4 IERS Workshops
4.1 IERS Workshop on Conventions

The IERS workshop on Conventions was held on September 20–21 at the BIPM. A total of 65 participants from about 15 countries attended the workshop. The group photo (taken on the second day) may be found at <http://www.bipm.org/en/events/iers/iers_documents.html>.

The Scientific Organizing Committee consisted of F. Arias, B. Luzum, G. Petit (chair), J. Ray, B. Richter, J. Ries, M. Rothacher, H. Schuh, T. van Dam, and P. Wallace.

The workshop programme, including all the presentations, may be found at <http://www.bipm.org/en/events/iers/iers_documents.html>. Additional contributions, provided after the workshop, and this summary may also be found on that same page.

This document is an extended summary of the presentations, discussions, and recommendations of the workshop. Without directly following the order in the workshop programme, it is structured in a list of 11 items, and concludes with a list of the recommendations.

1. Classification of models
2. Criteria for choosing models
3. Non-tidal loading effects
4. New models
5. Possible additions to the Conventions
6. Technique-dependent effects
7. Terminology concerning reference systems
8. Practical application to the rewriting of some parts of Conventions (2003)
9. Electronic diffusion of the Conventions
10. Links with other fields of geodesy
11. Next registered edition

1. Classification of models

The Position paper "Principles for conventional contributions to modelled station displacements" (<http://www.bipm.org/utils/en/events/iers/Conv_PP1.txt>), hereafter PP1, proposes to classify the models and effects to be considered in the scope of the Conventions into three categories:

Class 1 ("reduction") models are those recommended to be used *a priori* in the reduction of raw space geodetic data in order to determine geodetic parameter estimates, the results of which are then subject to further combination and geophysical analysis. The Class 1 models are accepted as known *a priori* and are not adjusted in the data analysis. Therefore their accuracy is expected to be at least as good as the geodetic data (1 mm or better). Class 1 models are usually derived from geophysical theories. Apart from a few rare exceptions, the models and their numerical constants should be based on developments that are fully independent of the geodetic analyses and results that depend on them. A good example is the solid Earth tide model for station displacements.

Class 2 (“conventional”) models are those that eliminate an observational singularity and are purely conventional in nature. This includes many of the physical constants. Other examples are the ITRF rotational datum, specifying the rotation origin and the rotation rate of the ITRF. As indicated by their name, Class 2 may be purely conventional or the convention may be to realize a physical condition. When needed, choices among possible conventions are guided by Union resolutions and historic practice, which may differ in some cases.

Class 3 (“useful”) models are those that are beneficial (or even necessary in some sense) but are not required as either Class 1 or 2. This includes, for instance, the zonal tidal variations of UT1/LOD. An accurate zonal tide model is not absolutely required in data analysis though it can be helpful and is very often used internally in a remove/restore approach to regularize the *a priori* UT1 variations to simplify interpolation and improve parameter estimation. In addition, such a model is very much needed to interpret geodetic LOD results in comparisons with geophysical excitation processes, for instance. Class 3 also includes models which cannot fulfil the requirements for Class 1 such as accuracy or independence from geodetic results, but are useful or necessary to study the physical processes involved. Class 3 model effects should never be included (that is, removed from the observational estimates) in the external exchange of geodetic results unlike Class 1 effects. Serious misunderstandings can otherwise occur.

R1 Classification of models

It is proposed to distinguish three classes of models in the Conventions. Class 1 (“reduction”) covers models which are physically based, accurately determined and needed to obtain usable results in data analysis; Class 2 (“conventional”) models are also needed but are based on conventional choice; Class 3 (“useful”) includes the other models.

2. Criteria for choosing models

The IERS Conventions should strive to present a complete and consistent set of the necessary models of the Class 1 and Class 2 types, including implementing software. Where conventional choices must be made (Class 2), the Conventions provide a unique set of selections to avoid ambiguities among users. The resolutions of the international scientific unions and historical geodetic practice provide guidance when equally valid choices are available, but models of the highest accuracy and precision are always preferred.

Class 3 models are included when their use is likely to be sufficiently common, or to minimize potential user confusion.

For station displacement contributions, the Conventions should clearly distinguish models which are to be used in the generation of the official IERS products from other (Class 3) models. Models in the first category, used to generate the IERS realization of the celestial and terrestrial reference systems and of the transformation between them, are referred to as “conventional displacement contributions”.

Conventional displacement contributions should be of the Class 1 type (essential and geophysically based) and generally obey the following selection criteria, as specified in PP1:

- Include subdaily tidal variations: Since the beginning of space geodesy, the basic observational unit has consisted of data processing integrations for 1 solar day or multiples. This choice provides a natural filter to dampen variations with periods near 24 and 12 h (and higher harmonics) caused by environmental, geophysical (tidal), and technique-related sources. However, 1-day integration by itself is inadequate for the highest accuracy applications. Unmodelled subdaily site variations can efficiently alias into other geodetic parameters, such as the 12-h GPS satellite orbits, and also alias into longer-term effects. In order to minimize such difficulties, all tidal displacements with periods near 24/12 h and having amplitudes of about 1 mm and greater should be included *a priori* using conventional models. The most accurate models available should be applied, but any residual model errors will be strongly attenuated in data processing that use 24-h integrations (or multiples).
- Model corrections must be accurate: It is imperative that when adjustments are applied directly to observational data based on any model, the errors introduced by the model must be much smaller than the effect being removed. This should be true over the full spectral range affected but especially over intervals equal to or smaller than the geodetic integration span. If random errors in the subdaily band are increased, for instance, at the expense of reducing systematic variations at seasonal periods in 1-day processing samples, then it is clear that the corrections should not be applied *a priori*. Instead, suitably filtered corrections may be considered in *a posteriori* studies without suffering any degradation of the original geodetic analysis.
- Models must be independent of the geodetic data: In order to avoid circular reasoning and the possibility of propagating geodetic errors into conventional geophysical models, the applied models should be fully independent of the geodetic analyses which depend on them. Ideally they should be founded on geophysical theories and principles that do not directly derive from

geodetic results. Only in a few exceptional cases where geophysical theory is inadequate (such as some parameters of the nutation model) is it necessary to rely upon geodetic estimates within an adjusted geophysical framework.

- Prefer models in closed-form expressions: For practical reasons of implementation, portability, and independence of processing venue, closed-form analytical models for site displacements are most attractive.
- Allow flexibility in interpretation of geodetic results: To the extent that geodetic results are sensitive to any particular geophysical effect and the models for that effect are not necessarily uniquely well realized or accurate, it is often desirable to measure the relative performance of alternative models. In order to do so easily, geodetic results should be presented to researchers in a form that readily facilitates such comparisons as much as possible. Generally this implies strong preference for *a posteriori* treatment of model displacements that are outside the subdaily band rather than requiring multiple processings of the same data with various different *a priori* models. Note that this recommended practice is consistent with the traditional approach that has been used to interpret excitation of Earth orientation variations, for example.

These considerations are summarized in the following recommendation.

R2: Choosing models for conventional station displacements

It is recommended that conventional station displacements include only Class 1 ("reduction") models, plus any technique-specific effects. Some specific criteria are that complete daily & sub-daily tidal variations should be included, and that models must be accurate (with respect to observation errors), as independent of geodetic data as possible, and preferably in closed-form expressions for ease of use. In addition, it should be sought to maintain flexibility to evaluate different models easily *a posteriori* when accuracy is questionable.

The classification of models and general criteria for their use and implementation should be explicitly stated in the Conventions, as stated in the next recommendation:

R3: Recommended Revision of Conventions Introduction

It is recommended that the Introduction of the IERS Conventions be amended to include, in substance, the guiding principles and the selection criteria presented in R1 and R2 above.

3. Non tidal loading effects

Non-tidal loading effects are considered in PP1 and in the Position paper "Towards a conventional treatment of surface-load induced deformations", hereafter referred to as PP2 (<http://www.bipm.org/utils/en/events/iers/Conv_PP2.pdf>).

As a brief summary, PP1 recommends not to include non tidal loading effects as conventional site model contributions and to expand Chapter 7 to discuss these effects as Class 3 models. PP2 recommends developing a dynamic reference Earth model (DREM) as the outcome of a sequence: first a model for atmospheric loading, then for the hydrological cycle, finally for all significant geophysical processes.

These views are compatible considering that PP1 describes the generation of reference frames now and in the coming years, while PP2 describes (i) studies to be conducted now and in the next years, for which models are needed, and (ii) future possible application to the generation of reference frames when models fulfil the conditions. It is not possible at this time to state when this will be possible as DREMs should cover with adequate uncertainty the full range of significant geophysical processes in order to be used for reference frame generation.

3.1 PP1: Handling Non-Tidal Displacements

Following section 2, PP1 specifically recommends that displacements due to non-tidal geophysical loadings not be included in the *a priori* modelled station positions, that is, in the "conventional displacement contributions". These effects fail all contribution selection criteria given above. Even if the somewhat arbitrary preference for models in closed-form expression (which is inconsistent with non-tidal models) is relaxed, the other more important criteria cannot be ignored. The most serious obstacles are:

- Reliability in the subdaily band: At best, non-tidal environmental models attempt to compensate mostly for seasonal variations, which are well outside the normal integration intervals for space geodetic data. None of the available global circulation models properly account for dynamic barometric pressure compensation by the oceans at periods less than about two weeks. Instead, both "inverted barometer" (IB) and non-IB implementations are produced as crude approximations of the actual Earth system behaviour even though these are both recognized as unreliable in the high-frequency regime. While effective at longer periods (especially seasonal), the undesirable and unknown degradation that would affect subdaily integrations is not an acceptable side-effect.
- Inaccuracies of the models: The basic types of studies and analyses that are normally considered a precondition to the adoption of a conventional model are mostly lacking for non-tidal models. Documentation of error analyses is a basic requirement that must be fulfilled. Specific studies on comparisons of products,

systematic effects and possible combination techniques are necessary: Some references may be found in PP1.

- Models must be free of tidal effects: Any non-tidal displacement corrections applied should be strictly free of tidal contaminations, otherwise the geodetic results will be adversely affected.
- Risk of long-term biases in the reference frame: Because environmental models do not yet conserve overall mass or properly account for exchange of fluids between states, use of non-tidal models in solutions for the terrestrial reference frame will generally suffer from long-term drifts and biases that are entirely artificial. This is an unacceptable circumstance.
- Need for new datum requirements for the reference frame: As an example, introducing pressure-dependent non-tidal site displacement contributions into standard geodetic solutions would necessitate the adoption of a global reference atmospheric pressure field. Such expansion of the ITRF datum to include such non-geodetic quantities may not be welcome nor understood by users.
- Need to easily test alternative models: As noted in section 2, it is vital to be able to compare different non-tidal models easily and efficiently, something that is not facilitated by direct inclusion of the models into geodetic analyses. It is far simpler to make such comparisons and studies *a posteriori* as has been done for many years in research into the excitation of Earth orientation variations. However, in solutions where non-tidal displacements have been applied, the full field of corrections used must be reported in new SINEX blocks that will need to be documented and may nevertheless permit only an approximate removal of the non-tidal corrections if the applied sampling is finer than the geodetic integration interval.

Therefore non-tidal displacements must not be included in operational solutions that support products and services of the IERS. Nevertheless the non-tidal loading effects can be readily considered in *a posteriori* studies with no loss whatsoever. For this purpose, it is recommended that models of non-tidal station displacements be made available to the user community through the IERS Global Geophysical Fluid Centre and its special bureaux, together with all necessary supporting information, implementation documentation, and software. Expansion of the IERS Conventions, Chapter 7, could include some essential aspects of this material to inform users, as Class 3 models. Continued research efforts are strongly encouraged, particularly to address the outstanding issues listed above.

R4: to include non-tidal models as Class 3

It is recommended that IERS Conventions, Chapter 7, be expanded to include the essential aspects of using non-tidal models in *a posteriori* studies and research, in order better to inform users.

3.2 PP2: Handling Non-Tidal Displacements

PP2 describes steps that would be needed to obtain a consistent description of Earth shape, gravity field and rotation at the accuracy level of 10^{-9} or better in an integrated approach. It proposes to extend the definition of the "regularized coordinates" by introducing a displacement field with components provided by the following actions:

- Improving the operational prediction of displacements due to atmospheric loading.
- Setting up an operational computation of ocean-bottom pressure anomalies and the computation of the induced surface displacements.
- Setting up an operational computation of terrestrial water storage anomalies and the computation of the induced surface displacements.
- A consistency check based on mass conservation should be used to link the 3 components above and to ensure that large errors in mass conservation are detected/avoided.

PP2 concludes with 3 recommendations that make up steps to establish a Dynamic Reference Earth Model (DREM):

- Recommendation 1 (atmosphere only): Recognizing that atmospheric loading is a geophysical process inducing surface displacements at sub-daily to interannual time scales significant at an accuracy level of 1 ppb, and that signals of atmospheric loading in the shape, gravity field and rotation of the Earth can be predicted with high accuracy, it is recommended that, as a first step, a dynamic reference model is developed and validated that consistently predicts with low latency the atmospheric loading signal in the surface displacement, gravity field and rotation of the Earth and that these predictions are taken into account in the determination of the ITRF as well as the products providing low-latency access to ITRF.
- Recommendation 2 (hydrological cycle): Recognizing that mass redistribution in atmosphere, oceans, and terrestrial hydrosphere are inherently related through processes in the global hydrological cycle, that these mass redistributions cause surface displacements at sub-daily to interannual time scales significant at an accuracy level of 1 ppb, and that the feedback between the individual components (reservoirs) of the hydrological cycle as well as the solid Earth also cause significant signals in the shape, gravity field and rotation of the Earth, it is recom-

mended that a dynamic Earth model is developed and validated that consistently predicts the geodetic signals of mass redistribution in the global hydrological cycle and that accounts for the geophysical interactions between the reservoirs of the hydrological cycle and the solid Earth.

- Recommendation 3 (all relevant geophysical processes): Recognizing that monitoring of point motion and detection of “anomalous motion” are key applications of a modern global reference frame and space geodetic techniques, and that for many applications a predictive reference frame is required, and that such a reference frame needs to be based on a DREM, it is recommended that a DREM is developed that accounts for all known geophysical processes significant at the level of 1 ppb and that predicts consistently the signals in Earth shape, rotation and gravity field caused by these processes.

Discussions determined that the change in the definition of “regularized coordinates” (associated with the ITRF) envisioned in PP2 does not appear realistic in the foreseeable future. However studies towards a DREM, following the steps proposed in PP2, should be promoted. Given the wide range of geophysical processes involved, it was not clear which practical steps could be taken.

R5: Recommend the IERS DB to promote the development of a DREM

It is recommended that the IERS DB promotes the development of a dynamic reference Earth model.

4. New models

Following previous work initiated by the Conventions Centre and the Advisory Board, a number of papers have been presented at the workshop, mostly in session 1 “Recent advances and validations of the IERS Conventions models”. The final discussion led to the proposition of updating the Conventions for the following models:

4.1. S1/S2 atmospheric loading

A model for S1/S2 atmospheric loading is provided by T. van Dam and R. Ray. The model is based on the S1/S2 model by Ponte and Ray (2003). The effect can be as large as 1 to 2 mm for station height components at equatorial regions and is significantly smaller at higher latitudes.

J. Böhm and V. Tesmer (<http://www.bipm.org/utils/en/events/iers/Boehm.pdf>) applied this model for the whole history of VLBI observations. Work is continuing to quantify the influence of this model on VLBI solutions.

J. Ries (additional contribution, see <http://www.bipm.org/utils/en/events/iers/Ries_s1_s2_slr.pdf>) applied this model to 6 months of SLR data and found a small improvement in the variance of the residuals.

It was recognized that the model is well founded, that the magnitude of the effect is significant and that the expected accuracy of the model is sufficient. Although the benefits are hardly visible in the results of VLBI and SLR analysis, the tests show that the model is valid and still indicate an improvement. In addition, it is likely to be useful for GPS analysis due to the resonance of this effect with the orbital period. Like for other loading effects, the compensating counter motion of the solid Earth due to fluid loading effects (translation of the observing network relative to the instantaneous centre of mass) should be included in the modelled station displacements, at least for those techniques that observe the dynamical motions of near-Earth satellites and respond to the centre of mass of the total Earth system. (See section 8.3)

4.2. Troposphere model

The recent update of Chapter 9 of the Conventions does consider horizontal gradients in the general formulation of the tropospheric delay, but no conventional *a priori* values are provided for these gradients.

P. Steigenberger, V. Tesmer, J. Böhm (<http://www.bipm.org/utils/en/events/iers/Steigenberger.pdf>) have investigated the use of *a priori* gradients in the analysis of GPS and VLBI observations. They show that there is a clear systematic behaviour of station coordinates if no residual gradients are estimated, but that there is hardly any difference if gradients are estimated unconstrained in the solutions. However when gradients are estimated and constrained, as in VLBI, there are systematic effects of order 40 µas on source declinations and < 2mm on station latitude. Therefore it is recommended to include in the tropospheric model a hydrostatic gradient due to the equatorial bulge.

4.3 Conventional model for the effect of ocean tides on geopotential

R. Biancale (<http://www.bipm.org/utils/en/events/iers/Biancale.pdf>) presented a software package based on the FES2004 ocean tide model and its application to the EIGEN gravity field models. It is proposed to adopt this package as conventional and to include it in Chapter 6 of the Conventions. Therefore FES2004 would be the conventional model of ocean tides, consistently for geopotential and displacement. (This should be made clear in Chapter 7.)

In addition a S1/S2 atmospheric tides model (Biancale & Bode model) derived from ECMWF 3-hour surface pressure fields, expressed in a similar form, is proposed.

It is also proposed to add a S1 ocean tide model (provided by F. Lyard at LEGOS). This S1 tide model is not purely gravitational, but the hydrodynamic ocean tide is constrained by the S1 atmospheric tide (see above). It is provided for users who cannot use ocean circulation models (such as MOG2D from LEGOS) which include the S1 response of the ocean to the atmospheric pressure.

4.4 Model for diurnal and semidiurnal EOP variations

The conventional model for diurnal and semidiurnal EOP variations (Chapter 8) has not changed since IERS Conventions (1996). R. Ray (<http://www.bipm.org/utils/en/events/iers/Ray_Richard.pdf>) considered the need to upgrade this model. New global tidal models are much improved over the TPXO.2 model used in 1996. However, a tidal model for EOP also requires global current velocity, but few such models are available. Also a model should add atmospheric thermal tides to oceanic effects but no clear consistency is obtained between air-tide models. Therefore it is considered that more work is still necessary at this stage.

R6: Recommended new conventional models

It is recommended to add new conventional models: a model for S1/S2 atmospheric loading as provided by T. van Dam and R. Ray; a model for the tropospheric hydrostatic gradient due to the equatorial bulge; a model for the effect of ocean tides on geopotential based on FES2004 tidal model. Work on a new model for diurnal and semidiurnal EOP variations should be pursued.

5. Possible additions to the Conventions

Besides the new models mentioned above, additional material to the Conventions is also under consideration. Two topics are specifically proposed.

5.1. Propagation of radio waves through the ionosphere

Dispersive effects of the ionosphere on the propagation of radio signals are classically accounted for by linear combination of multi-frequency observations. In past years it has been shown that this approach induces errors on the computed time of propagation that can reach 100 ps for GPS. For wide-band VLBI observations, the induced errors might reach a couple of ps. It is proposed to gather in a new section the estimation of the effect of higher-order neglected ionospheric terms and possible conventional models for these.

5.2. Better documentation for relativistic models

Needed improvements are generally small changes, but occur in many different parts of the Conventions. They concern the terminology used, information on the magnitude of effects, and more detail on time of propagation model for ranging techniques. In addition a section on clock synchronization and transformations of proper time to coordinate time (applied to GNSS) is recommended. See a review of possible improvements in the presentation by S. Klioner (<http://www.bipm.org/utils/en/events/iers/Klioner.pdf>).

6. Technique-dependent effects

Reports were presented from the analysis coordinators of the IVS, the IGS and the ILRS. For IVS (<http://www.bipm.org/utils/en/events/iers/Nothnagel.pdf>), thermal expansion, gravitational sag and tumbling of reference point were mentioned as well as the general question of local ties. For IGS (<http://www.bipm.org/utils/en/events/iers/Ray_IGS.pdf>), antenna phase model, satellite orbit models, satellite attitude models, satellite signal polarization models, ionospheric delay modelling (see section 5.1), inter-modulation signal delay biases, SP3 orbit frame and relativistic effects for GPS clocks (see section 5.2) were covered. For ILRS (<http://www.bipm.org/utils/en/events/iers/Pavlis.pdf>), satellite force model, satellite attitude model, satellite centre-of-mass offset and measurement biases were mentioned, along with the possible relation to other techniques.

R7: Technique-dependent effects

Technique services should maintain documentation on their technique-specific effects. Links to this documentation should appear in the IERS Conventions.

In addition, topics that concern (or may concern) several techniques could be specified in the Conventions. Examples are the following:

- IVS needs a reference temperature to model antenna thermal deformation. A “GPT-like” function, based on the present conventional model GPT, averaged over one year, might be sufficient to represent the true average temperature with adequate uncertainty (a few K). Harmonic representation of higher order may be useful (to be considered in a future version of the routine GPT). When defined, such a conventional reference temperature should be used whenever needed, as all measurement techniques have temperature dependence.
- Non gravitational acceleration affects all satellites (GNSS/SLR), but the precise implementation of models is to be considered as technique-dependent. However, a general description might be useful in the Conventions.

7. Terminology concerning reference systems

Terminology concerning reference systems has been a recurrent topic for years. It mostly impacts Chapter 4 of the Conventions. It is addressed in the presentation (<http://www.bipm.org/utils/en/events/iers/Boucher.pdf>) which discusses also the IUGG resolution on ITRS passed at the 2007 IUGG GA in Perugia. It also presents the IAG Inter-Commission Working Group (WG 1.3) on ‘concepts and terminology related to Geodetic Reference Systems’, chaired by C. Boucher which aims at defining such a terminology. Note also a link with the IAG study group SC1.2-SG1- IC-SG1, on ‘Theory, implementation and quality assessment of geodetic reference frames’ (jointly Commission 1, ICCT, IERS) chaired by A. Dermanis.

For direct application to the IERS Conventions, one option is to first update, in Chapter 4, the part describing the elaboration of the latest realization (so far ITRF2005). When the IAG inter-commission WG has concluded its work, the whole chapter should be reconsidered in view of the WG report.

8. Practical application to the rewriting of some parts of Conventions (2003)

8.1 Conventions introduction

This is described in sections 1 and 2 above, concluding with R2 in section 2.

8.2 Conventions Chapter 4

PP1 made the specific recommendation that the text of the IERS Conventions, Chapter 4, section 4.1.3, be replaced starting from the 4th paragraph to the end of the section with the following new text:

"The general model connecting the instantaneous *a priori* position of a point anchored on the Earth's crust at date t, X(t), and a regularized position $X_R(t)$, is $X(t) = X_R(t) + [\Sigma_i \, dX_i(t)]$. The purpose of the introduction of a regularized position is to remove mostly high-frequency time variations (mainly geophysically excited) using conventional corrections $dX_i(t)$ in order to obtain a position with regular time evolution. Among other reasons, such regularization permits improved estimation of the actual instantaneous station positions based on observational data. In this case, $X_R(t)$ can be expressed by using simple models and numerical values. The current station motion model is linear (position at a reference epoch t_0 and velocity): $X_R(t) = X_0 + X' * (t - t_0)$.

The numerical values are (X_0 , X'), which collectively constitute a specific TRF realization for a set of stations determined consistently. For some stations it is necessary to consider several discrete linear segments in order to account for abrupt discontinuities in position (for example, due to earthquakes or to changes in observing equipment).

Conventional models are presented in Chapter 7 for the currently recognized $dX_i(t)$ corrections, namely those due to solid Earth (body) tides, ocean tidal loading, polar motion-induced deformation of the solid Earth (pole tide), ocean pole tide loading, and loading from the atmospheric S1/S2 pressure tides. All of these models, except the atmospheric S1/S2 pressure tides, include long-period variations outside the subdaily band. While not necessary, this approach is recommended in order to maintain consistency with longstanding practice and to minimize user confusion. Station displacements due to non-tidal loadings are not recommended to be included in operational solutions but studies for research purposes are encouraged.

The compensating counter motions of the solid Earth due to all the fluid loading effects ('geocenter motion' of the observing networks relative to the ITRF origin) should generally be included in the modelled station displacements, at least for those techniques that observe the dynamical motions of near-Earth satellites, which respond to the centre of mass of the total Earth system.

Additional station-dependent corrections may be recommended by the various Technique Services due to effects that are not geophysically based but nonetheless can cause position-like displacements. These generally affect each observing methods in distinct ways so the appropriate models are technique-dependent and not specified by the IERS Conventions."

8.3 Changes to Chapters 4, 5 and 7

Position paper 3 (<http://www.bipm.org/utils/en/events/iers/Petit_PP3.pdf>) intends to give directions so that the question of the origin of the terrestrial reference system (i.e. "geocentre motion") is treated in a consistent manner throughout the Conventions. When a phenomenon (such as the ocean tides) causes displacements of fluid masses, the centre of mass of the fluid masses moves and must be compensated by an opposite motion of the centre of mass of the solid Earth. The stations, being fixed to the solid Earth, are subject to this counter-motion. There is considerable confusion in the use of "geocentre motion" to represent the vector between the "instantaneous centre of mass of the whole Earth" (here noted CM) and the "origin of ITRF" (here noted CF). However a consistent practice in the recent IERS applications has been to use this vector as oriented "from CM to CF", so that it is proposed to use this convention in all cases. It could help to use a new name for this vector, e.g. "origin translation". Implications on different chapters of the Conventions include:

In chapter 7, the "tidal" component of the origin translation associated with all modelled loading effects should be modelled at the observation level, following the procedure used for ocean loading in the update 25/11/2006 of Conventions.

In chapter 4, the description of ITRF elaboration should mention explicitly the conventional procedure used to account for the "seasonal" component of the origin translation.

In chapter 5, the EOP formulation should be specified in the transformation TRS-CRS. As the EOP values used are referenced to the ITRF origin, it is to be mentioned explicitly that ITRF coordinates (i.e. not referred to the instantaneous CM) should be used.

9. Electronic diffusion of the Conventions

B. Luzum and G. Brockett (<http://www.bipm.org/utils/en/events/iers/Luzum_Conv.pdf>) considered several options for the electronic dissemination of the Conventions. From the discussion following, it seemed to emerge a consensus that the system of occasional 'registered editions' which are produced with an interval of a few years is still preferred. For the time being, the registered edition will remain the 'paper' edition, which is used in a wider community than the IERS.

The current approach of providing updates between registered editions through electronic means in both TeX and PDF files with full archiving of successive evolutions is supported. Additional electronic augmentations to the Conventions will be explored in the future as resources permit.

B. Luzum and M.S. Carter (<http://www.bipm.org/utils/en/events/iers/Luzum_Soft.pdf>) reviewed the current situation of Conventions software from a software engineering perspective and proposed some guidelines to improve the situation. In particular, the inclusion of test cases for accepted software and the improvement in the documentation of the code were seen as achievable goals. Additional improvements such as improved error trapping, formal version control, improved formal testing, improved consistency between subroutines, and providing code in additional languages, while beneficial, are not seen as practical at this time.

M. Gerstl (<http://www.bipm.org/utils/en/events/iers/Gerstl_Soft.pdf>) recommended that the Conventions software be fully normalized and proposed some technical choices. Such an approach has merits but would require more manpower than is currently available.

In following discussions it was determined that minimum requirements were to provide all source code on the Conventions web site, to ensure version control, to provide documentation on the arguments, and to provide test cases. The importance of this issue was stressed, because very often the software itself is the *de facto* convention, much more than the description of the model in the Conventions or in the literature.

R8: IERS Conventions software

It is recommended that, when a model needs to be coded in an independent routine or set of routines, the Conventions Centre will provide all source code on the Conventions web site along with documentation on the arguments and test cases, and will ensure version control.

10. Links with other fields of geodesy

J. Ihde (<http://www.bipm.org/utils/en/events/iers/Ihde.pdf>) presented conclusions of the IAG Inter Commission Project 1.2 “Vertical reference frames” which he chaired. ICP1.2 considered draft Conventions for the definition and realization of a Conventional Vertical Reference System (CVRS) and also recognized the need for conventions for the definition and realization of an absolute gravity reference system (IGSN71 – IAG WG in preparation). The continuation of this work is proposed as an IAG Inter-Commission Working Group for the Global Vertical Reference System (GVRS).

11. Next registered edition

During the session “Evolution of the Conventions” and in the final general discussion, it was widely recognized that a new registered edition is needed, which should implement the conclusions of this meeting. It is foreseen that it could appear in the time frame 2008/2009.

R9: Next registered edition of the IERS Conventions

It is recommended to assemble a new registered edition of the IERS Conventions, implementing the conclusions of this workshop, aiming at a publication date in 2009.

Summary of Recommendations

R1: Classification of models

It is proposed to distinguish three classes of models in the Conventions. Class 1 (“reduction”) covers models which are physically based, accurately determined and needed to obtain usable results in data analysis; Class 2 (“conventional”) models are also needed but are based on conventional choice; Class 3 (“useful”) includes the other models.

R2: Choosing models for conventional station displacements

It is recommended that conventional station displacements include only Class 1 (“reduction”) models, plus any technique-specific effects. Some specific criteria are that complete daily & sub-daily tidal variations should be included, and that models must be accurate (with respect to observation errors), as independent of geodetic data as possible, and preferably in closed-form expressions for ease of use. In addition, it should be sought to maintain flexibility to evaluate different models easily *a posteriori* when accuracy is questionable.

R3: Recommended Revision of Conventions Introduction

It is recommended that the Introduction of the IERS Conventions be amended to include, in substance, the guiding principles and the selection criteria presented in R1 and R2 above.

R4: To include non-tidal models as Class 3

It is recommended that IERS Conventions, Chapter 7, be expanded to include the essential aspects of using non-tidal models in *a posteriori* studies and research, in order better to inform users.

R5: Recommend the IERS DB to promote the development of a DREM

It is recommended that the IERS DB promotes the development of a dynamic reference Earth model.

R6: Recommended new conventional models

It is recommended to add new conventional models: a model for S1/S2 atmospheric loading as provided by T. van Dam and R. Ray; a model for the tropospheric hydrostatic gradient due to the equatorial bulge; a model for the effect of ocean tides on geopotential based on FES2004 tidal model. Work on a new model for diurnal and semidiurnal EOP variations should be pursued.

R7: Technique-dependent effects

Technique services should maintain documentation on their technique-specific effects. Links to this documentation should appear in the IERS Conventions.

R8: IERS Conventions software

It is recommended that, when a model needs to be coded in an independent routine or set of routines, the Conventions Centre will provide all source code on the Conventions web site along with documentation on the arguments and test cases, and will ensure version control.

R9: Next registered edition of the IERS Conventions

It is recommended to assemble a new registered edition of the IERS Conventions, implementing the conclusions of this workshop, aiming at a publication date in 2009.

Gérard Petit, Brian J. Luzum,
and the workshop organizing committee