Modernizing national geodetic networks: Some experiences in Africa

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SUMMARY

United Nations emphasizes geodesy's role in sustainable development, urging countries to adopt modern, accurate, and accessible geodetic reference systems. In Africa, Uganda and Senegal recently modernized their networks with support from IGN FI, integrating GNSS/CORS stations and upgrading physical markers to align with the international ITRF framework.

Key Achievements

In Uganda (2017–2025) were Installed 40 permanent CORS stations, 426 1st/2nd-order markerswere rehabilitated , and the new UGRF reference system was adopted. Phase 2 (2023–2025) expanded coverage, ensuring redundancy in urban areas.

Senegal (2023–2026)16 CORS stations were deployed, integrated both private/public networks, and the RRS04 system was retained for continuity with historical data. Both projects used Bernese software for high-precision calculations.

Challenges & Solutions

Sustainability: Skills transfer and public-private partnerships were prioritized to maintain infrastructure. Local teams received training in network management and data processing.

Business Model: A collaborative approach balances free and paid services, ensuring financial viability while fostering user trust. Senegal's next phase aims for nationwide

coverage.

Impact

Modernized networks enable precise land administration, urban planning, and border management, supporting economic development. Future work focuses on governance structures and innovative funding to ensure long-term operation and national sovereignty.

United Nations has underscored the critical role of geodesy in sustainable development, calling on member states to establish modern, precise, and universally accessible geodetic reference systems. In Africa, where rapid urbanization and land management demands are growing, Uganda and Senegal have pioneered the modernization of their national geodetic infrastructures with technical support from IGN France International (IGN FI). These projects highlight the importance of GNSS (Global Navigation Satellite Systems) and CORS (Continuously Operating Reference Stations) in creating robust, future-proof geodetic frameworks that align with global standards while addressing local needs.

Project Overview and Objectives

The primary goal was to rehabilitate and upgrade national geodetic networks by:

Installing new permanent GNSS stations (CORS) to form a zero-level reference network.

Integrating existing public and private stations to ensure comprehensive coverage.

Rehabilitating physical geodetic markers (1st and 2nd order) to maintain historical continuity.

Establishing geodetic databases and secure web portals for data dissemination, including RINEX files and RTCM streaming for real-time applications.

Linking national systems to the International Terrestrial Reference Frame (ITRF) for global consistency.

In Uganda, the project unfolded in two phases (2017–2020 and 2023–2025), resulting in 40 new CORS stations and the rehabilitation of 426 physical markers. The country adopted a new reference system (UGRF) to replace outdated frameworks, ensuring compatibility with modern geospatial technologies. Senegal, meanwhile, deployed 16 CORS stations (2023–2026) and retained its RRS04 reference system—a 20-year-old ITRF-based framework—to preserve consistency with existing spatial data while integrating private stations for broader coverage.

Both projects utilized Bernese scientific software for high-precision data processing, ensuring that coordinates were calculated in the latest ITRF realization. Historical networks were also recalculated in the new reference frames, with velocity models applied to account for tectonic shifts. This approach guarantees centimeter-level accuracy, essential for applications like land administration, urban planning, and infrastructure development.

Technical and Operational Challenges

Reference System Transition:

Uganda opted for a completely new system (UGRF) due to the absence of a modern framework, while Senegal retained RRS04 to avoid disrupting historical records.

Stakeholder engagement was

crucial, as adopting a new system requires buy-in from surveyors, planners, and government agencies. Technical committees in both countries evaluated risks and benefits to ensure smooth adoption.

Sustainability and Skills Transfer:

Local capacity building was a cornerstone of the projects. IGN FI provided targeted training for national teams in network management, data processing, and maintenance, ensuring long-term operational autonomy.

A control center was established in each country to monitor station performance, perform quality checks, and distribute corrected data to users. These centers are equipped with servers, secure storage, and 24/7 operational tools to guarantee reliability.

Public-Private Collaboration:

Both countries recognized the value of integrating private CORS stations into the national network. Uganda's Phase 2 expanded coverage to 28 additional stations, improving redundancy in urban areas.

Senegal's initial phase laid the groundwork for future expansion, with plans to include more private stations through public-private partnerships (PPPs)—a model essential for financial sustainability and network density.

Business Model Innovation:

A gradual, collaborative pricing strategy was developed to balance free access (e.g., for public services) with paid premium services (e.g., high-precision positioning for commercial users).

This approach aims to build user trust while ensuring the network's financial viability, addressing the growing demand for geospatial services.

Strategic Impact and Future Prospects

Modernized geodetic networks are foundational for national development, supporting:

Land security and cadastre management, reducing disputes and improving tenure clarity.

Urban and regional planning, enabling precise infrastructure development.

Border management and national security, through accurate territorial mapping.

Climate resilience and disaster management, by providing reliable spatial data for risk assessment.

The projects also emphasize the need for clear governance structures to manage network expansion, maintenance, and funding. Uganda and Senegal are now exploring innovative economic models to sustain operations, including user fees, partnerships, and government funding.

The experiences of Uganda and Senegal demonstrate that modernizing geodetic infrastructure is not just a technical upgrade but a strategic investment in a country's socioeconomic future. By combining cutting-edge technology, stakeholder collaboration, and sustainable business models, these nations have positioned themselves as leaders in geospatial innovation in Africa. Future efforts will focus on scaling coverage, refining data services, and strengthening institutional frameworks to ensure that geodetic networks remain a pillar of national sovereignty and development.