

Session 3: Geodetic & Space Infrastructure in Africa: summary notes

GGOS-Africa 2026 Workshop, Nairobi · Monday 5 October 2026 · 15:49–17:03 EAT

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Written from the Zoom transcript. Audience speakers' names are given only where they could be identified with reasonable confidence. Survey figures are as presented; the full report has the definitive numbers. Please check against the recording before quoting anyone.

Key points

- **The GGOS-Africa infrastructure survey (46 respondents, 22 countries) found CORS networks in most countries, mostly government-run.** Space-geodetic techniques are very sparse: South Africa (HartRAO) has the only active VLBI and SLR on the continent, and DORIS is active only in Djibouti, Gabon and South Africa.
- **The reference-frame landscape is fragmented.** Countries use many ellipsoids (WGS84, Clarke 1880 variants and others) and ITRF realisations from ITRF2000 to ITRF2020.
- **VLBI simulations show any new African fundamental site improves global products.** One station can improve some EOPs by about 12%. Gains level off after about 5 well-spread stations and saturate at about 10. An Africa-only network would need **at least 10 stations**.
- **The simulation tools and results will be released publicly**, with per-country follow-up studies to be done in collaboration with national representatives.

Talks

Godfrey Ogonda: Geodetic Infrastructure in Africa (GGOS-Africa survey)

- The survey has two parts: infrastructure (presented today) and human and computational capacity (Session 8, Wednesday).
- **Aim:** document what already exists so GGOS-Africa can build on it (“we are not starting from zero”).
- **Method:** desktop review (including UN sources), a structured questionnaire and field visits.
- **Respondents:** 46 from 22 countries. Most were directors in government departments, plus academics, practitioners and private companies. Nigeria had the most respondents (9).
- **GNSS / CORS findings:**
 - CORS exist in most countries assessed. About 91% are government-run and about 9% private.
 - Some countries charge for services; most (about 64%) provide them free.
 - Typical station spacing is 50–100 km. Some networks are sparser (100–200 km) and some denser (under 50 km).
 - Services are mainly data and post-processing. Few offer RTK. A few provide gravity, height or geoid modelling.
- **VLBI:** only one active station (HartRAO, South Africa). Nigeria is building one, and Namibia, Botswana and Ghana report plans.
- **SLR:** only one active station (South Africa).
- **DORIS:** active in Djibouti, Gabon and South Africa; others are planned.
- **Reference frames:**
 - Ellipsoids include WGS84, Clarke 1880 and Clarke 1880 (modified), and in one or two cases International 1924.
 - ITRF realisations range from ITRF2000 (a few countries), through ITRF2008 and ITRF2014 (the majority), to ITRF2020 (a few).
- **Recommendations:**
 - Treat existing CORS as building blocks, but improve them to deliver real-time (RTK) and post-processing services reliably.
 - Upgrade stations to IGS/GGOS standards and guidelines.
 - Form regional cooperation first, then harmonise and link to the IGS.
 - Match the growth in CORS with comparable effort on VLBI, SLR and DORIS.

- The data have gaps, for example countries missing from the maps. Absence from the map does not mean no infrastructure.

Roelf Botha: Space Geodesy in Africa: Identifying New Fundamental Sites

(Work with Marisa Nickola, VLBI operations scientist; GGOS-Africa project work package 3: simulation and strategic planning for infrastructure)

- **What fundamental sites are.** They co-locate VLBI, SLR, GNSS and DORIS within a few kilometres, linked by local survey. VLBI is the only technique that ties the terrestrial frame to the celestial frame (quasars) and determines UT1 and nutation. Co-location lets the techniques “calibrate each other’s rulers”.
- **The southern sky problem.** The celestial reference frame (ICRF) has far fewer sources in the south because few VLBI telescopes are in the southern hemisphere. More southern dishes, including in Africa, would densify it.
- **Starting point.** Site geography for VLBI comes first (radio interference, bedrock, low horizon, away from large water bodies, within reach of power, roads and fibre). Next, which of those sites suit SLR (clear skies, high elevation, little light pollution or air traffic). GNSS and DORIS are less restrictive. Requirements follow the GGOS site-requirements document.
- **Method:**
 - One plausible good site per country.
 - Three network scenarios: *current* (the international VGOS network plus HartRAO), *near future* (adds sites nearly complete, such as Nigeria) and *far future* (adds planned or funded sites).
 - Simulations in **VieSched++**: 24-hour R1/R4-type EOP sessions, 1000 Monte Carlo runs per test site, adding one African site at a time.
 - Outputs: mean formal error and repeatability for the EOPs (polar motion x and y, UT1–UTC, nutation) and station coordinates, expressed as a percentage improvement over the baseline.
- **Results:**
 - **Adding any African site improves global products.** For example, one station improves the x-pole formal error (baseline 3.9 μ s) by about 12%.
 - Contributions differ by parameter and scenario; the far-future scenario is the most relevant.
 - **About 5 well-spread stations** is the turnover point; the network saturates after **about 10**.
 - Monitoring the **Nubian–Somalian plate boundary** is currently poorly served and should be a priority.
- **Africa-only (“continental sovereignty”) scenario.** Africa’s large north–south extent is a unique advantage.
 - With 5 stations, x-pole precision is about 10–12 times worse than the international network.
 - With 10–12 stations it approaches international levels; y-pole and nutation results are better still.
 - UT1, the hardest parameter, needs long east–west baselines. Further simulations are planned, for example with stations in the far north–west, Mauritius and Somalia.
 - Conclusion: **at least 10 stations** for an independent African EOP product.
- **The “dream”:** an African SBAS, and eventually an African GNSS constellation.
- **Next steps:**
 - Continental heat maps (geology, weather and other layers) and multi-criteria decision analysis.
 - Release the Python scripts and data packs into the public domain.
 - A full report early next year.
 - After the project: **per-country site studies** in collaboration with national representatives, who have local knowledge (geology, roads, fibre). An open invitation to collaborate.
- **Practical lesson:** small details decide projects. For example, at the Namibian EHT site, building a road up the mountain would cost more than the telescope.

Interactive discussion

- **GGOS candidate and core sites (Nigerian participant).** They described the rigorous process behind Nigeria’s GGOS candidate-site approval: simulations, RFI measurements, GNSS data quality analysis and geological and soil investigations. They plan to reapply for core-site status now that their VLBI project is nearly complete. They asked again whether GGOS-Africa will set its own membership criteria or classes.
 - **Botha:** GGOS-Africa is a collaboration and knowledge-sharing body. Applications and decisions stay with GGOS. Membership is open to any interested country through its government, with no technical

prerequisites. Its value is in sharing experience of the core-site process, which HartRAO is also going through for a second site. Standardised public tools (for example a ready-to-run virtual machine) would let any country simulate its own candidate sites.

- **Jack Radcliffe:** the simulation work comes from the UK-funded foundational project and is being offered to GGOS-Africa as policy input. GGOS-Africa supports core-site applications but does not set global standards.
- **Why Nigeria “disappears” from later maps.** In the near- and far-future scenarios, Nigeria’s station is assumed operational and becomes part of the baseline (which improves from about 11.6 to 10.6 for that parameter). It is not simulated as a test site.
- **Is an Africa-only VGOS network realistic, given GNSS-only Africa isn’t achieved yet?**
 - **Radcliffe:** a VGOS station costs about US\$3M plus operations. The viable route is **dual use**: geodesy plus astronomy plus space situational awareness. That brings multiple stakeholders, public–private partnerships, and the option of selling telescope time (for example spacecraft tracking) within the African space ecosystem.
 - **Botha:** HartRAO uses **hosting agreements** on cost-recovery terms. Russia (via BRICS) operates a laser-ranging station there and the US operates equipment too. It is the only site where both operate side by side. South Africa got the data and expertise without spending about R350M (about US\$25M) on its own SLR. Science should look beyond short-term geopolitics. Good, well-characterised sites attract partners: GNSS first, then SLR, then VLBI.
- **Ionosphere and solar cycle (question).** Why do equatorial sites show less improvement, and were ionospheric or solar-cycle effects modelled? Botha said 24-hour sessions average out many variations. The pattern depends on the parameter: southern sites help polar motion most because southern coverage is sparse, while equatorial sites help UT1. A detailed technical evaluation is still needed.
- **SBAS cost.** Botha said an SBAS would likely need AU-level effort and international partners. South African colleagues are involved in SBAS testing.

Close of Day 1: Tuesday sessions run as programmed but must finish by 15:00 for the Nairobi National Park excursion. Participants should bring identification documents.

Actions and follow-ups mentioned

- Full simulation report, scripts and data packs to be released publicly, with the report due early next year.
- Countries interested in per-country site studies to contact Roelf Botha.
- Clarify in the ToR how GGOS-Africa membership relates to GGOS candidate and core sites.
- Human-capacity part of the survey: Session 8, Wednesday.