Report on the
School on Reference Systems, Crustal Deformation and Ionosphere Monitoring and the SIRGAS 2013 General Meeting with occasion of the 20th Anniversary of SIRGAS
Panama City, Panama. October 21 - 26, 2013

SIRGAS (*Sistema de Referencia Geocéntrico para las Américas*) is the Sub-commission 1.3b (*Regional Reference Frame for South and Central America*) of the *International Association of Geodesy* (IAG) and a Working Group of the *Cartographic Commission* of the *Pan American Institute for Geography and History* (PAIGH). The integration in IAG provides scientific and technical guidance; the interaction with PAIGH guarantees access to the particular necessities of non-geodetic specialists requiring coordinates of high-precision in the Americas.

The main objectives of SIRGAS are the definition, realization and maintenance of the geocentric reference system for Latin America and the Caribbean, including a gravity field-related vertical reference system. The SIRGAS activities are coordinated by three Working Groups: WG1 (Reference System) is concentrating on the maintenance of the SIRGAS reference frame. WG2 (SIRGAS at national level) is in charge of supporting the activities oriented to extending, adopting and using the SIRGAS reference frame in the different SIRGAS member countries. WG3 (Vertical Datum) deals with the definition and realization of a unified vertical reference system that supports the determination and combination of geometrical and physical heights with high precision.

Activities, advances, and new challenges of SIRGAS are reported, discussed, and re-oriented (if necessary) in the SIRGAS yearly meetings, which have been realized since 1993. In this opportunity, the SIRGAS General Meeting was held together with the capacity building activity *School on Reference Systems, Crustal Deformation and Ionosphere Monitoring*, which is supported by a common project of the *International Union of Geodesy and Geophysics* (IUGG), the *International Association of Seismology and Physics of the Earth's Interior* (IASPEI), the *International Association of Geodesy* (IAG) and the *International Association of Geomagnetism and Aeronomy* (IAGA). Both activities, the school and the SIRGAS meeting, were also sponsored by the *Pan-American Institute of Geography and History* (PAIGH) and were hosted by the *Instituto Geográfico Nacional Tommy Guardia* of Panama in Panama City, from October 21 to 26, 2013.

School on Reference Systems, Crustal Deformation and Ionosphere Monitoring

In the frame of the IUGG Grants Program, the project *Monitoring crustal deformation and the ionosphere by GPS in the Caribbean* was granted for the term 2012-2014. This project is further sponsored by IASPEI, IAG, and IAGA. The main objective of this initiative is to invite the Caribbean countries to participate actively in geodetic and geophysical projects going on in the Central and South American region, in order to enable the use the acquired data for practice and science in their countries, and to promote geosciences. This includes capacity building activities providing the basis for profound education and sustainable development as well as the establishment of international and interdisciplinary contacts to participate in research projects at regional and global scales.

According to this, the *School on Reference Systems, Crustal Deformation and Ionosphere Monitoring* was carried out in Panama City, from October 21 to 23, 2013, in such a way, that the school attendees could also participate in the SIRGAS 2013 meeting, held in the three following days (from October 24 to 26). The main topics treated during the school were:

- Types of coordinates, their definitions, relations and transformations.
- Geodetic reference systems and frames (celestial and terrestrial reference systems and frames, regional reference frames, SIRGAS, vertical reference frames).
- Installation and maintenance of observation instruments (in particular of GNSS), real-time data dissemination (via Internet), and data archiving and management.
- Coordinates determination from GNSS (observation equations, uncertainties in GNSS positioning, controlling errors in GNSS positioning, adjustment of GNSS networks).
- Crustal deformation observation and modelling (geodynamic processes, plate tectonics, seismic deformation, aseismic crustal deformation, monitoring deformations by GPS)
- Ionosphere modelling and analysis (structure of the atmosphere, models of the ionosphere, observation techniques, analysis of the ionosphere).

The school was attended by 145 participants from 28 countries: Germany, Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Monserrat (UK), Nicaragua, Panama, Peru, Puerto Rico, Spain, St. Lucía, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, USA, and Venezuela. The main results of the school regarding this project are

- The purpose of Dominican Republic, Puerto Rico, Suriname, Trinidad and Tobago, Jamaica, St. Lucia and Turks and Caicos Islands to join the IAG activities developed by SIRGAS. Representatives of these countries started the necessary contacts to be integrated in different working and research groups.
- Trinidad and Tobago and Dominican Republic are interested on hosting a similar school in order to disseminate these topics to those people that were not able to come to Panama.
- Costa Rica, Dominican Republic, Guyana, Nicaragua and Puerto Rico are now integrating their geodetic reference stations into the continental reference frame.
- The objective of Dominica Republic to install a GNSS processing centre of high-level.
- Regarding other Caribbean countries, it should be mentioned that Colombia and Venezuela participate actively en SIRGAS since 1993; Costa Rica, Guatemala, Honduras, Mexico, Nicaragua and Panama joined SIRGAS in 2003, and Guyana joined SIRGAS in 2011.

SIRGAS2013 General Meeting

Immediately after the *School on Reference Systems, Crustal Deformation and Ionosphere Monitoring*, the SIRGAS2013 Meeting was held. This allowed the Caribbean countries, among other countries, the presentation of the current status of their geodetic/geophysical infrastructure during the meeting. Eighteen presentations about the infrastructure in Argentina, Bolivia, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Puerto Rico, St. Lucia, Uruguay, and Venezuela were given. Other main topics addressed during the meeting concentrated on the modernization/unification of the existing height systems (15 contributions); maintenance, extension, and new modelling strategies within the SIRGAS reference frame (12 contributions); SIRGAS approach to other geodetic space techniques (5 contributions); ionosphere and neutral atmosphere monitoring based on the SIRGAS infrastructure (7 contributions); usage and applicability of the SIRGAS reference frame in science and practice (15 contributions); modelling of non-lineal station motions within the reference frame (8 contributions). The main conclusions of the SIRGAS2013 meeting may be summarized as follow:

- The SIRGAS reference frame is officially adopted by most of the countries, which keep updated national densifications of the continental network and use this reference frame as the basis for a widely range of applications, e.g. GNSS real time services, geospatial data infrastructures, border demarcations, mapping activities, land management, etc.
- The first analysis centre for SIRGAS in Central America was installed under the responsibility of the *Escuela de Topografía, Cartografía y Geodesia* of the *Universidad Nacional* in Heredia, Costa Rica. After a successful test of one year, it will start operations as an official SIRGAS Analysis Centre in January 1, 2014.
- Complementary, the *Registro Nacional* of Costa Rica, national agency responsible for the geodetic reference frames in that country, subscribed an agreement with SIRGAS to incorporate the GNSS reference stations of Costa Rica into the SIRGAS continental reference frame.
- The *Instituto Geográfico Militar* of Bolivia starts activities as a SIRGAS experimental processing centre in October 2013. After a test period of one year, it may be declared official if the SIRGAS requirements are satisfied. With this, the SIRGAS objective of having at least one GNSS processing centre of high-level in each Latin American Country is closer.
- Several countries reported improvements on their first order levelling networks and the corresponding vertical connections with neighboring countries. This is a main consequence of the SIRGAS workshop on the *determination and adjustment of geopotential values* carried out in Rio de Janeiro from December 3 to 6, 2012. This workshop was supported by the *Instituto Brasileiro de Geografia e Estatistica* (Rio de Janeiro, Brazil) under the coordination of the SIRGAS-WG3. IUGG, IAG and PAIGH provided some attendees with travel grants.

The SIRGAS 2013 Meeting was attended by 158 participants. Presentations, main conclusions and a detailed report regarding the meeting are available at www.sirgas.org.

Thanks to the unconditional and generous backing of IUGG, IAG and PAIGH, it was possible to provide 26 participants from 15 countries with partial travel grants. SIRGAS deeply acknowledges this support.

20th Anniversary of SIRGAS

SIRGAS was created in October 1993 during the *International Conference for the Definition of a South American Geocentric Reference System* held in Asuncion, Paraguay. This conference was promoted and supported by the *International Association of Geodesy* (IAG), the *Pan-American Institute for Geography and History* (PAIGH), and the *US National Imagery and Mapping Agency* (NIMA), today *National Geospatial-Intelligence Agency* (NGA). The original acronym of SIRGAS (*Geocentric Reference System for South America*) was changed in 2001 to *Geocentric Reference System for the Americas*, since the SIRGAS2000 reference frame includes reference stations in North- and Central America, and because the United Nations Organization (UNO), through its 7th Regional Cartographic Conference for America (New York, January 22 – 26, 2001), recommends the adoption of SIRGAS as official reference system in all the American countries. This recommendation is further supported by the 8th (New York, June 27 - July 1, 2005) and 10th (New York, August 19 - 23, 2013) UNO Regional Cartographic Conferences for America.

During these 20 years of SIRGAS activities, among others, has been possible

- to extend the SIRGAS reference frame with more than 300 continuously operating GNSS stations distributed in most of the Latin American and Caribbean countries;
- to install eleven GNSS processing centres of high-level under the responsibility of Latin American organizations;
- to install a permanent service providing ionosphere parameters for practical and scientific applications in the SIRGAS region;
- to introduce SIRGAS as official reference frame in 14 Latin American countries, which implies the use of SIRGAS as the backbone for the development of governmental projects requiring precise geo-data (i.e. land management, cadastre, spatial data infrastructures, civil engineer projects, national and international demarcation, etc.);
- to advance in the implementation of the meta-data describing the national vertical networks as a fundamental requirement for the height datum unification in the SIRGAS region;
- to develop a reliable a sustainable infrastructure to provide the best reference frame in the region to satisfy practical requirements and to support the study of the System Earth.

In the frame of the SIRGAS2013 General Meeting, a session was devoted to the history, development, and past, current, and future challenges of SIRGAS. Three pioneers of SIRGAS summarized milestones and principal aspects of this initiative: Rubén Rodríguez (from Argentina) as representative of PAIGH in 1993, presented the development of SIRGAS from the PAIGH perspective; Hermann Drewes (from Germany), as representative of IAG since 1993, emphasized the SIRGAS scientific achievements and the role of the international cooperation under the coordination of IAG; and Melvin Hoyer (from Venezuela), past president of the SIRGAS-WG1, showed the point of view of a South American scientist participating as far as possible in the SIRGAS activities to guarantee its permanent development and sustainability. These three presentations were complemented with a talk given by the current SIRGAS president, Claudio Brunini (Argentina), giving special importance to the participation of Latin American geodesists in SIRGAS. More than the geodetic achievements, the really profit of SIRGAS is the human network that has been growing during these twenty years. Without the persons involved in SIRGAS, it would not be possible to present SIRGAS as one the most successful international geodetic initiatives. They are the really *SIRGAS-makers*, thanks to their support and continuous work these twenty years represent a very fruitful period in the Americas.

The celebration of the 20 years of SIRGAS were closed with a deep recognition, gratitude, and acknowledgment to Hermann Drewes, who was not only a pioneer of SIRGAS, but also has been a permanent *SIRGAS-maker* and over all, he is the father of SIRGAS!

Claudio Brunini, SIRGAS President
Laura Sánchez, SIRGAS Vice-president

Attendees of the School on Reference Systems, Crustal Deformation and Ionosphere Monitoring and the SIRGAS 2013 General Meeting.
Panama City, Panama.October 21 to 26, 2013.