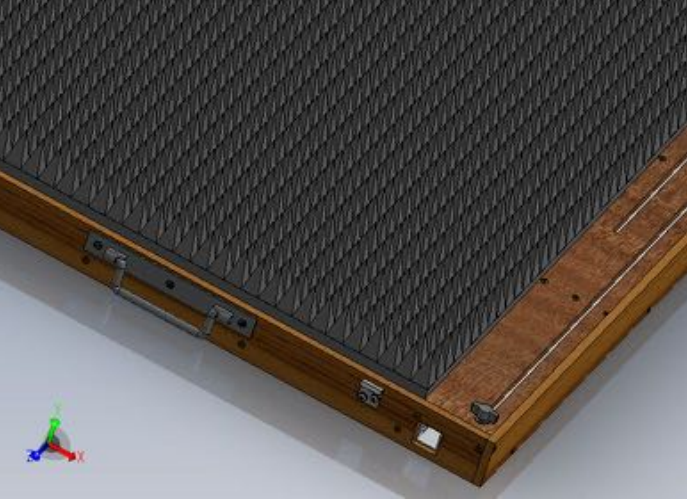
Ghana (March 2015) preparation – checking mirror alignment, replace feed cover and clips, center limit switches, refurbish brakes







The future..





LONGONOT II
THIS ANTENNA WAS OFFICIALLY OPENED
BY
H.E. THE HON. DANIEL T. ARAP MOI, C.G.H.M.P.
PRESIDENT OF THE REPUBLIC OF KENYA
AND
COMMANDER-IN-CHIEF OF THE ARMED FORCES
ON
26th MARCH 1981



Kenya - Nairobi kick-off of the JEDI workshop (November 2013)



Front (ltr): Dr Saara Richter, T.S. Venkatasubramani, Anita Looft, Dr Kaduki (University of Nairobi), Dr Simon Langat, Prof Lydia Njenga (University of Nairobi), Ann Njeri, Dr Zebione Dwitl.
Back (ltr) Dr JB Owour, Dr Nadeem Ozeer, Jephther Dindiki, Evans Muricki, Steven Odaor, Meshack Kinyua, Michael Oluo, Remy Kesa

Insert: Japheth Omondi



Kenya - Nairobi astro-physics graduates who completed the JEDI workshop (November 2013)















**Policy Environment
& Governance**

Sustainability



**Science
Infrastructure**

**Real science
facilities for world
class science**



(Skilled) people

**Collaborate,
collaborate**



**Physical
Infrastructure**

**Basic building
blocks for
knowledge
economies**



Policy Environ
& Governan

Sustainabi



VLBI = SCIENCE + POLITICS

- Science
 - Unique spatial resolution
 - Wide range of astrophysics
- Politics

- Attractiveness of VLBI to policy makers for building international scientific bridge between countries

- Europe, EVN, Radionet, JIVE
- Africa, AVN, SKA
- ERC Synergy Project "Event Horizon Telescope"

- Attractiveness of VLBI in using science for capacity building

- Africa, AVN, SKA-Africa
- Technology development
- Human capacity development

Science
Infrastructure

Real science
for world
science

(Skills

Collaborate,
collaborate



Physical
Infrastructure

Basic building
blocks for
knowledge
economies





George Miley (20 April 2015)
“VLBI = Science + Politics”





The team and the spirit of the AVN



Missing and recognizing the
contributions by Dr Mike
Gaylard, the true champion
for AVN.



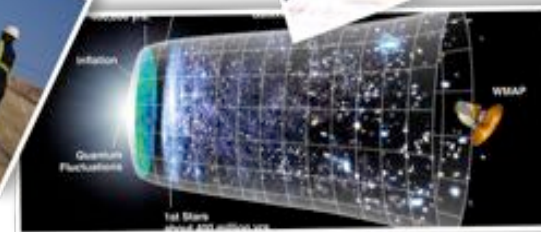
Summary

- AVN is an exciting project of global scientific interest;
- Africa will be ready to host SKA2 stations;
- Holistic approach towards institutional development, capacity building and collaboration critical success factors;
- Not fully funded, but some (new) funding from international institutions for capacity development;
- Collaborations – especially with regards to science – will be welcomed!

Perhaps the future of VLBI will look a bit different from the past, but that only means that exciting times are ahead!



Dankie
Enkosi
Ha khensa
Re a leboga
Ro livhuwa
Siyabonga
Siyathokoza
Thank you



www.ska.ac.za

www.skatelescope.org