GNSS measurements by Jean-Claude Poyard ©IGN

ONE CONTINENT, ONE REPRESENTATION

IGN FI, IGN FRANCE AND UNECA LOOK AT PROGRESS ON AFREF, A COMMON GEODETIC REFERENCE FRAME THAT CAN BE USED BY ALL THE COUNTRIES IN AFRICA

Geodesy has long been a specialist field. It was first of all used to understand the Earth's shape and dimensions, then to position ourselves in the best way possible on the Earth's surface.

But while rich countries started to create networks that enabled them to position points homogeneously across their entire territory down to the nearest decimetre, African countries remained with just a few astronomical points the accuracy of which could only be counted in decametres for many years.

As André Nonguierma, SIG expert for the United Nations Economic Commission for Africa, says: "The heterogeneity of technical approaches used by the various countries was a real hurdle in terms of the need for analysis and regional planning. It was therefore essential to rapidly obtain a good model for global representation of the Earth's surface which would allow us to clearly describe the geometric shape of objects as well as reference altitudes for the planet's surface."

The AFREF (African Geodetic Reference Framework) was created in 2002 as part of the GGRF (Global and National Geodetic Reference Frames), a worldwide project that aims to create between now and 2030 a common geodetic reference frame that can be used by all the countries in Africa. In its present form, the AFREF project consists of a network of permanent global navigation satellite systems (GNSS), spread over the whole continent so that any potential user is always within 1,000km of the nearest reference station.

But the countries' need for a transnational reference frame has become even more evident in recent years with the creation of regional project funders who are looking to open up access to certain countries and improve the mobility of goods and people between different African countries; also factors are the adoption of the Programme for Infrastructure Development in Africa (PIDA) and a call from the African Union of African States to delimit their borders between now and 2017.

IGN FI's geodetic expert Cyril Romieu looks back over the various technical advancements that have made the AFREF project possible. "It is of course the introduction of the first satellite positioning systems in the 1970s followed by the GPS system at the end of the 80s which will enable the creation of reference systems (mainly geographical institutes and mapping agencies) technically possible and more financially accessible. Modern GNSS technology now allows access to any national reference via several means: materialised networks using terminals, permanent GNSS stations distributing data via internet, PPP (Precise Point Positioning) type positioning.

"The technological progress made in topography varies widely from one African country to another, more than on any other continent. It is therefore crucial to ensure that a national reference system is accessible not only by the most advanced users with GNSS receivers in real-time GSM mode, for example, but also for those still using traditional angular measurement techniques and an optical method."

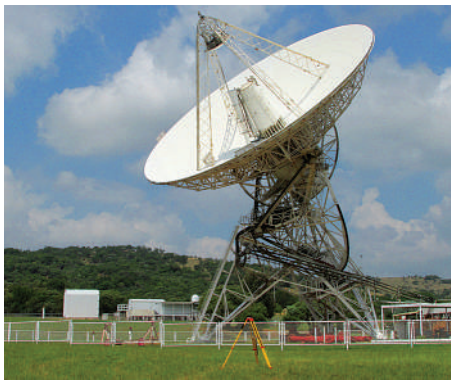
Access to a national reference system should then be possible via either networks with a density that varies according to the location (very dense in urban areas to allow single access for all users, much

GNSS measurements in Cotonou (Benin) ©IGN

Training on GNSS techniques in N'Djamena (Chad) ©IGN

Scintrex gravimeter (Sudan) ©IGN

Metrology of lunar laser ranging (LLR) by Georgia Roesh (South Africa) ©IGN



VLBI antenna in Hartebeeshtoek (South Africa) ©IGN

more spread out in rural areas where the developer is responsible for hooking up to the national reference system when specific projects are put in place) or through a network of permanent stations according to the number of GNSS receivers that local technical operators possess and how well they use internet networks.

The first step

The first step at present is to establish a network of permanent stations before having the possibility to create a materialised network, which shall be adapted according to the anticipated needs. GNSS technology and the existence of international networks today make it possible to gradually build up a reference system by establishing an initial station then progressively adding to the number of stations out in the field whilst remaining coherent with the stations that have already been put in place and with the GGRF (Global Geodetic Reference Frame) worldwide reference system adopted by the United Nations General Assembly on February 26 last year, including AFREF as the African branch. The best way to enable neighbouring countries to work together and ensure harmonious regional development is to implement the AFREF.

Having participated in all the geodetic projects on which IGN FI has worked, Cyril Romieu's view is that several factors must be taken into account right at the start of projects in order to ensure their success: "Firstly, it is important to carefully dimension an infrastructure for calculation, archiving and in particular, diffusion; one that is capable of managing all future stations and has trained personnel able to manage and maintain these networks. IGN's National School of Geomatic Sciences is often called on for this type of work in order to reinforce skills in organisations and companies abroad."

The second factor relates to links with previous networks, Romieu says. "It is important to integrate a few old geodetic points within the new reference system, if possible. It is in this field that Circé, the software developed by the geodetic and levelling department at IGN, can be very useful as it converts geographic or cartographic coordinates from one system

GNSS and DORIS stations co-located in Libreville (Gabon) ©IGN

into another. However, recent experience has proved that even though the new reference is defined and positions are often accurate to within a few centimetres, the fact that older networks are far less precise does not always allow transformation parameters to be calculated ensuring metric accuracy in relation to the older systems which are integrated into the new reference systems."

Romieu says the final factor is that all satellite positioning systems have the same weakness: "They are totally incapable of providing an altitude above that of the average sea level, which is an important piece of data to possess. The only possibility then is using a model which enables the value provided by GNSS technology to be transformed into an altitude comparable to that of sea level. Global models do exist: their average accuracy is 15cm to 20cm, with high points that can easily reach 80cm to 1m in Africa. It is therefore essential to develop regional or national models which enable a greater level of accuracy at altitudes down to a few centimetres, as is the case for Europe or all industrialised countries. These models require a lot of effort to create as they must combine GNSS measurements, accurate levelling and even gravimetric measurements as well as sophisticated calculation techniques."

In practice

The importance of geodesy in the development of the African continent has now been taken into account and a few countries have moved ahead with their work on the subject. This is the case for Senegal, for example, a country that started taking advantage of the project to update its 1:200,000 scale national maps right from the beginning of the 2000s, with the objective of harmonising its national geodetic network,

Altimetry tie of the Dakar recording tide gauge (Senegal) ©IGN

Levelling training (Senegal) ©IGN

the Senegalese Reference Network. This consists of 20 new fundamental points spread country-wide, as well as 17 old geodetic points recalculated using Circé.

The Government of Cameroon has more recently made the renewal of its national geodetic network a priority within its action plan for the 2010/2020 period and as part of a vast project covering land reform and modernisation of its cadastral plans. The country has invested in the update of its national geodetic reference network.

Until now, Cameroon only possessed local networks in each town that were neither inter-linked nor unified nationally. This meant that the existing networks were incompatible with modern positioning networks and, in particular, with GPS. Cameroon's Ministry of Land Affairs led the project to implement a national geodetic network in 2011. Some other countries, such as Sudan along the Nile Valley, had created more local networks. At the same time, they have ensured they are compatible with international networks so as to be able to widen and modernise their networks in the future without modifying their references. A geoid model with an accuracy of 100km along the Nile valley was also created in such a way that it could be easily and coherently integrated into a sub-regional or sub-continental model at a later date.

Progress so far

Although implementation of the AFREF was a little slow at the beginning, progress on the project has been regular and noticeable since 2006 – there were 65 international GNSS service stations by the end of last year, compared to just 15 stations in 2005. However, raising the awareness of politicians and funders as to the importance of using geodetics remains difficult and is a subject at the heart of the problems faced by an emerging African continent: planning land-use, the land sector, mining, environment, agriculture, climatic changes, sustainable development and so on.

Raising awareness is more important than ever, as the benefits of having implemented a geodetic reference system will be crucial for the African continent: improving demarcation of border limits and in particular helping African states to come to a credible compromise, improving cooperation and cross-border connections, the possibility of accessing accurate spatial information alongside numerous other preoccupations such as the environment, climatic change, land tenure, aerial navigation and even national defence.

THE BENEFITS OF HAVING IMPLEMENTED A GEODETIC REFERENCE SYSTEM WILL BE CRUCIAL FOR THE AFRICAN CONTINENT

Article co-written by IGN FI (www.ignfi.com), IGN France (www.ign.fr) and the United Nations Economic Commission for Africa (www.uneca.org)