Reflections on a New Structure for IAG Beyond 2000 — Conclusions From the IAG Section II Symposium in Munich

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ABSTRACT

The current structure and possible future modifications of the IAG were in the focus of the Section II meeting of IAG in October 1998 in Munich.

The main conclusion was, that the IAG should invoke a thorough review process within the next IAG "legislation period" from 1999-2003. This process should include at least one special retreat of the IAG Executive Committee with a well selected list of guests. It must involve all IAG sections and all other relevant IAG entities (like IAG services).

Section II is convinced that a thorough review process is necessary because

- geodesy underwent a dramatic development since the creation of the current structure,
- space geodesy became increasingly important in the same time period: today, it plays a dominant role in all sections,
- the current section structure does not seem to reflect the present-day situation in an adequate way.
- the IAG services (like IERS, IGS, etc.) play an increasingly important role also for research in geodesy and geodynamics but are not well (if at all) integrated in the current structure.

Section II is convinced that these facts fully justify a thorough reorganization. Section II is also convinced, however, that the entire spectrum of IAG must participate in this important process in order to converge to a satisfactory solution.

1. Current IAG Objectives and Structure

If someone wants to change or modify the objectives and/or the structure of an international organization, she or he is well advised to seriously inspect its current objectives and structure. In the case of the *IAG*, the *International Association of Geodesy*, this is best done by critically reading the latest version of the Geodesist's Handbook (1996). The Geodesist's Handbook is issued every four years following the *IUGG (International Union of Geodesy and Geophysics)* General Assemblies. The Association's work is documented in the *Travaux de l'Association de Géodésie*. The *Travaux* are issued every four years as well, immediately after

the IUGG General Assemblies. They describe the work performed during the preceding four years period. The latest version of the *Travaux* available when preparing this manuscript describes the work of IAG in the time period 1991-1995 Willis, (1995). In addition to these official sources of information we refer Mueller (1996) for most valuable background information.

According to Torge (1996) *"geodesy is the science of determining the size and the figure of the Earth, and its external gravity field. ... geodesy therefore is part of the geosciences, providing significant boundary conditions for modeling the Earth's body and its dynamics, including the oceans and the atmosphere. On the other hand geodesy has strong relations to surveying and cartography, to navigation and engineering".*

We fully agree with this characterization. It shows the strengths, but also the weaknesses of geodesy: On the positive side we note that interdisciplinarity is "so to speak" inherent in geodesy (we like to underline such facts, e.g., when writing proposals to funding agencies). The same aspect also points to a potential weakness: geodesy may be viewed as an "auxiliary science" (very much like mathematics from the point of view of a physicist) by other scientists.

The IAG is an Association of IUGG, the International Union of Geodesy and Geophysics (note that geodesy is explicitely mentioned in the name of the union); the IUGG in turn is member of *ICSU*, the *International Council of Scientific Unions*.

According to the Geodesist's Handbook (1996, p. 855) the objectives and the structure of the IAG are as follows:

a) *to promote the study of all scientific problems in geodesy and encourage geodetic research;*

b) *to promote and coordinate international cooperation in this field, and promote geodetic activities in developing countries;*

c) *to provide, on an international basis, for discussion and publication of the results of the studies, research works indicated in paragraphs a) and b) above.*

To achieve these objectives, the Association shall comprise a number of Sections, each of which deals with a distinct part of geodesy.

Commissions, Special Commissions and Special Study Groups may be formed as provided in the By-Laws.

It is interesting to note that *IAG Services* are not even mentioned in this breakdown of the IAG structure.

Let us conclude this brief review of the current IAG objectives and structure by mentioning that on the administrative side we have the

- *General Assembly*, consisting of the Delegates of the Member Countries,
- the *Council of the Association* consisting of the Delegates designated for meetings of the Council and formally accredited by the Adhering Body of Member Countries,
- *the IAG Bureau* consisting of the *President*, the *First Vice-President*, and the *Secretary General*, all of whom are elected by the Council, and
- *the IAG Executive Committee* consisting of the *Bureau*, the *immediate past president*, the *Second Vice President*, and the *Presidents of Sections*.
- Honorary Presidents, honorary General Secretaries, Presidents of Commissions, Secretaries of Sections, and the Chief Editor of the Journal of Geodesy may attend any meeting of the Executive Committee with voice, but without vote.

Sec	Year	**Title**
I	1957	Triangulation
	1971	Control Surveys
	1983	Positioning
II	1957	Precise Leveling
	1971	Satellite Surveys
	1983	Advanced Space Technology
III	1957	Geodetic Astronomy
	1971	Gravimetry
	1983	Determination of the Gravity Field
IV	1957	Gravimetry
	1971	Theory and Evaluation
	1983	General Theory and Methodolgy
V	1957	Geoid
	1971	Physical Interpretation
	1983	Geodynamics

Table 1: The IAG Sections

Let us quickly review the main elements of the current IAG structure, namely *Sections*, *Commissions* and *Services*. Table 1 lists the five sections

of IAG and the (remarkable!) development of their names in time, Table 2 the Commissions and Special Commissions, and Table 3 the IAG Services.

Table 1 shows that the *five section structure* goes back to 1957, the IUGG General Assembly in Toronto, which took place in the Geophysical Year and in the year of launch of *Sputnik I*. It is obvious, however, that the section definition was quite different from what it is today.

In 1960, at the IUGG General Assembly in Helsinki, the Commission on Organization, which was later on renamed to *Cassinis Committee*, was created. This committee reviews the IAG structure prior to every other general assembly and comes up with structural changes for approval by the IAG Council (see below) at the General Assemblies. In 1971, at the General Assembly in Moscow, the section definition was considerably changed. The section on *geodetic astronomy* disappeared and Section IV on *theory and evaluation* was established.

The latest major review of the section structure took place in 1983 at the General Assembly in Hamburg. According to Mueller (1996) a fine tuning took place to accomodate the fact that space techniques cut across the entire spectrum of the IAG organization.

Table 2 lists the current Commissions and Special Commissions. At present we count five Commissions and five Special Commissions. The numbers are no longer logical today. When Commissions or Special Commissions were dissolved, the other ones kept their numbers. Until 1983 the Commission and Special Commission presidents were not represented in the IAG Executive Committee. Since the Vienna General Assembly in 1991 they are members with voice but without vote. This latter change of the IAG statutes was motivated by the observation that a fair portion of the actual work of the IAG was performed in these IAG units.

The same statement might be made with regard to the IAG Services which are listed in Table 3. Some people even believe that some of the services are "IAG flag ships" today. When the present IAG structure was established, many of these services did not even exist. The IAG Executive Committee recognized the increasing importance of the services. This is why Prof. Ivan Mueller was asked to organize a special session at the IAG Scientific Assembly in Rio de Janeiro in 1997 giving the IAG Services the opportunity to describe their achievements, in particular their products and "customers". This effort is documented in Mueller (1998).

What makes the distinction between a service and a commission? The difference resides in the keywords *products* and *user community*. Each service makes available products, e.g., time series of Earth rotation and Earth orientation parameters to a broad user community. The user community may be purely scientific (e.g., the geosciences community) or much broader (e.g., the entire surveyor plus the navigation community in addition to the geosciences community, as in the case of the IGS). For additional information concerning the IAG Services we refer to Beutler (1999).

Commission/Sec.	**Title**
X/I	Global and Regional Geodetic Networks
SC4/I	Applications of Geodesy to Engineering
VIII/II	Intl. Coordination of Space Techniques for Geodesy and Geodynamics
SC6/II	Wegener Project
SC7/II	Gravity Field Determination by Satellite Gravity Gradiometry
III/III	Intl. Gravity Commission
XII/III	Intl. Geoid Commission
SC1/IV	Mathematical and Physical Foundations of Geodesy
V/V	Earth Tides
VII/V	Recent Crustal Movements
SC3/V	Fundamental Constants
SC8/V	Seal Level and Ice Sheet Variations

Table 2: The Current IAG Commissions and Special Commissions (marked SC)

Table 3 illustrates that the bandwidth of IAG services is broad indeed, covering pure documentation (e.g., the IIS and the IBS) and services dealing with almost the entire range of geodesy and geodynamics (like *IERS, IGS, IGeS, BGI, and ICET*). Other services, like, e.g., the PSMSL are truly interdisciplinary in nature.

This is not the place to discuss the IAG Services in detail. We refer to Mueller (1998) for a description of the "classical" IAG Services and to the *Travaux* covering the time period 1995-1999

for the newly created services ILRS and IVS. Additional information is available in Beutler (1999).

Let us point out that (at least some of) the services in Table 3 are essential elements of the IAG work, but not of the IAG structure. Currently, the services are considered as elements of the sections which is why they are "only" described in the sessions sections of the Geodesist's Handbook (1996).

Service/Section	Short Title
IGS/II	Intl. GPS Service
IVS/II	Intl. VLBI Service
ILRS/II	Intl. Laser Ranging Service
BGI/III	Intl. Gravimetric Bureau
IGeS/III	Intl. Geoid Service
IERS/V	Intl. Earth Rot. Service
BIPM/V	Intl. Bureau of Weights and Measures
ICET/V	Intl. Centre for Earth Tides
PSMSL/V	Permanent Service for Mean Sea Level
IBS/—	IAG Bibliographic Service
IIS/—	IAG Information Service

Table 3: The Current IAG Services

Three services are formally assigned to Section II, two to Section III, and four to Section V. Two services are not attributed to a specific Section. They probably should be viewed as associated with the IAG Bureau.

The services are not well embedded in the sections. In many cases the services' activities might be associated to several sections (the IGS and the IERS, e.g., are closely related to Sections I, II, and V). Usually, there is no representation of the services in the executive bodies of the IAG sections. The only link between the conventional IAG structure and a service consists of one or two IAG representatives in the services' governing or directing boards. Services are thus highly independent (the positive way of putting it) but they have a very limited influence on the "life" within IAG. In view of the actual impact of the services in the "real world" we conclude that this is a major defect of the present IAG structure.

In Beutler et al. (1999) we discuss some of the relationships between the services. These considerations indicate that coordinating bodies above the services would, at least in some cases, make sense. In view of the rather random distribution of the services over the sections it is clear that the sections cannot play this role. In some cases IAG commissions may take over this coordinating role.

2. Motivations for a Change

From the previous discussion of the current IAG structure and from events which took place in the 1995-1999 period we conclude that a thorough review of the IAG organization and structure must take place in the 1999-2003 period. Let us first summarize the events:

- Prominent IAG officers, e.g., the President of IAG (Prof. K.P. Schwarz) and the President of Section II (Prof. Reiner Rummel) of the 1995-1999 period are convinced that a major change is mandatory.
- The IGGOS-Symposium in October 1998 in Munich revealed that this attitude is in essence shared by the individuals, commissions, and services in Section II. (IGGOS stands for *Integrated Geodetic and Geodynamic Observing System* and will be addressed in Section 4).
- The conclusions of the symposium were presented as a proposal to the IAG Executive Committee at its meeting of March 22-23, 1999 to invoke a thorough review of the IAG Structure in the next four years period and to implement it in 2003. The proposal was endorsed by the IAG Executive Committee.
- One entire day of the G6-Symposium in Birmingham is devoted to the new IAG structure.

Let us summarize the arguments in favor of a thorough review of the IAG structure:

- Much of the work done within the Association is actually performed by the Services. The link between the IAG Services and Sections is weak, in some cases nonexistent.
- There is only a "one-way" link between the IAG Executive Committee and the Services (through so-called IAG representatives in the services' Boards).
- Similar statements may hold for some of the (special) commissions.

- According to Torge (1996) "geodesy is part of the geosciences, providing significant boundary conditions for modeling the Earth's body and its dynamics".

- We believe that only geodesy is capable of providing the terrestrial and celestial reference frames (and the connection between them) for all geosciences and for (fundamental) astronomy.

- Despite these facts, the *IAG* is not involved in any of the major "Geo-Programs", like, e.g.,

  - *WCRP* (World Climate Research Program),
  - *IGBP* (International Geosphere Biosphere Program), and
  - *GOOS* (Global Ocean Observing System).

- One might get the impression that the other geosciences are considering geodesy (and thus IAG) as an "auxiliary science" (like mathematics) or as a tool like a PC (Personal Computer).

- In the next decade there will be a number of space missions of profound interest to geodesy and to IAG. CHAMP, GRACE, GOCE, and JASON may serve as examples. A new IAG structure must guarantee that IAG actually will play a major role in the scientific exploitation and the dissemination of results and information related to these missions.

- Even since the latest major reorganization of IAG in 1983, the development of space geodesy was (at minimum) remarkable. It seems strange that space geodesy should be limited to section II. A new structure must acknowledge that space geodesy resp. its tools are essential in all branches of geodesy.

- There is not much interaction between the IAG sections. This is probably due to the fact that no attempt was made to build a structure around a central theme.

- *Reference Systems for the Geosciences, their Realization and Use* might be a central theme for the new IAG structure.

3. The Age of Space Geodesy

In *space geodesy* we study aspects of geodesy and geodetic astronomy by using natural or artificial celestial bodies as observed objects or as observing platforms. Space geodesy is thus defined through the observation techniques, the space geodetic techniques, or methods.

Space geodesy evolved rapidly in the second half of the twentieth century. The space age was initiated by the launch of the first artificial satellite, Sputnik I, on October 4 of the International Geophysical Year 1957. It became possible to deploy and use artificial satellites either to study figure and shape of the Earth from space or to observe them as targets from the surface of the Earth. The use of artificial Earth satellites for geodetic purposes is also referred to as satellite geodesy.

The second essential development in our centext consists of the Very Long Baseline Interferometry (VLBI) technique as a new tool to realize an extraordinarily accurate and stable inertial reference system and to monitor Earth rotation using quasars. VLBI is at present the only "non satellite geodetic" technique meeting modern accuracy requirements of geodesy, geodynamics, and fundamental astronomy. In view of our general definition above VLBI clearly is a space geodetic technique.

Today, space geodetic techniques are the primary tools to study size, figure, deformation and gravity field of the Earth, and the Earth's motion as a finite body in the inertial reference system. Space geodetic techniques thus are the fundamental tools for geodesy, geodetic astronomy, and geodynamics.

Space geodetic observations contain information concerning the position (and motion) of the observed object and the observer. Thus they also contain information concerning the transformation between the terrestrial and the inertial systems. The Earth orientation parameters, i.e., polar motion, UT1, precession and nutation define this transformation.

From these definitions we see that space geodesy covers an extremely broad spectrum. It includes virtually all reference frame aspects and the determination of the gravity field.

4. Guidelines for the Development of an Alternative Structure

We propose to adopt the following general principles for the review process:

- The "old" structure shall remain in place as long as the process to develop a new structure is not concluded.
- The restructuring process will be considered as terminated when the IAG Council has formally adopted the new structure.
- The process of defining a new structure must include the entire spectrum of geodesy.
- This process must in particular result in new *Statutes and By-Laws*.
- The new structure must have a *central theme*. This might be formulated as a mission statement.

4.1 A Possible Central Theme

There are several ways how the central theme of the future IAG might be defined. Our discussion follows the thoughts contained in Beutler et al. (1998) and Rummel (1998) which were presented at the Munich 1998 IGGOS Symposium. It should be viewed as an attempt to have *reference systems and reference frames (including gravity)* as the central theme of the proposed review of the IAG.

We propose that a *Global Integrated Geodetic and Geodynamic Observing System (GIGGOS)* shall be considered to be geodesy's resp. IAG's contribution to large international science programs like, e.g., the *WCRP* (World Climate Research Program), the *IGBP* (International Geosphere Biosphere Program). The *IAG* contribution shall provide the geodetic component to the Earth system research.

In the currently active programs the emphasis obviously lies on climate change and environment. Such programs leave to a large extent open how solid Earth and ice processes as well as their interaction with ocean and atmosphere are to be quantified and modeled, and that geodesy is in a position to fill this gap by offering a very concrete and central element, namely the *GIGGOS*, the central objectives of which are:

- To provide a well defined and reproducible *global terrestrial frame*,
- the integral effect on *Earth rotation* of all angular momentum exchange inside the Earth, between land, ice, hydrosphere and atmosphere, and with Sun, Moon, and planets,
- the *geometrical shape* of the Earth's surface (solid Earth, ice, and oceans), globally or regionally, and its *temporal variations*, whether they are horizontal or vertical, secular, periodical or episodic, and
- by adding the *Earth's gravity field* — stationary and time variable — mass balance, fluxes, and circulation.

The above four elements of *GIGGOS* are briefly referred to as

(1) *frame*,

(2) *geokinematics*,

(3) *Earth rotation*, and

(4) *gravity field*.

The aimed at precision of the observing system must be of the order of about 10^{-9}, provide a high spatial and temporal resolution, consistency and stability over decades. (This was by the way the topic of the entire first day of symposium G6 in Birmingham).

The *GIGGOS* shall play a strategic role for the *IAG* in two respects:

- *GIGGOS* should be seen as the contribution of geodesy to the large scale international programs mentioned above. This contribution should be recognized by all associations within *IUGG* or *ICSU*.
- *GIGGOS* could serve as a common and very challenging focal point for "practically all" current research activities inside IAG.

Many, if not most, of the elements of the *GIGGOS* already exist and are dealt with in a very satisfactory way by *IAG* entities, in particular by the *IERS*, *IGS*, *CSTG*. We mention the celestial and terrestrial reference systems, the time series of Earth rotation parameters connecting the two systems, we also mention the development of the *ISGN* which should be able by design to take over most of the observational part of *GIGGOS*.

Regional activities are very well addressed as well within *IAG* – we mention the *EUREF Subcommission*, the *SIRGAS Project*, and the *WEGENER Special Commission*.

It is our vision to view all these activities as the central theme of the new IAG structure and organization.

If we would only consider the first three of the four components of *GIGGOS*, we could safely state that *GIGGOS* is almost in place. The gravity field is an exception: our knowledge (as seen from the point of view of satellite geodesy) goes back essentially to optical and *SLR* tracking of geodetic satellites (like *Lageos 1,2, Starlette, etc.*) and to satellite altimetry. The aimed at accuracy (of 10^{-9}), with a very high time and space resolution, has not yet been achieved.

The new gravity-oriented satellite missions will dramatically improve our knowledge of the gravity field, however. This aspect will have to be addressed in the development of space geodesy.

4.2 Elements of the Restructuring Process

Let us point out that the process of restructuring IAG is not yet in an advanced stage. Right now, the authors are aware of four proposals, namely

- a structure proposed by the IAG president, K.-P. Schwarz at the Munich meeting, where the structure is centered around a central project (global observing system),
- a structure proposed by Martine Feissel at the Munich meeting, which in essence maintains the section structure but gives much more weight to services, projects, and research,
- a proposal to merge sections 1,2 and 3 thus yielding three new sections (measurement methods, modeling, geodynamics)
- to form sections according to the key words frames, geokinematics, Earth rotation, gravity field (as outlined above)

These proposals are not yet formulated in a way that they could be compared in a meaningful way. This is why we are convinced that more time is required for the restructuring process.

Let us, however, try to nail down the essential elements of the process:

- The process must be fundamental. We have to ask, e.g., whether the section structure still is appropriate.
- We have to give the proper weight to the IAG units (to services in particular) performing much of the work the Association stands for.
- We have to make sure that IAG is recognized as the international organization providing the reference frames for the other geosciences.
- We have to make sure that the upcoming gravity missions are playing an important role within the new IAG structure.

5. The Team and the Plan

We propose to proceed as follows:

- The new IAG structure based on the principles outlined above shall be developed in the 1999-2003 period.
- The process must be initiated at the Birmingham IAG Executive Committee meeting, where
  - a Steering Committee of about six IAG officers and
  - a Chairperson shall be designated by the IAG Executive Committee,
  - the Chairperson shall initiate the review process based on the outcome of the Birmingham G6 symposium.
  - the Steering Committee will review this summary. Afterwards this summary will be made available as background information to the authors of position papers.
- In summer 1999 the IAG Retreat to review the IAG Structure has to be prepared by the steering committee.
- A *list of 20-30 invitees*, a *draft agenda*, and a *list of authors of position papers* shall be proposed to the IAG Executive Committee by the Steering Committee end of November 1999.
- The *IAG Retreat* shall take place in fall 1999 early in the year 2000.

- A report about the IAG Retreat is prepared and presented to the IAG Executive Committee mid 2000.
- The IAG Executive Committee discusses, modifies, approves the recommendations and action items emerging from the retreat.
- The new IAG structure is defined and the new By-Laws are written.
- The resulting documents are published (summarized) in the Journal of Geodesy around the end of the year 2000.
- At the 2001 IAG Scientific Assembly one Session is devoted to presenting the new structure to the plenum.
- At the same assembly an extraordinary Council Meeting is organized to allow for a discussion and a formal acceptance (or refusal) of the new IAG Structure and By-laws.

6. Epilogue

The plan for the review process outlined above was intensively discussed at the IAG Symposium G6 in Birmingham. The plan and the timeline was approved by both, the IAG Executive Committee and the IAG Council. Both of these IAG Bodies approved the plan and the timeline specified.

The *IAG Review Committee* now has the demanding task to fill these plans with life. The committee (in alphabetic order) consists of:

- Georges Balmino
- Gerhard Beutler (chair)
- Fritz Brunner
- Jean Dickey
- Martine Feissel
- Rene Forsberg
- Reiner Rummel
- Fernando Sanso
- Klaus-Peter Schwarz

The committee has started to work. The *IAG Retreat* is scheduled to take place from February 14-16, 2000 at Jet Propulsion Laboratory (JPL) in Pasadena.

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