IAG SC 4.1 "Emerging Positioning Technologies and GNSS Augmentation"

Objectives and Structure for the Term 2015-19

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Abstract— **This paper presents the scientific objectives and the structure of the IAG Sub-Commission 4.1 for the new term 2015-19. Particularly, it discusses its role and placement within the Commission 4 of the IAG, it introduces the Working Groups and discusses their areas of specialty and specific objectives. The article concludes with a draft plan of dissemination activities scheduled for the first part of the term.**

Keywords— International Association of Geodesy; IAG Sub-Commission 4.1

I. IAG MISSION AND STRUCTURE

The *International Association of Geodesy* (IAG) forms a constituent Association of the IUGG (*International Union of Geodesy and Geophysics*). Its mission is the advancement of geodesy at an international level through research and teaching activities that include collection, analysis, modeling and interpretation of observational data and stimulation of technological development, including the provision of a consistent representation of the shape, rotation and gravity field of the Earth and the planets.

The Association's structure comprises a number of components including the *Commissions*, the *Scientific Services*, the *Global Geodetic Observing System* (*GGOS*) and the *Communication and Outreach Branch* (*COB*) which is responsible for the promotional and communication activities of IAG (Figure 1). Among other dissemination means such as conferences, workshops and web-based activities, the IAG publications include the *Journal of Geodesy*, the *IAG Symposia*

series, the *Geodesist's Handbook*, the *IAG Reports* (*Travaux de l'AIG*), and the *IAG Newsletter*. The presentation of the new structure and nominations of the IAG Commissions for the term 2015-19 took place on the occasion of the XXVI IUGG General Assembly in Prague in June 2015 and the new issue of the Geodesist's Handbook is due soon [1].
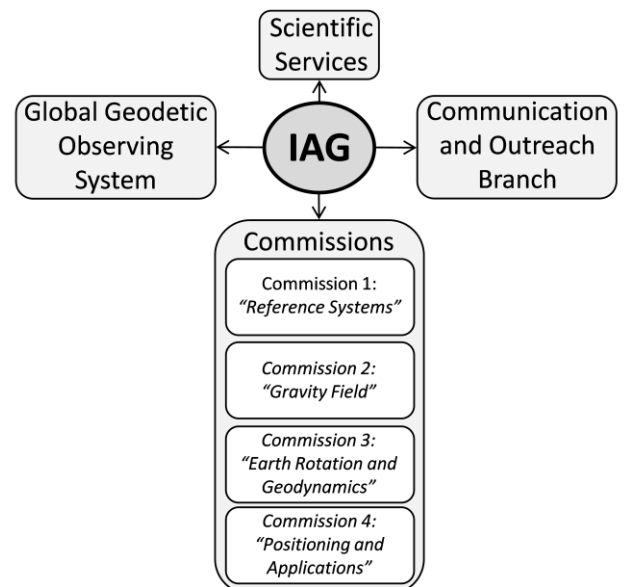

Fig. 1. Generic plan of IAG structure

II. IAG Commission 4: "Positioning and Applications"

IAG Commissions represent the Association in all scientific domains related to their field of geodesy. The main topics dealt by *Commission 4* are as follows: (a) terrestrial and satellite-based positioning systems development, including sensor and information fusion, (b) navigation and guidance of platforms, (c) interferometric laser and radar applications (e.g., Synthetic Aperture Radar), (d) applications of geodetic positioning using three dimensional geodetic networks (passive and active networks), including monitoring of deformations, (e) applications of geodesy to engineering, and (f) atmospheric investigations using space geodetic techniques.

The structure of IAG Commission 4 [2], comprises two main components; firstly, the *Sub-Commissions* which are in charge with specific topics of interest and secondly, the *Joint Study Groups* and *Joint Working Groups* which are setup to deal with specialized problems in collaboration with other interested IAG entities (i.e. Commissions, the *Commission on Theory*, the GGOS, etc.). As shown in Figure 2, IAG Commission 4 comprises four Sub-Commissions as follows: SC 4.1: Emerging positioning technologies and GNSS augmentation, SC 4.2: Geo-spatial mapping and geodetic engineering, SC 4.3: Atmosphere remote sensing, and SC 4.4: Multi-constellation GNSS.
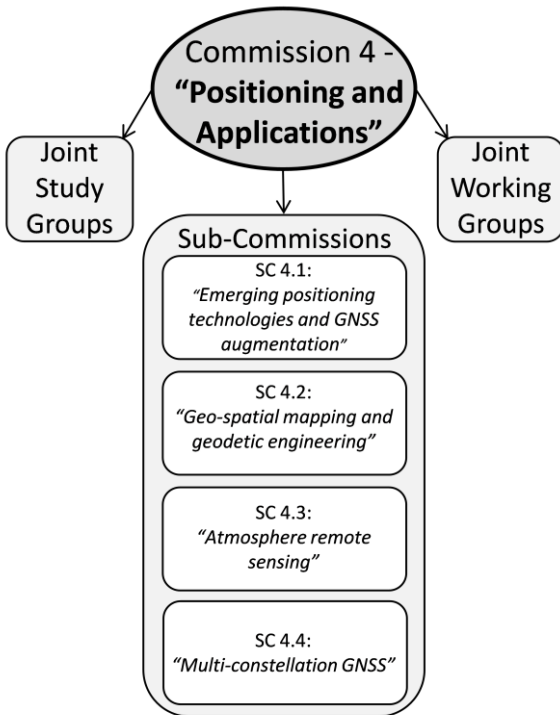

Fig. 2. Generic plan of IAG Commission 4

III. IAG Sub-Commission 4.1: "Emerging Positioning Technologies and GNSS Augmentation"

IAG Sub-Commission 4.1 intends to bring together scientists, researchers and professionals dealing with emerging positioning techniques and technologies aiming to address practical and theoretical solutions for positioning, navigation and guidance, including spatio-temporal monitoring and tracking of objects at various scales. For the term 2015-19 the focus will be on multi-sensor cooperative systems operating in adverse GNSS conditions for transportation, personal mobility, industrial and indoor positioning applications and to a lesser extent environmental monitoring. Except GNSS, the primary sensors of interest include inertial and wireless technologies as well as vision-based systems and laser scanning.

IAG, traditionally, in order to study complex problems the nature of which overspreads its area of activities, it pursues collaboration with other organizations that bestir in the broader field of geodesy & geomatics and beyond. A typical example of such a collaboration activity that relates to IAG Sub-Commission 4.1 for the past term (2011 – 2015), represents the formulation of a Joint IAG – FIG Working Group (IAG Joint WG 4.1.1 with FIG WG 5.5) on Ubiquitous Positioning Systems. The close collaboration between the two entities investigated the use of Collaborative Positioning (CP) through several field trials over the past four years. This investigation resulted CP is a viable solution if a "network" or "neighborhood" of users is to be positioned / navigated together, as it increases the accuracy, integrity, availability, and continuity of the PNT information for all users. Furthermore, the concept of CP was discussed in detail and selected results of these experiments were published in international conferences and scientific journals [3, 4].

For the next term, IAG Sub-Commission 4.1 will foster linkages and pursue its goals in close collaboration with other IAG entities, as well as sister scientific and professional organizations, primarily the ISPRS, FIG, ION and IEEE.

IV. Working Groups within IAG Sub-Commission 4.1

For the term 2015-19 IAG Sub-Commission 4.1 comprises four *Working Groups* established to address clearly defined, well focused scientific topics of limited scope within the field of the Commission. The scope and objectives of the IAG Sub-Commission 4.1 Working Groups are as follows (Figure 3).

A. WG 4.1.1 – Multi-Sensor Systems

This group is a joint working group between IAG and FIG. It focuses on the development of shared resources that extend our understanding of the theory, tools and technologies applicable to the development of multi-sensor systems. It has a major focus on:

- performance characterization of positioning sensors and technologies that can play a role in augmenting core GNSS capabilities,
- theoretical and practical evaluation of current algorithms for measurement integration within multi-sensor systems,
- the development of new measurement integration algorithms based around innovative modeling techniques in other research domains such as machine learning and genetic algorithms, spatial cognition etc.,
- establishing links between the outcomes of this WG and other IAG and FIG WGs (across the whole period),
- generating formal parameters that describe the performance of current and emerging positioning technologies that can inform IAG and FIG members.
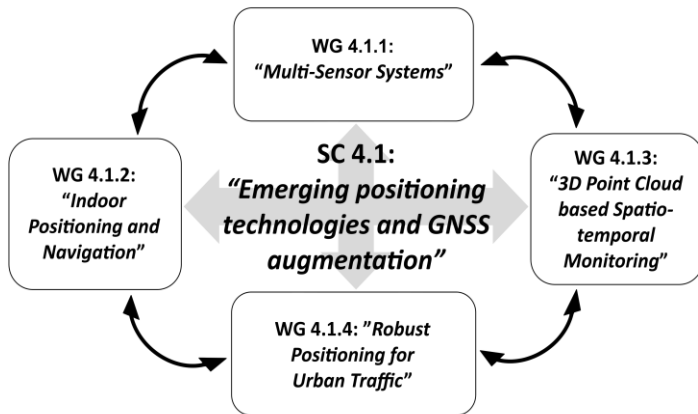
Fig. 3.   Working Groups of IAG Sub-Commission 4.1

B. WG 4.1.2 – Indoor Positioning and Navigation

The needs for indoor positioning and navigation have experienced unprecedented growth in the past decade due to the proliferation and ubiquitous usages of mobile devices and the rapid development of Internet of Things. Location information of people and objects in indoor environments becomes a key issue for many emerging and innovative applications. The primary aims of this working group are:

- to investigate emerging sensor technologies (e.g. LED, magnetometers), integrated techniques and protocols for indoor positioning and tracking,
- to discuss, investigate and develop new algorithm and smart solutions, and
- to bring key researchers and developers in this area together,
- to disseminate effectively the-state-of-the-art knowledge and new discoveries in the geospatial communities.

C. WG 4.1.3 – 3D Point Cloud based Spatio-temporal Monitoring

The WG will focus on spatio-temporal monitoring of artificial and natural objects with the aid of 3D point clouds acquired by means of multi-sensor-systems (MSS). The emphasis will primarily be placed on laser scanning technology and to certain extend on digital cameras. In general, monitoring applications over a certain period of time require a geo-referencing of the acquired data with respect to a known datum. Also, a kinematic MSS requires for a referencing to determine the time-dependent seven degrees of freedom (translation, rotation and scale). Specific objectives of the WG are as follows:

- performance characterization of laser scanners and cameras and their fusion in MSS with respect to spatio-temporal monitoring of artificial and natural objects in different scales. Potential objects or scenarios can range from plant phenotyping to infrastructure buildings,
- evaluate the object abstraction for epochal comparison by means of discrete point-wise, area-based and shape-based

approaches. One suitable method to investigate will be B-spline surfaces,

- investigate and develop suitable algorithms for change tracking over time in 3D point clouds, for instance by means of feature point tracking or shape matching,
- evaluate the fusion of heterogeneous data like 3D point clouds and ground-based synthetic aperture radar (GB-SAR) data with respect to structural health monitoring applications including infrastructure buildings.
- algorithms will be implemented in Python, Matlab, C++ whereas for basic 3D point cloud operations open source libraries should be used, such as point cloud library (PCL),
- establishing links to colleagues from civil and mechanical engineering to benefit from each other in terms of structural health monitoring, for instance loading tests of structural elements in lab and real conditions.
- establishing working links between this working group and similar national and international working groups such as DVW, ISPRS, IAG and FIG working groups.

D. WG 4.1.4 – Robust Positioning for Urban Traffic

The Work Group will focus on the navigation challenges on the urban environments for greener, safer and more comfortable traffic. At present, navigation is mainly based on the use of Global Navigation Satellite Systems (GNSS), providing good performance in open outdoor environments. However, navigation solution with sufficient accuracy and integrity is needed in urban canyons, where GNSS is significantly degraded or unavailable. For overcoming the aforementioned navigation challenges, research has been very active for decades for finding a suitable set of other methods for augmenting or replacing the use of GNSS in positioning for urban traffic. The Work Group has a major focus on:

- specification and characterization of the system requirements, especially from the environmental and safety viewpoints,
- evaluation of the usability of emerging technologies for the urban traffic navigation, including vision-aiding and collaborative driving systems,
- selection of best set of technologies fulfilling the system requirements,
- performance analysis of the selected system both for vehicles and pedestrians in urban areas,
- selecting the most suitable algorithms for map matching and routing.

V.   DISSEMINATION PLANS AND FORTHCOMING EVENTS

As part of its plan of actions for the upcoming four year legislature period, IAG Sub-Commission 4.1 will participate in various fora in order to promote its scientific activities and to disseminate respective developments and research results. As a "kick start" for the new term, an *IAG Commission 4 Positioning and Applications Symposium*" is organized in Wroclaw, Poland (Sept. 4-7, 2016) that Sub-Commission 4.1 will be actively participating [5]. The closing event of this legislation period is

scheduled to take place during the next IUGG General Assembly in Montreal, Canada (July 8-19, 2019).

REFERENCES

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