INTERNATIONAL EARTH ROTATION SERVICE (IERS)
SERVICE INTERNATIONAL DE LA ROTATION TERRESTRE

REPORT ON THE IERS DIRECTING BOARD MEETING No 17

Wednesday 13 December 1995, 17:30 - 20:00 in San Francisco (USA),
in conjunction with the Fall AGU meeting

Attendance:

G. Beutler, C. Boucher, W.E. Carter, T. Clark, M. Feissel, C. Ma, D.D. McCarthy, W.G. Melbourne, D. Salstein, B.E. Schutz, J. Vondrak, P. Willis.

C. Reigber, (Chairman of the Directing Board) being unable to attend, the meeting was chaired by W.G. Melbourne .

THE INTERNATIONAL CELESTIAL REFERENCE FRAME (ICRF) AND HIPPARCOS

The IAU Working Group on Reference Frames (WGRF) established a sub-group to prepare a version of the ICRF that was delivered in November 1995 to the European Space Agency for tying the Hipparcos catalogue to the extragalactic IAU Celestial Frame (see Annex 1).

C. Ma presents the main characteristics of the computation. All VLBI observations available up to July 1995 were included in a unique analysis performed with CALC+SOLVE 8. The frame was rotated to the International Celestial Reference System (ICRS) using 133 definition sources selected on the basis of several criteria: time span of observations, structure, apparent motion, etc. The listed uncertainties were made realistic by applying to the formal ones a scaling factor of 1.5 and adding quadratically a standard error of 0.25 mas. The work will be described in a paper to be published in a scientific journal.

The series of IERS Celestial Reference frames (noted IcrfNN) that were issued with the IERS Annual Reports (actually starting with the BIH 1987 Annual Report), and that were all referred to ICRS as well, are compared to this solution in the table hereafter. The table gives the percentages of sources whose coordinates are compatible with the IAU ones within the sum of uncertainties in the pairs of catalogues.

Frame:	Icrf87	Icrf88	Icrf89	Icrf90	Icrf91	Icrf92	Icrf93	Icrf94
Nsrces:	228	209	228	396	422	509	531	607
Percentages:								
R.A.	77	83	74	80	87	90	93	97
Dec.	75	79	68	67	79	74	85	89

REPORT ON THE INTERNATIONAL TERRESTRIAL REFERENCE FRAME (ITRF)
by C. Boucher

The ITRF Workshop. A Workshop was organized by the IERS Terrestrial reference Frame Section (ITFS) of the IERS Central Bureau in order to discuss with representatives of the Analysis centers as well as other interested people. It was held in Paris on 8 and 9 May 1995 and gathered 30 attendees. Nine contributed papers were presented to stimulate discussion. The proceedings are published and are available at the ITFS or IERS/CB. The main findings can be summarized as follows.

a) Necessity to improve the method of combination. This implies in particular:

- to use the full covariance matrix of individual solutions,
- to ask for minimal constrained or free solutions,
- to use the SINEX/ISEF1 format.

b) ITRF datum: an international agreement is needed. The baseline proposal will be:

- to fix the origin by a weighted mean of SLR, GPS and DORIS results,
- to fix the scale by a weighted mean of SLR, VLBI, GPS and DORIS results,
- to fix the orientation by a best alignment to past BIH/IERS orientation at 1988.0,
- to fix the time evolution by a no net rotation condition close to geophysical models.

c) Concerning the IERS Network, the following issues were stressed:

- the growing need to take actions concerning the design of this network,
- to try to improve the existence and quality of the local survey information,
- to adopt and apply a classification of stations belonging to the IERS network.

d) Multiplicity of ITRFs. An important aspect is the clarification of concepts and vocabulary. In particular, ITRF should be used for any frame published with an IERS label and which is a realization of the International Terrestrial Reference System (ITRS). In this scope, various types of ITRF can be considered:

- complete means that all available data received by IERS are used. It implies that the set of station coordinates is maximum, but requires a classification which indicates the various levels of quality;
- primary means that the solution is resulting from highest level standards concerning models, input data, station selection, datum...
- individual means a realization done by an individual Analysis Center but explicitely referred to ITRS;
- time series means that station positions are time series (daily, weekly, monthly, yearly..).

e) Links with WGS84. It was clearly recommended to investigate closely the connection between ITRS/ITRF and WGS84, and then widely publish the related information. The recent work of DMA on these issues should be used for that purpose.

Working Group on ITRF datum. Following a recommendation of the ITRF Workshop , the IERS/DB agreed in Boulder to create a Working Group on ITRF datum (see Report on IERS/DB meeting No 16, item 4). Present members are: C. Boucher, R. Eanes, M. Feissel, T. Herring, J. Kouba, J. Ray, P. Willis.

The ITRF94 solution. A first analysis of data presented during the Workshop using the received submissions at that time stimulated discussions. A set of specifications were then established by the ITFS and submitted at the Boulder meeting. In summary ITRF94 had to fulfill:

a) combination of the solutions providing positions and velocities with full covariance matrix;
b) the datums are selected as described in the report of the ITRF Workshop;
c) the received solution are divided into two classes. Class I solutions consist of positions and velocities with full covariance matrix in the SINEX format and with acceptable quality by comparison with ITRF93;

d) the analysis consists of succesive combinations of class I solutions: within each technique and then globally. One of the issues is to determine a convenient scaling factor for each a priori covariance matrix. The result is the ITRF94 solution;
e) a first attempt to classify the resulting station coordinates should be done;
f) the other received solutions (class II) are compared with the ITRF94 solution.

A pilot experiment for a monthly ITRF (ITRF-TM1). The ITFS has undertaken a pilot experiment to compute a monthly time series: ITRF-TM1. This test was considered mainly thanks to the IGS pilot experiment for weekly GPS solutions. Clearly the monthly GPS solutions will be derived from these weekly solutions without reprocessing from GPS analysis centers. For the other techniques, it is desirable to have at least one or preferably two monthly solutions (VLBI, SLR or DORIS). It is understood that LLR may not be suitable for this test but only for global contributions. A call for proposals has been issued among the analysis centers in order to select those which would accept to provide each month their contribution.

Committee on IERS Network Design and Implementation (CINDI). This committee was discussed during the Boulder meeting following a proposal by C. Boucher. The principle was accepted. It should take care particularly of the following tasks:

- select new sites by stimulating relevant national agencies to settle proper instruments;
- improve the number or the geographical distribution of colocations either by settlement of new instruments at existing sites or by the use of multiple systems such as the TIGO system under development in Germany;
- stimulate the improvement of the local excentricity data set either by adding new local surveys or by evaluating their actual quality;
- define a classification of stations and develop quality control, in particular to check the class assesment of each station as performed by the ITFS of IERS.

I think that this should go on although the organizational aspect could be rediscussed in a larger frame considering the need to update the whole IERS organization and in particular its Directing Board. The following bodies should be represented in this Committee: ITFS, coordinating centres by technique, CSTG SGMS (J. Bosworth), some major geodetic agencies, IAG Commission 10 on Global and Regional Geodetic Networks, FGRS proposal team.

Proposals to the IERS Directing Board

Recommendation 1. To adopt a protocole for the production of ITRF by establishing and accepting a set of documents and take care of their permanent updating:

A: General concepts and terminology related to TRS/TRF; Description of the ITRF datum (link with IERS Standards)

B: Interfaces between the IERS Terrestrial Frame Section (ITFS) and Analysis Centers

C: Procedures applied to realize a Primary Frame

D: Procedures applied to realize a Complete Frame

E: Procedures applied to realize a Time Series Frame

F: User's guide on the access to ITFS results (reports, mails, WWW...)

Recommendation 2. To adopt a conventional definition on the ITRF datum without constraints coming from EOP and to utilize it in order to obtain stable sets of coordinates for the various ITRF solutions.

Recommendation 3. To investigate the interest to adopt a reference ITRF in the same way one can adopt reference values for fundamental constants, by opposition with best estimates. This would also be THE current realization of ITRS.

CENTRAL BUREAU PLANS FOR THE 1996 ANNUAL REFERENCE FRAME ANALYSES

1996 will be a special year in the evolution of IERS, corresponding to a first maturity stage in the domain of established reference frames. The Central Bureau working scheme for global analyses is evolving accordingly, most of the time in connexion with existing or ad-hoc working groups on related topics. The main features are summarized hereafter.

ICRF. A version of the ICRF, established in the framework of the IAU WG on Reference Frames, was delivered to the Hipparcos project and will be delivered to IAU as the 'official' International Celestial

Reference Frame. It may be considered as the 'best estimate' for some years. It will be used as a conventional frame, i.e., no new global combined frame will be proposed as long as the amount of new information does not justify it.

The Analysis Centres will be invited to provide the same type of global solutions as in the past. These data will be used to validate (or update if necessary) the conventional ICRF, and to control the global consistency of IERS reference frames and Earth orientation series. The Annual Report would contain the conclusions of these validations and checks, and the usual feedback on the systematic and statistical agreement of the Analysis Centres solutions with the IERS ones. The published analyses may include also significantly improved coordinates for some sources and coordinates for newly observed sources.

ITRF. The 1995 Annual Report data collection will provide the basis for establishing a terrestrial reference frame that could be considered as conventional for some years, to be called ITRF-C1. The close cooperation initiated in 1995 with the Analysis centres will be continued in order to validate ITRF-C1. An ITRF Workshop will be organized in Paris, immediately before the IERS Workshop (see below).

Documentation. In this context, the Technical Description requested with the Analysis Centres submissions plays a fundamental role. It is currently revised, keeping the reference frames and their tie as the driving topic.

COORDINATION OF SPACE TECHNIQUES FOR GEODESY AND GEODYNAMICS (CSTG)

Gerhard Beutler, President of CSTG for 1995-1999, presented the structure and the plans of CSTG.

The CSTG Charter is to develop links between various groups engaged in the field of space geodesy and geodynamics by various techniques, coordinate the work of these groups, elaborate and propose projects implying international cooperation, follow their progress, and report on their advancement and results.

At the XXI-th General Assembly of the IUGG the structure of CSTG was defined/modified in the following way:

Subcommission on VLBI (Very Long Baseline Interferometry),

Subcommission on Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR),

Subcommission on Precise Satellite Microwave Systems,

Earth Science Sites Subcommission.

CSTG and its relations to IERS and IGS: The analysis centers of the it Subcommissions on SLR/LLR and on VLBI are working very closely together with the International Earth Rotation Service (IERS). The IERS is responsible for the definition and the maintenance of the terrestrial and the celestial reference frames (ITRF and ICRF) using the time series (station coordinates and EOPs) established by the analysis centers of all techniques as an input. The IGS, the International GPS Service for Geodynamics is playing a similar role within the GPS observation technique for the (at present seven) IGS Analysis Centers.

The IERS and the IGS are natural partners for the agencies involved in space geodesy. This is e.g. documented by the fact that all analysis centers of all techniques heavily rely on the IERS Standards (McCarthy, 1992) for their operational and scientific analyses. The fact that such a document exists and that it is regularly updated is of greatest importance in space geodesy. The CSTG, on the other hand, must provide a platform for

- developing new space techniques that contribute to geodesy andgeodynamics (today e.g. Doris, Prare, Glonass, in future SAR,...) and coordinating their activities with those of existing structures,

- developing new processing techniques which go beyond the currently adopted solution procedures (e.g. the direct generation of combined products, based on GPS, SLR, and VLBI observations),

- fostering special experiments, e.g. a concentrated troposphere experiment where VLBI, SLR, GPS, WVR, high quality barometers would be used together to decouple contributions from tropospheric refraction, station height motion, and antenna phase center variations.

Such developments may have a very direct impact on the procedures of the agencies contributing to the IERS. It is thus also clear that a close collaboration must be established between the CSTG, the IERS and the IGS and that a common analysis should be established wherever possible. We are convinced that this close relationship must be underlined by organizing common symposia or sessions within symposia. Such activites are actually planned for the time period between 1995 and 1999.

A project of special interest to IERS is the study of an "IUGG Fundamental Reference and Calibration Network" (see Annex 2).

THE EVOLUTION OF IERS

The Directing Board started in 1994 a general analysis of IERS missions, goals and needs. Three documents were prepared in 18 months: a brochure, "IERS: missions and goals for 2000", an internal document, "IERS five-year strategy", and a draft leaflet, "IERS". In addition, it was proposed to make a critical assessment of the performance of the various components of IERS.

The IERS Directing Board has decided to devote the next IERS Workshop to the review of current missions and the study of their possible extension.

The vitality of the IERS could be enhanced by placing it closer to those scientific areas that command the highest priority for study of global climate change and for mitigation of natural hazards. One would consider how to reform the IERS, without seriously abridging its present services, so that it encompassed those reference system areas that are associated with ocean circulation, sea level, crustal deformation and geopotential fields. One could also consider extending IERS activity to the monitoring of geophysical fluids that influence the Earth's rotation, like the oceans, or the global water balance. In this broader context, the technical and operational requirements for fulfilling the current and possible new missions should also be investigated.

IERS has realized a major breaktrhough by establishing, monitoring and making available unified celestial and terrestrial references. However the world is changing rapidly, with at the same time new global Earth science programs being operated and increased constraints on the budgets provided by the sponsoring agencies. This makes it necessary to evaluate the ability of the IERS organisation to face these new conditions. For example, one could consider restructuring the IERS so that it played a more active role in advocating and coordinating programs, both ground and space, that addressed these challenging scientific problems.

One hopes that the main products from the Workshop would be a consensus and a clear vision of the role of the IERS in the future, and equally as important, that a documented plan, including action items for individuals, for effecting the agreed upon changes to the IERS and its services would emerge from the Workshop.

The attendance to the Workshop will be by invitation to improve the efficiency of the work. The participation should cover the scientific, technical and organisational aspects.

The Directing Board will meet immediately before and after the Workshop.

It was also agreed that four sessions will be organized by the CSTG to discuss their problems (not unrelated to those of IERS...).

It was decided after the meeting that the IERS Workshop would take place in Paris in the week of 14 October 1996.

ORGANISATIONAL MATTERS

IERS Leaflet. M. Feissel presents a draft version. Comments are due back in January 1996. Considering the possibility that as a result of the 1996 IERS Workshop it could be proposed to extend the IERS missions, it may be wise to pause in the preparation of the leaflet until the possible new missions are clarified.

Sub-bureau for Rapid Service and Predictions. A questionnaire on the treatment of diurnal and semi-diurnal EOP variations was prepared with the Central Bureau and sent to the the operational analysis

centres. D. McCarthy and D. Gambis will monitor this question. The prediction method of the sub-bureau was improved. It is recalled that the EOP results published in Bulletins A and B are given at oh UTC.

New corresponding members. B. Archinal, B. Luzum and D. Gambis were elected. The updated list is given in Annex 3.

THANKS

This meeting is the last one that W.E. Carter attends in his capacity of VLBI Coordinator. The Directing Board express their thanks and appreciation for the importance of his action in developping VLBI operations for IERS and for his ambitious vision of the Service, that led him to always expect more and better from it. Bill, we'll miss your provocative interventions !

Annex 1. IAU WORKING GROUP ON REFERENCE FRAMES

Circular Letter No.2
Issued 3 Nov 95 by Leslie Morrison

Dear member

Six months have elapsed since I issued Circular No.1 to the WGRF. Whilst not much seems to be happening in some areas, I know that at least in the sub-group working on the construction of the International Celestial Reference Frame (ICRF) things have been going at a hectic pace! This was mostly dictated by the need to delivery the ICRF catalogue to Hipparcos at the beginning of November 95.

INTERNATIONAL CELESTIAL REFERENCE FRAME

The sub-group met this deadline by delivering to Jean Kovalevsky on 3 November 95 a catalogue of 212 high quality ICRF positions, plus 41 other sources of lesser quality which are also required for the Hipparcos link. Congratulations to the sub-group:

Chopo Ma, GSFC - coordinator
Chris Jacobs & Ojars Sovers, JPL
Marshall Eubanks & Alan Fey, USNO
Felicitas Arias & Anne-Marie Gontier, IERS.

The axes of the coordinates in the ICRF catalogue have been aligned to within 0.02 mas of those stipulated in the International Celestial Reference System (ICRS). More work needs to be done on assigning realistic errors to the positions. However, these positions will not be changed before the catalogue is published and adopted by the IAU at the General Assembly in 1997. Thereafter, even if positions of a few sources are adjusted or removed from the defining list of sources because subsequent observations show them to be astrometrically unreliable, the axes will remain fixed in the ICRS to within observational error.

So, this is a historic moment! The international celestial reference frame has been fixed with respect to the extragalactic nebulae, and the optical counterpart of this frame will now be attached using the Hipparcos catalogue. This will be achieved before the end of 1995, principally by using positions of radio stars as intermediate links.

MAINTENANCE OF THE ICRF

(i) RADIO

The Directing Board of the International Earth Rotation Service (IERS) accepted the request of our WG (Feb 95, Grasse) that the IERS should oversee the maintenance of the ICRS by the use of VLBI observations. This activity is an extension of thework on reference systems carried out by the IERS since 1988, and it will be closely associated with other prime objectives of VLBI observations which are the linking of the celestial and terrestrial reference frames, and the long-term monitoring of universal time, precession and nutation.

In September 95 the IERS issued a Call For Proposals for a Coordinating Centre and Analyses Centres which will have the responsibility for organizing, collecting, analysing and distributing VLBI data in support of the IERS objectives, including the maintenance of the ICRS. The IERS Directing Board will review the proposals and make the selection at its 1996 Spring meeting.

(ii) OPTICAL

Maintenance of the HIPPARCOS frame is also one of the top priorities of the WGRF. As a first step to coordinating such work, Jean Kovalevsky requested the Presidents of Commissions 8 and 24 to provide a list of programmes in operation or contemplated. The Presidents sent out a questionnaire on this topic in August 95 and they are colating the replies. Their report will be distributed to the WGRF, so that we can formulate our opinions on how to coordinate the work.

(iii) OTHER WAVELENGTHS

I thank Bob Hindsley (USNO) for offering his help in extending the ICRF to infrared wavelengths.

IAU WORKING GROUP ON REFERENCE FRAMES e-mail address list 3 Nov 95
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Annex 2. MEMORANDUM FOR THE RECORD

Establishment of the IAG/CSTG Working Group:
"IUGG Fundamental Reference and Calibration Network"

At the IAG Executive Committee Meeting on Friday, November 10, 1995 the decision was made to set up AN IAG/CSTG Working Group with the goals to

- come up with the scientific and logistic rationale for an IUGG FUNDAMENTAL REFERENCE AND CALIBRATION NETWORK, not replacing but supporting the existing individual networks

- present a report to the IAG Executive Committee at its next meeting (spring 1997) and to recommend specific actions.

It was agreed at that meeting that the approach must be broad enough

- to include all key contributors in the field of space geodesy,
- to include key contributors from geophysics within and outside of IAG,
- to consider not only individual stations, but also clusters of stations as constituents of such a network.

It was further agreed that the procedure to establish the working group should be handled by the president of IAG, K.P. Schwarz, the president of CSTG, G. Beutler, and by I.I. Mueller, the initiator of the idea. After some discussions by e-mail the following is proposed:

(1) The working group should represent a broad spectrum of scientists currently active in the field, i.e., it should be formed "bottom -->up" to the extent possible.

(2) The starting point should be an analysis of the current activities, particularly observational programs, equipment and technical state of the art of individual sites.

(3) The objectives are

- a concept for the implementation of a global IUGG FUNDAMENTAL REFERENCE AND CALIBRATION network, which would enhance the currently existing programs,
- a concept for the combination of existing stations in a region to "fundamental station clusters" with respect to sensor combination, calibration, observation time sharing, mutual technical support, cost optimization,
- to foster the global distribution of fundamental stations by establishing new stations where needed.

It is understood that the implementation of the above objectives requires close cooperation of the existing networks such as SLR, VLBI, and microwave systems, the participation of existing structures such as

- the CSTG SLR subcommission,
- the CSTG VLBI subcommission,
- the CSTG Microwave subcommission,
- the CSTG Earth Science Site Subcommission,
- the CSTG project Coordination and Combination of the Analysis,
- the managers of existing observatories,
- the IGS (service within IAG Section 2),
- the IERS(service within IAG Section 5)
- broader IAG/IUGG Aspects,

the incorporation of new technological developments in space geodesy such as

- the German TIGO project,
- the possibility to "move" observatories E.G. from Europe or the U.S. to regions of the world where at present no space geodetic observatories are available, and the consideration of existing geophysical networks, e.g., in gravity, seismology, magnetism, meteorology, and oceanography/ hydrography.

Representatives of all these groups will be asked to participate in the working group.

The starting point for the discussion within the working group will be two papers,

1. "An IUGG Network of Fundamental Geodynamic Reference Stations:
Rationale and Recommendations" by I.I. Mueller, H. Montag, Ch. Reigber, P. Wilson.

This should be considered as the current position paper with the "intention" to give the initial input for the discussion in the scientific and logistics discussion, and

2. "The Role of the CSTG Today and in the Near Future" by G.Beutler and H. Drewes.

This will insure consistency of this working group with current CSTG policy.

Revised versions of both documents will be made available prior to the first meeting of the working group. Both documents (after revision) will also be published in the next CSTG Bulletin.

The working group should consist of about 15 members. We suggest the following composition

- one of the authors of the position paper,
- six members representing CSTG, incl. one member from each of its five subcommissions and projects,
- one member representing IERS,
- one member representing IGS,
- five members representing the IUGG member Associations, incl. IAG's Section 3 (gravity), IASPEI, IAPSO, IAMAP AND IAGA.
- one member representing the managers of existing space geodetic observatories.

The composition of the working group should be well balanced from the organizational and the geographic point of view. Not more than two of its members should belong to the same institution.

The above groups will send their nominees to the IAG President for final approval and official appointment. Nominations from IUGG Associations will be requested by the IAG President, from others by the CSTG President.

The Working Group should elect a chair and a secretary at its first meeting. The first meeting will be called by the CSTG president.

December 1, 1995 Gerhard Beutler
Ivan I. Mueller
Klaus-Peter Schwarz

Annex 3.

IERS CORRESPONDING MEMBERS (December 1995)

B. Ambrosius
B. Archinal
M. Baltuck
G. Beutler
J. Bosworth
G. Blewitt
C.D. Boucher
Y. Bock
A. Brzezinski
P. Brosche
J. Campbell
B. Chao
T. Clark
J. Degnan
J.O. Dickey
J. Dow
R. Eanes
M. Eubanks
A.M. Finkelstein
D.M. Fubara
T. Fukushima
D. Gambis
I. Georgiev
V. Glotov
C. Goad
R. Gross
E. Groten
B. Guinot
T. Herring
R. Hide
Jin W.J.
K. Kaminuma
T. Kato
N. Kawano
R.W. King
B. Kolaczek
J. Kouba
J. Kovalevsky
J. LaBrecque
R.B. Langley
J.L. Le Mouel
J.-F. Lestrade
B. Luzum
D.D. McCarthy
P. McCulloch
C. Ma
G.L. Mader
Z. Malkin
S. Manabe
A.J. Miller
J.B. Minster
H. Montag
L.V. Morrison
I.I. Mueller
J. Müller
M. Murata
A. Nothnagel
R. Neilan
P. Pâquet
E. Pavlis
W.R. Peltier
G. Petit
R. Ponte
D. Pugh
J. Ray
C. Reigber
D.S. Robertson
R. Rosen
D. Salstein
V. Salyamov
T. Sasao
C. Schalinski
H.G. Scherneck
H. Schuh
H. Seeger
A. Sengoku
P. Shelus
O. Sovers
A. Sprent
A. Steppe
A. Stolz
F. Takahashi
V. Taradij
S. Tatevian
C. de Vegt
R.O. Vicente
J. Vondrak
K.F. Wakker
M. Watkins
A.L. Whipple
A. Whitney
J. Williams
G.A. Wilkins
C.R. Wilson
P. Wilson
W.H. Wooden
P. Woodworth
Y.Yatskiv
K. Yokoyama
T. Yoshino
T. Yunck
Zhu S.Y.
J.F. Zumberge

President of FAGS	: O.B. Andersen
General Secretary of IAU	: I. Appenzeller
President, IAU Division I	: J. Kovalevsky
President of IAU Commission 19	: J. Vondrak
President of IAU Commission 31	: H. Fliegel
General Secretary of IUGG	: G. Balmino
General Secretary of IAG	: C. Tscherning
President of IAG Section II	: R. Rummel
President of IAG Section V	: M. Feissel
President of IAG Commission 8 (CSTG)	: G. Beutler