RESULTS OF THE SURVEY ON FOLLOW-UP INITIATIVES OF THE UN/USA GNSS REGIONAL WORKSHOPS AND INTERNATIONAL MEETING OF EXPERTS: 2001-2002

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1. Introduction

The Global Positioning System (GPS) satellites were first developed to determine the location of a person or place. Taking advantage of the capacity of the GPS to determine locations and the interaction of the GPS signals with substances in the atmosphere, the use of GPS has been extended to various aspects including environmental monitoring and management. Various attempts have been made to derive precipitable water vapour (PWV) in the atmosphere from the GPS signal delay. The signals transmitted by GPS satellites are delayed (refracted) by atmospheric water vapour as they propagate to ground-based GPS receivers. The delay is proportional to the quantity of water vapour integrated along the signal path. The GPS Meteorology, which refers to the application of GPS data to the monitoring and analyses of atmospheric conditions, represents a major development in the improvement of environmental monitoring and weather/climate prediction. The monitoring of the atmosphere can be done by both ground-based and space-based GPS.

The GPS is also extensively used in monitoring the vertical profile of the atmosphere and mapping pollution, flooding, forests and fire among many other areas of applications.

The UN/USA GNSS regional workshops and international meetings of experts observed the potential use of GNSS in environmental monitoring and management and made recommendations to expand the uses and applications of GNSS in the area.

This report is a compilation of the results from the questionnaire responses and information obtained from the Internet on the various initiatives made to enhance the uses and applications of GNSS in environmental monitoring and management. The "www.google.com" search engine was also used to obtain relevant activities from the Internet. A total of 22 questionnaire responses were received. The countries from which the responses were received included Brazil, Colombia, Hungary, Kenya, Maldives, Nigeria, Poland, Romania, Syria, Slovakia and Viet Nam. The responses and Internet information are reflected in the next section according to the relevant recommendation addressed by the initiatives.

2. Initiatives Addressing The Various Recommendations

2.1 Recommendation to integrate the use of GNSS into environmental monitoring and disaster management as well as into hydrology and flood prediction systems.

2.1.1 Environmental Monitoring.

i. A meeting was held in Boulder from 21 to 23August 2002 to help plan the use of data from the $100 million COSMIC mission, which will begin operations in 2005. COSMIC, a satellite network, is being developed through a U.S.-Taiwan Province of China partnership. The globe-spanning satellite network will furnish round-the-clock weather data, monitor climate change and improve space weather forecasts by intercepting signals from the Global Positioning System (GPS). The project will benefit the meteorological community, hydrological community, the aviation industry, marine industry, public safety and all other initiatives affected by weather and climate. (Information taken from the Internet)

ii. The Hindu, Online edition of India's National Newspaper on Thursday, 26 July 2001, reported the invention of a system by Garrison and NASA engineer Stephen Katzberg that would use GPS signals to collect environmental data for studies aimed at understanding global climate change. The system is based on the reflection of the microwave signals constantly broadcast by the GPS. Because water is a especially good reflector of GPS signals, the new technique is promising for studying how ocean-related conditions affect global circulation and world climate. However, the current status of the invention at the time of writing this report is not known. The initiative will benefit the Global Climate Observing System (GCOS), meteorology, hydrology and other environmental sciences.

iii. Water vapour inter-comparison workshop 2002.

The comparisons of GPS versus radiosondes data observed high standard deviations in the summer months. The effect was attributed to the higher contents of the water vapour and its higher variability during the summer period. More studies were recommended to better understand the effect since there may be other causes. (Information taken from the Internet)

iv. Initiative - SIRGAS - Vertical Datum.

During the XXIII General Assembly of the International Union of Geodesy and Geophysics (IUGG), which took place from 30 June to 11 July in Sapporo, Japan, the technical foundations for the determination of a new vertical reference system, based on gravity observations, were presented and discussed. Among other tasks, the connections of the classical leveling networks between Colombia and Venezuela, Colombia and Ecuador, Argentina and Uruguay, Brazil and Venezuela and Argentina and Chile have been carried out. New connections are in the preparation process. GPS campaigns on tide gauges of the SIRGAS area have been realized in order to monitor the mean sea level and the sea topography as a complement of the satellite altimetry observations. EUREF and

SIRGAS have agreed, during the meeting in Sapporo, on the definition of a vertical datum. This is done under the framework of the Integrated Geodetic Global Observing System. Certain difficulties arise from the fact that the determination of heights with GNSS is more complicated than obtaining latitude or longitude values for a point. New measurements have to be done which demand the consolidation of larger and stronger teams of researchers in the SIRGAS area. Regarding the need for assistance, OSAA needs to make stronger linkages with the various institutions interested in GNSS applications.

v. IUGG, July 2003.

A presentation was made at this meeting on how the GPS Meteorology technique monitors Precipitable Water Vapour (PWV) and was used to monitor Typhoon RUSA, in the Korea peninsula during 30 August to 1 September 2002. More details may be obtained from Hong-Sic YUN (Department of Civil and Environmental Engineering, Sungkyunkwan University). (Information taken from the Internet)

vi. The global navigation satellite system project for COMESA/EAC.

The project is intended to enhance aviation safety. The tendering for the study has been concluded and it was agreed that the study should include environmental monitoring. The project will benefit aviation and environmental monitoring (Update from the East African Community (EAC) and COMESA).

vii. NASA brings new Earth monitoring technology to light.

On 14 May 2002, Scientists at NASA's Jet Propulsion Laboratory, Pasadena, California, were satisfied with early analysis of data from their prototype instruments aboard two international scientific spacecraft in low Earth orbit. Blackjack GPS receivers, which are fitted with special antennas that focus on Earth's horizon, are tracking the radio signals broadcast by each of the 28 high-orbiting global positioning system satellites as they rise and set on Earth's horizon. These receivers are located aboard the German Challenging Minisatellite Payload, or "Champ," and the Argentine "Satelite de Aplicaciones Científicas-C" (Scientific Applications Satellite). Preliminary evaluations indicate this technology will be applicable to fields as diverse as weather prediction and climate research, Sun-Earth interaction research, solid Earth dynamics and oceanography. It may also be used to create the first 3-D images of Earth's ionosphere. The initiative will benefit the Global Climate Observing System (GCOS), meteorology, hydrology and other environmental sciences. However, the current status of this new technology is not known. (Information taken from the Internet)

viii. Meteorological application of GPS integrated column water vapour measurements in the Western Mediterranean (MAGIC).

This project was intended to be concluded in April 2001. The initiative will benefit the Global Climate Observing System (GCOS), meteorology, hydrology and other

environmental sciences. More details may be obtained from (ACRI Mécanique Appliquée et Sciences de l'Environement, France (coordinator) CNRS Centre National de la Recherche Scientifique/Geoscience Azur, France IEEC Institut d'Estudis Espacial de Catalunya, Spain, ASI Agenzia Spaziale Italiana, and Centro de Geodisia Spaziale, Italy, DMI Danish Meteorological Institute, Denmark). (Information taken from the Internet)

ix. Initiative: Participating in the international project LBA (Large scale Biosphere Atmosphere Experiment in Amazon), which use GNSS in order to evaluate the water vapour in the Amazon atmosphere with the aim to provide support to several environmental studies in that region. Difficulties: Most difficulties are related to financial support to realize the fieldwork and the availability of equipments. The GPS Equipments used were borrowed from dealers. Assistance: To promote this kind of application for use in other related projects. (Response from João Francisco Galera Monico-Brazil).

x. Initiative: GPS Technology was used to assess the environmental damage caused to the reefs due to grounding vessels. This was conducted by taking positions and drawing grid lines. The same technology is also used to monitor erosion and reef degradation. Difficulty: Lack of resources and funding makes it very difficult to continuously monitor the damage caused by erosion. Assistance: A pilot project sponsored by UN to evaluate the erosion and reef degradation would be very beneficial. (Response from Mohamed Ibrahim-Republic of Maldives).

xi. Promoted group procurement of GPS radiosondes in meteorological community so as to enhance data availability in Africa. A follow-up meeting is scheduled in Geneva, from 23 to 26 November 2003. Mr. Nyakwada will make a presentation on "Options For Joint Procurement In Africa". This initiative is expected to benefit all weather/climate dependent activities in Africa (Response from William Nyakwada-Kenya).

2.1.2 Hydrology And Flood Prediction

i. Flash Flood Prediction in The Tropical Pacific: A University of Hawaii and National Weather Service Research Collaboration. It uses NWS and GPS data streams to develop diagnostic forecasting tools and algorithms that focus on the mesoscale/nowcasting aspect of flood forecasting. (Information taken from the Internet)

ii. Initiative: Used GNSS geo-referencing to map the wet land regions of the country to aid and boost rice production and delineate flood vulnerability regions. Difficulty: The major impediment has been finance. Capital vote already approved have not been released. Assistance: Assistance required from OOSA is in the form of grants to undertake such initiative as a key pilot project for sustainable food production.(Response from T. Ahmed Rufai-Nigeria)

2.2 To use GPS to monitor landslides and volcano Sierra Negra, a GPS Network was installed in order to monitor the Sierra Negra volcano. This project is an example of

collaboration between the University of Idaho, Darwin Research Station, Galapagos National Park and UNAVCO.

i. i. GPS Deformation Monitoring of greater London And The Thames Estuary: The project will develop a methodology for assessing the precise contribution of each of these two factors, and will put in place a network of stations for use by the Environment Agency, for the long term monitoring of subsidence in ground level into the next century. The monitoring itself will be based on measurements involving GPS navigation satellites. Should the technique prove effective, it could be used for monitoring long-term changes in regional ground level in other areas of the world, which are likely to suffer from mining subsidence, seismic activity or flooding. In order to ascertain ground movement, a number of monumental techniques were used by the IESSG. Perhaps the most substantial of these was the extensive use of ground anchors. These were driven down to various depths, depending on a number of considerations, including the local geology and the component of ground movement that was to be measured. For more detailed information, please contact Dr. Richard Bingley on +44 (0)115 951 3932 or email your message to richard.bingley@nottingham.ac.uk) - (Information taken from the Internet)

2.3 To Monitor And Map Animals And Insect Behaviors For Early Warning Of Extreme Climate Events

i. Initiative: Studies using GPS to monitor wildlife have been conducted in Egypt. Papers on the results of the findings were presented at the First International Egyptian Conference of Protected Areas, Savoy Hotel, October 2002, Sharm El Shiekh, Egypt and will be in scientific journals soon. (Information taken from the Internet)

ii. Initiative: Mr. Nyakwada studied traditional climate monitoring practices in Kenya and established that plants, animals and insects are still widely used to monitor and predict climate among the rural communities. The findings form a useful basis for mapping animal and insect behaviours. The study was supported by NOAA/OGP. The objective was to harmonize traditional and modern scientific methods of climate monitoring and prediction to form the basis for biometeorology. He is interested to study the behaviour of animals and insects in response to climate variability as a signal for disaster prevention. In addition, he intends to start with historical data and review of previous studies. A multidisciplinary workshop would help improve on the findings of the study. He would be very grateful if an expert from the United Nations Office for Outer Space Affairs made a presentation at such a workshop. The study and workshop could be held after the Vienna meeting. This study may serve as a pilot study that may be duplicated in other countries. The estimated cost is US$ 15,000. This is a multidisciplinary initiative involving climate scientist zoologists, Game Park Managers and traditional climate practitioners (William Nyakwada-Kenya).

2.4 To Use GPS To Manage The Forests

i. Training Opportunity, 2004 GPS for Fire Management: Two Classes: Mammoth Cave NP: Kentucky, from 1 to 5 March 2004 and Denver, Colorado: from 19 to 23 April 2004. The *GPS for Fire Management* course is a 36-hour course designed to meet the training needs of fire and incident management staff wanting to incorporate Geographic Positioning System (GPS) information into their regular activities. Fire personnel will navigate to known locations and/or collect GPS data that can be downloaded to a mapping program and used to create maps that meet the needs of the incident commander or fire manager. GPS data includes multiple waypoints and a variety of perimeter type lines using the datum requested. The use of GPS is one of the most efficient methods for documenting information regarding the location of facilities, conditions, and environments affected by Wildfire, Floods, Earthquakes, and other incidents. Candidates from all agencies involved in all risk incident management are encouraged to apply. (Information taken from the Internet)

2.5 Use Of The GPS To Manage Environmental Pollution

i. Mobile Urban Pollution: Prototype One -This prototype which is near completion, reads and record GPS position, time from GPS unit, pollution data (CO in parts per million) and temperature (Information taken from the Internet).

ii. Non-point Source Pollution Model - (First-Ever Model In Lake George). The Lake George Association (LGA) has joined forces with the Lake George Watershed Conference, Lake George Park Commission (LGPC) and the Department of State (DOS) Division of Coastal Resources to produce a model to identify pollution hot spots in the Lake George Basin. The model will incorporate technology from many sources including Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing satellites and image analysis software. This Lake George model will be the first of its kind in the area. (Information taken from the Internet).

iii. Environmental monitoring and management: GPS was used to determine the sites of solid wastes in Homs, Latakia, Tartos and Aleppo. This initiative would benefit solid waste management. The need for more training on using GPS and participation in relevant workshops is observed. (Response from Dr. Eng. Mohamad Rukieh-Syria)

2.6 Cross cutting initiatives

i. Initiative: Mr. Chodota coordinated the activities of the AFREF project in the RCMRD member States. In December 2002, a two-day workshop on AFREF was organized by the Centre and Namibia, which was attended by nine RCMRD member States and Namibia. It was financed by RCMRD. At the end of the Workshop, a document called the Windhoek Declaration was prepared. It outlined the future strategy for the project's implementation. In May 2003, a paper was presented at the CODI 3 meeting held at the ECA, Addis Ababa. The project was discussed together with the Windhoek Declaration . A resolution was adopted urging member States to implement

the project, as it was the basis for the implementation of the NEPAD projects for Africa. He is currently preparing the 2004 project implementation plan to be submitted to the Governing Council (GC) which will met in Arusha, Tanzania, in November 2003. Difficulties: Member states in Africa find it difficult to spare funds for the acquisition of GPS equipment and participation in the AFREF project. Assistance: UN assistance might be need in approaching donors to donate or loan any extra GPS equipment to those countries that can not buy theirs. Logistical support will also be need especially ICT, software and data processing (Response from Martins Chodota (RCMRD)-Kenya).

ii. Initiative: Matej Klobusiak and Katarina Leitmannova developed a project for the establishment of Slovak permanent GNSS service (SPGS), which is operated on the Slovak spatial observation system (SKSOS). SKSOS is the geodetic fundament for national multifunctional ground-based infrastructure for precise real-time positioning. The project was introduced to the public at a workshop in November 2002. Difficulties: lack of awareness among the Government authorities to support the development of ground-based national infrastructure and permanent service for multifunctional utilization. Assistance: support for participation at the long-term training courses. (Response from Matej Klobusiak and Katarina Leitmannova-Slovakia)

2.7 Training

i. Initiative: Master of Science Program - a Ph.D. course on Cartographic Science, in which there is a research stream on Geodetic Positioning and Atmospheric Monitoring using GNSS, was added to the program. Difficulty: The difficulties were to promote the Program in Latin America. Assistance: To promote the program to those that would be interested. The institution could offer grants (CAPES and CNPq) to students from several countries. (Response from João Francisco Galera Monico-Brazil).

ii. Initiative: Introduction and promotion of the new GNSS systems (EGNOS, Galileo) in Poland and Central Europe. Mr. Galazka co-organized the "EC/ESA Information Seminar on Space", Warsaw, 20 June 2002 and the 1st conference for EU Candidate Countries "GALILEO for an enlarged Europe", Warsaw, from 19 to 20 May 2003. Difficulty: Insufficient financial resources for R&D projects. Limited understanding of GNNS from decision-makers. Assistance: Assistance in finding financial support from sponsors and/or international organizations. (Response from Robert R.Galazka-Poland).

iii. Initiative: Mr. Nyakwada created awareness on the use of GPS in environmental monitoring, transport and disaster management. Difficulties: Lack of simplified user-based awareness materials. Furthermore, he indicated lack of resources to hold multidisciplinary workshops to address cross-cutting issues such as the contribution of GNSS to environmental monitoring and management, early warning for disaster prevention through animal and insect behaviour mapping, disaster management and implementation of some related pilot projects. Assistance: Mr. Nyakwada is interested in creating more awareness on the potential of the GNSS in environmental monitoring and management, and in disaster management. This requires simplified awareness raising

materials, which I can receive on email and be facilitated to print more. Printed copies, if mailed to him, may also meet his needs.(Response from William Nyakwada).

3. Summary and Conclusion

This survey report has taken into consideration the responses that were posted on the web site for the International Workshop on GNSS by Sunday 17 November 2003, as well as the information gathered from the Internet. It has established the implementation of various initiatives intended to expand the use of GNSS in environmental monitoring and management. The efforts are concentrated in the area of water vapour monitoring using the interactions of the GPS signals with the atmosphere. A total of seven (7) initiatives were observed to address the use of GPS to monitor atmospheric water vapour. The findings were mainly obtained from the Internet. The area seems not to have been explored in the developing countries possibly due to the accessibility to the required data, necessary infrastructure and inadequate training. The majority of the initiatives in this area are under implementation. It is important to mention that efforts in this area will benefit a wide spectrum of the scientific community involved in the monitoring of weather and climate, environment hydrology and other related sciences. Efforts should be made to explore the possibility of extending the method to developing countries to support meteorological services and environmental monitoring and management for sustainable development and disaster management.

Other responses were on environmental degradation, floods, land slides and volcanoes, forests, pollution and sampling vertical profile of the atmosphere. The majority of the initiatives in this area were in the development stage and were affected by lack of funding and inadequate awareness on the potential of the GNSS in these activities.

Animal monitoring had two initiatives. One of the initiatives implemented in Egypt was expected to have been concluded in April 2003. The initiative in Kenya has not been implemented due to lack of funding.

Many responses indicated the need for awareness raising activities and simplified user-based materials to support awareness-raising needs.

There were no reported activities in disaster management apart from the mapping of hazards such as fire, floods and volcanoes, which often evolve into disasters. I am aware that GPS is extensively used in search and rescue as an activity in support to disaster management.

In conclusion, the author wishes to indicate that the GNSS has a high potential in the monitoring and management of the environment. There is, however, a need for training in this area, which seems to be in the development stage apart from extensive use of GPS in radiosonde observations. The author of this report thanks the United Nations Office for Outer Space Affairs for giving him this opportunity to participate in the survey and in the expert discussions.