Survey on follow-up initiatives of the UN/USA GNSS Regional Workshops and International Meeting of Experts 2001-2002[1]

Surveying and Mapping, Earth Sciences

Report by I. Fejes

1. Introduction

The area of Surveying and Mapping, Earth Sciences has always been a pioneer of GNSS applications. Developments in this area, however, have been different, depending on the local conditions of the geographical regions around the world. In that connection, the United Nations/United States of America GNSS Workshops have been very useful, since these meetings have provided up to date information on the GNSS systems, developments and perspectives and examples of applications. The UN/USA meetings have also helped to promote GNSS systems with a certain authority and importance that have been given by the participation of high ranking UN/USA officials, decision-makers and experts at the national levels. The meetings have mobilized key experts, and in many cases initiatives that were considered of a lower level, or that had not been taken before, have been brought to the attention of high-level decision-makers working in governments.

More than 40 responses from 17 countries to the questionnaires have been received with a wide spectrum of actions, initiatives and problems. In addition, several other experts informally replied to the enquiry sent by the author of this report. In the following report, we compile the main points related to the Recommendations of the International Meeting of Experts, Working Group on Surveying Mapping and Earth Sciences, formulated in November 2002.

2. Follow-up actions

The Expert Meeting recommended 3 projects to be supported by the United Nations Office for Outer Space Affairs (UN/OOSA).

2.1. *The African reference System -AFREF- project*

(Contact : ***www.hartrao.ac.za*** or http://igscb.jpl.nasa.gov/mail/afref/afref.html)

Responses about AFREF had been received from Kenya, Namibia and South Africa. In December 2002 a two-day workshop on AFREF had been organized. In addition, nine states of the Regional Centre for Mapping or Resources for Development (RCMRD) area and Namibia coordinated the activities within AFREF. In the Windhoek declaration the project was summarized as follows:

The concept is, to establish a network of permanent GPS stations such that a user anywhere in Africa would have free access to, and would be at most 1000 km from, such stations. This frame will be the fundamental basis for the national three-dimensional reference networks, fully consistent and homogeneous with the International Terrestrial Reference Frame (ITRF) through International GPS Service (IGS). *The approach* to be adopted is that of continental coordination with national implementation. For practical effectiveness, an intermediate coordinating structure is proposed at the sub-regional level, resulting in sub-regional reference frames: NAFREF (for North Africa), SAFREF (for Southern Africa), CAFREF (for Central Africa), EAFREF (for East Africa) and WAFREF (for West Africa), all still conforming and compatible with IGS/ITRF specifications. Following the principle of national implementation, countries will be expected to maintain and secure the stations,

[1] Presented to the Joint Meeting of Action Team on GNSS and GNSS Experts of the UN/USA Regional Workshops and International Meeting 2001-2002, 8-12 December 2003, Vienna, Austria.

undertake field campaigns and submit the data to designated regional data centres. The Hartebeesthoek Radio Astronomy Observatory (HartRAO), a national facility of the National Research Foundation (NRF) of South Africa, is an International GPS Service (IGS) data centre and plays a key role in the implementation of AFREF.

The availability of vertical component and datum of AFREF has been supported through the African Geoid Project (South Africa).

Beneficiaries:

African countries can clearly benefit from a unified GNSS-based geodetic network, which will be the backbone of densification and a series of other applications.

Difficulties:

It was noted in the Declaration that countries may not be fully self-sufficient in terms of the resources required to establish and maintain permanent reference stations. Furthermore, some countries may have more responsibilities than others. Therefore, assistance may be sought for such countries from other African countries that have more capacity, and from the international community.

2.2. The European Position Determination System - EUPOS- project

(Contact: ***gerd.rosenthal@senstadt.verwalt-berlin.de***)

Following the second UN/USA Regional Workshop on the Use and Applications of Global Navigation Systems (GNSS) for the benefit of countries in Central and Eastern Europe, convened from 26 to 30 November 2001 in Vienna, the EUPOS project was initiated in July 2002 by representatives of 14 central and eastern European countries. Replies related to this subject had been received from Bulgaria, Germany, Hungary, Poland and the Slovak Republic.

EUPOS is planned to provide a ground-based GNSS infrastructure for differential correction of the GPS satellite data for real time users on a regional extent. The accuracy of real time positioning will be in the cm accuracy range. This means that a *"full scale accuracy*" integrated infrastructure will be available for all types of GNSS users. The project foresees the operation of about 400 permanent GPS stations in Central and Eastern Europe in an average distance of 70-100 km from each other. Each participating country will be in control of the establishment and operation of its own EUPOS network segment.

Project status:

EUPOS is in an advanced stage of planning. The Project Steering Committee has been established and has an office in Berlin, Germany. Up to now, 2 EUPOS Workshops and 4 Committee meetings have been held in order to discuss the project and its planning details with the participants. The Steering Committee meets regularly twice a year. Its last (4^{th}) meeting was held in Berlin on 23 November 2003. Total cost of the project will be in the order of 40 m EUR. EUPOS seeks financial support from the European Union and national sources.

Beneficiaries:

This infrastructure serves practically all GNSS applications and services in Central and Eastern Europe. The realization of the project increases the overall economic competitiveness of the region. The significance of EUPOS is beyond Europe. Other geographic regions could follow the example of EUPOS by establishing similar infrastructures, increasing competitiveness and economic growth in their own regions.

Difficulties:

At the time or reporting, there were no funds allocated to the project. Therefore, the rather work intensive project preparation meets difficulties in manpower, in travel and in organizational costs of the meetings.

2.3 The Densification of CORS for the Geocentric Reference System for the Americas – SIRGAS- Area project (Contact: *wamartin@igac.gov.co*)

Replies relating to this subject had been received from Brazil and Colombia. The South American Geocentric Reference System Project (SIRGAS) was being developed with the participation of many South American countries, under the coordination of IBGE (Brazil). In this project context, a continental geodetic network with scientific accuracy was determined in 1997, from which the South American national networks were supported. The integration between the SIRGAS reference network and the networks in other places was guaranteed by the existence of continuous operation stations (CORS) in the continent that belong to the IGS global network.

Colombia reported developments on the SIRGAS vertical datum. Connections of the classical leveling networks had been carried out between several South American countries. EUREF and SIRGAS agreed during the IAG meeting in Sapporo, Japan, on the definition of vertical datum. This will be done within the new project of the IAG, the Integrated Global Geodetic Observing System.

Beneficiaries:
Countries in the SIRGAS area, particularly South American countries will benefit from the project.

Difficulties:
Most of the countries in the SIRGAS area still need to tie their traditional local geodetic networks to ITRF.

2.4 Other follow-up actions

The remaining follow-up actions reported could be categorized into 5 main groups.

2.4.1. The development of passive and active GPS networks – GPS-based geodetic control. This issue was mentioned in many responses. Practically, in every participating country, geodesists had been working on transformation of traditional national (triangulation) geodetic control networks into GPS-based national networks at various levels (e.g. Colombia, Egypt, Hungary, India, Nigeria, Poland, Romania, Slovak Republic, etc.). This activity went in parallel with the adoption of ITRF (e.g. Australia, New Zeeland and Malaysia) or alternatively with the establishment of precise ties to ITRF. Intentions and campaigns supporting existing or future initiatives for regional (continental) developments of unified GPS-based networks were also received (e.g. Asia and Pacific Regional Geodetic Project – APRGP). AFREF was reported to be supported by Egypt, and SIRGAS CORS by Brazil and Colombia. A reply from Malaysia proposed the establishment of ASREF – the Asian Reference Frame, following the example of AFREF, EUREF or SIRGAS.

Beneficiaries:
These were basic and most important developments providing support for other GNSS applications in the thematic area. They should be considered as national, regional, and even, global infrastructure developments for the benefit of all economy sectors.

Difficulties:
The level of implementation was very diverse in different geographical areas. Africa was the region that most needed support for development. Central and Eastern Europe were probably the most advanced regions among the workshop regions. Lack of funds was the most frequently mentioned problem. Lack of awareness or not sufficient priority by governments was particularly mentioned by Slovak Republic.

2.4.2. Site quality, integrity and interference monitoring: This issue is closely related to 2.4.1. The establishment of active GPS networks needs careful evaluation of site quality, integrity (including operation quality) and interference free environment. All this boils down to the integrity of the

services. Users, on the other hand, need to know which areas are affected by interference. In that sense, Hungary reported actions in interference monitoring.

Beneficiaries:

By setting and enforcing quality standards, all kind of users would benefit. Higher quality products could increase efficiency and reduce production costs.

Difficulties:

Standards have not been worked out yet. Activities in this area were still in a very early stage. Solid project initiatives and international coordination are needed and could be addressed by the proposed GNSS Coordinating Board (GCB).

2.4.3. *Different GNSS applications:* Several questionnaires replies reported various applications of GNSS technology in their countries. Some examples included: boundary demarcation, volcano deformation, land subsidence and landslides – Indonesia; satellite image corrections and cartographic map corrections – Brazil; Earth science, geological survey, environment monitoring – Syria; updating maritime charts – Maldives, etc.

Beneficiaries:

The wide spectrum of specific GPS applications was evident from the replies. It was clear that a great number of problems could be solved by GPS more economically and quicker than by traditional methods.

Difficulties:

Listed difficulties, among others, included: lack of funds in Indonesia, Maldives, as well as lack of GNSS specialists in Brazil, and more education and training needed in Syria, etc.

2.4.4. *Institutional background:* A couple of our recommendations touched this subject. ("Establish national plans for GNSS", and "Governments take the responsibility for and support the design, development and operation of ground-based GNSS infrastructure on national levels".) Responses from Colombia, the Czech Republic, Hungary, Romania and the Slovak Republic indicated that actions had been undertaken to draw up national GNSS policy and set up high-level government bodies for coordination of GNSS activities. A GNSS-Galileo Application Center development had been started in Romania.

Beneficiaries:

High-level (government) support and coordination was a precondition of efficient application of GNSS technology. The beneficiaries would be the end users in every sector of national economies.

Difficulties:

These types of institutions were new in government structures and there were no visible examples reported. Therefore, the procedures to establish such institutions were slow. Sometimes, it was difficult to convince high-level decision-makers about this necessity.

2.4.5. *Education and outreach:* This area does not belong strictly to this report. However, the respondents did not channel several questionnaires dealing with this issue to the "Education and awareness" group. Therefore, we thought it necessary to report them here. The respondents in Brazil, Colombia, Hungary, Poland, Tanzania and Viet Nam organized workshops, seminars and trainings on GNSSS applications. Papers related to GNSS applications were also presented on national and international meetings.

3. Problem areas

The recommendation "Develop SDI (Spatial Data Infrastructure) based on consistent geodetic reference frame, enabled by GPS" had no specific response. This was probably due partly to the under

representation of SDI experts at the workshops on one hand, and to the great number of different players (NGO-s) on the field worldwide, on the other hand. The above recommendation should be more specifically addressed to international organizations (NGO-s). (See Analysis section). This implementation would certainly be in the interest of all actors of GIS and SDI.

4. Assistance

UN/OOSA could assist in the following recommendations.

In relation to the AFREF project:

- Support preparatory and technical meetings on AFREF and encourage (invite) all African countries to participate in these meetings. Proposed financial support of these meetings would be USD 30, 000. OOSA may also help in logistical means in the meetings organization.
- Financial assistance to set up permanent GPS reference stations in the planned AFREF network is highly recommended. The capital investment cost of a single station is estimated to be USD 35, 000. This type of assistance should be coordinated with the project manager and other potential donors. UN contribution in its capacity would encourage other donor organizations to list up.

In relation to the EUPOS project:

- A letter of support (endorsement) of the EUPOS project addressed to one of the EU promotional programs (specified later) and to the project coordinator (Rosenthal).
- Financial support for the organization of the 5th EUPOS Steering Committee Meeting in Bratislava, the Slovak Republic, in June 2004 and the 6th EUPOS Steering Committee Meeting in November 2004. Proposed funding would be USD 20, 000. Alternatively, the organization of these two meetings at the United Nations, Vienna, would be according to OOSA capacity.

In relation to the SIRGAS CORS project:

- Support meetings related to the project. Proposed funding would be USD 20, 000.
- Endorse SIRGAS CORS project and point out its importance to the South American countries – which have not yet signed up – and potential financial sources (e.g. Inter American Development Bank - IADB).

In relation with site quality, integrity and interference monitoring:

- An international working group should be established. A call for participation and logistical support could be issued by OOSA.

5. Analysis

A response from the Slovak Republic to the survey criticized the recommendations as "very general and not easy to be followed". Indeed, the recommendations addressed different levels of actions and decision-makers. In some cases they were too general indeed. In our thematic area (Surveying and Mapping, Earth Sciences) we identified three main categories of recommendations:

5.1. Projects

These were the most concrete and well-defined recommendations where the acting parties were identified. The role of OOSA is clear and implementation in most cases is under way (e.g. AFREF, EUPOS, SIRGAS). However, not all project-oriented recommendations were elaborated in

such details like the first three. “Site quality and interference monitoring projects” or “Accurate geoid model development” projects deserve proper attention and should be worked out later in more detail. We are of the opinion that *OOSA should focus its attention and provide support as a priority to the projects area.*

The development of GNSS-based geodetic control takes place in 3 phases:

1. The development of passive GPS networks using the monuments of classical (e.g. 4th order) geodetic control points. This is a relatively cheap and efficient way to introduce ITRF conform reference frame and the GNSS technology into land surveying. Part of AFREF could be in this phase.
2. The development of active GPS networks using sparse network of permanently operating GPS stations. This phase is more costly, but could supply correction data for geodesists in post processing mode and therefore make individual measurements more cost effective. SIRGAS CORS densification project and part of AFREF are in this phase.
3. The development of an integrated “full scale accuracy” ground-based multifunctional GNSS infrastructure of dense (70-100km) network of permanently operating GPS stations, which could provide cm accuracy real time corrections to all type of GNSS users. An example of such an infrastructure is EUPOS. This is the most expensive stage, but provides the highest economic rewards.

OOSA should invite further project initiatives, considering the different phases mentioned above. These projects could be developed at national or regional levels. *Recommend GNSS-based infrastructure developments to governments and policymakers*.

5.2. General policy

These recommendations addressed government decision-makers or professionals (e.g. “Establish national plan for GPS” or “Governments take the responsibility (…) of the ground-based GNSS infrastructure”, etc.). Here, the effect of the UN/USA Workshops and the role of OOSA could be very significant. OOSA actions could aim at government level policy and decision-makers. *Encourage establishments of national institutions dealing with GNSS issues (e. g. National GNSS Coordinating Board).*

.

5.3. Standardization issues

This category stressed the importance of common standards with GNSS in different fields of infrastructures (e.g. “Develop coordinate system consistent with ITRF”, or “Develop SDI on consistent geodetic reference frame enabled by GPS”). The main acting parties in these cases are international organizations (setting or recommending standards) such as the IAG or professional societies, such as the GSDI (Global Spatial Data Infrastructure, www.gsdi.org) or INSPIRE (Infrastructure for Spatial Information in Europe, www.ec-gis.org/inspire) and others. In this area, OOSA may establish contacts with prominent or leading officials of these organizations and commonly work out action plans or collaborations in order to promote the recommendations.

There are some further suggestions, which may help in the long run. In general, the realization of most of the recommendations in this thematic area would be eased, provided that OOSA:

- Established working relations with IAG to commonly promote international GNSS standards and produced information leaflet on the subject.
- Established working relations with Spatial Data Infrastructure organizations in order to promote the same basic standards in this very broad area.
- Supported production and edition of GNSS textbooks on native languages. (Production cost of such a book is in the order of USD 50, 000 (300 page, 1000 copies).

- Supported regional training courses on GNSS applications. For this, an estimated amount of USD 15, 000 for each course is recommended.
- OOSA website maintained comprehensive information about international events related to GNSS.