SANSA: Services and infrastructure

E Avenant

14 June 2019

History of Hartebeeshoek(HBK) Tracking station

1961-1975: NASA

HBK: SAC

- 1988: LSX, SRSC
- 1994: Launch support
- 1998: Ku/DBS band capability
- 1999: SA first satellite
- 2002: Ka-band capability (first ever Toss)
- 2003: MODIS and NOAA upgrade
- 2004: 5.4m X band antenna
- 2006: SPOT-5 direct reception
- 2010: 7.3m X band
- 2010: SumbandilaSat SA second satellite
- 2010: Established Mission control for Sumbandilasat
- 2010 Established Orbcomm facility

HBK: SANSA

- 2011 Established KSAT facility
- 2012 New Skytrax facility
- 2012 Established new C Band facility for Intelsat
- 2013 Established a new IOT facility for SANSA
- 2015 New CNES HBX ground station
- 2016 QZSS Reference site
- 2017 AVANTI Teleport
- 2018 KSAT Lite, Intelsat C39
- 2019 OneWeb, EGNOS V3

Service offerings at Hartebeeshoek

sansa
SOUTH AFRICAN NATIONAL
SPACE AGENCY

SANSA has four directorates:

- SANSA Space Science (Hermanus)
- SANSA Space Operations (Hartebeesthoek)
- SANSA Earth Observation (Pretoria)
- SANSA Space Program Division (Pretoria)

SANSA Space Operations

Ground station background

- 57 years in the business, reputation as top quality TT&C service provider
- Over 500 supported since 1984
- Frequency Bands: L, S, Ext C, C, X, Ku, DBS and Ka,
- 7 full motion TT&C antennas, 4 Remote Sensing systems
- 24 x 7 operations
- Dedicated Ku-band IOT antenna
- Dedicated IOT test facility
- Earth station verification
- Teleports

Value chain: TOSS, IOT & hosting services

SANSA as a whole – Vision , Mission & Strategy

SANSA Space Operations – Vision, Mission & Strategy

Launch vehicle support

- Lift off to separation
- Position the satellite safely in the correct orbit
- Critical operation

LEOP and TOSS Support

- LEOP: from satellite separating (from the launch vehicle) until satellite is safely positioned in its nominal orbit
- Critical operation

IOT Support

- IOT campaign measures the accuracy and stability of the satellite
- Assessing the quality of the signals
- Results gathered will set a benchmark throughout the satellites' operational life

Routine Operations

- Monitoring TM (currents, voltages, temperatures, status data, etc.) measured by on-board instruments
- Daily supports
- Normal operations
- 24x7

Hosting

- Hosting of space related infrastructure
- Providing maintenance to third party assist
- On-call support for emergency maintenance

End of life De-orbiting

- Manoeuvre satellite from normal position to de-orbit phase
- The satellite needs to burn out or send to graveyard orbit
- Critical operation

Make sure each and every Value Add is accounted for

LEOP Activities

- Pre-launch dataflows in order to verify compatibility of groundstation to mission
- Tracking of Spacecraft providing time stamped antenna pointing information to satellite operator
- Ranging to spacecraft: Providing time stamped distance information from the groundstation to the spacecraft
- Commanding: Relaying commands to spacecraft from ground network, see diagram
- Telemetry: Receiving spacecraft telemetry from the spacecraft for relay to the ground network.

Transfer orbit support

IOT Activities

- Test all subsystems on the spacecraft
- Verify transponder characteristics
- Verify satellite power handling capabilities
- Map antenna footprints from the spacecraft

Antenna Verification

Date	Time (UTC)	EUTELSAT	XDR	Test No.	Remarks
Tuesday 18/03/2014	07:00 – 07:10	E7A	G3	0	Pre-test **{see Note 3}**
"	07:10 – 07:20	E7A	G3	1	Polarization alignment
"	07:20 – 07:50	E7A	G3	3	EIRP (nominal and max. capability)
"	07:50 – 08:30	E7A	G3	2	Transmit XPD
"	08:30 – 10:00	E7A	G3	6	TX sidelobes (co-polar and cross-polar)
"	10:00 – 10:20	E7A	G3	4	G/T
"	10:20 – 11:00	E7A	G3		Contingency

- HBK on behalf of Eutelsat

FAX N.
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Ref.: 5.03. / TAN-DAR-009 — 19 March 2014

From: E Avenant / — - HBK IOT Team

To: Ms/MM. L. Rossi, T. Tran
Fax: +33 1 6388 8741 — - EUTELSAT HQ.

cc: — - HBK
E Avenant Fax : + — - TAN-DAR-009

SUBJECT: ESVA summary test results.

STATUS: EVAL REQ'D — EIRP,XPD,TX sl,G/T

ESVA ref. station (ERS) : AFS-KRU-1
Station Under Test (SUT) : TAN-DAR-009 / Diam:6.3x6.3
Satellite(s) used : E7A
Satellite channels : -(G3) -(-)
Test start-end times (UTC) : 18/3/2014 — 18/3/2014 15:25
Test types : Pretest, Polar alignment(2), Transmit XPD(2), EIRP(2), G/T(1), TX sidelobes(2), RX sidelobes(1)
Applicable test duration : 4.6 hour(s)
Space segment use : Channel -(G3) 3.7 hour(s); Channel -(-) 2.1 hour(s)

TEST 2: Tx XPD

Point :	1	2	3	4	5	6	7	8	9	
x over Y	>40	38.4	36.7	35.3	37.3	38.3	36.8	>40	>40	dB
Y over x										dB
						(I)-	(I)+	Au-	Au+	
Worst isolation from peak to 1dB depointing loss (from antenna pattern cuts)					x over Y	39.0	38.0	> 40	36.0	dB
					Y over x					dB

TEST 3a and 3b : EIRP + TX GAIN

	Co-polar XDR EIRP max	PM n/y	TX gain	Cross-polar XDR EIRP max	PM n/y	TX gain
HPA 1	77.00 dBW	4.2 dBm	57.7 dBi	dBW	dBm	dBi
HPA 2	dBW	dBm	dBi	dBW	dBm	dBi

Expected antenna gain: 57.7 dBi
Theoretical max. EIRP with rated HPA power into antenna flange: 96.45 dBW
Measured/Extrapolated max. EIRP: 77.00 dBW

TEST 4: G/T

	EIRP towards SUT	P2-P1	Bandwidth	G/T
Co-polar	dBW	dB	0 dBHz	dB/K
Cross-polar	dBW	dB	0 dBHz	dB/K
Beacon	dBW	dB	60 dBHz	dB/K

Expected G/T: 35.07 dB/K. Could not be completed: Beacon level too low at SUT

TEST 5: Rx sidelobes
To be sent asap by SUT to ERS and EUTELSAT.

TEST 6: Tx sidelobes
Results under evaluation, see attached raw plots.(Main peak: .. dB over mask at .. degrees in ..)

Weather conditions:
ERS: Light Cloud
SUT: Light Cloud

Regards,
E Avenant /

HBK TOSS and IOT support

Distribution of workload and infrastructure

Operational Workload

Infrastructure distribution

Telemetry Tracking and Command

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

ULA
United Launch Alliance

Telesat

BOEING

eutelsat
COMMUNICATIONS

Intelsat
inspiring connections

inmarsat

UNIVERSAL SPACE NETWORK

EADS
ASTRIUM

ThalesAlenia
A Thales / Finmeccanica Company
Space

इसरो isro

LOCKHEED MARTIN

SPACE SYSTEMS LORAL

NASA

KONGSBERG

BONUM-1

ASTRA

esa

SPACEX

SANSA SO: Site layout

New Oneweb site

SPACE WEATHER: REGIONAL WARNING CENTRE FOR AFRICA

- Monitoring the Earth-Space system, predictions and forecasts
- Distributing data and creating new knowledge
- Only Space Weather Centre in Africa
- Chosen by ICAO to host Space Weather centre for Aviation

INFRASTRUCTURE: SPACE SCIENCE

measuring space from the ground

SANSA Space Science Instruments

GEOPHYSICAL LABORATORY
PROVIDING THE DATA TO INVESTIGATE SPACE

- Ionosondes
- GPS receivers (dual frequency & scintillation)
- VLF receivers
- Doppler Radar
- Magnetometers (variation & pulsation)
- Riometer
- MT Stations
- Radar
- Lidar
- Lightning detectors
- Neutron Monitor

Space Science in Remote Areas

ANTARCTIC AND ISLANDS RESEARCH

- SANSA is part of the South African National Antarctic Programme (SANAP)
- Conducts several on-going space science and space weather related research projects in Antarctica, Marion Island and Gough Island.
- SANSA sends 3 overwintering engineers per year
- 5 months technical training in Hermanus + 1 month survival training in Cape Town
- Engineers spend 14 months in Antarctica and Marion Island
- Space science students have a high chance of doing a relief voyage to Antarctica for 3 months

NASA STDN

ANDOVER
CLARENVILLE
GREENHILL, R.I.
ETAM
GSFC
ROSMAN
BERMUDA
C. KENNEDY
GRAN BAHAMA
(GRAND BAHAMA)
MIAMI
ST. THOMAS
BOGOTA
QUITO
SANTIAGO
TAT-1
TAT-3
TAT-2
TAT-4
TAT-5
OBAN
LONDRES (LONDON)
PARIS
LISBOA (LISBON)
MADRID
CONIL
CANARIA (CANARY)
TANGER
(TANGIER)
C.
VERDE
INTELSAT
V F-2
CABLE DEL
ATLANTICO DEL SUR
(SOUTH ATLANTIC CABLE)
ASCENSION
INTELSAT
III F-3
CEDUNA
TANANARIVE
PERTH
PRETORIA
CIUDAD DEL CABO
(CAPE TOWN)
JOHANESBURGO
(JOHANNESBURG)

Global legacy infrastructure and the options

Resolution of Sensor Portfolio

Importance of sensor portfolio which covers varying spatial, spectral and temporal resolution

- Spatial resolution:
  - Very high resolution eg. WorldView 3 (30cm)
  - High resolution eg. SPOT 5 pansharpened (2.5m)
  - Medium resolution eg. Landsat (15m)
  - Low resolution eg. MODIS (250m), MISR (275m)
- Spectral resolution:
  - 4 bands to 8/9 bands (including SWIR) to hyperspectral
- Temporal resolution:
  - Long term data sets – historic record, eg. MODIS, MISR
  - Near real-time response (eg. fire warnings)

Earth observation constellations: Planetlabs, SkyBox, Drones

September 2018, the company had launched a total of 298 satellites, 150 of which were still active

Amazon AWS ground stations

Amazon AWS ground station

Mosaic product

now dependant on spot 2.5m res mosaic

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agriculture
Department:
Agriculture
REPUBLIC OF SOUTH AFRICA

Statistics South Africa
Preferred supplier of quality statistics

the dplg
Department:
Provincial and Local Government
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF SCIENCE AND TECHNOLOGY
REPUBLIC OF SOUTH AFRICA

DBSA
Development Bank of Southern Africa

defence
Department:
Defence
REPUBLIC OF SOUTH AFRICA

environment & tourism
Department
Environmental Affairs and Tourism
REPUBLIC OF SOUTH AFRICA

Eskom

water & forestry
Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

Flood monitoring using SumbandilaSat

Fire burn scars monitoring

Water quality assessment- eutrophication

Informal settlements change detection

Search and Rescue (SAR)

- Each vessel has transponder
- With Galileo a return channel exist to acknowledge call
- Position information also relayed

LEOLUT Diagram

Satellite: AIS(Automatic identification system)

Uses LEO Constellation
Commercial offering
Differnet satellites has receivers
Example: Orbcomm
Combine this info with SAR data to discern between 'friendly' and dubious traffic

AIS as a commercial service

Satellite: ADS-B

- Uses Iridium Next constellation
- Upper airspace management
- MH370?

- ADS-B as a commercial service

GNSS + SBAS
GNSS
No integrity
Time to Alarm, Response Time
30 s
10 s
5 s
2 s
1 s
Geodesy
Precise Maritime positioning
Rescue
Rescue
Fleet Mangt
Oceanic
Terminal
En Route
Inland waterways
Precise Farming
Rail Surveillance
Harbour approach
Rural Tracking
NPA
Transport Urban
Utilisation Urbaine
PA
Rail Guidance
CAT 2/3
Maritime Collision
Terminal Docking
Space
Horizontal accuracy

Satellite Navigation

- January 2009 Initial EU-SA Space Dialogue South Africa
- February 2010 – Nov 2011 ESESA
- July 2010 Joint Program Office, SANSA Establishment
- February 2012 – September 2013 SATSA
- Joint Statement signed by EC VP Tajani and RSA Minister Naledi Pandor 21-3-2012
- July 2012 EU-SA Space Dialogue meeting: Task force established
- January 2013 Task Force Document
- February 2013 GLUG workshop
- September 2013 SATSA Final Dissemination event
- January 2014 Conclusion of GNSS contribution to EU-SA Dialogue
- April 2015: SBAS Africa

Augmentation

Different kinds of augmentation

To improve accuracy

- –Differential GPS (DGPS)
- –Real Time Kinematic (RTK)
- –Wide Area Corrections
- –Hybridization

To provided added value as integrity

- –Receiver Autonomous Integrity Monitoring (RAIM)
- –Ground Based Augmentation Systems (GBAS)
- –Space Based Augmentation Systems (SBAS)

SBAS (Space based augmentation)

>Ground Monitoring Station (GMS) network

- Use of TRIGNET stations while installing dedicated stations

8U Rack

Installed GNSS reference stations

System Performance: Accuracy

Horizontal Accuracy (95%)

Vertical Accuracy (95%)

	Horizontal	Vertical
Accuracy (95%)	~ 1m	~ 2m
Integrity Protection Levels	10m – 16m	18m – 25m
Integrity Time to Alarm	< 6 s	
Availability	> 99.5%	
Continuity	$< 5x10^{-4}$	

ECLAYR v9.1.1, Produced by GMV

Applications

- Personal Navigation
- Aviation
- Maritime Navigation
- Road Transportation
- Fleet Management systems
- Asset tracking

- Professional Applications
  - Survey
  - Power Grid
  - Oil drilling Rigs
  - Telecommunications
- Emergencies and Welfare
  - Search and Rescue
  - Epidemiology
  - Assistance to the blind
  - Mapping emergencies

- Farming and Fishing
  - Monitor and quality control
  - Precision Agriculture
  - Fishing
  - Electronic herding

Applications

- Science

Ionosferics studies

Plate tectonics

Troposferic studies

Sea altitude

Wildlife studies

Radiotelescope synchronization

Precision agriculture, General Aviation trials

Courtesy Pildo Labs

Courtesy of GMV

Static and drone trials: 0.5m horizontal accuracy 1.75m vertical

Courtesy of Haevic

SBAS	2D (m)	3D (m)
95%	0.49	1.28
99%	0.52	1.57
100%	0.56	1.75

GPS	2D (m)	3D (m)
95%	2.01	4.5
99%	2.40	5.71
100%	5.31	10.43

Artemis

Integrated Exploration Manifest: 2019-2024
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
Sustainable Low-Earth Capability
Commercial Crew Test Flights and Certification
ISS MCB (transition)
LEO Commercialization Studies
Other LEO Commercialization Activities (in work):
Multi-Agency Working Group (through NSpC)
ISS Capabilities Pricing Policy
Government LEO Research Policy (through NSpC)
LEO Commercial Capabilities Solicitation
Development/Procurement Starts Now (2019)
Sustainable Lunar Orbit Staging Capability
AA-2
EM-1
EM-2
CLV
CLV w/fug
EM-3
3 CLVs
NextSTEP Hab ground prototypes complete
Sustainable Lunar Surface Exploration
Enhanced Science and Exploration Capability
Human Lunar Landing
CLPS opportunity
Candidate Tech Insertion Opportunities
NDL
NDL ISRU
NDL, ISRU, & HPSC
HPSC, NDL, ISRU, haz. detection, CFM, & TRN
Predecisional - For NASA Internal Use Only

Matjiesfontein(MJT): Deep Space Communications

Figure 4: View toward proposed Matjiesfontein site from main road

Figure 5: View from proposed main site towards main road and town of Matjiesfontein

Areas of interest in Matjiesfontein

Deep Space: SANSA

Geodecy: SARAO

Development adjacent to Matjiesfontein

Site requirements:

Land ownership
Environmental Impact Assessment
Site Accessibility
Backhaul Connectivity
Geological
Mechanical infrastructure
Power Requirements
Fire protection
Environmental
Security
Maintenance

SANSA Terrestrial communication infrastructure

- The estimated dark fibre route distance is 120KM with provision for repeater station when needed.
- DWDM Technology is used to transmit/multiplex/Demux different wavelengths on a single fibre pair
- Provide access to 10Gbps capacity per channel
- Provide access to more than 80 Network Operations at Teraco Johannesburg
- Teraco is the first provider of resilient, outsourced, vendor neutral data centre environments in South Africa

Continental space application projects

- Use the concept of co-location in order to maximise use of resources
  - Technical know how
  - Security
  - Power
  - Communication
- GNSS: SBAS
- EO: Global numerical weather prediction input data

Countries with consolidated space programs in Africa

Algeria Space Agency – Algeria

South African Space Agency – South Africa

National Space Research and Development Agency – Nigeria

Egypt Space Agency – Egypt

Kenya Space Agency – Kenya

Zimbabwe National Geospatial and Space Agency – Zimbabwe

Gabinete de Gestao do Programa Espacial Nacional – Angola

The Royal Center for Remote Sensing Space – Morocco

Ghana Space Science and Technology Centre – Ghana

Libya Center for Remote Sensing and Space Science – Libya

National Remote sensing Center (NRSC) – Sudan

Tunisia Space Agency – Tunisia

Agence Gabonaise d'Etudes et d'Observations Spatiales (AGEOS) – Gabon

Ethiopian Space Science and Technology Institute – Ethiopia

STATUTE OF THE AFRICAN SPACE AGENCY

The main objectives of the African Space Agency are to promote and coordinate the implementation the African Space Policy and Strategy and to conduct activities that exploit space technologies and applications for sustainable development and improvement of the welfare of African citizens.

ADOPTED BY THE THIRTIETH ORDINARY SESSION OF THE ASSEMBLY, HELD IN ADDIS ABABA, ETHIOPIA ON 29 JANUARY 2018

How to reach SBAS implementation in Africa

- Several scenarios available for SBAS in Africa,
- No «best option» fixed yet
- Allowing EU users to benefits from SBAS services in Africa with best compromise between services (L1 legacy/DFMC), schedule and costs
- Not impacting on EGNOS services for Europe

SBAS current initiatives in Africa

- Four modules have been identified for Africa by JPO:
  - Northern (M1),
  - West-Central (M2),
  - Eastern Africa (M3),
  - Southern (M4)

SAWIDRA RARS

Current RARS coverage

THE SATELLITE AND WEATHER INFORMATION FOR DISASTER RESILIENCE IN AFRICA (SAWIDRA) PROJECT

Regional Retransmission Services (RARS) for Africa

Inter-regional connection (EARS & RARS Africa)

Location are indicative

SAWIDRA-RARS

- 4 RARS stations (X/L Band)
- Operationally independent from EARS but complementary
- Detailed network architecture need design study (telecomm, central facility)
- Sustainability is key: hosting conditions, maintenance and operational aspects (telecom) are a driving factor for cost and thus sustainability

Project lead by ACMAD with funding from ADB

Astronomy
SKA AVN
Geodesy
GNSS
EO(GIS)
SpaceScience
Ionosphere
&
Space Weather
Operations
Satcomms
Applications
Applications
Applications

SPACEOPS 2020

THE 16TH INTERNATIONAL CONFERENCE ON SPACE OPERATIONS

18 - 22 MAY 2020 | CAPE TOWN INTERNATIONAL CONVENTION CENTRE

CAPE TOWN, SOUTH AFRICA

MDM	**Mission Design and Management**
OC	**Operations Concept**
FE	**Flight Execution**
GSE	**Ground Systems Engineering**
DM	**Data Management**
PS	**Planning and Scheduling**
GNC	**Guidance, Navigation, and Control**
CAN	**Communications Architectures and Networks**
HSO	**Human Spaceflights and Operations**
CSIS	**Cross Support, Interoperability, and Standards**
HFT	**Human Factors, Training and Knowledge Transfer**
STO	**Space Transportation System**
AI	**Artificial Intelligence for Space operations**
CYB	**Cyber Security for Space Operations**
SSU	**Safety and Sustainability of Space Operations**
BBO	**Beyond Borders in Human Endeavour**

- Call for Papers imminent
- www.spaceops2020.org
- Close for abstract submission 16 Aug 2019

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