

**CALL FOR PARTICIPATION**

**in the**

**UNIFICATION OF AFRICAN REFERENCE FRAMES**

**The AFREF Project**

**2005-2010**

Committee on Development Information, *Geo-Information Subcommittee*  
(CODI-GEO)

United Nations Economic Commission for Africa (UNECA)

<http://geoinfo.uneca.org/afref/T>

**Endorsed by:**

**International Association of Geodesy (IAG)**

**International Global Navigation Satellite System Service (IGS)**

**United Nations Office of Outer Space Affairs (UNOOSA)**

**Federation of International Surveyors (FIG)**

**August 2005**

## Contents

- Executive summary-----3
- Call for Participation (summary)-----4-5
- Areas of participation (details)-----6-9
- Background of AFREF (detailed description)----- 10-14
- References -----15

# THE UNIFICATION OF AFRICAN REFERENCE FRAMES, THE AFREF PROJECT

The Committee on Development Information (CODI) of the United Nations Economic Commission for Africa (UNECA) supports AFREF as the unified geodetic reference frame for Africa and as the fundamental basis for the national and regional 3D reference networks fully consistent and homogeneous with the International Terrestrial Reference Frame (ITRF) Standards.

## Executive summary

There are more than 53 countries in Africa each with its own geodetic reference frame based on reference systems and datums that are in some cases over 100 years old. As a result of these disparate reference frames and associated geospatial information, the planning and execution of cross border development projects is exceptionally difficult and becomes a somewhat haphazard exercise. The AFREF project, therefore, has been designed to unify many national co-ordinate reference frames of Africa into a single reference frame based on the internationally accepted International Terrestrial Reference System (ITRS) and its realization, the International Terrestrial Reference Frame.

In broad terms, it is planned that a network of Continuously Operating GPS Reference Stations (CORS) will be established such that any user will be within 500km of any one station and have free access to the data generated by that station. The network will create a zero order or fiducial reference frame based on ITRF from which local campaigns may be conducted to densify the network. The densification will be either at the national or regional level to create denser networks of CORS or short campaigns to create networks of permanently marked reference points from which further project-based campaigns shall be conducted.

The project will also include the unification and development of a continent wide vertical reference frame based on a single datum, using internationally accepted practices of geoid estimation.

A major concept of the project is that it must be designed, managed and executed by African countries with the assistance and advice of the international geodetic community. This will enhance the skills of African geodesists, surveyors and researchers in geodesy and the applications of Global Navigational Satellite Systems (GNSS) and Global Positioning System (GPS) in particular.

The project will be run primarily under the auspices of the Committee for Development Information - Geo- Information, (CODI-GEO) of the United Nations Economic Commission for Africa (UNECA). It has the support of international organisations and bodies such the United Nations Office for Outer Space Affairs (UNOOSA), the International Association of Geodesy (IAG) and its service organisations including the International GNSS Service (IGS), the International Earth Rotation and Reference System (IERS), and Global Geodetic Observing System (GGOS)

## CALL FOR PARTICIPATION (Summary)

Support is sought from all interested and capable organisation and institutions in the establishment of a modern and unified African reference and coordinate system-AFREF

### Areas of Participation

Participation is requested in the following areas:

- Tracking station networks and Centres;
- GNSS hardware and software, ancillary equipment, communications infrastructures;
- Data Centres;
- Analysis Centres, Associate analysis Centres;
- Coordination Centres;
- AFREF affiliated professional bodies;
- Capacity building resources;
- Support of international geodetic and related scientific bodies; and
- Financial and in kind support.

### Letter of Intent

Organizations interested in submitting a proposal in response to this Call for Participation should send a Letter of Intent to:

Dr Chukwudozie Ezigbalike  
United Nations, Economic Commission for Africa  
Team leader Geo information Development services Division, CODI IV  
P. O. Box 3001, Addis Ababa, Ethiopia  
Telephone: +251 1 44 45 69  
Fax: +251 1 51 05 12  
E mail [ezigbalike.uneca@un.org](mailto:ezigbalike.uneca@un.org)  
Web page: <http://geoinfo.uneca.org/afref/>

This letter should include the following information:

- Organization name and address;
- Name, address, and telephone and fax numbers of the principal point of contact; and
- Specific areas of support.

Letters of Intent must be received on or before 21<sup>st</sup> October 2005. Material in these letters will be for information purposes only and will not be binding on the signatories. Those organizations responding will if required receive additional documentation and information to enable them prepare their proposals for participation.

### General proposal information

Proposals submitted in response to the Call for Participation must include specific details on the technical, professional, logistic, infrastructure or financial support that will be offered by the organization. Proposals must be signed by an official authorized to certify institutional support, sponsorship and management of the proposed activities.

Proposals are due on or before 16th December 2005 at the addresses provided above. Due to the importance of the project, groups may join at any time afterwards during the life of the Project. However, a Letter of Intent will be necessary for groups willing to join after the closing date.

## **Project Plan & Time Line**

The following is an outline project plan for initial implementation phase of AFREF until January 2007.

- Letter of Intent to be received by 21<sup>st</sup> October 2005;
- Participation proposals to be received by 16<sup>th</sup> December 2005;
- Review of the participation proposals by AFREF Steering Committee during the proposed AFREF technical meeting to be held in January 2006 in Cape Town, South Africa
- Demonstration of initial concept phase to be completed with streaming of first AFREF GNSS data - January 2007.

## 1.0 Areas of Participation (details)

The AFREF Project Steering Committee, through this call for participation, solicits support for the establishment of the African Reference frame (AFREF). The participation is open to a broad range of organizations. National Mapping Organizations (NMOs), Universities and research organizations dealing with earth and environmental sciences including geo informatics, seismology, geophysics, meteorology etc in Africa are expected to participate. It's expected that international organizations, such IERS, IGS, IAG, and FIG, whose aims and goals are similar to those of AFREF, though global in nature, are expected to participate. The scope of the participation is not limited to any area of support. However, support should be consistent with capabilities and interests. Following are some of the identified areas requiring support;

- Tracking station networks and Centres;
- GNSS hardware and software, ancillary equipment, communications infrastructures;
- Data Centres;
- Analysis Centres, Associate Analysis Centres;
- Coordination Centres;
- AFREF affiliated professional bodies;
- Capacity building resources;
- Support of international geodetic and related scientific bodies; and
- Financial and in kind support.

### 1.1 GNSS data acquisition stations

Support is sought for participation in the establishment of data acquisition stations which shall form the AFREF network whose observations shall be used to meet AFREF objectives. The data networks shall be categorized as core Continuous Operating GNSS Reference Stations (CORS) GNSS network, National GNSS networks and levelling Networks.

#### **Core CORS GNSS networks**

A continental network of Continuous Operating GNSS Reference Stations (CORS) will be required to meet the basic requirements of the wide use and applications of GNSS technology for sustainable development in Africa and the needs of the global scientific community. The stations must provide sufficient coverage with inter site spacing and location to optimize its practical use in support of both the scientific and social goals. Windhoek Declaration proposed inter-site spacing and distribution of at least 500Km and at least one station for every African state. The AFREF network shall be integrated with the existing IGS network which is sparse (see IGS network in Africa-Fig.1) for the realization of a common and modern GNSS-based reference frame. The core CORS system shall form the AFREF network which shall be continentally distributed, of high quality tracking sites and with continuous, reliable operation and near real time data acquisition and dissemination to data holding/processing centres. The CORS network is expected to be established according to the guidelines adopted by IGS.

#### **National GNSS networks**

National GNSS geodetic networks are also expected to be established by each African country to meet AFREF objectives at national level including differential correction broadcasting to field GNSS users and daily data provision to users requiring post processing for precise applications. The network could be a CORS system in combination with a more dense permanent non-CORS GNSS coordinated sites. These are to be used to determine the relationship between the national geodetic systems with respective GNSS systems and ITRF in order to refine the transformations parameters between them.

### **Levelling networks**

Connect national and core GNSS sites with national levelling networks integrated with gravity measurements. Such shall be used to determine geoid models and undulations from the various GNSS systems.

#### **1.1.1 Tracking stations networks and Centres**

This call goes to organizations willing to provide suitable sites to establish and operate Continuous Operating Reference GNSS Stations (CORS) and disseminate the acquired GNSS data to data holding /analysis centres. The support is limited to organizations within Africa with stable power and suitable communication facilities. The organizations participating in the provision of the sites shall be responsible in the GNSS data acquisition and disseminations to the data holding /analysis centres.

#### **1.1.2. Hardware and software, ancillary equipment, and communication infrastructure**

This calls to organizations willing to provide GNSS hardware and software; as well as ancillary equipment needed to implement Core CORS stations for locations where funding and resources for capital investment are limited. These shall include, but not limited to geodetic GNSS (See GPS) multi-frequency receivers, GNSS dissemination and precise processing software, precise clocks, meteorological instruments and suitable computers.

GNSS products developers and manufacturers are particularly encouraged to provide cost subsidies on their products.

Donor community and African development partners are also encouraged to give support directly to AFREF Steering Committee, national governments and international AFREF supporting organizations. National governments are also encouraged to source funding from donor communities via national project proposals.

### **1.2. Data Centres**

Support is requested from organization with capability to implement and maintain a data centre for data from core CORS stations. Such organization may refer to the IGS '*IGS Data Centres Charter*' which includes duties such as collecting data from GPS tracking stations and ancillary equipment; data validation; permanent archival; providing online availability; and transmittal to and equalization with other data Centres. Such Centres are expected to provide for open access to IGS data and products by IGS participants and all external users. The online archive of GNSS data available through the AFREF Data Centres should include:

- Daily files of GNSS/GPS data at a 30-second sampling rate;
- Hourly files of GNSS/GPS data at a 30-second sampling rate if available; and
- High-rate, low-latency GNSS/GPS data as available.

All data should be available in RINEX format, both Hatanka-compacted and Unix (.Z)-compressed. The data archive should also include broadcast ephemeris and meteorological RINEX files.

Current IGS data centres, regional Centres and earth science research institutions in Africa are particularly encouraged to participate. National working groups are expected to nominate suitable national institutions to act as national data Centres for National GNSS geodetic networks.

### **1.3. Analysis Centres, Associate Analysis Centre**

Willing organizations are invited to participate as AFREF Analysis Centres. Analysis Centres shall be processing data from AFREF core CORS network in order to calculate and make available products consistent with the AFREF objectives. Initially, the list of products may include, but not be limited to, the following;

- Precise satellite orbits, satellite clock estimates, station coordinates baseline lengths, earth orientation and reference frame information, atmospheric modelling, assessment reports on data and product quality, and geoid modelling.

Analysis Centres are expected to use data from the core CORS for IGS Global GNSS integration. The centre may directly collect data from core CORS GNSS tracking sites.

National working groups are expected to nominate suitable national institution to carryout data analysis duties for national GNSS geodetic networks.

### **1.4 Coordination centre and regional centres**

Proposals are sought for participation as Coordinating Centre responsible for the implementation of AFREF across a number of supporting organizations responsible for data acquisition and management, product development and distribution.

The Coordinating Centre is envisioned to consist of a coordinator in charge of the coordination of AFREF for smooth implementation at all levels. The coordinator will be a member of the Steering Committee and the principal AFREF project interface with the steering committee, regional and national working groups and international supporting organizations including IAG/IGS/IUGG, FIG and UN OOSA etc.

The Coordinating Centre will be responsible for all the functions critical to the overall success in the implementation AFREF and shall also function as the Secretariat of AFREF.

Existing regional Centre are expected to coordinate the implementation in their member States.

### **1.5 Capacity building resources**

Most African countries may not have qualified human resources necessary to implement and manage AFREF sustainably. Suitable person from regional centres and other appropriate African organizations shall be trained on station installation, data handling and dissemination, and precise analysis based on IGS standard using scientific GNSS processing software. The trained persons shall organize and carryout same training programs at their Centres and build capacity of other participants in African countries.

Participation is sought from training and research institutions within Africa to organize and provide training venues.

Development partners are invited to provide finances to meet travel, accommodation and training expenses to the participants and resource persons.

Participation is also sought from international scientific and professional organizations and research institutions to provide the required capacity building needs including resource persons.

### **1.6 Industry partners**



Partners in industry are sought to assist with acquiring and implementing the necessary equipment and technical support for Project AFREF, such as GPS receivers and antennas, station computers, power supply, monumentation hardware, analysis computers, software, communication infrastructure, internet accesses, etc.

### **1.7 Financial support for mass acquisition of GNSS hardware & software**

To realize AFREF project, funds and support will be needed both to initiate and sustain the activities. Funding assistance is essential. In-kind support for any of the areas is similarly requested.

Participation is therefore sought from development partners to provide finances for mass acquisition of GNSS hardware and software required in AFREF, particularly in the establishment of the GNSS CORE CORS network.

Support for the establishment of National GNSS networks may be sought through the call for participation and project proposal at national level. The national working groups led by national mapping organizations are expected implement this.

## 2.0 BACKGROUND ON AFREF (Detailed description)

### 2.1 Introduction and background

According to United Nations Economic Commission for Africa (UNECA) Committee on Development Information (CODI), the African Geodetic Reference Frame (AFREF) was conceived as a unified geodetic reference frame for Africa to be the fundamental basis for the national and regional 3D reference networks, fully consistent and homogeneous with the International Terrestrial Reference Frame (ITRF) Standards. ITRF is the global reference frame system for the earth as adopted by the International Association of Geodesy (IAG).

When fully implemented, it will consist of a network of permanent GPS stations, continuous or otherwise, such that a user anywhere in Africa would have free access to GPS data and products, and would be at most 1000 km from such stations. Its full implementation will include a unified vertical datum and shall support efforts to establish a precise African Geoid.

The concept of a unified geodetic datum for Africa is not entirely new. An effort was made in the 1980s to establish a unified datum using satellite techniques via the African Doppler Survey (ADOS) project. The ADOS project was started in 1982 and was completed in 1986.

Realizing a unified geodetic system throughout Africa is fully aligned with the principles and objectives of the New Partnership for Africa's Development (NEPAD), a vision and strategic framework for Africa's renewal. <http://www.nepad.org/2005/files/inbrief.php>.

### 2.2 Justifications & benefits

Any application, service or product requiring geo-referencing requires a coordinate reference system. Cross border national, regional, continental and global geo-referenced applications, services and products require a uniform coordinate reference system. Most regions and nations have different coordinate reference systems. Similarly some countries such as Kenya use different coordinate reference system, some based on local origin. This makes geo-referenced applications, services, and products difficult. This, therefore, calls for the establishment of a common and uniform continental reference coordinates system.

All African countries have started embracing the use and applications of Global Navigation Satellite System (GNSS) technologies particularly Global Positioning system (GPS) in the various geo-information applications, services and products. GPS is a satellite based positioning system developed by USA as a follow-on global navigation system to replace the TRANSIT system. While originally is envisioned as primarily for military use, it has been used by the civilian users all over the world and was formally declared a dual-use system by US Presidential directive in 1996. Geodetic System 1984 (WGS84) coordinates system. WGS 84 system is a modern, global and uniform coordinate system best fitting the earth. The International Terrestrial Reference System (ITRS) is the global terrestrial reference system officially adopted by the International Association of Geodesy (IAG). The WGS84 reference system of GPS, which is widely used in the world and Africa as stated earlier, is now identical to ITRS at centimetre level. GPS technology may therefore be used in the implementation of AFREF.

GPS technology is very accessible, precise, economical and sustainable. Most GPS products do not require the user to have in depth knowledge of its technology as their production is application based with user in mind. With the increased use and application of GNSS (read GPS) and the requirements to relate the GPS solutions with the already existing mapping products based on local and national coordinates reference systems, there is an urgent need to establish

and determine the transformation data to and from such systems to GNSS reference systems. This will be achieved on full realization of the AFREF project.

The priority areas of NEPAD for sustainable growth of Africa require maps and other geographic information products for effective planning and efficient implementation of relevant and appropriate projects. Geographic information products provide the link between all activities and the places or locations where they happen. Everything that happens actually happens somewhere. Activities are therefore not complete without the information about the location where they will be implemented. Traditionally, this information has been presented in form of maps, but with the recent technological advancements, they are now presentable in digital formats using digital mapping techniques. Geo-information (geomatics) scientists including surveyors and other mapping and planning professionals will not be able to produce maps and other geographic information products on which all planning is based without the use of an established reference frame and coordinate system.

Countries have traditionally maintained their own reference frames resulting in maps which are not edge-matched properly at the borders. Apart from increasing the potential for misunderstanding and conflicts, this situation makes it difficult for countries to share information and to work on joint plans and projects. Information on one country's maps could not be easily referenced to that on another country's maps. As we move towards regional integration, and adopt regional approaches to peace and security, environmental management, trade and industry, we need maps that are continuous across national boundaries. This shall be possible via a common and modern reference frame and coordinate system, such as AFREF.

The realization of AFREF has vast potentials for geodesy, mapping, surveying, geo-information, natural hazards mitigation, earth sciences, etc. Its implementation will provide a major springboard for the transfer and enhancement of skills and knowledge in surveying, geodesy and especially Global Navigation Technologies (GNSS) with its applications.

The international framework, of which AFREF will be a part, is a prerequisite for many multi-disciplinary applications. The International GNSS Service (formerly the international GPS service-IGS), a service of the IAG, supports a number of projects and applications dependent on the robust reference systems that are thriving at both global and regional levels. The classic IGS products, based on the global network provide information to generate global plate motion maps, enable strain and fault motion monitoring for earthquake hazard research and support dense regional GPS networks. This fundamental reference system can further increase the understanding of complex earth science systems and assist and facilitate in solving regional and global problems.

A key outcome of the AFREF project will be the transformation parameters from AFREF to local frame on which currently most geo referenced products including maps are based. Conversion of all national surveying and mapping products may be converted to the same common reference system (AFREF). A practical outcome of this will be the ease with which cross-border and regional geo-referenced projects can be carried out. In addition to scientific project applications, this will include projects for the development of agricultural schemes, road, rail, power line construction or eradication of disease, hazard mitigation, etc.

Satellite positioning techniques have the potential for long-term climate monitoring, ground-based weather forecasting, long-term sea level trends at the millimetre level, and low-Earth orbiting satellites with on-board GPS receivers which will contribute to much greater understanding of the earth's gravity field and atmosphere, ionosphere mapping and research, precise timing and time transfer. With a uniform geodetic system throughout the continent, the applications of GPS promise increasing benefit to society through greater understanding of earth science systems. GPS is used in many locations to monitor crustal deformation phenomena,

such as earthquakes, volcanoes, tectonic motions and subsidence along coastal regions. Crustal deformation monitoring studies for Eastern African Rift Systems for disaster preparedness and management is an example of studies which will greatly benefit from AFREF project. Few UN coordinated studies on the East African rift systems are already taking place in Kenya, Ethiopia, and Egypt.

### **2.3 Objectives of AFREF**

The primary goal of the AFREF project is:

*To unify the horizontal and vertical geodetic reference systems, datums and references frames in Africa in support of the ideals of NEPAD.*

(For the ideals of NEPAD see "The New Partnership for Africa's development (NEPAD)" October 2001 <http://www.nepad.org/2005/files/home.php>)

The objectives of the AFREF project to support this broad goal have been identified as follows:

- Define the continental reference system of Africa. Establish and maintain a unified geodetic reference network as the fundamental basis for the national 3-d reference networks fully consistent and homogeneous with the global reference frame of the ITRF;
- Realize a unified vertical datum and support efforts to establish a precise African geoid, in concert with the African Geoid project activities;
- Establish continuous, permanent GNSS stations such that each nation or each user has free access to, and is at most 500km from, such stations, with the total number per country to be determined.
- Provide a sustainable development environment for technology transfer, so that these activities will enhance the national networks, and numerous applications, with readily available technology;
- Understand the necessary geodetic requirements of participating national and international agencies; and
- Assist in establishing in-country expertise for implementation, operations, processing and analyses of modern geodetic techniques, primarily GNSS.

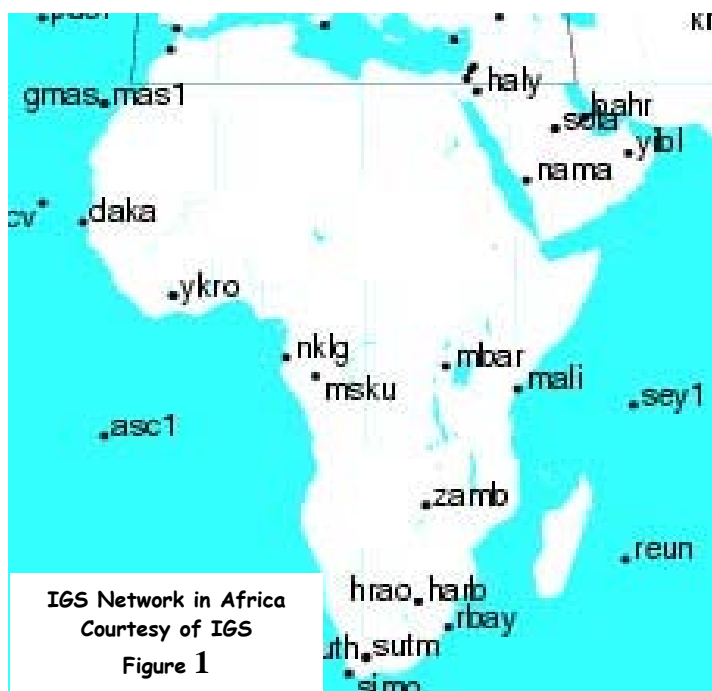
Added to these objectives is the underlying principle that the project should be planned, managed and executed by the African countries with technical assistance and support from the international geodetic and GNSS community, sponsors of geodetic science, including manufacturers and vendors of appropriate technology.

### **2.4 Scope AFREF Activities**

A sparse CORS GNSS network exists in Africa which contributed significantly to the IGS and is established and managed by African entities and partners. Figure 1 shows the current distribution in Africa. Densification of IGS networks with its products in Africa is the first step toward the realization of AFREF. The densification requires that at least one GNSS CORS is established in every African country. Such a network of CORS shall form the basis of and act as focal points for the establishment of national GNSS networks. Where possible, more than one such station shall be established in a country. The network so established shall form the AFREF core CORS GNSS networks which shall be integrated with IGS global network.

The densification of Core CORS GNSS network, largely on a country-by-country basis, to determine the relationship between the national geodetic systems, GNSS geodetic systems including GPS, GLONASS, & Galileo and the ITRF, and to refine the transformation parameters

necessary to relate the national systems to ITRF shall follow. The densification shall be carried out by individual countries by way of establishing national GPS networks through either continuous or semi continuous permanent GNSS/GPS stations. However on full realization of AFREF, every country shall have a CORS GNSS network with capabilities to fully serve varied national needs and provide other useful products to users, e.g., broadcasting differential corrections.



Also important are the development of a more refined geoid model for Africa and the definition of a common vertical datum for the continent. This shall also be done on country basis with regional and continental coordination.

For the project to be realized, African countries are expected to actively participate by establishing tracking sites, data holding and analysis centres, with the necessary equipments and personnel for smooth and sustainable implementation and management.

## 2.5 Management and operation

Figure 2 shows the proposed management structure for AFREF. The Steering Committee (SC) is responsible for the over all management and coordination on the implementation of AFREF as described in its Terms of Reference (TORs). It draws its membership from the Regional Centres in Surveys and Mapping technologies, IAG through the commission on reference frames and Africa, and AFREF implementation regions as listed herewith;

1. Regional Centre for Mapping of Resources for Development(RCMRD), the Director General, Dr. Wilbur K Ottichilo, Chair;
2. African Organisation of Cartography and Remote Sensing(AO CRS), the General Secretary ;
3. Regional Centre For Training In Aerospace Surveys(RECTAS), the Director General, Dr. Jide Kufoniyi;
4. International Association of Geodesy(IAG) sub commission on Reference Frames , Africa(SC 1.3d), Chaired by Mr. Richard Wonnacott;
5. NAFREF represented by head of National Surveys & Mapping Organisation, Tunisia;
6. EAFREF represented by Director of Surveys & Mapping, Mr. Lazarus Mollel, Tanzania ;
7. WAFREF represented by head of NMO, Nigeria;
8. SAFREF represented by Director of Surveys & Mapping, Dr. Karim Owolabi, Namibia; and

9. CAFREF represented by head of NMO, Congo Brazzaville.

The regional bodies dealing with earth sciences, including surveying, mapping, geodesy, space sciences and geo-information in Africa are expected to play a large role in the coordination and implementation of AFREF. However they may require expressing their interests in the participation.

For AFREF to make impact in poverty alleviation and sustainable African development, national and regional working groups shall be formed. The working groups shall have a wide and relevant participation as possible including representation from national mapping organizations, academics and research institutions, transportation, communication and professional bodies.

At national level, National Mapping Organisations (NMOs) are expected to spearhead the formation of an all-inclusive national working group (comparable with NSDI structure).

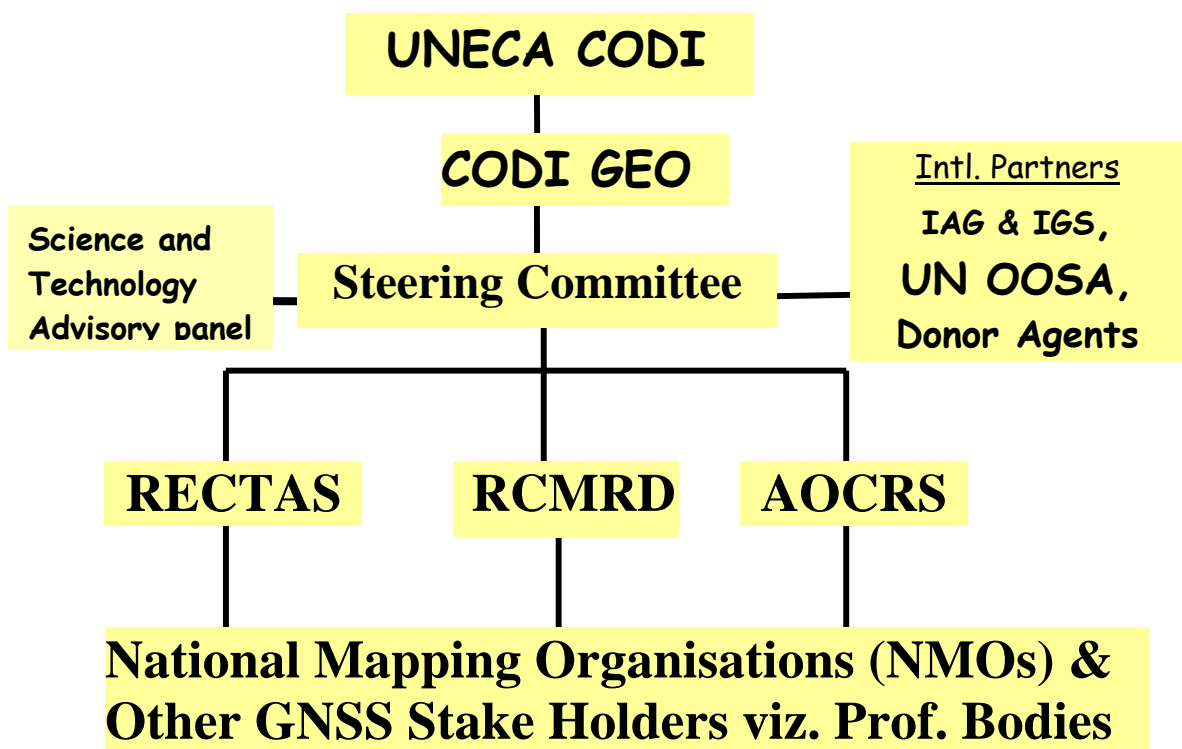


Figure 2: Management Structure

## 3.0 REFERENCES

### 3.1 Literature references

1. Windhoek declaration, formulated during RCMRD Governing Council meeting Windhoek, Namibia. November 2002.
2. Proceeding of AFREF workshop held during RCMRD Governing Council (GC), Windhoek, Namibia. November 2002.
3. Proceeding of AFREF workshop during AARSE Conference held RCMRD, Nairobi, Kenya. October 2004
4. Proceeding of AFREF meetings held during FIG/GSDI Conference, Cairo, Egypt. April 2005
5. AFREF proposal to International Council of Science (ISCU), prepared for IUGG/IAG by Ms Ruth Neilan, Director, IGS Central Bureau, USA and Mr. Richard Wonnacott, Director, Survey & Mapping South Africa. March 2002
6. Call for participation for IGS, prepared by IAG. February 1991
7. Call for participation for GLONASS service, Pilot project, Prepared by IGS. May 2000

### 3.2 Web site references

AFREF <http://geoinfo.uneca.org/afref>  
IAG <http://www.iag-aig.org/index.php>  
IGS <http://igscb.gpl.nasa.gov/index.html>  
EUREF <http://www.euref-iag.net>  
HartRAO <http://www.hartrao.ac.za/geodesy/>  
CODI <http://www.uneca.org/codi/codi4>  
RCMRD <http://www.rcmrd.org>