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Office for Outer Space Affairs

# United Nations/Russian Federation Workshop on the Applications of Global Navigation Satellite Systems

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# Abstracts

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## Argentina

**1. Argentina: GNSSs as a new field of cooperation for Argentina**

By: **Stanislav MAKARCHUK**
National Commission on Space Activities

Space activities developed in the frame of the National Space Plan.

CONAE is the National Commission on Space Activities- the civil entity, established in the 1991. The mission of CONAE is to propose and implement a National Space Plan, approved by the Government. CONAE activities and projects are focused on generating of space information for the socio-economic benefits of our country.

One of the Pillars of the National Space Plan is the International Associative Cooperation to realize the projects in cooperation with other partners – foreign Space Agencies.

International Associative Cooperation allowed Argentina develop the space missions for the Earth Observation, such as 4 satellite of Serie SAC already launched in cooperation with the NASA, ASI, CNES and other partners, the Serie SAOCOM (SAR Satellite) actually under construction, in cooperation with Italy and the SABIA /MAR mission in cooperation with Brazil.

In the domain of the Space Exploration and the study of Universe and Solar System and beyond, Argentina and CONAE, in the frame of the International Associative Cooperation acquired the experience through the establishing of the Deep Space - 3 Antenna of the ESA for Deep Space Exploration in the Province of Mendoza already in operation, and the Chinese Deep Space Antenna for the Chinese Lunar Exploration Program actually under construction.

The Global Navigation Satellite GNSS is a new and very promissory field of space activity for Argentina and CONAE which can be materialized in cooperation with other partners.

Argentina understands the benefits of navigations systems in all the aspects of the everyday life and would like to contribute in the development of the GNSSs for the benefits of Argentina.

Argentina is open for the new projects of cooperation in the frame of development of the global and regional navigation systems.

Exists already experience in the allocation of the GPS Differential station in the Province of Cordoba, connected to the NASA Space Geodesics Network to improve the exactitude of the GGOS in the world and Regional measurements.

In the past, also existed the negotiations with GALILEO.  Actually is under negotiation the project of Installation of the Control and Differential Monitoring Stations for GLONASS.

CONAE is also interested to cooperate in the projects of Augmentations of the regional systems (WAAS, EGNOS, SDCM, GAGAN among others).

CONAE is interested in the training courses on the GNSS, in the Institute for Advanced Space Studies Mario Gulich, in the Province of Cordoba, Argentina for the potential users of Argentina and the region.

With the help and cooperation of UNOOSA in the participation of CONAE in this Workshop in Krasnoyarsk, CONAE had the opportunity to introduce its capacity to the GNSS Community and it is willingness to contribute to the development of GNSSs and propose to organize together with the UNOOSA one of the future regional Meetings on the GNSS in Argentina.

**2. Bangladesh: Aiding Surveying and Mapping with the Help of Global Navigation Satellite System (GNSS) in Bangladesh**

By: **Sanjeev DELWAR**
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Introduction

Global Navigation Satellite System (GNSS) technology brought a revolutionary change in Surveying & Mapping. Now a days GNSS is used for various purposes. The major field of GNSS applications are Tectonic Plate Movement Measurement, Map-making, Navigation, Topographic Survey, Geological Survey, Disaster Relief/Emergency Services, Weather Forecasting and many other scientific uses.

GNSS technology was first introduced in Bangladesh in 1992 for establishing a new geodetic network under a project implemented by Survey of Bangladesh (SOB) with the cooperation of Japan International Cooperation Agency (JICA).

Establishment of National Horizontal Datum

Under the above mentioned project a national horizontal datum (Dhaka 303) was established at Gulshan, Dhaka in 1994, from which the position of all GNSS control points are determined. Seven days continuous GNSS observations were made at the horizontal datum in order to determine the exact geographical position in the World Geodetic System 1984 (WGS 84). The coordinate of the datum was fixed with respect to four IGS monitoring stations located at Tsukuba (Japan), Wettzell (Germany), Yaragadee (Australia) and Hartebeesthoek (South Africa).

Establishment of 1st Order Horizontal Control Points Network

SOB established 1st order horizontal control points (GNSS points) network all over the country in two phases. The first phase was done in the year 1992 – 1994. It covered a two-third area of Bangladesh excluding Chittagong Hill Tracts and coastal areas. 140 control points were established in the first phase by GNSS survey. The second phase was done in the year 2001 – 2003 in Chittagong Hill Tracts area and in coastal area by establishing more 138 control points. The total number of 1st order horizontal control points (GNSS points) then became 278. The average base line length of the 1st order horizontal control network is 30 km.

Establishment of 2nd Order Horizontal Control Points Network

Based on the 1st order horizontal control points, SOB started establishing 2nd order horizontal control network in 2009 with average base line length 12 km which is till continued. The total numbers of 2nd order horizontal control points (GNSS points) as of June 2014 are 797.

## Updating of Map

SOB uses GNSS technology for updating the map for the last 10 years. Mobile Mapper and Hand Held GNSS Receiver are used for collecting the position of features.at present SOB is implementing a project under which the base map scale is changing from 1: 50000 to 1: 25000. Under this project aerial photograph of the whole country is taken in the year 2010-2011. A comprehensive GIS database is under process which can utilize as base information for further study/research. My thesis project is preparing an open series 1:25000 scale map under this project.

## Establishment of GNSS CORS

In 2011, SOB has established six GNSS (Global Navigation Satellite System) CORS (Continuously Operating Reference Station) and a data center in Dhaka for improving geodetic infrastructure and to improve its public service delivery mechanism. The locations of the six GNSS CORS are in Dhaka, Chittagong, Rajshahi, Khulna, Rangpur and Maulvibazar. SOB has a plan to densify GNSS CORS by establishing more 60 stations.

## Conclusion

The application of GNSS technology is increasing day by day all over the world. Bangladesh also trying her best to implement this technology for the infrastructure development in all sectors. I hope it is not far away when a GNSS receiver will be an important tools in our everyday life. GNSS technology can make an effective role to build ‘Digital Bangladesh’ which is the vision of the Government of Bangladesh.

## Bosnia and Herzegovina

**3. Bosnia and Herzegovina: Ionosphere and solar activities monitoring in Bosnia and Herzegovina using OS software-preliminary results**

By: **Medzida MULIC**
University of Sarajevo, Faculty of Civil Engineering, Geodesy Department

The GNSS positioning accuracy is strongly influenced by the ionosphere, which due to its dispersive nature, causes a group delay or phase acceleration of GNNS signals on their way between satellite and receiver. As a result of this, the measured distance between satellite and receiver will not be the same as their real geometric distance.

In order to investigate the accuracy that can be provided by using the absolute positioning method for the elimination of ionosphere impacts on GNSS measurements, a data processing using measurements of the permanent EPN station SRJV in Sarajevo performed. A precise point positioning-PPP method was apllied using the OS software gLAB. The ionosphere-free combination methodes used which enables the elimination of 99.9 % of the ionospheric impact on dual-frequency measurements. As a result, the coordinate positions of the permanent station obtained, which were further compared with the appropriate weekly EPN solutions in order to determine the achieved accuracy. The analyse of the results showed that the gLAB software provided the expected centimeter accuracy. Beside that, some results of the estimated ionospheric corrections from the GNSS SRJV observations, using OS gLab software are shown.

In addition, a monitoring station for the ionospheric anomalies established. Monitor consist of a receiver and an antenna that were able to receive low frequency signals. SID software enables the detection of sudden ionospheric anomalies. The electronic components for the receiver and antenna were provided by the University in Stanford. Analyzing the strentgh of the received signal from selected distant transmitters, efforts were made to notice the periods of the Solar enhanced activity. The analyze showed that the monitoring station is able to track enhanced solar radiation, resulting from flars that are happening daily on Sun's surface.

**4. Brazil: The Brazilian EMBRACE Space Weather Monitoring Program**

By: **Andre RYPL**
Diplomat –Secretary – Office of Outer Space, Ocean, and Antarctic Affairs, Ministry of External Relations

The presentation will detail the activities of the Brazilian EMBRACE Program (Estudo e MonitoramentoBRAsileiro do ClimaEspacial - Space Weather Monitoring and Study in Brazil).

The Embrace Program plays the role of Regional Warning Center for Space Weather for Brazil and is a partner of the International Space Environment Services (ISES), where it provides solutions and warning/defense mechanisms for space-related technological systems, such as GNSS.

Some examples of activities, include Total Electron Content (TEC) maps over South Amrica, which are generated and made available every 10 minutes. These maps are used, for example, to generate vertical error maps for GNSS. EMBRACE applications are provided to sectors such as civil aviation, oil industry, agriculture, geographical information and defense.

In addition, opportunities for international cooperation on the field of space weather and GNSS will be presented.

## 5. Brazil: Recent Experience in Operating the First Quantum and Optical System of Satellite Laser Ranging Installed in Brazil

By: **Renato ALVES BORGES** (G.A. BORGES, G. SAENKO, A. PAVLOV)
Electrical Engineering Department, Faculty of Technology, University of Brasilia, Brazil

The Russian serial laser station «Sazhen-TM-BIS» has been deployed and set into regular operation in the city of Brasilia on July 2014. The facilities of the laser station are deployed at the University of Brasilia inside two buildings: one equipped with the dome-shaped cover for quantum-optical hardware module and another one which is the technical room for placing the electronic hardware, with two operating positions inside the technical room.

Stations of this type are designed for:
• measuring distances to geodetic and navigational spacecrafts equipped with laser retroreflector systems;
• measuring angular coordinates and photometric characteristics of other spacecrafts and space debris objects observed in the reflected sunlight.

Distance measurements in first place are used for domestic navigational system of GLONASS. On the basis of these measurements the following goals can be achieved:
• precision control of the orbital parameters of the GLONASS system spacecrafts;
• precision control of the ephemeris data transmitted in the navigational signals of the system;
• precision control of the GLONASS ephemeris transmitting the State geocentric coordinate system;
• construction and support of the State geocentric coordinate system and its interconnections with the International Terrestrial Reference System;
• calibration of the measurements produced by the BIS ground radio stations of the GLONASS system.

Angular coordinates and photometric parameters measurements are also used in the domestic navigational system of GLONASS, providing solutions to the following tasks:
• determination of the motion parameters of the blackout and defective GLONASS spacecrafts;
• detection of the space debris objects in the vicinity of the GLONASS spacecrafts.

The structure of the laser station also includes a one-way measurement station which is designed for, using the laser data, calibration of the measurements provided by other one-way stations included into the ground segment of the GLONASS system.

In the scope of the international cooperation the station measurement data are used by the International Laser Ranging Service (IRLS Site Code BRAL, Station #7407, DOMES# 48081S001, 15.7731 S, 132.1347 W) to set up and support the International Terrestrial Reference System and evaluate the Earth revolution parameters. The limits of the international cooperation can be expanded with the assistance of Russia in the project of creating the Global Geodetic Observation System.

The necessity of the laser station deployment in Brazil is determined by the fact that the increase in precision of the solutions for the tasks stated above provided by the Russian Federal target program «Support, usage and development of the GLONASS system for the period of 2012-2020» can be provided in the first place owing to creation of the network of globally distributed ground measurement instruments.

In this framework, the first application interest and investigation conducted by the team of the Laboratory of Application and Innovation in Aerospace Science (LAICA) at UnB will be in the user segment. The goals at the beginning are ground tracking of the LAICAnSat platform; a high altitude scientific platform being developed at UnB. Recently, the team has made two successful launches using the Automatic Package Reporting System (APRS) for real time communications. The used radio was equipped with a built-in GPS antenna and it was used for tracking the platform during its flight hitting an altitude of 27.18km in the first launch and 28.02 km in the second one. For future launches the team is considering the use of GLONASS antenna in order to check the quality and verify the improvements in accuracy of GLONASS positions due to the operation of the new laser ranging facility at UnB, Brazil, as well as the differential correction and monitoring system. A second research interest consists in development and evaluation of atmospheric error models, algorithms for GNSS calibration and satellite tracking. The availability of such station at UnB will allow the development of such research activities.

**6. Bulgaria: SUGAC: Sofia University GNSS Analysis Center**

**By: Keranka VASSILEVA** (T. SIMEONOV, D. SIDOROV, N. TEFERLE, G.GUEROVA, E. EGOVA, I. MILEV, G. MILEV)
National Institute of Geophysics, Geodesy and Geography, BAS, Bulgaria

The Sofia University GNSS Analysis Centre (SUGAC, suada.phys.uni-sofia.bg) is a new analysis centre established via collaboration between the Department of Meteorology and Geophysics of Sofia University, the IPOS - BULiPOS GNSS network in Bulgaria and the University of Luxembourg. In April 2014, the first processing campaign took place. One year GNSS data from 7 stations of the BULiPOS network are processed in collaboration with the University of Luxembourg. Tropospheric products (Zenith Total Delay) with 5 min temporal resolution are obtained using the NAPEOS software, developed by ESA. Integrated Water Vapour (IWV) with 30minutes resolution from the BULiPOS network was compared with IWV from the Weather Research and Forecasting (WRF) model with the same resolution.

The analysis of the data showed high correlation (between 0.8-0.95) between the datasets. A significant difference in the average values from the datasets was detected and will be further analyzed. The tropospheric products from this campaign will be used for validation of the Weather Research and Forecasting (WRF) model as well as for case studies during intense precipitation events and fog. Future work will be the establishment of autonomous near real-time processing of the regional ground-based GNSS network in Southeast Europe in support of the EUMETNET E-GVAP and COST ES1206 ”Advanced Global Navigation Satellite Systems for Severe Weather Events and Climate” projects.

**7. China: New Approach for Prompting International GNSS Education**

By: **Jingnong WENG**
Beihang University, Director, APSCO Education and Training Centre (China), Executive Director of the Regional Centre for Space Science and Technology Education in the Asia and Pacific (China) (affiliated to the United Nations), Invited Expert of Beidou Satellite Navigation Office (CSNO)

In recent decades, space applications have been playing a more and more important role in our life and the demands on space education from developing Countries are growing rapidly.

Considering the accomplishments to date and the considerable changes and developments in the field of space applications, especially GNSS applications, the time has come to review space application education and to consider new approach in International GNSS Education with the development of remote learning, crowd computing, online education and etc. Follow the GNSS curriculum recommended and released by UNOOSA in 2014, a GNSS visualization system which can help people to know and understand GNSS will be presented in the presentation. And how to use GNSS related MOOCs to facilitate the International GNSS Education also will be discussed.

With the increasing international cooperation and application of BeiDou system, the BeiDou International Exchange and Training Center (BDIETC, http://bdietc.buaa.edu.cn ) was established and sponsored by BeiDou Office at Beihang University in 2013. An international graduate degree program on GNSS has been established at this center. Other activities of BeiDou Center in the last year also will be introduced.

## 8. China: BeiDou Navigation Satellite System (BDS)

By: **Jian YANG**
China Satellite Navigation Office (CSNO)

As a global navigation satellite system compatible with other navigation satellite systems worldwide, BeiDou Navigation Satellite System (BDS) is independently established and operated by China.

This presentation introduces relevant information about BDS's construction, application popularization and international cooperation.

BDS is steadily accelerating the construction based on a "three-step" development strategy. In 2000, BeiDou Demonstration System was accomplished and it has been able to provide regional services by the end of 2012. Around 2020, BDS will have the Global service capabilities. At present, BDS could provide services to most parts of Asia-Pacific areas. Its service performance can meet the nominal service performance indicator and is even better than this in some districts.

The Chinese authority attaches high importance to the application promotion of BDS and has published series of governmental documents. BDS has made great progress in the field of basic product industrialization and also implemented several application demonstrations in the field of transportation, fishery, meteorology, intelligent city, etc. Meanwhile BDS has got recognition from the mass market both home and abroad.

BDS commits to cooperate with other satellite navigation systems, promoting the compatibility and interoperability of multi-GNSS, so as to provide better services for global users. BDS will continuously promote the international coordination on multilateral platforms, and make efforts to enter into the international standardization, promote the popularization of satellite navigation, and facilitate the academic exchange, education and training in the navigation area.

## 9. China: BeiDou Navigation Satellite System (BDS)

By: **Xiaolei ZHANG**
International Cooperation Center of China Satellite Navigation Office

The presentation includes three key parts. The first part is about BDS system status and unique features. Since December, 2012, BeiDou has formally possessed Full Operational Capability for most parts of the Asia-Pacific region. By 2020, the BeiDou with global coverage will be completely established. The unique BDS features directly support reliable, high-quality GNSS applications. International cooperation and international market development have been a very important part of the BeiDou program.

The second part lists the pivotal applications for international markets, such as high-precision positioning, mass market, tourism and intelligent transportation, disaster prevention and relief, marine applications.

The third part lists international application promotion activities, such as BADEC and BeiDou Asia-Pacific Tours, iGMA initiative, joint effort with APSCO, CORS services and applications, traffic information management. The BDS/GNSS applications have been growing very rapidly; the results from early adopters are very promising – the results are comparable with those from other GNSS systems, and are superior in some application environments.

## Colombia

### 10. Colombia: Incorporating the broad concept of GNSS as a geodetic tool of high importance in academic aspects and applied research in Colombia, South America

By: **Hector MORA-PAEZ** (J..MEJIA and N.CASTANO)
University of Manizales, Colombia and Colombian Geological Survey

Major advances in space geodesy as well as the rapid development of GNSS hardware and data transmission capabilities has launched a global revolution in the field of geodesy, allowing its application in various disciplines. However, it is important to consider how the users of the Latin American countries are prepared to face these new challenges, and in the particular case of Colombia, how we will take advantage of having two operational systems (GPS and GLONASS) and be able to count in the near future on two other systems (GALILEO and BEIDOU).

The receivers that are being offered in the market are GNSS type, which means they are able to receive signals from different constellations. However, there is not enough evidence of the appropriate use of this capability. Therefore, it is important for the academy to strengthen teaching at the undergraduate and graduate level, so that students will be aware of the vast opportunities that arise with the GNSS technology as a broad concept. It is necessary to fill the informacion gap that exists regarding the simultaneous use of the existing two constellations with different purposes. Under this premise, the intention of the University of Manizales is to serve as a university center to build skills and strengthen human resources, so that students are conceptually and academically prepared to exploit the opportunities that GNSS space geodesy offers for research as well as the performance of projects that can impact the development of the country.

Our countries are gradually making great efforts toward the implementation of GNSS geodetic networks at different levels (national, regional and local networks), but the data is commonly processed with only the GPS component, leaving aside the GLONASS component, usually through ignorance or by not being able to count on the appropriate tools for proper use. Our purpose is to establish some programs of cooperation with experienced research centers, allowing us to develop research projects in the study fields of Solid, Liquid and Atmospheric Earth, from the broad concept of GNSS.

It is evident that the application of the modern technology of Space Geodesy is capable of contributing to a multitude of research activities, the reach and success of which has been demonstrated in the developed world in an environment of great research capability. By now, GPS signals are widely used for geodesy positioning, and there has recently been an increase in its use for understanding the deformation of the earth's crust, of both tectonic and volcanic origin. However, there is still limited use of GNSS signals for ionospheric and tropospheric studies, to name just two examples. Therefore, it is essential to expand the knowledge levels of these applications, but preferably from the concept of GNSS that will greatly enhance the accuracy and reliability of the positioning geodesy as a source for the National Spatial Data Infrastructure (SDI) in each country.

## El Salvador

### 11. El Salvador: Spatial Data Infrastructure in El Salvador

**By: Luis Roberto GIRON SEGOVIA**
Innovation and Information Technology Direction, Presidency of El Salvador

This abstract is about the project to build the Spatial Data Infrastructure in El Salvador, and the process we are following as a government to implement it.

The National Spatial Data Infrastructure of El Salvador (SINADE) will be a group of norms, politics and procedures which together will be monitoring, regulating and facilitating all different actions, projects or initiatives that allow the access to most of geospatial information which will be published in internet.
Specific Objectives:

To share the geographical information with the different institution of the federal government in El Salvador.
To interoperate between geographical information suppliers and consumers
To have an infrastructure with the ability of growing.
To create a policy with information flow about government statistic data. This information would be showed in a Geoportal.
To make a tool that facilitates spatial data information to help the government decision makers.
To design an IT network which show geospatial data in real time.

Features
Serving data from various institutions from their own source
Having the complete metadata of all information in the government institution

Coordinator Institution:
Presidency of El Salvador
Scope:
The different actions, regulations and policies will be generated and implemented by the SINADE. This group will include all public institutions that produce spatial and georeferencial information.

All users will have an impact on the agenda of the SINADE. The SINADE will be led by the Technical and Planning Secretariat of the Presidency.

Suppliers and producers of spatial information services will be the government institutions; However, they may incorporate step by step other providers of spatial information such as the Academy, the private sector, NGOs and international organizations.

Citizens will be one of the users of spatial information published by the system nd they will use the data for their own interest about of planning, business or personal decisions.

Groups into the National Spatial Data System.

For the success of a National Spatial Data is necessary to involve progressively all the private companies, universities, NGO, which produce and require government geo-referential information.

Statistical Committee and Georeferential Information (CEG)
This group is composed for the Head of all institutions which produce Geo-information including government institutions, academia, private sector, representatives of international organizations and NGOs; this group is coordinated by the Technical and Planning Secretary of the President, who shall attend to the needs and interests of the country in this specific area.

Its main functions are:
a. Establish legal institutional arrangements for the regulation of SINADE.
b. Propose the laws and regulations necessary and relevant to the development of production of spatial data.
c. Promote the implementation of standards and norms, to be ensured the accessibility and the interoperability of the infrastructure and establish the technical basis to allow the interoperability of data and implementation of resources.
d. Advising the decision-makers “political level”
e. Ensuring the financial resources necessary for the establishment of SINADE and to obtain their financial resources for its sustainability.
f. Make agreements with embassies to use satellites of other countries to get images instantly for reaction in a case of emergency.

National Institute of Spatial Data
The ISDE is the regulator of SINADE which will aim the coordination and standardization of spatial data management. It will promote the creation of production processes and quality control, as well as forming the base mapping with layers legally defined. It will implement the necessary mechanisms for monitoring and evaluation of spatial data infrastructure. The base of the ISDE will be incorporating some features of Geographic Institute and National Cadaster including its technical infrastructure and human resource.

Group Managers Nodes SINADE
They will be the responsible for the development and maintenance of the nodes which will publish geographical data in an interoperable web services. For the case of El Salvador, the Technological Innovation and Information Technology Area of the

Government of El Salvador (ITIGES) will be responsible for its administration with the support of CEG instance.

Committee BaseMap (COMAB)
In the case of El Salvador is called COMAB (Base Area Committee) who will be responsible for producing and maintaining the base mapping, which will be the only reference for all the spatial data generated by institutions, and its diffusion through services geographic information (display, download and see). National institutions involved in this Committee are: CNR, MARN, MOP, led by the STPP and ITIGES.

Interagency Committee on Spatial Data (COINDE)
It consists of all institutions involved in providing geo-referenced statistical data at national and regional level.

User Group
They are those who use the data and services provided by SINADE. It should be emphasized that there will be various types of users depending on the needs of government decision-makers, public institutions, academia, private, public, NGOs and international organizations.
This project will be implemented by the end of 2017

# Finland

## 12. Finland: Finland's public precise positioning service based on nationwide GNSS network

By: **Laura RUOTSALAINEN**
Department of Navigation and Positioning, Finnish Geospatial Research Institute FGI, NLS

Modern society is highly reliant on Global Navigation Satellite Systems (GNSS). Positioning accuracy obtained using consumer grade receivers, namely around 5 meters in favorable conditions in open outdoor environments, is sufficient for many use cases, but there exists many crucial applications where sub-meter accuracy is required. This presentation discusses an ongoing project, called P3 Service, at the Finnish Geospatial Research Institute aiming at providing all GNSS users half a meter positioning accuracy. The method under development will utilize the Finnish National FinnRef GNSS network which is operated by the Finnish government and available free of charge to the general public.

GNSS carrier phase measurements have been used for decades by professional surveyors for obtaining even sub-centimeter level positioning accuracy. The utilization of carrier phase measurements requires either a connection to a reference receiver in a Real Time Kinematics (RTK) approach, or precise correction data for Precise Point Positioning (PPP). At the moment the utilization of both RTK and PPP has been evaluated too expensive or computationally demanding and therefore the methods have not been generally implemented into consumer grade GNSS receivers. However, the research on improving the situation has been very active lately.

Based on a survey conducted in the beginning of the project (2013), there is a need for sub-meter positioning also among the non-professional GNSS users. Intelligent Transportation Systems (ITS) are an important example. Possibility to obtain lane level position information and non-collision aiding would improve traffic safety significantly and lower greenhouse gas emissions. Also, a huge business potential arises for equipment manufacturers and companies providing applications building on accurate positioning, for example GNSS based vehicle parking, sport and leisure applications.

The Finnish Geospatial Research Institute has operated the FinnRef GNSS network for nearly two decades. FinnRef, consisting of 19 permanent GNSS stations around the country, forms the basis for maintaining the national coordinate reference system. Some of the FinnRef stations are also part of the global IGS (International GNSS Service) and the European EPN (Euref Permanent Network) networks. The lately modernized FinnRef network provides data from four existing GNSS, namely US GPS, Russian Glonass, European Galileo and Chinese BeiDou. The new positioning service was opened in January 2014 for free of charge public use and is at the moment under test use. The presentation will give a review of the system and its feasibility for positioning.

The P3 Service project develops innovative methods discussed in the presentation, utilizing both

RTK and PPP, for providing half meter accuracy with consumer grade receivers, even with smartphones. FinnRef based RTK will be used for initializing the accurate positioning. However, RTK requires continuous connection to the network and data transfer, which drains fast the receiver's battery. PPP performs independently from a network, but its initialization requires very precise correction data and is too time consuming. Therefore in P3 Service, after initializing the carrier phase positioning using RTK, a handover to PPP algorithm is committed and thereby the best features from both methods taken into use; fastness of RTK and independence of PPP.

**13. India: GLONASS from India: review of the revitalised system performances**

By: **Anindya BOSE** (G.S. REDDY, S. SARKER, D. DUTTA and M. KUMAR)
Department of Physics, The University of Burdwan

Satellite-based navigation (SATNAV) is now used extensively for several benefits. Current fully operational global SATNAV systems are GPS and GLONASS and other systems are evolving fast. A generic term, Global Navigation Satellite System (GNSS) has emerged representing all systems together and stakeholders are expecting to exploit the benefits of the situation. Multi-GNSS would be especially important for India because of the typical geographical location for availability of large number of simultaneous signals from several GNSS systems in near future. Following a modernization plan revitalized GLONASS was declared fully operational in late 2011. A stable GLONASS constellation is observed for the last three years and it is of interest to study the GLONASS performances from India as an active component of a multi-GNSS environment.

This presentation discusses (i) briefly the GLONASS modernization plan, implementation and current status observed from India, (ii) the experimental plan and study results on GLONASS from India made during last three years in details and (iii) future scopes of studies using GLONASS with other systems viz. GPS and GALILEO.

Between December 2004 and December 2014, 40 GLONASS satellites were launched and as of early April 2015, there are 28 GLONASS satellites in the constellation - 24 fully operational, 01 Spare, 02 in Flight Testing phase and 01 under check; all of these current operating satellites are launched in or after December 2006 and have started operation since early 2007. Latest operating GLONASS satellite was launched in March 2014 while the last launched GLONASS satellite in December, 2014 (# 702) is in Spare state.

An experimental plan was made to observe GLONASS from India using multiple GPS-GLONASS (GNSS) receivers. Two of those were collocated at a point for collecting long-term data over 2012-2014 and another GNSS receiver was used to collect data from several geographically scattered locations of India during 2012 and the required customised software were developed in house. Following studies were made using the collected data and the detailed results would be presented in details:

Visibility, signal strengths

Data from different parts of India shows at least 04 GLONASS satellites are always visible except for very brief time intervals and the average visibility varies between 5 to 8 satellites for different locations. Common visibility of more than 04 GLONASS satellites also found to be satisfactory for locations largely separated by latitude and longitude.

Solution accuracy (standalone and in integrated modes)

Efforts were made to observe GLONASS only and GPS+GLONASS integrated operations. Results shows better accuracy for GPS+GLONASS over the individual modes and GPS shows better accuracy over GLONASS. Standard deviations of position solution for GLONASS operation lie within a range of 3.5 m x 3.5 m and variation in latitude found to be higher than that in longitude. Studies also include effects of increasing number of GLONASS used for GPS+GLONASS solutions that shows proportional improvement of achievable accuracy.

GPS-GLONASS interoperability

GPS, GLONASS and GPS+GLONASS modes are alternated fast to simulate almost simultaneous operations and variations in solutions can be observed both for GPS-only and GLONASS-only operations while GPS+GLONASS mode shows better stability. Mostly there is a difference of the order of 1 m between the values for GPS and GLONASS solutions components.

Multi-GNSS satellite geometry in limited satellite visibility conditions

Multi-GNSS operation shows better satellite geometry and DOP values found to be in the favorable order of Mixed, GPS and GLONASS. In case of limited GPS visibility, GLONASS supports to augment the situation. With intentional elevation masking of 450, the requirement of 04 satellite-visibility is fulfilled only using both the systems together.

Available GLONASS Signal Strength

GLONASS L1 C/A signal strength shows SNR values better than 40 dB*Hz for elevation angles higher than 200, signal strength becomes stable above 300 elevation and saturates above 600-700 with a nominal SNR value around 50 dB*Hz. Interestingly, comparison of simultaneously received GPS L1 C/A, GLONASS L1 C/A and GALILEO E1 signal strengths revels GLONASS signal strength to be the strongest and more stable than GPS for elevation angles more than 150.

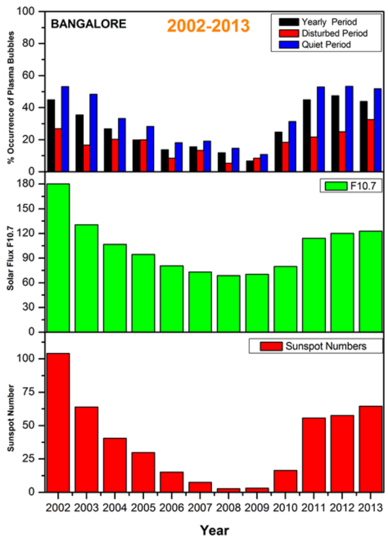
With the operating GALILEO IOV signals, studies were made on all-in-view operation towards a robust multi-GNSS signal environment from India. Experiences of GALILEO-only solutions shows modest solution accuracy with degraded DOP values; Initial “all-in-view” GPS+GLONASS+GALILEO operations provides more than 20 satellite signals for use, good interoperability, solution accuracy and PDOP values.

**14. India: GPS-TEC and Equatorial Plasma Bubbles observations during the period 2002-2013**

By: **Dadaso J. SHETTI**
Smt. Kasturbai Walchand College, Sangli

The Total Electron Content (TEC) is computed from Global Positing System (GPS) from Bangalore (13.020N, 77.570E) IGS station for the period 2002 to 2013. We present the mean diurnal, monthly, seasonal, and annual variation in the ionospheric TEC and % occurrence rate of Equatorial plasma bubble during the highest to highest solar activity phase for the periods of 2002–2013. The total 4383 days during the period 2002-2013, out of which 4229 days GPS data were available for analysis i.e. 96.48%. Total 1175 days data shows signature of plasma bubbles (occurrence rate of EPBs were 27.78%). The occurrence rates of EPBs were 17.86% during the disturbed period and 34.57% during quiet period.

These results show that the EPBs occurrence rate is higher in quiet period than the disturbed period and is nearly twice in % than that of disturbed period. We also found that the both average GPS-TEC and % occurrence rate of plasma bubbles are positively correlation with solar flux for the entire 12 year period. This study investigates the causal linkage between bubbles using their occurrence statistics during the solar minimum and maximum period. The % occurrence rate is maximum in quiet period than the disturbed period which directly affects the communication system, mainly due to depletions in the Total Electron Content (TEC) produces most of the effects on GPS signal.



## Italy

**15. Italy: Training on EGNOS-GNSS in Africa (TREGA)**

By: **Claudia PAPARINI** (X.O.VILLAMIDE, O.E.ABE, H.R.NGAYA, S.M.RADICELLA, B. NAVA)
The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy

Scientific research has been conducted by TREGA (TRaining on EGNOS-GNSS in Africa) laboratory members concerning the analysis of apossibleSatellite Based Augmentation System (SBAS) in Sub-Saharan African regions as part of its "training through research." TREGA is a joint project carried out through a Contribution Agreement of the European Commission (EC) and the International Centre of Theoretical Physics (ICTP) to help improving Africa's aviation sector. The European Geostationary Navigation Overlay Service (EGNOS) is one of the leading schemes in the Global Navigation Satellite System (GNSS) augmentation area devoted mainly to aviation. The scope of this project is to train a core number of African professionals to face technical problems related to the conditions of Sub-Saharan Africa and to provide technical assistance, capacity building, provision and use of a test/simulation platform for the implementation of GNSS/EGNOS in Sub-Saharan Africa. Satellite Based Augmentation Systems (SBAS) are considered to be the future of navigation in civil aviation in replacement of the existing navigation technologies. It is well known that these systems are particularly vulnerable to some factors; among them, ionosphere is a major source of error.

The TREGA group is carrying out a deep study to investigate the behavior of the equatorial ionosphere anomaly, which presence characterizes the Sub-Saharan African region. The study includes statistical results on the APV-I availability according to the International Civil Aviation Organization (ICAO) requirements laid down in the SARPs (Standards And Recommended Practices), Annex 10 Volume1. For this study data from GNSS African stations has been analysed during solstice and equinox months of the year 2013, characterized by high solar activity.

The analysis emphasizes in particular the ionospheric effects that degrade the SBAS performance at this particular region at low-latitudes especially during post-sunset and post midnight. Different parameters have been used in order to investigate the ionospheric behaviour. Total Electron Content (TEC) is used as a descriptive measure of the ionosphere and as a parameter widely used in studies of the near-Earth plasma environment. While for the analysis of the ionospheric irregularities, rate of change of TEC (ROT) has been taken and in particular rate of change of TEC index (ROTI) has been chosen as a proxi of the presence of the ionospheric irregularities and its effects on signals (scintillations).

Different solar-geomagnetic disturbed days have been also selected in order to evaluate the different behavior and eventual degradation or improvement of the SBAS system performance. Finally a particular emphasis is given to the existing geomagnetic and solar indices, used in connection with those ionospheric disturbances, in order to understand if there is a possible correlation with the SBAS system performance. The analysis would indicate that standard geomagnetic and solar indices do not have the same effect on the low latitude ionosphere and they do not reflect the behaviour of the SBAS system availability in the Sub-Saharan African region.

**16. Lao PDR: GNSS activities in Lao PDR**

**By: Mr. Sengdaungthip SOUNAKHEN**
Ministry of Post and Telecommunication, Department of Telecommunication, Lao Satellite Project

Lao PDR is a landlocked country, Located in the centre of Indochina. It shares borders with China and Burma to the north, Cambodia to the south, Thailand to west and Vietnam to the east.

We use GPS for positioning, Mapping, Air traffic navigation, Land management, Vehicle Safety protection, Vehicle traffic navigation, etc.

In fact there are many organizations used GNSS in Laos. But there no organization responsible for this work. Ministry of Post and Telecommunication (MPT) responsible for communication and broadcasting satellite. MPT is temporary responsible this work until the government has assign who responsible for this work.

**Space Technology Application in Lao PDR**

| No: | Ministries and organizations in Lao PDR | Using the Space Technology |
|---|---|---|
| 1 | Ministry of Information and Culture | - Radio Television Broadcasting via APSTAR<br>- Lao Star TV Broadcasting via Thaicom |
| 2 | Ministry of Agriculture and forestry | Remote Sensing and GIS |
| 3 | Ministry of Education and Sports | Tele-education in National University of Laos |
| 4 | Ministry of Post Telecommunication | Telephone and Internet Services via Thaicom, Intelsat and Inmarsat |
| 5 | Ministry of Public Work and Transportations | GIS for Urban Planning, Road Construction |
| 6 | Ministry of Energy and Mines | Remote Sensing for Mining Projects |
| 7 | Ministry of Natural Resources and Environment | Meteorology Dept, Remote Sensing Center |
| 8 | National Bank of Lao PDR | ATM Services via Satellite |
| 9 | National Geographic Department | GIS for Land Mapping Management |
| 10 | Mekong River Commission | Remote Sensing and GIS to monitor water level |

## Mexico

### 17. Mexico: Comparative Analysis of the Current Navigation Infrastructure between Mexico City International Airport, Jackson, Atlanta International Airport, and Frankfurt International Airport

By: **Julio CASTILLO URDAPILLETA**
Mexican Space Agency

Mexico´s city International Airport is the one of the main transport and commercial hubs in Latin America, which entitles it as one of the most critical airports in the region. This requires a growing and updated navigation since the excessive transit can affect the operations creating delays, conflicts in the air traffic, economic loss for the airlines, lack of efficiency, and impacts on the environment.

One of the most ambitious national projects for the present administration in Mexico is the planning, design and construction of a new airport in Mexico City that would start operations by 2020 and the old airport –the one that is currently operational- will be scrapped. In order to stand as a world-class airport as it is planned, state-of-the art technology for navigation should be considered to comply with the highest international standards of security for navigation. Currently, air navigation in Mexico is based on radio systems such as VOR (VHF Omnidirectional Radio Range), DME (Distance Measuring Equipment), ILS (Instrument Landing System), INS (Inertial Navigation System), and MLS (Microwave Landing System), among others. Nevertheless, this sort of equipment present operational failures in its maintenance and lacks the precision for having an optimum efficiency for navigation and air control management. On the other hand, satellite navigation and tracking technologies such as GNSS (Global Navigation Satellite Systems) offers an outstanding precision in terms of altitude, latitude and longitude in the threshold of meters or even centimeters, if using a Multi-GNSS receiver or an augmentation system. This level of precision is translated into benefits for the air controllers, cost reductions for the airlines and a lower environmental impact.

For the reasons mentioned above, a comparative analysis is made between the air navigation technologies currently implemented in Mexico City International Airport and two of the major airports in the world in terms of air transit, flights demand and passengers; Atlanta International Airport, and Frankfurt International Airport.

This study aims to identify the benefits of implementing satellite navigation technology and infrastructure for the new Mexican Airport. The objective is to demonstrate that the adoption of GNSS technologies and the implementation of a national augmentation system for the country would help to reduce gradually the problems of air transit, economic losses for the aviation industry and the environmental impact that the country experiences due to the lack of an optimal navigation infrastructure.

# Mongolia

## 18. Mongolia: GPS application in Mongolia

By: **Bolorchuluun CHOGSOM**
Department of Geography, National University of Mongolia

Navigating in Mongolia, even with a GPS is difficult. Most countries can get by with a combination of a good map, reading the road signs and asking the locals. This is possible in Mongolia but fraught with difficulty. Whilst people can buy road maps of Mongolia, they are very inaccurate and more importantly there are so few features on the ground to match up with the map that knowing where you are is often difficult.
The main reason of these difficults are coming from coordinate systems of Mongolia.

The three different coordinate systems used by Mongolia since 1950s are State, Local and GPS. The State coordinate system has been used to produce topographical maps covering whole country, while local coordinate system is used for creating Ulaanbaatar city map, and GPS coordinate system is used exclusively for cadastral mapping. Five different Geodetic networks have been established in Mongolia; Triangulation, Polygonometry, Gravity, Leveling /height/ and GPS networks.

Because of three different coordinate systems, users would have difficulties with digital data production. In order to ease data exchange, implement GPS technology and satellite imagery in all areas and to improve cooperation between different organizations the Administration of Land affairs, geodesy and cartography, a Government agency has decided to use only GPS coordinate system in Mongolia.

Topographically the country is covered relatively well as indicated by the coverage shown on attached maps. Most of the topographic mapping at a scale 1:100,000 were done in the early 1940s by army specialists of the former Soviet Union for military purposes. These maps were published in the Russian language. Most maps were rechecked, reedited and published in the early 1980s by topographers from Mongolian institutions in Mongolian language. Topographic maps are published at scales 1:1,000,000, 1:500,000, 1:200,000, 1:100,000, 1:50,000 and 1:25,000. Topomaps at larger scales e.g. 1:10,000 published by special order.

The country has established a geodetic network. The geodetic system is based on cartographic projection by Gauss-Kruger and ellipsoid projection by Krasowskiy; altitude is being defined by Baltic system. All topographic and geodetic survey are under one government institution, the State Cartographic Agency. Maps at scales of 1:1,000,000, and 1:500,000 are sold, and 1:100,000-1:25,000 scale topographic maps are included in a “top secret” list of data according to the Law. These maps can be used for any purpose within country after special permission from the Security Agency and the Mongolian State Administration of Land Affairs, Geodesy and Carthography. These maps cannot be taken out of the country.

During the period 1996-1997, a Mongolian GPS netwok has been established through the execution of the project. The network connects the national country's system to the ITRF system. Data of this survey are in digital format. This primary GPS network has 34 points, which also exists in higher order triangulation and gravity network points. The GPS network survey was executed on the existing second order triangulation points to approximately estimate seven parameter datum conversion coefficients between WGS-84 and local system Krassovsky and to establish a primary high accuracy GPS network with ITRF connection in Mongolia.

The Mongolian Government started land privatization from 2003 and cadastral maps were produced for this purpose based on GPS coordinate system.

2D and 3D transformation parameters have been calculated to convert topographical maps and other spatial data produced in State and local coordinates systems into GPS coordinate system.

In 2000-2003 when calculated transformation parameter used only Monref97 points' data. 3-4 m accuracy was achieved. After densification of Monref97 more data were used but accuracy was not better than 1-2 m for zone calculation of transformation parameter.

The Mongolian Mining authority calculated transformation parameter between State and GPS coordinate system in 2007 with accuracy of 1-2 m with assistance from World Bank project to convert mining cadastral coordinate system into GPS coordinate system. Modcon application has been developed for conversion between two coordinate systems. 2D transformation parameter between State and GPS coordinate system with accuracy 1-2m used to convert 1:100,000 scale digital topographic maps into GPS coordinate system, which have been updated using satellite images.

Transformation parameter between local and GPS coordinate systems was calculated with 0.30m accuracy which exceeds requirements stated in the Mongolian law on Cadastral mapping and land registry.

In Mongolia a set of 58 GPS points on first-order leveling benchmarks were available, giving independent quasigeoid values _ = hGPS – Hnormal. The comparison statistics showed mean = 1.14 m and standard deviation = 0.20 m. These values mainly reflect the datum offset of the Kronstadt (Baltic) leveling datum of Mongolia, as well as known loop closing errors in the Mongolian first-order leveling network.

## Mongolia

**19. Mongolia: GNSS Measurements in Ulaanbaatar and it's vicinity**

By: **Erdenezul DANZANSAN**
Seismological Department of Institute of Astronomy and Geophysics,
Mongolian Academy of Science, Ulaanbaatar, Mongolia

The territory of Mongolia is one of the most seismically active zone as an intra-continental areas in the world, that is associated four strong earthquakes (M > 8) with a hundred of kilometers faults in the western Mongolia in XX century: Tsertserleg (Mw=8.1) 1905/07/09; Bulnai (Mw=8.1) 1905/07/23; Fun-Yun (Mw=8) 1931/08/10; Gobi-Altai (Mw=8.1) 1957/12/04;
A seismic activity is taking place near and within Ulaanbaatar area since 2005. This seismic activity, related to previously unknown active fault, impacts the seismic hazard assessment of the capital of Mongolia where 1/3 of the Mongolian population lives and the majority of industries of the country is concentrated.

Recent developments of space techniques, especially, an application of Global Navigation Satellite System (GNSS) is one of the most effective and state-of-art techniques for the study of the Earth's surface deformation. Today GNSS data is being used in studies of surface deformation processes and for the prediction of strong earthquakes.
Areal study of modern horizontal velocities of displacement and deformation in Mongolia started in 1997 within the framework of cooperation between the Institute of Astronomy and Geodesy of the Mongolian Academy of Science, the Institute of the Earth's Crust, Siberian Branch of the Russian Academy of Science, and Géosciences Azur, National Center for Scientific Research. As a result of the international program was created Baikal - Mongolian GNSS network, which included more than 20 field sites established in western and northern Mongolia and the Baikal region, as well as two stations that are part of the international network IGS - ULAB and IRKT.
The first results of GNSS data analysis were obtained by scientists (Calais and Amarjargal, 2000). It was revealed that the velocity of the Amurian/North China block's movement in the ESE direction was by a factor of 3 to 6 faster than the movement rate predicted by models based on the hypothesis that deformation in Central Asia is entirely driven by the India/Eurasia collision.

The amount of geodetic measurements of crustal deformation in Mongolia (in central Asia) is still limited.

In 2010, Institute of Astronomy and Geophysics of Mongolian Academy of Sciences (IAG, MAS), together with the Institute of the Earth's Crust Siberian Branch of

Russian Academy of Sciences (IEC SB RAS) launched the joint program on the development of the regional geodynamic network.

In frame of this program, local and regional geodetic networks for the repeated measurements established in Central and Eastern Mongolia and 7 permanent GNSS sites has been installed for the monitoring. Today Eastern geodetic network of 9 measurement sites are in operation in Eastern of Mongolia and two local geodynamic polygons, which include 20 sites, are located in Ulaanbaatar and its surrounding areas for the study of tectonic movement and seismic hazards. The first polygon covers the territory of Ulaanbaatar and its vicinity; the second polygon is located along the “Emeelt” seismic active fault zone. Within the past years (2010-2014), seven field campaigns were carried out at each polygon and recorded GPS data has been analysed. Here, we present preliminary results of our investigations in GPS measurements in Ulaanbaatar, its vicinity.

## Morocco

**20. Morocco: Use of GNSS and terrestrial laser scanner for DAMS auscultation**

By: **Mourad BOUZIANI**
Department of Geodesy, IAV Hassan

The monitoring of dams is necessary for the surveillance and the follow-up of their behavior over time. Many flood risks can be then avoided. In Morocco Geometric auscultation is made, in most cases, by determining the movement of different targets in the dam using angle measurements and leveling. This method is precise but very difficult and time consuming.

Other techniques such as Global Navigation Satellite Systems (GNSS) and Terrestrial Laser Scanner (TLS) represent a good alternative. The speed and the ease of use given by these technologies are of great interest, but the question which arises is the following : Can these techniques be as accurate as the conventional method in the auscultation of dams?

We conduct an experimentation in which we use GNSS and TLS to monitor targets movements over one year. The project aims at establishing a comparative study between these techniques using a quantitative and a qualitative comparison.

The methodology consist of collecting observations of many targets in the Dam using the optic method, GNSS and TLS. After a step of processing, we calculate Three-dimensional positions of the targets. A comparison is then conducted based mainly on two criteria : precision and time.

A case study related to the dam of Sidi Mohamed Ben Abdellah situated in Rabat will be presented. The results illustrate the benefit of using GNSS and TLS in dams monitoring. An approach of integration is proposed.

## Nepal

### 21. Nepal: Regulatory and Strategic GNSS Roadmap of Nepal

By: **Shobha K. LAMICHHANE**
BP Koirala Memorial Planetarium, Observatory and Science Museum Development Board, Ministry of Science Technology and Environment, Government of Nepal

Nepal is a landlocked country situated between India and China's Tibetan Autonomous region. It rises from as low as 59 meters(194 ft) elevation in the tropical Terai to some 90 peaks over 7,000 meters (22,966 ft) including Earth's highest 8,848 meters (29,029 ft) Mount Everest. Because of this sort of difficult terrain and wide geographical diversity, providing nationwide positioning applications (like: precision agriculture, environmental monitoring, land and traffic management, weather precautions service etc) is a big challenge in the country. There is also a vast variation in the density of inhabitation.

There are cities like Kathmandu where the population density is 4408 to the cities like Manang where the population density is 3 per sq. ft. which has further contributed to the difficulty not only in the field of communication but also in mapping and surveying, natural resources management, disaster warning, aviation and land transportation too. In this context, the use of Global Navigation Satellite Systems (GNSS) supposed to achieve tremendously for the development of Nepalese humankind. However, variation in geography, population distribution, distribution of natural resources (forest, yarshagumba etc), and gap in planning land management etc of our country directly influence our unsatisfied people’s needs (national development) which threatens our social cohesion as well as the equilibrium of the living systems of the national harmony and hence GNSS reserves potential to develop its solutions to integrate the most remote and difficult locations of our society to the mainstream.

## Pakistan

**22. Pakistan: Fishing in View: Satellite Technology based Monitoring, Control and Surveillance System for Pakistan Marine Sector**

By: **Iftikhar KHAN**
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Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)

Fishery plays an important role in the national economy of Pakistan. The marine fisheries sector is the main component, contributing about 57 percent in terms of production. During 2012-13, about 729 thousand tons fish catch from marine (467) as well as inland (262) sources was realized which is expected to grow in year 2013-14. At present Pakistan's seafood exports stand at just $300 million and contribute 0.44% in national GDP.

The current trend in the production of global marine fisheries resources presents an alarming concern for food security and sustainable development. Some of the fisheries resources which were previously regarded as inexhaustible are now either seriously depleted or overexploited.

Maritime trespassing and Illegal Unreported Unregulated (IUU) fishing is now generally acknowledged to be a major contributor to this crisis in global fisheries, with negative economic, environmental, ecological, and social consequences for many countries, especially developing countries. IUU fishing is a top international priority area that account for 13 to 31% of global fish catch and valued at $10 to $23bn annually. Nearly 50% of global IUU is carried out in the western and eastern Indian Ocean.

"Fishing in View" is a concept of applying satellite technology for Monitoring, Control and Surveillance (MCS) of fishing vessels in Pakistan's Exclusive Economic Zone (EEZ). The MCS system will comprise of Master Control Center located on coast and Vessel Monitoring System (VMS) installed on each of the fishing vessel. VMS will comprise of GNSS receiver along with fish catch report system to transmit real time position and catch report via satellite/UHF/VHF/Cellular transceivers, to Master Control Center established on the coast at Maritime Security Agency (MSA) premises. Real-time monitoring of each of the registered fishing vessels inside national EEZ will be ensured via MCS system and alarms will be generated whenever IUU fishing vessel is detected by MCS system. The satellite technology based MCS system will also help to perform functions such as limit entry, cap on total allowable catch (TAC), monitor closed areas and seasons, trip limits, mesh restrictions, send & receive text messages, limit boat size, gear restrictions, and search & rescue alarm system.

MCS system may also be augmented by Remote Sensing/Synthetic Aperture Radar (SAR) satellite image processing based vessel detection system. This will allow detecting the fish vessels which don't have GNSS based VMS system installed on the boat or unavailability of VMS data due to tampering in hardware/software of VMS module. The data from Remote Sensing/SAR satellite will be acquired, processed and correlated with GNSS based VMS positional data in near real-time (15-90mins) to confirm the presence of fish vessel in EEZ. SAR image is expensive option but provide day/night surveillance whereas remote sensing satellite image is relatively less expensive but can only provide surveillance during day/clear weather only. Integration of VMS with Remote Sensing/SAR satellite imagery will minimize the IUU fishing in Pakistan's EEZ.

The presentation will provide concept of applying Satellite technology for the Monitoring, Control and Surveillance of fishing vessels in Pakistan. It will also highlight the technical components and deliverable of "Fishing in View" project.

## Pakistan

### 23. Pakistan: Synergy between GNSS and GIS Application for Monitoring Landuse Production – An Integrated Approach

By: **Muhammad Umar IQBAL,** (S. NISAR)
Space Technology Applications Directorate
Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)

Pakistan is a country with diversified physiographic characteristics ranging from mountains to rivers and cultivated land to deserts. Each characteristic has its own importance in socio-economic development of the country. Study for physiographic features is diverse in nature that is done using several methods specifically and simultaneously such as geological surveys, geomorphological investigations and modern ways of satellite images classification. Specific types of satellite image classifications are used on the basis of physiography and the targeted information along with the information gathered from several other sources that is mapped through landuse / landcover mapping. Classification methods provide unambiguous characterization of earth surfaces and helps identifying human interventions for utilizing the use of land that is pertinent for the decision makers for better planning.

Pakistan is an agricultural based country where the majority of the population is directly dependent on agriculture and livestock for their livings. Yield of agriculture is waning in quantity day-by day due to different causes, possibly including unavailability of fertilizers or because of using low standard fertilizers or weak anticipation for using the fertilizer at appropriate timing, unavailability of sufficient water particularly at required time, unavailability of funds for seeds or for fertilizers, the utilization of funds and also the accurate identification and collection of crop/yield information. Taking specific right-measures-on-right-timing is very important for the achievement of seasonal crop production and for that local agencies conduct paper based surveys for crop/yield monitoring and a huge time is spent for the analysis of survey data to identify the short falls and come up with realistic estimates.

Proposed is an integrated Global Navigation Satellite System (GNSS) and Geographic Information System (GIS) for collecting accurate and real time agriculture field data and to analyze each agricultural field for any possible deficiency through Real Time Kinematics (RTK) enabled customized real time application. The system comprises a smart phone app with real time transmission of GNSS and field data through communication medium, a customized precise GIS application for viewing, analyzing and reporting of survey data, Spatial database with landuse / landcover based information at centralized location and a communication server to transfer data to and from field using Android based smart phone by the crop reporters. The methodology is named as "Integrated Monitoring System" derived from four technologies employed including

GNSS (GPS/GLONASS/Galileo/BeiDou), RTK, GIS and GSM (GPRS/EDGE/3G). The system is capable of collecting precise crop/yield data, generating reports and digital maps to serve current needs. The system can enhance the crop yield by keeping an eye on all the collected data with remarks, suggestions and problems described by the farmers or observed by the monitoring team. The system can also create the thematic maps on various crops, sowing patterns etc. in order to address the needs of agricultural production activities. The system is integrated with GNSS, GIS and allied technologies to help generate better and accurate estimates for the production and monitoring in all seasons.

## South Africa

### 24. South Africa: Performance Evaluation of the GPT2w and UNB3M Tropospheric Delay correction Models over Africa

By: **Isioye A. OLALEKAN** (C. LUDWIG, B.O. JOEL)
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Tropospheric delay is a major error source in positioning by Global Navigation Satellite Systems(GNSSs). Many techniques are available for tropospheric delay mitigation consisting of surface meteorological models and global empirical models. Surface meteorological models need surface meteorological data to give high accuracy mitigation while the global empirical models need not. However, most GNSS stations in the African region are not equipped with meteorological sensor for the collection of surface meteorological data during the measurement. Zenith Tropospheric Delay (ZTD) is often calculated by the various high precision GNSS software by utilising standard atmosphere values. Lately, researchers in the University of New Brunswick and Vienna University of Technology have both developed global models (University of New Brunswick (UNB3M) and Global Pressure and Temperature2 wet (GPT2w) models) for tropospheric delay correction, respectively. The earlier (UNB3 model) is a neutral atmosphere model which utilises a lookup table with annual mean and amplitude of temperature, pressure, and water vapour pressure varying with regard to latitude and height.

These parameters are computed for a particular latitude and day of the year using a cosine function of the annual variation and a linear interpolation for latitude. Similarly, the GPT2w is a blind tropospheric delay model which is based on gridded values of water vapour pressure, water vapour decrease factor, and weighted mean temperature. All climatological parameters have been derived consistently from monthly mean pressure level data of ERA-Interim fields (European Centre for Medium-Range Weather Forecasts Re-Analysis)with a horizontal resolution of 1� .

This report represents an appraisal of the conduct of the GPT2w andUNB3M models with high accurate International GNSS Service (IGS)-tropospheric estimation for ten IGS stations over a period of 1 year on the Africa continent. All the models perform significantly better at the mid-latitudes than at the equator. There was better agreement between the GPT2w and IGS estimate at all stations. Thus, the GPT2w model can be used as a correction model of the tropospheric error for the GNSS real-time positioning and navigation on the African Continent.

## Tunisia

**25. Tunisia: Seismic risks assessment around the Mediterranean region**

By: **Ferdaous CHAABANE** (A. RIGO, P. BRIOLE, T. MOURABIT, M. BEZZEGHOUD, T. TAHAYT, J. M. DIAZ)
Higher School of Communication of Tunis SUPCOM

Augmentation of a global navigation satellite system (GNSS) is a method of improving the navigation system's attributes, such as accuracy, reliability, and availability, for aircraft navigation and landing applications. through the integration of external information into the calculation process. There are many such systems in place and they are generally named or described based on how the GNSS sensor receives the external information. Some systems transmit additional information about sources of error (such as clock drift, ephemeris, or ionospheric delay), The existing core satellite constellations alone however do not meet strict aviation requirements.

To meet the operational requirements for various phases of flight, the core satellite constellations require augmentation in the form of aircraft-based augmentation system (ABAS), satellite-based augmentation system (SBAS) and/or ground-based augmentation system (GBAS). ABAS relies on avionics processing techniques or avionics integration to meet aviation requirements. The other two augmentations use ground monitoring stations to verify the validity of satellite signals and calculate corrections to enhance accuracy. SBAS delivers this information via a geostationary earth orbit (GEO) satellite, while GBAS uses a VHF data broadcast (VDB) from a ground station. GNSS can improve airport usability, through lower minima, without the need to install a NAVAID at the airport. GNSS may support approach procedure with vertical guidance (APV) on all runways, with proper consideration of aerodrome standards for physical characteristics, marking and lighting.

When a landing threshold is displaced, the flexibility inherent in GNSS can allow continued operations with vertical guidance to the new threshold. GNSS may also be used to support surface operations.

**26. Uzbekistan: Ionospheric Total Electron Content disturbances observed before earthquakes: Tashkent and Kitab GNSS stations**

By: **Husan ESHQUVATOV**
Astronomical Institute of Academy of Sciences of the Republic of Uzbekistan

The main source of the ionization in the ionosphere is the solar radiations such as extreme ultra violate (EUV) and X-ray radiations. In addition to photoionization, collisional ionization due to particle precipitation from the magnetosphere is another source of ionization, in particular in the high latitude region. One of the widely used ionospheric parameter is Total Electron Content (TEC), which is the number of electrons in a column of one-meter-squared cross section that extends all the way up from the ground through the ionosphere.

Anomalous variations of Ionospheric Total Electron Content (TEC) a few days before local earthquakes can be regarded as a precursory signals. Since the Global Navigation Satellite System (GNSS) data can be used to measure the ionospheric TEC, the technique has received our attention as a potential tool to detect ionospheric perturbations related to the earthquakes. We analyze GPS derived TEC disturbances from two GPS stations located in Tashkent and Kitab (Uzbekistan), for possible earthquake ionospheric precursors. Our analysis encompasses the earthquakes from year 2006 to year 2014 which occurred mostly in and around Uzbekistan in seismically active zones.

We study TEC anomalies in the light of the earthquakes that occurred within 1000 km from the observing stations during the period of observation. We produce Total Electron Content (TEC) time series over both sites and apply them to detect anomalous TEC signals preceding or accompanying the local earthquakes. The results show anomalous enhancements before the local earthquakes, for examples, before earthquake of magnitude of 6.1 occurred on 24 January, 2011 Tajikistan and 1,3,4 days before earthquake denotes the precursor days and magnitude of 5.5 occurred on 4 June, 2014 near the Caspian sea, Offshore Turkmenistan and 3,6 days before earthquake denotes the precursor days. In general the anomalies occurred 1–6 days before the earthquakes as ionospheric precursors. To indentify the anomalous values of TEC we calculated differential TEC (dTEC). dTEC obtained by subtracting monthly averaged diurnal vTEC from the values of observed vTEC at each epoch. This procedure removes normal diurnal variations of vTEC.

**27. Uzbekistan: Intermediate reference frame for Uzbekistan topographic maps**

By: **Erkin MIRAMAKHMUDOV** (S. PRENOV, K. MAGDIEV, D. FAZILOVA)
National University of Uzbekistan

Intermediate reference frame construction is given in this work. Uzbekistan map have the grid system based on Gauss-Kruger projection. This projection has become a national standard in the former SU (also in Uzbekistan), and are likely to remain so. The aim of this work is to develop recommendations for improvement of Uzbekistan topographic maps. Coordinate system of Uzbek topographic map will be improved with the help of GPS measurements.

National grid coordinates are nowadays determined by GPS rather than theodolite triangulation. The increasing accuracy of GNSS makes it possible to derive information on the kinematics of tectonic plates from repeated or continuous measurement. Geodetic point coordinates are obtained in WGS84 system that has been constructed itself using real observations, a geodetic datum: a physical realization of a coordinate system used for describing point locations.

The establishment of national reference frame is not an easy task because Earth's crust continuously undergoes various deformations. In order to develop the national reference frame of Uzbekistan based on the GPS technology it is necessary to investigate more correctly converting between CS42 and WGS84 and such to determine an intermediate reference frame. For this purpose results from repeated measurements across the 3 sites CATs GPS network will be used.