AFRICAN GEODETIC REFERENCE FRAME (AFREF)-NEWSLETTER

Secretariat: Regional Centre for Mapping of Resources for Development (RCMRD)

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Introduction

The purpose of this newsletter is to create a forum for discussions and exchange of information and experiences in the implementation of AFREF. The objective of the AFREF initiative is to unify and modernize the the national and regional geodetic reference networks in Africa. When fully implemented, it will consist of a network of continuous, permanent GPS stations such that a user anywhere in Africa would have free access to the generated data .

I am pleased to welcome you to read the ninth edition of the AFREF newsletter. In this issue we report on the AFREF workshop held in Addis Ababa during CODIST1 meeting. Some information on GNSS Augmentations Systems available in Africa and the GNSS systems under development, Europe's GALILEO and China's COMPASS are presented.

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AFREF Workshop Held at CODIST Meeting

A workshop on AFREF was held on 29th April 2009, during the first Committee on Development Information, Science and Technology (CODIST) meeting held in Addis Ababa, Ethiopia. More than 40 delegates from African countries attended the workshop. The aim of the workshop was to involve the community of AFREF stakeholders in defining the next steps to move the project forward. The main objectives were:

- Provide updates on the status and on-going activities of the AFREF Project.
- Review of the project objectives and milestones
- Present, discuss and adopt the correct methodologies for the future computing of the first AFREF coordinates solution
- Discuss and endorse the implementation plan proposed by ECA and AUC,

On the status of AFREF, it was reported that the demonstration phase of AFREF started in 2007. The objective of this phase is to show the installation, operation, data dissemination and analysis capabilities. The following countries have already established at least one Continuous Operation GNSS Reference Stations (CORS); Algeria, Egypt, Mozambique, Ghana, Kenya, Benin, Botswana, Morocco, South Africa, Namibia, Zambia, Ivory Coast, Uganda, Malawi, Ethiopia, Nigeria, Mauritius, Tanzania, Niger, Cameroon. Some data from the established CORS is already being received by HartRAO data Centre in South Africa and the International GNSS Service (IGS). The next phase is to densify the CORS and compute and realize the Africa Reference Frame that can be adapted by African Countries.

A report was presented on the best approaches and methodologies to compute the first AFREF solution that will be used by African countries as a basis for their national geodetic networks. Case studies that can support the implementation and maintenance of AFREF as a regular service were presented. Issues related to data access, distribution, and quality control were also discussed. Specifications for receivers, other hardware components, monuments and data policy were provided to the participants. The role and functions of data holding and computing centres were discussed. The retrieval of ephemeris data and access to GNSS archives at IGS centres were also presented.

Finally a report was given on the implementation plan proposed by Economic Commission of Africa(ECA) and African Union Commission(AUC), placing particular emphasis on the proposed management structures, formalizing coordinating arrangements between the various partners and stakeholders, and building capacity in Africa for the successful implementation of AFREF.

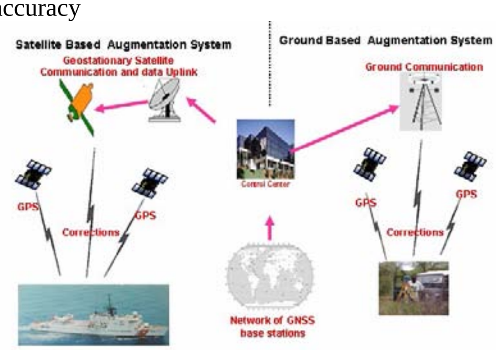
AFREF and GNSS data processing Training to be held at RCMRD, Kenya

A two-week AFREF and GNSS data processing training will be held at RCMRD from 24th[th] August to 4[th] September 2009. The purpose of the course is to provide technical skills on satellite geodesy and GNSS technologies concepts, establishment of GNSS base stations, GNSS data processing including online processing.

The target groups are Land surveyors, Geodesist, Engineers, Researchers and Cartographers from African countries with some experience in Global Navigation satellite System (GNSS) technologies. (Contact muyack@rcmrd.org for details).

Augmentation System Services available in Africa

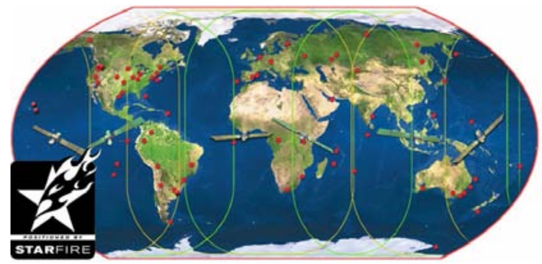
GNSS Augmentation System Service improves the accuracy of the GNSS satellite navigation system. Normally satellite's positioning accuracy is impeded by errors in its clock and signal delays caused by atmospheric conditions. Augmentation system compensates for those discrepancies by transmitting corrections to the GNSS receivers either via satellite or terrestrial radio thereby improving the normal of ±15m to decimeter accuracy



An augmentation system uses earth stations that have been very carefully surveyed, and their exact locations are known with great precision. As they receive signals from the GNSS satellites, they are compared with the values they should be receiving, and the differences are used to calculate corrections. The corrections are transmitted either to the GNSS receivers via geostationary satellites or terrestrial radio. Satellite Based Augmentation Systems(SBAS) include the Wide Area Augmentation System(WAAS), operated by the US Federal Aviation Administration (FAA), The European Navigation Overlay Service(EGNOS), operated by the European Space Agency, The commercial Starfire Navigation System, operated by John Deere and the commercial OmniSTAR DGPS System, operated by Fugro.

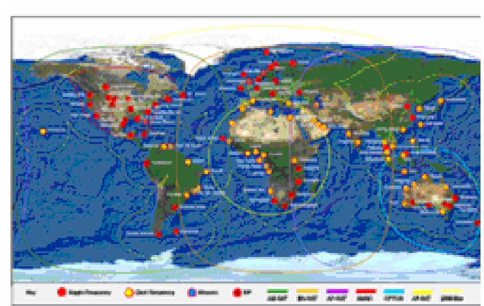
Star Fire DGPS service

Star Fire™ is a privately owned subscription based Global Satellite-based Augmentation System (GSBAS) that provides decimetre (typically 10cm) positioning accuracy on a worldwide basis, allowing users to roam freely while maintaining the most precise positioning information.



To accomplish this, Star Fire™ utilizes a network of more than 60 GPS reference stations around the world to compute GPS satellite orbit and clock corrections. Two completely redundant processing centers and multiple communication links ensure the continuous availability of StarFire™ GPS corrections. These corrections are broadcast via three geostationary satellites, providing worldwide coverage and enabling precise real-time navigation without the need for local ground base stations. Source; NAVCOM Technologies, USA(www.navcomtech.com/StarFire/)

OmniSTAR



OmniSTAR like starfire, is also a privately owned, subscription based GSBAS via three geostationary communication satellites, three satellite uplink stations and two network control centres. The corrections are computed from over 100 stations. Currently, three levels of service are offered including "VBS" which offers sub-meter positioning, "XP" achieves better than 20 centimetres, and "HP" is better than 10 centimetres.

New GNSS Systems under Development

Galileo GNSS

Galileo is a Global Navigation Satellite System(GNSS) currently being built by the European Union (EU) and European Space Agency (ESA). It will be an alternative and complementary to the U.S. Global Positioning System (GPS) and the Russian GLONASS. It's expected to be fully operational by 2013. When in operation, it will have two ground operations centers, one in Germany, and another in Italy.

Galileo is intended to provide more precise measurements than available through GPS or GLONASS(Galileo will be accurate down to the meter range) including the height above sea level, and a better positioning services at high latitudes. The political aim is to provide an independent positioning system upon which European nations can rely even in times of war or political disagreement, since Russia or the USA could disable use of their national systems by others (through encryption).

Like the US GPS, use of basic (open) Galileo services will be free for everyone. However, more qualified services will be accessible with pecuniary or military restrictions.

Galileo constellation will consist of 30 satellites orbiting the earth at an altitude: 23,222 km in 3 orbital planes inclined at 56° with each orbit having 9 operational satellites and one active spare. There will be four different navigation services available namely Open service, Commercial Service, Public Regulated Service (PRS) and Safety of Life Service (SoL).

The **Open Service** (**OS**) will be free for anyone to access and will broadcast in two bands, at 1164–1214 MHz and at 1563–1591 MHz. Receivers using both bands shall achieve an accuracy of <4 m horizontally and <8 m vertically while those that use only a single band will achieve <15 m horizontally and <35 m vertically, comparable to what the civilian GPS C/A service provides today.

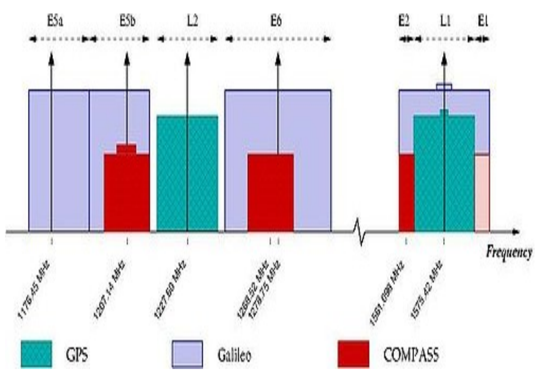
The encrypted **Commercial Service (CS)** will be available for a fee and will offer an accuracy of better than 1 m. The CS can also be complemented by ground stations to bring the accuracy down to less than 10 cm. This signal will be broadcast in three frequency bands, the two used for the OS signals, as well as at 1260–1300 MHz.

The encrypted **Public Regulated Service** (**PRS**) and **Safety of Life Service** (**SoL**) will both provide accuracy comparable to the Open Service. Their main aim is robustness against jamming and the reliable detection of problems within 10 seconds. They will be targeted at security authorities and safety-critical transport applications. In addition, the Galileo satellites will be able to detect and report signals from Cospas-Sarsat search-and-rescue beacons in the 406.0–406.1 MHz band.

Compass GNSS

COMPASS is a Global Navigation Satellite System(GNSS) currently being developed by China Academy of Space Technology, which is part of the China Aerospace Science and Technology Corporation .

COMPASS will consist of a constellation of 35 satellites, which include 5 geostationary orbit (GEO) satellites and 30 medium Earth orbit (MEO) satellites, that will offer complete coverage of the globe. The ranging signals are based on the CDMA principle and have complex structure typical to GALILEO or modernized GPS. Similar to the other GNSS, there will be two levels of positioning service: open and restricted. The public service shall be available globally to general users. When all the currently planned GNSS systems are deployed, the users will benefit from the use of a total constellation of 75+ satellites, which will significantly improve all the aspects of positioning, especially availability of the signals in so-called "urban canyons".



Frequency allocation of GPS, Galileo and Compass; the light red color of E1 band indicates that the transmission in this band has not yet been detected

Frequencies for Compass are allocated in four bands: E1, E2, E5B, and E6 and overlap with GALILEO. The fact of overlapping could be convenient from the point of view of the receiver design, but on the other hand raises the issues of inter-system interference, especially within E1 and E2 bands, which are allocated for GALILEO’s publicly-regulated service. However, under International Telecommunications Union (ITU) policies, the first nation to start broadcasting in a specific frequency will have priority to that frequency, and any subsequent users will be required to obtain permission prior to using that frequency, and otherwise ensure that their broadcasts do not interfere with the original nation's broadcasts. It now appears that Chinese Compass satellites will start transmitting in the E1, E2, E5B, and E6 bands before Europe's Galileo satellites and thus have primary rights to these frequency ranges.

Almost nothing has yet been officially announced by Chinese authorities about the signals of the new system, but the launch of the first Compass satellite permitted independent researchers not only to study general characteristics of the signals but even to build a Compass receiver. The second modernized Compass (Beidou 2) satellite was launched on April 14 2009. This is a geostationary spacecraft named Compass G2— reflecting the geostationary nature of its orbital position about 22,300 miles above the equator.

Kinematic GNSS Survey for Evaluation of TANDEM-X Digital Elevation Model

TanDEM-X is an innovative space borne Earth observation mission based on two synthetic aperture radar satellites operating in close formation as a single-pass interferometer and allowing flexible baseline selection. The mission is currently prepared and implemented in the framework of a public-private partnership between the German Aerospace Center (DLR) and EADS Astrium GmbH. The first satellite, TerraSAR-X, is already successfully put into a sun synchronous orbit. The launch of the second satellite is planned for September 2009. The mission’s primary goal is the derivation of a global, consistent Digital Elevation Model (DEM) with a relative vertical accuracy of 2 m. The elevation data will be provided for scientific (via DLR) and commercial use (Infoterra Deutschland).

The DEM will be evaluated by precise kinematic GNSS measurements. The required accuracy for kinematics measurements shall be in the range of 0.3 m to 0.6 m, since the GNSS shall serve as a reference of the DEM. Tracks having lengths of up to some 1000’s km distributed around the globe will be measured.

In Africa, two tracks have been identified running along major road as marked in the above map in the north and south of the equator. RCMRD together with University of Lisbon, Portugal are carrying out Kinematic GPS on the southern track starting from Dar es Salaam through Northern Zambia to Angola. Dual frequency GPS receiver in dynamic mode will be used to take the

measurements and post processing will be carried out using Precise Point Positioning (PPP) strategy which allows better accuracy oppositions from GPS raw observation data without any reference or master station.