



The goal of the IAU/IAG Joint Working Group on the Theory of Earth Rotation

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INTRODUCTION

- ✗ The International Association of Geodesy (IAG) and the International Astronomical Union (IAU) set up a new **Joint Working Group** on **Theory of Earth Rotation** recently in 2013.
- ✗ The elaboration of the proposal was initiated around the IAU General Assembly held in Beijing in August 2012 where a business meeting of IAU Commission 19 took place. The draft was opened to suggestions and discussions at the beginning of 2013. The final proposal was approved officially by the *IAU C19 Organizing Committee*, the *IAU Division A Organizing Committee*, and the *IAG Executive Committee* along past April.

PURPOSE

- ✘ *Following the proposal, the purpose of the new JWG is:*

To promote the development of **theories** of Earth rotation that are **fully consistent** and that agree with observations and provide **predictions** of the Earth Rotation Parameters (ERP) with the **accuracy required to meet the needs of the near future** as recommended by, e.g., **GGOS**, the Global Geodetic Observing System of the IAG.

SOME CONSIDERATIONS (1/5)

- ✗ Let us recall that GGOS 2020 demands an accuracy of **1 mm** to the systems of reference, besides a stability in time of 0.1 mm/y.
- ✗ That corresponds roughly to an angle of **30 μ as**
- ✗ From the observational side, the accuracy and performance of the major techniques is increasing. A good example is provided by the new generation of VLBI. A number of stations compliant with the 2010 specifications are already being deployed or have been approved. Besides, the various IAG services are committed to reach GGOS goals

SOME CONSIDERATIONS (2/5)

- ✗ Therefore, it can be expected that series of more accurate Earth Orientation Parameters (EOP) will be produced in some years. Besides EOP series with higher time resolution are also expected.
- ✗ Presently, series of Earth Orientation Parameters (EOP) are provided by several Analysis Centres and by IERS, the international body in charge of earth rotation prediction and monitoring and of the realization and maintenance of the Celestial and Terrestrial Reference Frames (ICRF and ITRF).

SOME CONSIDERATIONS (3/5)

- ✘ The set of EOP currently in use was agreed near 1980 following the recommendation of an IAU Working Group and comprises five angles, which corresponds to the transformation between ICRF and ITRF
 - + **Precession/nutation** (dX , dY offsets in the new paradigm - or $d\epsilon$, $d\psi$ in the old one)
 - + **Earth rotation angle** (ERA, formerly GMST or GAST - Greenwich Mean or Apparent Sidereal Times)
 - + **Polar motion** (x , y)
- ✘ Let us recall that the rotation linking both frames is specified by 5 EOP instead of 3, because an intermediate system is used, associated to the Celestial Ephemerides Pole (CEP), now changed by the Celestial Intermediate Pole (CIP)

SOME CONSIDERATIONS (4/5)

- ✘ **Other interesting properties** that favoured the adoption of those EOP were that both sets of nutation angles and polar motion (PM) were **free from diurnal components** either in the “inertial” or the “body-fixed” reference systems, respectively.

Besides, **nutations** gather mainly astronomically driven, **predictable** effects, while **PM** obeys mainly to geophysical, **difficult to predict** causes.

- ✘ Precise definitions of the main and auxiliary parameters and frames can be found in the IERS Conventions 2010, Supplement to the Nautical Almanac or SOFA (Standards of Fundamental Astronomy) documentation, for instance.

SOME CONSIDERATIONS (5/5)

- ✘ IAU adopted a new nutation theory in 2000, based on *MHB2000*, and a new precession model in 2006, based in *P03* by *Capitaine et al.* They are known as IAU 2000 and IAU 2006 – *IAU 2000/2006 for short.*
- ✘ **Present accuracy of current precession/nutation models is stabilised around 150 μ as**, in terms of wrms of the observation-model differences. The remarkable efforts made in the last years provided a better insight into the problem, but have not been compensated yet by a significant reduction of the residuals. And this concerns to only 2 of the 5 EOP!
- ✘ Therefore, **the goal of the JWG is really challenging**

TERMS OF REFERENCE (1/3)

1. A main objective of the Working Group (WG) is to **assess and ensure the level of consistency of ERP predictions derived from theories** with the corresponding ERP determined from analyses of the **observational** data provided by the various geodetic techniques. ***Consistency must be understood in its broader meaning***, referring to models, processing standards, conventions etc.
2. **Clearer definitions of polar motion and nutation are needed** for both their separation in observational data analysis and **for use in theoretical modelling**.

TERMS OF REFERENCE (2/3)

3. **Theoretical approaches must be consistent with IAU and IAG Resolutions** concerning reference systems, frames and time scales.
4. **Searching for potential sources of systematic differences between theory and observations is encouraged**, including potential effects of differences in reference frame realization.
5. The **derivation of comprehensive theories** accounting for all relevant astronomical and geophysical effects and **able to predict all ERP is sought**. In case more than one theory is needed to accomplish this, their consistency should be ensured.

TERMS OF REFERENCE (3/3)

6. There are no *a priori* preferred approaches or methods of solution, although solutions must be suitable for operational use and the simplicity of their adaptation to future improvements or changes in background models should be considered.
7. The **incorporation** into current models of **corrections** stemming from newly studied effects or improvements of existing models **may be recommended** by the WG when they **lead to significant accuracy enhancements**

DESIRED OUTCOMES

1. **Contribute to improving the accuracy of precession-nutation and ERP theoretical models** by proposing both new models and additional corrections to existing models.
2. **Clarify the issue of consistency** among conventional ERP, their definitions in various theoretical approaches, and their practical determination.
3. **Establish guidelines or requirements for future theoretical developments** with improved accuracy.

It is clear that the overall goals of the WG cannot be achieved within only 2 years, but the first term (until the next General Assembly of both IAU and IAG, i.e., mid 2015) should be used to develop a solid concept of how to reach its aims.

STRUCTURE

The structure of this JWG is **more complex than usual** and follows the characteristics of the current EOP as well as the fields of specialization of researchers.

The WG has several people in charge:

- ✕ **Chair:** Jose M. Ferrándiz (IAU)
- ✕ **Vice-Chair:** Richard Gross (IAG)

The WG is structured in three Sub-Working Groups (SWG):

1. **Precession/Nutation** (Chair: Juan Getino)
2. **Polar Motion and UT1** (Chair: Aleksander Brzezinski)
3. **Numerical Solutions and Validation** (Chair: Robert Heinkelmann)

STRUCTURE

SWG 3 will be dedicated to numerical theories and solutions, relativity and new concepts and validation by comparisons among theories and observational series.

These SWG should **work in parallel** for the sake of **efficiency** and **they should be linked together as closely as the needs of consistency demand**. To guarantee that, the **Chair** and **Vice-chair** of the WG will be **involved in all SWG** as will the **President of C19**, Chengli Huang. And a number of people will be members of more than one SWG

MEMBERS

SWG 1

Chair: Juan Getino,
Spain

Y Barkin, Russia
N Capitaine, France
V Dehant, Belgium
A Escapa, Spain
J Ferrándiz, Spain
M Folgueira, Spain
A Gusev, Russia
R Gross, USA
T Herring, USA
CL Huang, China
J Mueller, Germany
Y Rogister, France
H Schuh, Germany
J Souchay, France
V Zharov, Russia

SWG 2

Chair: Aleksander Brzezinski,
Poland

BF Chao, Taipei
W Chen, China
J Ferrándiz, Spain
R Gross, USA
CL Huang, China
SG Jin, China
W Kosek, Poland
J Nastula, Poland
J Ray, USA
D Salstein, USA
H Schuh, Germany
F Seitz, Germany
WB Shen, China
D Thaller Germany
QJ Wang , China
YH Zhou, China

SWG 3

Chair: Robert Heinkelmann,
Germany

BF Chao, Taipei
W Chen, China
V Dehant, Belgium
J Ferrándiz, Spain
D Gambis, France
E Gerlach, Germany
R Gross, USA
CL Huang, China
B Luzum, USA
Z Malkin, Russia
JF Navarro, Spain
J Ray, USA
Y Rogister, France
ME Sansaturio, Spain
H Schuh, Germany
F Seitz, Germany
M Thomas, Germany
QJ Wang , China

ADDITIONAL INFORMATION

- ✗ A first web site of the JWG is operating already, hosted by the Chair's institution – University of Alicante
- ✗ <http://web.ua.es/es/wgther>

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REMINDER OF JWG MEETING

- ✘ It is scheduled on **Wednesday 18th from 14-16 h**, at the **Paris Observatory**
- ✘ The agenda is not closed and aims at considering the issues more relevant to keep the coordination of the three SWG. Especial attention should be paid to discuss potential sources of inconsistency.
- ✘ Besides WG members, other interested JSR attendants would be welcome.
- ✘ Conciseness will be appreciated since many people has to travel that afternoon/evening

Thank you for your attention!