Report on the project

Implementation of the United Nations' Resolution on the Global Geodetic Reference Frame (UN-GGRF) for Sustainable Development in Latin America

The project *Implementation of the United Nations' Resolution on the Global Geodetic Reference Frame (UN-GGRF) for Sustainable Development in Latin America* was granted by the International Union of Geodesy and Geophysics (IUGG) within the special grants program to celebrate in 2019 the centennial year of the IUGG foundation. The International Association of Geodesy (IAG) is the primary applicant of this project, and the International Association of Seismology and Physics of the Earth's Interior (IASPEI), and the IUGG National Committees of Argentina, Brazil, Chile, Colombia and Costa Rica supported it.

The principal project participants are

- Laura Sánchez, Lead of the Focus Area Unified Height System of the IAG Global Geodetic Observing System (GGOS), Technische Universität München, Munich, Germany, lm.sanchez@tum.de
- Claudio Brunini, Director of the Argentinean-German Geodetic Observatory (AGGO), Universidad Nacional de La Plata, CONICET, La Plata, Argentina, claudiobrunini@yahoo.com

The main objective of the workshop was the realization of a capacity building activity (workshop) on the United Nation's Resolution on the Global Geodetic Reference Frame (GGRF) for Sustainable Development released in February 2015. As this resolution opens a wide range of opportunities to capture the attention of policy makers (particularly at the political level) in geodetic and geophysical matters, the main idea was to develop, together with the Latin American colleagues responsible for the national geodetic reference frameworks, a strategy based on political, scientific and technical arguments, aimed at sensitizing the governments of the region about the need and convenience of investing in geodetic and geophysical infrastructure.

The schedule of the project was as follows:

May 2018: The IUGG Central Bureau informs the project applicants about the decision to award the project.

Aug – Sep 2018: The project principal participants worked out a proposal about the possible topics and speakers for the main capacity building. This capacity building is called *International Workshop for the Implementation of the Global Geodetic Reference Frame in Latin America*.

Oct 2018: A brainstorming meeting was held within the Symposium SIRGAS2018 (Aguascalientes, Mexico). SIRGAS stands for the *Geocentric Reference System for the Americas*. It is a sub-commission of the IAG and convenes the largest geodetic community in Latin America. In this preparatory meeting, the project principal participants outlined the contents (possible sessions) of the workshop and proposed dedicated lecturers for the selected sessions. The Latin American colleagues helped to improve the proposal by suggesting additional topics and lecturers.

Jan – July 2019: The project principal participants contacted the lecturers proposed during the brainstorming meeting in Aguascalientes. With the help of the lecturers, it was decided on

- the structure and duration of the sessions to be developed during the workshop,
- the detailed contents of each lecture,
- technical and scientific background of the attendants.

During this time, the project principal participants also made different calls for participation in order to reach as many Latin American Geoscientists as possible.

Sep 16 – 20, 2019: The workshop was held in Buenos Aires, Argentina. The *Instituto Geográfico Nacional* (IGN) of Argentina and the *Argentine-German Geodetic Observatory* (AGGO) organised the logistics needed for the successful realization of the meeting. In total, 130 participants from 20 countries (Argentina, Australia, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Dominican Republic, France, Germany, Guatemala, Italy, Mexico, Panama, Paraguay, Peru, United States of America, Uruguay, and Venezuela) attended the workshop. With 52 presentations distributed in eight sessions, it was possible to convene for the first time politics (United Nations Committee of Experts on Global Geospatial Information Management – UN-GGIM, UN-GGIM Subcommittee on Geodesy, Group on Observations – GEO, ICG-UNOOSA), international organisations promoting science (IUGG, IAG, IASPEI, International Science Council – ISC, International Federation of Surveyors – FIG, Pan-American Institute of Geography and History – PAIGH), the highest level of expertise in Geodesy worldwide (IAG, IAG Scientific Services, the Global Geodetic Observing System – GGOS), and regional specialists in Geodesy (SIRGAS, gravity field modelling, geodetic observatories) to identify appropriate strategies to make real the objectives of the UN-GGRF initiative. Twenty-eight travel awards for colleagues from fourteen Latin American countries were covered with the money granted by the IUGG. In addition to this support, the workshop counted on the sponsorship of the *International Committee on Global Navigation Satellite Systems* (ICG) of the *United Nations Office for Outer Space Affairs* (UNOOSA). ICG-UNOOSA provided six flight tickets for colleagues from Colombia, Peru, Chile, Brazil, Costa Rica, and Ecuador. The topics presented along the five days and the conclusions/recommendations arising from the discussions surely represent the appropriate start point to face the required activities to advance in the establishment of the GGRF in Latin America. Presentations, list of participants, and conclusions of the workshop are available at http://www.sirgas.org/en/ggrf/.

Annex 1 presents a detailed summary of the workshop, while *Annex 2* contains the financial report of the project.

Nov 2019: A follow-on meeting was held within the Symposium SIRGAS 2019 (Río de Janeiro, Brazil) to discuss ways of implementation of the conclusions outlined during the workshop in Buenos Aires. The Directing Council of SIRGAS will give special care to the continuity and a long-term perdurability of the benefits reached with the workshop and started to introduce some organisational changes to accomplish better the recommendations raised from the workshop. *Annex 3* contains the presentation given by the principal project participants at the Symposium SIRGAS2019.

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Annex 1

Summary of the International Workshop for the Implementation of the Global Geodetic Reference Frame in Latin America
Buenos Aires, Argentina. Sep 16 – 20, 2019

International workshop for the

Implementation of the Global Geodetic Reference Frame (GGRF) in Latin America

Buenos Aires, Argentina, Sep 16 - 20, 2019

The *International Workshop for the Implementation of the Global Geodetic Reference Frame in Latin America* was held in Buenos Aires, Argentina, from Sep 16 to 20, 2019. This workshop is a capacity building activity of the project "*Implementation of the* ***United Nations' Resolution on the Global Geodetic*** *Reference Frame (UN-GGRF) for Sustainable Development in Latin America"* of the International Union of Geodesy and Geophysics (IUGG) within the special grants program to celebrate in 2019 the centennial year of the IUGG foundation. The International Association of Geodesy (IAG) is the primary applicant of this project, and the International Association **of Seismology and Physics of the Earth's** Interior (IASPEI), and the IUGG National Committees of Argentina, Brazil, Chile, Colombia and Costa Rica supported it. In addition to the IUGG, IAG and IASPEI support, the workshop counted on the sponsorship of the International Committee on Global Navigation Satellite Systems (ICG) of the United Nations Office for Outer Space Affairs (UNOOSA). Twenty-eight travel awards for colleagues from fourteen Latin American countries were covered with the money granted by the IUGG. ICG-UNOOSA provided six flight tickets for colleagues from Colombia, Peru, Chile, Brazil, Costa Rica, and Ecuador. The Instituto Geográfico Nacional (IGN) of Argentina and the Argentine-German Geodetic Observatory (AGGO) organised the logistics needed for the successful realisation of the meeting. The support of IUGG, ICG-UNOOSA, IGN, AGGO and all the experts participating in the workshop is highly appreciated.

In total, 130 participants from 20 countries (Argentina, Australia, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Dominican Republic, France, Germany, Guatemala, Italy, Mexico, Panama, Paraguay, Peru, United States of America, Uruguay, and Venezuela) attended the workshop. With 52 presentations distributed in eight sessions, it was possible to bring together politics, international organisations promoting science, the highest level of expertise in Geodesy worldwide, and regional specialists in Geodesy to provide the Latin American colleagues responsible for the national geodetic reference frames with scientific and political arguments to convince policy makers about the necessity of investing in geodetic and geophysical infrastructure in their countries.

Attendants to the International Workshop for the Implementation of the Global Geodetic Reference Frame (GGRF) in Latin America. Buenos Aires, Argentina, Sep 16 – 20, 2019.

The first session, *Geodesy of reference in Latin America*, focused on the status of the GNSS-based geocentric reference frame SIRGAS (Sistema de Referencia Geocéntrico para las Americas), the existing gravity infrastructure, advances in the geoid modelling, and recent regional activities related to space geodetic techniques, especially in SLR (Satellite Laser Ranging), VLBI (Very-Long Baseline

Interferometry) and DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite). Speakers in this session were:

- Virginia Mackern, Vice-president (2015 – 2019) of SIRGAS
- Denizar Blitzkow, Vice-chair (2015 – 2019) of the IAG SC 2.4b: Gravity and Geoid in South America
- Cristina Pacino, Chair (2015 – 2019) of the IAG SC 2.4b: Gravity and Geoid in South America
- Ricardo Cesar Podestá, Director of the Observatorio Astronómico Félix Aguilar, Universidad Nacional de San Juan (Argentina).

The second session, *UN-GGRF definition and organisation*, was devoted to the political framework outlined by the Subcommittee on Geodesy (SCoG) of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM). This session started with an introductory presentation about the UN-GGIM Regional Committee for the Americas (UN-GGIM Americas) followed by a detailed description of the definition, objectives, organisational structure, implementation plan, and road map for the realisation of the UN-GGRF. A third presentation summarised the governance arrangements that are being implemented to ensure the UN-GGRF sustainability, in special the proposal of installing a Global Geodetic Centre of Excellence (GGCE) under the auspices of UN-GGIM. This topic was extended by a following talk about the efforts of the SCoG Working Group on Education, Training and Capacity Building to support the UN-GGRF road map and implementation plan. The session finished with an overview of the new opportunities offered by the UN-GGIM initiative to improve the existing global geodetic infrastructure. These topics were addressed by

- Sergio Cimbaro, South America Board Member of UN-GGIM Americas
- Gary Johnston, Co-chair of the UN-GGIM Subcommittee on Geodesy (SCoG)
- Daniel Roman, US Representative to the UN-GGIM SCoG Working Group on Governance
- Allison Craddock, Member of the SCoG Working Group on Education, Training and Capacity Building
- Zuheir Altamimi, Lead of the SCoG Working Group on Geodetic Infrastructure.

The session *Global and regional cooperation frameworks* gave the opportunity to know the mission, vision, structure, current projects, and interaction with Latin America of international organisations promoting science. Organisations presented in this session were:

- International Science Council (ISC) by Alik Ismail-Zadeh, Secretary of ISC
- International Union of Geodesy and Geophysics (IUGG) by Alik Ismail-Zadeh, Secretary General (2007 – 2019) of IUGG
- International Association of Geodesy (IAG), including the IAG sub-commissions in Latin America, and the IAG vision on the implementation of the UN-GGRF road map by
    - Harald Schuh, President (2015 - 2019) of IAG,
    - Hermann Drewes, Secretary General (2007 – 2019) of IAG, IAG Representative to SIRGAS, SIRGAS Honorary President,
    - Zuheir Altamimi, President (2019 – 2023) of IAG
- International Federation of Surveyors (FIG) by Daniel Roman, Chair of FIG Commission 5 (Positioning and Measurement)
- International Association of Seismology and Physics of the Earth's Interior (IASPEI) and its Latin American and Caribbean Seismological Commission (LACSC) by Marcelo Assumpção, Executive Secretary of IASPEI-LACSC
- Pan-American Institute of Geography and History (PAIGH) by César Fernando Rodríguez Tomeo, Secretary General of PAIGH
- The International Committee on Global Navigation Satellite Systems (ICG) of the United Nations Office for Outer Space Affairs (UNOOSA), presentation prepared by Sharafat Gadimova (Executive Secretariat of ICG-UNOOSA) and given by A Craddock, manager of GGOS External Relations and Central Bureau Director and Secretariat of the International GNSS Service (IGS).

To close the session, a summary of the SIRGAS achievements from the organisational point of view (no the scientific one) was presented by Claudio Brunini (President (2007 – 2015) of SIRGAS). He described the relationship of SIRGAS with the IAG (for scientific support and guidance), with PAIGH (for scientific and practical applications in the Latin American countries), with UN-GGIM Americas (as single supplier of the geodetic reference frame for the region), and with national governmental and non-governmental organisations, who recognise, use and recommend SIRGAS as the regional geodetic reference frame.

Based on the political and organisational frameworks addressed by the previous sessions, the next three sessions of the workshop concentrated on the scientific fundamentals and geodetic infrastructure provided by the IAG for the realisation of the UN-GGRF. These sessions included the four international

reference systems/frames defined and maintained within the IAG, the scientific infrastructure provided by the IAG Services, and the Global Geodetic Observing System (GGOS) of the IAG. The session *Global geodetic reference systems and frames* covered:

- The International Celestial Reference System and Frame (ICRS/ICRF) by Robert Heinkelmann, Analysis Coordinator of the International Earth Rotation and Reference Systems' Service (IERS)
- The International Terrestrial Reference Frame (ITRF) by Zuheir Altamimi, Primary scientist of the International Terrestrial Reference System (ITRS) Centre of the IERS
- The International Gravity Reference System (IGRS) by Axel Rülke, on behalf of the IAG JWG 2.1.1: Establishment of a global absolute gravity reference system (chair: Hartmut Wziontek)
- The International Height Reference System and Frame (IHRS/IHRF) by Laura Sánchez, Lead of the GGOS Focus Area "Unified Height System"

To complete the session, a presentation about the status of the high-resolution gravity field model EGM2020 (Earth Gravitational Model 2020) was given by Daniel E Barnes of the US National Geospatial-Intelligence Agency (NGA).

The session dedicated to the IAG Scientific Services included:

- The International GNSS Service (IGS) by Gary Johnston, Chair of the IGS Governing Board
- The International DORIS Service (IDS), including science contributions of DORIS and synergy with other geodetic techniques by Laurent Soudarin, Director of the IDS Central Bureau and Frank G. Lemoine, IDS Chair
- The International Laser Ranging Service (ILRS) by Michael Pearlman, Director of the ILRS Central Bureau
- The International VLBI Service for Geodesy and Astrometry (IVS) by Dirk Behrend, Director of the IVS Coordinating Centre
- The International Earth Rotation and Reference Systems' Service (IERS) by Robert Heinkelmann, IERS Analysis Coordinator
- The International Centre for Global Earth Models Service (ICGEM) by Elmas Sinem Ince, Director of ICGEM

- The International Gravity Field Service (IGFS) and its components by Riccardo Barzaghi, Chair of the IGFS.

In these presentations, the different IAG Services emphasised the benefits of a stronger joint work with Latin America, not only by installing and maintaining more geodetic observing stations but also by participating in the data analysis. To understand better the huge amount of work and effort behind each IAG Service, two additional presentations showed the perspective of two agencies supporting the activities of the IAG Services. From one side, Daniela Thaller (Director of the IERS Central Bureau) talked about the efforts of the German Bundesamt für Kartographie und Geodäsie (BKG) to provide geodetic reference data and products (global space-geodetic data analysis and data repositories). From the other side, Elmas Sinem Ince (Director of ICGEM) addressed recent gravity field modelling studies and future plans at the Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences.

The *GGOS session* initiated with an overview of the objectives, structure, current projects, and organisational aspects of this observing system. Afterwards, the two GGOS Bureaus (Bureau of Networks and Observations, and Bureau of Products and Standards) gave dedicated presentations showing in detail their objectives, working plans, current challenges, and achievements. Four further contributions concentrated on the improvements in the realisation of the ITRF if more SLR and VLBI stations were available in Latin America; on the advances for the definition of Essential Geodetic Variables (EGV); on the handling of Digital Object Identifiers (DOI) for geodetic data and products; and on the external relations managed by GGOS to share, advertise and disseminate geodetic achievements. Contributors to this session were:

- Richard Gross, Vice-president (2019 – 2023) of IAG, President (2017 – 2019) of GGOS
- Michael Pearlman, Director of the GGOS Bureau of Networks and Observations (GGOS-BNO)
- Laura Sánchez, Member of the GGOS Bureau of Products and Standards (GGOS-BPS)
- Daniela Thaller, Chair of the GGOS Standing Committee on Performance Simulations and Architectural Trade-Offs (PLATO)
- Allison Craddock, Manager of the GGOS External Relations.

The next session focused on the *IAG alignments with Priority Engagement Areas of the Group on Observations* (GEO). The primary objective of this session was to make evident how Geodesy contributes to address present needs of society and why it is important to advertise geodetic products and achievements in a standardised language, comprehensible by any group of specialists in any scientific, social, economic or political discipline. The first presentation of this session provided an overview of GEO. It was followed by a summary of the GGOS efforts in support of the United Nations Sendai Framework for Disaster Risk Reduction, and a review about how Geodesy contributes to the United Nations Sustainable Development Goals. To conclude the session, the objectives and implementation plan of UN-GGIM Integrated Geospatial Information Framework (IGIF) were presented. IGIF is a joint initiative of UN-GGIM and the World Bank and its primary goal is to provide guidance for developing, integrating, and strengthening geospatial information worldwide. The contents of this session was defined by Allison Craddock (Manager of the GGOS External Relations). Her support is especially acknowledged. The topics were presented by

- Richard Gross, Vice-president (2019 – 2023) of IAG, President (2017 – 2019) of GGOS
- Allison Craddock, Manager of the GGOS External Relations
- Nicholas Brown, Chair of the Permanent Committee on Geodesy of the Intergovernmental Committee on Surveying and Mapping (ICSM).

The last day of the workshop was dedicated to the *Argentine–German Geodetic Observatory* (AGGO), the only one fundamental geodetic observatory installed in Latin America. In the morning, six oral presentations described the contribution of BKG to the core geodetic infrastructure worldwide; the geodetic techniques installed at AGGO; the German and Argentine efforts and challenges to install and maintain AGGO operational; and the learnings and recommendations from the Argentine-German cooperation to install in Latin America further fundamental geodetic observatories similar to AGGO. In the afternoon, the workshop participants had the opportunity to follow guided visits at the AGGO fundamental station. These themes were addressed by

- Johannes Bouman, Director of the Department of Geodesy, Bundesamt für Kartographie und Geodäsie (BKG), Germany
- Claudio Brunini, Science Director of AGGO, Universidad Nacional de La Plata, CONICET, Argentina
- Hayo Hase, Director of Operations of AGGO, BKG
- Michael Häfner, Head of the SLR Team at AGGO, BKG
- The complete AGGO staff: Claudio Brunini (CONICET), Hayo Hase (BKG), Augusto Cassino (CONICET), Romina Ronchi (CONICET), Michael Häfner (BKG), Florencia Toledo (CONICET), Federico Salguero (CONICET), Alfredo Pasquaré (CONICET), José Vera (CONICET), Federico Bareilles (CONICET), Romina Galván (CONICET), Pablo Antico (CONICET).

Every day of the workshop, a brainstorming session was planned to have the opportunity of discussing the topics addressed in the oral sessions. Main conclusions of these discussions are:

The UN-GGIM has identified the establishment of a perdurable GGRF as a crucial need for sustainable human development. This initiative becomes a key tool to promote the implementation of better life and infrastructure conditions in developing countries. However, these countries have to be aware about the new opportunities offered by the UN initiative and they have to be prepared to face that opportunities. With this workshop, attendants were provided with scientific, technical, social and political arguments to negotiate with the local policy makers the implementation of the UN initiative on the GGRF at regional level. A core aspect of the workshop was the knowledge transfer in politics, international cooperation, and geodetic infrastructure management. To maximise this benefit, attendants should act as knowledge multipliers in their home countries.

Thanks to the international cooperation supported by IUGG and its Associations (in particular IAG and IASPEI), PAIGH, FIG and ICG-UNOOSA during the last decades, several geodetic and geophysical initiatives have successfully implemented many research projects in the region. However, the participation of the Latin American countries in these initiatives has not been homogeneous and the sparseness of infrastructure, technical expertise, and scientific competence and skills is still evident. This workshop contributed to the knowledge transfer and the creation of new capacities in the participating Latin American institutions to formulate regional initiatives oriented to the implementation of the UN-GGRF with a long-term sustainability. The workshop also made evident how important the international and multidisciplinary cooperation within the ISC, IUGG, IAG (and its Services and GGOS), IASPEI, FIG, ICG-UNOOSA, UN-GGIM and PAIGH is.

The progress in geodetic matters under the umbrella of SIRGAS during the last 25 years is incontrovertible. SIRGAS is today an operating organisation that coordinates a powerful observation and analysis infrastructure, generates reliable and community-accepted products, and provides outreach and capacity building at the regional level. Thanks to its performance, SIRGAS has been endorsed by the main regional forums related to the generation and use of geo-referenced data, like the UN Cartographic Conference for the Americas, PAIGH, and UN-GGIM Americas. However, continuous improvement is required to avoid degradation of the geodetic infrastructure (geodetic reference stations, processing centres, geodetic products, etc.) and to guarantee a long-term sustainability of the regional reference frame organisation in the region.

The implementation of the UN-GGRF has opened a debate on how Geodesy should be represented in UN-GGIM Americas. This debate must start on the solid foundations constructed by SIRGAS and should turn around the changes that have to be implemented in SIRGAS to better fit the UN-GGRF road map designed by UN-GGIM SCoG. The SIRGAS statute should be reviewed and the necessary modifications to comply better with the UN-GGIM Americas structure should be introduced. For instance, the governance in SIRGAS could be strengthened by demanding that countries officially designate national representatives (for example, following a procedure similar to that used by the Organisation of American States) and that representatives should be empowered to make binding decisions. The SIRGAS Working Group II (SIRGAS at national level) should be more intensely committed to the implementation of geodetic standards, mechanisms for data sharing, and the improvement of geodetic infrastructure in accordance with the UN-GGRF objectives. A stronger networking between SIRGAS and the representatives of the Americas to the UN-GGIM SCoG should be sustained.

To cover the complete spectrum of the geodetic geometric and physical reference frames, SIRGAS should install new working groups dedicated to gravimetry and gravity field modelling. This will allow a harmonised and consistent densification of the ITRF, the IHRF and the IGRF in Latin America. This goal has to be necessarily supported by the IAG Regional Sub-Commissions for Reference Frames and Geoid Modelling. If this is accomplished, t**he meaning of the 'G' in SIRGAS** could be changed from **'Geocentric' to 'Geodetic'**: SIRGAS – Sistema de Referencia *Geodésico* para las Américas.

A main current challenge of Global Geodesy is the improvement of the geographical distribution of the geodetic core observatories, in particular in the southern hemisphere. This is the reason because AGGO played a prominent role in the realisation of the workshop. It is clear that the enterprise of installing geodetic observatories similar to AGGO in Latin America cannot be assumed by only one country. Multilateral cooperation between less developed and industrialised countries is indispensable. From this perspective, the UN Resolution of GGRF not only opens new opportunities for developing countries to invest in geodetic infrastructure, but also commits industrialised countries to cooperate and to invest in those uncovered regions to fill the gaps where core observatories are needed. This procedure must be accompanied by dedicated capacity building activities.

The installation, operation and maintenance of AGGO is a successful enterprise thanks to the efforts of a strong Argentine-German cooperation program. The main learnings of this cooperation can be summarised as follows:

- Binational formal agreements are needed to define the contribution of each part. Patience, mutual understanding, and close collaboration are the key ingredients for a successful cooperation.
- Geodetic instruments are mainly provided by Germany. Local infrastructure and operational staff are mainly provided by Argentina.
- Customs procedures are very complicated (due to non-usual equipment to be imported) and regulations change every often. The local partner must allocate personnel and time for handling import/export procedures specifically.
- For the binational treatments, it is recommendable to define only one partner from each side and to have only one communication channel. This prevents liability from being diluted among a multiplicity of partners. Other institutions in each country can contribute to the main partner of their country without reducing the responsibility of this main partner.
- The primary objective of a core observatory like AGGO is to produce observational data according to international standards. This ensures a good impact of the core observatory in the international community. However, to guarantee a long-term support in the station home country, it is necessary that the national community understands the importance of the observatory and that it is involved in the use of data produced by the observatory. In other words, AGGO (or similar stations) should not only be concerned with the production of high quality data, but also with motivating the national community to formulate research projects based on its data. This implies continuous knowledge transfer and capacity building activities, not only for the staff of the observatory, but also for the national colleagues involved in Geodesy and affine disciplines.
- In the less developed regions, political changes and economic instabilities are difficult to predict. The probability of occurrence cannot be ruled out and partners must be prepared for that. In addition, the differences between developed and less developed countries go beyond economic capabilities or scientific/technical skills. They include, among others, the maturity of institutional practices, e.g.; written agreements do not automatically translate to facts, periodical negotiations and re-negotiations are required; there is little awareness that a project does not end with the initial investment; that long-term maintenance is even more demanding than initial investment; etc. Strategies for dealing with these kind of problems could be included in a 'Lessons Learned' document related to the UN-GGRF implementation plan.

This workshop convened for the first time politics (UN-GGIM, UN-GGIM Subcommittee on Geodesy, GEO, ICG-UNOOSA), international organisations promoting science (ICS, IUGG, IAG, IASPEI, FIG, PAIGH), the highest level of expertise in Geodesy worldwide (IAG, IAG Services, GGOS), and regional specialists in Geodesy (SIRGAS, gravity field modelling, geodetic observatories) to identify appropriate strategies to make *real* the objectives of the UN-GGRF initiative. The topics presented along the five days and the conclusions/recommendations arising from the discussions surely represent the appropriate start point to face the required activities to advance in the establishment of the GGRF in Latin America. Presentations, list of participants and conclusions of the workshop are available at http://www.sirgas.org/en/ggrf/.

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Annex 2

Financial report of the project Implementation of the United Nations' Resolution on the Global Geodetic Reference Frame (UN-GGRF) for Sustainable Development in Latin America granted by the IUGG in 2018 – 2019

Implementation of the United Nations' Resolution on the Global Geodetic Reference Frame (UN-GGRF) for Sustainable Development in Latin America

Financial Report

This document summarises the travel grants awarded with the money provided by the IUGG to the project. IUGG granted 15,000 US dollars, which were transferred to the bank account of the principal project participant Laura Sánchez in Munich, Germany. The amount received in Euros is 13,150.oo.

Receipt No.	Last name, name	Affiliation, City, Country Grant description	Amount in Euros
01	Pacino, Cristina	Universidad Nacional de Rosario, Rosario, Argentina Travel grant	300.oo
02	Cordero Gamboa, Gabriela	Universidad de Costa Rica, San José, Costa Rica Travel grant	200.oo
03	Caubarrere, Gustavo	Instituto Geográfico Militar, Montevideo, Uruguay Travel grant	300.oo
04	Suárez, Norbertino	Grupo Asesor Estratégico – IPGH, Montevideo, Uruguay Travel grant	300.oo
05	Pacheco, Ana	Universidad Nacional de San Juan, San Juan, Argentina Travel grant	300.oo
06	Mackern, Virginia	Universidad Nacional de Cuyo, Universidad Juan A. Meza, Mendoza, Argentina Travel grant	300.oo
07	Parada Pichuante, Ignacio	Instituto Geográfico Militar, Santiago de Chile, Chile Travel grant	350.oo
08	Reyes Norabuena, Claudio	Instituto Geográfico Militar, Santiago de Chile, Chile Travel grant	350.oo
09	Blitzkow, Denizar	Universidade de São Paulo, São Paulo, Brazil Travel grant	350.oo
10	Costa, Sonia Maria Alves	Instituto Brasileiro de Geografia e Estatistica, Río de Janeiro, Brazil Travel grant	400.oo
11	Moisés Sepúlveda, Leidy Johanna	Instituto Geográfico Agustín Codazzi, Bogotá, Colombia Travel grant	400.oo
12	Assumpção, Marcelo	Universidade de São Paulo, São Paulo, Brazil Travel grant	400.oo
13	Fortes Luiz, Souto Paulo	Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil Travel grant	400.oo
14	Cioce Pérez, Víctor José	Universidad del Zulia, Maracaibo, Venezuela Travel grant	500.oo
15	Bastos, Sara	Universidad Nacional, Heredia, Costa Rica Travel grant	500.oo
16	Arias Paradeda, Daniel	Disergemil, Asunción, Paraguay Travel grant	500.oo
17	Cordero, Rubén	Instituto Geográfico Militar, La Paz, Bolivia Travel grant	500.oo
18	Echalar, Arturo	Instituto Geográfico Militar, La Paz, Bolivia Travel grant	500.oo
19	Cortés Bolívar, Diego Armando	Instituto Geográfico Agustín Codazzi, Bogotá, Colombia Travel grant	700.oo
20	Cornejo, Javier	Instituto Geográfico Nacional "Tommy Guardia", Panama City, Panama Travel grant	700.oo
21	Coyago, Ricardo	Instituto Geográfico Militar, Quito, Ecuador Travel grant	700.oo
22	Cruz, Oscar	Instituto Geográfico Nacional, Guatemala City, Guatemala Travel grant	700.oo
23	Sánchez, Laura	Technische Universität München, München, Germany (Flight ticket Munich – Buenos Aires – Munich, Airport Transfer)	1,103.13
24	Brunini, Claudio Drewes, Hermann Sánchez, Laura	AGGO, La Plata, Argentina Technische Universität München, Munich, Germany Technische Universität München, Munich, Germany Accommodation in Buenos Aires during the workshop	1,417.33
25	Sánchez, Laura	Technische Universität München München, Germany (Flight ticket Munich – Rio de Janeiro – Munich: the ticket costed 1,009.17; 979.54 Euros were covered with IUGG money, the rest was paid by other source).	979.54
Total			13,150.oo

Annex 3

Presentation about the main conclusions of the International Workshop for the Implementation of the Global Geodetic Reference Frame in Latin America given at the Symposium SIRGAS2019.
Rio de Janeiro, Brazil. Nov 11 – 14, 2019

IUGG IAG IASPEI AGGO IGN ICG

International workshop for the

Implementation of the Global Geodetic Reference Frame (GGRF) in Latin America

Buenos Aires, Argentina, Sep 16 - 20, 2019

Summary

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UN Global Geodetic Reference Frame – GGRF

The GGRF is an *authoritative, reliable, highly accurate, and global spatial referencing infrastructure*. It is the foundation of almost every aspect of the *collection, management and use* of national geospatial information and global monitoring of the Earth. The GGRF underpins: Earth and Climate science, Economic Development and Sustainability, Public Safety and Disaster Management, Land and Water Administration, Environmental Management, etc.

The GGRF includes:

- the celestial and terrestrial reference frame products and Earth Orientation Parameters (EOPs) that connect them,
- gravimetric observations and products as well as height systems,
- the infrastructure used to create them, the observational data, the data analysis, and product generation systems.

Achievements of the International Association of Geodesy

→ – International Celestial Reference System and Frame (ICRS/ICRF)
– International Terrestrial Reference System and Frame (ITRS/ITRF)

→ – International Gravity Reference System and Frame (IGRS/IGRF)
– International Height Reference System and Frame (IHRS/IHRF)
– Global Gravity Models (GGM)

→ – IAG Commissions and Inter-Commission Committees → Theory and innovation
– IAG Scientific Services → Data storage, data analysis, product generation in a continuously operational basis
– IAG Global Geodetic Observing System (GGOS) → Integrated geodetic infrastructure for monitoring the Earth System and global change research

Long-term sustainability of geodetic infrastructure

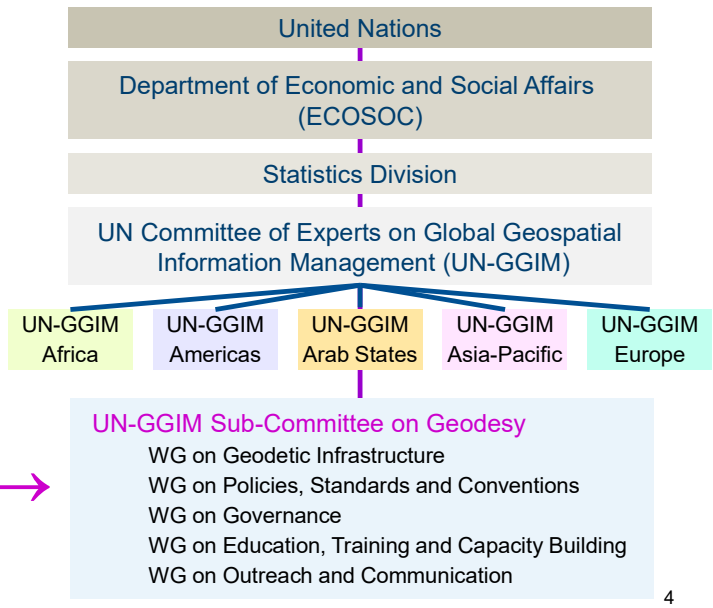
- The achievements of the IAG are the result of an international cooperation based on the *best effort principle*.
- All the IAG Components (Commissions, Inter-Commission Committees, Scientific Services, GGOS) are working on a highly professional level but *unpaid* by IAG or other international organisations.
- The geodetic infrastructure (observing stations/networks, data centres, processing centres, data repositories, etc.) is installed, maintained and operated mainly by *national agencies/institutes/universities (usually) founded by local/national/regional governments*. But
  - The geodetic infrastructure is *degrading*,
  - The geographical distribution is *biased towards North*,
  - *Gaps* in the networks of infrastructure exist, even in the North,
  - Many of the legacy infrastructure are *aging, difficult to maintain, and of poor performance*,
  - Operating *costs* for geodetic infrastructure are at risk for sustainable operation,
  - Coordination across nations, regions and globally is not always fully effective.

The UN Resolution on the Global Geodetic Reference Frame (GGRF)

A direct *channel of communication between Geodesy and Governments*; it opens a wide range of opportunities to *capture the attention of policy makers* (at the political level) in geodetic matters.

Key objectives:

- Development of a *global geodetic road map for the GGRF* (to be used by UN Member States and development organisations *to drive investment*),
- Global *cooperation* in providing technical assistance in Geodesy for those countries in need to ensure the development, sustainability and advancement of a GGRF,
- Implementation of *open geodetic data sharing*,
- Improvement and maintenance of *national geodetic infrastructure*,
- Enhanced *multilateral cooperation* to address infrastructure gaps and duplications globally,
- Appropriate outreach to make the GGRF more visible and understandable to society; *if decision makers understand the value of investing in geodetic infrastructure, they will prioritise investments in Geodesy*.

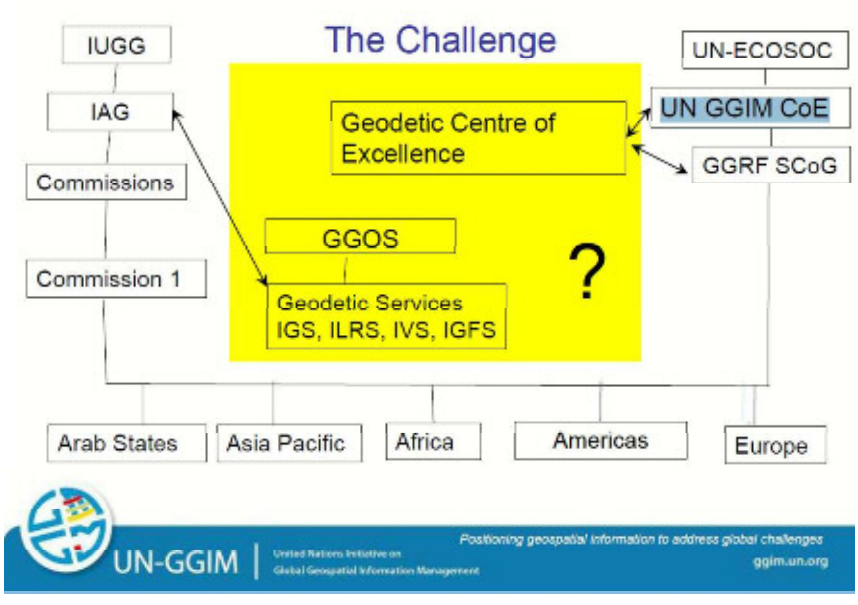


Use of appropriate vocabulary

- To make evident how Geodesy contributes to address present needs of society, it is important to *advertise geodetic products and achievements in a standardised language, comprehensible by any group of specialists in any scientific, social, economic or political discipline*.
- Geodesists have to use *words that are attractive for and comprehensible by politicians*.
- Priority initiatives at the United Nations level:
  - Sendai Framework for Disaster Risk Reduction 2015-2030,
  - Sustainable Development Goals,
  - The Paris Agreement on Climate Change.
- UN-GGIM Integrated Geospatial Information Framework (IGIF)
  - Guide for developing, integrating and strengthening geospatial information management.
  - Developed in collaboration between the United Nations and the World Bank.

Global Geodetic Centre of Excellence (GGCE)

- Coordination (under the auspices of UN-GGIM) of all entities contributing/supporting the GGRF to avoid duplication and to ensure the maximum use of available resources. Priorities:
  - Enhance global cooperation,
  - Provide operational coordination,
  - Provide technical assistance and capacity building.



Taken from Johnston 2019, GGRF Workshop, Buenos Aires, Sep 2019

Workshop for the implementation of the GGRF in Latin America

The two main objectives of the workshop were

1) To bring together
   - Politics (*UN-GGIM, UN-GGIM Subcommittee on Geodesy, GEO, UNOOSA-ICG, IGIF*)
   - International organisations promoting science (*ISC, IUGG, IAG, IASPEI, FIG, PAIGH*)
   - The highest level of expertise in Geodesy worldwide (*IAG, IAG Services, GGOS*) and
   - Regional experts in Geodesy (*SIRGAS, gravity field modelling, geodetic observatories*)

   to identify/design strategies that allow the Latin American agencies responsible for the geodesy of reference to approach policy makers for getting support to improve the geodetic infrastructure in their countries.
2) To know in detail *how AGGO was planned and installed and how it is maintained*. The improvement of the global geodetic infrastructure necessarily requires the installation of more geodetic observatories like AGGO in “uncovered” regions (Latin America, Africa, Oceania), but *costs and know-how* are a challenge for “local” geodesists. Could the *AGGO experience* be an example to be followed?

Supporting entities

- Project *Implementation of the United Nations’ Resolution on the Global Geodetic Reference Frame (UN-GGRF) for Sustainable Development in Latin America*, initiated by L. Sánchez (lead in the implementation of the IHRF) and C. Brunini (Science Director of AGGO).
- 15,000 USD → 28 travel awards for colleagues from 14 Latin American countries.
- Six flight tickets (Colombia, Peru, Chile, Brazil, Costa Rica, Ecuador)

International Committee on Global Navigation Satellite Systems (ICG) of the United Nations Office for Outer Space Affairs (UNOOSA)

- Logistical organisation

Supporting entities: International organisations supporting/promoting the GGRF

Supporting entities: IAG Scientific Services

Supporting entities: Speaker's affiliation (33 speakers)

Conclusions/recommendations

- Attendants were provided with *scientific, technical, social and political arguments* to negotiate with the local policy makers the implementation of the UN initiative on the GGRF at regional level. To maximise this benefit, attendants should act as knowledge multipliers in their home countries.
- The workshop made evident how *important the international and multidisciplinary cooperation* within the ISC, IUGG, IAG (and its Services and GGOS), IASPEI, FIG, ICG-UNOOSA, UN-GGIM and PAIGH is.
- The *progress* in geodetic matters under the umbrella of *SIRGAS* during the last 25 years is *incontrovertible*. SIRGAS is today an operating organisation that coordinates a powerful observation and analysis infrastructure, generates reliable and community-accepted products, and provides outreach and capacity building at the regional level. However, *continuous improvement is required* to avoid degradation of the geodetic infrastructure (geodetic reference stations, processing centres, geodetic products, etc.) and to guarantee a long-term sustainability of the regional reference frame organisation in the region.
- Thanks to its performance, *SIRGAS has been endorsed by the main regional forums* related to the generation and use of geo-referenced data, like the UN Cartographic Conference for the Americas, PAIGH, and UN-GGIM Americas. *SIRGAS plays the key role in the implementation of the GGRF in Latin America*.

Conclusions/recommendations

- Problem: *SIRGAS covers de facto Latin America*. UN-GGIM Americas includes also *USA and Canada*. Therefore, the implementation of the UN-GGRF has opened a debate on how Geodesy should be represented in UN-GGIM Americas.
- This debate should be based *on the solid foundations constructed by SIRGAS* and should turn around the changes that have to be implemented in *SIRGAS to better fit the UN-GGRF road map* designed by UN-GGIM Sub-Committee on Geodesy.
- The *SIRGAS statute should be reviewed* and the necessary modifications to comply better with the UN-GGIM Americas structure should be introduced.
- The objectives of *SIRGAS Working Group II* (SIRGAS at national level) should be focused *on supporting the implementation of the GGRF in the Latin American countries*. This implies the implementation of geodetic standards, mechanisms for data sharing, and the improvement of geodetic infrastructure in accordance with the UN-GGRF objectives. A *stronger networking* between *SIRGAS* and the representatives of the Americas to *the UN-GGIM Sub-Committee on Geodesy* should be sustained.

Conclusions/recommendations

- To cover the complete spectrum of the geodetic geometric and physical reference frames, *SIRGAS should install new working groups dedicated to gravimetry and gravity field modelling*. This will allow a harmonised and consistent densification of the ITRF, the IHRF and the IGRF in Latin America. This goal has to be necessarily supported by the IAG Regional Sub-Commissions for Reference Frames and Geoid Modelling. If this is accomplished, *the meaning of the 'G' in SIRGAS could be changed from 'Geocentric' to 'Geodetic': SIRGAS – Sistema de Referencia Geodésico para las Américas*.
- The enterprise of installing geodetic observatories similar to AGGO in Latin America *cannot be assumed by only one country*. Multilateral cooperation between less developed and industrialised countries is indispensable. From this perspective, the UN Resolution of GGRF not only opens new opportunities for developing countries to invest in geodetic infrastructure, but also *commits industrialised countries to cooperate and to invest* in those uncovered regions to fill the gaps where core observatories are needed. This procedure must be accompanied by dedicated capacity building activities.
- The installation of geodetic core observatories in less-developed regions should follow the example given by *AGGO and the efforts of the strong Argentine-German cooperation*.

130 participants from 20 countries (Argentina, Australia, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Dominican Republic, France, Germany, Guatemala, Italy, Mexico, Panama, Paraguay, Peru, United States of America, Uruguay, and Venezuela).

Presentations, list of participants and conclusions of the workshop are available at http://www.sirgas.org/en/ggrf/.